FUNDAÇÃO GETÚLIO VARGAS
ESCOLA DE ECONOMIA DE EMPRESAS DE SÃO PAULO

Olivier Joel Claude Boileau

Precious Metals, a shiny hedge for investors?

SÃO PAULO
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Campo do Conhecimento:
International Master in Finance

Orientador Prof. Dr. Marcelo Fernandes (advisor)

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RESUMO

Serão os Metais Preciosos um “hedge” valioso para os investidores?

Recorrendo a duas abordagens diferentes, regressão e correlação, e cobrindo os últimos vinte anos de dados diários para sete países, esta tese investiga as propriedades “safe haven” e “hedge” dos metais preciosos, em comparação com acções internacionais para um dado estado da economia.

Adicionalmente, esta tese avalia o desempenho de diferentes portfolios, dentro e fora da amostra, com o objectivo de verificar se o investimento em metais preciosos poderá ajudar a atenuar a gestao do risco por parte do investidor.

Os principais resultados são os que se seguem: (i) O ouro é o melhor metal precioso para um “hedging” internacional em oposição às acções (ii) O ouro permite obter valiosos benefícios de gestão de risco do portfolio (iii) 60/40 dos portofios atribuidos com ouro permitem ao investidor obter bons resultados.

Palavras Chave: Metais Preciosos, activo “hedge” & “safe haven”, família ARCH, gestão de portfolio.

ABSTRACT

Precious Metals, a shiny hedge for investors?

Using regression and correlation approaches covering the last twenty years of daily data for seven countries, this thesis investigates safe haven and hedge abilities of precious metals against international equities over a given state of the economy. Furthermore, this thesis examines different portfolios performance in-samples and out-of-samples with the aim to observe whether investing in precious metals can help to mitigate investor risk management. The key results are: (i) Gold is the finest precious metal for international hedging against equities (ii) Gold provides valuable portfolio risk management benefits (iii) 60/40 portfolios allocated with gold proffer good investor outcomes.

Key words: Precious metals, hedge & safe haven asset, ARCH family, portfolio management.

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1. Introduction

This work project intends to discuss if precious metals are hedge-safe haven assets against the global international equity market. The main contribution of the current paper relies on the study of an innovative recent dataset and regression model selection. This paper also elects the shiniest hedging precious metal and investigates if it can be reflected as a valuable portfolio hedge asset to hold under two delimited portfolio environments – under an in-sample bias and under a possibly more practical environmental bias (out-of-sample procedure).[1]

Wherefore, this work project seeks to identify which of the precious metals over the last 20 years (1995 to 2015) is the best alternative, with the intent to potentially decrease portfolio risk management for a global representation of the financial world market. This finding is partially determined by the election of a regression model belonging to the ARCH family. The ARCH family aims to tackle conditional heteroskedastic variance present in the data set studied. With respect to the previous results, a US portfolio analysis will be undertaken in order to display the importance that will provide the finest given precious metals to optimize returns, while minimizing US portfolio risk management. Consequently, the structure of this paper is organized as follows:

Section 1 presents an introduction to the work project purposes and a general literature review on precious metals. Section 2 sets out which precious metal is the finest in terms of hedge-safe haven asset versus the global stock market. The latter results will be utilized in Section 3 to discover if the best precious metal can help to mitigate global

[1] Discussion is relevant for the last 20 years (1995-2015).

investor portfolio. Finally, Section 4 contains a summary of findings. The paper also includes references, and an appendix containing additional tables and figure.

1.1 General overview of precious metals and actual global state of economy

Precious metals (gold, silver, platinum and palladium) are as old as the earth itself. Silver and gold have roughly 6000 years of recorded history. Platinum enjoys a relatively recent history since its discovery goes back to the 16th century when Spanish conquistadors discovered it in Ecuador, and it is only 100 years later that palladium was isolated. Precious metals were and still are a crucial element of every human culture. They are principally used to serve two purposes that drive the total demand: commodity (used in jewelry and in several industry applications, such as electronics, dentistry, automotive, or nanotechnology sectors) and also as a medium of exchange. From the very beginning, precious metals have been appreciated – they gained a religious and cultural significance that led them to become a symbol for luxury and wealth. Empires were built and destroyed because of precious metals (notably in the case of gold). Indeed, it is for the love of precious metals that new world civilizations such as the Aztecs and Incas were conquered. For a period of over one hundred years prior to 1971, gold played an important role within the global economic architecture, by backing a number of currencies, such as the US Dollar ("USD") and the British Pound. In March 1973 the U.S. Government faced the situation when major currencies began to float against each other. This new floating exchange system introduced by major European banks affected the convertibility of the Dollar to gold and resulted in the collapse of the system (Wang, et al., 2011). Gold was demonetized and currencies were allowed to float freely due to the reform of the international monetary system required by the United States of America. This was mainly because the USA could not print enough USD to face the costly Vietnam War (this historic event contributed to the creation of

the USD fiat currency). Nevertheless, nowadays precious metals are still importantly held by most of central bank reserves and governments as a mean of national health protection and preservation against economic instability. The main reason for this phenomenon is that metals enjoy the following characteristics: high liquidity, diversification, economic security (metals maintain their purchasing power over time and hence have no credit risk). Other crucial characteristics include physical security and insurance against past market crises (as shown in section 2).

The actual global state of the economy can be characterized by a general economic uncertainty.

First of all, emerging countries are facing several issues. There is an ongoing slowdown in emerging market economies represented by a low economic growth, which is likely to continue to be dampened by the lethargic pace of the required structural reforms. Since 2011, most of emerging countries have been facing the currency devaluation in comparison to the USD (roughly -48% for BRICS)[2]. Moreover, emerging country motors are slowing down meaning China, Brazil and India growth not having reached the provisioned and expected target growth. China even faced a market trepidation in the summer 2015.

Secondly, developed countries are also currently facing challenges. The three major central banks, i.e. Federal Reserve Board (FED), Bank of Japan and European Central Bank, closely monitor the financial market situation by flowing the economy with liquidity (see the example of the USA in Figure 1) by the intermediary of fixing extremely low interest rates (negative interest rates for Europe) and quantitative easing (QE) policies.

[2] See appendix table 17.

QE allows private banks to sell the government debt directly to the local central bank at a favorable price. Those policies were an appropriate answer to face the last global financial crisis of 2009, but today they nourish the financial sphere and do not really pay back into the real economy. In addition, these monetary policies foster the increase of both private and public debt and, as a repercussion, the world is facing new "record" of debt in most of developed and emerging countries, as outlined in Figure 2.

Nevertheless, the global state of the economy is not limited to a bearish perspective. In fact, lower oil prices since mid-2014 boost international consumption and facilitate international importation and exportation. Consequently, this should improve households and support global growth. Those macroeconomic theories are supported by the international monetary fund (IMF). Aasim M. Husain´s work states that the fall in oil prices should raise the global growth by about 0.5% points in 2016 (Husain, et al., 2015). In addition, the Chinese growth is rebuilding after the threat of last summer, while Europe enjoyed great returns on stocks in 2015. Moreover, the USA results are on a better path and the FED recently increased interest rates and investors´ first reactions seemed to be positive[3]. In the long term, higher interest rates in the USA could negatively affect the global economic outlook since the appreciation of the Dollar will strongly impact the countries that were issued billions of dollars of US debt (such as Brazil).

In accordance to the above described situation investors might seek more flight-to-quality[4] investment assets in the hope to protect the portfolio. A US pilot survival kit contains neither US Dollar nor any other paper currency, but gold. Therefore, even under unusual situations, as previously illustrated, the yellow metal apparently plays a

[3] Financial Times; when interest rates rise. http://ig.ft.com/sites/when-rates-rise/

[4] "The action of investors moving their capital away from riskier investments to the safest possible investment vehicles" - http://www.investopedia.com/terms/f/flighttoquality.asp

hedge role and hence appears a possible safe investment vehicle. The question is whether this is also true for other precious metals. According to the empirical result of this thesis, all the examined precious metals can play a hedging role. This result is in line with Chong and Miffre's studies (Chong & Miffre, 2010). Moreover, section 2 shows that those performances vary depending on the type of the precious metal and the analyzed country.

For the last 20 years (1995-2015), gold was found to be the most desirable precious metal to be held facing local and global financial turmoil in the prospect to hedge equity returns. Gold superior attractiveness as an effective and investible vehicle for risk management has been widely confirmed. The current work project also demonstrates crucial insights in allocating gold into a portfolio in order to reduce financial losses and increase real returns. Those results stay in line with the recent article "Will Precious metals Shine? A Market Efficiency Perspective" (Charles, Darne, & Kim, 2014), which highlights that among precious metals, the gold market exhibits the highest degree of market efficiency and precious metals are an important component of investment portfolios. Therefore, the present thesis input adds consistency and insight on the existing precious metal literature review discussed in the following paragraph.

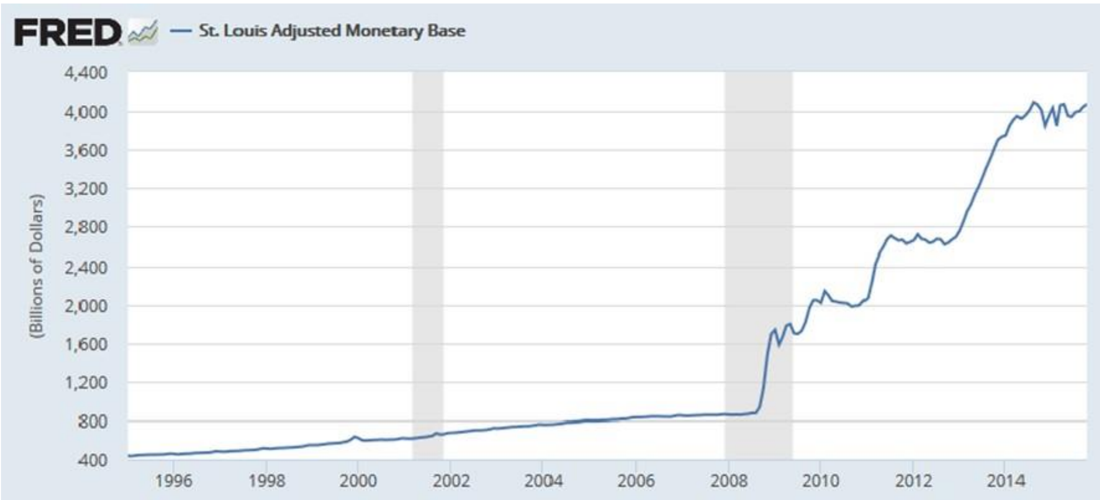

Figure 1. USA Monetary Base (1995-2015). Source: Federal Reserve Bank of St. Louis.

Figure 2. USA Total Public Debt (1966-2015). Source: US. Department of the Treasury. Fiscal service.

1.2 Related literature review

During the times of financial stress or turmoil, investors are more disposed to rebalance their portfolios toward less risky securities generally represented by a fixed income and treasury bills (Abel, 1988), (Durand, Junker, & Szimayer, 2010). A fixed income and treasury bills, however, are not the only way to turn aside financial turmoils to positive returns. Amenc, Martellini and Ziemann, demonstrated that commodities are a valuable investment for long-term investors (Amenc, et al., 2009), while Chow, Jacquier, Kritzman and Lowry, suggested that commodity portfolios are even more attractive when the general financial climate is negative (Chow, et al., 1999). These results are consistent with Jensen, Johnson, and Mercer's finding (Jensen G., et al, 2002) that commodity futures enhance portfolio performances for investors. Numerous studies have disclosed that gold can be used as a store of wealth and therefore appears to be a great flight-to-quality asset. For instance, according to Smith, "when the economic environment becomes more uncertain attention turns to investing in gold as a safe haven asset" (Smith, 2002). In more recent empirical works, researchers confirmed that gold globally plays a role of hedge and safe haven against stocks, thanks to the interpretation of a GARCH(1,1) model (Lucey & Baur, 2010), (Baur &

McDermott, 2010). They followed Capie, Mills, and Wood’s approach that found evidences on gold ability to hedge against the dollar by the estimation of a dynamic regression model, correcting conditional autoregressive heteroskedasticity via a GARCH process for the residuals (Capie, et al., 2005).

The existing literature that explores the use of gold for protecting investors' wealth is quite representative, but there are only a few analyses concerning the potential hedging role of other precious metals. The most important contribution is presented by Chong and Miffre´s research suggesting that precious metals (i.e. gold, silver and platinum) are a valuable diversifier and a "refuge asset" for stock markets (Chong & Miffre, 2010). By applying a GARCH (1,1), Hillier, Draper and Faff state that precious metals have an ability to improve the portfolio efficiency in terms of a higher reward-to-risk-ratio (Hillier, et.al,, 2006). Moreover, the reaserchers commented that platinum offers some hedging potential for stock during the time of extreme market volatility.

2. The role of precious metals as a safe haven-hedge asset

2.1 Data

The empirical analysis was conducted using daily data spanning from 1995 to 2015[5]. The database was collected through Bloomberg and the federal bank reserve of St. Louis. With the aim to avoid possible distorting effects of the common currency denomination, the data set is adjusted for currency move by quoting precious metal price and indices into local currency. The data set is composed of: future prices of precious metals (gold, silver, palladium and platinum) and local MSCI of seven countries. The MSCI Country Index allows to capture 85% of total market capitalization

[5] Note that the data period selection is based on the data availability of the MSCI and the wish to ensure sufficient historical data to include different business cycles.

and mirrors the global economic diversity of that market[6]. The multi-country analysis selection was reduced to seven countries (USA, Australia, China, India, Germany, South Africa, and Russia), with the goal to represent a reasonable sample of the international world equity market. Such a selection of countries permits to exhibit dissimilar profiles: emerging markets are represented by Russia, India, China and South Africa while developed countries are pictured by the USA, Australia and Germany. Additionally, these countries possess versatile demand and supply balance profile. USA, Russia and China are experiencing an important interior consumption of precious metals, while South Africa is mainly producing precious metals for exportation. Furthermore, Germany and India possess few mines, and are mainly net buyers of precious metals.

Three sub-period analyses will be run in the prospect of introducing further insights and clarity on whether precious metals are valuable to protect investors' wealth against a given state of the local economy. In other words, does precious metal play a role of safe haven-hedge asset against the local economic diversity and business cycle? To answer this question, the sample period is partitioned into three distinct scenarios: scenario 1 (full sample), scenario 2 (recession), and scenario 3 (full period – recession). The recession period of the United States of America was delimited by NBRE recession indicator, while the recession period of the remaining countries was determined by OECDE recession indicators.

An Augmented Dickey Fuller test (ADF) had been conducted. At level, all data series was found not stationary. In order to obtain no unit root, the data set has been

[6] "MSCI adjust for Free Float and increase coverage to 85%", MSCI press release. Geneva, December 10, 2000.

modified to returns (1st difference[7]). Afterward, the ADF test outlined unit "stationarity" for all series. Hence, the remaining data set is modified into returns.

Table 1 provides a descriptive statistic summary[8] of daily returns over the entire study period for precious metals (palladium, platinum, gold, and silver) and local MSCI indices. The data illustrate that during a standard situation, with no financial turmoil, emerging countries (China, India, South Africa, and Russia) generally manifest superior average returns and a higher risk (standard deviation) on the stock market than developed countries. The result also displays that usually, for any given environment and scenario, gold has the smallest standard deviation (STD), whereas platinum is the most volatile asset. This might be explained by gold specific characteristic, i.e. it's monetary and widest total and non-industrial demand among precious metals (for instance, in 2014 palladium demand was about 7.28 million of ounces as compared to 138.37 million of ounces for gold)[9]. In the case of developed countries (USA, Australia, Germany) and among precious metals, gold provides the greatest positive Sharpe ratio (2% in USA, 2.4% in Australia and 3.2% in Germany) for the past 20 years. Meanwhile, platinum offers the best investment in term of risk-return ratio in emerging countries. These findings alter accordingly to dissimilar business cycle. During the recession time (Scenario 2, Table 2), gold emerges as the most appealing precious metals since it proffers the highest Sharpe ratio for 5 out of 7 studied countries (USA, Germany, Russia, South Africa and India), whereas palladium advance to higher investment concern for leftover countries (China and Australia). Under scenario 3 (Table 3), a lower general volatility stands on the global equity market and implies a positive Sharpe

[7] Note that we also find stationarity under the 2nd difference.

[8] Number of observation is available in tables 7-8-9.

[9] GFMS Platinum & Palladium Survey 2015 - Gold Demand Trends Full Year 2014, Published 12-02-2015 by World Gold Council.

ratio result for all MSCI indices (the opposite situation to the recession period where every MSCI Sharpe ratio is negative, excluding the case of Australia). Investors' best assets to target under scenario 3 seem to be palladium and platinum for all the examined countries, excluding Australia, where the yellow metal is the shiniest precious metal.

Scenario 1	Palladium	Platinium	Gold	Silver	MSCI Index	Measures
USA	0.000329	0.000168	0.000221	0.000214	0.000252	Mean [1]
	2.18%	1.49%	1.11%	1.95%	1.24%	STD [2]
	1.5%	1.1%	2.0%	1.1%	2.0%	Sharpe Ratio [3]
China	0.000332	0.000350	0.000176	0.000280	0.000137	[1]
	2.58%	1.42%	1.10%	1.93%	2.03%	[2]
	1.29%	2.46%	1.60%	1.45%	0.68%	[3]
Australia	0.000340	0.000245	0.000270	0.000363	0.000250	[1]
	2.52%	1.41%	1.11%	1.79%	1.04%	[2]
	1.3%	1.7%	2.4%	2.0%	2.4%	[3]
Russia	0.000939	0.001017	0.000841	0.000921	0.000739	[1]
	2.79%	1.81%	1.63%	2.21%	3.03%	[2]
	3.4%	5.6%	5.2%	4.2%	2.4%	[3]
South Africa	0.000657	0.000696	0.000522	0.000600	0.000257	[1]
	2.62%	1.56%	1.30%	1.92%	1.79%	[2]
	2.5%	4.5%	4.0%	3.1%	1.4%	[3]
India	0.000520	0.000545	0.000371	0.000468	0.000405	[1]
	2.59%	1.41%	1.12%	1.90%	1.81%	[2]
	2.0%	3.9%	3.3%	2.5%	2.2%	[3]
Germany	0.000294	0.000265	0.000352	0.000383	0.000169	[1]
	2.05%	1.47%	1.09%	1.87%	1.53%	[2]
	1.4%	1.8%	3.2%	2.1%	1.1%	[3]

Table 1. Descriptive statistical analysis on daily returns (Scenario 1).

Scenario 2	Palladium	Platinium	Gold	Silver	MSCI Index	Measures
USA	-0.001409	-0.000647	0.000387	0.000039	-0.000764	Mean [1]
	2.80%	2.26%	1.56%	2.55%	2.10%	STD [2]
	-5.0%	-2.9%	2.5%	0.2%	-3.6%	Sharpe Ratio [3]
China	0.000110	-0.000302	-0.000225	-0.000309	-0.000436	[1]
	2.16%	1.44%	1.07%	1.94%	2.25%	[2]
	0.5%	-2.1%	-2.1%	-1.6%	-1.9%	[3]
Australia	0.000882	0.000405	0.000343	0.000381	0.000171	[1]
	2.10%	1.60%	1.28%	1.87%	1.17%	[2]
	4.2%	2.5%	2.7%	2.0%	1.5%	[3]
Russia	0.000410	0.000772	0.000995	0.000788	-0.000696	[1]
	3.40%	2.23%	2.04%	2.54%	3.47%	[2]
	1.2%	3.5%	4.9%	3.1%	-2.0%	[3]
South Africa	-0.000465	0.000551	0.000555	0.000480	-0.000271	[1]
	3.37%	1.80%	1.48%	2.01%	2.08%	[2]
	-1.4%	3.1%	3.8%	2.4%	-1.3%	[3]
India	-0.000452	0.000439	0.000411	0.000012	-0.000478	[1]
	3.01%	1.62%	1.26%	2.01%	1.95%	[2]
	-1.50%	2.71%	3.26%	0.06%	-2.45%	[3]
Germany	-0.000759	-0.000203	0.000174	-0.000148	-0.000239	[1]
	0.02	0.01	0.01	0.02	0.02	[2]
	-3.6%	-1.4%	1.6%	-0.8%	-1.3%	[3]

Table 2. Descriptive statistical analysis on daily returns (Scenario 2).

Scenario 3	Palladium	Platinium	Gold	Silver	MSCI Index	Measures
USA	0.000566	0.000279	0.000197	0.000234	0.000392	Mean [1]
	2.07%	1.35%	1.03%	1.85%	1.06%	STD [2]
	2.7%	2.1%	1.9%	1.3%	3.7%	Sharpe Ratio [3]
China	0.001150	0.001352	0.000711	0.001091	0.001003	[1]
	2.13%	1.42%	1.13%	1.82%	1.69%	[2]
	5.4%	9.5%	6.3%	6.0%	5.9%	[3]
Australia	-0.000043	0.000133	0.000219	0.000351	0.000305	[1]
	2.78%	1.26%	0.98%	1.73%	0.93%	[2]
	-0.2%	1.1%	2.2%	2.0%	3.3%	[3]
Russia	0.001425	0.001238	0.000705	0.001026	0.002043	[1]
	2.09%	1.31%	1.13%	1.84%	2.57%	[2]
	6.8%	9.5%	6.2%	5.6%	7.9%	[3]
South Africa	0.001362	0.000782	0.000505	0.000689	0.000576	[1]
	2.02%	1.38%	1.17%	1.86%	1.58%	[2]
	6.7%	5.7%	4.3%	3.7%	3.6%	[3]
India	0.001330	0.000629	0.000335	0.000846	0.001129	[1]
	2.17%	1.20%	1.00%	1.81%	1.68%	[2]
	6.1%	5.2%	3.4%	4.7%	6.7%	[3]
Germany	0.001465	0.000720	0.000602	0.001191	0.000609	[1]
	1.96%	1.41%	1.08%	1.79%	1.25%	[2]
	7.5%	5.1%	5.6%	6.7%	4.9%	[3]

Table 3. Descriptive statistical analysis on daily returns (Scenario 3).

2.2 The methodology

With the objective to investigate safe haven and hedging abilities of precious metals, a two-step procedure will be undertaken.

- Step one simply consists in observing the correlation of precious metals against local indices.

- Step two consist in the interpretation of the β coefficient obtained under the given regression analysis that seems to fit best each dataset in accordance with the specificity of countries and scenarios.

Both schemes are based on Lucey's & Li definition of safe haven and hedge asset (Lucey & Li, 2013). According to their research, an asset that tends to be negatively correlated (uncorrelated) with an underlying asset in times of market stress

is called a strong (weak) safe haven asset. When it is negatively correlated (uncorrelated) with an underlying asset on average, it is called a strong (weak) hedge.

Since all series studied have stationary features at the same level order (1rst difference), a cointegration test had been run at level (raw data) with the view to observe the existence or lack of cointegration among our data set. Johansen cointegration test displayed that at level there is no cointegration among our data set[10] (fail to reject the null hypothesis of no cointegration, since p-value >5%), therefore, the Vector Error Correcting Model is not reliable for our case study. Under a basic Ordinary Least Square regression method (OLS), the evidence of heteroskedacity in the residuals is revealed. In fact, all series present residuals (error term) that fluctuate with clustering volatility profile, indeed long period of low volatility (high volatility) tend to be followed by a long period of low volatility (high volatility)[11]. Moreover, the interpretation of the White Test (with and without cross terms) and Breush-Pagan-Godfrey test adds consistency to the existence of conditional heteroskedacity on the residual[12] (we reject the null hypotheses of homoscedasticity since all observed prob. of Chi-square <5%). In addition, under OLS regression an ARCH effect on the error term is exhibited by ARCH test[13]. Breush-Godfrey serial correlation LM Test[14] suggests that residuals possess a strong serial correlation probability (0%) into the OLS regression model (we reject the null hypotheses of no serial correlation since observed prob. of Chi-square <5%).

In accordance with the previously stated data features, regressions under an ARCH family model seem reasonable in the optic to interpret and forecast the coefficient

[10] See appendix example for USA on table 18.
[11] See appendix example for USA on figure 6.
[12] See appendix example for USA tables 19-20-21.
[13] See appendix example for USA table 22.
[14] See appendix example for USA table 23.

estimator and Std. Error. ARCH family regressions (i.e. CARCH, GARCH, EGARCH, and TARCH Model) were mainly inspired by Rob Engle work (Engle & K.F, 1995).

As mentioned in the literature review, the GARCH regression model has been used by several economists in the view to remove conditional heteroskedastic variance and to reveal precious metals hedge and safe haven properties. In contrast to the literature review, the current work project seeks to select the ARCH regression that fits best the data set of each country and scenario studied. Consequently, CARCH(1,1), GARCH(1,1), GARCH(2,1) EGARCH(1,1,1), and TARCH(1,1,1) models have been compared by the intermediary of AIC & SIC information criteria and diagnostic tests of residuals (serial correlation, ARCH effect and normality distribution) with an aim to decide upon and select the regression model that well-suits individual data set series[15] . The guideline followed the rule that the lower the value of AIC and SIC, the better-fitted the model. Meanwhile, the residual diagnostic needs to exhibit neither serial correlation nor ARCH effect. After the selection of the ARCH model that fits best the given series (under Normal Gaussian error distribution assumption), the error distribution that well-suits residuals has been selected according to AIC, SIC criteria and residuals: serial correlation, Arch effect and Normality properties[16]. The table summarizing the regression models chosen along with the previously-described methodology is given in the appendix[17]. Concerning the normality test, residuals of ARCH family regression are globally not normally distributed and could provide a limitation with respect to the accuracy of upcoming empirical analysis results. Nevertheless, it is common to observe non-normality in long-period data sets.

[15] See appendix tables 24-26-28.
[16] See appendix tables 25-27-29.
[17] See appendix table 30.

2.3 Empirical results

Tables 4-5-6 exhibits correlation between daily return on precious metals price versus daily return generated by local indices. The low correlation within precious metals and equities (they are uncorrelated) between 1995 and 2015 supports that precious metals can fulfill a hedging responsibility (weak). Meanwhile, a negative correlation on gold return against equities returns can be noticed (except in China). Therefore, gold appears to be the finest precious metal hedging tool, since at any time it enjoys strong hedge properties against international equities. Note that South Africa presents singularity. In fact, all precious metals studied for the last 20 years were a strong safe haven and hedge asset according to the negative correlation results for scenarios 1 & 2.

Nevertheless, according to the given state of the economy, precious metals globally bear distinctive properties of performance. Indeed, table 5 (recession period) exhibits that the correlation of gold versus international equities negatively increases during the period of recession (for instance, the yellow metal correlation in USA ranges from -0.004 with no recession to -0.072 during recession), while the correlation among other precious metals increases positively. Accordingly, safe haven achievement of gold during the recession period is stronger, whereas safe haven properties of other metals seem to decrease. Scenario 3 (table 6) also reveals different results - during the no recession period the precious metal hedging role shades off, but the yellow metal still endures to act as a strong hedge asset (with a decrease in negative correlation value) for the USA, Australia, India and South Africa. In leftover countries (China, Russia and Germany) gold still offers hedging properties (weak hedge).

Scenario 1	Palladium	Platinum	Gold	Silver
USA	0.1441	0.1069	-0.0244	0.0774
China	0.1032	0.1699	0.0557	0.1342
Australia	0.0436	0.0298	-0.1185	0.0387
Russia	0.0218	-0.0065	-0.1145	0.0276
South Africa	-0.0309	-0.0182	-0.3256	-0.0335
India	0.0723	0.0321	-0.0918	0.0598
Germany	0.0189	0.0128	-0.0231	0.0219

Table 4. Daily returns correlation (Scenario 1).

Scenario 2	Palladium	Platinum	Gold	Silver
USA	0.1599	0.0968	-0.0718	0.0698
China	0.0892	0.1739	0.0446	0.1297
Australia	0.0614	0.02701	-0,1632	0.0345
Russia	-0.0284	-0.0376	-0.1736	-0.0242
South Africa	-0.0561	-0.0179	-0.3866	-0.1103
India	0.0781	0.0381	-0.1402	0.0487
Germany	0.2197	0.1521	-0.0955	0.1056

Table 5. Daily returns correlation (Scenario 2).

Scenario 3	Palladium	Platinum	Gold	Silver
USA	0.1394	0.1109	-0.0042	0.0813
China	0.1332	0.1482	0.0485	0.1332
Australia	0.0341	0.0329	-0.0673	0.0427
Russia	0.1199	0.0564	0.0131	0.1145
South Africa	0.0011	-0.1871	-0.2632	0.0339
India	0.0618	0.0229	-0.0351	0.0692
Germany	0.1994	0.1483	0.1012	0.1959

Table 6. Daily returns correlation (Scenario 3).

The results for the ARCH family regression are illustrated in tables 7-8-9. Given that the constant alpha is generally too small to be taken into consideration, table 7-8-9 does not contain the alpha variable. A low R-squared is not a surprise since the model does not intend to portray MSCI move. What is, however, required for this study is the interpretation of the slope (beta coefficient).

Table 7-8-9 adds consistency to previous findings. The coefficient estimator of the ARCH family suggests that in the case of daily data, precious metals commonly act

as a hedge asset against international equities (in general, small β coefficients are observed). Nevertheless, Tables 7-8-9 also suggests that for any given scenario and country selected silver is the worst asset regarding hedge and safe haven asset properties (highest β coefficient among precious metals for every scenario and country). Meanwhile, the yellow metal asset exhibits a consistent and durable compensating diversification as well as hedging effect versus international equity market. Indeed, all beta coefficients are negative and statistically significant at 5% significance level (p-value >5%).

In depth, according to table 7 over the course of the past 20 years a move of 1% in the local indices involves a countercyclical average move of gold in the neighborhood of 0.10% to 0.69% (-0.098% in Australia, -0.13% in USA, -0.15% in China, -0.22% in Germany, 0.32% in India, -0.62% in Russia and -0.69% in South Africa). Palladium appears to be the second best precious metal in terms of hedging properties since almost every beta coefficient is small (under 10%). Notice that in South Africa, platinum also possesses strong hedge properties (-0.10%). According to the R-Square, gold explains roughly 18% of the South African MSCI, this variance comparing to other R-square results might be elucidated by the distinctive profile. Indeed, in South Africa mining is the backbone of the economy as it represents 30-35% of total exportation and 8% of total national income in 2014[18].

During market duress (the case of recession period, table 8), gold remains the best safe haven asset for all the analyzed countries. Gold beta estimations are even more negatively connected to local indice movements than during the full sample. Currently, beta coefficients range from -0.16 in China to -0.87 in Russia (-0.19 in Australia, -0.30

[18] South African Chamber of mine, annual report of 2013-2014, May 2015.

in USA, -0.37 in Germany, -0.60 in India and -0.68 in South Africa). Moreover, leaving aside the specific case of silver, other precious metals retain safe haven features (β close to 0) when facing the recession period. Therefore, as foreseen by the findings exhibited in the table 8, during the recession (higher STD and lower MSCI returns) the yellow metal becomes more reliable for investors in the outlook to reduce portfolio risk management that might struggle due to the global equity downside. During the no recession period (table 9), gold continues to exhibit a strong hedging property in the USA, Australia, India and South Africa. Nevertheless, smaller negative beta coefficients are observed and now range from -0.11 in USA to 0.69 in South Africa. Likewise, in India and South Africa, platinum can be used by investors as a possible strong hedge asset (negative β coeff.). Also remark that for other scenarios and countries, platinum suggests to retain its hedge and safe haven role. For instance, platinum negative beta coefficient during recession in USA (-0.014) suggests that platinum could play a (relatively strong) safe haven role during high volatility market changes, as it had been suggested by Hillier, Draper and Faff's study (Hillier., et al, 2006). Nevertheless, most platinum beta coefficients are not significant in the statistical view (for instance, in USA and during scenario 2, platinum p-value = 72%). Therefore, any fix and transparent interpretation of platinum role versus the equity market can be undertaken for the past 20 years.

To sum up, gold can be considered as the supreme precious metal in terms of safe haven and hedge role for any given business cycle and country selection. Its hedging effect varies according to the state of economy. For instance, gold hedging effect is stronger when hedging is needed most, i.e. during the recession period. Those results stay in line with previous findings (N. Amenc., et al,). Indeed, when the portfolio returns struggle facing regional or international duress, the beta coefficient and the negative correlation of gold counterbalance the losses of the stock market. Compared

to the yellow metal, the protection of a portfolio that relies on palladium, platinum and more categorically silver, seems not sufficiently trustworthy. The upcoming section will attempt to corroborate that the yellow metal offers an adequate valuable hedge in a more specific lifelike environment – an investor portfolio management analysis.

Country	Palladium		Platinum		Gold		Silver		R^2	Obs
	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value		
Usa	0.046	0.000	0.054	0.000	-0.134	0.000	0.056	0.000	0.036	4983
China	0.045	0.000	0.135	0.000	-0.150	0.000	0.087	0.000	0.037	4983
Australia	0.014	0.020	0.010	0.332	-0.098	0.000	0.046	0.000	0.028	4953
Russia	0.082	0.000	0.029	0.280	-0.619	0.000	0.313	0.000	0.055	4956
South Africa	0.048	0.000	-0.102	0.000	-0.686	0.000	0.308	0.000	0.185	4886
India	0.053	0.000	-0.029	0.126	-0.323	0.000	0.160	0.000	0.042	4846
Germany	0.093	0.000	0.067	0.000	-0.224	0.000	0.113	0.000	0.060	4109

Table 7. Coefficient estimation (Scenario 1).

Country	Palladium		Platinum		Gold		Silver		R^2	Obs
	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value		
Usa	0.076	0.013	-0.014	0.716	-0.301	0.000	0.141	0.000	0.057	617
China	0.054	0.002	0.128	0.000	-0.158	0.000	0.079	0.001	0.036	3013
Australia	0.030	0.014	0.011	0.524	-0.189	0.000	0.074	0.000	0.060	2051
Russia	0.041	0.096	0.068	0.039	-0.872	0.000	0.380	0.000	0.082	2361
South Africa	0.011	0.521	-0.031	0.235	-0.684	0.000	0.227	0.000	0.197	1881
India	0.053	0.004	0.068	0.004	-0.589	0.000	0.252	0.000	0.081	2210
Germany	0.094	0.000	0.098	0.000	-0.370	0.000	0.119	0.000	0.075	1778

Table 8. Coefficient estimation (Scenario 2).

Country	Palladium		Platinum		Gold		Silver		R^2	Obs
	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value	β Coeff	P-value		
Usa	0.042	0.000	0.048	0.000	-0.106	0.000	0.046	0.000	0.031	4366
China	0.046	0.023	0.114	0.000	-0.187	0.000	0.119	0.000	0.037	1611
Australia	0.008	0.244	0.010	0.406	-0.061	0.001	0.033	0.001	0.012	2903
Russia	0.089	0.000	0.028	0.486	-0.380	0.000	0.263	0.000	0.030	2596
South Africa	0.072	0.000	-0.164	0.000	-0.688	0.000	0.315	0.000	0.173	3006
India	0.044	0.003	-0.069	0.011	-0.149	0.000	0.099	0.000	0.016	2636
Germany	0.112	0.000	0.051	0.006	-0.220	0.000	0.138	0.000	0.052	2331

Table 9. Coefficient estimation (Scenario 3).

3. Investor portfolio analysis

3.1 Data

Aligned with previous section outcomes from1995 to 2015, gold was the finest precious metal in term of safe haven-hedge properties against the United State of America stock market and, more generally, versus the sample of international equity.

Accordingly, the upcoming section investigates the yellow metal portfolio risk management aspiration properties implemented in a given portfolio. The portfolio is composed of the usual investor global macroeconomic concerns:

- Equity: MSCI World (MXWO) used as a benchmark to measure international equity performance; MSCI EA (MXEA) is used to track the performance of about two dozen developed countries in Europe, Australia, Asia and the Far East; MSCI US (MXUS) is used to focus on the USA equity market; MSCI Emerging Market Index (MXEF) is used as a benchmark for emerging stock market.

- Commodity: S&P GS Commodity Index (S&P GSCI). Recognized as the leading measure of commodity prices. It is a broad-based, production-weighted and meant to be representative of the global commodity market beta.[19]
- Bonds: US 10Y Treasury Bills and 3M Treasury Bills.

All data have been obtained from the Bloomberg database. The data set spans from January 1995 to October 2015. In the following section, all strategies and data sets are developed and implemented in U.S. Dollar terms (USD), as a consequence no currency hedging is needed. Moreover, for simplicity, the constraint of no short selling is undertaken ($0 \leq wi \leq 1$) along with no leverage ability (total weight = 1). The risk free rate is calculated as the traditional average of 3M T-BILL.

[19] According to McGraw HILL FINANCIAL - http://us.spindices.com/indices/commodities/sp-gscidynamic-roll

3.2 Gold as a natural portfolio diversifier

The benefits of the portfolio diversification have been praised for more than six decades. Harry Markowitz provided the academic bedrock for diversifying the portfolio interest. He found out that by combining assets that are disparately correlated the risks embedded in a portfolio are diminished, while portfolio can reach higher risk-adjusted returns (Markowitz, 1952). Hence, a well-diversified portfolio holds a scope of different assets that permit to smooth out unsystematic risk events in a portfolio. This is the case since positive (negative) performance will counterbalance negative (positive) performance due to discordant correlations.

Table 10 exhibits the yellow metal correlation versus the studied portfolio composite. Gold holds a diversifier role that is outlined by the low correlation with most of the studied assets, and a negative correlation against MSCI US and Bonds. Commodities (S&P GSCI) bear the highest positive correlation with gold, but the correlation remains relatively low (27%). It is due to the fact that gold sustains a small weight in the SPGCI index (1.58%) and is partially a commodity, partially a luxury consumption good and partially a financial asset.

Correlation	Gold
S&P GSCI	0.27783
MXEF	0.19585
MXEA	0.12774
MXUS	-0.05084
MXWO	0.04896
TBILL	-0.07377
WGS10Y	-0.04907
Gold	1

Table 10. Correlation of monthly returns between gold and selected assets.

Additionally, precious metals behave as a diversification tool against Dollar fluctuations. In fact, this type of commodity is dollar-denominated and a depreciation in the currency leads to an increase in the gold price, due to a higher demand. Sellers seek compensation for currency loss and this puts a pressure on the price of gold. These observations were validated by Mark Joy (Joy, 2011). Using a GARCH model, he demonstrated gold currency hedge capacity against the USD for a period of 25 years. Gold is also acknowledged as a financial store of value, known to maintain its purchasing power over a long period of time, according to The Golden Constant originally published in 1977 and recently revised in June 2009 by Leyland (Leyland, 2009).

3.3 Portfolio selection

The forthcoming five portfolio strategies with and without gold will be historically simulated in the hope to answer the two questions: if gold happened to behave as a valuable risk management tool for the last twenty years and which portfolio that contained gold emerges as the most optimal one. Our five strategies consist of the following:

- Equally weighted portfolio (EWP): Portfolio weight is equally distributed for each asset and remains constant over time. In our case nine different assets retain an equivalent investment weight of 12.5% according to the no leverage assumption.

- Risk Parity: In 1996 Bridgewater launched a risk parity fund named *all weather asset allocation*, but the term risk parity has been popularized by Edward Qian (Qian, 2005). Risk parity aims to equalize risk contributions of portfolio components by equally weighting asset according to STD, so that no asset contributes more than any other asset to the total risk of the portfolio. In this section two distinct risk parity

scenarios are considered. The first one is risk parity for all assets (RP1), while the second consists of risk parity between stocks and bonds (RP2).

- 60/40 Portfolio: 60% of total portfolio weight is dedicated to stock and the remaining 40% is invested in fixed income. 60/40 portfolio is often associated with the traditional balanced portfolio.

- Mean-Variance portfolio (MV): According to You and Daigler, Markowitz's portfolio theory can also be applied for commodity instrument diversification (You & Daigler, 2010). MV is a portfolio allocation based on Markowitz research from 1952 (Portfolio selection). MV represents a portfolio with the highest expected return for the given level of risk. Moreover, the tangency portfolio enjoys the highest reachable Sharpe ratio since it is the interception of the Capital Asset Line (CAL) and efficient frontier. An efficient frontier is represented by a myriad of optimal portfolios that enjoy the lowest possible level of risk for a maximum level of return. Therefore, a rational investor would be willing to handle a portfolio that lies on the efficient frontier. In order to minimize portfolio variance, the following weights were chosen:

$$\sigma^2 = \omega' \Omega^2 \omega$$

3.4 Performance measures

Main performance measure tools assessed with the intent to illustrate the portfolio performance are: Sharpe Ratio, value at risk and a new ratio introduced for the sake of this thesis (NR). Those measures will allow to interpret each portfolio achievement by means of comparing it to another to maintain homogeneity and transparency.

- Sharpe Ratio (SR): risk performance adjusted method developed in 1966 by the 1990 Nobel laureate (awarded for his input into the Capital Asset Pricing Model), William F. Sharpe.

$$SR = \frac{Er - Rf}{\sigma}$$

- Nowadays the ratio serves as an industry standard for calculating risk-adjusted return that is the average return earned by the portfolio (Er) in excess of the average risk-free rate (Rf) per unit of portfolio risk assumed to be the standard deviation (σ). The greater the value of SR, the more attractive in term of return per unit of risk the portfolio is.

- Value at Risk (VAR): initially developed by the insurance sector in the 80's, VAR had been popularized by JP Morgan Chase & Co in the 90's. VAR enables investors to have a simple quantitative and probabilistic measure of the portfolio maximum potential losses that may occur, according to a time horizon (t)[20] and for a given confidence interval (CI)[21].

- New Ratio (NR): was created and developed for the sake of this thesis and allows investors to interpret the mean-variance risk management by taking into consideration the percentage of the maximum potential loss of the given investment. It consists of the composite of the Sharpe ratio and VAR.

$$NR = \frac{SR}{Investment / VAR}$$

[20] t=1.

[21] CI=95%.

NR grants that investors can get a quick overview of excess returns per unit of risk, determined by STD and VAR.

3.5 In-sample analysis

Gold performs as a portfolio diversifier and acts as a safe haven and hedge asset against the international equity market. Thus, gold allocation in a given portfolio might insinuate superior mean-variance returns for the selected portfolio. In that sense, the imminent in-sample portfolio analysis will pursue to verify the assumption that the yellow metal may appear charming to investors.

An in-sample analysis is a historical simulation that estimates the optimal weight of a given portfolio by using at once all initial historical data available and then, comparing the fitted values of the model to the actual realizations of the portfolio. However, noise in the data may still appear due to the size of the data set.

3.5.1 Empirical results

The summarized results of the selected portfolio based on historical simulation are exhibited in table 11. As it exemplifies, the yellow metal appears to offer outstanding profit opportunities in portfolio performance and portfolio risk management. In fact, adding gold to the portfolio mix lowers standard deviation and value at risk without sacrificing the expected returns for any given portfolio strategy. For instance, the yellow metal allows investors to outperform Sharpe ratio in the range of 4.4 basis points to 13.1, while decreasing the total portfolio value at risk from 0.7% to 2.6%. Without any surprise, the portfolio that reports the finest performance in terms of SR is the tangency portfolio (0.7). Nevertheless, according to VAR and NR performance measures, the risk parity portfolio (RP2) surpasses every other portfolio.

The efficient frontier incorporating gold (figure 3) is quite similar to the efficient frontier without gold (figure 4). But having said that, it is important to notice a slight

upward shift on the efficient frontier on figure 3. The shift in question can be explained by the absence of gold diversification along with the absence of hedge and safe haven feature benefits as it is materialized in figure 4. This confirms that adding gold to the mix is a move worthy of undertaking. Moreover, figures 3 and 4 display that RP2 and 60/40 balanced portfolio fall on the efficient frontier (as the tangency portfolio, by definition) and are defined as an optimal portfolio strategy for a rational investor. A conservative investor would opt for the tangency and risk parity portfolio, rather than 60/40 portfolio with more likely maximum losses that may be favored by more aggressive investors. In contrast, RP1 and EWP portfolio do not lie on the efficient frontier and must be ignored by the investor since they are portrayed by an inadequate risk level for a given level of expected returns. Table 12 exhibits the weight of gold for each optimal portfolio strategy. The potential adequate general weight for gold allocation over the past 20 years could be assigned around 15% to 26%. Those weight allocations are in line with the previous study that claimed that adding 20% to gold maximizes risk-adjusted returns.[22]

To sum up, gold allocation in a portfolio decreases the total volatility without sacrificing the expected returns. Consequently, Sharpe ratio is continually improved for a portfolio that includes the yellow metal. Gold can be seen as a strategic investment choice not only because it offers better rewards for a given risk. The yellow metal also permits investors to diminish potential maximum loss, i.e. decrease the value at risk of a portfolio. All five buy and hold selected portfolio strategies established that gold is a concrete valuable tool to manage the portfolio risk by increasing the portfolio return while decreasing the standard deviation and value at risk. This thesis will now

[22] Michael Ide- value walk- http://www.valuewalk.com/2013/12/20-gold-allocation-has-best-risk-rewardratio/

investigate if gold rewards are maintained in a more practical investor environment. To be able to present such a situation, the so called Out of Sample (OOS) analysis will be implemented for our set of optimal portfolio strategies.

Portfolio Strategy		Portfolio Performance Measures			Gold Benefits		
		SR	VAR	NR	SR	VAR	NR
EWP	Gold	0.42	0.15	2.7	4.4%	-1.3%	0.5
	No Gold	0.37	16.7%	2.23			
RP2	Gold	0.65	7.7%	8.5	11.4%	-0.7%	2.1
	No Gold	0.54	0.08	6.4			
RP1	Gold	0.47	9.9%	4.8	6.7%	-0.7%	0.9
	No Gold	0.41	10.6%	3.84			
MV	Gold	0.70	8.6%	8.1	8.6%	-0.7%	1.5
	No Gold	0.61	9.3%	6.5			
60/40	Gold	0.66	10.3%	6.5	13.1%	-2.6%	2.3
	No Gold	0.53	12.9%	4.13			

Table 11. Portfolio summary results.

Portfolio Strategy		R SPGCI	R MXEF	R MXEA	R MXUS	R MXWO	R GOLD	TBILL	WGS10Y
RP2	Gold	2.0%	0.0%	0.0%	13.6%	2.7%	15.2%	0.0%	66.5%
	No Gold	6.6%	0.0%	6.7%	12.1%	2.9%	0.0%	0.0%	71.7%
MV	Gold	0.9%	0.0%	0.0%	25.9%	0.0%	17.5%	0.0%	55.8%
	No Gold	5.6%	0.0%	0.0%	29.8%	0.0%	0.0%	0.0%	64.6%
60/40	Gold	5.1%	0.0%	0.0%	28.8%	0.0%	26.1%	0.0%	40.0%
	No Gold	16.5%	0.0%	6.5%	37.0%	0.0%	0.0%	0.0%	40.0%

Table 12. Optimal portfolio weight.

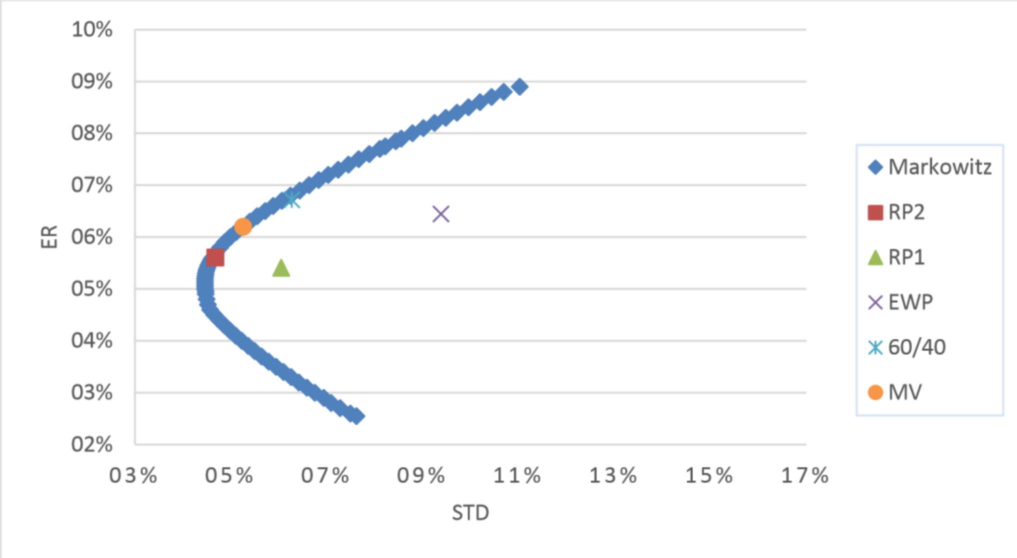

Figure 3. Portfolio plot (with gold).

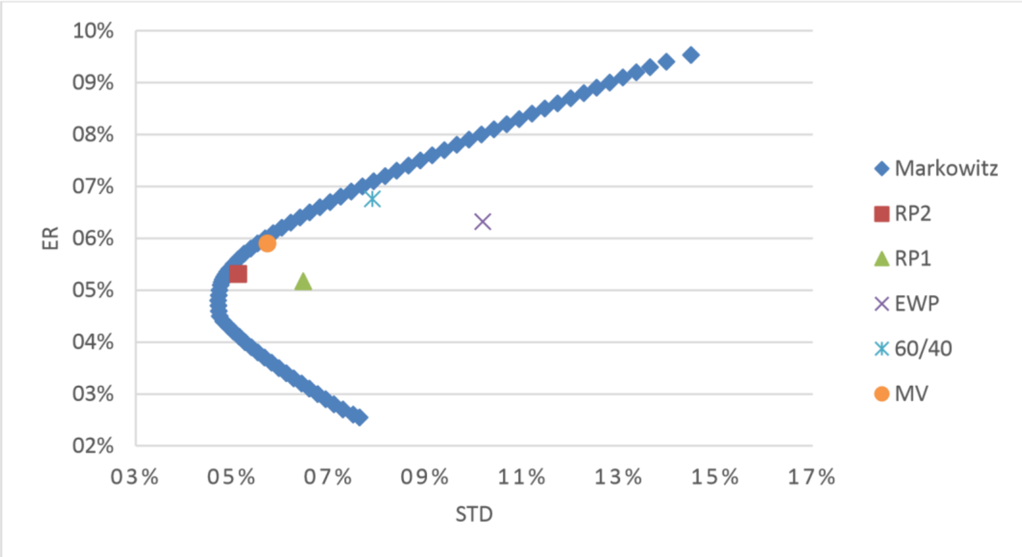

Figure 4. Portfolios plot (without gold).

3.6 Out of sample analysis

3.6.1 Methodology

Previous assertions were conducted under the “in-sample” procedure using historical information of the past 20 years. Nevertheless, it is advisable for an investor to subordinate portfolio strategy test under a more pragmatic lifelike environment. Consequently, a more realistic assessment will be based on an OSS approach for RP2

and 60/40 portfolio. The model is inspired by DeMiguel, Garlappi, Nogales and Uppal's work (DeMiguel, et al., 2009). The methodology: T (monthly) asset observations and K the size of the rolling window to use to measure optimal allocation weights where, K ≥T. The weight of assets is computed by taking into account data from the first trading day of each month throughout the whole dataset period. Returns and standard deviation of past rolling windows are used as a tool to forecast finest potential future allocation strategy to be held for the next month. In other words, the optimal asset weight of previous rolling windows will be used by the investor as a proxy for weight allocation of the next upcoming month. To provide more robustness of the obtained results, we use two alternative rolling-windows (30 and 60 months). The weight of an asset can be described in the following way:

$$w_i^t = \frac{\frac{1}{\sigma_i^t}}{\sum_{i=1}^{10} \frac{1}{\sigma_i^t}}$$

Where σ_i^t denotes the reported volatility of an asset in the 30 or 60 previous months (30M or 60M). As it was shown in the prior section, major performance measures to compare the portfolio result are SR, VAR, and NR.

3.6.2 OSS empirical results

Table 13 is a synopsis of the yellow metal ability to protect the investor portfolios. According to table 13, under OOS bias, gold remains an effective hedge against portfolio losses without affecting the expected returns (in average gold now increases NR by 3.89 basis points and SR by 0.21 basis point, while it decreases monthly VAR by 4.1%). This positive outcome is on average more significant for OOS analysis as in every situation higher gold benefits can be observed on SR, VAR and

NR. Moreover, gold benefit over NR, SR and VAR are stronger than previous in-sample optimal portfolio results (+1.69 NR, +0.09 SR, 2.5% VAR). Gold benefits enlarge when using 30M rolling periods instead of 60M. These results may be explained by the fact that a smaller rolling window seems to reveal more accurate information on the future returns and standard deviation and apparently adds consistence to investors' ability to forecast more suitable individual asset weight allocation towards following months.

Table 14 is a summary of portfolio performance results under OOS bias. It displays that the out of sample analysis, besides improving gold benefits, also enhances total portfolio performances. Indeed, in contrast to the previously obtained theoretical result (the in-sample approach), table 14 exhibits a global superior average portfolio SR and NR. Therefore, thanks to 30M and 60M look back period, investors are now able to anticipate market moves in a more reliable and transparent way. Hence, 30M and 60M look back periods provide investors with a finest future weight allocation, in comparison to adjusting weight allocation based on the analysis of the past 20 years returns and annualized variance/covariance matrix. Nevertheless, RP2 portfolio worsens under OOS method as NR decreased from 8.5 to 7.41 in 30M rolling periods and 4.04 for 60M rolling windows.

The in-sample analysis reflected that RP2 strategies can shine but in a more pragmatic simulation, the RP2 strategy seems no longer a strategy worth to be invested in. Under OSS and under every circumstance, the simplest traditional balanced portfolio (60/40) performs better than a more complicated risk-parity system in terms of SR and NR. Moreover, 60/40 30M gold allocated portfolio represents the best strategy to implement for the given dataset, since it provides by far the greatest NR (12.6) thanks to its high Sharpe ratio (0.98), and a relatively low annual value at risk (7.8%) relationship. One drawback of 60/40 portfolio to be mentioned is that even if in terms of Dollar the

portfolio is well diversified between equities and bonds, in terms of risk diversity the 60/40 offers poor diversification. This can be seen when comparing 60/40 to RP2 portfolios in which a high proportion of risk comes from equities. Still, notice that all strategies, including gold position interest within a 30M look back period scenario, led to positive monthly returns for every single month since January 1995.

The previous findings are highlighted by figure 5 that exhibits all OSS portfolio strategies studied. Let us recall that a rational investor incorporates gold to boost the portfolio performance as it always provides higher returns, NR, SR, lower standard deviation and VAR for any given world selected (accordingly to tables 11 and 13). Figure 5 confirms the results of the previous observations and shows that optimal portfolios over the efficient in-sample frontier are only represented by gold allocated portfolios (60/40 30&60M). Since risk parity strategies for any time selection studied (in case of 30&60M rolling window) lead to non-optimal portfolio selection, such portfolios must be dropped by potential rational investors.

Performance Measures	Gold benefits			
	Risk Parity 30M	Risk Parity 60M	60/40 30M	60/40 60M
Mean Return	1.1%	1.2%	2.4%	1.6%
Mean Volatility	-0.4%	-0.6%	-2.4%	-2.9%
Sharpe Ratio	0.16	0.14	0.33	0.22
NR	2.91	1.61	8.01	3.03
Monthly VAR* VAR (%)	-$4,824 1.7%	-$6,581 -2.3%	-$17,991 -6.2%	-$18,428 -6.4%
Max. Monthly Return (%)	0	0	0	0
Min. Monthly Return (%)	0.2%	0	0.9%	0
Positive Month Returns (%)	6.5%	0	10.2%	0.5%

* $ 1,000,000 investment

Table 13. Gold benefits under out of sample bias.

Performance Measures	Out Of Sample - 30 month rolling window: Portfolio Strategy				Out Of Sample - 60 month rolling window: Portfolio Strategy			
	Risk Parity with Gold	Risk Parity without Gold	60/40 with Gold	60/40 Without Gold	60/40 with Gold	60/40 Without Gold	Risk Parity with Gold	Risk Parity without Gold
Annual Mean Return	4.6%	3.5%	11.4%	9.1%	9.6%	8.0%	5.0%	3.8%
Annual Mean Volatility	7.7%	8.1%	11.6%	14.0%	13.6%	16.5%	10.4%	11.0%
Annual Sharpe Ratio	0.60	0.44	0.98	0.65	0.71	0.49	0.49	0.35
Annual NR	7.41	4.50	12.63	4.62	5.58	2.55	4.04	2.43
Monthly VAR*	$23,287	$28,111	$22,382	$40,373	$36,659	$55,086	$34,716	$41,296
Annual VAR (%)	8%	10%	8%	14%	13%	19%	12%	14%
Max. Monthly Return (%)	0.6%	0.6%	1.9%	1.9%	1.6%	1.6%	0.6%	0.6%
Min. Monthly Return (%)	0.1%	-0.1%	0.1%	-0.8%	-0.2%	-0.2%	-0.1%	-0.1%
Positive Month Returns (%)	100.0%	93.5%	100.0%	89.8%	98.9%	98.4%	98.9%	98.9%

* $ 1,000,000 investment

Table 14. OOS portfolio summary results.

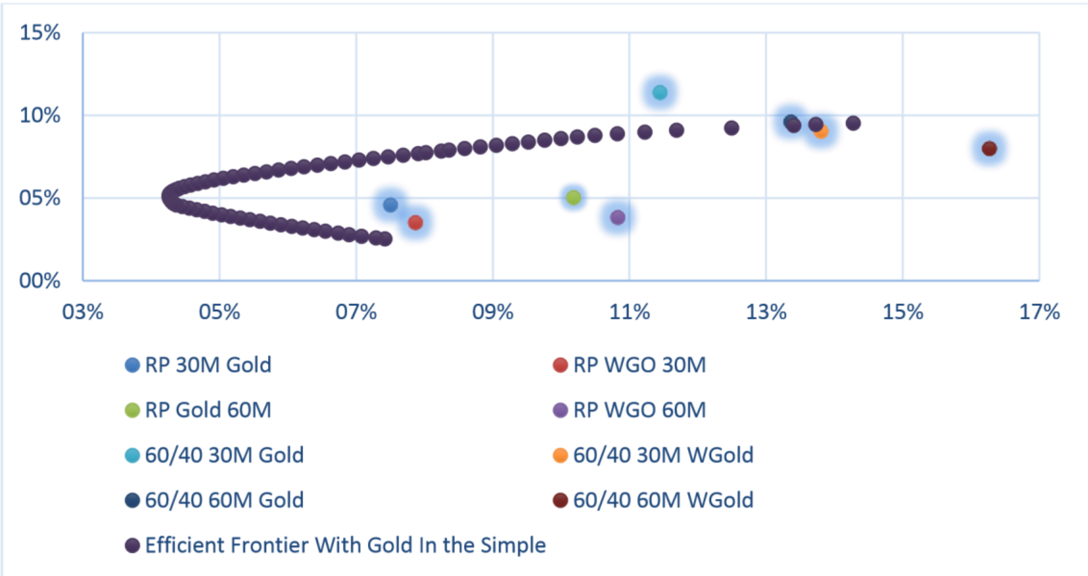

Figure 5. OOS portfolio mean-variance.

To assess the magnitude of the potential gains that can be realized by an investor, it is necessary to analyze the out of sample performance of the strategies including the transaction cost. Indeed, all portfolios studied using out of sample procedures are actively managed. Therefore transaction costs will be incurred due to a monthly rebalancing. Subtracted transaction cost of monthly returns will provide investors with a more meticulous representation of the actual investor universe. Transaction cost incorporation will focus only on portfolios that seem investible in accordance with previous findings (30M and 60M look back period of 60/40 portfolio with gold

allocation). Portfolio without gold interest will also be studied in order to compare once more how adding gold to a portfolio can make the investment shine. The following formula is used to compute monthly returns after transaction costs:

$$Er,t = [ws,t * Rs,(t+1) - ABS(ws,t - ws,(t-1)) * Tc]$$
$$+ [wb,t * Rb,(t+1) - ABS(wb,t - wb,(t-1)) * Tc]$$

"S" stands for $\sum_{t=1}^{i} Stocks$ and "b" for r $\sum^{i}{}_{t=1} Bonds$. This formula takes into account change in weight and transaction costs (Tc) that are paid at the entry and at the exit of the position. Transaction costs are assumed to be 0.10%. No leverage constrains need to be undertaken. Note that it is realistic to assume that some market participants are unable or unwilling to use leverage. Nevertheless, in order to add realism to the findings, a further research could integrate leverage and short sell according to investor risk preferences.

Table 15 summarizes the portfolio performance adjusted to the transaction cost[23] and exhibits that portfolio transaction cost only slightly impacts mean returns without modifying STD, hence the Sharpe ratio, NR and value at risk are slightly negatively modified. Therefore, transaction costs do not fundamentally change the previous findings and 60/40 30M look back period with gold interest remains the finest portfolio to hold according to SR, VAR and thus NR.

If an investor had implemented the previous OSS portfolio strategy with data starting from year 1995, he would have been able to invest in August 1997 and would have enjoyed $675.841 compounded returns in September 2015, equivalent to $351.601

[23] See appendix table 31 for transaction cost implication without gold interest.

when adjusted to inflation[24]. An investor may wish to observe his benefits adjusted to inflation that measure the average change "in the prices paid by urban consumers for a representative basket of goods and services"[25]. The real return is calculated by subtracting the total USA inflation increases of compounded returns over the entire investment period. The inflation indicator is computed as follows using a monthly CPI index[26].

$$Inflation = \frac{Old\ CPI - Current\ CPI}{Old\ CPI}$$

Table 16 relates computed returns of 60/40 to 30M and 60M look back period. The investment has been established accordingly to the earliest 60/40 60M possible investment date (February 2000). The result is in line with the previous finding that 30M rolling window provides higher returns as compared with a 60M look back period. For instance, investing $100 000 in gold allocated 60/40 30M portfolio provides real returns of $304.250 against $258.098 under 60M rolling window[28]. In contrast, with no gold allocation constraints, adding gold to the portfolio mix provides an increase in real returns of respectively 32.5% and 20.6% under 30M and 60M look back period.

[24] Real return for the initial investment of $100 000 and inflation (August 1997 to October 2015) ≈ 0.4798.

[25] CPI definition proposed by the U.S. Bureau of Labor Statistics. Consumer Price Index (CPI).

[26] Provided by the U.S. Bureau of Labor Statistics. Consumer Price Index (CPI).

[28] Return adjusted to inflation from February 2000 to September 2015, (40.1%).

Performance Measures	Transaction Cost implications	
	60/40 with Gold 30M	60/40 with Gold 60M
Mean Return	-0.17%	-0.18%
Mean Volatility	0%	0%
Sharpe Ratio	-0.015	-0.014
NR	-0.46	-0.18
Monthly VAR $	56.888,06 $	92.166,36 $
VAR (%)	0.17%	0.18%
Max. Monthly Return (%)	0%	0%
Min. Monthly Return (%)	-0.12%	-0.18%
Positive Month Returns (%)	-0.46%	-0.54%

Table 15. Transaction cost implication (with gold).

Computed returns*				
	With Gold		Without gold	
Date	60/40 30M TC	60/40 60M TC	60/40 60M TC	60/40 30M TC
29/02/2000	$100,897	$100,995	$100,995	$100,897
28/02/2001	$111,191	$113,053	$113,053	$111,191
28/02/2002	$118,411	$120,425	$120,425	$117,875
28/02/2003	$122,193	$121,896	$121,896	$119,872
27/02/2004	$132,688	$129,244	$129,817	$123,529
28/02/2005	$149,675	$136,871	$139,606	$140,262
28/02/2006	$174,972	$146,636	$150,813	$163,968
28/02/2007	$195,462	$163,549	$169,567	$183,169
29/02/2008	$223,720	$189,674	$196,653	$209,025
27/02/2009	$245,297	$210,477	$216,118	$218,396
26/02/2010	$273,594	$235,136	$232,025	$217,495
28/02/2011	$302,252	$266,672	$247,890	$214,230
29/02/2012	$344,179	$297,518	$259,322	$239,692
28/02/2013	$379,402	$331,291	$268,542	$256,209
28/02/2014	$407,281	$349,557	$279,607	$275,035
27/02/2015	$450,018	$383,230	$306,541	$303,895
30/09/2015	$475,025	$403,687	$322,905	$320,782
30/09/2015	**$284.386	**$ 241.677	**$ 193.315	**$ 192.044

* $ 100,000 Investment and transaction cost included.

** Returns adjusted to inflation (USA CPI).

Table 16. Computed returns OSS 60/40 portfolios.

4. Summary of finding

Over the last 20 years (1995-2015), precious metals perform as a safe haven and hedge asset against a sample willing to represent the international equity market. More particularly, gold appears to be the shiniest precious metal in terms of safe haven-hedge properties under correlation and ARCH family regression approaches. For every time period within any portfolio strategy or environment approach studied, the yellow metal consistently offers valuable clear-cut advantages by decreasing the portfolio management risk and total potential maximum losses, and increasing the expected returns. Thereby, the yellow metal can effectively achieve a superior Sharpe ratio. Such profit opportunities may be explained by its different historical purpose and meaning in comparison to other commodities (religious interest, financial value storage, investment use, industrial and luxury application, portfolio diversifier). For the past twenty years, a gold portfolio 60/40 balanced on a 30M look back period offers the finest investment strategy to implement. In fact, investors can enjoy the greatest positive NR performance measure that is characterized by a relatively high Sharpe ratio and a low value at risk relationship. In other words, this portfolio strategy for the given time period can multiply the investor real returns by 3.52 (1.37 without gold) with respect to the initial investment, while the portfolio enjoys 99.5% (88.9% without gold) of monthly positive returns with compounded returns and including transaction cost constraints. The bottom line is, gold appears as a profit opportunity for any rational investor. The financial portfolios containing the yellow metal always perform significantly better than standard equity portfolios with no gold allocation. Nonetheless, note that appropriate portfolio strategies always depend on the individual investor risk adversity and in all cases, the presented results should be interpreted as a potential investor's guideline rather than an exact recommendation.

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6. Appendix

Country	Ticker	02/05/2011	02/01/2016	% Move
Brazil	BRL	1.59	3.96	60%
Russia	RUB	27.35	73.00	63%
India	INR	44.27	66.24	33%
China	CNY	0.68	0.92	27%
South Africa	ZAR	6.64	15.56	57%

Table 17. BRICS currency moves against USD.

Sample (adjusted): 26/09/1995 09/10/2015
Included observations: 4979 after adjustments
Trend assumption: Linear deterministic trend
Series: MXUS_INDEX_AT_LEVEL PALLADIUM_AT_LEVEL PLATINUM_AT_LEVEL GOLD_AT_LEVEL SILVER_AT_LEVEL
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.003987	44.46626	69.81889	0.8474
At most 1	0.002573	24.57552	47.85613	0.9295
At most 2	0.000994	11.74841	29.79707	0.9403
At most 3	0.000745	6.797698	15.49471	0.6013
At most 4	0.000620	3.089045	3.841466	0.0788

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.003987	19.89074	33.87687	0.7642
At most 1	0.002573	12.82711	27.58434	0.8943
At most 2	0.000994	4.950714	21.13162	0.9960
At most 3	0.000745	3.708653	14.26460	0.8888

At most 4	0.000620	3.089045	3.841466	0.0788

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Ho (Trace and Maximum Eigenvalue): There is no cointegration.

Table 18. Johansen cointegration test. (Full sample USA).

Heteroskedasticity Test: White

F-statistic	42.76980	Prob. F(14,4968)	0.0000
Obs*R-squared	535.9846	Prob. Chi-Square(14)	0.0000
Scaled explained SS	2424.361	Prob. Chi-Square(14)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 26/09/1995 08/10/2015
Included observations: 4983

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.08 E-05	6.76 E-06	13.42554	0.0000
PALLADUM_RETURNS^2	-0.002121	0.006757	-0.313962	0.7536
PALLADUM_RETURNS*PLATINUM_RETURNS	0.112360	0.019970	5.626482	0.0000
PALLADUM_RETURNS*GOLD_RETURNS	-0.191302	0.041058	-4.659354	0.0000
PALLADUM_RETURNS*SILVER_RETURNS	0.012937	0.022407	0.577362	0.5637
PALLADUM_RETURNS	-0.000188	0.000343	-0.548302	0.5835
PLATINUM_RETURNS^2	0.000276	0.006039	0.045718	0.9635
PLATINUM_RETURNS*GOLD_RETURNS	-0.201000	0.053599	-3.750069	0.0002
PLATINUM_RETURNS*SILVER_RETURNS	0.285398	0.035647	8.006130	0.0000
PLATINUM_RETURNS	0.000908	0.000563	1.613510	0.1067
GOLD_RETURNS^2	0.754408	0.047447	15.89995	0.0000
GOLD_RETURNS*SILVER_RETURNS	-0.617138	0.051475	-11.98900	0.0000
GOLD_RETURNS	1.16E-05	0.000834	0.013885	0.9889
SILVER_RETURNS^2	0.084760	0.014563	5.820234	0.0000
SILVER_RETURNS	-0.000948	0.000487	-1.947928	0.0515

R-squared	0.107563	Mean dependent var	0.000146
Adjusted R-squared	0.105048	S.D. dependent var	0.000441
S.E. of regression	0.000417	Akaike info criterion	-12.72279
Sum squared resid	0.000865	Schwarz criterion	-12.70318
Log likelihood	31713.84	Hannan-Quinn criter.	-12.71592
F-statistic	42.76980	Durbin-Watson stat	1.723185
Prob(F-statistic)	0.000000		

H0: There is Homoscedasticity.

Table 19. Heteroskedasticity White test with cross terms. (Full sample USA).

Heteroskedasticity Test: White

F-statistic	52.28095	Prob. F(4,4978)	0.0000
Obs*R-squared	200.8943	Prob. Chi-Square(4)	0.0000
Scaled explained SS	908.6836	Prob. Chi-Square(4)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 26/09/1995 08/10/2015
Included observations: 4983

Variable	Coefficient	Std. Error	t-Statistc	Prob.
C	0.000106	6.81 E-06	15.58857	0.0000
PALLADUM_RETURNS^2	0.022408	0.004958	4.519344	0.0000
PLATINUM_RETURNS^2	0.023858	0.005278	4.520208	0.0000
GOLD_RETURNS^2	0.155909	0.021066	7.400935	0.0000
SILVER_RETURNS^2	0.014181	0.006626	2.140307	0.0324

R-squared	0.040316	Mean dependent var	0.000146
Adjusted R-squared	0.039545	S.D. dependent var	0.000441
S.E. of regression	0.000432	Akaike info criterion	-12.65416
Sum squared resid	0.000930	Schwarz criterion	-12.64762
Log likelihood	31532.84	Hannan-Quinn criter.	-12.65187
F-statistic	52.28095	Durbin-Watson stat	1.624390
Prob(F-statistic)	0.000000		

H0: There is Homoscedasticity.

Table 20. Heteroskedasticity White test without cross terms. (Full sample USA).

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	7.619970	Prob. F(4,4978)	0.0000
Obs*R-squared	30.32482	Prob. Chi-Square(4)	0.0000
Scaled explained SS	137.1650	Prob. Chi-Square(4)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Sample: 26/09/1995 08/10/2015
Included observations: 4983

H0: There is Homoscedasticity.

Table 21. Heteroskedasticity Breusch-Pagan-Godfrey. (Full sample USA).

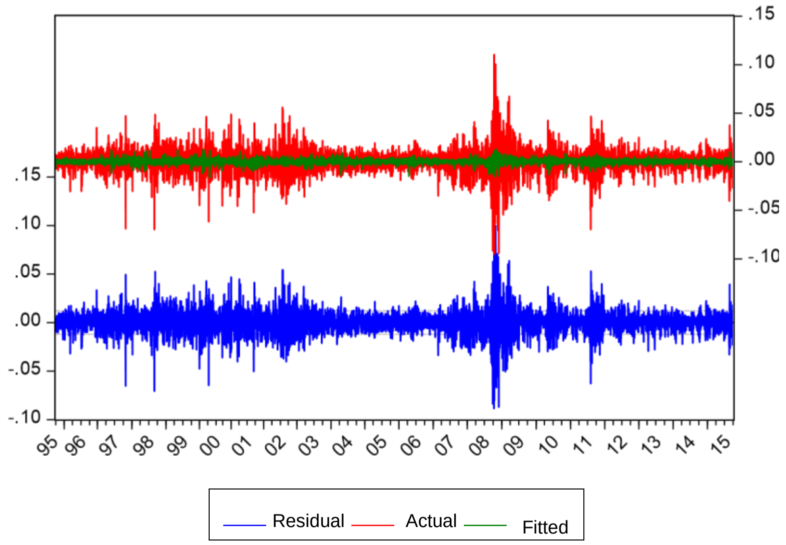

Figure 6. Residual distribution plot (OLS full sample USA)

Heteroskedasticity Test: ARCH

F-statistic	153.6678	Prob. F(12,4958)	0.0000
Obs*R-squared	1347.629	Prob. Chi-Square(12)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Included observations: 4971 after adjustments

Variable	Coefficient	Std. Error	t-Stat.	Prob.
C	2.41 E-05	6.18 E-06	3.907511	0.0001
RESID^2(-1)	0.023097	0.014183	1.628498	0.1035
RESID^2(-2)	0.162681	0.013981	11.63556	0.0000
RESID^2(-3)	-0.063972	0.014168	-4.515264	0.0000
RESID^2(-4)	0.060704	0.014182	4.280296	0.0000
RESID^2(-5)	0.168850	0.014195	11.89523	0.0000
RESID^2(-6)	0.078880	0.014357	5.494210	0.0000
RESID^2(-7)	0.074324	0.014357	5.176899	0.0000
RESID^2(-8)	0.044008	0.014195	3.100264	0.0019
RESID^2(-9)	0.046037	0.014182	3.246030	0.0012
RESID^2(-10)	0.020685	0.014170	1.459799	0.1444
RESID^2(-11)	0.169542	0.013983	12.12461	0.0000
RESID^2(-12)	0.051411	0.014185	3.624212	0.0003

R-squared	0.271098	Mean dependent var	0.000147
Adjusted R-squared	0.269334	S.D. dependent var	0.000442
S.E. of regression	0.000377	Akaike info criterion	-12.92380
Sum squared resid	0.000706	Schwarz criterion	-12.90677
Log likelihood	32135.11	Hannan-Quinn criter.	-12.91783
F-statistic	153.6678	Durbin-Watson stat	1.998168
Prob(F-statistic)	0.000000		

H0: There is no ARCH effect .

Table 22. ARCH effect test. (Full sample USA).

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	23.10984	Prob. F(2,4976)	0.0000
Obs*R-squared	45.85874	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Sample: 26/09/1995 08/10/2015
Included observations: 4983

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Stat.	Prob.
PALLADUM_RETURNS	0.002212	0.009714	0.227710	0.8199
PLATINUM_RETURNS	0.003545	0.015303	0.231642	0.8168
GOLD_RETURNS	-0.007012	0.023770	-0.295000	0.7680
SILVER_RETURNS	0.007215	0.013687	0.527113	0.5981
C	-1.41E-06	0.000171	-0.008230	0.9934
RESID(-1)	-0.090326	0.014322	-6.306914	0.0000
RESID(-2)	-0.043237	0.014178	-3.049527	0.0023

R-squared	0.009203	Mean dependent var	1.97 E-19
Adjusted R-squared	0.008008	S.D. dependent var	0.012104
S.E. of regression	0.012055	Akaike info criterion	-5.997191
Sum squared resid	0.723185	Schwarz criterion	-5.988041
Log likelihood	14949.00	Hannan-Quinn criter.	-5.993983
F-statistic	7.703280	Durbin-Watson stat	1.998576
Prob(F-statistic)	0.000000		

H0: There is no serial correlation .

Table 23. Breusch-Godfrey Serial Correlation LM Test (Full sample USA).

Model	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
CARCH(1,1)	AIC	-6.370	-5.351	-6.598	-4.700	-5.607	-5.480	-5.908
	SIC	-6.357	-5.338	-6.585	-4.687	-5.593	-5.466	-5.893
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.28	0.76	0.87	0.18	0.05	0.72	0.43
	Kurtosis	4.4	6.4	4.5	6.5	4.6	6.2	3.9
GARCH(1,1)	AIC	-6.366	-5.343	-6.595	-4.686	-5.602	-5.476	-5.908
	SIC	-6.356	-5.333	-6.585	-4.675	-5.592	-5.465	-5.904
	Serial Corr	lag 2-8	No	No	lag 1	lag 1-9	No	No
	ARCH Effect	0.13	0.09	0.42	Yes	Yes	0.70	0.51
	Kurtosis	4.5	6.7	4.6	7.0	4.7	6.6	3.9
GARCH(2,1)	AIC	-6.369	-5.343	-6.595	-4.689	-5.605	-5.476	-5.909
	SIC	-6.357	-5.332	-6.583	-4.678	-5.593	-5.464	-5.895
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.38	0.51	0.61	0.93	0.15	0.91	0.43
	Kurtosis	4.5	6.8	4.6	7.1	4.6	6.5	3.9
EGARCH (1,1,1)	AIC	-6.409	-5.349	-6.629	-4.674	-5.609	-5.483	-5.932
	SIC	-6.397	-5.337	-6.616	-4.662	-5.597	-5.471	-5.918
	Serial Corr	lag 1,3,5	lag 1-12	No	lag 1-21	lag 1-36	No	lag 5-36
	ARCH Effect	Yes	Yes	0.44	Yes	Yes	0.56	0.09
	Kurtosis	4.4	6.5	4.0	7.5	4.7	6.9	4.1
TGARCH (1,1,1)	AIC	-6.407	-5.348	-6.619	-4.688	-5.612	-5.481	-5.934
	SIC	-6.395	-5.337	-6.608	-4.677	-5.600	-5.469	-5.920
	Serial Corr	lag 1-5	lag 1-7	No	lag 1	lag 1-4	No	lag 1-32
	ARCH Effect	Yes	0.06	0.96	Yes	Yes	0.81	Yes
	Kurtosis	4.3	6.7	4.0	7.1	4.6	7.0	4.0

Table 24. ARCH model selection (Scenario 1).

Error Distribution	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
Normal Gausian	AIC	-6.370	-5.351	-6.627	-4.689	-5.605	-5.481	-5.909
	SIC	-6.357	-5.338	-6.615	-4.678	-5.593	-5.469	-5.895
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.28	0.76	0.62	0.93	0.15	0.81	0.43
	Kurtosis	4.4	6.4	4.01	7.1	4.6	7.0	3.9
Student	AIC	-6.401	-5.418	-6.641	-4.784	-5.643	-5.551	-5.924
	SIC	-6.387	-5.403	-6.628	-4.771	-5.630	-5.538	-5.909
	Serial Corr	No	No	No	No	lag 1-10	No	No
	ARCH Effect	0.07	0.35	0.52	0.91	Yes	0.57	0.08
	Kurtosis	4.49	6.55	4.02	7.47	4.74	7.93	3.94
GED	AIC	-6.401	-5.417	-6.637	-4.778	-5.637	-5.536	-5.925
	SIC	-6.387	-5.403	-6.624	-4.765	-5.624	-5.523	-5.910
	Serial Corr	lag 2-5	No	No	No	lag 1-2	No	No
	ARCH Effect	Yes	0.48	0.57	0.91	Yes	0.65	0.16
	Kurtosis	4.48	6.57	4.01	7.38	4.64	7.62	3.92

Table 25. Error distribution selection (Scenario 1).

Model	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
CARCH(1,1)	AIC	-5.346	-5.172	-6.392	-4.604	-5.389	-5.465	-5.701
	SIC	-5.275	-5.152	-6.365	-4.579	-5.359	-5.439	-5.673
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.78	0.71	0.78	0.0835	0.52	0.85	0.90
	Kurtosis	3,23*	7.8	3.9	6.4	4.5	5.9	3.4
GARCH(1,1)	AIC	-5.324	-5.164	-6.386	-4.594	-5.386	-5.464	-5.698
	SIC	-5.266	-5.158	-6.364	-4.574	-5.362	-5.443	-5.675
	Serial Corr	lag 1,6-11	No	No	lag 1	lag 1	No	lag 1,2.3.5
	ARCH Effect	Yes	0.34	0.57	Yes	Yes	0.73	Yes
	Kurtosis	3.3	8.1	4.0	7.1	4.7	5.9	3.4
GARCH(2,1)	AIC	-5.334	-5.163	-6.386	-4.598	-5.389	-5.464	-5.701
	SIC	-5.270	-5.145	-6.361	-4.576	-5.362	-5.441	-5.676
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.76	0.61	0.78	0.69	0.42	0.85	0.87
	Kurtosis	3.29*	8.2	4.0	7.1	4.5	6.0	3.4
EGARCH (1,1,1)	AIC	-5.359	-5.176	-6.407	-4.600	-5.411	-5.477	-5.732
	SIC	-5.295	-5.158	-6.382	-4.578	-5.384	-5.453	-5.707
	Serial Corr	No	lag 1-4	No	lag 1-4	lag 1	No	lag 1-8
	ARCH Effect	0.12	Yes	0.78	Yes	Yes	0.81	Yes
	Kurtosis	3.2	7.8	3.9	7.3	4.3	6.1	3.5
TGARCH (1,1,1)	AIC	-5.361	-5.174	-6.401	-4.607	-5.411	-5.472	-5.738
	SIC	-5.296	-5.156	-6.377	-4.585	-5.384	-5.449	-5.713
	Serial Corr	No	No	No	No	No	No	lag 1-8,11
	ARCH Effect	0.1288	0.11	0.47	0.0823	0.138	0.56	Yes
	Kurtosis	3.18*	8.2	3.9	7.1	4.3	6.1	3.3

*Normality acording to Jarque-bera probability (>5%)

Table 26. ARCH model selection (Scenario 2).

Error Distribution	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
Normal Gausian	AIC	-5.361	-5.172	-6.407	-4.598	-5.389	-5.477	-5.701
	SIC	-5.296	-5.152	-6.382	-4.576	-5.362	-5.453	-5.676
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.13	0.71	0.78	0.69	0.42	0.81	0.87
	Kurtosis	3.18*	7.8	3.89	7.1	4.5	6.1	3.4
Student	AIC	-5.359	-5.263	-6.424	-4.683	-5.428	-5.532	-5.707
	SIC	-5.287	-5.241	-6.397	-4.659	-5.399	-5.507	-5.679
	Serial Corr	No	No	No	No	lag 3	No	No
	ARCH Effect	0.14	0.38	0.84	0.28	0.08	0.99	0.56
	Kurtosis	3.20	7.98	3.94	7.91	4.68	6.67	3.45
GED	AIC	-5.361	-5.261	-6.421	-4.675	-5.419	-5.519	-5.709
	SIC	-5.289	-5.239	-6.393	-4.650	-5.390	-5.493	-5.681
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.13	0.49	0.81	0.41	0.21	0.87	0.67
	Kurtosis	3.20	7.99	3.91	7.70	4.60	6.43	3.44

Table 27. Error Distribution selection (Scenario 2)

Model	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
CARCH(1,1)	AIC	-6.521	-5.509	-6.586	-4.797	-5.741	-5.482	-6.137
	SIC	-6.506	-5.475	-6.566	-4.775	-5.721	-5.460	-6.114
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.23	0.47	0.61	0.91	0.39	0.67	0.48
	Kurtosis	4.5	4.4	5.0	6.3	4.5	8.0	4.2
GARCH(1,1)	AIC	-6.517	-5.507	-6.735	-4.793	-5.741	-5.482	-6.138
	SIC	-6.505	-5.480	-6.718	-4.775	-5.725	-5.464	-6.120
	Serial Corr	lag 2-7	No	No	No	No	No	No
	ARCH Effect	0.28	0.32	0.36	0.29	0.09	0.91	0.68
	Kurtosis	4.6	4.4	5.0	6.4	4.5	8.3	4.2
GARCH(2,1)	AIC	-6.518	-5.506	-6.735	-4.795	-5.741	-5.483	-6.138
	SIC	-6.505	-5.476	-6.716	-4.775	-5.723	-5.463	-6.117
	Serial Corr	lag 2	No	No	No	No	No	No
	ARCH Effect	0.38	0.98	0.85	0.71	0.33	0.71	0.48
	Kurtosis	4.6	4.4	5.1	6.4	4.5	8.0	4.2
EGARCH (1,1,1)	AIC	-6.560	-5.504	-6.779	-4.775	-5.738	-5.495	-6.165
	SIC	-6.547	-5.474	-6.760	-4.754	-5.720	-5.475	-6.144
	Serial Corr	lag 1-5	No	No	lag 1&3	lag 1-12	No	lag 5-36
	ARCH Effect	Yes	0.27	0.32	0.07	Yes	0.96	0.16
	Kurtosis	4.5	4.5	3.9	6.8	4.7	8.6	4.5
TGARCH (1,1,1)	AIC	-6.555	-5.507	-6.767	-4.792	-5.744	-5.490	-6.163
	SIC	-6.542	-5.476	-6.749	-4.772	-5.726	-5.470	-6.155
	Serial Corr	lag 1-5	No	No	No	No	No	lag 5-36
	ARCH Effect	Yes	0.43	0.64	0.2849	0.077	0.78	0.0725
	Kurtosis	4.5	4.4	3.9	6.3	4.5	9.5	4.4

Table 28. ARCH model selection (Scenario 3)

Error Distribution	Indicator	Usa	China	Australia	Russia	South Africa	India	Germany
Normal Gausian	AIC	-6.521	-5.506	-6.779	-4.797	-5.741	-5.495	-6.138
	SIC	-6.506	-5.476	-6.760	-4.775	-5.723	-5.475	-6.120
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.23	0.98	0.32	0.91	0.33	0.96	0.68
	Kurtosis	4.5	4.4	3.87	6.3	4.5	8.6	4.2
Student	AIC	-6.553	-5.539	-6.788	-4.897	-5.776	-5.584	-6.164
	SIC	-6.537	-5.505	-6.768	-4.872	-5.756	-5.561	-6.143
	Serial Corr	No	No	No	No	lag 1	No	No
	ARCH Effect	0.11	0.85	0.28	0.64	Yes	0.97	0.32
	Kurtosis	4.59	4.43	3.91	6.52	4.59	9.23	4.36
GED	AIC	-6.554	-5.540	-6.786	-4.891	-5.772	-5.566	-6.164
	SIC	-6.538	-5.507	-6.765	-4.867	-5.752	-5.544	-6.144
	Serial Corr	No	No	No	No	No	No	No
	ARCH Effect	0.15	0.87	0.30	0.76	0.14	0.98	0.50
	Kurtosis	4.55	4.42	3.88	6.40	4.53	9.09	4.33

Table 29. Error Distribution selection (Scenario 3)

Sceanrios	Scenario 1		Scenario 2		Scenario 3	
	Model	Err Dist	Model	Err Dist	Model	Err Dist
Usa	CARCH(1,1)	N	TGARCH(1,1,1)	N	CARCH(1,1)	GED
China	CARCH(1,1)	St	CARCH(1,1)	St	GARCH(2.1)	GED
Australia	EGARCH(1,1,1)	St	EGARCH(1,1,1)	St	EGARCH(1,1,1)	St
Russia	GARCH(2,1)	St	GARCH(2,1)	St	CARCH(1,1)	St
South Africa	GARCH(2,1)	N	GARCH(2,1)	GED	GARCH(2.1)	GED
India	TGARCH(1,1,1)	St	EGARCH(1,1,1)	St	EGARCH(1,1,1)	St
Germany	GARCH(1,1)	GED	GARCH(2,1)	GED	GARCH(2.1)	GED

Table 30. ARCH family scenarios.

Performance Measures	Transaction Cost implications	
	60/40 without Gold 30M	60/40 without Gold 60M
Mean Return	-0.23%	-0.15%
Mean Volatility	0%	0%
Sharpe Ratio	-0.02	-0.01
NR	-0.19	-0.07
Monthly VAR $*	101,801.90 $	137,219.42 $
VAR (%)	0.23%	0.15%
Max. Monthly Return (%)	0%	0%
Min. Monthly Return (%)	0.00%	-0.18%
Positive Month Returns (%)	-0.93%	0.00%

** $ 100,000 Investment*

Table 31. Transaction cost implication (without gold).

* Tables 18-19-20-21-22-23 and figure 6 represent the full sample of USA (scenario 1), tables and scenarios concerning other countries are available upon request. olivier.boileau@hotmail.fr