

# WORLD GOLD COUNCIL

## **Why is gold different from other assets? An empirical investigation.**

by

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## Executive Summary

The lack of correlation between returns on gold and those on financial assets such as equities has become widely established. This research tested the argument that the fundamental reason for this lack of correlation is that returns on gold are not correlated to economic activity whereas returns on mainstream financial assets are. Other commodities, which are generally thought to be correlated with economic activity, were also tested.

A number of different relationships were examined to show that returns on gold are independent of the business cycle. Using both static and dynamic analysis this study examined to what extent there is a relationship between economic variables and (i) financial indices (ii) commodities and (iii) gold.

Using the gold price and US macroeconomic and financial market quarterly data from January 1975 to December 2001, the following conclusions were reached:

- There is no statistically significant correlation between returns on gold and changes in macroeconomic variables such as GDP, inflation and interest rates;
- Returns on financial assets such as the Dow Jones Industrial Average Index, Standard & Poor's 500 index and 10-year US government bonds are correlated with changes in macroeconomic variables;
- Changes in macroeconomic variables have a much stronger impact on other commodities (such as aluminium, oil and zinc) than they do on gold; and
- Returns on gold are less correlated with returns on equity and bond indices than are returns on other commodities.

These results support the notion that gold may be an effective portfolio diversifier.

It is thought that the reasons which set gold apart from other commodities stem from three crucial attributes of gold: it is fungible, indestructible and, most importantly, the inventory of above-ground stocks of gold is enormous relative to the supply flow. This last attribute means that a sudden surge in gold demand can be quickly and easily met through sales of existing holdings of gold jewellery or other products (either to fund new purchases or for cash), in this way increasing the amount of gold recovered from scrap. It may also be met through the mechanism of the gold leasing market allied to the trading of gold bullion Over-the-Counter. The potential for gold to be highly liquid and responsive to price changes is seen as its critical difference from other commodities.

Although returns on gold may be correlated with those on other commodities, it is thought that the strength of this relationship depends on the extent to which each commodity shares the crucial attributes of gold, particularly that of high liquidity. Further study is, however, required to isolate the effect of liquidity variation of different commodities.

## 1. Introduction

The flow demand of commodities is driven primarily by exogenous variables that are subject to the business cycle, such as GDP or absorption. Consequently, one would expect that a sudden unanticipated increase in the demand for a given commodity that is not met by an immediate increase in supply should, all else being equal, drive the price of the commodity upwards. However, it is our contention that, in the case of gold, buffer stocks can be supplied with perfect elasticity. If this argument holds true, no such upward price pressure will be observed in the gold market in the presence of a positive demand shock.

Gold Fields Mineral Services Ltd estimate the above-ground stocks of gold to have been some 145,200 tonnes at the end of 2001, a figure that dwarfs annual new mined supply of around 2,600 tonnes. Much of this is held in a form that can readily come back to the market under the right conditions. This is obviously true for investment forms of gold but it is also true for much jewellery in Asia and the Middle East. In these regions jewellery traditionally fulfills a dual role, both as a means of adornment and as a means of savings. Notably, it is particularly important for women in Muslim and Hindu cultures where traditionally a woman's jewellery was often in practice her only financial asset. Such jewellery is of high caratage (21 or 22 carats), and is traded by weight and sold at the current gold price plus a moderate mark-up to allow for dealing and making costs. It is also fairly common for jewellery to be bought or part-bought by the trading in of another piece of equivalent weight; the traded-in piece will either be resold by the jeweller or melted down to create a new piece.

In Asia and the Middle East both gold investments and gold jewellery are considered as financial or semi-financial assets. It is not known how much of the total stocks of gold lie in these regions but in recent years they have accounted for approximately 60% of total demand; while the long-held cultural affinity to gold would suggest that the majority of stocks in private hands lie in this area. Consumers are very aware of price movements and very sensitive to them. Gold will be sold in times of financial need but holders will frequently take profits and sell gold back to the market if the price rises. Thus the supply of scrap gold will normally automatically rise if the gold price rises. Even gold used for industrial purposes such as electrical contacts in electronic equipment is frequently recovered as scrap and a rise in the gold price will increase the incentive for such recovery.

The existence of a sophisticated liquid market in gold leasing<sup>1</sup> has, over the past 15 years, provided a mechanism for gold held by central banks and other major institutions to come back to the market. Although the demand for gold as an industrial input or as a final product (jewelry) differs across regions, we argue that the core driver of the real price of gold is stock equilibrium rather than flow equilibrium. This is not to say that exogenous shifts in flow demand will have no influence at all on the price of gold, but rather that the large supply of inventory is likely to dampen any resultant spikes in price. The extent of this dampening effect depends on the gestation lag within which liquid inventories can be converted in industrial inputs.<sup>2</sup> In the gold industry such time lags are typically very short.

Gold has three crucial attributes that, combined, set it apart from other commodities: firstly, assayed gold is homogeneous; secondly, gold is indestructible and fungible; and thirdly, the inventory of above-ground stocks is astronomically large relative to changes in flow demand. One consequence of these attributes is a dramatic reduction in gestation lags, given low search costs and the well-developed leasing market. One would expect that the time required to convert bullion into producer inventory is short, relative to other commodities which may be less liquid and less homogenous than gold and may require longer time scales to extract and be converted into usable producer inventory, making them more vulnerable to cyclical price volatility. Of course, because of the variability of demand, the price responsiveness of each commodity will depend in part on precautionary inventory holdings.

Finally, there is low to negative correlation between returns on gold and those on stock markets, whereas it is well known that stock and bond market returns are highly correlated with GDP.<sup>3</sup> This is because, generally speaking, GDP is a leading indicator of productivity: during a boom, dividends can be expected to rise. On the other hand, the increased demand for credit, counter-cyclical monetary policy and higher expected inflation that characterize booms typically depress bond prices.<sup>4</sup>

The fundamental differences between gold and other financial assets and commodities give rise to the following “hard line” hypothesis: the impact of cyclical demand — using as proxies GDP, inflation,

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<sup>1</sup> See, for example, Cross (2000) and Neuberger (2001).

<sup>2</sup> See Kydland and Prescott (1982) and Lawrence and Siow (1985A) on Time To Build and the Aggregate Fluctuations).

<sup>3</sup> Returns on bonds are defined as the value of coupons plus changes in the bond price. All variables used in this paper are real.

<sup>4</sup> See Litterman and Weiss (1985).

nominal and real interest rates, and the term structure of interest rates — on returns on gold, is negligible, in contrast to the impact of cyclical demand on other commodities and financial assets.

Using the gold price and US macroeconomic and financial market quarterly data from January 1975 to December 2001, the following conclusions may be drawn:

- (1) There is no statistically significant correlation between returns on gold and changes in macroeconomic variables, such as GDP, inflation and interest rates; whereas returns on other financial assets, such as the Dow Jones Industrial Average, Standard & Poor's 500 index and 10-year government bonds, are highly correlated with changes in macroeconomic variables.
- (2) Macroeconomic variables have a much stronger impact on other commodities (such as aluminium, oil and zinc) than they do on gold.
- (3) Returns on gold are less correlated with equity and bond indices than are returns on other commodities.

Assets that are not correlated with mainstream financial assets are valuable when it comes to managing portfolio risk. This research establishes a theoretical underpinning for the absence of a relationship that has been demonstrated empirically for a number of years; namely, that between returns on gold and those on other financial assets.

The remainder of the paper is organized as follows. In Section 2 we formally state the hypotheses to be tested. In Section 3 we describe the data and methodology used in this study. Sections 4 and 5 present the empirical findings based on the analysis of static correlations and a dynamic VAR system, respectively. Section 6 contains a discussion of the conclusions that may be drawn from the results and suggests avenues for further research.

## 2. Statement of hypotheses

The purpose of this study is to explore certain attributes of gold, which distinguish it from other commodities. More specifically, we are concerned with testing a theory as to why gold is so little correlated with financial assets.

Generally, the flow demand of any commodity is driven primarily by exogenous variables such as GDP or absorption. To the extent that gold behaves like other commodities, one would expect that a sudden unanticipated rise in the demand for gold which cannot be matched by an immediate increase in supply should, all things being equal, drive the price of gold up. However, it is argued here that the supply of gold is perfectly elastic, given the existence of large, homogeneous and liquid above-ground stocks.

The term “contango” is used to describe a market situation where the spot price is lower than the forward price, the difference between them representing carrying costs (e.g. storage) and the time value of money (interest rates). The gold futures and forwards market is typically in contango; this is a reflection of the ready availability of gold for leasing. The gold lease rate is the difference between the US\$ LIBOR rate nominal borrowing rate and the convenience yield or “the demand for immediacy”.<sup>5</sup> The lease rate is the rate at which a lender is willing to lend gold (measured in real units of gold). The convenience yield is the rate the borrower is willing to pay for borrowing gold. In equilibrium, the convenience yield equals the lease rate. If, however, a demand surge occurs in the presence of restricted supply and illiquid borrowing, the borrower (or the purchaser of the commodity) will be willing to pay a higher rate to obtain the commodity immediately. In this case, the lease rate might exceed US\$ LIBOR, or, equivalently, the spot price might exceed the forward price – a situation described as backwardation. The fact that backwardation in the gold market is extremely rare indicates that there is less “urgency” to borrow gold. Backwardation typically occurs in markets that experience sudden unexpected shocks where firms desperately need to replenish inventory as soon as possible.

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<sup>5</sup> The “demand for immediacy” refers to the “urgent time” demand for a commodity as an input in production, where producers’ opportunity costs are so high if they fail to deliver a finished product, they are willing to lend money at very cheap rates (even negative in a backwardation mode (see Miller (1988) and Economides and Schwartz (1995)). This approach emphasises demand for immediacy, which is the willingness to buy or sell now rather than wait. This demand depends on the volatility of the underlying price and the extent to which the underlying price affects the wealth of the buyer or seller.

<sup>6</sup> Backwardation is the opposite of contango, i.e. describes a market situation where the spot price exceeds the forward price.

This difference between gold and other commodities can be attributed to three crucial attributes of the yellow metal: (1) assayed gold is homogenous, (2) gold is indestructible and fungible and (3) the inventory of above-ground stocks is extremely large relative to changes in flow demand. These attributes set gold apart from other commodities and financial assets and tend to make its returns insensitive to business cycle fluctuations.

The above argument can be stated formally as a set of inter-related hypotheses as follows:

- (1) Changes in real<sup>7</sup> GDP, short term interest rates and the money supply are not correlated with the real rate of return of gold.
- (2) Changes in real GDP, short term interest rates and the money supply are correlated with real returns on equities and bonds.
- (3) Real rates of return on durable commodities other than gold such as oil, zinc, lead, silver and aluminium are correlated with real changes in GDP, short term interest rates and the money supply.
- (4) Given that hypotheses 1, 2 and 3 hold, one may hypothesize further that:
  - (a) Returns on gold are not correlated with those on equities and bonds. This is tantamount to suggesting that whilst core macroeconomic variables are the critical determinants of financial index performance, they have no impact on the real price of gold.
  - (b) Returns on other commodities are correlated with returns on equities and bonds.
  - (c) Whilst returns on gold may be correlated with returns on other commodities, this correlation tends to be small, and is a function of the extent to which the other commodities share the crucial attributes of gold that set it at the extreme end of the continuum ranging from highly liquid to very illiquid supply.

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<sup>7</sup> The deflator used throughout is the U.S. Producer Price Index.

### 3. Data and Methodology

The time series used in this study consisted of quarterly data from January 1975 to December 2001.<sup>8</sup> The analysis was conducted using real data, obtained by deflating nominal series using the percentage (logarithmic) change in United States producer price index as a proxy for inflation, with the exception of the US GDP growth rate, which was based on constant GDP at 1990 prices. Quarterly returns have been annualized. Table 1 below describes the data used in more detail.

The hypotheses listed in Section 2 are tested using two methods: firstly, by calculating simple pair-wise correlations between the variables. The advantage of this approach is that it is widely used and the results are therefore easier to understand. The Pearson product moment correlation coefficients associated with each hypothesis are reported along with the relevant p-values, used to evaluate whether each coefficient is significantly different from zero.<sup>9</sup> A short-coming of pair-wise correlation analysis is that it provides a static view of relationships, i.e. a snapshot in time. In this study, only contemporaneous correlation coefficients were calculated. However, changes in a given economic variable affect other economic variables over time, and these lags are long and variable. Therefore, to gain insight into the dynamics of the relationships between the variables, the four hypotheses are then tested using a Vector Auto Regressive (VAR) system.<sup>10</sup> The advantage of the second approach, although it is more difficult to apprehend, is that it becomes possible to identify relationships between several variables across different time periods. For example, VAR analysis enables one to identify whether the change in the interest rate in the previous period affects returns on gold in the current period.

A VAR system usually takes the following form:

$$X_t = \psi_0 + \sum_{i=1}^T X_{t-i} * \psi_i + \varepsilon_t$$

where  $X_t = [x_{1t}, x_{2t}, \dots, x_{kt}]'$  is a vector of variables;  $\psi_i = [\phi_2^i, \phi_2^i, \dots, \phi_k^i]'$  is the coefficient vector for lag  $i$ ;  $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{kt}]'$  is a vector of error terms,  $E[\varepsilon_t] = 0$  and  $E[\varepsilon_t \varepsilon_t'] = \Omega$

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<sup>8</sup> Data source: EcoWin

Variable	Short code	Description
Inflation	INFL	Log change of United States Producer Price Index (PPI).
GDP growth rate	RGDP	Real growth rate of United States GDP, defined as log change of GDP measured at 1990 prices. DGDP is used as a proxy for real growth in "aggregate absorption". <sup>11</sup>
Cyclical GDP	CGDP	Real growth rate of seasonally adjusted GDP defined as the difference between the growth rate in the current period (DGDP <sub>t</sub> ) and the three-year quarterly moving average of DGDP. <sup>12</sup>
Interest rate	R3M	Annualized 3 month United States Certificate of Deposit (CD) real rate of return, defined as 3 month United States CD nominal return, deflated using the US PPI. This is used as a proxy of the short-term US interest rate.
Money supply	NRM2	Growth rate of nominal monetary expansion of M2 defined as log change of nominal M2.
S&P 500	RSP	Real percentage returns on the S&P 500 index (see Note 1). <sup>13</sup>
Dow	RDJ	Real percentage returns on the Dow Jones Industrial Index (Dow) (see Note 1).
Bonds	RBOND	Real rate for return on 10-year United States government bonds, constructed from ten year bond yield, deflated using the US (PPI). <sup>14</sup>
Gold	RGOLD	Real percentage returns on the London PM gold price fix (USD) (see Note 1).
Commodities	RCRB	Real percentage returns on the CRB index (see Note 1). <sup>15</sup>
Aluminium	RALUM	Real percentage returns on aluminium (see Note 1).
Copper	RCOPPER	Real percentage returns on copper (see Note 1).
Lead	RLEAD	Real percentage returns on commodity lead (see Note 1).
Zinc	RZINC	Real percentage returns on zinc (see Note 1).
Oil	RWTI	Real percentage returns on Western Texas Intermediate oil spot price (see Note 1).
Silver	RSILVER	Real percentage returns on silver (see Note 1).

Notes: (1) Defined as the log change in the index or price, deflated using the US PPI.

**Table 1: Description of time series**

In the present context, since we are investigating the dynamic relationship between returns on gold (and other assets) and a set of macroeconomic variables, we incorporate the gold return and relevant

<sup>9</sup> See, for example, Conover(1980), which compares the Pearson tests with Kendall's tau rank correlation test and Spearman's rank test.

<sup>10</sup> Simms(1980), Litterman and Weiss(1985), Lawrence and Siow(1986).

<sup>11</sup> We also experimented with Industrial Production Index but found it too narrow to represent aggregate spending.

<sup>12</sup> Because economic growth has been shown to exhibit significant changes in regimes, we have defined the long term trend as a 12 quarter moving average to avoid misspecification .

<sup>13</sup> This does not take account of returns on reinvested dividends, i.e. is not a total return index. The same applies to the Dow.

<sup>14</sup> The bond is sold at the end of each quarter and the total rate of return (in log form) is calculated, including coupons and capital gains but excluding transaction costs. A new 10-year bond is purchased with the proceeds at the end of each period. This provides a true theoretical measure of the real returns on 10-year US government bonds with a duration proxying the current 10-year benchmark security.

macro economic variables into the VAR system. The VAR system for returns on gold ( $GOLD_t$ ), cyclical GDP ( $CGDP_t$ ), short term interest rates ( $R3M_t$ ) and inflation ( $INFL_t$ ) can be written as:

$$\begin{bmatrix} GOLD_t \\ CGDP_t \\ R3M_t \\ INFL_t \end{bmatrix} = \begin{bmatrix} \phi_1^0 \\ \phi_2^0 \\ \phi_2^0 \\ \phi_4^0 \end{bmatrix} + \sum_{i=1}^T \begin{bmatrix} \phi_1^i \\ \phi_2^i \\ \phi_2^i \\ \phi_4^i \end{bmatrix} \begin{bmatrix} GOLD_{t-i} \\ CGDP_{t-i} \\ R3M_{t-i} \\ INFL_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_1^t \\ \varepsilon_2^t \\ \varepsilon_2^t \\ \varepsilon_4^t \end{bmatrix}$$

In the above dynamic system, the value of each variable depends on not only its own lags but also on the lags of the other variables in the system. This model therefore enables us to explore how the variables interact over time. The VAR system specified above consists of four equations, each of which is estimated separately using ordinary least squares. The key reason for estimating them jointly as a system of equations is that one can explore the impact of a shock, encapsulated in the error term of the period in which the shock occurred (for example,  $\varepsilon_{it}$ ), on the dynamic path of all four variables ( $GOLD_t$ ,  $CGDP_t$ ,  $R3M_t$  and  $INFL_t$ ). In other words, we can identify how a shift in a given macroeconomic variable affects all the other variables in the system over time. This makes it possible to evaluate whether or not unexpected money growth, for example, affects the price of gold in the current period and in the future. The partial cross correlations play a critical role. For example, an unanticipated change in the short-term interest rate will affect the long-term rate and could also conceivably affect CGDP. The changes in these variables could in turn affect the real rate of return on gold. In addition to providing a dynamic view of the interaction between variables, the VAR system also sheds light on indirect and spill over effects. Although each equation in the system is estimated separately, the method allows for some interesting analysis, providing a richer framework than is possible within the constraints of static correlation or univariate regression techniques.

All time series were tested for unit roots using Dickey Fuller tests. Level variables in log form were found to be non-stationary, suggested that variable pairs might be cointegrated. Return series proved to be stationary (see the final column of Table A1, Appendix A). In the event that series are cointegrated, it is not appropriate to analyse them using a VAR system (cointegrated non-stationary

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<sup>15</sup> For more information on this index, visit [http://www.cbtrader.com/crbindex/nfutures\\_current.asp](http://www.cbtrader.com/crbindex/nfutures_current.asp).

data should be analysed using a Vector Error Correction Model (VECM)).<sup>18</sup> Therefore, the Engle Granger approach was used to test for cointegration of the variables. The results showed that the log of real prices of gold and other commodities (using the Producer Price Index as a deflator) are not cointegrated with the log of real GDP. Therefore, real rates of return were selected as the underlying variables both for the static correlation analysis and the dynamic VAR analysis

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<sup>18</sup> See the seminal paper by Simms (1980) and later papers by Engle and Granger (1987) on unbiased and efficient estimation.

#### 4. Analysis of static correlations

The tables reported in this section contain correlation coefficients between variable pairs and the p-value associated with each correlation coefficient<sup>19</sup>. The p-value indicates the significance level at which the null hypothesis, defined as a zero correlation coefficient between the pair of variables can be rejected. We have performed significance tests at the 1% and weaker 5% levels. For example, if a p-value is less than 0.05, the null hypothesis (that there is no correlation between the variables) can be rejected at a 5% level of significance; the probability of erroneously rejecting the null hypothesis (whereas it is true) is less than 5%. In other words, the correlation between the variables is significantly different from zero (they may be positively or negatively correlated). Conversely, if a p-value is greater than 0.05, it is *not* possible to reject the null hypothesis of no correlation between the variables at the 5% level of significance. In this case, it is reasonable to conclude that the variables are not correlated. The lower the p-value, the less likely it is that the variables are not correlated.<sup>20</sup>

Table B2 in Appendix B consists of a correlation matrix covering all the variables tested. In the discussion below, results are broken down into subsets of this table as applicable to each of the four main hypotheses that were tested.

The first hypothesis was that changes in real GDP, short-term interest rates and the money supply are not correlated with the real rate of return on gold. Table 2 reports the results of the statistical analysis, along with the p-value associated with each correlation coefficient. Based on the results obtained, it is concluded that the null hypothesis holds and that there is no correlation between changes in the macro-economic variables covered and returns on gold for the period covered.

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<sup>19</sup> Pearson's correlation coefficient is the covariance of a pair of variables, X and Y, divided by the product of the standard deviations of X and Y, i.e.  $\frac{\sigma_{X,Y}^2}{\sigma_X \sigma_Y}$ .

<sup>20</sup> We thus wish to perform a two tailed test in which we can reject the null hypothesis  $H_0: \rho = 0$  at the 1% and 5% levels of significance. The correlation coefficient (see Canover 1980) follows a Student's t distribution, where the test statistic,  $t = \rho \sqrt{(n-2)/(1-\rho^2)}$  where  $n-2$  is the number of degrees of freedom and  $\rho$  is the correlation coefficient. Note that the t distribution is symmetric if  $\rho = 0$ , but is skewed for  $\rho$  not equal to 0. In the tests performed above, we assume the null and hence a symmetric distribution.

	RGDP	R3M	INFL	NRM2	RBOND
RGOLD	-0.13	-0.17	0.11	0.03	0.01
P-val	(0.18)	(0.08)	(0.25)	(0.78)	(0.94)

**Table 2: Return Correlation between gold and macro variables**

The second hypothesis tested was that the key macro economic variables, real GDP growth, changes in short term real interest rates and the rate of growth of money supply are correlated with real returns on equities and bonds. The correlation coefficients and their corresponding p-values are reported in Table 3 below. In this case, a low P-value is required to support the hypothesis being tested. The p-value in the table measures the level of significance that the hypothesis of zero correlation can be rejected. Thus the lower the value, the greater the likelihood that the null hypothesis can be rejected. Any p-value less than 5% suggests the null is rejected at 5% and the stronger rejection of the null for a p-value less than 1%.

	RGDP	R3M	INFL	NRM2	RBOND
RSP	-0.01	0.27	-0.34	-0.01	0.34
P-val	(0.90)	(0.01)	(0.00)	(0.91)	(0.00)
RDJ	-0.02	0.27	-0.37	-0.04	0.33
P-val	(0.87)	(0.01)	(0.00)	(0.68)	(0.00)
RBOND	-0.33	0.42	-0.54	0.06	1.00
P-val	(0.00)	(0.00)	(0.00)	(0.55)	(0.00)

**Table 3: Return Correlations between financial indices and macro variables**

Real returns on both the Dow Jones Industrial Average and the S&P 500 indices are found to be significantly positively correlated with changes in real short-term interest rates and with the returns on 10-year government bonds, and are negatively correlated with inflation. Note that returns on bonds are calculated as described in footnote 3 on page 3. However, there appears to be no contemporaneous correlation between returns on equity indices and the growth rates of real GDP and the money supply.

Whilst it may seem surprising that the real GDP growth rate does not directly affect returns on the stock market indices, the simple correlations suggest that the mechanism of transmission is through interest rates. This is consistent with the findings of Litterman and Weiss. Moreover, the apparent lack of relationship may mask the dynamics of lagged effects.

We reach one key conclusion: financial assets tend to be significantly correlated with underlying macroeconomic variables in contrast to gold prices. This provides support for our second key hypothesis, that while gold returns tend to be independent from macroeconomic shocks, fixed income and equity prices are driven by common macroeconomic factors. However, the mechanism of transmission, while suggestive, needs to be more fully explored in a dynamic system where partial correlations and autocorrelations are estimated. This is analysed in section 5 using VARs.

The third hypothesis tested was that, in contrast to gold, the real rates of return on durable commodities such as oil, zinc, lead, silver and aluminium *are* correlated with real changes in GDP, short-term interest rates and the money supply.

	RGOLD	RCRB	RALUM	RCOPPER	RLEAD	RZINC	RWTI	RSILVER
RGDP	-0.13	0.07	0.15	0.19	0.20	0.26	0.03	0.04
	0.18	0.45	0.11	0.05	0.04	0.01	0.74	0.71
INFL	0.11	0.08	0.04	0.06	0.00	0.06	0.49	0.14
	0.25	0.42	0.68	0.54	0.96	0.57	0.00	0.15
NRM2	0.03	-0.04	0.11	-0.11	0.02	-0.05	-0.04	0.03
	0.78	0.67	0.27	0.28	0.85	0.63	0.71	0.76
R3M	-0.08	-0.21	-0.19	-0.04	-0.12	0.05	0.09	-0.12
	0.42	0.03	0.04	0.70	0.21	0.58	0.34	0.21
RBOND	0.01	-0.14	-0.15	-0.14	-0.21	-0.26	-0.32	-0.24
	0.94	0.14	0.12	0.14	0.03	0.01	0.00	0.01

**Table 4: Return correlation between assets and macroeconomic variables.**

The test results are found in Table 4. Price changes in copper, lead and zinc are positively correlated with the growth rate of real GDP, while returns on oil, represented by the WTI index, are strongly correlated with inflation. The test results suggest that there is no contemporaneous correlation

between the rate of growth of the money supply and returns on any of the commodities, nor on the CRB Index, which covers a wider basket of commodities. Returns on the CRB Index and on aluminium appear to be negatively correlated with short-term interest rates at the 5% level of significance. The correlation coefficients between returns on 10-year government bonds, on the one hand, and those on lead, zinc, oil and silver, on the other hand, were found to be negative. Out of all the commodity returns that were analysed, only those on gold were not correlated with changes in any of the macro-economic variables.

Again we can conclude that the nature of the commodity is important in determining the responsiveness of price action to macro disturbances. Gold appears to be different from all other commodities. The dynamics need further exploration.

The fourth hypothesis supporting our argument consisted of three sub-hypotheses, the first of which (hypothesis 4a) was that returns on gold are not correlated with those on equities and bonds; in other words, it should not be possible to reject the null hypothesis of no correlation (the corresponding p-value would exceed 0.05). The results presented in Table 5 below indicate that there was no significant contemporaneous correlation between returns on gold, on the one hand, and those on the S&P 500, Dow Jones Industrial Average, bonds and short-term interest rates over the period covered.

	RSP	RDJ	RBOND	R3M
RGOLD	-0.07	-0.09	0.01	-0.17
P-val	0.45	0.38	0.94	0.08

**Table 5: Return correlation between gold and other financial assets**

The second sub-hypothesis (hypothesis 4b) was that returns on other commodities, which are driven by macroeconomic factors, tend to be correlated with returns on equities and bonds, which are themselves correlated with changes in macroeconomic variables. In this case, a p-value less than 0.05 is needed to reject the null hypothesis (no correlation), in support of our argument.

The results reported in Table 6 indicate that returns on all commodities, with the exception of gold, aluminium and copper yields, are correlated with financial assets. Lead, zinc, WTI (oil), and silver returns are inversely correlated with bond yields. Returns on the CRB, WTI (oil) and silver are negatively correlated with short-term interest rates, implying that higher bond yields (falling bond prices) would tend to be associated with lower returns on commodities. Gold, aluminium and copper<sup>23</sup> are the only commodities that appear to have no correlation with returns on any of the financial assets considered. The same argument can be drawn from the correlation between de-trended shifts in these variables. Oil, as proxied by the WTI index, is significantly negatively correlated with each of the financial assets considered. Gold is, once again, shown to be independent of returns on financial assets, as is copper, despite its strong correlation with GDP.

	RGOLD	RCRB	RALUM	RCOPPER	RLEAD	RZINC	RWTI	RSILVER
R3M	-0.17	-0.22	-0.17	-0.09	-0.07	-0.03	-0.48	-0.23
P-val	0.08	0.03	0.09	0.36	0.46	0.79	0.00	0.02
RSP	-0.07	-0.04	-0.01	-0.12	-0.18	-0.03	-0.29	0.03
P-val	0.45	0.71	0.94	0.22	0.07	0.78	0.00	0.77
RDJ	-0.09	-0.01	0.02	-0.08	-0.12	-0.01	-0.31	0.02
P-val	0.38	0.90	0.81	0.42	0.23	0.95	0.00	0.80
RBOND	0.01	-0.14	-0.15	-0.14	-0.21	-0.26	-0.32	-0.24
P-val	0.94	0.14	0.12	0.14	0.03	0.01	0.00	0.01

**Table 6: Return correlation between financial assets and commodities**

The third, and final, sub-hypothesis (hypothesis 4b) was that, whilst returns on gold may be correlated with returns on other commodities, this correlation tends to be small, and depends on the extent to which the other commodities share the crucial attributes of gold that set it at the extreme end of the continuum ranging from highly liquid to very illiquid supply. Defining this in rather starker terms for the purposes of evaluation, the hypothesis to be tested is that there is no significant correlation between returns on gold and those on the other commodities (in which case the p-value will exceed 0.05).

<sup>23</sup> In section 5 we show that in contrast to gold, copper is a leading indicator of the PPI. In this sense, copper prices are not insulated from business cycles.

	RCRB	RALUM	RCOPPER	RLEAD	RZINC	RWTI	RSILVER
RGOLD	0.20	0.23	0.21	0.20	0.10	0.14	0.63
P-val	0.04	0.02	0.03	0.04	0.31	0.14	0.00

**Table 7: Return correlation between gold and other commodities**

The results reported in Table 7 show that this hypothesis is not supported. Specifically, there is a positive correlation between returns on gold and those on the CRB index, aluminium, copper, lead and silver. The only returns not correlated with those on gold were zinc and oil (as proxied by the WTI index). Taking the CRB as the general or reference commodity market index, a significant “beta” coefficient exists between all commodities (excluding zinc and WTI) and the CRB index. Gold has a significant correlation of 0.20\*\*, whilst all the others lie between 0.10\*\* and 0.63\*. Thus commodities as a group with the exception of oil and zinc tends to move around “together” despite the differences in the influence of macro economic variables. Gold returns are significantly correlated with aluminium, copper, lead and silver.

This suggests that commodity prices in a given time period are influenced by common factors other than the macro-economic environment in the same time period.

## **5. Dynamic analysis of gold and other asset returns over the business cycle**

### **a) Vector Auto Regressions**

We continue our investigation of the relationship between gold and macroeconomic variables in a dynamic context using Vector Auto Regressions (VAR).<sup>25</sup> We then contrast our findings with the behaviour of other financial and commodity assets. Our key finding, using simple correlation analysis as reported in Section 4, was that, while gold returns are independent of the business cycle, returns on other assets, including a range of commodities, are profoundly dependent on the business cycle; although there is a significant relationship between contemporaneous returns on gold and those on a number of other commodities.

The advantage of the VAR technique is that it enables us to explore the interrelationship between asset returns and all the macro variables in a multivariate setting and, furthermore, to explore some of the dynamics.

The VAR system is a system of simple regression equations (estimated using ordinary least squares) in which each dependent variable is regressed on lags of all the other variables and lags of itself. The dataset as described in Table 1 contains quarterly data over the period 1978-Q3 to 2001-Q4.

### **b) Estimation and significance tests.**

In tables C1 to C10 (see Appendix C), we estimate a VAR system which includes the (real) rate of return of the asset and five core macro economic variables including cyclical GDP (CGDP)<sup>26</sup>; the long term real rate of return, RBOND; the short-term three month real rate of return, R3M; the rate of nominal monetary expansion, NRM2; and the rate of inflation, INFL. Each VAR system includes the real rates of return on assets - these are RGOLD, RSP, RBOND, RSILVER, RCOPPER, RCRB, RZINC, RLEAD, RWTI, and RALUM. We have included two lags of each of the five independent variables.

In each ordinary least square regression equation we perform the standard F-statistic test. The null hypothesis is that the joint impact of the lags of the independent variables on the dependent variable is zero. The greater the F-statistic, the more likely it is that we can reject the null hypothesis of no impact and confirm that the lagged variables do have a dynamic impact. We also report the significance level at which we can reject the null hypothesis. The lower the significance level the greater the likelihood that the null can be rejected. We assume the null is rejected at the 5% (and hence the stronger 1 %) significance level.

c) Results: commodity yields over the business cycle

The F-statistics that result from each VAR system estimated for commodities and macroeconomic variables (reported in detail in Appendix C, tables C1 to C10) are summarised in Table 8 below. Statistically significant relationships are highlighted in grey in this table.

The key empirical finding is that while the real rate of return of gold is independent of all macroeconomic variables, the other commodities in the sample are all affected by at least one of the macro-economic variables, with the exception of zinc.

	Gold	CRB	WTI	Silver	Copper	Alum	Zinc	Lead
CGDP		**	**	**				
NRM2								
R3M		**	**		**			**
RBOND		**		**				
INFL		**	**	**	**	**		**

Note: A \*\*-relation between return of commodity and macroeconomic variables implies either the F-test is significant at 5% level or one can explain more than 10% of the other's variance. For detailed results, please refer to Tables C1-C10 in Appendix C.

**Table 8: Summary of VAR results**

Only gold and zinc have no dynamic relationship with any of the core macroeconomic variables, i.e., based on the F-statistics, the null cannot be rejected at the 5% level of confidence. This implies that the real rate of return of gold follows a random walk and cannot be predicted using lagged

<sup>25</sup> See section 3, page 8 for an explanation of the Vector Autoregression analysis.

<sup>26</sup> CGDP is estimated as the difference between actual real GDP growth and a twelve quarter moving average of real GDP growth. We select this method to allow for secular changes in the economic growth rather than using the deviation from trend proxy for cyclical GDP.

macroeconomic data. In other words, the dynamic path (or history) of macro variables has no impact whatsoever on the real rate of return of gold.

Tables C1 through C10 demonstrate that real rates of return of commodities other than gold and (zinc) have a significant relationship with core macroeconomic variables, although the mechanism differs from one commodity to another. Silver returns are significantly influenced by long-term real bond yields ( $F = 3.23^{**}$ ). By estimating the decomposition of variance we find that 52% of the variability of RSILVER three quarters out is explained by macro economic variables. The real rate of return of copper is a significant leading indicator of the producer price index and thus correlated with economic activity. The F-statistic on the lagged impact of RCOPPER on INFL is significant at the 5% level of significance ( $F = 2.98^{**}$ ). After one year the macroeconomic variables explain 36% of the variability and after 2 years 40%, far higher levels than those achieved by gold.<sup>27</sup>

The remaining commodity yields, including the CRB index, aluminium, lead and oil, are all correlated with the business cycle, with varying mechanisms and causalities. The CRB index is, not surprisingly, a strong leading indicator of economic activity - the F-statistics are  $5.5^{**}$  on cyclical GDP,  $7.19^*$  on inflation,  $3.83^*$  on long-term real bond yields and  $3.57^{**}$  on short-term yields, all significant at the 5% confidence level. Thus investments in CRB components provide little insulation from the business cycle. Lead is similar in behaviour to the CRB index, being a significant leading indicator of business activity.

Oil is significantly correlated with lags of long-term bond yields at the 6% significance level and the lagged response of oil on short-term rates is significant at the 5% level.

Only zinc and, to a lesser extent, aluminium have significant cross correlations with the macroeconomic variables. In the case of aluminium however, inflation explains about 12% of its volatility within one year. In this sense it is weakly correlated with the business cycle.

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<sup>27</sup> There is no "causality" running from any of the macro variables to RCOPPER. The correlation between economic activity and RCOPPER in section 4 results from the value of copper as a leading indicator of economic activity.

With the exception of zinc, we can conclude that the evidence presented here suggests that returns on investments in non-gold commodities will be affected by the business cycle.

d) Stock and bond yields over the business cycle

In tables C2 and C3 we show how real returns of the S&P 500 Index and bond yields are affected by macroeconomic variables in strong contrast to the behaviour of the gold yield. Returns on the S&P 500 are significantly affected by cyclical GDP and long-term bond yields at the 5% critical level. Furthermore, the S&P 500 is a strong leading indicator of the business cycle. The F-statistic of lagged S&P 500 on CGDP is 4.11\*, significant at the 1% critical level. The decomposition of variance suggests that the macro variables explain about 42% of the variation of the S&P 500 index within a year.

Real long-term bond yields, whilst not affected directly through cyclical GDP, are strongly affected by short-term real yields ( $F=5.14^*$ , significant at the 1% level). The combined impact of all the macro variables explains over 60% of the variation in long-term yields.

The above results should be contrasted to gold yields where no macroeconomic variable has any notable lagged effect.

e) The relationship between financial yields and commodity yields

Whilst we have demonstrated that gold yields are independent of the business cycle and other commodities (except zinc) and financial assets are not, this does not necessarily imply that gold is a good diversifier.<sup>28</sup> To investigate this question further, we estimate Vector Autoregressions (VAR) for each commodity yield with short-term real rates, bond yields and equity returns. The gold yield VAR is found in table C1 and the others are found in C11 thru C18 (see Appendix C). The results are further summarised in table 9 below.

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<sup>28</sup> Much depends upon the magnitude of the impact of the business cycle on the yields described above. If the business cycle explains the bulk of the variation, then we are likely to find that gold is a good diversifier due to its independence. In essence this section indirectly tests how important the business cycle is in explaining both the volatility and correlation across assets.

	CRB	WTI	Silver	Copper	Alum	Zinc	Lead	Gold
RSP	-	**	**	-	-	-	**	-
RBOND	**	**	**	-	-	-	**	-
R3M	**	**	**	-	-	-	**	-

\*\* indicates a lead-or-lag causality at 10% significance level of F-test in VAR system. For detailed statistics, please refer to Tables C11 to C18 in Appendix C.

**Table 9: The relationship between returns of commodities and financial indices**

Table C11 describes the VAR of RGOLD, RSP, RBOND and R3M. All the F-statistics rule out the possibility that gold yields are determined by lagged returns of RSP, RBOND and R3M. Indeed as the decomposition of variance suggests – within one year lags of RGOLD explain 95% of the variation. This is consistent with the random walk equation described in C1. This clearly demonstrates that the lack of correlation between gold yields and equity returns found by Smith (2001, 2002) can be attributed to the properties of gold that immunize it from business cycle fluctuations.

Tables C12 through C18 describe significance tests for the VAR of the other commodities with equity returns, the long-term bond yield and the short term real rate. The results here are mixed. We find that the CRB index, WTI, silver and lead yields are significantly related to the financial market yields, whereas copper, aluminium and zinc are not. We find that the CRB index yield has a lagged effect on both money market and long term bond yields with no effect on the equity market, whereas oil, silver and lead all have significant (cross) correlations with the three financial assets. The dynamics of the relationship differ from commodity to commodity.<sup>29</sup>

<sup>29</sup> . When RCRB is the dependent variable, the F statistics appear to suggest that RCRB is invariant to lagged shifts in real yields of alternative assets. However, the data is suggestive in that lagged RCRB does have an impact (9% level of significance) on RBOND and R3M (F= 2.7524 0.068). In table C13 RBOND does have a significant impact on RSILVER (F= 2.87, 0.0917) as well as the RSP (F=2.4348, .092). However, RSILVER has an impact on short-term interest rates (2.9744\*\*). After a period of a year, the yields on financial assets explain (directly and indirectly) 29% of the variation of silver. This confirms the importance of the business cycle in explaining the real yield on silver.

The F statistics rule out that copper (Table C14), zinc (Table C16) and aluminium (Table C18) real returns are correlated with lags of the returns of RSP, RBOND or R3M. Finally, WTI (Table C15) has a significant effect on predicting short-term real rates (F= 3.50\*\*) and RBOND has significant effect on RWTI (F=3.07\*\*) at the 5% significance level. This confirms the linkage of oil to financial market yields. In Table C17 we note that RBOND has a significant impact RLEAD (F=4.6343\*) at the 1% significance level and RLEAD is a leading indicator of short-term real rates (F= 4.1224\*) at 1% level of significance.

## 6. Conclusions

The purpose of this research was to investigate whether or not the gold price is “insulated” from the business cycle, in contrast to other financial assets and commodities. The “insulation” hypothesis hinges on the fact that the supply and potential supply of inventory used in manufacturing is huge in contrast to the flow demand of gold as an input. As aggregate demand rises through the cycle, the increased demand is easily met through the incipient increase in supply without pressure on the gold price. Commodities which exhibit all or most of the characteristics of gold such as homogeneity, indestructibility, liquidity, identifiability and short inventory gestation lags would also tend to exhibit price behaviour which is insulated in part from the business cycle. By examining simple correlations and using dynamic VAR analysis we cannot reject our four core hypotheses:

- (a) GDP and other core macro economic variables are uncorrelated with the real rate of return of gold.
- (b) Core macro economic variables are correlated with the S&P index, the Dow Jones Industrial Index, a money market index and a bond index (all variables are defined as real rates of return).
- (c) Real rates of return of other commodities other than gold such as oil, zinc, lead, silver, aluminium, copper and the CRB index are correlated with macro-economic variables.
- (d) Gold and the financial indices are uncorrelated (this is tantamount to suggesting that the above macro-economic variables are the critical determinants of financial index performance).
- (e) Other commodities and financial indices are correlated since the core risk factors are driven by the business cycle.

This study represents an initial exploration and necessarily leaves many stones unturned. Firstly, we have not explicitly tested any theoretical paradigm and thus we can only state that the results are consistent with our inventory hypothesis. Secondly, we have narrowly focused on only a few financial assets. The range of assets should be expanded to include credit-based products and international stock indices. Thirdly, we have focused on the US business cycle. Since cycles are not always synchronized it is important to examine the hypotheses in a global setting. Fourthly, we believe that a key portfolio aspect of gold is that it has “option” based attributes-that is, it is a store of value in times

of crisis. To examine this hypothesis the data will have to be decomposed with respect to frequency. We believe that the gold price would exhibit highly correlated behavior when extreme outliers, such as a breakdown of governance, war, or disaster, occur. For example, over the period 1982-1983, the gold price rose by about 67% at a time when the economy, equity markets and inflation were all in bad shape. Our findings do not at all support any relationship between booms and busts and gold prices. Over the period, 1999-2000, during the dotcom frenzy, gold rose by 24% between June and December. This rise, in particular, can be attributed at least in part to the announcement of the Central Bank Agreement on Gold in September of the same year, an event that had little direct relationship, if any at all, with the economic cycle.

Our findings confirm that gold appears to be independent of cycles in contrast to other commodities, making it worth considering as a good portfolio diversifier.

## References:

- Canover W.J **Practical Non-parametric Statistics** 2<sup>nd</sup> edition Wiley, 1980.
- Cross Jessica , **Gold Derivatives: The Market View**, World Gold Council, August 2000.
- Dickey, D and Wayne A Fuller." Distribution of the Estimates for Autoregressive Time Series with a unit Root." *Journal of American Statistical Association* 1979 74,427-431
- Dickey, D and Wayne A Fuller, "Likelihood Ration Statistics for Autoregressive Time Series with a Unit Root." *Econometrica*, 1981; 49 1057-1072.
- Economides, Nicholas and Robert A. Schwartz (1995), "Equity Trading Practices and Market Structure: Assessing Asset Managers' Demand for Immediacy", **Financial Markets, Institutions & Instruments**, Volume 4, No. 4 (November 1995).
- Enders Walter, **Rats Handbook for Economic Time Series**, John Wiley and Son, 1996.
- Engle, Robert F and Clive W.J. Granger,"*Cointegration and Error Correction: Representation, Estimation and Testing.*" **Econometrica** 1987: 55 251-276.
- Frye J(1997), Principals of Risk, Finding VAR through factor based interest rate scenarios in VAR: Undertanding and Applying Value at Risk, **Risk Publications**, London, pp275-288.
- Granger C.W.J, *Investigating Causal relations by econometric models and cross spectral methods*, **Econometrica**, 37 424-438, 1969.
- Grossman, S.J. and M. Miller (1988), **Liquidity and Market Structure**, 43 (3).
- Kydland F.E and Prescott E.C, *Time to Build and Aggregate Fluctuations*, **Econometrica** 50;1345-70, 1982.
- Lawrence Colin and A. Siow (1995a), *Interest rates and Investment Spending: Some Empirical evidence from Postwar U.S Producer equipment.* **Journal Of Business**, Volume 58, no.4, October, 1985 pp. 359-376.
- Lawrence Colin and Siow (1985b), *Investment variable interest rates and gestation periods*, First Boston Series, Columbia Graduate School of Business.
- Litterman R and Weiss L 1985, *Money, real interest rates and output: A reinterpretation of Postwar US data*, **Econometrica** 53 no1 29-56.
- Litterman R and Sheinkman J, (1988), *Common Factors affecting Bonds Returns*, **Journal of Fixed Income**, 54-61.
- Neuburger Anthony , **Gold Derivatives:The Market Impact**, World Gold Council Report, May 2001.
- Simms Christopher(1980), *Macroeconomics and Reality*,**Econometrica**,48,no.1, 1-48.
- Smith Graham, "The Price of Gold and Stock market Indices for the USA", unpublished paper, November, 2001.
- Smith Graham, "London Gold Prices and Stock Prices in Europe and Japan", unpublished paper, February 2002

## Appendix A

**Table A1: Summary statistics and unit root test statistics**

<b>Asset</b>	<b>Obs</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>	<b>Low</b>	<b>High</b>	<b>Skewness</b>	<b>Kurtosis</b>	<b>UnitRoot</b>
<b>RGDP</b>	107	3.16	3.12	3.24	-8.24	15.12	-0.23	2.75	-7.448
<b>R3M</b>	107	4.38	4.13	5.16	-6.53	19.95	0.39	0.21	-6.054
<b>INFL</b>	107	3.03	2.24	5.60	-16.23	19.08	-0.04	1.43	-5.282
<b>NRM2</b>	107	6.64	6.59	3.83	-1.33	22.12	0.62	1.77	-5.388
<b>RSP</b>	107	6.78	10.41	32.21	-107.65	79.38	-0.54	0.95	-10.534
<b>RDJ</b>	107	6.57	7.44	32.73	-118.72	77.74	-0.65	1.49	-10.461
<b>RBOND</b>	107	5.50	4.54	21.32	-65.26	70.72	0.12	1.18	-9.399
<b>RGOLD</b>	107	-1.36	-6.54	34.49	-98.67	131.25	0.70	2.14	-8.497
<b>RCRB</b>	107	-3.03	-1.30	19.95	-55.30	42.92	-0.14	0.09	-12.128
<b>RALUM</b>	107	-1.63	-8.56	45.59	-165.16	130.52	0.11	2.10	-9.595
<b>RCOPPE R</b>	107	-2.71	-2.92	46.07	-110.68	181.91	0.67	2.22	-10.6353
<b>RLEAD</b>	107	-3.30	-6.79	56.89	-179.74	155.47	-0.09	1.23	-12.057
<b>RZINC</b>	107	-3.21	-6.75	44.71	-119.43	123.34	0.03	0.19	-10.22
<b>RWTI</b>	107	-0.98	-4.95	59.76	-294.70	262.85	-0.24	7.91	-10.402
<b>RSILVER</b>	107	-2.80	-6.72	53.91	-176.37	182.33	0.56	2.95	-8.778
<b>CGDP</b>	96	-0.16		3.08	-10.86	9.66	-0.60	0.05	-7.148

**APPENDIX B: TABLE B1 - Correlation and significance tests**

	RGDP	R3M	INFL	NRM2	RSP	RDJ	RBOND	RGOLD	RCRB	RALUM	RCOPPER	RLEAD	RZINC	RWTI	RSILVER	
RGDP	1.00															
	0.00															
R3M	-0.12	1.00														
	0.20	0.00														
INFL	0.05	-0.82	1.00													
	0.61	0.00	0.00													
NRM2	0.03	0.10	0.03	1.00												
	0.76	0.30	0.76	0.00												
RSP	-0.01	0.27	-0.34	-0.01	1.00											
	0.90	0.01	0.00	0.91	0.00											
RDJ	-0.02	0.27	-0.37	-0.04	0.95	1.00										
	0.87	0.01	0.00	0.68	0.00	0.00										
RBOND	-0.33	0.42	-0.54	0.06	0.34	0.33	1.00									
	0.00	0.00	0.00	0.55	0.00	0.00	0.00									
RGOLD	-0.13	-0.17	0.11	0.03	-0.07	-0.09	0.01	1.00								
	0.18	0.08	0.25	0.78	0.45	0.38	0.94	0.00								
RCRB	0.07	-0.22	0.08	-0.04	-0.04	-0.01	-0.14	0.20	1.00							
	0.45	0.03	0.42	0.67	0.71	0.90	0.14	0.04	0.00							
RALUM	0.15	-0.17	0.04	0.11	-0.01	0.02	-0.15	0.23	0.29	1.00						
	0.11	0.09	0.68	0.27	0.94	0.81	0.12	0.02	0.00	0.00						
RCOPPER	0.19	-0.09	0.06	-0.11	-0.12	-0.08	-0.14	0.21	0.30	0.39	1.00					
	0.05	0.36	0.54	0.28	0.22	0.42	0.14	0.03	0.00	0.00	0.00					
RLEAD	0.20	-0.07	0.00	0.02	-0.18	-0.12	-0.21	0.20	0.29	0.24	0.42	1.00				
	0.04	0.46	0.96	0.85	0.07	0.23	0.03	0.04	0.00	0.01	0.00	0.00				
RZINC	0.26	-0.03	0.06	-0.05	-0.03	-0.01	-0.26	0.10	0.35	0.27	0.48	0.43	1.00			
	0.01	0.79	0.57	0.63	0.78	0.95	0.01	0.31	0.00	0.01	0.00	0.00	0.00			
RWTI	0.03	-0.48	0.49	-0.04	-0.29	-0.31	-0.32	0.14	0.07	0.11	0.10	0.03	0.03	1.00		
	0.74	0.00	0.00	0.71	0.00	0.00	0.00	0.14	0.49	0.27	0.31	0.80	0.76	0.00		
RSILVER	0.04	-0.23	0.14	0.03	0.03	0.02	-0.24	0.63	0.27	0.31	0.23	0.26	0.16	0.10	1.00	

## APPENDIX C

### Explanatory notes:

1. Dependent variable fields have a gray background with text in *italics*, for ease of reference
2. F-statistics that are significantly different from zero at the 5% level of significance are reported in **bold**.

**Table C1: VAR of Gold and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RGOLD</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>0.7170</i>	1.7990	0.2660	0.6545	0.4636	0.0768
<b>Significance</b>	<i>0.4912868</i>	0.1720182	0.7671034	0.5224257	0.6306431	0.9261651
<b>Equation 2</b>						
	<i>CGDP</i>	RGOLD	INFL	<b>RBOND</b>	<b>R3M</b>	NRM2
<b>F-statistic</b>	<b>8.0658</b>	0.6269	1.9923	<b>3.8306</b>	<b>3.5977</b>	0.6572
<b>Significance</b>	<b>0.000639</b>	0.536805	0.143004	<b>0.025729</b>	<b>0.031848</b>	0.521049
<b>Equation 3</b>						
	<i>INFL</i>	RGOLD	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>8.7798</b>	2.0125	0.9911	3.5369	<b>2.5715</b>	1.0671
<b>Significance</b>	<b>0.000354</b>	0.140276	0.375637	0.033678	<b>0.082649</b>	0.348803
<b>Equation 4</b>						
	<i>RBOND</i>	RGOLD	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	<i>1.0475</i>	0.461	0.9297	1.4334	<b>4.6656</b>	2.2651
<b>Significance</b>	<i>0.355514</i>	0.632304	0.398831	0.244473	<b>0.012085</b>	0.110353
<b>Equation 5</b>						
	<i>R3M</i>	RGOLD	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>4.4194</b>	2.3157	0.2909	2.362	2.8043	1.4488
<b>Significance</b>	<b>0.015078</b>	0.105197	0.748392	0.100695	0.066439	0.240875
<b>Equation 6</b>						
	<i>NRM2</i>	RGOLD	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>8.0948</b>	1.0312	0.1402	<b>6.0656</b>	<b>4.0401</b>	<b>3.8605</b>
<b>Significance</b>	<b>0.000624</b>	0.361214	0.869436	<b>0.00351</b>	<b>0.021257</b>	<b>0.025038</b>

Table C2: VAR of RSP (S&P 500) and Macroeconomic Variables

Equation 1						
	Dependent Variable	Independent Variables				
	<i>RSP</i>	<b>CGDP</b>	INFL	<b>RBOND</b>	R3M	NRM2
<b>F-statistic</b>	0.7221	<b>4.025</b>	0.025	<b>3.1694</b>	0.0871	0.06
<b>Significance</b>	0.48883	<b>0.02155</b>	0.975322	<b>0.04729</b>	0.916638	0.941853
Equation 2						
	<b>CGDP</b>	RSP	INFL	<b>RBOND</b>	R3M	NRM2
<b>F-statistic</b>	<b>8.6367</b>	<b>4.1138</b>	2.3518	<b>3.4191</b>	<b>4.2816</b>	0.5661
<b>Significance</b>	<b>0.0004</b>	<b>0.01988</b>	0.101664	<b>0.03754</b>	<b>0.017076</b>	0.569969
Equation 3						
	<b>INFL</b>	RSP	CGDP	<b>RBOND</b>	R3M	NRM2
<b>F-statistic</b>	<b>8.1313</b>	2.0328	0.5204	<b>3.3735</b>	1.7751	0.6175
<b>Significance</b>	<b>0.00061</b>	0.137603	0.59626	<b>0.03915</b>	0.175991	0.541784
Equation 4						
	<i>RBOND</i>	RSP	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	0.6158	2.2537	0.8334	1.1371	<b>4.8076</b>	2.235
<b>Significance</b>	0.542693	0.111557	0.438259	0.325812	<b>0.010642</b>	0.113551
Equation 5						
	<i>R3M</i>	RSP	CGDP	INFL	<b>RBOND</b>	NRM2
<b>F-statistic</b>	<b>5.4798</b>	1.4357	0.106	2.0668	3.0876	0.8702
<b>Significance</b>	<b>0.005861</b>	0.243946	0.899539	0.133209	0.051021	0.422755
Equation 6						
	<i>NRM2</i>	RSP	CGDP	INFL	<b>RBOND</b>	R3M
<b>F-statistic</b>	<b>8.9633</b>	0.0299	0.1927	<b>5.618</b>	<b>4.0847</b>	<b>3.2655</b>
<b>Significance</b>	<b>0.000304</b>	0.970601	0.825134	<b>0.00519</b>	<b>0.020413</b>	<b>0.043261</b>

**Table C3: VAR of Macroeconomic Variables: Bonds, Short-term interest rates, M2 growth, GDP**

<b>Equation 1</b>					
	<b>Dependent Variable</b>	<b>Independent Variables</b>			
	<i>RBOND</i>	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	0.9525	0.9305	1.2336	<b>5.1441</b>	2.5105
<b>Significance</b>	0.389952	0.398434	0.296519	<b>0.00783</b>	0.087382
<b>Equation 2</b>					
	<i>CGDP</i>	RBOND	INFL	R3M	NRM2
<b>F-statistic</b>	<b>8.8971</b>	<b>4.0156</b>	2.5796	<b>4.2529</b>	0.6473
<b>Significance</b>	<b>0.000316</b>	<b>0.021644</b>	0.081869	<b>0.017443</b>	0.526077
<b>Equation 3</b>					
	<i>INFL</i>	RBOND	CGDP	R3M	NRM2
<b>F-statistic</b>	<b>7.8624</b>	<b>3.3044</b>	0.7055	1.7538	0.9321
<b>Significance</b>	<b>0.000747</b>	<b>0.04161</b>	0.496781	0.17947	0.397801
<b>Equation 4</b>					
	<i>R3M</i>	RBOND	CGDP	INFL	NRM2
<b>F-statistic</b>	<b>5.8013</b>	2.5979	0.1423	2.2933	1.1061
<b>Significance</b>	<b>0.004383</b>	0.080477	0.867561	0.107298	0.335669
<b>Equation 5</b>					
	<i>NRM2</i>	RBOND	CGDP	INFL	R3M
<b>F-statistic</b>	<b>9.2348</b>	<b>4.2344</b>	0.2004	<b>5.7607</b>	<b>3.3421</b>
<b>Significance</b>	<b>0.000239</b>	<b>0.017738</b>	0.818824	<b>0.004542</b>	<b>0.040184</b>

**Table C4: VAR of Silver and Macroeconomic Variables**

**F-Tests, Dependent Variable RSILVER**

Equation 1						
	Dependent Variable	Independent Variables				
	<i>RSILVER</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>0.6423</i>	0.8306	0.9503	<b>3.2028</b>	2.2231	0.9866
<b>Significance</b>	<i>0.528719</i>	0.439447	0.390912	<b>0.045845</b>	0.114833	0.377263

**Table C5: VAR of Copper and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RCOPPER</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>0.1123</i>	0.1774	1.5172	1.6062	1.1681	0.2465
<b>Significance</b>	<i>0.893944</i>	0.837738	0.225492	0.206971	0.316136	0.782154
<b>Equation 2</b>						
	<i>CGDP</i>	RCOPPER	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>8.7046</b>	0.0404	2.54	<b>3.8887</b>	<b>4.1573</b>	0.5872
<b>Significance</b>	<b>0.000376</b>	0.960419	0.08513	<b>0.024401</b>	<b>0.019112</b>	0.558212
<b>Equation 3</b>						
	<i>INFL</i>	RCOPPER	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>8.2827</b>	2.9772	0.6496	<b>3.8567</b>	2.1926	1.0252
<b>Significance</b>	<b>0.000534</b>	0.056537	0.524969	<b>0.025123</b>	0.118205	0.363319
<b>Equation 4</b>						
	<i>RBOND</i>	RCOPPER	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	<i>0.9567</i>	0.1256	0.9451	1.236	<b>5.0116</b>	2.5577
<b>Significance</b>	<i>0.388459</i>	0.882167	0.392901	0.295954	<b>0.008871</b>	0.083725
<b>Equation 5</b>						
	<i>R3M</i>	RCOPPER	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>5.9492</b>	2.8157	0.1532	2.8758	3.0501	1.0547
<b>Significance</b>	<b>0.003884</b>	0.065736	0.85819	0.062148	0.052826	0.353034
<b>Equation 6</b>						
	<i>NRM2</i>	RCOPPER	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>8.9694</b>	0.1537	0.2494	<b>5.5341</b>	<b>3.96</b>	<b>3.3382</b>
<b>Significance</b>	<b>0.000303</b>	0.857791	0.779868	<b>0.005587</b>	<b>0.022865</b>	<b>0.040447</b>

**Table C6: VAR of RCRB and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RCRB</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	1.0876	0.0238	1.218	0.2435	2.9631	0.8415
<b>Significance</b>	0.34188	0.976455	0.301175	0.784433	0.057284	0.4348
<b>Equation 2</b>						
	<i>CGDP</i>	RCRB	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	6.8279	5.503	2.9264	4.5013	3.5704	0.372
<b>Significance</b>	0.001818	0.005743	0.059279	0.014006	0.032656	0.690535
<b>Equation 3</b>						
	<i>INFL</i>	RCRB	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	10.3485	7.1931	1.164	2.3308	3.7313	0.8237
<b>Significance</b>	9.95E-05	0.001332	0.317414	0.103702	0.028177	0.442426
<b>Equation 4</b>						
	<i>RBOND</i>	RCRB	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	0.4678	3.8319	1.5633	0.8376	1.9035	1.667
<b>Significance</b>	0.628043	0.025698	0.215699	0.43644	0.155661	0.195221
<b>Equation 5</b>						
	<i>R3M</i>	RCRB	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	2.3578	3.5703	0.4108	1.3827	2.1137	1.1672
<b>Significance</b>	0.101097	0.032661	0.664497	0.256768	0.1274	0.316404
<b>Equation 6</b>						
	<i>NRM2</i>	RCRB	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	9.7034	0.8048	0.248	5.0261	4.1591	1.7099
<b>Significance</b>	0.000167	0.450742	0.78096	0.008758	0.019079	0.187353

**Table C7: VAR of Zinc and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RZINC</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>0.068</i>	0.8011	0.1475	0.8946	0.2048	0.1237
<b>Significance</b>	<i>0.934354</i>	0.452376	0.863096	0.412783	0.815197	0.883801
<b>Equation 2</b>						
	<i>CGDP</i>	RZINC	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>6.5498</b>	0.6816	2.6544	<b>4.3485</b>	<b>4.3846</b>	0.666
<b>Significance</b>	<b>0.002309</b>	0.508688	0.076456	<b>0.016074</b>	<b>0.015559</b>	0.516547
<b>Equation 3</b>						
	<i>INFL</i>	RZINC	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>7.8194</b>	2.3643	0.3655	2.6696	1.7067	1.0483
<b>Significance</b>	<b>0.000785</b>	0.100476	0.69501	0.075377	0.187927	0.355253
<b>Equation 4</b>						
	<i>RBOND</i>	RZINC	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	<i>0.4869</i>	1.682	1.0576	1.0953	<b>5.2925</b>	2.7685
<b>Significance</b>	<i>0.616327</i>	0.192432	0.352021	0.339343	<b>0.006914</b>	0.068704
<b>Equation 5</b>						
	<i>R3M</i>	RZINC	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>6.0919</b>	1.7906	0.1605	2.4773	2.0258	1.1985
<b>Significance</b>	<b>0.003431</b>	0.173405	0.851966	0.090313	0.138512	0.306928
<b>Equation 6</b>						
	<i>NRM2</i>	RZINC	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>8.9615</b>	0.0821	0.2468	<b>5.6007</b>	<b>4.1269</b>	<b>3.2488</b>
<b>Significance</b>	<b>0.000305</b>	0.921249	0.781908	<b>0.00527</b>	<b>0.019646</b>	<b>0.043934</b>

**Table C8: VAR of Lead and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RLEAD</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	1.8806	0.2893	1.5228	2.422	2.8971	2.6011
<b>Significance</b>	0.159093	0.749594	0.224281	0.095147	0.06092	0.08038
<b>Equation 2</b>						
	<i>CGDP</i>	RLEAD	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>8.7712</b>	0.5254	2.8206	<b>3.2181</b>	<b>4.5243</b>	0.6938
<b>Significance</b>	<b>0.000356</b>	0.593318	0.065433	<b>0.045201</b>	<b>0.013719</b>	0.502629
<b>Equation 3</b>						
	<i>INFL</i>	RLEAD	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>9.7861</b>	2.8634	0.4193	<b>3.2204</b>	2.3502	0.6466
<b>Significance</b>	<b>0.000156</b>	0.06287	0.658937	<b>0.045105</b>	0.101822	0.52651
<b>Equation 4</b>						
	<i>RBOND</i>	RLEAD	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	0.5597	0.8722	0.7933	1.1948	<b>4.6679</b>	2.7976
<b>Significance</b>	0.573601	0.421936	0.455853	0.308029	<b>0.01206</b>	0.066854
<b>Equation 5</b>						
	<i>R3M</i>	RLEAD	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>5.7957</b>	<b>4.1963</b>	0.0283	2.2286	2.339	0.9017
<b>Significance</b>	<b>0.004442</b>	<b>0.018447</b>	0.972066	0.114246	0.102907	0.409931
<b>Equation 6</b>						
	<i>NRM2</i>	RLEAD	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>9.0787</b>	0.2075	0.1693	<b>5.4466</b>	<b>3.8615</b>	<b>3.1259</b>
<b>Significance</b>	<b>0.000277</b>	0.813012	0.84458	<b>0.006035</b>	<b>0.025014</b>	<b>0.049235</b>

**Table C9: VAR of Oil (WTI) and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RWTI</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	2.2388	0.6243	1.5597	2.7928	1.6443	1.5749
<b>Significance</b>	0.113146	0.538195	0.216446	0.067158	0.199535	0.213294
<b>Equation 2</b>						
	<i>CGDP</i>	RWTI	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<b>8.6547</b>	0.0158	0.1313	<b>3.7916</b>	<b>4.1066</b>	0.5899
<b>Significance</b>	<b>0.000392</b>	0.984354	0.877131	<b>0.026663</b>	<b>0.02001</b>	0.556747
<b>Equation 3</b>						
	<i>INFL</i>	RWTI	CGDP	RBOND	R3M	NRM2
<b>F-statistic</b>	1.5954	2.265	0.6054	2.825	1.5935	1.5302
<b>Significance</b>	0.20913	0.110368	0.548329	0.065167	0.209527	0.22269
<b>Equation 4</b>						
	<i>RBOND</i>	RWTI	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	0.862	1.0167	0.9889	1.2388	<b>5.907</b>	2.9762
<b>Significance</b>	0.426158	0.366356	0.376431	0.295148	<b>0.00403</b>	0.056589
<b>Equation 5</b>						
	<i>R3M</i>	RWTI	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>6.7635</b>	3.0232	0.0967	2.3752	1.9629	1.8163
<b>Significance</b>	<b>0.001921</b>	0.054169	0.90792	0.099445	0.147077	0.169192
<b>Equation 6</b>						
	<i>NRM2</i>	RWTI	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>9.981</b>	1.4075	0.2454	1.2263	<b>3.5684</b>	2.2512
<b>Significance</b>	<b>0.000133</b>	0.250668	0.782989	0.298765	<b>0.032718</b>	0.111826

**Table C10: VAR of Aluminium and Macroeconomic Variables**

<b>Equation 1</b>						
	<b>Dependent Variable</b>	<b>Independent Variables</b>				
	<i>RALUM</i>	CGDP	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>1.073</i>	0.5225	1.3487	2.6785	0.9713	0.0562
<b>Significance</b>	<i>0.346801</i>	0.594993	0.265332	0.074748	0.382946	0.945425
<b>Equation 2</b>						
	<i>CGDP</i>	RALUM	INFL	RBOND	R3M	NRM2
<b>F-statistic</b>	<i>0.4729</i>	2.4202	<b>7.5585</b>	2.1002	1.2576	1.8529
<b>Significance</b>	<i>0.624886</i>	0.095306	<b>0.000978</b>	0.129044	0.289814	0.163364
<b>Equation 3</b>						
	<i>RBOND</i>	RALUM	CGDP	INFL	R3M	NRM2
<b>F-statistic</b>	<i>0.4786</i>	1.6858	0.9209	0.9007	<b>4.9907</b>	<b>3.407</b>
<b>Significance</b>	<i>0.621381</i>	0.19174	0.40228	0.410332	<b>0.009038</b>	<b>0.037959</b>
<b>Equation 4</b>						
	<i>R3M</i>	RALUM	CGDP	INFL	RBOND	NRM2
<b>F-statistic</b>	<b>4.2799</b>	2.0005	0.0927	1.6635	1.7978	1.8439
<b>Significance</b>	<b>0.017103</b>	0.141901	0.911578	0.195874	0.172211	0.164776
<b>Equation 5</b>						
	<i>NRM2</i>	RALUM	CGDP	INFL	RBOND	R3M
<b>F-statistic</b>	<b>8.6231</b>	0.6922	0.1689	<b>5.7232</b>	3.777	<b>3.2854</b>
<b>Significance</b>	<b>0.000403</b>	0.50339	0.844889	<b>0.004733</b>	0.027021	<b>0.042473</b>

Table C11: VAR of Gold and Financial Assets

Equation 1				
	Dependent Variable	Independent Variables		
	<i>RGOLD</i>	RSP	RBOND	R3M
<b>F-statistic</b>	1.7195	1.5864	0.0526	0.3462
<b>Significance</b>	0.184625	0.209978	0.948787	0.708249
Equation 2				
	<i>RSP</i>	RGOLD	RBOND	R3M
<b>F-statistic</b>	0.8582	0.3188	<b>3.4461</b>	0.2728
<b>Significance</b>	0.427166	0.727801	<b>0.03586</b>	0.761866
Equation 3				
	<i>RBOND</i>	RGOLD	RSP	R3M
<b>F-statistic</b>	0.0516	0.8386	2.2785	<b>4.3489</b>
<b>Significance</b>	0.949743	0.435467	0.107956	<b>0.01556</b>
Equation 4				
	<i>R3M</i>	RGOLD	RSP	RBOND
<b>F-statistic</b>	<b>7.9262</b>	0.8379	1.6763	0.7758
<b>Significance</b>	<b>0.000652</b>	0.435746	0.192494	0.463217

**Table C12: VAR of CRB index (RCRB) and Financial Assets**

<b>Equation 1</b>				
	<b>Dependent Variable</b>	<b>Independent Variables</b>		
	<i>RCRB</i>	RSP	RBOND	R3M
<b>F-statistic</b>	1.6039	1.6	0.9769	1.7435
<b>Significance</b>	0.206455	0.207228	0.380194	0.180406
<b>Equation 2</b>				
	<i>RSP</i>	RCRB	RBOND	R3M
<b>F-statistic</b>	0.7075	0.0531	<b>3.2754</b>	0.3808
<b>Significance</b>	0.495405	0.948284	<b>0.04207</b>	0.684375
<b>Equation 3</b>				
	<i>RBOND</i>	RCRB	RSP	R3M
<b>F-statistic</b>	0.1501	2.4496	1.6813	<b>3.7228</b>
<b>Significance</b>	0.860804	0.09171	0.191558	<b>0.02772</b>
<b>Equation 4</b>				
	<i>R3M</i>	RCRB	RSP	RBOND
<b>F-statistic</b>	<b>6.4009</b>	2.7524	1.7142	0.8239
<b>Significance</b>	<b>0.002457</b>	0.06881	0.18557	0.441803

**Table C13: VAR of Silver and Financial Assets**

<b>Equation 1</b>				
	<b>Dependent Variable</b>	<b>Independent Variables</b>		
	<i>RSILVER</i>	RSP	RBOND	R3M
<b>F-statistic</b>	<b>8.503</b>	2.4358	2.8729	1.0758
<b>Significance</b>	<b>0.000398</b>	0.09292	0.06141	0.345106
<b>Equation 2</b>				
	<i>RSP</i>	RSILVER	RBOND	R3M
<b>F-statistic</b>	<i>0.7683</i>	0.0201	2.4233	0.0358
<b>Significance</b>	<i>0.466654</i>	0.98013	0.09403	0.964837
<b>Equation 3</b>				
	<i>RBOND</i>	RSILVER	RSP	R3M
<b>F-statistic</b>	<i>0.3652</i>	1.3796	2.6676	2.8699
<b>Significance</b>	<i>0.694993</i>	0.256623	0.074562	0.06158
<b>Equation 4</b>				
	<i>R3M</i>	RSILVER	RSP	RBOND
<b>F-statistic</b>	<i>12.5342</i>	2.9744	1.5299	2.7462
<b>Significance</b>	<i>1.5E-05</i>	0.0558	0.221784	0.06922

**Table C14: VAR of Copper and Financial Assets**

<b>Equation 1</b>				
	<b>Dependent Variable</b>	<b>Independent Variables</b>		
	<i>RCOPPER</i>	RSP	RBOND	R3M
<b>F-statistic</b>	<i>0.0413</i>	1.1587	1.6154	0.4338
<b>Significance</b>	<i>0.959599</i>	0.318242	0.204172	0.649302
<b>Equation 2</b>				
	<i>RSP</i>	RCOPPER	RBOND	R3M
<b>F-statistic</b>	<i>0.7811</i>	0.0258	<b>3.467</b>	0.3487
<b>Significance</b>	<i>0.460801</i>	0.974537	<b>0.03517</b>	0.706497
<b>Equation 3</b>				
	<i>RBOND</i>	RCOPPER	RSP	R3M
<b>F-statistic</b>	<i>0.0173</i>	0.0059	2.2616	<b>5.5464</b>
<b>Significance</b>	<i>0.982844</i>	0.994071	0.109704	<b>0.00525</b>
<b>Equation 4</b>				
	<i>R3M</i>	RCOPPER	RSP	RBOND
<b>F-statistic</b>	<b>8.9726</b>	2.0307	1.8919	0.709
<b>Significance</b>	<b>0.00027</b>	0.136846	0.156369	0.494672

Table C15: VAR of Oil (RWTI) and Financial Assets

Equation 1				
	Dependent Variable	Independent Variables		
	<i>RWTI</i>	RSP	RBOND	R3M
<b>F-statistic</b>	<b>9.3254</b>	2.5471	3.0703	1.5168
<b>Significance</b>	<b>0.0002</b>	0.083591	0.05099	0.224621
Equation 2				
	<i>RSP</i>	RWTI	RBOND	R3M
<b>F-statistic</b>	<i>0.7654</i>	0.049	2.4205	0.0537
<b>Significance</b>	<i>0.467982</i>	0.952222	0.09429	0.947713
Equation 3				
	<i>RBOND</i>	RWTI	RSP	R3M
<b>F-statistic</b>	<i>0.2374</i>	1.0435	2.6504	2.5472
<b>Significance</b>	<i>0.789108</i>	0.35618	0.07579	0.083581
Equation 4				
	<i>R3M</i>	RWTI	RSP	RBOND
<b>F-statistic</b>	<i>13.1289</i>	<b>3.5039</b>	1.648	<b>3.3286</b>
<b>Significance</b>	<i>9.1E-06</i>	<b>0.03398</b>	0.197832	<b>0.04003</b>

**Table C16: VAR of Zinc and Financial Assets**

<b>Equation 1</b>				
	<b>Dependent Variable</b>	<b>Independent Variables</b>		
	<i>RZINC</i>	RSP	RBOND	R3M
<b>F-statistic</b>	<i>0.1154</i>	0.435	1.1486	0.2036
<b>Significance</b>	<i>0.891115</i>	0.648518	0.321403	0.816143
<b>Equation 2</b>				
	<i>RSP</i>	RZINC	RBOND	R3M
<b>F-statistic</b>	<i>0.6772</i>	0.4995	2.7085	0.2911
<b>Significance</b>	<i>0.510471</i>	0.608418	0.07173	0.748131
<b>Equation 3</b>				
	<i>RBOND</i>	RZINC	RSP	R3M
<b>F-statistic</b>	<i>0.1875</i>	1.4599	2.1844	<b>6.0927</b>
<b>Significance</b>	<i>0.829351</i>	0.237359	0.118112	<b>0.00323</b>
<b>Equation 4</b>				
	<i>R3M</i>	RZINC	RSP	RBOND
<b>F-statistic</b>	<i>10.4638</i>	0.8963	1.4534	0.3204
<b>Significance</b>	<i>7.7E-05</i>	0.411468	0.238878	0.726645

Table C17: VAR of Lead and Financial Assets

Equation 1				
	Dependent Variable	Independent Variables		
	<i>RLEAD</i>	RSP	RBOND	R3M
<b>F-statistic</b>	2.1636	1.4628	<b>4.6343</b>	0.917
<b>Significance</b>	0.120479	0.236711	<b>0.01199</b>	0.40319
Equation 2				
	<i>RSP</i>	RLEAD	RBOND	R3M
<b>F-statistic</b>	0.7011	2.5105	2.5249	0.3522
<b>Significance</b>	0.498583	0.08655	0.08537	0.70406
Equation 3				
	<i>RBOND</i>	RLEAD	RSP	R3M
<b>F-statistic</b>	0.1361	0.654	2.4359	<b>5.1348</b>
<b>Significance</b>	0.87296	0.522238	0.092916	<b>0.00761</b>
Equation 4				
	<i>R3M</i>	RLEAD	RSP	RBOND
<b>F-statistic</b>	10.4177	<b>4.1224</b>	1.5741	0.3951
<b>Significance</b>	8E-05	<b>0.01916</b>	0.2125	0.674686

Table C18: VAR of Aluminium and Financial Assets

Equation 1				
	Dependent Variable	Independent Variables		
	<i>RALUM</i>	RSP	RBOND	R3M
<b>F-statistic</b>	1.8457	0.0331	2.1832	0.1513
<b>Significance</b>	0.163475	0.967487	0.11824	0.859809
Equation 2				
	<i>RSP</i>	RALUM	RBOND	R3M
<b>F-statistic</b>	0.7734	0.3819	<b>3.6463</b>	0.3552
<b>Significance</b>	0.464279	0.68361	<b>0.02976</b>	0.701962
Equation 3				
	<i>RBOND</i>	RALUM	RSP	R3M
<b>F-statistic</b>	0.1075	0.7236	2.3087	<b>5.2826</b>
<b>Significance</b>	0.898214	0.487652	0.104889	<b>0.00666</b>
Equation 4				
	<i>R3M</i>	RALUM	RSP	RBOND
<b>F-statistic</b>	<b>8.1248</b>	1.9137	1.7143	0.7094
<b>Significance</b>	<b>0.00055</b>	0.153125	0.185561	0.494521