HEC MONTRÉAL

Are Gold and Platinum Prices Able to Forecast U.S. Macroeconomic Variables?

by

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Master Thesis

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Abstract

This thesis explores the predictive relationship between precious metals and macroeconomic factors. Gold and platinum spot and future prices are obtained in the first instance, along with a list of US macroeconomic and financial indicators. Gold and platinum data are then regressed with all the macroeconomic and financial indicators to analyze whether precious metals can forecast these indicators. Gold futures and platinum futures are evaluated in a predictive regression with Newey-West correction, which is used to understand the short term and long term behavior of macroeconomic factors (one month to 7 years). Similarly, gold-platinum spread and forward premiums are investigated with the same list of indicators to see if they too have an effect on US macroeconomic and financial variables. From the results, the observations prove that both precious metals are effective at forecasting the macroeconomic indicators, with gold and platinum futures and gold-platinum spread being notably more successful at forecasting than gold and platinum premiums.

Résumé

Ce mémoire explore la relation prédictive entre les métaux précieux et les facteurs macroéconomiques. Des données sur l'or et le platine sont obtenues ainsi que des indicateurs macroéconomiques et financières pour analyser si les métaux précieux peuvent prévoir la tendence de ces indicateurs. Les contrats futures de l'or et du platine sont évalués en utilisant une régression prédictive qui incorpore la méthode de correction Newey-West, pour apprendre plus sur le comportement à court terme et à long terme des facteurs macroéconomiques. De plus, l'écart or-platine et les primes des contrats forwards sont étudiés d'une manière similaire. À partir des résultats de recherche, les observations prouvent que ces deux métaux précieux sont efficaces dans la prédiction des indicateurs macroéconomiques, surtout dans les cas des contrats futures et l'écart or-platine, et moindre dans le cas des primes.

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I would like to first and foremost thank my thesis supervisors Dr. Jeanneret and Dr. Dorion for their unwaivering support for me, I am very grateful for their precious guidance and teaching. I wish to also say thank you to everyone who has inspired and encouraged me throughout the years.

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Introduction

For a long time, gold is recognized as the symbol of ancient monetary system and platinum is better known as a catalyst for industrial processes. Both are currently used vastly as jewelry material, and in many respects, they are metals that are highly substitutable. This thesis will investigate the predictability of US macroeconomic data using precious metals (gold and platinum) as predictors. Gold and platinum have been chosen for their stability among precious metals. Gold's status in precious metals is very significant, simply by market volume and liquidity, this fact can be authenticated: the market size of gold is in the range $150-350 billion and $2-4 billion for platinum in 2012 (Lubber 2013). Gold and platinum have their respective financial centers for trading. For example, the gold market, though traded in seven global markets, is based mainly in London OTC market and New York (COMEX), whereas platinum and palladium markets are centralized in Zurich (Gold Field Mineral Services Ltd. 2015). Gold has often been regarded as a safe haven symbol in times of financial crises. Platinum in recent times has also been named a notable safe haven at times, therefore it is a metal equally worth exploring. Gold has reached its highest price in 2008 and platinum in 2011, they are correlated positively sometimes and negatively during other times, therefore this correlation has not been consistent over time. It is therefore highly recommended that these precious metals be included into portfolios for diversification to account for times of crises and upheavals. This is also partially due to the low correlation between stocks and the main precious metals in general (i.e. gold, platinum, silver, and palladium). Additionally, situations in mines and recently developed ETFs (e.g. SPDR Gold Trust) impact more directly the current spot and futures prices of precious metals, as well as mining shares.

The goal of the thesis is to find out whether precious metals such as gold and platinum can predict US macroeconomic data and see how their relationship would span out through predictive regression in the short term and in the long term. As there have been many papers on the impact of macroeconomic data on gold, there are not many papers that present observations in the opposite direction or that elaborate on the economic role of platinum, therefore it is worth analyzing whether gold and platinum futures have an impact on the general US macroeconomic data. For example, one of the macroeconomic indicators is CPI, the objective would be in this case to understand how gold and platinum products would affect CPI in the short run and in the long run. In this thesis, apart from gold and platinum futures, the macroeconomic series will in addition be tested for gold-platinum spread, gold forward premiums and platinum forward premiums. The method used for this investigation is a predictive OLS regression with Newey-West correction that helps to obtain relevant t-statistics and R-squared values. To ensure the robustness of the results, three controls are employed in the regression: US GDP, S&P500 and VIX. After completion of this predictive regression, the results support gold and platinum futures and spread's ability to forecast the selected macroeconomic data. Some factors would move positively while others negatively with respect to an increase in precious metal price return.

In this thesis, literature review will first be developed in Section I. Then, Section II will concentrate on data sources. This is followed by Section III which will focus on methodology and theoretical background on predictive regression. The results will eventually be examined in Section IV and finally discussions will be presented in Section V.

I. Literature Review

Gold and platinum are two of the most important metals in the precious metals category of commodities. Research papers on gold exceed platinum papers in number, however researchers have tried extracting methods and modeling from gold papers and applying them to platinum data. There have been many papers relating gold with US inflation (Adrangi et al. 2003, Beckmann and Czudaj 2013, Christie-David et al. 2000), exchange rates (Apergis et al. 2014, Ciner 2017), business cycles (Apergis and Eleftheriou 2016, Pierdzioch et al. 2014), oil price (Charlot and Marimoutou 2014, Zhang and Wei 2010, Hammoudeh and Yuan 2008, Le and Chang 2012, Reboredo and Ugolini 2016, Eryigit 2017), consumer price index (CPI) (Sharma 2016), interest rate/US three month Treasury bill rate (Hammoudeh and Yuan 2008), US 10 year bonds (Lucey and Li 2014), US Dollar (Joy 2011, Reboredo 2013, Sjaastad 2008), stocks (Hillier et al. 2006, Jordan et al. 2017), US industrial production and US M1 & M2 monetary aggregates (Fernandez 2017). Most of these papers focus on the impact of these macroeconomic factors on gold, but few papers to date research on the importance of gold in forecasting the behaviors of macroeconomic indicators, which is what this thesis will try to accomplish.

Only a select group of papers researches platinum in more detail, it is presented often in combination with silver as the two most important white precious metals. Bredin et al. (2017) for example look into platinum's hedging properties using the value-at-risk (VAR) method against an S&P 500 portfolio, where they found that platinum tend to reduce downside risk at short horizons and increase portfolio risk at long horizons. Moreover, Chen et al. (2010) observe the predictive effects of exchange rates on commodity precious metal prices, including platinum, gold and silver. To achieve this, they create spot metal price index and forward rate index out of

metal forward data for this investigation. What they also did was to evaluate prediction in the opposite direction, to see whether commodity prices are able to predict exchange rates. They found this to be less robust than the case where exchange rates served to forecast commodity prices.

Of all the macroeconomic indicators, oil and inflation are two of the most popular research topics. Inflation in general can often be approximated with the consumer price index (CPI). The correlation between oil and gold returns is proven to be positive by Le and Chang (2012), a conclusion that is supported by Simakova (2011). This relationship has even been recognized as bi-directional for gold and oil futures (Narayan et al. 2010). Return spillovers and volatility transmission also exist between oil and precious metals (as well as their ETFs), this is characterized using an E-GARCH model by Lau et al. (2017). On top of this, Batten et al (2014) and Lucey et al. (2016) note that the time varying cointegration between the gold and US inflation need to be highlighted despite zero cointegration between the two at the beginning. This trait becomes apparent with time and they suggest that underlying interest rate effects in fact bring out the monetary value of gold, and that this time varying relationship allows for an inflation hedge by gold in the long run (Beckmann and Czudaj 2013). This hedge also happens to be more effective for US and UK compared to Euro Area and Japan. Similar cointegration has been found for precious metals by Chevallier and Ielpo (2013) by observing together oil, gold, equity (S&P 500) and bonds (US 10-Yrs). In essence, gold returns are believed to be a good short-run and long- run hedge for expected inflation, albeit not for unexpected inflation (Adrangi et al. 2003).

A representative paper for macroeconomic news would be that of Smales (2017) where he studies the behaviour of commodity markets during financial crisis in response to

macroeconomic news (e.g. GDP, Industrial production, New Home Sales, Personal Income). This paper demonstrates that during financial turmoil, forward-looking macroeconomic news have the most influence on commodity markets. Roache and Rossi (2010) propose that macroeconomic news have a unique effect on gold futures prices, more so than other commodities, and reveal that gold prices are influenced by retail sales, nonfarm payrolls and real interest rates. Christie-David et al. (2000) in turn perform the same with macroeconomic announcements for gold, and the impact on gold was detected to be most significant originating from CPI, Capacity Utilization, PPI, and Domestic Product. The reaction of precious metals to macroeconomic news is a swift response. This fast change due to news is more influential during times of recession (Hess et al. 2008, Elder et al. 2012). Furthermore, seasonality of gold and silver returns may be evident from observing conditional and unconditional means and variances of collected data (Lucey and Tully 2006).

By using a DCC model, Sensoy (2013) points out the strong correlation between the precious metals (gold, silver, platinum and palladium) and the importance of platinum in diversifying a portfolio. From studies on return spillovers between precious metals, a closer connection is apparent between gold, silver and platinum, rather than with palladium (Batten et al. 2015). But correlation between gold and platinum can be positive or negative depending on the period of interest (Kearney and Lombra 2008 & 2009, Kucher and McCoskey 2016). Other relationships include a negative correlation discovered between gold spot price and global macroeconomic indicators using a factor-augmented vector autoregressive (FAVAR) by Lili and Chengmei (2013). And gold and platinum returns tend to demonstrate low correlations with especially equity returns, emphasizing again the fact that a portfolio should be diversified with precious metals (Hillier et al. 2006)

It is believed that each metal's volatility react differently to macroeconomic variables (Batten et al. 2010). Based on this, the precious metals should therefore be distinct from each other and not be considered altogether one asset class. Cai et al. (2001) explore the importance of US macroeconomic news on gold future return volatility, and among 23 macroeconomic announcements, only 4 of them have a stronger impact on gold volatility: employment, GDP, CPI, and personal income. They notice that, apart from macroeconomic variables, Treasury bond and FX have even a greater effect than these four. To explore further, there exist volatility transmission between currencies and gold and platinum, as well as four kinds of volatility to account for changes in gold price (daily absolute returns, realized volatility, integrated volatility and realized bipower volatility) (Khalifa et al. 2011, 2016).

Some properties of precious metal prices such as asymmetry in volatility have been investigated by researchers to shed light on the real conditions of news announcements. Asymmetry is the condition when the returns react differently during economic boom and recession periods. Asymmetry also might exist in the movement of commodity return volatility as a result of positive or negative news (Baur 2012). Tully and Lucey (2007) test an asymmetric power GARCH (APGARCH) model to evaluate such impact of macroeconomic variables on gold futures. Smales (2014) confirms that asymmetry indeed causes gold futures returns to move more significantly with negative news than positive news. He then extends this idea into periods of recession and states that gold's response to positive news prevails in reaction amplitude than negative news in those special times. The response time to the news impact is recorded to be mostly around 90s (Smales and Yang 2015). This property of asymmetry has now been extended into other research in relation to gold price and gold mining share returns (Batten et al. 2017).

Several papers propose that concepts of hedge and safe haven be applied to gold (Baur and Lucey 2010, Iqbal 2017). They define a strong safe haven as the state when stock returns are correlated negatively with gold and define a weak safe haven as when they are uncorrelated (Baur and McDermott 2010). Gold can be described as both a hedge for stocks and a strong safe haven in a highly volatile and financial turmoil environment. This notion can be applied in the same manner to platinum and other white precious metals such as palladium and rhodium. A recent study by McCown and Shaw (2017) highlights that platinum may be a safe haven but during different periods of time. In relation to this topic, different researchers employed financial models to offer various opinions on whether the metals they study are more akin to a hedge or a safe haven. For example, by both implementing conditional correlations dynamic DCC-GARCH models, Joy (2011) detects that gold would be a weak safe haven in relation to the US currency, and Klein (2017) demonstrates the safe haven status of gold and platinum, while specifying platinum as a temporal surrogate safe haven. Hood and Malik (2013) similarly decide that gold should be regarded as a weak safe haven for equity compared to the stronger VIX, while platinum is neither a hedge nor a safe haven in category. Finally, there are certain groups that decide to expand their view and suggest that during market instabilities, gold, US Treasury bonds, Swiss franc and US dollar should all be identified as financial safe havens (Baur and McDermott 2016).

II. Data Sources

First, the data for gold and platinum futures prices are sourced from the Bloomberg platform. The gold and platinum spot prices used in calculating precious metal forward premiums also originate from Bloomberg. The initial data will be transformed from prices to returns for further analysis. Spot and futures prices from Bloomberg, as shown in Table 1, are all priced according to USD per ounce.

Secondly, the macroeconomic and financial data come from the Federal Reserve Bank of St-Louis, more commonly known as Federal Reserve Economic Data (FRED). The macroeconomic data that have been selected are the Industrial Production Index, Consumer Price Index (CPI), M2 Money Stock, S&P/Case-Shiller US National Home Price Index, and Personal Savings Rate. And the financial data are Trade Weighted US dollar index, crude oil price-West Texas Intermediate (WTI), effective federal fund rate, US-UK foreign exchange rate, and TED spread. The controls used for predictive regression are the US gross domestic product (GDP), S&P 500 and CBOE Volatility Index (VIX). Overall, the data's chose dates range from earliest available date until 2017 (see Table 1).

	Unit	Frequency	Starting Year
Precious Metals			
Gold futures	USD per ounce	Daily	1975-01
Gold Spot	USD per ounce	Daily	1950-06
Platinum futures	USD per ounce	Daily	1986-04
Platinum Spot	USD per ounce	Daily	1987-01

US Macroeconomic Data			
Industrial Production Index	Index 2012 =100	Monthly	1919-01
Consumer Price Index	Index 1982-1984 =100	Monthly	1913-01
M2 Money Stock	Billions of Dollars	Monthly	1959-01
S&P/Case-Shiller US National Home Price Index	Index	Monthly	1975-01
Personal Savings Rate	Percent	Monthly	1959-01
GDP (Control)	Billions of Dollars	Quarterly	1947-01
US Financial Data			
Trade Weighted Dollar index	Index Mar 1973 =100	Daily	1973-01
S&P500 (Control)	Index	Daily	2007-11
Crude oil price (WTI)	Dollars per Barrel	Daily	1986-01
Effective federal fund rate	Percent	Daily	1954-07
US-UK foreign exchange rate	US Dollars to one British Pound	Daily	1971-01
TED Spread	Percent	Daily	1986-01
CBOE Volatility Index VIX (Control)	Index	Daily	1990-01

Table 1. Data Specifications

Source: Federal Reserve Economic Data (FRED) from Federal Reserve Bank of St-Louis & Bloomberg

This table lists all the data that have been collected from online sources for this research. There are three types of data: precious metal prices (in USD), US macroeconomic data and US financial data. Precious metal data are collected via Bloomberg, and US macroeconomic and financial data are collected via FRED. Each element is specified in terms of its unit, frequency and starting year. In addition, GDP, S&P500, and CBOE volatility Index (VIX) are selected as controls for the predictive regression.

III. Methodology

1.1 Price and Return

Before preliminary tests, the data for precious metals and macroeconomic data require cleaning and dimensional matching. The dates for both kinds of series are different and therefore necessitate matching to offer an intersection of the dates. Then, the desired data undergo filtering and the length of both time series is matched to continue towards predictive regression. For the period under consideration, the number of elements remaining following initial treatment revolves around daily points or monthly points in a series. From the obtained futures prices, the returns are simply calculated through the log equation (1).

$$x_t = log \frac{F_{t+1}}{F_t} \tag{1}$$

where F_{t+1} = Price of precious metal futures at time t+1

x_t = Return of precious metal futures at time t

The rate of change for macroeconomic factors is generated in a similar manner with the newly cleaned macroeconomic data using the log equation (2).

$$y_t = log \frac{M_{t+1}}{M_t} \tag{2}$$

where M_{t+1} = Value of macroeconomic data at time t+1

y_t = Rate of change for macroeconomic data at time t

Apart from platinum and gold futures values, the gold-platinum spread is also simulated for results, and it is calculated according to the equation (3):

$$Spread_{Gold\text{-}Platinum} = F_{pl} - F_{gd} \quad (3)$$

where F_{pl} = Futures Price of Platinum

F_{gd} = Futures Price of Gold

In addition, we are interested in the forward premium which can be described by equation (4):

$$Forward\ Premium = \frac{F-S}{S} \quad (4)$$

where F = Futures Price of Gold or Platinum (F_{pl} or F_{gd})

S = Spot Price of Gold or Platinum

1.2 Unit Root Tests

Then unit roots such as Augmented Dickey Fuller (ADF) test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test are applied to each series. These will test for stationarity and unit root, to prevent spurious and inaccurate regression results. In a unit root test, one needs to determine whether one can reject the null hypothesis or not, the null hypothesis being that there is a unit root. The p-value associated to test outcome would be suggestive of its level. For example, if the $p>0.01$, then a strong autocorrelation exists. In comparison, $p<0.01$ would mean a significant inclination to remove the null hypothesis. To clarify this, an augmented Dickey Fuller (ADF) with g lags, c drift and δ trend is presented in equation (5).

$$y_t = c + \delta t + \phi y_{t-1} + \beta_1 \Delta y_{t-1} + \cdots + \beta_g \Delta y_{t-g} + \varepsilon_t \quad (5)$$

Null Hypothesis $H_0: \phi = 1$

Alternative: $H_0: \phi < 1$

The KPSS test looks at trend stationarity rather than unit root. It has a reversed null and alternative hypothesis from that of ADF test, because the alternative hypothesis now is that a unit root exists. In this case, p<0.01 is linked to rejection of the null hypothesis which is stationarity, and p>0.01 would mean that stationarity cannot be rejected. The following equations (6.1 and 6.2) depict a KPSS test with v_{1t}, a stationary process, and v_{2t}, an iid process that is (0, σ^2).

$$y_t = c_t + \delta t + v_{1t} \quad (6.1)$$

$$c_t = c_{t-1} + v_{2t} \quad (6.2)$$

Null Hypothesis $H_0: \sigma^2 = 0$

Alternative: $H_0: \sigma^2 > 0$

1.3 Autocorrelation

Autocorrelation must be verified for all precious metals and macroeconomic data. The requirement on the raw data series is their autocorrelation must be zero, this is necessary in order to proceed to predictive regression and beyond.

2. Predictive Regression with OLS estimation

The predictive regression equation (7) is different from the general OLS equation. It resembles more closely the predictive regressive equation from Huang (2016). Here, the dependent variable on the left hand side of the equation is a cumulative sum of y, the logarithmic rate of change of

the macroeconomic variables. On the right hand side, the parameters π_0 and π_1 are respectively the mean offset and the coefficient of the independent variable X_t. More precisely, X_t is the logarithmic return of precious metals for t from t=1 to t=T samples. And this cumulative sum is made from h=0 to h=H. As an example for H, a horizon H of 84 months equals a duration of 7 years. Finally, the matrix form of equation (7) is depicted in equations (8.1) and (8.2), to list the variables for all T samples.

a) Without controls

$$\sum_{h=0}^{H} y_{t+h} = \pi_0 + \pi_1 X_t + \varepsilon_{t+H} \tag{7}$$

$$\begin{bmatrix} 1 & x_1 \\ : & : \\ 1 & x_T \end{bmatrix} \begin{bmatrix} \pi_0 \\ \\ \pi_1 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1+H} \\ : \\ \varepsilon_{T+H} \end{bmatrix} = \sum_{h=0}^{H} \begin{bmatrix} y_{1+h} \\ : \\ y_{T+h} \end{bmatrix} \tag{8.1}$$

or

$$X\pi + \varepsilon = \sum y \tag{8.2}$$

b) With controls (US GDP, S&P 500 and VIX):

In equations (9), (10.1) and (10.2), the predictive regression equation now includes three controls (C_{1t} stands for US GDP, C_{2t} for S&P 500, and C_{3t} for VIX) which have their own coefficients (π_2, π_3, π_4) in front of them.

$$\sum_{h=0}^{H} y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H} \tag{9}$$

$$\begin{bmatrix} 1 & x_1 & c_{11} & c_{21} & c_{31} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & x_T & c_{1T} & c_{2T} & c_{3T} \end{bmatrix} \begin{bmatrix} \pi_0 \\ : \\ \pi_4 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1+H} \\ : \\ \varepsilon_{T+H} \end{bmatrix} = \sum_{h=0}^{H} \begin{bmatrix} y_{1+h} \\ : \\ y_{T+h} \end{bmatrix} \tag{10.1}$$

or

$$X\pi + \varepsilon = \sum y \tag{10.2}$$

IV. Results

As part of the study, input data are graphed (Figure 1 and 2) to provide an idea of the trend experienced throughout its lifetime.

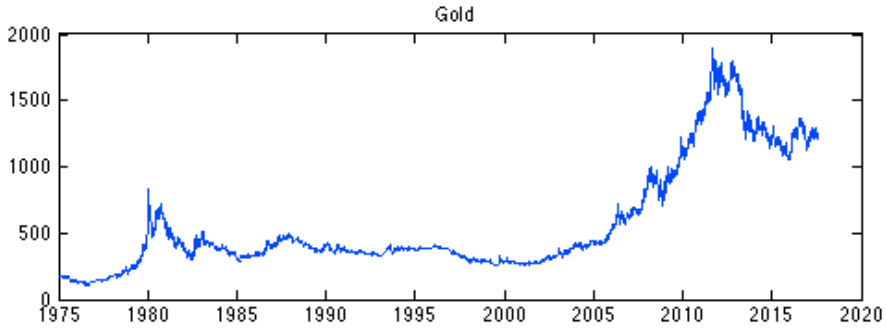

Figure 1. Futures Price of Precious Metal (Gold)

NOTE. This figure displays the trend of gold price (in unit of U.S. Dollars per ounce) with respect to time. The peak attained in 2011 reaches almost $2000 per Barrel. Figures depicting trends over time such as this one have been generated for all precious metal data from Table 1.

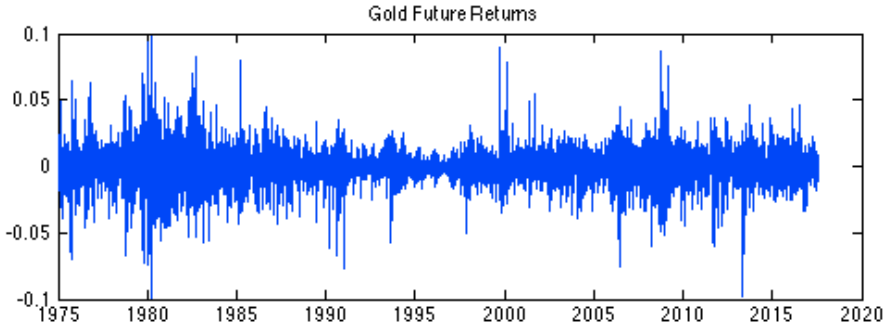

Figure 2. Futures Return of Precious Metal (Gold)

NOTE. This figure displays the rate of change in gold with respect to time. Highest variations in gold price are observed around 1980. Figures depicting rate of change such as this one have been generated for all precious metal data from Table 1.

Following unit root tests and descriptive statistics (Table A1 of Appendix A), autocorrelation must be plotted in Matlab before running each predictive regression. The generated graphs contain red dots within blue line boundaries, this configuration signifies that there is no autocorrelation in the sample and it stays this way until lag 20 for all plots, ensuring adequacy for regression. In the Appendix A, Figure A1 and A2 depict the same trends for oil as for gold. For oil, there was also no autocorrelation in the sample until lag 20. This procedure is subsequently performed for all series in question for quality control. Also among macroeconomic variables, the least stationary has proven to be Case-Shiller Index according to ADF test (-4.163), and CPI according to KPSS test (1.074).

Results - Predictive Regression

The predictive regression is spanned over a duration of H=84 months or 7 years. The results (Table A2-A6 of Appendix A) are respectively the estimated π_1 parameters of independent variables (from equation 9), its t-statistics, and the coefficient of determination R^2. Figures A3-A7 (Appendix A) feature t-statistics that include controls (GDP, S&P 500 & VIX) in their computation, the results with controls offer higher R^2 and model precision than without controls, therefore figures without controls have been omitted. The t-statistics for π_1 are featured in Figures A3-A7 with t-bars and 95% intervals.

The gold and platinum futures have larger t-statistics magnitudes than gold and platinum premiums and do not alternate from positive to negative as much. At first glance, one remarks that the Case-Shiller Index for gold futures has high negative t-statistics magnitude throughout

the horizon (Figure A3). The Case-Shiller Index graph has a distinct wavy appearance in futures and in premiums. Then, the Dollar Index and Oil for platinum futures also have higher t-statistics magnitude, with Dollar Index in negative range and Oil in positive range. In the gold premiums series of Figure A6, the factors start off with an oscillatory period of larger t-statistics magnitude for about 15 months and then all close in towards the zero axis. In contrast with the latter, the platinum premium series stays at about the same level horizontally (and so does not all go to zero, albeit slight directionality) throughout the entire horizon, especially for CPI, M2 supply, Oil, TED spread, and US-UK exchange rate. By estimating π_1, one could detect if change in π_1 is caused by actual change or pure randomness. Here, the hypothesized value π_0 in equation (21) is 0, which is equivalent to null hypothesis. Hence when t-statistics are positive, the hypothesized value is too small, and when t-statistics are negative, it is the opposite case.

The values found outside the two 5% significance level lines reject the null hypothesis, and therefore should be of most interest as it differs most from zero and has the most predictive significance. In Figures A3-A7, there are normally values that reject the null hypothesis near the first few months (about 5 to 12 months) of the horizon, meaning that during this period the precision of the predictive regression is highest. For gold futures, this occurs not only near the first few months, but also during the last few months of the 7 year horizon for most of the macroeconomic factors, with bars reaching or almost reaching 95% interval line in Figure A3. In comparison, for the platinum futures in Figure A4, this occurrence revolves around the first 5-10 months. Also, it should be noted that t-statistics for the gold-platinum spread are smaller in magnitude compared with those of gold and platinum futures for the entire horizon, it has its best precision within its first 5-10 months. As for the premiums, one can see that from Figure A6 gold

premium's t-statistics are the closest to zero among the precious metal series, therefore its p-values are naturally the largest. Similar situation applies to platinum premiums (Figure A7), accentuating the fact that gold and platinum premiums have the least precision of all these precious metal series.

From Tables A2-A6, the macroeconomic factors that are incremental with time in terms of π_1 for both gold and platinum future returns are 1) M2 supply, 2) Personal Savings and 3) TED spread. In contrast, those that are decremental for both metals are 1) Case-Shiller Index, 2) CPI, 3) Federal Fund Rate, and 4) Industrial Production. The π_1 parameter estimates for gold and platinum forward premiums are more stationary and less directional than gold and platinum futures. Also the magnitude is much smaller for premium returns than for metal future returns, and the magnitude of gold-platinum spread may be situated somewhere between these two magnitudes. These characteristics lead to the conclusion that π_1 description is most significant in the case of future returns.

The R^2 in Tables A2-A6 are overall larger values than the estimation values without controls, thus these results with controls suggest the data are fit closer to the regression line. R^2 mostly starts off high and decreases towards zero, with an exception being CPI for platinum futures. In the short term (up to approximately 10 to 20 months), the R^2 is much higher in general, symbolizing a higher accuracy of model fitness in the short run. Before the R^2 returns to zero, it would take longer for Federal Fund Rate and TED spread to reach nil (i.e. around 40 to 50 months). In comparison, US Dollar Index would spend the shortest time of all (around 2 months) to move to the vicinity of zero. Furthermore, the M2 money supply and TED spread rate have the

most distinct trends of spiked oscillations with 2-3 year cycles. One of the more unpredictable series is the gold-platinum spread series, as it has sporadic R^2 peaks in its mountain-like terrains. In general, forward premiums for gold and platinum as well as gold-platinum spread have smaller R^2 than gold and platinum futures, indicating a higher accuracy for precious metal future returns.

Gold and Platinum Forecasting Macroeconomic Factors (Short term and long term)

The M2, Oil, Personal Savings, TED spread, US-UK Rate are macroeconomic factors that increase when gold and platinum future returns rise for most of the 7 year horizon, while Dollar Index, Federal Fund Rate, Industrial Production would decrease for an increase in gold and platinum future returns for most part of the studied horizon. Federal Fund Rate and Industrial Production π_1 estimates are in the positive range in the short term and would switch to negative range in the long term. M2 and Personal Savings are another pair where their π_1 are in the negative range in the short term and then switch to positive range in the long term. There are two exceptions that do not exhibit the same trends for each precious metal: CPI and Case-Shiller Index. First, CPI for the 7 year horizon would increase for the first half and decrease for the second half of the horizon as the gold future returns increment, but it is mostly incremental with respect to an increase in platinum futures returns until the 70^{th} month. Secondly, Case-Shiller Index is decremental with positive gold future returns, and varies in highly oscillatory fashion between positive and negative rates of change for positive platinum future returns.

For gold-platinum spread, the indicators that rise in response to a positive change in spread return for the most part of the examined horizon are Case-Shiller Index, CPI, M2, Oil and US-

UK Rate, and those that drop with it are Dollar Index and Personal Savings. Other remaining factors such as Federal Fund Rate, Industrial Production and TED Spread would rise with a spread return increase for the first half of the 7 year horizon but then would decrease for the second half of the horizon.

For gold forward premium, and for most of its horizon, the factors that increase with the premium return growth are Case-Shiller Index, CPI, Dollar Index, Industrial Production, Oil, TED Spread, and those that decrease with it are M2 and US-UK Rate. Interestingly, Federal Fund Rate and Personal Savings rates of change would alternate between a positive and negative relationship with any increase in gold forward premium returns.

For platinum forward premium, the factors that increase for the major part of the horizon with the premium return growth are Dollar Index, Industrial Production, M2 and Personal Savings, and those that decrease with it are Case-Shiller Index, CPI, Federal Fund Rate, Oil, and US-UK Rate. Just as before, it is now the TED Spread that would alternate between a positive and a negative relationship with any increase in platinum forward premium returns.

V. Discussion

In the results section, the best prediction is detected around the first 5 to 15 months depending on which macroeconomic factor. This kind of prediction works best for gold and platinum futures as well as the gold-platinum spread. The gold and platinum premiums do not provide adequate predictions, this is because their π_1 parameters are too small (on the order of 10e-5 and 10e-6) and their t-bars suggest null hypothesis (Figures A6-A7), despite the fact that R^2 shows some significance at the beginning of the horizon, causing their π_1 to remain relatively stable and unchanged throughout the entire horizon. This means that short term prediction of gold and platinum futures and gold-platinum spread is possible with the predictive regression method. Long term and short term behaviors of π_1 vary for all macroeconomic factors, with the macroeconomic factors moving positively or negatively with the precious metals, and most factors would display an alternating behavior over time.

Overall, gold and platinum future returns have proven to have predictive power for all of the macroeconomic factors under examination because they are equipped with larger values of t-statistics, R^2, and π_1 than other precious metal products. This answers the question that gold and platinum are indeed able to forecast US macroeconomic variables to different degrees. And as the projected π_1 coefficient estimates and t-statistics of precious metal futures, premiums, and gold-platinum spread are very distinct from each other, these gold and platinum products would be perfectly suitable to diversify a portfolio that carries precious metals, where gold and platinum would be perceived not as one asset class but as individual precious metals with their own identities.

Conclusion

This study is written to appreciate the forecast ability of the gold and platinum for US macroeconomic and financial factors such as CPI, Home Price Index and exchange rates. The overall trends of the predictive relationship are specific to each macroeconomic factor but they can be quite predictable through predictive regression in the short term and long term, with short term prediction being more precise than long term prediction. Gold and platinum futures and spread also present considerable predictive advantage over gold and platinum forward premiums for the forecasting of macroeconomic indicators. From existing literature that mostly focuses on macroeconomic predictors to forecast metal commodities, one can ascertain now that the direction of prediction for macroeconomic factors and precious metals (gold and platinum) works in both directions. This is true for precious metal futures and gold-platinum spread, but does not hold in the case of gold and platinum forward premiums, therefore it is a good idea to keep these gold and platinum products in a portfolio for diversification purposes.

Future research on this topic could involve a more in-depth view into other macroeconomic factors from other foreign countries. And precious metals like silver and palladium could also provide more insight into the relationship of white metals and macroeconomic variables. In addition, many more estimation models could be of interest to the readers, and their diverse characteristics would allow for a better in-depth understanding of the predictive relationship between precious metals and macroeconomics. Finally, other commodities such as cotton, sugar or natural gas could eventually enter the macroeconomic picture alongside precious metals like gold and platinum.

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Appendix A

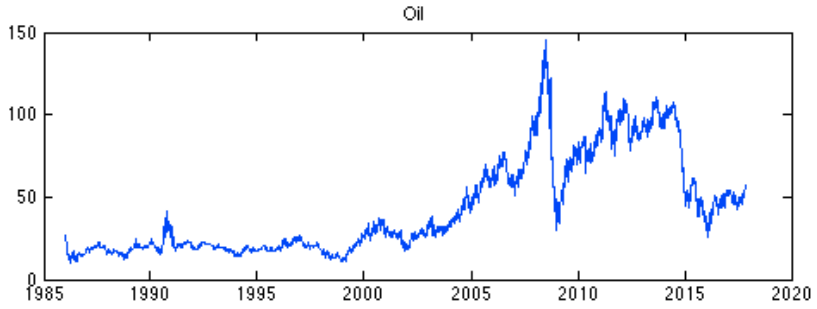

Figure A1. Financial Data (Oil)

NOTE. This figure displays the trend of oil price (in unit of U.S. Dollars per Barrel) with respect to time. The peak attained in 2008 is close to $150 per Barrel. Figures depicting trends over time such as this one have been generated for all macroeconomic and financial data from Table 1.

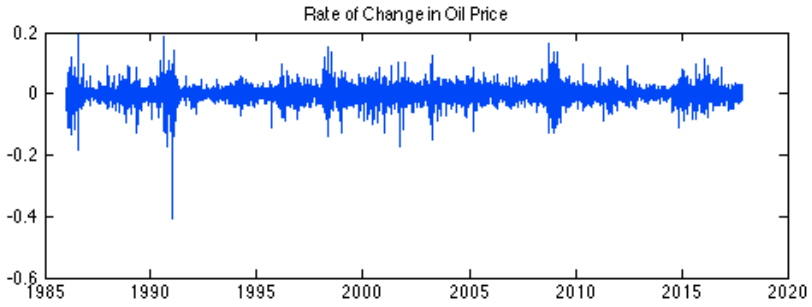

Figure A2. Rate of Change in Financial Data (Oil)

NOTE. This figure displays the rate of change in oil with respect to time. Highest variation in oil price was observed around 1991. Figures depicting rate of change such as this one have been generated for all macroeconomic and financial data from Table 1.

TABLE A1. Descriptive Statistics and Unit Root Tests

This table depicts descriptive statistics and unit root tests (ADF and KPSS) t-statistics for precious metals and macroeconomic series (Industrial Production (INDPRO), Consumer Price Index (CPI), M2 Money Stock, Case-Shiller National Home Price Index, Personal Savings Rate, West Texas Intermediate (WTI) Crude Oil, US-UK Foreign Exchange Rate, Effective Federal Fund Rate, Trade Weighted US Dollar Index and TED Spread)

	mean	median	maximum	minimum	standard dev	skewness	kurtosis	ADF	KPSS
GOLD	0.0185%	0.0000%	0.09745	-0.0991	0.0124	-0.0700	10.1354	-104.99	0.1002
PLATINUM	0.0107%	0.0506%	0.12716	-0.2719	0.0144	-1.1244	22.7420	-85.93	0.0959
INDPRO	0.2570%	0.2840%	0.15321	-0.1096	0.0191	0.2858	14.2128	-19.49	0.0928
CPI	0.2570%	0.2410%	0.05716	-0.0321	0.0065	0.7059	11.5264	-19.38	1.0741
M2	0.5470%	0.5920%	0.02700	-0.0155	0.0060	-0.3036	3.5860	-15.80	0.3692
Case/Shiller	0.4000%	0.4400%	0.02014	-0.0228	0.0062	-0.7723	4.8886	-4.16	0.7982
Savings	-0.1780%	0.0000%	0.81410	-0.8473	0.1092	-0.5963	24.2061	-34.22	0.0078
Oil	0.0098%	0.0510%	0.19151	-0.4064	0.0252	-0.6537	16.6394	-91.06	0.0468
US/UK	-0.0050%	0.0054%	0.04589	-0.0817	0.0060	-0.4012	10.3392	-103.59	0.0563
Fed Fund Rate	0.0001%	0.0000%	2.44569	-1.6094	0.1180	2.5073	89.1884	-175.17	0.0037
Dollar Index	-0.0018%	0.0001%	0.02953	-0.0544	0.0042	-0.3188	8.8896	-104.56	0.0716
TED spread	-0.0213%	0.0000%	1.01693	-0.6931	0.0913	0.1630	11.3514	-106.19	0.0055

Table A2. Predictive regression results for gold futures

Gold Futures							
	Horizon	1m	1qt	1yr	3yr	5yr	7yr
Dollar Index	estimate:	-0.1025	-0.1173	-0.1673	-0.2772	-0.1966	-0.0303
	t-stat:	-5.8586	-4.1797	-3.2891	-3.7649	-1.3166	-0.2782
	R-squared	0.0954	0.0216	0.0229	0.0321	0.0089	0.0055
TED Rate	estimate:	0.3408	0.2626	0.6229	0.8810	1.5790	0.2450
	t-stat:	1.4702	2.4767	1.7144	1.5636	1.9455	0.3096
	R-squared	0.0858	0.0804	0.0550	0.0321	0.0219	0.0273
Pers. Savings	estimate:	0.0278	0.1154	0.0057	0.4658	1.0111	1.2713
	t-stat:	0.2193	0.7889	0.0389	2.0220	4.4581	4.0232
	R-squared	0.0243	0.0131	0.0025	0.0061	0.0128	0.0189
Oil	estimate:	0.1918	0.5658	0.6174	0.8342	0.2182	-0.4368
	t-stat:	2.5408	2.4863	3.9925	1.8032	0.8996	-0.9653
	R-squared	0.0812	0.0402	0.0118	0.0221	0.0051	0.0186
M2	estimate:	0.0007	-0.0028	-0.0030	0.0305	0.0769	0.1406
	t-stat:	0.1121	-0.6501	-0.3186	0.8198	0.8596	1.4034
	R-squared	0.0222	0.0598	0.0075	0.0069	0.0073	0.0126
Ind.Production	estimate:	0.0071	0.0122	0.0006	-0.0753	-0.1456	-0.3043
	t-stat:	2.1157	0.9748	0.0218	-1.0802	-3.3270	-6.4597
	R-squared	0.0342	0.1276	0.0636	0.0077	0.0088	0.0187
Fed Fund Rate	estimate:	0.1388	0.3554	0.2193	-1.5395	-1.0436	-2.4033
	t-stat:	1.1445	1.1489	0.9382	-1.5519	-1.0749	-2.2757
	R-squared	0.1448	0.0851	0.0551	0.0424	0.0175	0.0175
US-UK Rate	estimate:	0.0944	0.0844	0.1118	0.1133	0.1520	-0.2335
	t-stat:	4.2518	1.9122	1.8234	1.2372	1.0639	-1.8755
	R-squared	0.0795	0.0291	0.0053	0.0027	0.0037	0.0058
Case-Shiller	estimate:	-0.0137	-0.0361	-0.0844	-0.2688	-0.4992	-0.8005
	t-stat:	-2.7529	-2.0728	-2.0004	-2.0881	-2.3709	-2.7277
	R-squared	0.0685	0.0725	0.0291	0.0237	0.0165	0.0242
CPI	estimate:	0.0112	0.0212	0.0194	0.0098	-0.0385	-0.0746
	t-stat:	2.4557	1.9923	1.3899	0.3482	-1.8717	-3.5630
	R-squared	0.1069	0.0542	0.0306	0.0256	0.0247	0.0463

This table presents predictive regression results for gold futures incorporating three controls (GDP, VIX and S&P 500), with horizons shown for 1 month, 3 months, 1 year (12 month), 3 year (36 months), 5 years (60 months) and 7 years (84 months). Predictive regression follows the equation $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of gold futures, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation represents the rate of change in each listed macroeconomic factor. The estimate rows indicate the π_1 coefficient estimate of the independent variable or gold futures return X_t, and the t-statistics and R-squared rows are generated according to the Newey-West method. For example Oil, for 3 year horizon, has π_1 =0.8342, tstat=1.8032, and R^2=0.0221, meaning a 10% increase in gold futures return predicts an 8.3% increase in oil price return.

Table A3. Predictive regression results for platinum futures

Platinum Futures							
	Horizon:	1m	1qt	1yr	3yr	5yr	7yr
Dollar Index	estimate:	-0.0556	-0.0915	-0.0308	-0.1104	-0.2105	-0.0964
	t-stat:	-4.1582	-2.0215	-0.9089	-2.0306	-3.1880	-1.5657
	R-squared	0.0612	0.0237	0.0120	0.0244	0.0124	0.0065
TED Rate	estimate:	-0.4524	-0.3352	0.5517	0.1400	0.2456	-0.3036
	t-stat:	-1.3993	-1.6157	1.6615	0.3107	0.7952	-0.8988
	R-squared	0.0929	0.0819	0.0560	0.0302	0.0173	0.0276
Pers. Savings	estimate:	0.0137	0.0997	0.0087	0.3083	0.5628	0.5079
	t-stat:	0.2154	0.7740	0.0691	2.1190	3.4707	2.7380
	R-squared	0.0242	0.0134	0.0025	0.0053	0.0078	0.0093
Oil	estimate:	0.2526	1.0279	0.6931	0.8436	0.9456	0.4525
	t-stat:	4.5292	4.4050	4.5190	3.6578	5.3170	1.0804
	R-squared	0.1050	0.1193	0.0220	0.0281	0.0176	0.0198
M2	estimate:	0.0034	-0.0239	-0.0079	0.0310	0.0713	0.1288
	t-stat:	1.2745	-4.5615	-0.6609	0.7811	1.1755	2.0631
	R-squared	0.0234	0.0774	0.0080	0.0075	0.0085	0.0153
Ind.Production	estimate:	0.0076	0.0335	0.0248	-0.0588	-0.0856	-0.2039
	t-stat:	1.9006	4.7584	1.0777	-1.4923	-2.3481	-4.0826
	R-squared	0.0373	0.1419	0.0651	0.0078	0.0073	0.0173
Fed Fund Rate	estimate:	0.2022	1.1275	0.4368	0.0833	-0.8834	-0.7583
	t-stat:	1.5630	2.1531	1.1096	0.1579	-1.4134	-1.1111
	R-squared	0.1527	0.1273	0.0564	0.0397	0.0178	0.0134
US-UK Rate	estimate:	0.0541	0.1158	0.0089	0.0528	0.1927	-0.0457
	t-stat:	3.1069	1.3794	0.2030	0.9371	3.1504	-0.5655
	R-squared	0.0669	0.0402	0.0024	0.0018	0.0076	0.0010
Case-Shiller	estimate:	0.0021	0.0494	0.0034	-0.0389	-0.1209	-0.1316
	t-stat:	0.5477	5.9688	0.0906	-0.3863	-0.8253	-0.9367
	R-squared	0.0602	0.0839	0.0244	0.0171	0.0064	0.0049
CPI	estimate:	0.0123	0.0428	0.0299	0.0211	0.0168	-0.0261
	t-stat:	2.2422	2.7258	2.4978	1.0061	0.6578	-1.7684
	R-squared	0.1370	0.1356	0.0452	0.0274	0.0231	0.0411

This table presents predictive regression results for platinum futures incorporating three controls (GDP, VIX and S&P 500), with horizons shown for 1 month, 3 months, 1 year (12 month), 3 year (36 months), 5 years (60 months) and 7 years (84 months). Predictive regression follows the equation $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of platinum futures, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation represents the rate of change in each listed macroeconomic factor. The estimate rows indicate the π_1 coefficient estimate of the independent variable or platinum futures return X_t, and the t-statistics and R-squared rows are generated according to the Newey-West method. For example Oil, for 3 year horizon, has π_1 =0.8436, tstat=3.6578, and R^2=0.0281, meaning a 10% increase in platinum futures return predicts an 8.4% increase in oil price return.

Table A4. Predictive regression results for gold-platinum spread

Gold-Platinum Spread							
	Horizon:	1m	1qt	1yr	3yr	5yr	7yr
Dollar Index	estimate:	-0.0010	-0.0035	-0.0007	-0.0015	-0.0018	-0.0048
	t-stat:	-0.8541	-1.0690	-0.1703	-0.1607	-0.1409	-0.4086
	R-squared	0.0256	0.0126	0.0136	0.0273	0.0103	0.0080
TED Rate	estimate:	-0.0217	0.0090	0.0198	0.0052	-0.0205	-0.0186
	t-stat:	-1.5151	0.5038	1.4065	0.0844	-0.6264	-0.3004
	R-squared	0.0873	0.0809	0.0538	0.0344	0.0176	0.0288
Pers. Savings	estimate:	-0.0115	-0.0069	-0.0024	-0.0057	-0.0003	-0.0112
	t-stat:	-1.2901	-0.6543	-0.2076	-0.3276	-0.0135	-0.4641
	R-squared	0.0295	0.0161	0.0045	0.0034	0.0036	0.0067
Oil	estimate:	0.0060	0.0278	0.0133	0.0252	0.0175	0.0172
	t-stat:	1.2281	1.4473	0.7349	0.5367	0.4637	0.2184
	R-squared	0.0743	0.0384	0.0070	0.0287	0.0085	0.0258
M2	estimate:	-0.0004	-0.0008	-0.0001	0.0009	0.0023	0.0034
	t-stat:	-0.7898	-0.9794	-0.0813	0.1796	0.3441	0.5423
	R-squared	0.0313	0.0687	0.0101	0.0110	0.0090	0.0113
Ind.Production	estimate:	0.0003	0.0009	0.0013	-0.0002	-0.0003	-0.0025
	t-stat:	1.1106	1.3766	0.6281	-0.0339	-0.0358	-0.1628
	R-squared	0.0344	0.1286	0.0662	0.0088	0.0087	0.0164
Fed Fund Rate	estimate:	0.0033	0.0251	0.0353	0.0220	-0.0146	0.0007
	t-stat:	0.5675	0.9806	1.1317	0.3352	-0.1984	0.0121
	R-squared	0.1439	0.0899	0.0571	0.0426	0.0186	0.0133
US-UK Rate	estimate:	0.0014	0.0036	-0.0026	0.0010	0.0021	0.0034
	t-stat:	1.0180	1.0095	-0.6099	0.1311	0.1921	0.9192
	R-squared	0.0499	0.0277	0.0032	0.0033	0.0045	0.0011
Case-Shiller	estimate:	0.0005	0.0015	0.0008	0.0011	0.0029	0.0058
	t-stat:	1.0219	0.8452	0.2623	0.1849	0.4408	0.6489
	R-squared	0.0639	0.0712	0.0246	0.0172	0.0054	0.0047
CPI	estimate:	0.0001	0.0005	0.0003	0.0002	0.0001	-0.0003
	t-stat:	0.8676	0.9731	0.4692	0.1176	0.1054	-0.1282
	R-squared	0.0836	0.0442	0.0281	0.0307	0.0226	0.0400

This table presents predictive regression results for gold-platinum spread incorporating three controls (GDP, VIX and S&P 500), with horizons shown for 1 month, 3 months, 1 year (12 month), 3 year (36 months), 5 years (60 months) and 7 years (84 months). Predictive regression follows the equation $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of gold-platinum spread, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation represents the rate of change in each listed macroeconomic factor. The estimate rows indicate the π_1 coefficient estimate of the independent variable or gold-platinum spread return X_t, and the t-statistics and R-squared rows are generated according to Newey-West method. For example Oil, for 3 yr horizon, has π_1 =0.0252, tstat=0.5367, and R^2=0.0287, meaning 10% increase in g-p spread return predicts 0.25% increase in oil price return.

Table A5. Predictive regression results for gold forward premium

Gold Forward Premium							
	Horizon:	1m	1qt	1yr	3yr	5yr	7yr
Dollar Index	estimate:	0.0010%	0.0010%	0.0026%	0.0002%	0.0004%	0.0028%
	t-stat:	269.4700%	396.1600%	219.1400%	13.4100%	23.9000%	142.0000%
	R-squared	2.2030%	0.5600%	1.2000%	2.1300%	0.5900%	0.5500%
TED Rate	estimate:	0.0373%	0.0145%	0.0544%	0.0109%	0.0205%	0.0057%
	t-stat:	299.4300%	119.5800%	501.1500%	90.1700%	163.3200%	36.0700%
	R-squared	9.2600%	8.0300%	5.7400%	3.0200%	1.7400%	2.7200%
Pers. Savings	estimate:	-0.0067%	0.0099%	0.0066%	-0.0039%	0.0007%	0.0006%
	t-stat:	-944.1600%	890.2600%	218.2700%	-109.8200%	14.9600%	7.0400%
	R-squared	2.5460%	1.3800%	0.2900%	0.2600%	0.1000%	0.4700%
Oil	estimate:	0.0059%	0.0056%	-0.0052%	0.0043%	0.0016%	-0.0134%
	t-stat:	422.6600%	361.7900%	-80.9800%	126.0300%	31.8600%	-166.1500%
	R-squared	7.3070%	2.5100%	0.4200%	1.4800%	0.4700%	1.7700%
M2	estimate:	-0.0004%	-0.0002%	-0.0002%	-0.0008%	-0.0008%	-0.0014%
	t-stat:	-152.5100%	-103.6700%	-91.6300%	-242.0500%	-151.8400%	-95.3400%
	R-squared	2.5080%	5.9900%	0.7500%	0.6400%	0.5500%	0.8600%
Ind.Production	estimate:	0.0010%	0.0002%	0.0004%	0.0002%	0.0002%	0.0010%
	t-stat:	56.5800%	194.8200%	83.7200%	25.4300%	30.4000%	66.6700%
	R-squared	3.1660%	12.6600%	6.3700%	0.5700%	0.4600%	0.6000%
Fed Fund Rate	estimate:	-0.0205%	-0.0208%	-0.0344%	0.0025%	0.0032%	0.0152%
	t-stat:	-304.8300%	-405.6900%	-531.5400%	15.5600%	18.2400%	61.7700%
	R-squared	15.7600%	8.4900%	5.6300%	3.9700%	1.6400%	1.2400%
US-UK Rate	estimate:	-0.0016%	-0.0011%	-0.0025%	-0.0006%	-0.0007%	-0.0026%
	t-stat:	-330.2200%	-398.6000%	-240.4200%	-41.0300%	-48.8400%	-108.1600%
	R-squared	4.9960%	2.4800%	0.2800%	0.1300%	0.1700%	0.0700%
Case-Shiller	estimate:	-0.0004%	0.0000%	0.0004%	0.0010%	0.0008%	-0.0009%
	t-stat:	-465.4600%	4.9600%	71.5800%	72.7000%	49.0700%	-32.3700%
	R-squared	6.1490%	6.7900%	2.4400%	1.6900%	0.5200%	0.3800%
CPI	estimate:	0.0001%	-0.0000%	-0.0002%	0.0001%	0.0002%	0.0002%
	t-stat:	214.2500%	-19.0300%	-108.8700%	32.9000%	47.0000%	36.8000%
	R-squared	8.3640%	4.1700%	2.6400%	2.5300%	2.2200%	3.9500%

This table presents predictive regression results for gold forward premium incorporating three controls (GDP, VIX and S&P 500), with horizons shown for 1 month, 3 months, 1 year (12 month), 3 year (36 months), 5 years (60 months) and 7 years (84 months). Predictive regression follows the equation $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is return of gold forward premium, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation represents the rate of change in each listed macroeconomic factor. The estimate rows indicate the π_1 coefficient estimate of the independent variable or gold forward premium return X_t, and the t-statistics and R-squared rows are generated according to Newey-West method. For example Oil, for 3 yr horizon, has π_1 =4.27E-05, tstat=1.2603, and R^2=0.0148, meaning 10% rise in gold premium return predicts 0.00043% rise in oil price return.

Table A6. Predictive regression results for platinum forward premium

Platinum Forward Premium							
	Horizon:	1m	1qt	1yr	3yr	5yr	7yr
Dollar Index	estimate:	0.0011%	0.0012%	0.0018%	0.0016%	0.0013%	0.0004%
	t-stat:	341.9700%	563.4200%	352.3400%	244.6500%	141.8900%	37.4600%
	R-squared	2.4530%	0.6200%	1.2000%	2.1500%	0.6000%	0.5400%
TED Rate	estimate:	0.0019%	-0.0040%	0.0035%	-0.0081%	0.0073%	-0.0190%
	t-stat:	25.4800%	-62.7800%	83.0500%	-151.4400%	110.8800%	-301.8400%
	R-squared	8.2680%	7.9800%	5.2800%	3.0200%	1.7200%	2.7800%
Pers. Savings	estimate:	0.0029%	0.0084%	0.0074%	0.0008%	0.0007%	0.0098%
	t-stat:	62.0800%	174.4500%	380.0500%	21.7200%	24.8800%	576.0700%
	R-squared	2.4660%	1.4500%	0.3500%	0.2600%	0.1000%	0.5400%
Oil	estimate:	-0.0057%	-0.0039%	-0.0050%	-0.0025%	0.0024%	-0.0073%
	t-stat:	-507.3300%	-184.5400%	-473.1700%	-139.5100%	96.6100%	-170.4200%
	R-squared	7.5460%	2.5100%	0.4300%	1.4800%	0.4700%	1.7700%
M2	estimate:	0.0002%	0.0002%	0.0001%	-0.0000%	-0.0002%	-0.0001%
	t-stat:	240.9400%	418.6800%	79.8400%	-16.3100%	-89.1500%	-34.1700%
	R-squared	2.3300%	6.0100%	0.7500%	0.6200%	0.5400%	0.8500%
Ind.Production	estimate:	0.0004%	0.0003%	0.0003%	0.0002%	0.0002%	0.0001%
	t-stat:	525.0500%	248.3200%	163.3000%	61.7800%	39.9900%	24.1200%
	R-squared	3.6910%	12.6900%	6.3700%	0.5700%	0.4600%	0.5900%
Fed Fund Rate	estimate:	0.0007%	-0.0029%	-0.0042%	0.0003%	0.0029%	-0.0069%
	t-stat:	80.8100%	-66.4400%	-90.1600%	4.9500%	53.9300%	-161.0900%
	R-squared	14.2100%	8.2800%	5.4900%	3.9700%	1.6400%	1.2400%
US-UK Rate	estimate:	-0.0009%	-0.0009%	-0.0022%	-0.0017%	-0.0020%	-0.0007%
	t-stat:	-130.1000%	-246.6900%	-203.8300%	-167.6000%	-262.9600%	-84.8000%
	R-squared	4.8890%	2.4800%	0.3000%	0.1400%	0.2000%	0.0700%
Case-Shiller	estimate:	-0.0001%	-0.0003%	0.0000%	0.0001%	0.0000%	0.0001%
	t-stat:	-131.4900%	-318.9200%	0.0100%	16.0200%	5.1300%	11.2700%
	R-squared	5.9980%	6.8100%	2.4400%	1.6900%	0.5200%	0.3800%
CPI	estimate:	0.0001%	-0.0001%	-0.0001%	-0.0001%	-0.0001%	-0.0004%
	t-stat:	23.0900%	-273.1000%	-103.3500%	-50.4700%	-67.2200%	-168.8300%
	R-squared	8.2880%	4.1800%	2.6300%	2.5300%	2.2200%	3.9600%

This table presents predictive regression results for platinum forward premium incorporating three controls (GDP, VIX and S&P 500), with horizons shown for 1 month, 3 months, 1 year (12 month), 3 year (36 months), 5 years (60 months) and 7 years (84 months). Predictive regression follows the equation $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of platinum forward premium, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation represents the rate of change in each listed macroeconomic factor. The estimate rows indicate the π_1 coefficient estimate of the independent variable or platinum forward premium return X_t, and the t-statistics and R-squared rows are generated according to the Newey-West method. For example Oil, for 3 yr horizon, has π_1 =-2.51E-05 tstat=-1.3951, R^2=0.0148, meaning 10% rise in platinum premium return predicts 0.00025% decrement in oil price return.

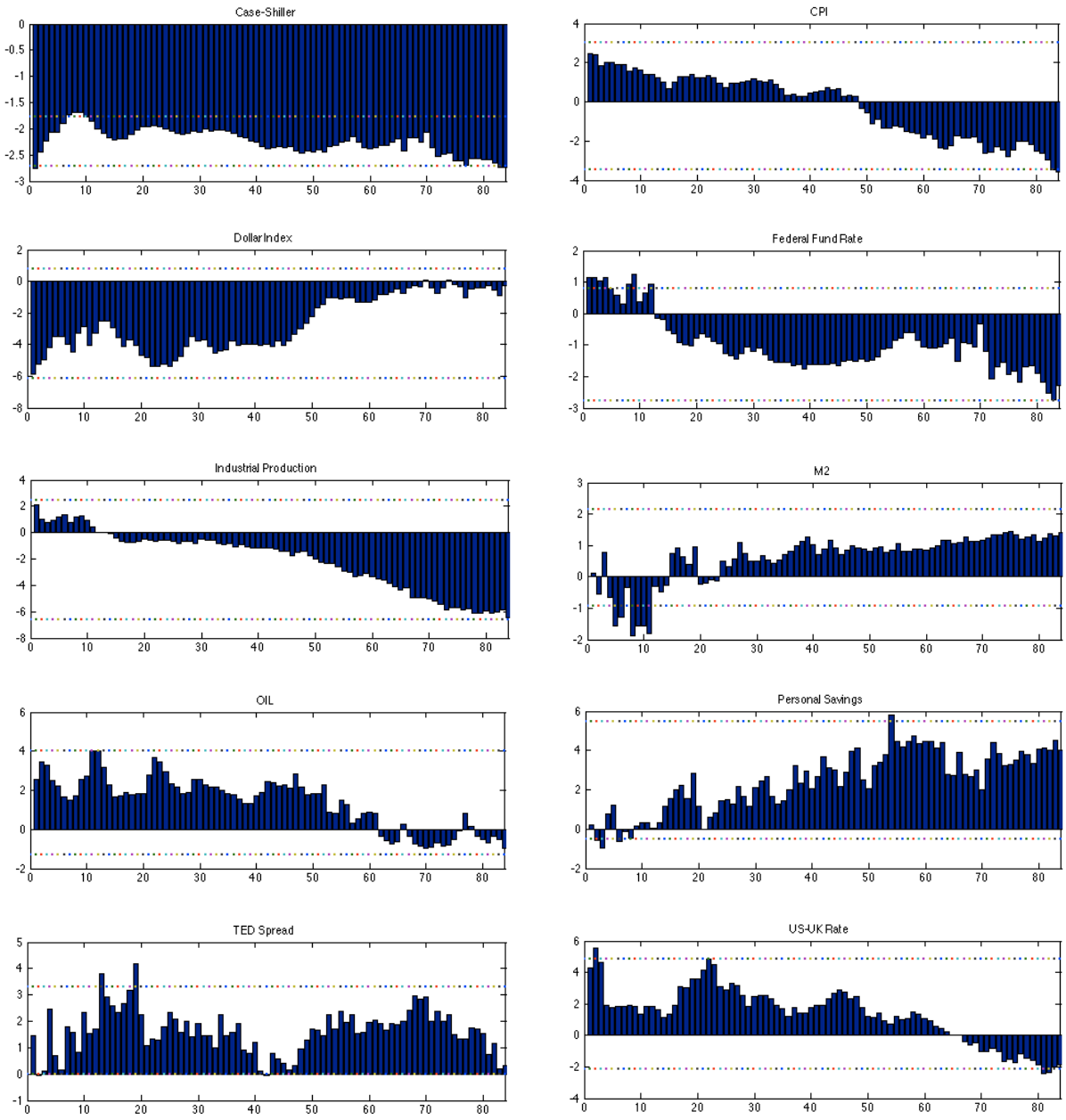

Figure A3. Predictive regression t-statistics for gold futures

This figure presents predictive regression t-statistics for gold futures (H=84 months or 7 years horizon) with controls (GDP, VIX and S&P 500) at 5% significance. Macroeconomic factors listed are Case-Shiller Index, CPI, Dollar Index, Federal Fund Rate, Industrial Production, M2 Money Supply, Oil, Personal Savings, TED Spread, US-UK Exchange Rate. Regression performed on $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of gold futures, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation is the rate of change in each listed macroeconomic factor. For the example of Oil, the t-statistics have higher positive magnitude until 60th month, with the mean at around 1.

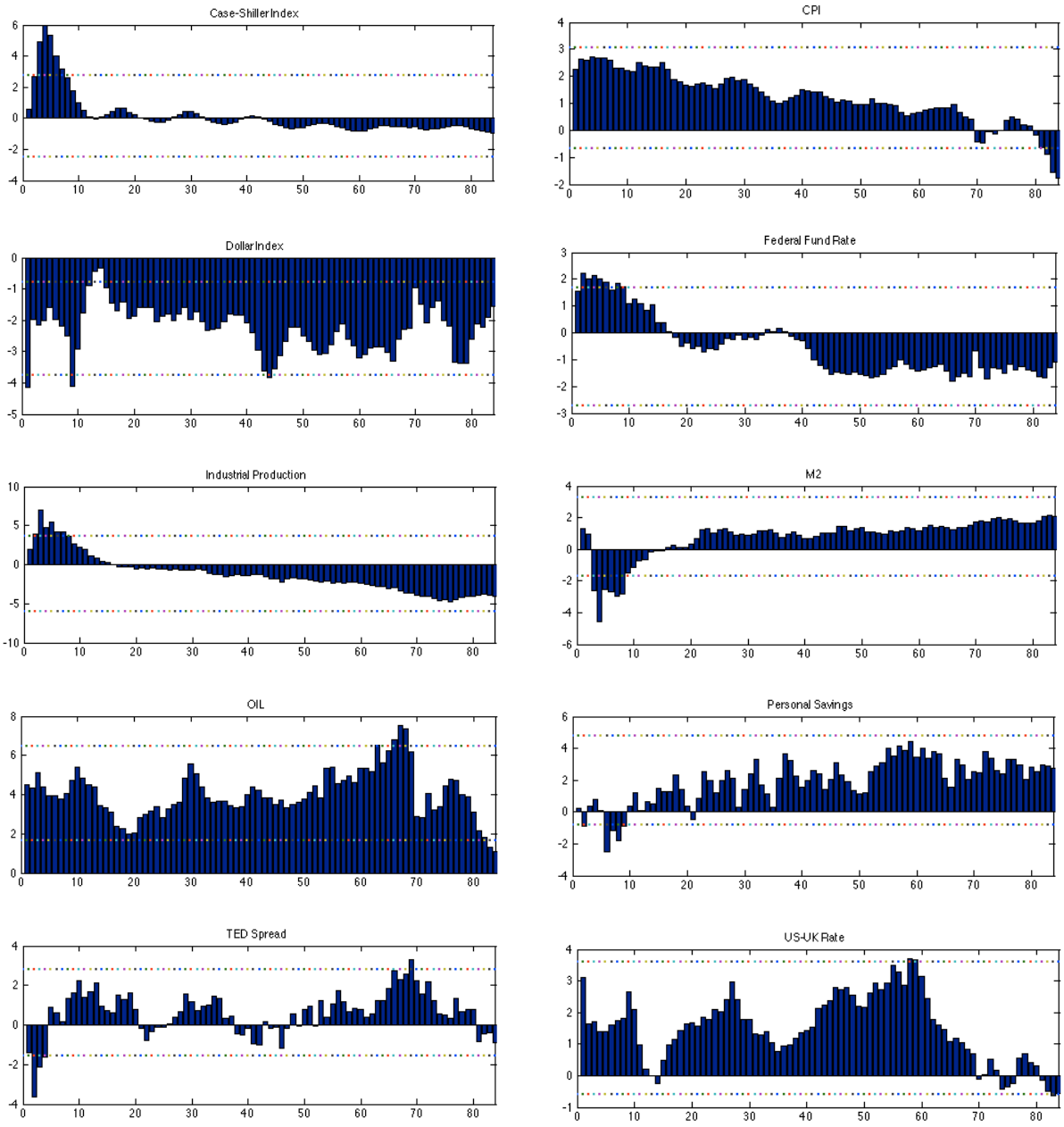

Figure A4. Predictive regression t-statistics for platinum futures

This figure presents predictive regression t-statistics for platinum futures (H=84 months or 7 years horizon) with controls (GDP, VIX and S&P 500) at 5% significance. Macroeconomic factors listed are Case-Shiller Index, CPI, Dollar Index, Federal Fund Rate, Industrial Production, M2 Money Supply, Oil, Personal Savings, TED Spread, US-UK Exchange Rate. Regression performed on $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of platinum futures, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation is the rate of change in each listed macroeconomic factor. For the example of Oil, the t-statistics have high positive magnitude throughout its 7 year horizon, with the highest mean among indicators at around 4.

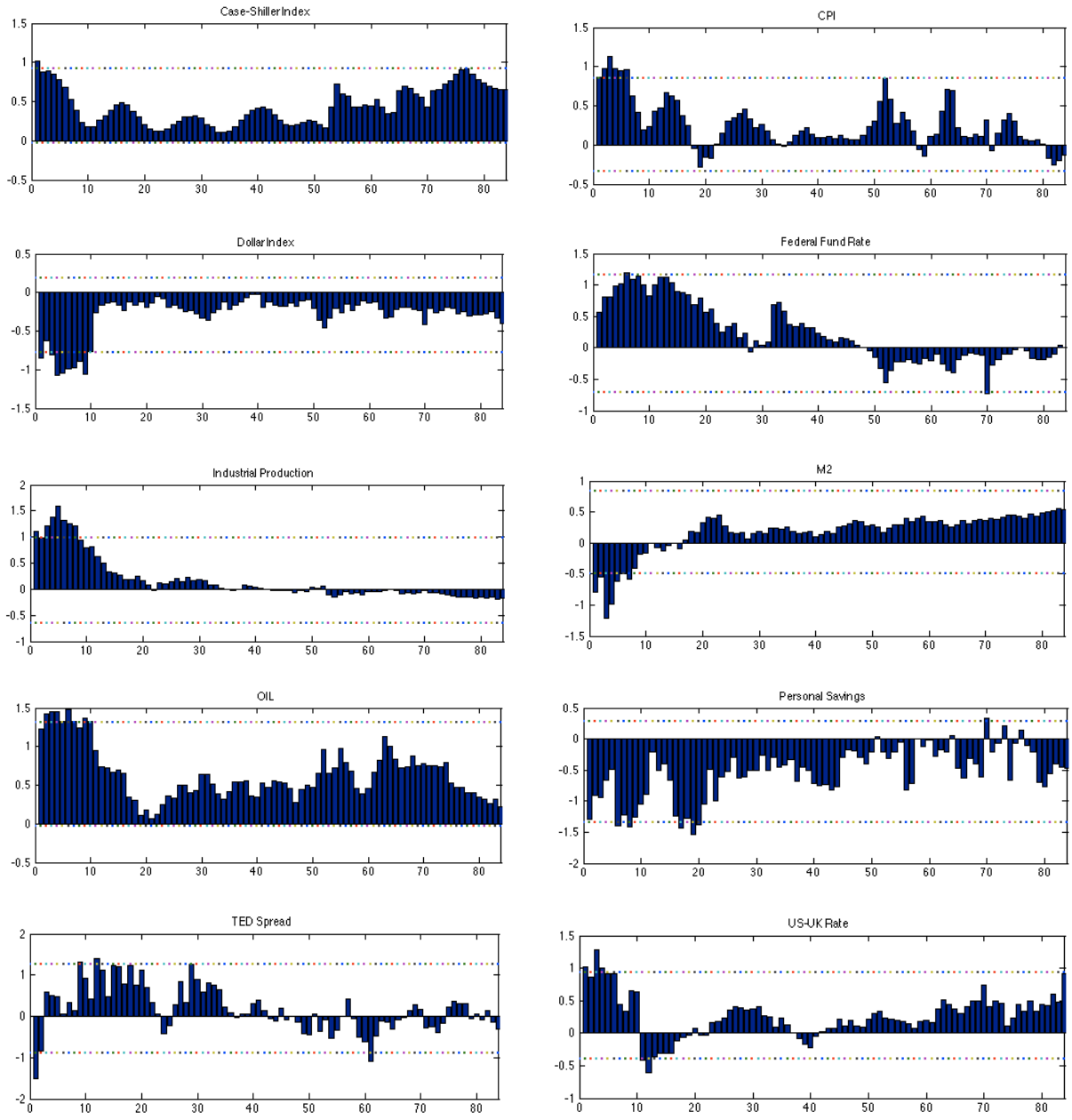

Figure A5. Predictive regression t-statistics for gold-platinum spread

This figure presents predictive regression t-statistics for gold-platinum spread (H=84 months or 7 years horizon) with controls (GDP, VIX and S&P 500) at 5% significance. Macroeconomic factors listed are Case-Shiller Index, CPI, Dollar Index, Federal Fund Rate, Industrial Production, M2 Money Supply, Oil, Personal Savings, TED Spread, US-UK Exchange Rate. Regression performed on $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of gold-platinum spread, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation is the rate of change in each listed macroeconomic factor. For the example of Oil, the t-statistics have high positive magnitude throughout its 7 yr horizon (especially in the first 10 months), with the highest mean among indicators at around 0.65.

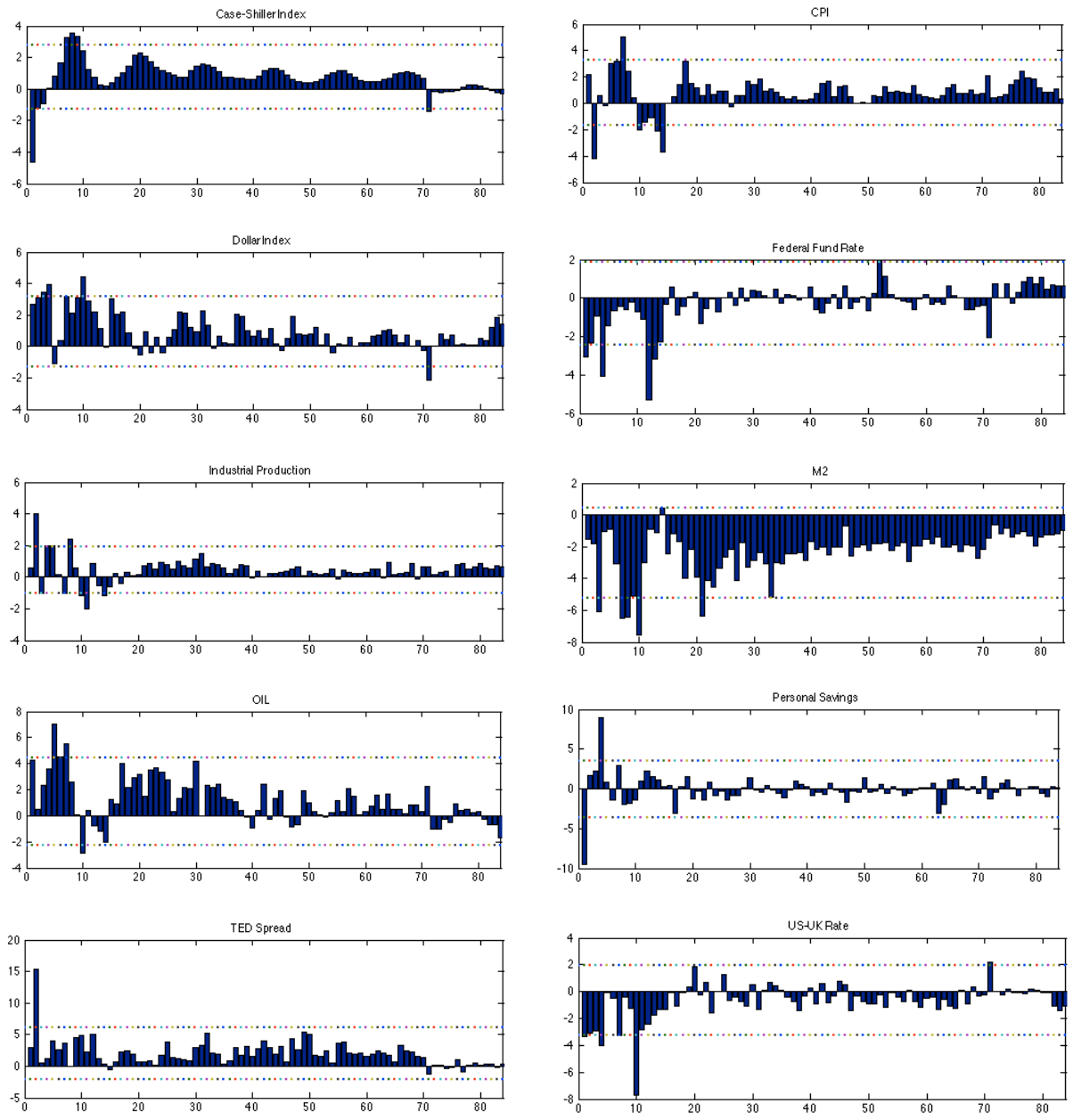

Figure A6. Predictive regression t-statistics for gold forward premium

This figure presents predictive regression t-statistics for gold forward premium (H=84 months or 7 years horizon) with controls (GDP, VIX and S&P 500) at 5% significance. Macroeconomic factors listed are Case-Shiller Index, CPI, Dollar Index, Federal Fund Rate, Industrial Production, M2 Money Supply, Oil, Personal Savings, TED Spread, US-UK Exchange Rate. Regression performed on $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of gold forward premium, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation is the rate of change in each listed macroeconomic factor. For the example of Oil, the t-statistics have mostly positive magnitude throughout its 7 yr horizon (especially in the first 10 months), with mean at around 1, the magnitude of the bars gradually become closer and closer to zero.

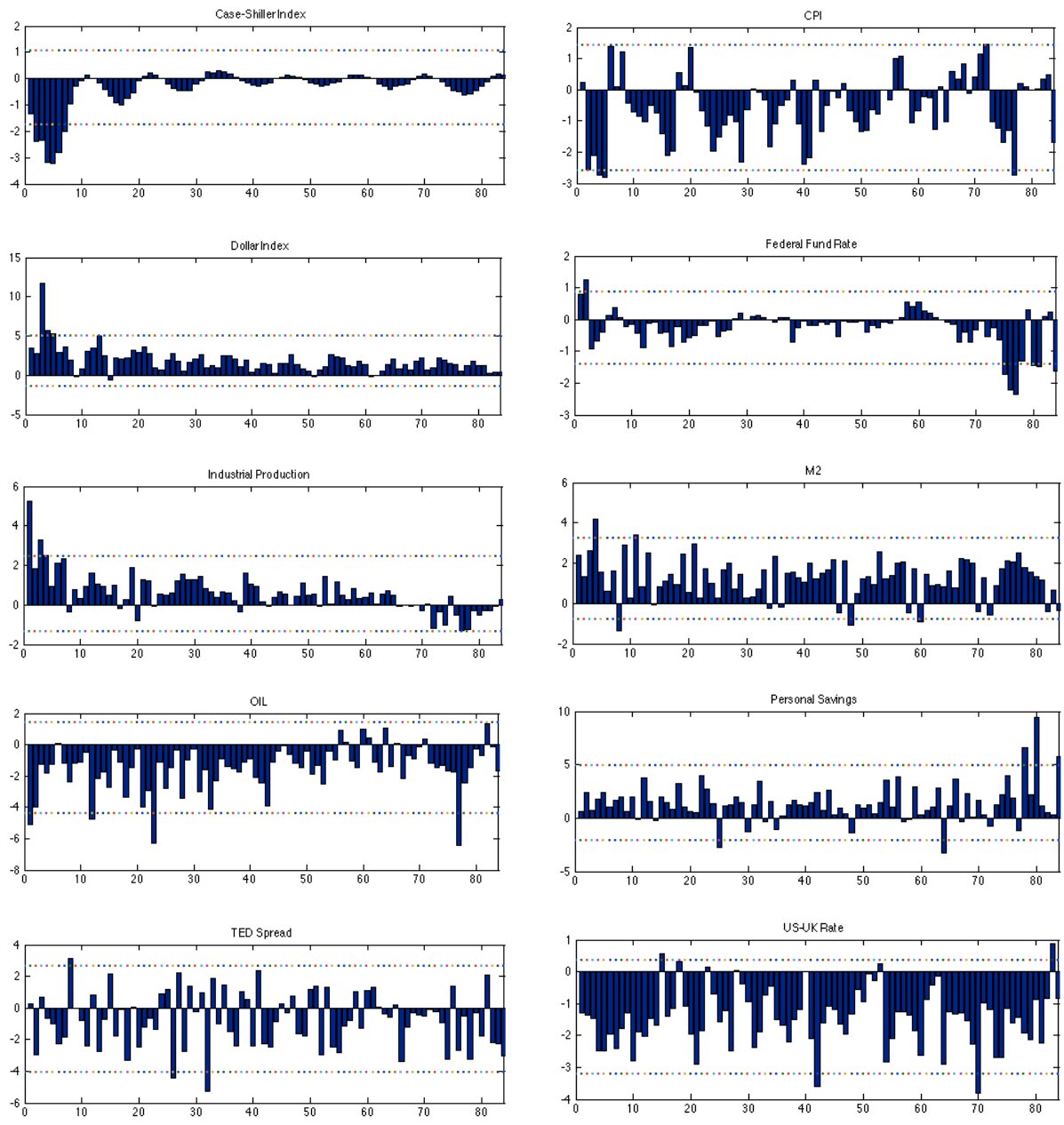

Figure A7. Predictive regression t-statistics for platinum forward premium

This figure presents predictive regression t-statistics for platinum forward premium (H=84 months or 7 years) with controls (GDP, VIX and S&P 500) at 5% significance. Macroeconomic factors listed are Case-Shiller Index, CPI, Dollar Index, Federal Fund Rate, Industrial Production, M2 Money Supply, Oil, Personal Savings, TED Spread, US-UK Exchange Rate. Regression performed on $\Sigma y_{t+h} = \pi_0 + \pi_1 X_t + \pi_2 C_{1t} + \pi_3 C_{2t} + \pi_4 C_{3t} + \varepsilon_{t+H}$ where X_t is the return of platinum forward premium, C_{1t} stands for first control GDP, C_{2t} stands for second control VIX, C_{3t} stands for third control S&P 500, and the left hand of the equation is the rate of change in each listed macroeconomic factor. For the example of Oil, the t-statistics have mostly negative magnitude throughout its 7 yr horizon, with mean at around -1.