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ASSET BUBBLES: THEIR IMPORTANCE, IDENTIFICATION, AND IS THERE A BUBBLE IN GOLD?

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ABSTRACT

Without a doubt, bubbles in asset prices, whether real or nominal, have reemerged as an important point of discussion amongst policy makers and the public alike. This is not surprising given that 1) there is widespread agreement that a bubble had formed in the housing market and 2) the bursting of the bubble has resulted in the most severe downturn in the US and world economies since the Great Depression. The Federal Reserve has admittedly taken the stance that asset bubbles are too difficult to identify and too costly to 'prick' even if you could identify them. The most recent bursting of the housing bubble and its damage to the global economy has the Federal Reserve re-evaluating its position on asset price stability, and perhaps thinking hard about being more proactive in managing asset bubbles. This being the case, the first step is to be able to identify bubbles as they are forming, and then deliberate as to the appropriate policy. This paper builds on the work by Dokko et al. (2009), where they use conditional forecasts from a vector autoregression to identify the bubble in the housing market. Employing the same methodology, we identify a (current) bubble in gold prices and given the reemergence in the interest in bubble management, this methodology can be used by policymakers to identify bubbles in other assets.

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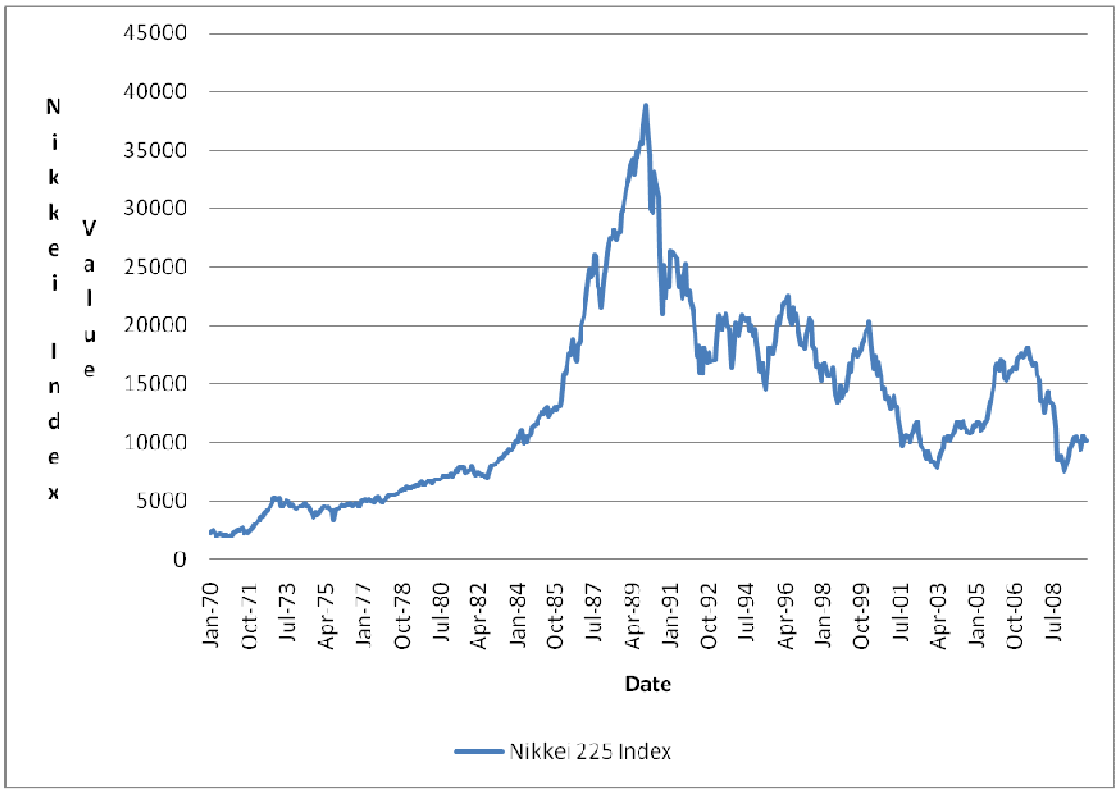
Introduction

Asset bubbles in the history of finance have been a difficult issue for world economies and central banks to deal with. Historically, many, but not all, asset bubbles devastate the economies that they affect once they have burst, and some of the recent bubble bursts have had long-lasting effects on their respective economies. Okina, Shirakawa and Shiratsuka's paper (2001), "The Asset Price Bubble and Monetary Policy: Japan's Experience in the Late 1980s and the Lessons," define a bubble economy as one with "rapid rise in asset prices, the overheating of economic activity, and a sizable increase in money supply and credit." The bursting of the Japanese asset price bubbles (real estate and stocks) that occurred in the late 1980s to the early 1990s (see Figure **1**) left Japan's economy in shambles for more than a decade. Japan is still recovering from this episode and the effects have been so dramatic that people commonly refer to the aftermath as "The Lost Decade." The U.S. recently experienced a few bubbles of its own, such as the U.S. dot-com bubble that inflated during the mid to late 90s, and most recently, the U.S. housing bubble, from which the U.S. is still recovering. While it is exhibiting signs of recovery, the U.S. economy has a long way to go before it recovers the 8 million jobs that have been lost since December 2009. Most economists believe that is will take years for the unemployment rate to return to levels consistent with full employment.

Figure **1**: Nikkei 225 Monthly Historical Data



Source: Nikkei, Bank of Japan

Bubbles are an important economic phenomenon to identify because of the damages they have done to economies in their wake. According to Shiratsuka (2003), the formation of the Japanese asset price bubbles was characterized by robust economic growth and stable inflation. The intensified bullish expectations were clearly supported by the aggressive behavior of financial institutions, the process of financial deregulation, and inadequate risk management on the part of financial institutions. Additional factors include the introduction of the capital accord, protracted monetary easing, taxation and regulations biased toward accelerating the rise in land prices, and finally, overconfidence and euphoria. Initially, the decline in asset prices was seen as a burst in the bubble and

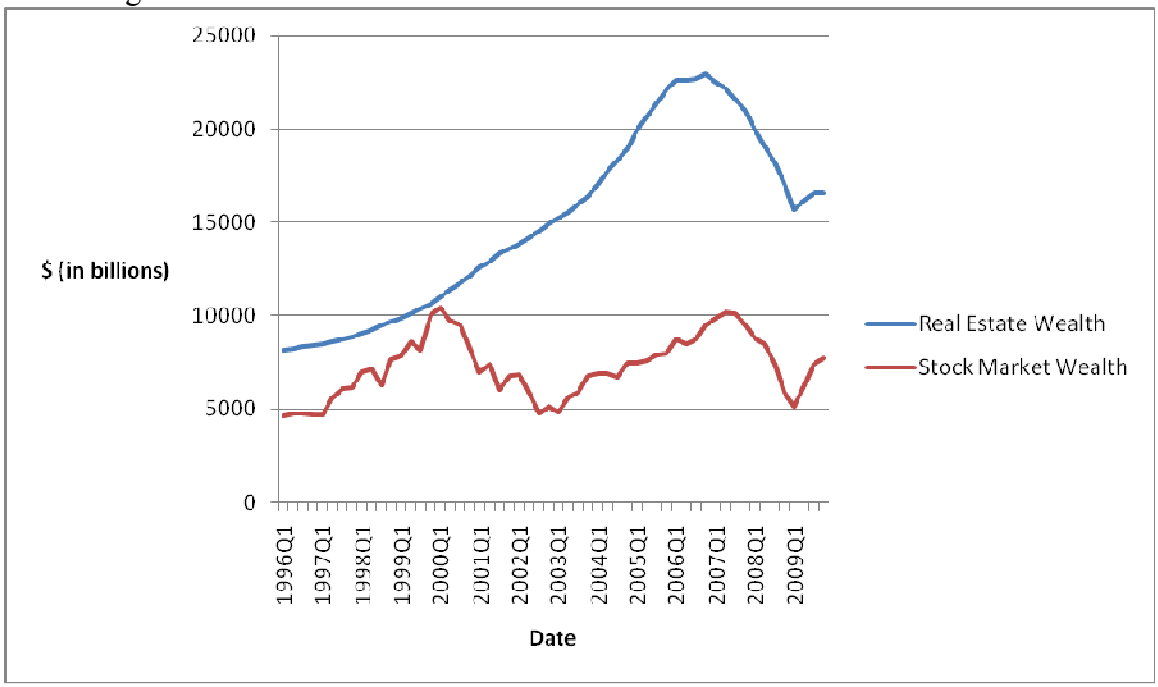
amplification of a business cycle. While the importance of cyclical aspects of the drop in asset prices cannot be denied, the subsequent declines in asset prices after the mid-1990s reflect a downward shift in the trend growth rate beyond a normal boom-and-bust cycle. The Nikkei stock index closed at a high of 38,957 on December 29, 1989 before crashing down to around 15,910 in July of 1992, losing 59% of its value in two and a half years. The Nikkei has since moved sideways and recently reached an even lower point due to the most recent global financial crisis. As Japan's economy underwent the adjustment during the Lost Decade, it experienced a relatively high unemployment rate, a weak nominal GDP growth, and worst of all, a sustained decline in the general price level. The deflationary episodes that Japan experienced was particularly damaging to its economy during the Lost Decade due to the threat of a deflationary spiral, where the decrease in price can lead to lower production, which then leads to lower wages and lower demand, which leads to further decrease in prices, etc., a so-called "vicious cycle." In an already weak economy, deflation makes growth very difficult. There are numerous policies that central banks can follow to combat deflation, the most common of which is expansionary policy to increase the money stock. Much has been written about the reaction of the Bank of Japan (BOJ) to the bursting of the bubbles, and most agree that the BOJ was not expansionary enough as they failed to prevent the deflation that ensued.

The United States has, by most accounts, experienced two severe bubbles of its own in the last fifteen years. The first bubble, the dot-com bubble, was characterized by start-up of many new Internet-based companies that were referred to as the "*dot-coms."* In hindsight, the dot-com bubble contained many of the elements that precede an asset price bubble, such as rapidly increasing equity prices, over-exuberance in market

confidence, and widely available venture capital allowed the stock prices to rise significantly above their fundamentals.[1] The NASDAQ peaked at 5048.64 on March 10th, 2000, and collapsed subsequently after that. In a period between March 2000 and Oct 2002, the bursting of the dot-com bubble wiped out $5 trillion in market value in technology stocks. Unlike the Japanese Asset Price Bubble, where Japan experienced a simultaneous decline in both housing/properties and stock market, the U.S. economy was very resilient as the subsequent recession was relatively mild by most standards. While the stock market wealth dropped significantly during this period, real estate wealth was unscathed and continued to steadily appreciate in value despite the recession (see Figure **2**). The official recession lasted only 8 months, from March 2001 to November 2001 (NBER.org, 2010).

[1] Greenspan's famous remark in the speech titled "The Challenge of Central Banking in a Democratic Society" in 1996 coined the term "irrational exuberance," which was a warning that the stock market might've been overvalued.

Figure **2:** U.S. Real Estate and Stock Market Wealth



Source: Data Download Program: Board of Governors

In contrast to the bursting of the dot-com bubble, the most recent U.S. financial crisis, the bursting of U.S. housing bubble, has devastated the U.S. economy. Due to the fact that many of the loans and securitized assets in the United States are tied to home values, a burst in the housing bubble caused many of these assets to fall in value, affecting many investors and investment banks that have exposures to these financial assets. Hank Paulson, then the U.S. Secretary of the Treasury, declared that the bursting housing bubble "the most significant risk to our economy." Indeed, the damage to the economy was severe; the housing crisis is the most severe since the Great Depression (PRLEAP.com, 2007) and it directly led to many unprecedented bankruptcies such as Bear Stearns and Lehman Brothers, two of the most prominent investment banks, in 2008. The financial crisis led to many unprecedented actions by the U.S. Treasury

Department and the Federal Reserve, as Paulson unveiled the $700 billion Troubled Asset Relief Program, or TARP, in October 2007, permitting the U.S. government to purchase assets and equity from financial institutions to stabilize the U.S. financial sector. Ben Bernanke and the Federal Reserve devised many strategies such as quantitative easing, creation of auction facilities, setting the federal funds rate at the zero bound, and purchases of $1.25 trillion in mortgaged-backed securities, among others. All of these non-traditional policies were designed to prevent, in a big way, another Great Depression.

Due to the damaging nature of bubbles to financial systems, some have argued the Federal Reserve (and other central banks) should broaden its price stability objective. Currently, the Federal Reserve has two primary objectives, referred to as the dual mandate: maximizing employment and ensuring price stability (Mishkin, 2007). The focus of price stability specifically is:

> With respect to the second objective--that of price stability--there is now a broad consensus among policymakers, academic economists, and the general public in support of the principle that maintaining a low and stable inflation rate provides lasting benefits to the economy. In particular, low and predictable inflation promotes social welfare by simplifying the savings and retirement planning of individual households and by facilitating firms' production and investment decisions. Furthermore, an environment of overall price stability contributes to economic efficiency by reducing the variability of relative prices and by minimizing the distortions that arise because the tax system is not completely indexed to inflation. (Mishkin, 2007)

What is missing in the second objective is asset price stability, which can potentially avert asset bubbles. Historically, Bernanke has been skeptical about aggressive asset price management through monetary policy, as he revealed in a speech (Bernanke, 2002):

> Aggressive bubble-poppers would like to see the Fed raise interest rates vigorously and proactively to eliminate potential bubbles in asset prices. To be frank, this recommendation concerns me greatly.

Most recently, the Federal Reserve has been re-evaluating its position on fighting asset bubbles. Bernanke, in light of the recent burst of housing-and-credit bubble, now sees financial booms as "perhaps the most difficult problem for monetary policy this decade" (Hilsenrath, 2009). The Fed's traditional strategy has been to 'mop up' after a bubble bursts with expansionary policy to reduce the damage to the economy and restart growth, which is the approach Bernanke has endorsed and Chairman Greenspan, Bernanke's predecessor, also embraced. This is no surprise since the recession following the bursting of the dot-com bubble was so mild.

Given the widespread devastation to the economy from the bursting of the housing bubble, the identification of a bubble in progress may be invaluable to the Federal Reserve. One of the assets that have been experiencing tremendous growth recently and may be in a midst of a bubble is gold.

Gold as an Asset

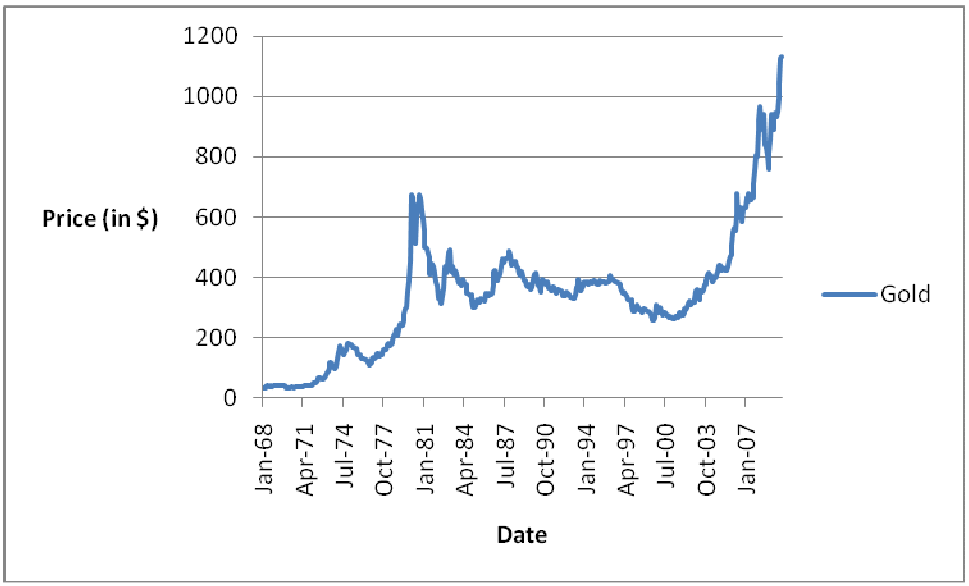
Gold has historically been an asset class that is associated with safety or hedges against different financial conditions, such as inflation or financial crisis. However, recently, since-mid 2005, gold has experienced an unprecedented bull market by doubling its value from $424.48/oz to $939.77/oz in a short time. At the end of 2009, gold was trading at its recording high, despite other commodities trading far below their record highs. This deserves some attention as to whether or not gold price is overvalued.

Looking back at history of gold prices in the past four decades (see Figure **3**), it is not the first time that gold price experienced such a spike in prices. The Bretton Woods System, instituted since the end of World War II to ensure stability in foreign exchange,

provided a system of fixed exchange rates that would link world currencies to the U.S. dollar (Cohen, 2002). The dollar would be further convertible to gold at $35/oz. This ensures that since the dollar would be fixed to gold and the major world currencies would be pegged to the dollar within a 1% band, the world currencies would remain relatively stable as long as the dollar peg to the dollar is maintained. However, the Bretton Woods System rested on the assumption of stable U.S. economic policy. According to Cohen, the U.S. fiscal policy after 1965 became destabilizing due to social programs and Vietnam War, and soon the Bretton Woods system became incapable of dealing with the widening U.S. payment deficit. Finally, on August 15th, 1971, the convertibility of the dollar to gold and vice versa was suspended; the dollar, world currencies and gold were allowed to float freely against each other. The suspension of the convertibility created significant volatility and weakness of dollar against gold due to the U.S. fiscal deficit, flight of asset away from U.S., and inflation. Immediately after the dissolution of Bretton Wood system, the gold appreciated steadily, reaching $100/oz by end of 1973 from $42.73/oz in August 1971, the month of abolishment of Bretton Woods; by 1974 to 1978, gold seems to stabilize around $100-200/oz. Then, gold price rose dramatically in the next three years, spiking and peaking at $675.30/oz in the month of January of 1980 before declining two years following that, re-stabilizing around $400/oz in mid-1981 (see Figure **4**). The spike in gold prices during this period is arguably due to the significant inflation by the oil shock of the 70s and the accompanying period of stagflation prior to Paul Volcker's reign as chairman of the Federal Reserve. It created a great challenge for Chairman Volcker, and it is well known that he was successful in crushing inflation by bringing the federal funds rate as high as 20%. Interestingly, the immediate response of

gold from the high federal funds rate was that the price of gold spiked, as investors used gold to hedge against inflation and the declining dollar. It was also influenced by oil, as the (nominal) price of oil spiked from $14.85 a barrel in January of 1979 to $39.5 a barrel by April of 1980, then much like gold subsequently declined. The explanation here is that oil is priced in dollar, and as the dollar weakens, it would require more dollars to purchase the same amount of oil. Thus, gold responded as a hedge against inflation to both the weaker dollar and the higher price of crude oil since both have inflationary effects on the economy.

Figure **3**: Price of gold (nominal) from 1968 to 2009



Source: Kitco and Yahoo! Finance

Figure **4**: Price of gold (nominal) from 1970 to1985

Source: Kitco and Yahoo! Finance

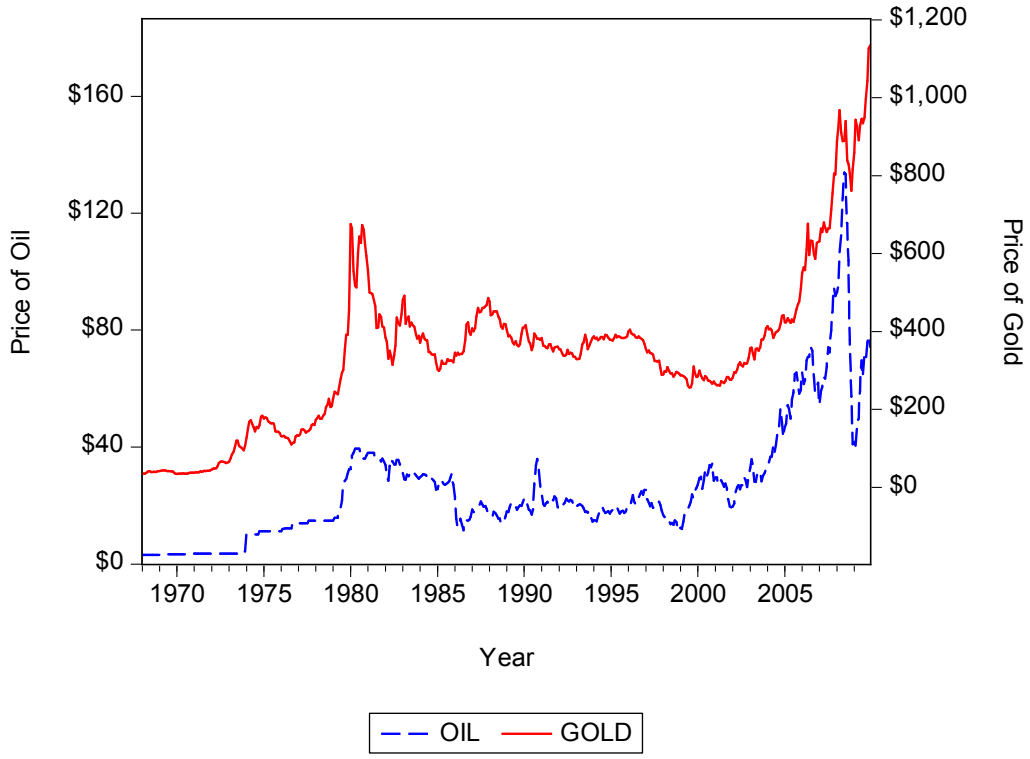
Gold remained relatively stable in the next two decades from 1980s, trading between $300-400/oz range from the post-Volcker period until beginning of 2004, when the pressure began to build for gold's price in 2004 and finally spiking upwards while breaking new highs today. Similar to the previous build up in price in 1979, oil and dollar contributed significantly to the rise of gold prices. Alongside gold's bull market was oil, whose value more doubled in that short time span as well, as it went from $58.7 a barrel to $133.93 a barrel from July 2005 to July 2008. The dollar also weakened significantly from that time frame, as measured by the Broad Trade Weighted Exchange Index, which measures dollar against a broad basket of currencies. Weaker dollar translates into higher gold prices due to the fact that weak dollar is inflationary.[2] While oil rode alongside with gold to their historic highs (the trade weighted exchange index did not reach historical low), starting from mid 2008, which is the beginning of the housing/financial crisis, oil experienced a crash from $133.93 in July 2008 to $41.74 in Jan 2009, a 68.8% drop in six months. The dollar in contrast strengthened due to the perception of the dollar as safe haven during the financial crisis, contributing to both the drop in oil and gold since a stronger dollar decreases the risk of inflation. Also, during a recession, the demand for raw materials and commodities are lower, thus leading to a further depression in prices.

[2] The correlation between inflation, measured by PCE (Personal Consumption Expenditure) Core Index, and the U.S. dollar, measured by Trade Weight Exchange Index: Broad, is -.90, suggesting a tight inverse relationship.

However, while oil experienced a very noticeable crash from $133.93 to $41.74, gold has held up relatively well in price and was breaking new high into the end of 2009. It dropped from $939.77/oz to $858.69/oz in July 2008 to Jan 2009, a mild drop of 8.63% in comparison to oil; by the end of the 2009, it reached $1134.72, a record high for gold (see Figure **5**). This is quite unusual since there is a disinflationary threat, which should translate to a much lower gold price. Does this mean that there is a bubble brewing for gold?

The timing of the growth of gold prices is curious as well. Why has the price of gold, being relatively stable for two decades post-Volcker, suddenly experience the growth and the accompanied volatility? Also, most importantly, what is different about this run than in 1979?

Figure **5**: Price of oil and gold (nominal) from 1968 to 2009



Source: Kitco and NYMEX.

Differences in Two Periods

The principal factors that have affected gold prices in 1979 and 2005 are different. In 1979, the main driver of the gold bull market was inflation, evident by the high PCE Core rate that Volcker responded to with the accompanied high real interest rate. When Volcker was able to tame inflation during his tenure as the Chairman of the Fed, gold prices declined from its then-record high to a normal level of $400/oz and eventually stabilized.

The story is different in 2000, as inflation was relatively tame compared to 1979. While it became more pronounced from 2005 on until mid-2008, it was around a mild 2.0-2.5%, which was much lower and more stable than in the Volcker period. Despite the lack of inflationary threat, gold still rose in price. Thus, inflation no longer is the strong explanatory variable in the change of gold's prices in the 2000s; instead, oil and the dollar exhibit a stronger relationship to gold. Why has gold's relationship decoupled from inflation and strengthened between dollar and oil?

The stronger argument for the gold's run-up in the 2000s is the flight to safe haven due to economic uncertainty, especially with the financial crisis. Given the current U.S. fiscal outlook and budget deficit, the relatively unknown fate of the dollar, and the global economy from the financial crisis, gold may be a hedge against fear and uncertainty. Though, even with the perceived safety of gold, the price of gold could still be irrationally high, much like the bubbles we've seen in the past. It is therefore important to have an empirical technique to identify bubbles, and Ben Bernanke, the current Chairman of the Federal Reserve, demonstrated an empirical technique with respect to the housing bubble that may be employed to identify bubbles in asset prices.

Recent Housing Bubble

On January 3rd, 2010, Chairman Bernanke presented at the Annual Meeting of the American Economic Association a paper titled "Monetary Policy and the Housing Bubble." His goal was to show that Federal Reserve's policies were not the primary contributor to the run-up in housing prices and showed that Federal Reserve's policies were consistent with the existing structural relationships in the macroeconomy. The Federal Reserve has been under scrutiny for being one of the main contributors to the financial crisis by enacting policies that fueled the housing bubble and having a monetary policy was too loose. Robert Gordon (2009, p. 6) writes:

> It is widely acknowledged that the Fed maintained short-term interest rates too low for too long in 2003-2004, in the sense that any set of parameters on a Taylor Rule-type function responding to inflation and the output gap predicts substantially higher short-term interest rates during this period than actually occurred…thus indirectly the Fed's interest rate policies contributed to the housing bubble.

Monetary Policy and Housing Prices

Ben Bernanke argued that monetary policy only contributed a small portion to the increase in housing prices in the 2000s via a statistical model, employed by Dokko et al. (2009). The model estimates the structural relationships among seven key macroeconomic indicators (Dokko et al., 2009). The statistical technique employed in the model is vector autoregression (VAR) analysis and was used to construct conditional forecasts of housing prices and federal funds rate.

Formally, Dokko et al. used the estimated equation from the VAR system that would allow conditional forecasts of the variable in question. The approach is illustrated with the following equation:[3]

$$HP_t = \alpha + \sum_{i=1}^{n} \beta_n HP_{t-n} + \sum_{i=1}^{n} \zeta_n iff_{t-n} + \sum_{i=1}^{n} \gamma_n PCE_{t-n}$$

Where HP_t = housing prices, α = constant, iff_{t-n} = nominal federal funds rate, and PCE_{t-n} = core rate of inflation as measured by the personal consumption expenditure index, n represents number of lags in the model, and β, ζ, and γ are parameters to be estimated.

The conditional forecasts are produced by using the actual values of all the right-hand-side variables except housing prices, i.e. the forecast variable. This technique allows us to predict future path of the housing prices given future actual data of all the other right-hand-side variables.

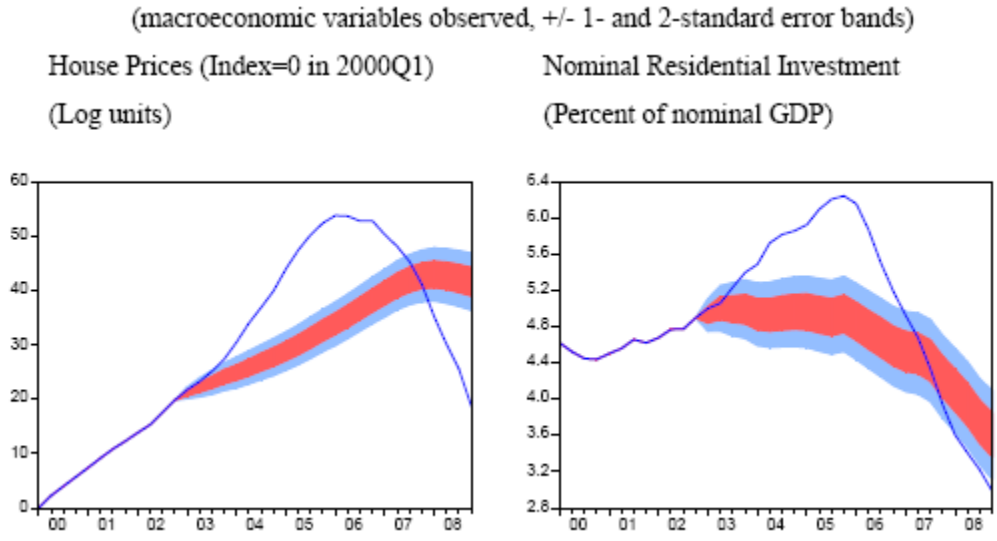
Dokko et al. estimated a 7-variable VAR using the following seven macroeconomic variables: real GDP, real personal consumption expenditures (in log levels), the (nominal) share of residential investment in GDP, real house prices (as measured by LoanPerformance Index), core PCE inflation, unemployment rate, and the nominal federal funds rate. These variables represent a core set of macro and housing related variables. Their VAR includes two lags of each variable, which amounts to a half-year lag given the quarterly data. The idea is to compare the realized path of

[3] This equation is a simplified version of Dokko et al.'s model. Dokko et al.'s model also includes other macroeconomic variables that are related to housing prices.

housing prices to the conditionally forecasted path of housing prices. Their results indicate that the actual path deviated significantly from the forecasted path. In particular, Dokko et al. constructed 95% confidence bands (conditional forecast +/- 2 standard errors) of the conditional forecast and found that the actual value of HP was well outside the upper band of the 95% confidence interval.

Figure **6** is from Bernanke's presentation and Dokko et al.'s paper and clearly shows that the actual path of housing prices (left diagram) and nominal residential investment as part of GDP (right diagram) is well above the conditional forecast and outside the upper 95% confidence bands for both series.

Figure **6**: Conditional Forecasts for Residential Investment Share and House Prices



Source: Dokko et al., 2009.

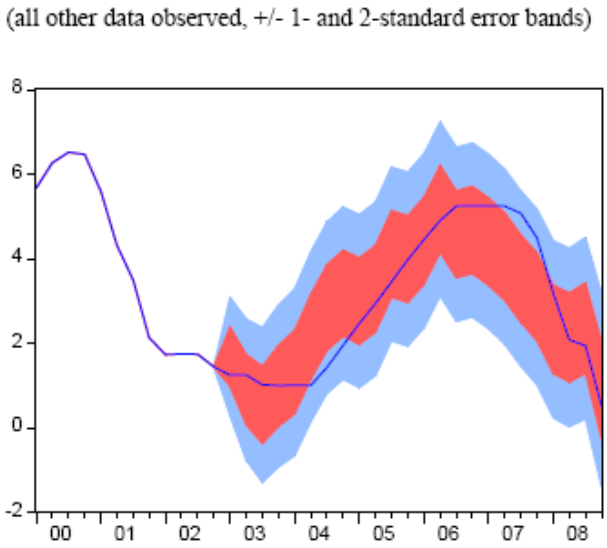
(http://www.federalreserve.gov/pubs/feds/2009/200949/200949pap.pdf)

Dokko et al. write (2009):

> …the housing developments over 2003 through 2008 were far outside the 2-standard deviation confidence bands based on observed macro variables, *including the federal funds rate* and the VAR's estimated parameters. With that said, it is important to note that the confidence interval for the share of residential investment in GDP includes 5 percent for much of the period up to 2006 – which would have been the highest realized share in over 20 years; in this respect, accommodative monetary policy was certainly supportive of macroeconomic activity and a source of strength in the housing market. Nonetheless, the simulation suggests that macroeconomic conditions did not drive the housing market developments in this period – at least not in a historically typical manner, as captured by the VAR.

Dokko et al. conducted the same exercise and created conditional forecasts for the federal funds rate for the same period. Figure **7** below shows the realized path and the conditional forecasts (with 95% confidence bands) for the federal funds rate.

Figure **7:** Conditional Forecast for the Federal Funds Rate (percent)



Source: Dokko et al., 2009.

(http://www.federalreserve.gov/pubs/feds/2009/200949/200949pap.pdf)

The figure shows, unlike housing prices and residential investment as part of GDP, that the federal funds rate did behave within the fundamentals as the realized path of the federal funds rate is within the 2-standard deviation conditional forecast band throughout the forecasting period. The results suggest that the Federal Reserve's monetary policy was well-aligned with the existing structure of in the macroeconomy. Dokko et al. (2009) write:

> …the realized path of the federal funds rate is within the…conditional forecast band, suggesting that policy was not unusually loose in this period. From this perspective, it is very clear that the path of the federal funds rate over the past decade has been very consistent with the policy strategy over the preceding twenty five years.

And from Bernanke (2010):

> The shaded area in the figure is constructed using the results of the statistical model; it shows the range of possible outcomes that would be considered "normal" for the federal funds rate, assuming that the other six variables included in the model took their actual values during the years 2003 through 2008. Values of the federal funds rate that fall in the shaded area are relatively "close to" (technically, within 2 standard deviations of) the corresponding forecast values. In line with our earlier discussion, the left panel of the figure suggests that, although monetary policy during the period following the 2001 recession was accommodative, it was not inconsistent with the historical experience, given the macroeconomic environment of the time.

In what follows, we employ the same technique to compare the actual price of gold to the conditional forecast of gold. Before doing so, we thought it would be a useful exercise to replicate Dokko et al.'s results for two reasons. First, we want to validate their results, and second, we wanted to make sure we were conducting the methodology correctly so we would be confident with our results regarding the conditional forecasts of gold. Below are the procedures and results of our replication.

Replicating Dokko et al. Results

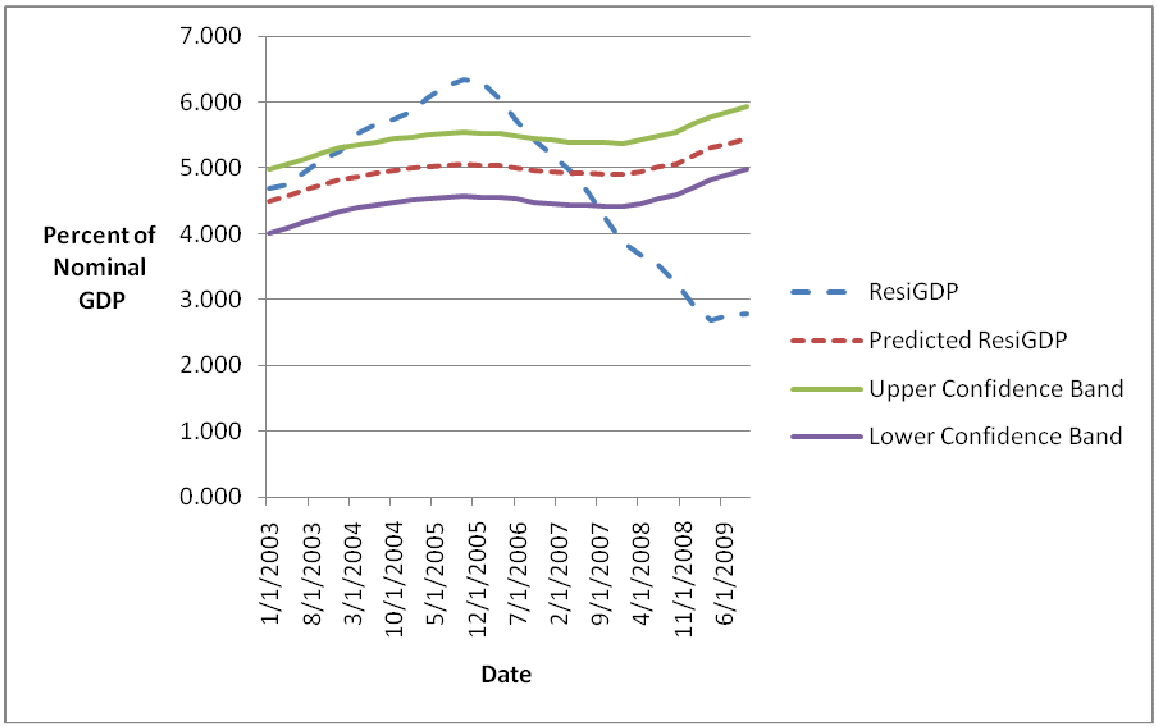
For the most part, we were able to collect the actual data that Dokko et al used.[4] Our VAR contained the following estimated equation for the conditional forecast of nominal residential investment as part of GDP:

$$resiGDP_t = 0.198 - 0.002GDP_{t-1} - 0.001GDP_{t-2} + 1.430resiGDP_{t-1} - 0.453resiGDP_{t-2}$$
$$-0.037iff_{t-1} + 0.022iff_{t-2} - 0.058PCE_{t-1} + 0.070PCE_{t-2} - 0.023Ump_{t-1} + 0.015Ump_{t-2}$$

We used the same sample period as Dokko et al (1977:Q1 to 2002:Q4) to estimate the parameters and then used those parameters to derive our conditional forecasts. The results are provided in Figure **8**:

[4] The predicted ResiGDP from 2008 is slightly different than Dokko et al.'s conditional forecast for ResiGDP due of lack of Housing Prices in our model. The LoanPerformance Index that Dokko et al. used in their conditional forecast is a private index by a division of First American CoreLogic that is not publicly available.

Figure **8**: Conditional Forecast of Nominal Residential Investment as part of GDP



Source: Author's calculations

The results are very similar to those provided in the right hand panel Figure 6 in that the actual share of nominal residential investment as a share of GDP rose above the 95% confidence interval of the conditional forecasts in the 2003–2004 period. As a result, we are confident in applying the same methodology to investigate gold.

Using the VAR Technique for Gold

We are seeking to answer whether or not the recent rise in gold prices is atypical of the historical relationships to other variables. The variables we used to construct the VAR are oil, real interest rate, value of the U.S. dollar, slope of the yield curve, and platinum.[5]

For our gold VAR, we elected to begin the sample period after the volatile Volcker period in the late 1970s and early 1980s because during that period, asset prices and many macroeconomic variables deviated significantly from their historical averages in response to the stagflation episodes. Additionally, the economic climate in the volatile Volcker period is very different from the post Volcker period, where inflation is much lower, prices are more stable, and the Federal Reserve returned to its federal funds rate regime. We estimated VARs for two sample periods: from 01/1985 to 12/1995 and from 01/1985 to 12/2005. The idea is to use the estimated parameters form two different sample periods for robustness reasons. As in Dokko and our replicated results, we examine the forecasted path of dependent variable (gold) with its 95% confidence interval vs. the realized path of the dependent variable (gold). We used six lags in our model in order to correspond with Dokko et al.'s lag length.

The estimated equations for both sample periods are quite long due to the six lags, and are included in appendix B. Formally, the estimated forecasting equation is:

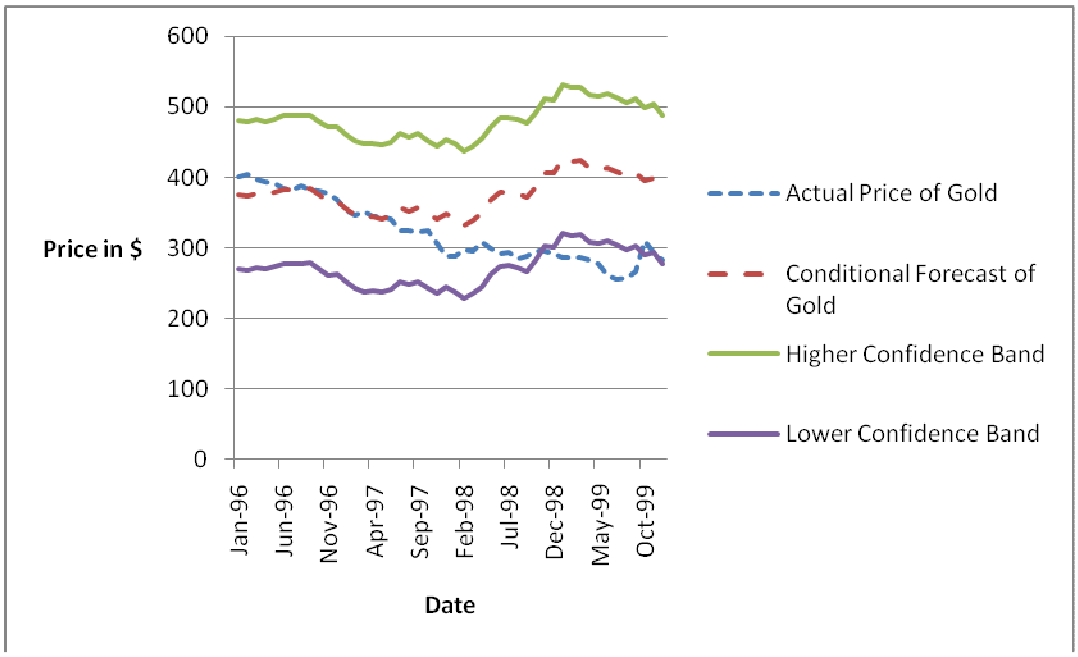
[5] Justifications of the variables in the VAR model can be found in appendix A.

$$G = \alpha_0 + \sum_{i=1}^{6} \beta_i (G_{t-i}) + \sum_{i=1}^{6} \zeta_i (Oil_{t-i}) + \sum_{i=1}^{6} \chi_i (r_{t-i}) + \sum_{i=1}^{6} \eta_i (EX_{t-i})$$
$$+ \sum_{i=1}^{6} \varphi_i (YC_{t-i}) + \sum_{i=1}^{6} \theta_i (plat_{t-i})$$

where G = price of gold, Oil = price of Oil, r = real interest rate,[6] EX = dollar measured by Broad Trade Weighted Exchange Index, YC = slope of the Yield Curve, and plat = price of Platinum. $\beta_i, \zeta_i, \chi_i, \eta_i, \varphi_i$ and θ_i are parameters to be estimated.

The results from 1985-1995 sample period with four years of conditional forecasts are shown in Figure **9**:

Figure **9**: 4-year Conditional Forecasts for Gold (Sample Period 1985 to 1995)



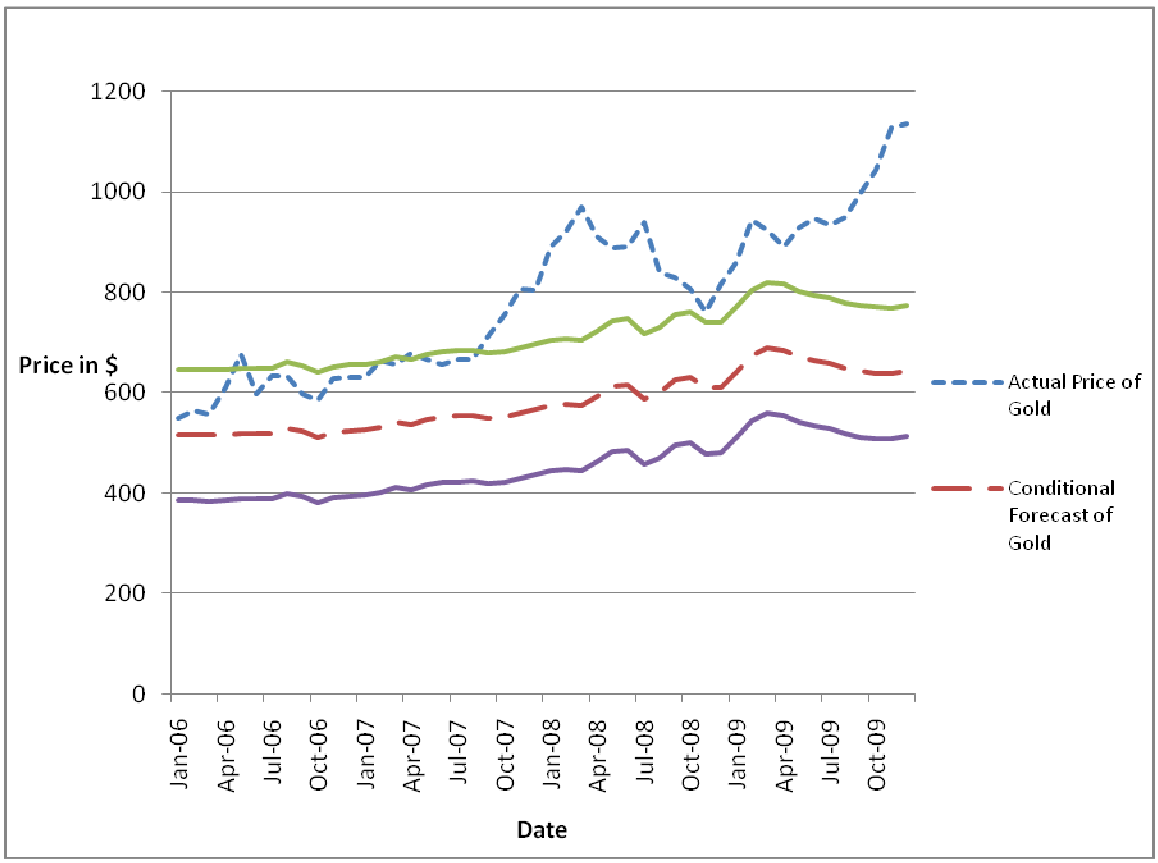
Source: Author's calculations

[6] Derived from the fisher equation: $r = i - \pi$, where r = real interest rate, i = federal funds rate, *and* π = inflation rate measured by PCE Core Index.

Our results indicate that the actual prices of gold were generally within the 95% confidence interval of the conditional forecast of gold. Only at the end of the forecast period did the actual price of gold fall outside the 95% band, and at this time, it fell below the lower band of the forecast. This suggests that prices of gold in this period were reasonable and did not deviate significantly from its fundamentals.

We updated our estimation sample period from 1985 to 2005 and ran the model to conditionally forecast the price of gold up to 12/2009. The results are provided in Figure **10**:

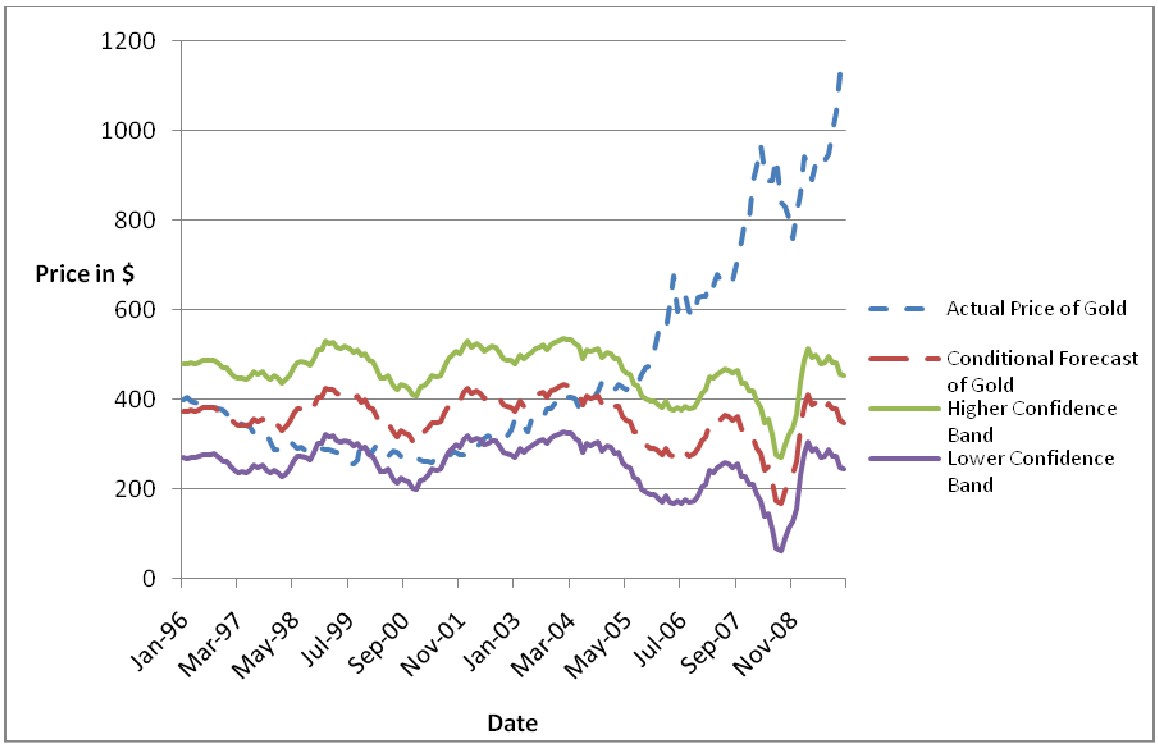
Figure **10**: 4-year Conditional Forecasts for Gold (Sample Period 1985 to 2005)



Source: Author's calculations.

The behavior of gold during this period is in stark contrast to the earlier period. The realized path of gold stayed within the bands from the beginning of the forecast period until 2007, then it remained outside the bands from that point on. This is similar to the results by Dokko et al. regarding the behavior of actual housing prices relative to its conditional forecast as well as for and nominal residential investment as a percent of GDP and its conditional forecast. Our conclusion, using Dokko's methodology, is that there is a bubble in gold much like Dokko's conclusion that there was a bubble in housing prices. As a robustness check as to whether there is a bubble in gold, we used the estimated parameters from the 1985-1995 sample period to conditionally forecast gold through 2009. The results are provided in Figure **11**.

Figure **11**: Conditional Forecasts for Gold from 1996 to 2009 (Sample Period 1985 to 1995)



Source: Author's calculations.

Using the 1985 to 1995 sample, the price of gold began to break the upper confidence band in 2005 and remained well outside throughout the end of the sample period. While both models presented different time periods for the start of the bubble, it is unequivocal that there is a bubble forming as both forecasting models suggests. The former model using the sample period 1985 to 2005 indicates September 2007 as the time

when the bubble in gold began. This is noteworthy since this is the time that coincides with the beginning of the credit crisis.[7]

[7] It can be argued that the estimation period from 1985 – 2005 would provide more accurate forecasts since it includes more recent date and perhaps more accurate parameters than the earlier and shorter 1985 – 1995 estimation period.

Conclusion

In the past twenty years, the formation of asset bubbles and the associated bursting of these bubbles have wreaked havoc not only on the economy in which the bubble had formed, but also, on economies worldwide. Given the globalization of financial markets, it is more likely that one country's economic contraction due to a bubble in asset prices would spread to other economies. The recent experience regarding the bursting of the real estate bubble in the US is a case in point. In addition, the bursting of bubbles is likely to have detrimental effects in the long term, as the case of Japan and the lost decade suggests. Simply put, the bursting of bubbles has been extremely costly to economic welfare and thus, we need to re-examine the way we think about and deal with bubbles.

The Federal Reserve's position on dealing with bubbles has been to mop up after the bubble bursts since they feel that it is very difficult to identify bubbles and even if we could, pricking the bubble would be extremely costly to economic welfare. Given the recent experience in the US, the Fed is rethinking their approach in dealing with potential asset bubbles. While the strategy of mopping up after the bubble burst may have worked in the past, the devastation that the housing bubble has wrought has demonstrated that this approach may not be the best, and the Federal Reserve may consider broadening their price stability objective to include various asset prices, including perhaps gold.

In order to manage asset price bubbles, the empirical identification of bubbles is paramount. While in hindsight, bubbles are easy to spot, especially after they have burst, the difficulty arises in identifying a bubble that is in the formation phase. Dokko et al.'s methodology through VAR analysis provides an attractive mechanism to spot bubbles.

Dokko et al. successfully identified the bubble in the housing market earlier this decade. Our research indicates that there is currently a bubble in gold. According to two different forecasting models, gold's bubble has been forming since September 2007, coinciding with the beginning of the U.S. financial crisis.

What makes this methodology attractive is that it is simple and flexible and thus, can be employed in a variety of contexts. Thus, if the Federal Reserve chooses to include asset price stability in its price stability objective, this methodology presents a practical tool to the first step of bubble management, and that is the identification of bubbles.

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Appendix A

Factors Affecting Gold Prices

To forecast gold, we chose five variables that have a significant relationship with gold. They are: prices of oil, real interest rate, dollar measured by Trade Weighted Exchange Index: Broad, slope of the yield curve (derived from taking the difference in yield between the 10-year Treasury bond and 3-month Treasury bill), and platinum. It is important to note that gold is a unit root variable, or a nonstationary time series. This means that shocks to a nonstationary time series are necessarily permanent. The mean and/or the variance of a nonstationary time series is therefore time dependent, meaning:

1.) There is no long-run mean to which the series returns.

2.) The variance is time dependent and goes to infinity as time goes to infinity.

This is particularly important in our examination of gold because this means that there is not necessarily a long-run mean to which gold returns due to shocks from other variables in the system; the change of level in different time in the series is therefore permanent.

Oil

Oil is one of the most actively traded commodities and, like gold, is sought after as a good store of value against inflation or weakening dollar, as the data shows from 2005 to 2008 and also during the period immediate after the dissolution of the Bretton Woods System. Oil is known to be volatile to supply disruptions, demand shocks, and the strength/weakness of the dollar, but historically it has tracked gold quite well. Macroeconomically, in the past decade, oil has experienced a boom due to global demand

from emerging markets, particularly China and India, thus during the global economic boom from the early part of 2000s, oil experienced a run up similarly to gold (see Figure **4**).

Empirically, oil is an important variable in our model because it is cointegrated with gold. Both gold and oil are unit root variables or nonstationary time series. Therefore, cointegration testing is possible to see if there exists a linear combination of integrated variables that is stationary and thus cointegrated. This means that any equilibrium relationship among a set of nonstationary variables implies that their stochastic trends must be linked, since the equilibrium relationship means the variables cannot move independently of each other, necessitating that the variables be cointegrated. Since the trends of cointegrated variables are linked, the dynamic paths of such variables must have some relation to the current deviation from the equilibrium relationship. With the cointegrated relationship, oil is a power variable in our model in forecasting gold.

Real Interest Rate

The real interest rate is derived from taking the federal funds rate and subtracting by the PCE inflation, in accordance to the fisher equation:

$r = i - \pi$, where r is the real interest rate, i is the nominal interest rate (represented by the nominal federal funds rate) and π is the inflation rate (represented by rate of PCE Core index in our model).

The real interest rate can affect the price of gold because it is a proxy for inflation. Since investors view gold as a hedge against inflation, a negative real interest rate implies an inflationary environment, and gold should thus react by having higher prices. Conversely, a higher real interest rate would be bad for gold because that would mean

that inflation would be less likely and thus gold prices would either stay flat or decline. It is important to note real interest rates effect on gold would typically have lags because monetary policy, which affects the federal funds rate and thus the real interest rate, would typically from 3 months to 2 years to affect variables (Federal Reserve Bank of San Francisco).

Looking at the data from 2008 would show that U.S. real interest rate was negative, and the gold continued its upward trend during that time. While looking back from 1995 to around 2000, when the real interest rate was around 3-4%, gold prices was stable and hovered around $250-300. More interesting is during the Volcker period when the real interest reached the peak around 1980-1981, gold prices, along with inflation, responded to the high real interest rate and subsequently came down in price.

Dollar

Trade Weighted Exchange Index: Broad is the index we chose to measure dollar's strength relative to a broad basket of world currencies. The dollar has been volatile in the decade of 2000 and had steadily declined in strength from the early 2000s. The trend reversed at the beginning of the financial crisis in August 2008, when the dollar steadily strengthened again due to the perceived safety of the dollar as a safe haven during the financial crisis. Gold price, in the meantime, steadily gained in value during the dollar's decline since a weak dollar is inflationary. Surprisingly, while the dollar strengthened as investors sought the safety of the dollar during the financial crisis, gold rose in prices significantly. This may be due to dollar's uncertainty due to the U.S. fiscal policy and debt burden, as well as the dollar's status as the reserve currency by central banks worldwide. However, dollar still remains a strong variable to forecast gold prices.

Yield Curve

The slope of the yield curve is a popular forward-looking economic indicator that can show U.S.'s economic expected economic activity and expected inflation. Traditionally, the slope of the yield curve has been a great predictor for economic activities and recessions because it usually becomes inverted (or negative) right before recessions, and becomes normal (positive) again leading up to economic recovery from the recession. The steepness of the yield curve also can suggest different economic conditions, such as inflation if the slope is quite steep or disinflation/deflation signaled by a flat/negative yield curve. Thus, the implication of the yield curve relative to the price of gold is that with a steep yield curve, it could indicate that there may be inflation on the horizon, and could be signal for gold prices to rise, and vice versa.

Platinum

Platinum, like gold, is a precious metal that has tracked gold very closely and is a close substitute with gold. Its correlation to gold is .86 comparing monthly prices from 1995 to 2009, suggesting that there is a tight relationship between the prices of the gold and platinum (author's calculations).

Appendix B

Estimated Equation for Gold

Sample Period: 1985-1995

$$G_t = 68.655 + 1.136G_{t-1} - 0.374G_{t-2} - 0.060G_{t-3} + 0.177G_{t-4} + 0.012G_{t-5}$$
$$-0.068G_{t-6} - 2.037Oil_{t-1} + 2.856Oil_{t-2} - 2.702Oil_{t-3} + 1.238Oil_{t-4} - 0.206Oil_{t-5}$$
$$-0.328Oil_{t-6} + 5.682r_{t-1} - 9.448r_{t-2} + 5.471r_{t-3} + 1.093r_{t-4} - 9.300r_{t-5} + 5.671r_{t-6}$$
$$-3.272EX_{t-1} + 3.631EX_{t-2} - 2.473EX_{t-3} + 2.252EX_{t-4} + 0.018EX_{t-5} - 0.115EX_{t-6}$$
$$+4.872YC_{t-1} - 17.416YC_{t-2} + 33.605YC_{t-3} - 27.844YC_{t-4} + 8.368YC_{t-5} - 2.364YC_{t-6}$$
$$+0.017\,plat_{t-1} - 0.037\,plat_{t-2} + 0.077\,plat_{t-3} - 0.066\,plat_{t-4} - 0.037\,plat_{t-5}$$
$$+0.104\,plat_{t-6}$$

Sample Period: 1985-2005

$$G_t = 41.789 + 1.111G_{t-1} - 0.376G_{t-2} + 0.170G_{t-3} + 0.061G_{t-4} - 0.016G_{t-5}$$
$$-0.025G_{t-6} + 0.154Oil_{t-1} - 0.295Oil_{t-2} + 0.238Oil_{t-3} - 0.138Oil_{t-4} + 0.261Oil_{t-5}$$
$$-0.191Oil_{t-6} + 4.133r_{t-1} - 6.395r_{t-2} + 5.776r_{t-3} - 6.539r_{t-4} + 0.272r_{t-5} + 0.738r_{t-6}$$
$$-1.223EX_{t-1} + 1.203EX_{t-2} - 0.537EX_{t-3} + 1.077EX_{t-4} - 0.503EX_{t-5} - 0.184EX_{t-6}$$
$$+1.630YC_{t-1} - 5.053YC_{t-2} + 3.975YC_{t-3} - 2.794YC_{t-4} + 1.792YC_{t-5} - 1.360YC_{t-6}$$
$$+0.004\,plat_{t-1} + 0.008\,plat_{t-2} + 0.026\,plat_{t-3} - 0.029\,plat_{t-4} - 0.089\,plat_{t-5}$$
$$+0.099\,plat_{t-6}$$

Source: Author's calculation

G = prices of gold, Oil = prices of Oil, r = real interest rate,[8] EX = dollar measured by Trade Weighted Exchange Index: Broad, YC = slope of the Yield Curve, and plat = prices of Platinum.

Summary statistics of both equations are found in the next page.

[8] Derived from the fisher equation: $r = i - \pi$, where r = real interest rate, i = federal funds rate, *and* π = inflation rate measured by PCE Core Index.

Summary Statistics for Conditional Forecast of Gold, 1985-1995 Sample Period

Dependent Variable: GOLD
Method: Least Squares
Date: 03/05/10 Time: 12:09
Sample: 1985M01 1995M12
Included observations: 132

R-squared	0.948570	Mean dependent var	378.8311
Adjusted R-squared	0.929081	S.D. dependent var	39.51074
S.E. of regression	10.52195	Akaike info criterion	7.776486
Sum squared resid	10517.59	Schwarz criterion	8.584544
Log likelihood	-476.2481	Hannan-Quinn criter.	8.104844
F-statistic	48.67163	Durbin-Watson stat	2.026786
Prob(F-statistic)	0.000000		

Summary Statistics for Conditional Forecast of Gold, 1985-2005 Sample Period

Dependent Variable: GOLD
Method: Least Squares
Date: 03/05/10 Time: 12:10
Sample: 1985M01 2005M12
Included observations: 252

R-squared	0.966779	Mean dependent var	358.8954
Adjusted R-squared	0.961216	S.D. dependent var	54.65061
S.E. of regression	10.76266	Akaike info criterion	7.724902
Sum squared resid	24904.48	Schwarz criterion	8.243112
Log likelihood	-936.3376	Hannan-Quinn criter.	7.933419
F-statistic	173.7999	Durbin-Watson stat	1.988937
Prob(F-statistic)	0.000000		

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