SIGFIRM Working Paper No. 3

Central Banks and Gold Puzzles

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August 2012

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Central banks and gold puzzles

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February 26, 2012

Abstract

We study the curious patterns of gold holding and trading by central banks during 1979-2010. With the exception of several discrete step adjustments, central banks keep maintaining passive stocks of gold, independently of the patterns of the real price of gold. We also observe the synchronization of gold sales by central banks, as most reduced their positions in tandem, and their tendency to report international reserves valuation excluding gold positions. Our analysis suggests that the intensity of holding gold is correlated with 'global power' – by the history of being a past empire, or by the sheer size of a country, especially by countries that are or were the suppliers of key currencies. These results are consistent with the view that central bank's gold position signals economic might, and that gold retains the stature of a 'safe haven' asset at times of global turbulence. The under-reporting of gold positions in the international reserve/GDP statistics is consistent with loss aversion, wishing to maintain a sizeable gold position, while minimizing the criticism that may occur at a time when the price of gold declines.

Keywords: International reserves, Central banks, Gold, exchange rate regimes

JEL Classification: E58, F31, F33

1 Introduction

The patterns of gold holding remain a debatable topic, especially at times when the relative price of gold has appreciated while the global economy has experienced the recessionary effects of the global 2008-9 crisis. While most of the debate deals with the private holding and trading of gold, we focus on the curious patterns of gold holding and trading by central banks. Specifically, we study two puzzles: the passive holding of sizable gold quantities by OECD central banks during most of the last fifty years, and the tendency to report international reserve valuations excluding gold positions. While this omission is reasonable for central banks with negligible positions, it's more puzzling for OECD central banks that continue holding, mostly passively, large stocks of gold. Figure 1 shows the remarkable persistence of gold positions (Billion ounces) for most OECD countries during past years. With the exception of several discrete step adjustments, central banks keep maintaining passive gold stocks, independently of the market price of gold. Another puzzle is the synchronization of gold sales by central banks, as most reduced their positions in tandem. As the central banks' adjustment of gold positions may move markets, one may expect central banks to stagger their stock adjustments, yet this has been the exception.

In an era when 'plastic money' and 'electronic money' gain importance in providing intermediation services, the case of holding, mostly passively, large piles of precious commodity remains an enigma. By revealed preferences, central banks keep viewing gold as a useful part of their portfolio. We compare the patterns of Non Gold International Reserve/GDP and Gold/GDP ratios, applying a prevailing econometric specification for explaining international reserves. Our analysis suggests that the

intensity of holding gold is correlated with 'global power.' While we focus on the OECD countries, we include also the two emerging "super countries," China and India, noting that their recent gold holdings increased in tandem with the sharp rise in their economic power. These results are consistent with the view that a central bank's gold position signals economic might. This status is not a free lunch, as for most of the sample the return on gold was lower than the return on US government bond. Yet, at times of global turbulence, gold has retained the attractiveness of offering a potential hedge (Baur and McDermott (2010)).[1]

The tendency to under report gold positions in the conventional international reserve/GDP statistics remains a managerial issue that deserves explanation. A possible take on it is that, as a rule, most central banks prefer portfolios offering a stable valuation in terms of the chosen basket of global currencies. Central banks refrain from holding stocks, thereby giving up possible gains from diversification and a higher expected yield (recall that during most of the past 50 years, stocks outperformed bonds, a situation dubbed 'the equity premium puzzle'). A possible explanation for central banks portfolios is that being a public institution, diversification into equities is risky. Central bank managers face the downside risk of being blamed for large declines in a central bank's portfolio valuation at times of weakening equity markets, while getting very limited gratitude at times of bullish equity markets. These reward patterns encourage 'loss-aversion' on behalf of central bank managers, as sizable equity positions come with the risk of a manager's job termination during bad times.[2]

[1]Looking at the patterns during 1979 to 2009, they found that gold is both a hedge and a safe haven for major European stock markets and the US but not for Australia, Canada, Japan and large emerging markets such as the BRIC countries. Gold was a strong safe haven for most developed markets during the peak of the recent financial crisis.

[2]See Aizenman and Marion (2003) for a further discussion on loss-aversion and central banks.

In these circumstances, the volatility of the price of gold possesses a challenge for international reserves managers. Not reporting the market value of gold as part of the international reserve position may be a working solution for a central bank wishing to maintain a sizeable gold position, while minimizing the criticism that may occur at times when the price of gold declines. Similar incentives apply when the central bank is concerned that capital gains associated with gold appreciation may be taxed by the fiscal authority, whereas capital losses associated with Gold depreciation would be viewed as reflecting portfolio mismanagement. In either case, the central bank is exposed.

2 Empirical methodology

In this section, we set up the empirical framework to study the first puzzle: the passive holding of sizable gold quantities by OECD central banks during most of the last fifty years. In order to identify the determinants of gold holdings relative to GDP and compare gold holdings with those of international reserve holdings, our panel regression is based on the econometric specification explaining international reserve used by Cheung and Ito (2009):[3]

Central banks' loss aversion may also explain why Sovereign Wealth Funds frequently are managed outside of central banks.

[3]See Appendix A for overview of the literature explaining International reserves patterns since 2000. Cheung and Ito (2009) investigate the determinants of international reserve holdings using the cross-section regression framework with four control types: 1) macro variables; 2) financial variables; 3) institutional variables; and, 4) dummy variables that control for individual economies' characteristics. They find that the demand for international reserves of developed economies is different from that of developing economies, and the set of (significant) explanatory variables also changes across different sample periods. Furthermore, they show that a developed economy tends to hold a lower level of international reserves than a developing economy, and there is only limited evidence that East Asian economies including China and Japan are accumulating an excessive amount of

$$\frac{IR_{i,t}}{GDP_{i,t}} = c + X_{i,t}^{'}\alpha + Y_{i,t}^{'}\beta + Z_{i,t}^{'}\gamma + D_{i,t}^{'}\delta + \mu\frac{IR_{i,t-1}}{GDP_{i,t-1}} + \epsilon_{i,t} \quad (1)$$

$$\frac{Gold_{i,t}}{GDP_{i,t}} = c + X_{i,t}^{'}\alpha + Y_{i,t}^{'}\beta + Z_{i,t}^{'}\gamma + D_{i,t}^{'}\delta + \mu\frac{Gold_{i,t-1}}{GDP_{i,t-1}} + \epsilon_{i,t} \quad (2)$$

$$\frac{TR_{i,t}}{GDP_{i,t}} = c + X_{i,t}^{'}\alpha + Y_{i,t}^{'}\beta + Z_{i,t}^{'}\gamma + D_{i,t}^{'}\delta + \mu\frac{TR_{i,t-1}}{GDP_{i,t-1}} + \epsilon_{i,t} \quad (3)$$

IR is non-gold international reserve holdings, Gold is official gold holdings and TR is total reserve. $X_{i,t}$ is a vector of macro variables, $Y_{i,t}$ is a vector of financial variables, $Z_{i,t}$ is a vector of institutional variables and $D_{i,t}$ is a vector of dummy variables. c is a constant and $\epsilon_{i,t}$ is an error term. Specifically, macro variables are GDP per capita, ratio of import of goods and services to GDP, population and volatilities of IR, Gold and TR. Financial variables include the ratio of M2 to GDP; the opportunity cost, defined as a differential between 3-month US Treasury bill yield and domestic lending rate; the ratios of net equity, FDI and debt liabilities to GDP. The Dummy variable is the 'Empire dummy.'[4] [5] [6]

international reserves.

[4]When we run the same regressions with all ratio variables in log, many samples are lost due to severe collinearities and zero values of some variables, such as net equity liabilities. Therefore, we use the partial log linear regressions as the baseline specification, similar to Cheung and Ito (2009).

[5]Due to the data availabilities, we drop institutional variables used in Cheung and Ito (2009).

[6]The 'Empire dummy' is based on economic and military strength during the past 300 years, following Kennedy (1989). After France lost its power, the United Kingdom overwhelmed other European nations, especially in terms of its economic power in the 18th century. The rising power of Germany in 19th century and the emergence of the United States as a global superpower after World War I and II added these two countries to the list. Finally, in Asia, Japan intended to become an empire in the first half of the 20th Century. We choose these 5 countries for the 'Empire dummy' list. Russia, classified as emerging country today, was the other pole of the bipolar world during the Cold War. We review the gold holdings by Russia separately in the section dealing with emerging super countries, focusing there on China, India and Russia.

3 Data

We refer to Cheung and Ito (2009) for variables used in the panel regressions. Our sample covers 22 developed countries; Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherland, Portugal, Spain, Australia, Canada, Denmark, Iceland, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom, and United States. The details on the data are in the Appendix B. While Cheung and Ito (2009) use cross sectional variations alone, we focus on the panel data for developed countries. The reasons are: 1) we want to use both time and cross sectional variations in order to identify the history dependence of gold holdings; 2) gold holdings are likely to matter mainly for developed countries; and 3) the degree of freedom in the cross section data is too small for the developed country panel. For the baseline regression, our sample is from 1979 to 2010. Due to the data availabilities, we drop from the regressions the Chinn-Ito index and exchange rate regime dummies.

4 Results of the baseline regression

Table 1 presents the results for the full sample (1979 to 2010) of 22 developed countries. Our preferred estimates apply the pooled OLS methodology.[7] [8] [9] Table 2 to Table 4 show the results for the subsamples used in Cheung and Ito (2009); 1975 to 1981 for Table 2; 1983 to 1993 for Table 3; and 1999 to 2005 for Table 4. The main finding is that in each subsample period, gold and non-gold international reserves have similar sets of determinants, yet these determinants are not stable over time. During most of the sample periods, the significant coefficients on lagged ratio of reserve holdings to GDP indicate strong history dependences of gold and non-gold international reserve holdings. Moreover, volatility measures of gold and non-gold international reserves have significant coefficients with positive signs – more volatile reserve positions are associated with higher reserves held by central banks.

[7] We also include the Between Estimates (BE) in the Table 1.

[8] To gain further insight, we run the same baseline panel regressions in order to see the difference in determinants of reserve holdings between 1960 to 1969 (during the Bretton Woods era) and 1970 to 1979 (after the Bretton Woods). Data availability consideration induced us to drop 7 countries (Finland, Germany, Ireland, Italy, Portugal, Australia and NZ) and 4 covariates (op_cost, $equity\_gdp$, fdi_gdp, and $debt\_gdp$) from the sample. The results (available upon request) show that there is no clear difference in determinants of gold and non-gold international reserve holdings during and after the Bretton Woods era.

[9] Because NZ and Norway have no gold holdings since 1993 and 2004 respectively, we take the data for NZ and Norway since 1993 and 2004, respectively, from our sample. As a robustness check, we eliminate NZ and Norway from the sample and re-estimate our baseline regressions under the full sample (1979 to 2010). Comparing the results (not shown, provided as requested) with Table 1, the qualitative results are similar. Therefore, taking NZ and Norway from our sample due to their zero gold position was not crucial to our empirical analyses, though this treatment may cause the self-selection bias.

5 Tests for the Regime Changes

As central banks adjustment of gold positions may move markets, one may expect central banks to stagger their stock adjustments, yet this has been the exception. Figure 2 shows changes of gold holdings (from the previous year in billion ounces) for the US and the rest of 21 countries included in our sample. The figure indicates that gold trading by central banks are synchronized during some specific periods of time, while gold holdings are stable for the other periods; hence, there are likely regime changes of gold holdings. To identify the timing of regime changes, from 'constant gold holdings regime' to 'variable gold holdings regime,' we run the following regressions for individual countries:

$$log(Gold_{i,t}) = a + b\ log(Gold_{i,t-1}) + \epsilon_{i,t} \tag{4}$$

where Gold is measured in Billion Troy ounces. The regime with 'constant gold holdings' is equivalent to the regime under the null hypothesis that

$$H_0\ :\ a = 0\ and\ b = 1 \tag{5}$$

We use the monthly data on gold holdings, from 1960 to 2010. For each country, equation (4) is estimated annually, with 12 monthly observations, conducting the F test of the null hypothesis (5). When this null hypothesis is rejected at the 5 percent level, we identify the country as having an 'active gold trading' regime during that year, and assign a value 1 to the "country's regime" dummy. Otherwise, the country is identified as having a 'stable regime,' and the "country's regime" dummy is assigned

a zero value. Figure 3 shows the share of countries with the active trading regime; equals the percentage of the countries which had active trading regime out of 22 sample countries ($\frac{1}{22}\sum_{i=1}^{22} regime_{i,t}$).[10] The figure also reports the average volatility of the log nominal exchange rates per the USD for the 21 sample currencies, excluding the USD. The two series indicate that the share of countries in the 'actively gold trading regime' is likely to increase when the volatilities of nominal exchange rates are large.

To track the global regime shifts, we identify the global regime as switching from stable to active 'gold trade regime' when the share of countries in the 'active regime' moves above $\frac{1}{3}$ (hence, $\frac{1}{22}\sum_{i=1}^{22} regime_{i,t} \geq \frac{1}{3}$). Figure 2 traces the 'active global gold trading' by the shadowed areas, indicating that the global active regime periods also correspond to the large changes in gold holdings.

Next, we verify whether the determinants of gold holdings differ in the active regime and stable regime. To answer this question, we include the regime dummy variables for each country (called "$regime$," which takes 1 if the country has an active regime at the year) in the panel regressions of the equation (2). Specifically, we add the regime dummies and interaction terms of the regime dummies with all covariates. We also include volatility of the log nominal exchange-rate. Table 5 reports the results, where the coefficient with $\_act$ stands for the differential effect during the active gold trading regimes. The first column is for the full sample, the second to fourth columns are for the subsamples used in Cheung and Ito (2009).[11] As almost all

[10] Data for Gold holdings by Australia from 1960 to 1965 are missing, thereby there are 21 countries in the sample from 1960 to 1965. Moreover, NZ and Norway have stopped holding gold since 1993 and 2004, respectively. We treat NZ and Norway as having stable regimes since then.

[11] From 1975 to 1981, op_cost is dropped due to many missing variables.

coefficients of differential effects are insignificant, we conclude that the determinants of Gold/GDP are not statistically different between the active and the stable regimes.

6 Probit for gold regime change

For robustness, we run a probit estimation to identify the determinants of "gold trading regime." The dependent variable is the regime dummy variable ($regime$) for each country (obtained in the previous section),[12] and the covariates are similar to those in the baseline regression;[13]

$$Regime_{i,t} = c + X_{i,t}^{'}\alpha + Y_{i,t}^{'}\beta + Z_{i,t}^{'}\gamma + D_{i,t}^{'}\delta + \mu\frac{Gold_{i,t-1}}{GDP_{i,t-1}} + \epsilon_{i,t} \tag{6}$$

where $X_{i,t}$ is a vector of macro variables, $Y_{i,t}$ is a vector of financial variables, $Z_{i,t}$ is a vector of institutional variables and $D_{i,t}$ is a vector of dummy variables. c is a constant and $\epsilon_{i,t}$ is an error term. Recalling that Figure 3 suggests that high exchange rate volatility impact gold position, we added a control for exchange rate volatility. We also control for the log of nominal exchange rates per the USD, since the fear of USD depreciation may induce central banks to diversify its exposure by hold more gold.[14]

[12] Due to the zero gold holdings, we take the data for NZ and Norway since 1993 and 2004, respectively, from our sample.

[13] We dropped the time trend.

[14] We also re-estimated the Probit model recognizing the possibility that European countries used to peg their currencies to the Deutsche Mark. To verify, we included the following additional controls: 1) log of nominal exchange rate per the Deutsche Mark, 2) volatility of log exchange rate per the Deutsche Mark, and 3) difference of log exchange rate volatility from the previous year (for the USD and the Mark, respectively). The results (available upon request) indicate that our results are robust to the inclusion of Deutsche Mark controls.

The first column of Table 6 shows the probit model results. As Johnston and DiNardo (1997) suggest, for the sake of comparison we also run the same model using the logit and OLS methodology, reported in the second and third columns, respectively. Since the probit and logit models are non-linear, the coefficients cannot be compared directly. Yet, the sign patterns and statistical significance are the same across these three specifications. As a rough approximation, the following relation is also known;

$$\beta_{logit} \approx 1.6 \beta_{probit} \tag{7}$$

where β is a coefficient for logit and probit model, respectively. This relation roughly holds in our estimates. Therefore, the inference below does not depend unduly on the particular choices of model specification. In Table 6, we show the results for 1) the full sample from 1979 to 2010 in the first to third columns; 2) the subsample from 1979 to 2006 (in the fourth column for probit) just before the current crisis; and 3) the subsample from 2007 to 2010 (in the fifth column for probit), which includes the 2008-crisis period. Since the Probit is a non-linear estimation, the marginal effects are not unique and depend on where they are evaluated. To interpret the coefficients, Table 7 converts the probit estimates into average marginal effects, where marginal effects are evaluated at averages of the covariates. The 'average marginal effects' mean that if an average of the covariate increases by one unit, the probability of staying in the active gold trading regime increases by the average marginal effect in Table 7. The results of the Probit indicate that the determinants of gold holdings regime are still likely to change over time, and differ from the period prior to the recent crisis to the recent crisis period (though the sample sizes differ).

In the Probit model, the 'Empire dummy' becomes significant with a negative sign, especially for the crisis period. Hence, countries classified as Empire are more likely to be under the stable regime during the recent crisis. Our analysis suggests that the intensity of holding gold may be correlated with 'global power,' by history of being a past empire, or by the sheer size of a country, and especially by countries that are or were the suppliers of key currency. Historically, holding large piles of gold indicated global power, as Gold and silver were the foundations of the traditional monetary system. The United Kingdom, the greatest economic power in Europe during 18th and 19th centuries, accumulated a massive amount of gold. Under the gold standard, London established its status as the global financial market and acted as the lender of the last resort for gold by the early 20th century.[15] More recently, under the Bretton Woods system after the Second World War, the USD, the only currency pegged to gold, became the key currency for international goods and assets trading. Even after the collapse of the Bretton Woods system, the United States remains the dominant economic power and the largest gold holder [Table 8]. Consequently, large gold positions of a central bank remain a signal of economic might, as may be the case if gold provides 'safe haven' services at times of global turbulences.

Exchange rate volatility is statistically significant with a negative sign before the recent crisis. As the exchange rates per the USD become more volatile, central banks are more likely to be under the stable regime. Intriguingly, the sign of log nominal exchange rate changes before and during the recent crisis periods. Before the crisis, as the exchange rate depreciates, central banks were, on average, in the 'stable gold trading regime.' When the exchange rate depreciated during the crisis, central banks

[15]Kennedy (1989), p.245.

were more likely to trade gold actively. Moreover, the coefficient of equity also changes the sign before versus during the crisis. Debt becomes significant only during the recent crisis period. In countries that incurred more equity liabilities before the crisis, the central banks were more likely to be under the "stable regime." In contrast, in countries that incurred more equity and debt liabilities during the crisis, the central banks were more likely to trade gold actively. The more FDI liabilities the countries incurred before the recent crisis, the more likely the central banks were under the 'stable gold trading regime.' Finally, M2/GDP becomes significant only during the recent crisis. In countries with higher M2/GDP ratio, the central banks were more likely to be in the 'stable gold trading regime.'

7 Gold holdings and sovereign debt in Europe

Given the significant current gold holdings by the Euro area countries, it's of interest to assess the gold positions of the Euro zone countries. Figure 4 reports the estimated Gold/Sovereign debt ratios of the Euro countries, the top panel reports these ratios since 1960, the bottom panel since 1990.[16] In 2010, Germany had the largest ratio, well over 10 percent, followed by Portugal (about 9 percent). The gold/Sovereign debt ratios of the other Euro periphery countries were substantially lower: Italy (about 5 percent), Spain (about 2 present), Greece (about 1 percent), and Ireland (close to zero). While several Euro zone countries keep holding significant gold/sovereign debt

[16]We use data on Gross Central government debt (total domestic plus external) as a percent of GDP (naming it Debt/GDP) from Reinhart and Rogoff (2010) and estimate the ratio as $\frac{100 * Gold\ (in\ USD)}{Debt/GDP * Nominal\ GDP\ in\ USD}$. Gold is from "International Financial Statistics" and GDP is from "World Development Indicators." For Italy and Netherland, general government debts are used because of the data availabilities.

ratios, their holdings probably reflect historical factors, and do not adjust rapidly to changing circumstances.[17] Institutional features, such as the independence of central banks and the Central Bank Gold Agreement,[18] may prevent central governments from selling their central bank gold as means of cutting their sovereign debts.

8 Gold holdings by emerging China, Russia and India

Recognizing the growing global might of key emerging markets, we close the empirical discussion by noting the recent sharp increase in the gold positions of the largest emerging countries: China, India, and Russia [Figure 5]. Table 8 shows that as of November 2011, China is the 6th largest gold holder in the world, Russia is the 8th, and India is the 11th largest. Several recent articles indicate that these countries are likely to continue building up their gold reserves.[19] This trend is consistent with the desire of 'super emerging markets' to signal their economic might, to diversify their reserves, and to insure themselves during the global turbulence.

9 Conclusion

Our study showed that Gold retains its unique status in central bank portfolios – sizable physical positions that are held mostly passively, reported at historical valuation.

[17] For examples, see Box 1 for a case study of Portugal.
[18] See Box 2 for the details.
[19] See Box 3 for the details.

A central bank's gold position retains the stature of signaling economic might. The intensity of holding gold is correlated with 'global power' – by a history of being a past empire, or by the sheer size of a country, especially by countries that are or were the suppliers of key currencies. The tendency to under report gold positions in the conventional international reserve/GDP statistics is a working solution for the central bank's wish to maintain sizeable gold positions, while minimizing the criticism that may occur at times when the price of gold declines.

A Appendix - Papers on international reserves, since 2000

A top cited paper on international reserves since 2000[20] is Rodrik (2006). He explains the logic of the Guidotti-Greenspan rule,[21] linking the desirable level of IR to the short-term foreign borrowing and the costs of sudden stops. He pointed out that the reason why developing countries have not tried harder to reduce short-term foreign liabilities remains a puzzle.

Dooley, Folkerts-Landau and Garber (2004) promote modern mercantilism, dubbed, "Bretton Woods II," as the explanation for large reserves accumulation in East Asia. They view reserves accumulation as a by-product of promoting exports, which is needed to create better jobs, thereby absorbing abundant labor in traditional sectors.

Jeanne and Ranciere (2006) present a model of the optimal level of international reserves for a small open economy that is vulnerable to sudden stops in capital flows. Reserves allow the country to smooth domestic absorption in response to sudden stops, but yield a lower return than the interest rate on the country's long-term debt. They derive a tractable formula for the optimal level of reserves, and show that plausible calibrations can explain reserves of the order of magnitude observed in many

[20]Google Scholar platform was searched for "International Reserves" since 2000 (the search was done on April 23, 2011). Papers are ordered below by larger citations.

[21]The Guidotti-Greenspan rule is that countries should hold liquid reserves equal to their foreign liabilities coming due within a year.

emerging market countries. However, the recent buildup of reserves in Asia seems in excess of what would be implied by an insurance motive against sudden stops.

Aizenman and Marion (2003) show that reserve holdings over 1980-1996 seem to be the predictable outcome of a few key factors, such as the size of international transactions, their volatility, the exchange-rate arrangement, and political considerations. However, after the 1997 financial crisis, these factors significantly underpredict the reserve holdings of several key Far East countries. They show that sovereign risk and costly tax collection to cover fiscal liabilities lead to a relatively large precautionary demand for international reserves. On the other hand, countries with high discount rates, political instability or political corruption find it optimal to hold smaller precautionary balances. They also show that models that incorporate loss aversion predict a relatively large demand for international reserves. If a crisis increases the volatility of shocks and/or loss aversion, it will greatly increase the demand for international reserves.

Aizenman and Lee (2007) compare the importance of precautionary and mercantilist motives in the hoarding of international reserves by developing countries during the 1980s and 1990s. Overall, their empirical results support precautionary motives; in particular, a more liberal capital account regime increases international reserves. Theoretically, large precautionary demand for international reserves arises as a self-insurance to avoid costly liquidation of long-term projects when the economy is susceptible to sudden stops. The welfare gain from the optimal management of international reserves is of a first-order magnitude, reducing the welfare cost of liquidity shocks from a first-order to a second-order magnitude.

Flood and Marion (2003) provide a comprehensive analysis of the degree to which the buffer stock model, used during the Bretton Woods system to account international reserves, applies in the Post Bretton Woods regime. The results are mixed: the buffer stock model of international reserve holding works about as well in the era of high capital mobility as it did when capital was less mobile. Its prediction that increased volatility significantly increases reserve holdings is very robust. While the model works well statistically, it explains very little about countries' reserve holdings. Most of the "explanation" in their regressions is due to country specific fixed effects. Effective exchange-rate stability and a country's financial and real-side openness, together with volatility and opportunity-cost elements, can explain about 40 percent of the variation in countries' reserve holdings.

Aizenman and Marion (2004) view precautionary hoarding of international reserves needed to stabilize fiscal expenditure in developing countries. Specifically, a country characterized by volatile output, inelastic demand for fiscal outlays, high tax collection costs, and sovereign risk may want to accumulate both international reserve

and external debt, a combination that allows the country to smooth consumption when output is volatile. Their framework also suggests that greater political instability would reduce reserve accumulation, a result that is supported by the data. By implication, higher international reserves, other things being equal, may signal lower susceptibility to crisis, thereby reducing sovereign spreads.

Garcia and Soto (2004) provide a useful framework quantifying the effect of reserves on crisis probability and integrated it into a loss function analysis of the optimal precautionary levels of reserves. They conclude that the stocks of reserves for most countries in the early 2000s were consistent with an optimal self-insurance policy under reasonable assumptions regarding the cost of a crisis.

Jeanne (2007) constructs a small open economy model with vulnerability to the crisis and conducts a cost-benefit analysis of reserve holdings and evaluates the degree to which the recent reserve holdings are consistent with the model prediction, especially in Asia, since 2000. Holding reserves yields benefits in terms of crisis prevention and crisis mitigation, while the cost is measured as the difference in returns between the international reserves and more profitable investment opportunities. He shows that the reserve accumulation in Asian emerging market countries is difficult to justify in terms of self-insurance against capital flow volatility and capital account crisis, unless the output cost of the crisis is assumed to be unrealistically high. On the other hand, his model works well for Latin American economies. The main reason for a small marginal return of holding reserves in Asia is that their probabilities of crisis are estimated to be small.

Obstfeld, Shambaugh and Taylor (2010) link the reserve hoarding trend to three key factors associated with the shifting positions in the Trilemma configuration since 1990. The first factor is the "fear of floating," manifested in the desire to tightly manage the exchange rate (or to keep fixing it). The desire to stabilize the exchange rate reflects a hybrid of factors - to boost trade, to mitigate destabilizing balance sheet shocks in the presence of dollarized liabilities, and to provide a transparent nominal anchor used to stabilize inflationary expectations [see Calvo and Reinhart (2002)]. The second factor is the adoption of active policies to develop and increase the depth of domestic financial intermediation, through a larger domestic banking and financial system relative to GDP. The third factor is complementing the deepening of domestic financial intermediation with an increase in the financial integration of the developing country with international financial markets. The combination of these three elements increases the exposure of the economy to financial storms, in the worst case leading to financial meltdowns, as was vividly illustrated by the Mexican 1994-5 crisis, the 1997-8 East Asian crisis, and the Argentinean 2001-2 financial collapses.

B Appendix - Data description

Data was collected for 22 industrialized countries[22] in Cheung and Ito (2009). This data is mainly available since 1970, with a limited coverage since 1960. The balanced panel data is available since 1979. To make the panel balanced, we make several assumptions described below, estimating various missing data points.

Data descriptions

Name of variable		*Units*	*Definition/Description*	*Source*
Dependent variables				
IR	(Non-Gold International Reserve)	end of period in Billion USD	- Converted from Total Reserve minus Gold in SDR to in USD by the USD/SDR rate at the end of periods	IFS (1)
Gold	(Official Gold Holdings)	end of period in Billion USD	- Converted from fine troy ounces to USD values by London Gold Price data	IFS (1)
TR	(Total Reserve)	end of period in Billion USD	- sum of ``IR" and ``Gold"	IFS (1)
These reserve data are normalized by nominal GDP.				
Explanatory variables				
Traditional Macro variables				
GDP	(Nominal GDP)	currency USD in Billion USD	- used to normalize the Reserve and Gold data as well as asset holding data	WDI (2)
GDP_PC	(GDP per capita)	2000 USD	- log is taken (3)	WDI (2)
IM_GDP	(Imports of goods+services)	percent of GDP		WDI (2)(4)
POP	(Population, total)	in Million	- log is taken	WDI (2)
IR_Var	(Non-Gold International Reserve Volatility)	end of period percent	- historical volatility of IR over the past 12 months - normalized by the period average of IR	IFS (1)
Gold_Var	(Official Gold Holdings Volatility)	end of period percent	- historical volatility of Gold over the past 12 months - normalized by the period average of Gold	IFS (1)
TR_Var	(Total Reserve Volatility)	end of period percent	- historical volatility of TR over the past 12 months - normalized by the period average of TR	IFS (1)

continued

Notes

1) IFS is the IMF, ``International Financial Statistics."

2) WDI is the World Bank, ``World Development Indicator."

3) For Australia in 2010 we use GDP per capita in 2010-USD from the FRED database to estimate 2000-USD data in 2010. Specifically, we multiply 2000-USD data in 2009 from WDI by the growth rate of 2010-USD data in 2010 from the FRED.

4) For 2010, we use the FRED database for ``Import of goods and services" of each country. Then, data are converted into the USD values by using exchange rates at the end of year (December).

[22] Our sample covers 22 developed countries; Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherland, Portugal, Spain, Australia, Canada, Denmark, Iceland, Japan, New Zealand, Norway, Sweden, Switzerland, United Kingdom, and United States.

Data descriptions - continued

Name of variable		*Units*	*Definition/Description*	*Source*
Financial variables				
M2_GDP	(Money and quasi-money)	percent of GDP	- M2 for non Euro countries are from WDI - M2 for Euro zone, UK and some missing data points are from IFS (5)	WDI (2) IFS (1)
op_cost	(Opportunity costs of holding reserve)	percent	- defined as the differential between the 3-month US Treasury yield (TB3M) and domestic lending rates	IFS (1) WDI (2)
Rate	(Lending interest rate)	percent	- Many data points before 1978 are missing and interpolated (6)	IFS (1)
TB3M	(3-Month Treasury Bill)	percent	- Secondary Market Rate	FRED(7)
equity_gdp	(Net Equity Liabilities: Liabilities - Assets)	percent of GDP	- Net equity liabilities in current USD divided by GDP - 2008 to 2010 are estimated by adding changes in net Equity liabilities from the IMF data (9).	LM(2007) (8) IMF(9)
fdi_gdp	(Net FDI Liabilities: Liabilities - Assets)	percent of GDP	- Net FDI liabilities in current USD divided by GDP - 2008 to 2010 are estimated by adding FDI/GDP (on BoP basis) from WDI.	LM(2007) (8) WDI (2)
debt_gdp	(Net Debt Liabilities: Liabilities - Assets)	percent of GDP	- Debt = portfolio debt + other investment - 2008 to 2010 are estimated by adding changes in net Debt liabilities from the IMF data (9).	LM(2007) (8) IMF(9)
Gov_Debt	(Net Central government debt)	percent of GDP	- Total domestic plus external - For some countries, General gov debt is used.	RR(2010) (10)
Dummy variables				
Empire	(Nominal GDP)		- France, Germany, Japan, UK and USA are chosen as empires. See footnote (6) in the main text.	Authors' calculations
Other variables				
ner_usd	(Nominal exchange rates per the USD)		- National Currency per the USD	IFS (1)
sd_ner	(Volatility of log exchange rate)		- Historical Standard Deviation of log Nominal Exchange Rates per USD (over the past 12 months)	IFS (1)

Notes

5) Since M2 for Euro Zone countries before the introduction of Euro are not available in WDI, we use IFS for their M2. Specifically, Currency issued plus Demand Deposits plus Other Deposits (L34a.n+L34b.n+L35n) is equivalent to Money plus quasi Money. For Austria, Belgium, France and Netherland, the data at the end of 1998 are unavailable. Therefore, we use the nearest data point of their monthly M2 data series in 1998 for the end of 1998. Unfortunately, the data for Netherland in 1998 are unavailable. Therefore, assuming that the growth rates of demand and other deposits are the same as that of the currency issued only available in 1998, we interpolate the missing data. Finally, the data for Australia in 2010 is estimated by the growth rate of M3 from the FRED database.

6) We interpolate data for Austria, Belgium, NZ and Switzerland by assuming that the growth rates of lending rates are the same as those of other domestic short-term interest rates from IMF and OECD. Furthermore, since many data for Euro Zone countries are missing after the introduction of Euro, we interpolate the missing data of Euro Zone countries after 1999 by assuming that the growth rate of lending rate in each country is the same as that of Euribor 3-month from OECD. The same methodology is applied to Denmark, Norway and Sweden.

7) FRED is the FRB of St. Louis, FRED database.

8) LM(2007) is from Lane and Milesi-Ferretti (2007).

9) ``Coordinated Portfolio Investment Survey'' is used.

10) RR(2010) is from Reinhart-Rogoff (2010) and the data are available from Dr. Reinhart's website.

Figure 1: Gold holding in Billion ounces

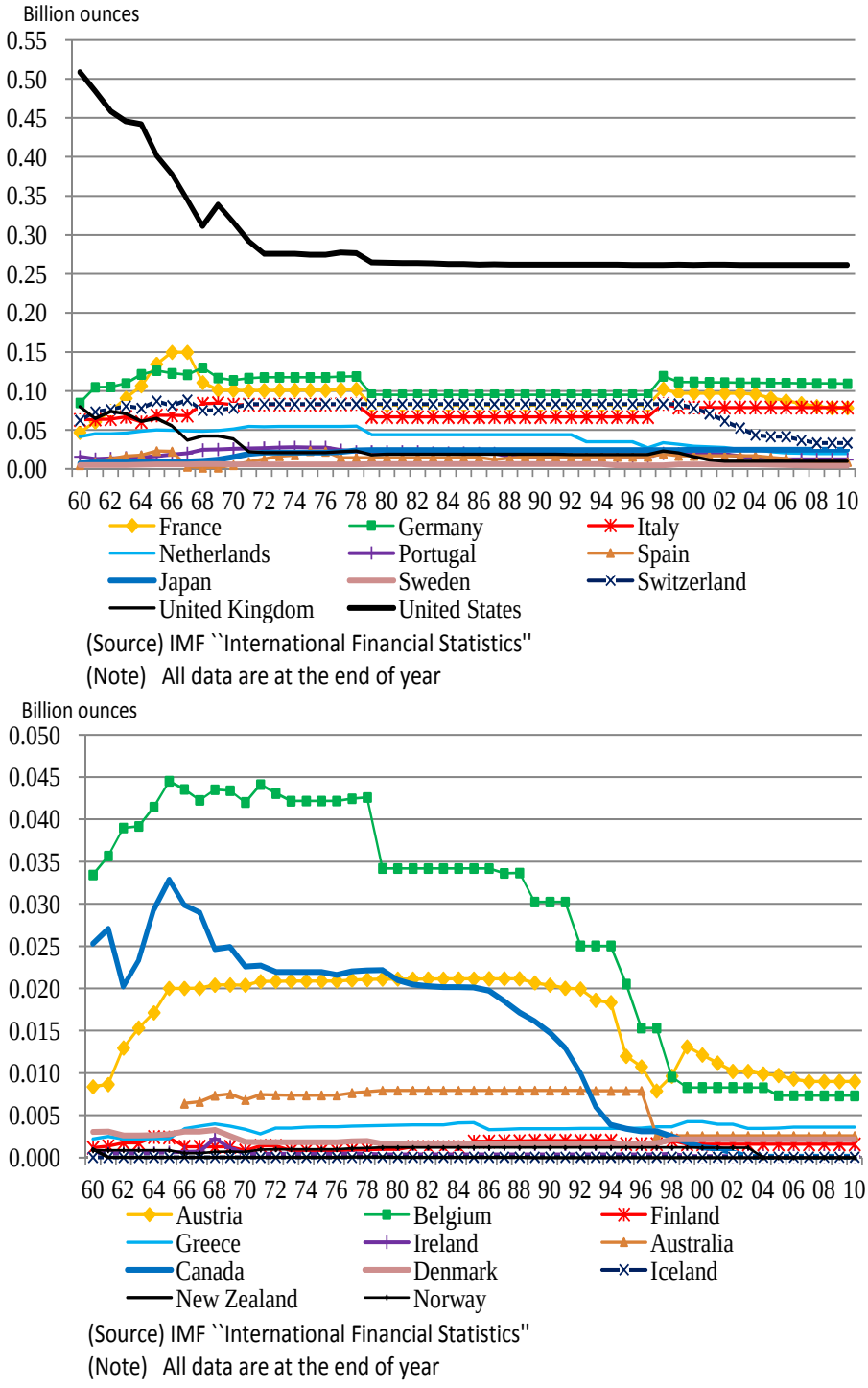
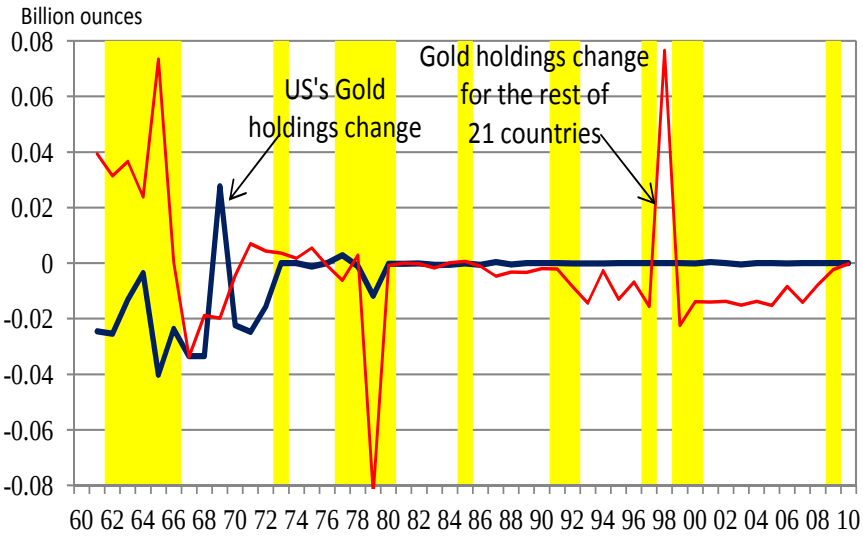


Figure 2: Change of gold holdings in Billion ounces under active regime

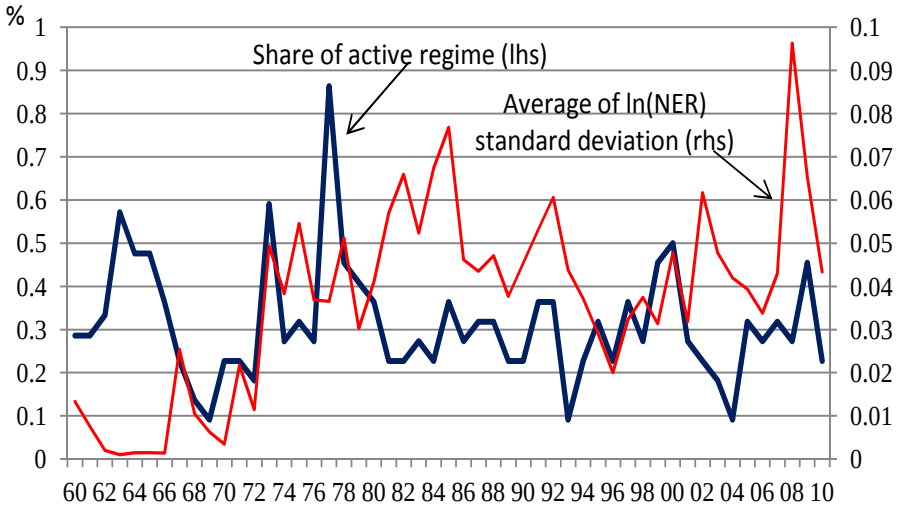


(Source) IMF ``International Financial Statistics''

(notes) 1. Shadowed years are under the active trading regime with share of actively gold trading countries out of 22 countries greater than or equal to 1/3.

2. Change of gold holdings is a difference of gold holdings from the previous year.

Figure 3: Share of active gold trading regime and average volatility of Nominal Exchange Rates (NER) per the USD



(Notes) 1. Share of active trading regime (scaled on the left-hand-side axis : lhs) is the percentage of the countries which had active trading regime out of 22 sample countries.

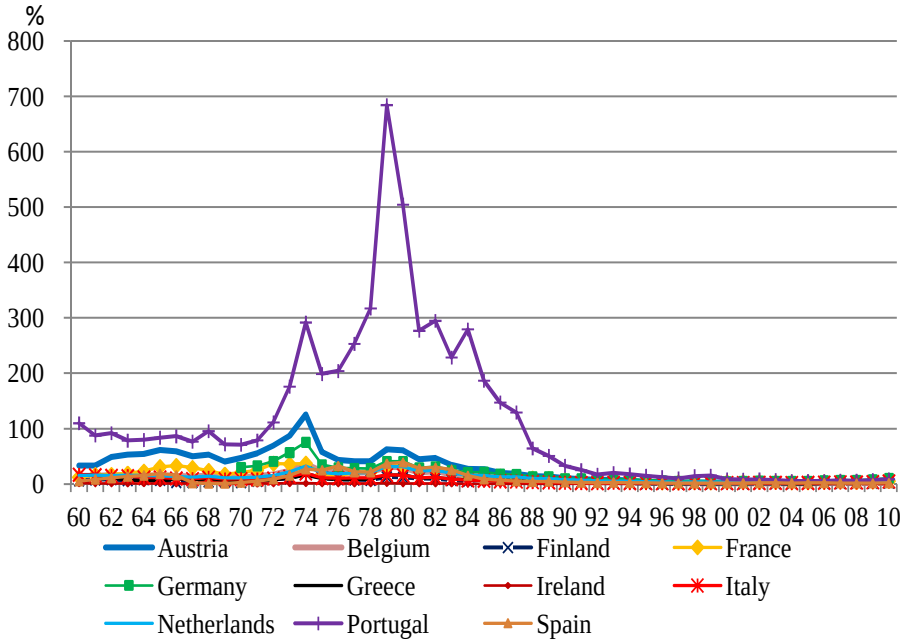
2. Active trading regime is identified by rolling regressions with 12 month window for each country: log Gold = a + b logGold(-1). When the null hypothesis that a=0 and b=1 is rejected at 5 percent level, the country is identified as having active gold trading regime at the year.

3. Standard deviation of log Nominal exchange rates (NER) per USD is calculated over the past 12 months, and standard deviations of 21 currencies (excluding USD) are averaged. The average standard deviation is scaled on the right-hand-side axis (rhs).

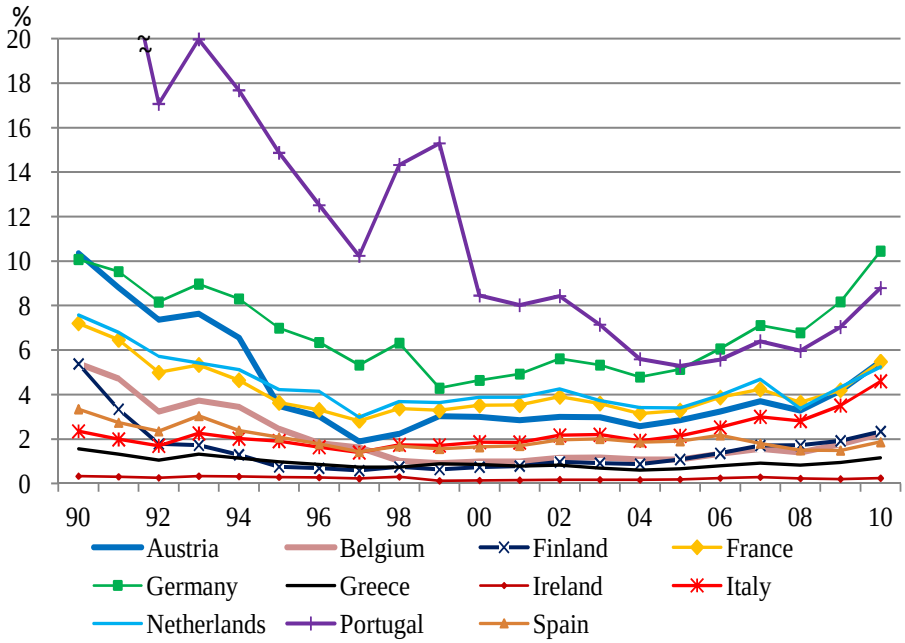
4. Sample is from 1960 to 2010. Data for Gold holdings by Australia from 1960 to 1965 are missing.

5. NZ and Norway stop holding gold since 1993 and 2004, respectively. I suppose they have stable regimes for these years.

Figure 4: Gold Sovereign debt Ratio for Euro member countries

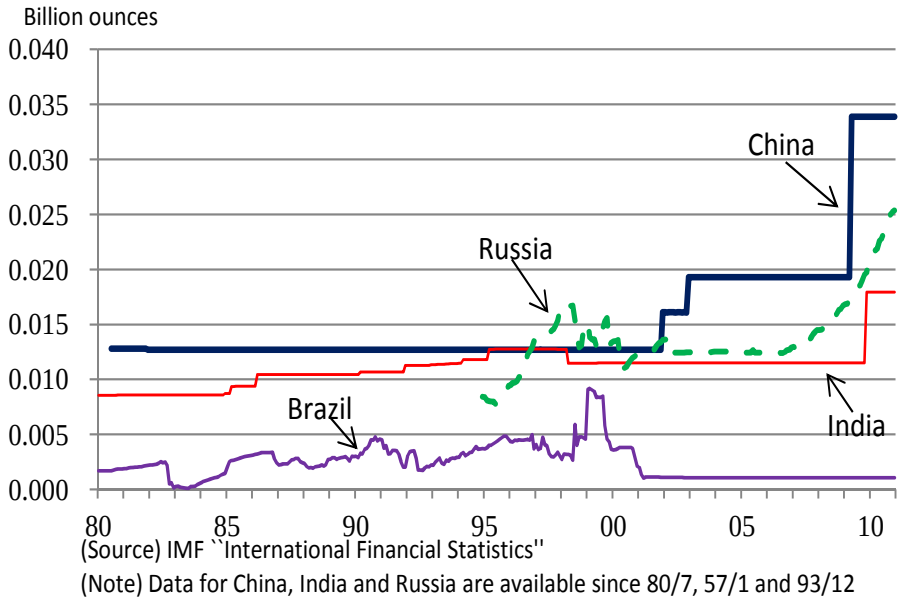


(Source) IMF ``International Financial Statistics'' and Reinhart and Rogoff (2010)
(Note) Gold/Debt = 100* Gold (in USD) / (Debt/GDP * Nominal GDP in USD)



(Source) IMF ``International Financial Statistics'' and Reinhart and Rogoff (2010)
(Note) Gold/Debt = 100* Gold (in USD) / (Debt/GDP * Nominal GDP in USD)

Figure 5: Gold holdings by BRICs



(Source) IMF ``International Financial Statistics''

(Note) Data for China, India and Russia are available since 80/7, 57/1 and 93/12

Table 1: Estimation results : Baseline regression: The full sample (1979 to 2010)

	(1)	(2)	(3)	(4)	(5)	(6)
	ir_OLS2	ir_BE	g_OLS2	g_BE	tr_OLS2	tr_BE
VARIABLES	ir_gdp	ir_gdp	gold_gdp	gold_gdp	tr_gdp	tr_gdp
year	-0.028***		-0.005	0.008	-0.031***	
	(0.010)		(0.008)	(0.006)	(0.012)	
L.ir_gdp	0.963***	0.993***				
	(0.034)	(0.018)				
L.gold_gdp			0.903***	0.964***		
			(0.041)	(0.004)		
L.tr_gdp					0.935***	0.967***
					(0.031)	(0.013)
gdp_pc	0.309	0.185	-0.651*	-0.078	-0.165	-0.002
	(0.309)	(0.137)	(0.378)	(0.060)	(0.508)	(0.245)
ln_pop	-0.139	-0.217***	-0.192*	-0.025	-0.308***	-0.341***
	(0.093)	(0.065)	(0.104)	(0.022)	(0.099)	(0.081)
im_gdp	0.012	0.003	-0.000	-0.002*	0.011	-0.004
	(0.008)	(0.005)	(0.006)	(0.001)	(0.008)	(0.004)
op_cost	-0.035*	-0.013	0.037*	-0.001	0.006	-0.008
	(0.018)	(0.015)	(0.019)	(0.005)	(0.025)	(0.018)
ir_var	0.010***	0.014***				
	(0.003)	(0.004)				
gold_var			0.017**	0.001		
			(0.008)	(0.001)		
tr_var					0.014***	0.012**
					(0.003)	(0.004)
m2_gdp	0.008***	0.001	0.004**	-0.000	0.009***	0.003
	(0.002)	(0.002)	(0.002)	(0.000)	(0.003)	(0.002)
equity_gdp	0.010	-0.003	-0.003	-0.001	0.007	-0.007
	(0.006)	(0.003)	(0.002)	(0.001)	(0.006)	(0.004)
fdi_gdp	-0.013**	-0.004	-0.009**	-0.003***	-0.020***	-0.008*
	(0.006)	(0.002)	(0.003)	(0.001)	(0.007)	(0.004)
debt_gdp	0.010*	0.004	-0.003	-0.002**	0.009	-0.000
	(0.005)	(0.002)	(0.002)	(0.001)	(0.006)	(0.003)
empire	-0.043	0.121	-0.147	0.004	-0.105	0.053
	(0.200)	(0.110)	(0.169)	(0.028)	(0.248)	(0.129)
Constant	-2.316	-1.823	7.332**	0.539	3.436	0.892
	(2.998)	(1.546)	(3.646)	(0.467)	(5.015)	(2.731)
Observations	704	704	679	679	704	704
R-squared	0.876	0.999	0.926	1.000	0.914	1.000
No of country		22		22		22

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2: Estimation results : The sample from 1975 to 1981

	(1)	(2)	(3)	(4)	(5)	(6)
	ir_OLS2_75	ir_BE_75	g_OLS2_75	g_BE_75	tr_OLS2_75	tr_BE_75
VARIABLES	ir_gdp	ir_gdp	gold_gdp	gold_gdp	tr_gdp	tr_gdp
year	-0.029		0.213**		0.192	
	(0.042)		(0.101)		(0.122)	
L.ir_gdp	0.933***	1.027***				
	(0.055)	(0.026)				
L.gold_gdp			0.777***	0.998***		
			(0.078)	(0.005)		
L.tr_gdp					0.784***	0.994***
					(0.072)	(0.014)
gdp_pc	0.524	0.661**	-2.973*	0.165	-2.504	0.791**
	(0.471)	(0.219)	(1.536)	(0.109)	(1.566)	(0.304)
ln_pop	-0.168	-0.042	-0.564*	-0.061*	-0.898***	-0.178
	(0.109)	(0.075)	(0.320)	(0.033)	(0.293)	(0.104)
im_gdp	-0.000	-0.011	0.044*	-0.003	0.072*	-0.009
	(0.013)	(0.008)	(0.026)	(0.003)	(0.038)	(0.009)
ir_var	0.033***	0.011				
	(0.004)	(0.008)				
gold_var			0.019*	-0.000		
			(0.011)	(0.001)		
tr_var					0.025*	0.004
					(0.013)	(0.004)
m2_gdp	0.002	-0.000	0.028**	-0.000	0.040***	0.003
	(0.005)	(0.003)	(0.012)	(0.001)	(0.013)	(0.004)
equity_gdp	0.023	-0.036	0.300	0.011	0.358*	-0.050
	(0.072)	(0.049)	(0.208)	(0.020)	(0.201)	(0.052)
fdi_gdp	-0.007	-0.020	-0.063	0.008	-0.030	-0.000
	(0.021)	(0.012)	(0.050)	(0.005)	(0.059)	(0.013)
debt_gdp	0.006	0.006	-0.024	-0.005*	-0.037	-0.009
	(0.010)	(0.007)	(0.037)	(0.003)	(0.041)	(0.008)
empire	-0.328	-0.375	0.199	0.027	0.552	-0.236
	(0.367)	(0.247)	(0.711)	(0.100)	(0.785)	(0.276)
Constant	-3.462	-6.084**	18.896	-1.301	15.528	-6.931**
	(5.138)	(2.059)	(14.074)	(1.044)	(15.249)	(2.895)
Observations	154	154	154	154	154	154
R-squared	0.920	0.998	0.880	1.000	0.909	1.000
Number of country		22		22		22

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Estimation results : The sample from 1983 to 1993

	(1)	(2)	(3)	(4)	(5)	(6)
	ir_OLS2_83	ir_BE_83	g_OLS2_83	g_BE_83	tr_OLS2_83	tr_BE_83
VARIABLES	ir_gdp	ir_gdp	gold_gdp	gold_gdp	tr_gdp	tr_gdp
year	-0.017		-0.003	-0.009	-0.021	
	(0.043)		(0.018)	(0.170)	(0.042)	
L.ir_gdp	0.836***	1.077***				
	(0.060)	(0.021)				
L.gold_gdp			0.853***	0.868***		
			(0.025)	(0.005)		
L.tr_gdp					0.841***	0.948***
					(0.030)	(0.021)
gdp_pc	-0.481	-0.402*	-0.044	-0.020	-0.597	-0.026
	(0.563)	(0.197)	(0.246)	(0.086)	(0.639)	(0.408)
ln_pop	-0.197	0.139*	0.007	-0.038	-0.181	-0.076
	(0.145)	(0.072)	(0.062)	(0.028)	(0.143)	(0.136)
im_gdp	0.024**	-0.003	0.009	-0.000	0.035**	-0.002
	(0.012)	(0.006)	(0.006)	(0.002)	(0.015)	(0.013)
op_cost	0.003	-0.039**	-0.011	0.007	-0.012	-0.005
	(0.029)	(0.015)	(0.010)	(0.005)	(0.030)	(0.030)
ir_var	0.007**	-0.008*				
	(0.003)	(0.004)				
gold_var			-0.000	0.002		
			(0.007)	(0.004)		
tr_var					0.008*	0.007
					(0.005)	(0.010)
m2_gdp	0.005	0.005**	0.002	-0.002*	0.007	-0.000
	(0.004)	(0.002)	(0.002)	(0.001)	(0.004)	(0.004)
equity_gdp	0.065**	-0.008	0.022	0.002	0.085***	0.017
	(0.026)	(0.014)	(0.013)	(0.005)	(0.030)	(0.028)
fdi_gdp	0.008	-0.028***	-0.003	-0.001	0.003	-0.003
	(0.017)	(0.008)	(0.005)	(0.002)	(0.018)	(0.014)
debt_gdp	0.004	0.010***	-0.004	-0.006***	-0.000	0.010
	(0.007)	(0.003)	(0.005)	(0.001)	(0.010)	(0.007)
empire	-0.038	0.002	0.019	-0.066	-0.063	-0.071
	(0.338)	(0.172)	(0.146)	(0.064)	(0.370)	(0.361)
Constant	6.037	2.834	0.323	1.138	7.054	0.481
	(5.313)	(2.206)	(1.788)	(8.622)	(5.996)	(4.584)
Observations	242	242	241	241	242	242
R-squared	0.832	0.999	0.981	1.000	0.936	0.999
Number of country		22		22		22

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimation results : The sample from 1999 to 2005

	(1)	(2)	(3)	(4)	(5)	(6)
	ir_OLS2_99	ir_BE_99	g_OLS2_99	g_BE_99	tr_OLS2_99	tr_BE_99
VARIABLES	ir_gdp	ir_gdp	gold_gdp	gold_gdp	tr_gdp	tr_gdp
year	-0.075		-0.006	0.055	-0.076	
	(0.060)		(0.009)	(0.092)	(0.058)	
L.ir_gdp	0.887***	1.004***				
	(0.054)	(0.071)				
L.gold_gdp			0.942***	0.963***		
			(0.025)	(0.022)		
L.tr_gdp					0.891***	0.958***
					(0.052)	(0.068)
gdp_pc	1.949***	1.512**	-0.075	-0.001	1.708***	1.336*
	(0.608)	(0.534)	(0.069)	(0.114)	(0.600)	(0.638)
ln_pop	-0.101	-0.018	-0.006	0.003	-0.092	-0.161
	(0.177)	(0.300)	(0.021)	(0.041)	(0.175)	(0.317)
im_gdp	-0.034**	-0.012	0.001	-0.001	-0.031**	-0.020
	(0.013)	(0.021)	(0.001)	(0.002)	(0.013)	(0.022)
op_cost	-0.073	0.011	0.000	0.006	-0.076	0.048
	(0.060)	(0.105)	(0.006)	(0.012)	(0.059)	(0.107)
ir_var	0.003	0.007				
	(0.002)	(0.006)				
gold_var			0.006*	-0.002		
			(0.003)	(0.006)		
tr_var					0.004**	0.009
					(0.001)	(0.006)
m2_gdp	0.007*	-0.001	-0.000	-0.001	0.006	-0.003
	(0.004)	(0.007)	(0.000)	(0.001)	(0.004)	(0.007)
equity_gdp	-0.003	-0.002	-0.000	-0.001	-0.004	-0.007
	(0.005)	(0.009)	(0.000)	(0.001)	(0.005)	(0.010)
fdi_gdp	0.007	0.008	-0.000	0.001	0.003	0.006
	(0.008)	(0.008)	(0.002)	(0.001)	(0.008)	(0.010)
debt_gdp	-0.000	0.005	0.000	-0.000	-0.001	0.002
	(0.005)	(0.007)	(0.001)	(0.001)	(0.006)	(0.008)
empire	-0.631*	0.108	0.024	0.089	-0.594	0.145
	(0.336)	(0.545)	(0.065)	(0.060)	(0.362)	(0.552)
Constant	-13.402*	-15.159**	1.220*	-3.503	-10.915	-12.065
	(7.277)	(6.586)	(0.712)	(5.847)	(7.496)	(8.125)
Observations	154	154	145	145	154	154
R-squared	0.903	0.992	0.988	1.000	0.920	0.993
Number of country		22		21		22

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Estimation results : Gold holding regime switch

	g_OLS	g_OLS_75	g_OLS_83	g_OLS_99
VARIABLES	gold_gdp	gold_gdp	gold_gdp	gold_gdp
regime	3.438	13.693	0.207	2.675
	(7.099)	(32.602)	(4.622)	(3.293)
year	0.011	0.184	0.027*	-0.016*
	(0.010)	(0.141)	(0.015)	(0.009)
year_act	-0.038*	0.087	-0.221**	0.002
	(0.020)	(0.232)	(0.112)	(0.032)
L.gold_gdp	0.954***	0.922***	0.851***	0.951***
	(0.046)	(0.207)	(0.018)	(0.040)
l_gold_gdp_act	-0.114	-0.240	-0.063	-0.019
	(0.080)	(0.238)	(0.078)	(0.080)
gdp_pc	-0.639	-2.569	-0.105	-0.004
	(0.507)	(2.039)	(0.225)	(0.062)
gdp_pc_act	-0.180	-1.487	0.791	-0.275
	(0.714)	(3.467)	(0.803)	(0.219)
ln_pop	-0.236**	-0.538	-0.058	0.004
	(0.120)	(0.393)	(0.064)	(0.019)
ln_pop_act	0.059	-1.195	0.105	-0.042
	(0.251)	(0.911)	(0.172)	(0.076)
im_gdp	-0.006	0.010	0.001	0.001
	(0.006)	(0.053)	(0.007)	(0.001)
im_gdp_act	0.012	0.041	0.033**	-0.003
	(0.013)	(0.073)	(0.015)	(0.006)
op_cost	0.012		0.006	0.003
	(0.013)		(0.009)	(0.006)
op_cost_act	0.067		-0.103*	0.012
	(0.074)		(0.056)	(0.019)
gold_var	0.025***	0.031***	0.011	0.007***
	(0.006)	(0.010)	(0.007)	(0.002)
gold_var_act	-0.009	-0.018	-0.013	0.007
	(0.012)	(0.014)	(0.011)	(0.009)
m2_gdp	0.004	0.026*	-0.001	0.000
	(0.003)	(0.015)	(0.002)	(0.000)
m2_gdp_act	0.001	0.043	0.031*	-0.000
	(0.006)	(0.036)	(0.018)	(0.002)
equity_gdp	-0.001	0.167	0.042***	-0.000
	(0.002)	(0.240)	(0.015)	(0.000)
equity_gdp_act	-0.003	0.001	-0.056**	-0.003
	(0.004)	(0.416)	(0.024)	(0.003)
fdi_gdp	-0.005	-0.079	0.003	-0.000
	(0.003)	(0.065)	(0.007)	(0.001)
fdi_gdp_act	-0.010	0.026	-0.016	-0.004
	(0.007)	(0.106)	(0.015)	(0.006)
debt_gdp	-0.002	0.039	-0.007	0.000
	(0.002)	(0.087)	(0.005)	(0.000)
debt_gdp_act	0.001	-0.115	0.016*	-0.001
	(0.003)	(0.100)	(0.008)	(0.003)
empire	-0.070	0.283	-0.001	0.003
	(0.199)	(1.010)	(0.140)	(0.050)
empire_act	-0.262	1.608	-0.323	0.069
	(0.293)	(1.983)	(0.400)	(0.133)
sd_ner	-4.663	-20.702	4.997*	2.415***
	(4.462)	(13.608)	(2.796)	(0.866)
sd_ner_act	12.863	-25.057	-3.578	4.198*
	(7.915)	(28.062)	(4.568)	(2.362)
Constant	6.426	16.592	-0.192	1.009
	(4.914)	(21.466)	(1.988)	(0.882)
Observations	679	154	241	145
R-squared	0.930	0.896	0.985	0.989

Table 6: Estimation results : Probit for gold holding regime switch

	(1)	(2)	(3)	(4)	(5)
	g_probit	g_logit	g_ols	g_probit_79_06	g_probit_07_10
VARIABLES	regime	regime	regime	regime	regime
L.gold_gdp	-0.004	-0.005	-0.001	-0.005	0.343*
	(0.011)	(0.018)	(0.004)	(0.011)	(0.178)
gdp_pc	-0.791***	-1.322***	-0.247***	-1.068***	3.768**
	(0.201)	(0.346)	(0.067)	(0.227)	(1.633)
ln_pop	-0.019	-0.033	-0.011	-0.094	1.330***
	(0.065)	(0.113)	(0.022)	(0.070)	(0.462)
im_gdp	0.003	0.004	0.001	0.003	-0.025
	(0.005)	(0.008)	(0.001)	(0.005)	(0.018)
op_cost	0.003	0.004	0.000	0.006	0.047
	(0.012)	(0.020)	(0.004)	(0.013)	(0.070)
gold_var	0.005**	0.008**	0.001***	0.002	-0.002
	(0.002)	(0.004)	(0.000)	(0.002)	(0.008)
m2_gdp	-0.000	-0.000	0.000	0.002	-0.030***
	(0.002)	(0.003)	(0.001)	(0.002)	(0.010)
equity_gdp	-0.000	-0.000	0.000	-0.009**	0.032***
	(0.003)	(0.005)	(0.001)	(0.004)	(0.009)
fdi_gdp	-0.020***	-0.033***	-0.006***	-0.025***	-0.019
	(0.004)	(0.008)	(0.001)	(0.006)	(0.013)
debt_gdp	0.000	0.000	-0.000	-0.002	0.015**
	(0.002)	(0.003)	(0.001)	(0.002)	(0.006)
empire	-0.394**	-0.636*	-0.109*	-0.303	-2.735***
	(0.198)	(0.334)	(0.065)	(0.214)	(0.947)
ln_ner_usd	-0.056*	-0.091*	-0.017	-0.090***	0.402**
	(0.030)	(0.052)	(0.010)	(0.033)	(0.179)
sd_ner	-5.322**	-9.106**	-1.701**	-7.528***	2.011
	(2.503)	(4.393)	(0.753)	(2.858)	(6.125)
Constant	7.635***	12.805***	2.837***	10.672***	-40.187**
	(2.077)	(3.576)	(0.699)	(2.363)	(17.173)
Observations	679	679	679	599	80
R-squared			0.073		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Average Marginal Effects of Probit for gold holding regime switch

Average marginal effects

Expression : Pr(regime)

Full sample Number of obs = 679

	dy/dx	Standard Error	Z value	p value
Gold/GDP(-1)	-0.001	0.004	-0.320	0.746
gdp_pc	-0.256	0.063	-4.060	0.000
ln_pop	-0.006	0.021	-0.300	0.766
im_gdp	0.001	0.001	0.700	0.485
op_cost	0.001	0.004	0.260	0.798
gold_var	0.002	0.001	2.330	0.020
m2_gdp	-0.000	0.001	-0.110	0.910
equity_gdp	-0.000	0.001	-0.040	0.966
fdi_gdp	-0.006	0.001	-4.830	0.000
debt_gdp	0.000	0.001	0.050	0.958
empire	-0.127	0.064	-2.000	0.046
ln_ner_usd	-0.018	0.010	-1.870	0.062
sd_ner	-1.721	0.802	-2.150	0.032

Subsamples Number of obs = 599 Number of obs = 80

	1979-2006				**2006-2010**			
	dy/dx	SE	Z value	p value	dy/dx	SE	Z value	p value
Gold/GDP(-1)	-0.002	0.004	-0.490	0.622	0.074	0.037	2.000	0.045
gdp_pc	-0.339	0.068	-4.980	0.000	0.813	0.349	2.330	0.020
ln_pop	-0.030	0.022	-1.340	0.181	0.287	0.092	3.100	0.002
im_gdp	0.001	0.002	0.470	0.635	-0.005	0.004	-1.450	0.147
op_cost	0.002	0.004	0.440	0.657	0.010	0.015	0.670	0.503
gold_var	0.001	0.001	1.010	0.313	-0.000	0.002	-0.180	0.856
m2_gdp	0.001	0.001	0.800	0.425	-0.006	0.002	-3.260	0.001
equity_gdp	-0.003	0.001	-2.210	0.027	0.007	0.002	4.110	0.000
fdi_gdp	-0.008	0.002	-4.300	0.000	-0.004	0.003	-1.580	0.113
debt_gdp	-0.001	0.001	-0.670	0.501	0.003	0.001	2.390	0.017
empire	-0.096	0.068	-1.420	0.156	-0.590	0.202	-2.930	0.003
ln_ner_usd	-0.028	0.010	-2.720	0.006	0.087	0.039	2.250	0.025
sd_ner	-2.385	0.895	-2.660	0.008	0.434	1.326	0.330	0.743

Table 8: Ranking of World official gold holdings (as of Nov or earlier 2011*)

Rank	Countries/Org	Tons	% of reserves
1	United States	8,133.5	76.9%
2	Germany	3,396.3	74.2%
3	IMF	2,814.1	
4	Italy	2,451.8	73.9%
5	France	2,435.4	73.7%
6	**China**	**1,054.1**	**1.8%**
7	Switzerland	1,040.1	16.8%
8	**Russia**	**873.6**	**9.6%**
9	Japan	765.2	3.3%
10	Netherlands	612.5	63.0%
11	**India**	**557.7**	**10.0%**
12	ECB	502.1	34.8%
13	Taiwan	422.4	6.1%
14	*Portugal*	*382.5*	*89.8%*
15	Venezuela	372.9	71.1%
	World	30,788.9	
	Euro Area (incl. ECB)	10,788.0	66.0%

Source : World Gold Council

Note: * Data are taken from the IMF's IFS, Dec 2011 edition. Holdings are as of November 2011 for most countries and October 2011 or earlier for late reporters.

Box 1 - The case of Portugal

Historically, Portugal gold holdings have represented a large share of its international reserves, and very high Gold holdings to Sovereign debt ratio. Portugal experienced huge increases in the gold-sovereign debt ratio in 1979 and 1980. These hikes were mainly caused by rapid increases in gold price with gold holding in quantity constant, and decreases in Portugal's gross central government debt as a percent of GDP. According to the Wall Street Journal article ("Portugal's Golden Dilemma," May 17, 2011), Portugal was able to accumulate gold during the World War II because of its neutrality. After the war, the Portuguese government preferred to save gold rather than invest it in Portugal's economic development. Portugal couldn't sell off its gold holdings in order to reduce Portugal's sovereign debt problems because selling its gold may revive the uncomfortable debate about the past. The Bloomberg article ("Gold Makes Dead Portuguese Dictator Top Investor Without Gains," July 21, 2010) noted that the proceeds from Portuguese gold sales still cannot be transferred to the state treasury.

Box 2 - Central Bank Gold Agreement

The recent official gold holdings follow the agreement among the Euro zone countries, called the Central Bank Gold Agreement. According to the World Gold Council,[a] in response to the concern that uncoordinated central bank gold sales were destabilizing the market, driving the gold price sharply down, fifteen European central banks announced the first Central Bank Gold Agreement on September 26, 1999. The Central Bank Gold Agreement (also known as the Washington Agreement on Gold) stated that gold would remain an important element of global monetary reserves, and agreed to limit their collective sales to 2,000 tons over the following five years, or around 400 tons a year. A number of other major gold holders, such as the US, Japan, Australia, the IMF and the BIS, informally associated themselves with the Agreement (or announced at other times that they would not sell gold). The proportion of gold reserves covered by the Agreement or similar announcements amounted to around 85 percent. The current agreement is the third one, invoking the same limits on gold sales as those in the first agreement. Notably, the actual sales have been significantly under the ceiling set by the agreement.

[a]The following description is from the website of the World Gold Council: $http://www.gold.org/government\_affairs/reserve\_asset\_management/central\_bank\_gold\_agreements/$

Box 3 - Increasing appetite to build up gold reserves by China, Russia and India

According to the Wall Street Journal (November 18, 2011),[a] while the central banks had been net sellers of gold for about two decades before 2009, they became net buyers in the second quarter of 2009. Several monetary authorities in emerging countries, including China, Russia and India, have been building up their gold reserves during the last 3 years.

- When the IMF decided to sell one eighth of its total gold holdings in September 2009, India became a counterparty of the gold sales, and purchased 200 tons from the IMF.[b] According to the FT.com (November 3, 2009),[c] India's finance minister said that the purchase "reflected the power of an economy that laid claim to the fifth largest foreign reserves in the world."

- China, the country with the largest foreign exchange reserves in the world, has increased its gold holdings in a quiet manner.[d] The recent rise of Chinese gold holdings may reflect diversification of its large exposure to the USD.[e]

- Russia has followed its long-term program of gold accumulation, and its holdings have been gradually increasing.

[a] The article is "Gold Lures Central Banks."

[b] According to the World Gold Council website, the central banks of Sri Lanka and Bangladesh purchased 10 tons each, and Mauritius also bought 2 tons. The IMF began phased on-market sales in February 2010 and has sold around 15-20 tons of gold per month since that date.

[c] The article is "India flexes its foreign reserve muscles."

[d] BBC News on April 27, 2009, "China quietly build gold reserve"

[e] Forbes on December 27, 2011, "China's Central Bank Clamps Down On Gold, The Only Safe-Haven Left"

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