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HOW MUCH GOLD SHOULD CENTRAL BANKS IN OPEN ECONOMIES HOLD

BY

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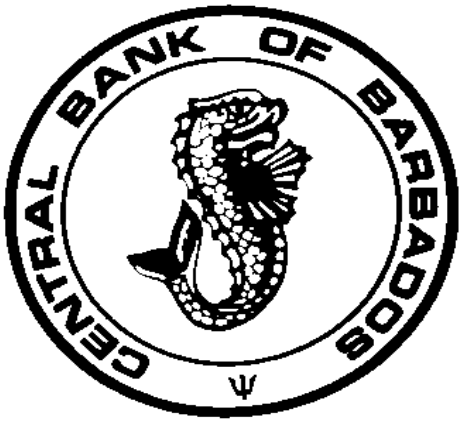

CENTRAL BANK OF BARBADOS

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How much gold should central banks in open economies hold?

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Abstract

Both gold and sovereign securities – primarily US Treasuries – are liquid assets that make up foreign exchange reserves. If the monetary authority's objective is to maintain an ample number of months of import cover in liquid foreign reserves, it should hold approximately 2.5 per cent of its foreign reserves in gold. This result is calculated using mean-variance portfolio theory, time-series data on gold and US Treasuries, and the assumption that the central bank's primary objective relating to foreign reserve management involves special liquidity needs and capital preservation.

I. Introduction

Several commentators have recently called for emerging market economies to hold more gold as part of their foreign exchange reserves. Most notably, Kenneth Rogoff (2016) notes that emerging economies are competing for the same pool of US Treasury bonds, thereby driving down the interest rate they receive. He argues replacing some of the US Treasury securities with gold will serve to rebalance the international markets and increase yields. Moreover, the return on gold could be higher since there is no upper limit to the price of gold. Plender (2016) makes a similar point, as well noting the high level of indebtedness of the advanced economies limits their capacity for further debt expansion, thereby reducing the supply of sovereign securities.

There appears to be no direct answer to this question in the literature (Chen et al 2014, p. 2562). Kalyanaraman (2007) asks the same question with respect to India, but did not provide a specific answer. This essay therefore uses portfolio theory to address the question from emerging markets' perspective. The essential assumption made herein is that the central bank focuses on holding foreign exchange (FX) reserves for the long term instead of actively seeking to maximize short-term returns. This means there must be enough liquid foreign reserves and a stable capital base, as observed by Putnam (2004). Therefore, we make the assumption the central bank seeks to minimize risk associated with holding liquid FX reserves, primarily as it relates to capital preservation and foreign exchange management. This is even more important in light of the recent empirical finding which suggests the international rule-of-thumb of 12 weeks

of import cover may be insufficient (Moore and Glean 2015). These authors note that open economies may need to hold FX reserves that provide for as many as 25 weeks of import cover.

II. Background Information

Table 1 presents the tonnes and per cent of FX reserves for several advanced and emerging economies. The advanced economies such as United States, France, Italy, Germany and Netherlands tend to hold the largest shares of gold, possibly owing to the legacy of the Bretton Woods System. However, the United Kingdom only has 9 per cent of gold as FX reserves. Japan has only 2.5 per cent of reserves in gold. In general the emerging economies and developing countries tend to hold far less gold with the exception of Venezuela, which holds 66.8 per cent gold as share of total reserves. The European Central Bank has around 27.2 per cent. India holds around 6.3 per cent while China has approximately 2.3 per cent. On the relatively higher end for emerging economies – but not at the level of Venezuela – are Pakistan (13.3%), Russia (15.6%), South Africa (11%) and Turkey (17.2%). Small open economies such as Haiti, Mauritius, Singapore and Trinidad and Tobago tend to hold less than 10 per cent.

Table 1 official gold holding of selected countries as at June 2016

Country	Metric tons	Percent of FX reserves	Country	Metric tons	Percent of FX reserves
Brazil	67.2	0.8%	Netherlands	612.5	62.3%
China	1,808.3	2.3%	Pakistan	64.5	13.3%
Egypt	75.6	19.4%	Peru	34.7	2.3%
European Central Bank	504.8	27.2%	Russia	1,476.6	15.6%
France	2,435.7	64.5%	Saudi Arabia	322.9	2.2%
Germany	3,381.0	69.3%	Singapore	127.4	2.1%
Ghana	8.7	7.8%	South Africa	125.2	11.0%
Haiti	1.8	3.7%	Switzerland	1,040.0	6.6%
India	557.8	6.3%	Taiwan	422.7	3.9%
Indonesia	78.1	3.0%	Thailand	152.4	3.4%
Italy	2,451.8	68.6%	Trinidad and Tobago	1.9	0.8%
Japan	765.2	2.5%	Turkey	481.9	17.2%
Malaysia	36.4	1.5%	United Kingdom	310.3	9.0%
Mauritius	9.9	9.0%	United States	8,133.5	75.3%
Mexico	121.2	2.8%	Venezuela	230.1	66.8%

Source: World Gold Council

III. Portfolio Analysis

We use historical data from 1969 to 2015 to estimate the average return on gold and US Treasury assets, as well as their respective variances. The typical assumption that US Treasuries are risk-free is not kept for this purpose of this work, largely because central banks demand Treasuries over the long term and the yields fluctuate over time; hence adding variance to the portfolio. Therefore, it is important to compare the fluctuation of yields and the return on gold. Comparing their relative standard deviations is helpful for analysing which asset contributes to a more stable portfolio of central banks' reserves.

In keeping with the idea that the central bank is focused on the long run instead of actively investing in the short run (e.g. to maintain a currency peg), this paper utilizes annual historical time series data. The mean-variance portfolio helps to determine the optimal percentage of gold that should be demanded given the historical return and the risk as measured by the standard deviation. The primary assumption of this essay is that the central bank seeks to minimize risk associated with holding a combination of two liquid assets – Treasuries and gold. Moreover, the monetary authority has to signal credibly that its balance sheet is stable if it is going to be able to overlook the stability of the entire financial system. This credibility is also reinforced by maintaining a stable and adequate number of months of imports covered in FX reserves.

The proportion of the two-asset portfolio held in gold is w_G and the proportion in Treasuries is w_T, where $w_G + w_T = 1$. The return on the portfolio can be expressed as

$$r_P = w_G r_G + (1 - w_G) r_T \quad (1)$$

where r_G is the average historical return on gold from 1969 to 2015 and r_T represents the average yield or return on Treasuries for the same period; r_T is calculated by taking the average of the 3-month Treasury bill rate, the 1-year rate and the 5-year rate. The standard deviation of the portfolio can be expressed as

$$\sigma_P = [w_G^2 \sigma_G^2 + (1 - w_G)^2 \sigma_T^2 + 2 w_G (1 - w_G) \sigma_G \sigma_T \rho_{GT}]^{1/2} \quad (2)$$

σ_G^2 indicates the historical variance of gold returns, σ_T^2 is the historical variance of the average Treasury yields, and ρ_{GT} is the correlation coefficient.

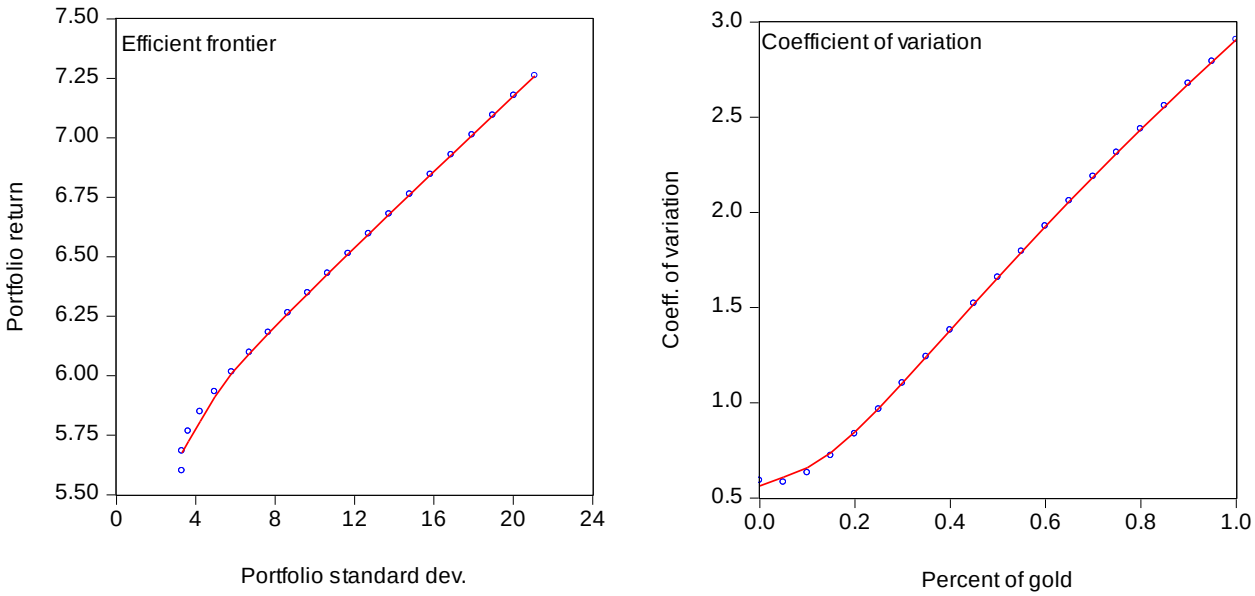
Table 2 presents a statistical summary of the annual return on gold and Treasury yields. The mean return on gold is higher at 7.26 per cent compared with 5.6 per cent for Treasuries. However, the median return on Treasuries (5.64 per cent) is slightly higher suggesting less variability in Treasuries. The relative certainty of the Treasury yields is indicated by the relatively lower standard deviation and coefficient of variation (CV). The CV for Treasuries is only 0.59 while that of gold returns is 2.91 because the standard deviation of gold returns is greater than its mean. The Jarque-Bera test for normality indicates that the null of normality of Treasury returns cannot be rejected given the high p-value of 0.682. On the other hand, the null hypothesis of normally distributed gold returns can only be rejected at the 10 per cent level of significance. Overall, the Jarque-Bera test tends to suggest both series are normally distributed, thereby making mean-variance portfolio analysis more plausible.

Table 2 Descriptive statistics of historical gold returns and Treasury yields

	Gold	US Treasuries
Mean	7.26%	5.60%
Median	5.25%	5.64%
Standard deviation	21.1	3.31
Coefficient of variation	2.91	0.59
Jarque-Bera	5.08 (p-val. = 0.079)	0.75 (p-val. = 0.682)

Figure 1 presents the efficient frontier (left panel) showing the risk-reward profile of combinations of gold and Treasuries. The right panel presents the portfolio's coefficient of variation, which tends to explode as the percentage of gold in the portfolio rises. It is difficult to visually determine the optimal ratio of gold from the chart; therefore, this is calculated from taking the partial derivative of the portfolio variance equation.

Figure 1 Efficient frontier and portfolio coefficient of variation



To obtain the optimal percentage of gold a central bank should demand can be found by taking the partial differentiation of equation 2.

$$\frac{\partial \sigma_P}{\partial w_G} = \frac{1}{2} \frac{[2w_G\sigma_G^2 - 2\sigma_T^2 + 2w_G\sigma_T^2 + 2\sigma_G\sigma_T\rho_{GT} - 4w_G\sigma_G\sigma_T\rho_{GT}]}{[w_G^2\sigma_G^2 + (1-w_G)^2\sigma_T^2 + 2w_G(1-w_G)\sigma_G\sigma_T\rho_{GT}]^{1/2}} \qquad (3)$$

Setting this equal to zero and solving for w_G yields

$$w_G = \frac{\sigma_T^2 - \sigma_G\sigma_T\rho_{GT}}{\sigma_G^2 + \sigma_T^2 - 2\sigma_G\sigma_T\rho_{GT}} = \frac{3.31^2 - (21.1)(3.31)(-0.0077)}{21.1^2 + 3.31^2 - 2(21.1)(3.31)(-0.0077)} \approx 2.5\% \qquad (4)$$

The correlation coefficient between the two assets was found to be -0.0077. Given the calculations reported in Table 2, and the correlation coefficient, the optimal percentage of gold should be approximately 2.5 per cent for central bank portfolio, taking into consideration this institution is more focused on long-term exchange rate management instead of short-term investment activism. As noted earlier, Chen et al (2014) observe there is no direct answer to this question in the literature; therefore, we hope this exercise provides some light on the issue. A detailed review of the literature by O'Connor et al (2015) observes that the optimal percentage for private portfolio to be around 10 per cent gold and gold stocks. Central banks in open emerging economies, of course, hardly ever hold private stocks or more specifically the stocks of

gold companies. In that context, therefore, our value of approximately 2.5 per cent seems reasonable.

IV. Concluding Remarks

This essay applied portfolio theory analysis to determine the optimal quantity of gold central banks in open economies should hold. A policy of accumulating gold also has important implications for monetary policy and exchange rate management, since gold has to be purchased from local miners (and/or citizens owning existing stock) or in the international markets. In the case of the former, the central bank injects domestic currency reserves into the banking system, thereby encouraging the commercial banks to adjust their own asset portfolio allocation. The commercial banks may expand domestic credit, invest in foreign currency assets, purchase more government securities or hoard excess reserves in local currency.

Buying gold in the international market requires exchanging the main vehicle currency such as the US dollar for gold. These topics, of specific relevance to the group of emerging markets in the post global financial crisis environment, are beyond the scope of this paper and they would require more detailed exploration, particularly as it relates to monetary policy. Time-series econometric methods can be utilized to examine the dynamic portfolio adjustments of commercial banks when the central bank buys gold domestically.

References

Chen, Ku-Hsieh; Joe-Ming Lee and Chen-Huan You (2014), "Who upholds the surging gold price? The role of central banks worldwide." *Applied Economics*, Vol. 46 (22): 2557-2575.

Kalyanaraman, Lakshmi (2007), "Should India add more gold to its foreign exchange reserves?" *Social Science Research Network*, Unpublished Working Paper.

Moore, Winston and Adrian Glean (2015), "Foreign exchange reserve adequacy and external shocks." *Applied Economics*, Vol. 48 (6): 490-501.

O'Connor, Fergal; Brian Lucey; Jonathan Batten and Dirk Baur (2015), "The financial economics of gold – a review." *International Review of Financial Analysis*, Vol. 41: 186-205.

Plender, John (2016), "Emerging markets should shift from dollars into gold." *Financial Times*, May 29.

Putnam, Bluford (2004), "Thoughts on investment guidelines for institutions with special liquidity and capital preservation requirements." In C. Bernadell, P. Cardon, J. Coche, F. Diebold and S. Manganelli (editors), *Risk Management for Central Bank Foreign Reserves*, Frankfurt, Germany: European Central Bank.

Rogoff, Kenneth (2016), "Emerging markets should go for the gold." *Project Syndicate*, May 3.