

U.S. Monetary Policy and Central Banks' Physical Gold Reserves: Evidence from a Cross-Country Panel, 2000–2025

Hongjie Cai

*School of Economics and Trade, Zhongnan University of Economics and Law, Wuhan, China
cheongkingtsoi@gmail.com*

Abstract. This study examines the relationship between U.S. monetary policy and adjustments in central banks' physical gold reserves. Unlike the U.S.-dollar value of gold reserves, physical gold tonnage is not mechanically revalued when gold prices change. We construct a quarterly cross-country panel from raw data covering 2000Q1–2025Q4, after lagging and common-sample screening, the effective estimation window is 2000Q3–2025Q4. The empirical specification includes country fixed effects, country-specific linear and quadratic trends, quarterly seasonal indicators, and Driscoll-Kraay standard errors that allow for heteroskedasticity, serial correlation, and cross-sectional dependence. The baseline sample contains 5,832 observations for 65 economies. The coefficient on the one-quarter-lagged effective federal funds rate is -0.0167 and statistically significant at the 1% level. Estimates retain the same direction when the shadow rate is used, additional macroeconomic controls and the U.S. real yield are included, the reserve ratio is winsorized, and the sample begins in 2006. The absolute point estimate for the low-foreign-exchange-reserve group is about 1.94 times that for the high-reserve group, but the interaction is not statistically significant and does not establish a structural difference. After lagged gold holdings are included, the policy coefficient approaches zero, it is also statistically insignificant in first differences. The evidence therefore indicates a negative medium-run association with the level of physical gold reserves, but does not show that central banks actively sell gold in response to a rate increase. The results support rule-based reserve rebalancing across return, liquidity, and safety objectives rather than treating short-run U.S. policy changes as mechanical signals to buy or sell gold.

Keywords: U.S. monetary policy, central bank gold reserves, cross-country panel, shadow rate, reserve management

1. Introduction

International reserve management is shifting from a narrow focus on liquidity toward a broader balance among safety, returns, and strategic resilience. Within the global financial cycle, U.S. monetary policy generates systematic spillovers to financial conditions across economies through cross-border credit, risk pricing, and related channels, with important consequences for central bank reserve allocation [1]. Global central bank gold demand has risen sharply in recent years. Net purchases reached a historical high in 2022 and remained above 1,000 metric tons in both 2023 and

2024. Although purchases declined to 863 metric tons in 2025, they still exceeded the 2010–2021 average. This pattern may reflect greater sanctions risk and stronger demand for reserve diversification [2, 3].

Previous studies have examined the determinants of central bank gold reserves from the perspectives of opportunity cost, safe-haven demand, and related considerations. Two important gaps remain. First, most studies use the U.S.-dollar value of gold reserves or their portfolio share as the dependent variable. Such measures do not isolate passive valuation effects caused by changes in gold prices and therefore cannot clearly identify active changes in physical holdings. Second, the literature relies heavily on static level regressions, rarely distinguishing medium-run level relationships from short-run active adjustment or examining the identification constraints created by a common policy shock [4, 5].

This study uses quarterly panel data for 65 economies from 2000 to 2025. The dependent variable is physical gold tonnage, which avoids the mechanical valuation effects inherent in dollar-denominated reserve measures. Controlling for country fixed effects, country-specific trends, and seasonal indicators, the analysis evaluates the relationship between U.S. monetary policy and central bank gold reserves. The evidence points mainly to a negative medium-run association in levels, with no robust indication of short-run active sales. The study contributes by using physical tonnage to identify quantity adjustments more precisely, comparing static and dynamic specifications systematically, and stating the limits of interpretation explicitly. Section 2 develops the theoretical mechanisms and empirical specification, Section 3 describes the sample and data, Section 4 presents the empirical results, Section 5 discusses the findings, and Section 6 concludes.

2. Theoretical mechanisms and model specification

2.1. Transmission mechanisms and hypotheses

The opportunity-cost channel yields the most direct negative prediction. When the federal funds rate rises, yields on U.S. Treasury securities and other highly liquid dollar-denominated assets generally increase. Gold pays no interest and entails storage, transportation, and transaction costs. If a central bank seeks a higher portfolio return subject to a given safety constraint, gold becomes relatively less attractive. O'Connor et al. [6] show that real interest rates, the U.S. dollar, and uncertainty are central variables in the financial economics of gold. This reasoning leads to the first hypothesis:

H1: Holding other factors constant, U.S. monetary tightening is negatively associated with the level of central banks' physical gold reserves.

Central banks, however, are not ordinary investors. Gold can provide diversification benefits and safe-haven value under extreme market conditions, and its strategic value may increase when confidence in the U.S. dollar or cross-border settlement systems deteriorates. At the same time, economies with limited foreign exchange reserves are likely to face tighter liquidity constraints when dollar financing conditions tighten. In the financial-stability model of Obstfeld et al. [7], reserve demand rises with domestic financial liabilities, measured by M2/GDP, and with capital-account openness. During a tightening phase of the global financial cycle, economies with thinner reserve buffers are more exposed to capital outflows and exchange-rate pressure, making their reserve portfolios more sensitive to external conditions [1]. To preserve their capacity to finance imports, service external debt, and intervene in foreign exchange markets, low-reserve economies may be more inclined to reduce their relatively illiquid gold holdings. By contrast, central banks with ample foreign exchange reserves have more room to absorb short-run gold-price volatility and limited liquidity. This reasoning motivates the second hypothesis:

H2: The negative association between U.S. monetary tightening and physical gold reserves is expected to be stronger for economies with relatively low foreign exchange reserves than for economies with relatively high reserves.

This hypothesis concerns only the direction of heterogeneity, it does not presume that the difference between groups is statistically significant. Gold allocation is also shaped by institutional arrangements, historical holdings, and preannounced purchase programs, while the level of foreign exchange reserves may not fully capture a central bank's capacity to adjust its portfolio.

2.2. Econometric model and identification limits

The baseline model is specified as follows:

$$\ln(1 + Gold_{it}) = \alpha_i + \beta Policy_{t-1} + \gamma Global_{t-1} + \delta Country_{i,t-1} + \lambda_i t + \kappa_i t^2 + Season_t + \varepsilon_{it} \quad (1)$$

$Gold_{it}$ denotes the physical gold holdings, in metric tons, of economy i in quarter t . $Policy_{t-1}$ is the one-quarter-lagged effective federal funds rate (EFFR), the Wu-Xia shadow federal funds rate is used as an alternative policy indicator in the robustness analysis [8]. Global variables include gold returns, $\ln(VIX)$, and the U.S. Treasury interest-burden measure. Country-level variables include exports as a share of GDP, imports as a share of GDP, and foreign exchange reserves as a share of GDP. The term α_i captures time-invariant country characteristics, while $\lambda_i t$ and $\kappa_i t^2$ absorb slowly evolving country-specific trends. $Season_t$ denotes quarterly seasonal indicators. All continuous explanatory variables are lagged by one quarter to mitigate contemporaneous feedback.

The U.S. policy rate takes the same value for every economy in a given quarter. If a complete set of quarterly fixed effects were included, the policy variable would be perfectly collinear with the time indicators and β could not be identified. The model therefore does not include full time fixed effects. Instead, observable common shocks are accounted for through global controls, country-specific trends, and seasonal indicators. Standard errors are estimated using the Driscoll-Kraay procedure with a Bartlett kernel and a maximum lag of four, allowing for heteroskedasticity, serial correlation, and cross-sectional dependence [9]. Because the data are quarterly, four lags span one full year and can accommodate the persistence of monetary-policy and reserve-adjustment disturbances across adjacent quarters. Relative to the 102-period time dimension, this bandwidth also avoids excessive information loss from a longer lag structure. Although the design improves the robustness of inference, it cannot eliminate every omitted shock that moves with U.S. policy. Accordingly, β is interpreted as a conditional association rather than a strict causal effect.

For the heterogeneity analysis, economies are divided into high- and low-reserve groups at the median of each economy's sample-period mean of foreign exchange reserves as a share of GDP. The following interaction model is then estimated:

$$\ln(1 + Gold_{it}) = \dots + \beta_1 Policy_{t-1} + \beta_2 (Policy_{t-1} \times HighReserve_i) + \dots + \varepsilon_{it} \quad (2)$$

The policy slope for the low-reserve group is β_1 , whereas that for the high-reserve group is $\beta_1 + \beta_2$. The coefficient β_2 directly tests whether the two slopes differ significantly.

3. Sample, variables, and descriptive statistics

3.1. Sample and data processing

The raw dataset covers 104 quarters (2000Q1–2025Q4), 89 economies, and 16 variable sheets. The United States is both the source of the policy variable and an exceptionally large holder of monetary gold. It is therefore removed first to prevent it from exerting disproportionate leverage on the cross-country relationship, leaving 88 economies. Physical gold holdings, the lagged EFFR, gold returns, $\ln(\text{VIX})$, the U.S. Treasury interest burden, exports/GDP, imports/GDP, and foreign exchange reserves/GDP are then merged by economy and quarter, and a complete-case procedure is used to construct the baseline common sample. Because 23 economies lack one or more baseline controls, particularly exports, imports, or foreign exchange reserves, the final sample contains 65 economies, 5,832 observations, and 102 quarters. It is an unbalanced panel spanning 2000Q3–2025Q4. Among the available physical-gold observations after the United States is excluded, 75 of 8,881 nonmissing records are zero, a share of 0.84%. These zeros occur mainly in the early periods for economies that had either not yet reported official holdings or held no official gold. The baseline common sample contains 15 zero observations, or 0.26%, all from Paraguay and Hungary. The transformation $\ln(1 + x)$ retains these observations while limiting the influence of very large holdings.

The data sources and variable definitions are as follows. Physical gold reserves are drawn from official World Gold Council statistics [3], the EFFR is obtained from FRED, the Wu-Xia shadow rate is from the Federal Reserve Bank of Atlanta, VIX is from CBOE, balance-of-payments, foreign exchange reserve, and exchange-rate variables follow IMF IFS/BOP definitions, and GDP and selected interest-rate series follow CEIC definitions. All series are converted to quarterly frequency and merged by economy and quarter. Because CEIC and certain other commercial databases impose licensing restrictions, the underlying restricted series are not redistributed. Public sources, variable definitions, and sample-screening rules are provided in Table 1.

3.2. Variable definitions and descriptive statistics

Table 1 defines the core variables. The dependent variable is physical tonnage rather than a dollar value, which is the main distinction between this study and studies based on valuation measures. U.S. Treasury safety is proxied by interest expenditure as a share of current fiscal revenue, a larger value indicates a heavier debt-service burden. Foreign exchange reserves as a share of GDP have a pronounced right tail, so the robustness analysis winsorizes this variable at the 1st and 99th percentiles.

Table 1. Variable definitions and data sources

Category	Variable	Definition	Main source
Dependent variable	Gold reserves	Central bank physical gold holdings (metric tons), $\ln(1 + x)$ in regressions	World Gold Council
Policy variable	EFFR	Effective federal funds rate, %	FRED
Alternative policy variable	Shadow rate	Wu-Xia shadow federal funds rate, %	Federal Reserve Bank of Atlanta
Global controls	Gold return, $\ln(\text{VIX})$, U.S. Treasury burden	Quarterly return, log volatility index, interest expenditure/fiscal revenue	WGC, CBOE, CEIC
Country controls	Exports, imports, foreign exchange reserves	Each as a share of GDP, %	IMF, CEIC

Table 1. (continued)

Additional controls	GDP growth, exchange rate, financial account, real yield	Quarterly growth rate or GDP share	IMF, CEIC, FRED
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Table 2 presents descriptive statistics for the main variables. Physical gold holdings vary substantially across economies, with a mean of 230.64 metric tons and a standard deviation of 570.32 metric tons. After the logarithmic transformation, the standard deviation falls to 2.03. The mean EFFR is 2.01%, while the mean shadow rate is 1.53%. Foreign exchange reserves as a share of GDP are highly dispersed, partly because of a small number of financial centers, the standard deviation reaches 459.81 percentage points, indicating that estimates based on the raw ratio may be sensitive to extreme observations. Over the sample period, the EFFR covered the post-financial-crisis zero-rate period, renewed easing after the pandemic, and rapid tightening beginning in 2022. Aggregate physical gold holdings in the 65-economy baseline sample trended upward over the same period, although they did not fall during every tightening episode. Figure 1 is descriptive and cannot substitute for regression evidence that controls for country-specific trends.

Table 2. Descriptive statistics

Variable	N	Mean	Std. dev.	Minimum	Maximum
Gold reserves (metric tons)	9,049	230.640	570.324	0.000	3,468.601
$\ln(1 + \text{gold reserves})$	9,049	3.586	2.025	0.000	8.152
EFFR (%)	9,152	2.008	2.024	0.060	6.520
Shadow rate (%)	9,152	1.533	2.486	-2.922	6.439
Gold return (%)	9,064	2.940	6.859	-21.510	17.300
VIX	9,152	19.837	7.363	10.310	58.750
U.S. Treasury interest burden	9,152	0.155	0.023	0.124	0.220
Exports/GDP (%)	6,009	46.929	33.887	6.480	240.231
Foreign exchange reserves/GDP (%)	6,328	98.539	459.807	0.332	17,362.652

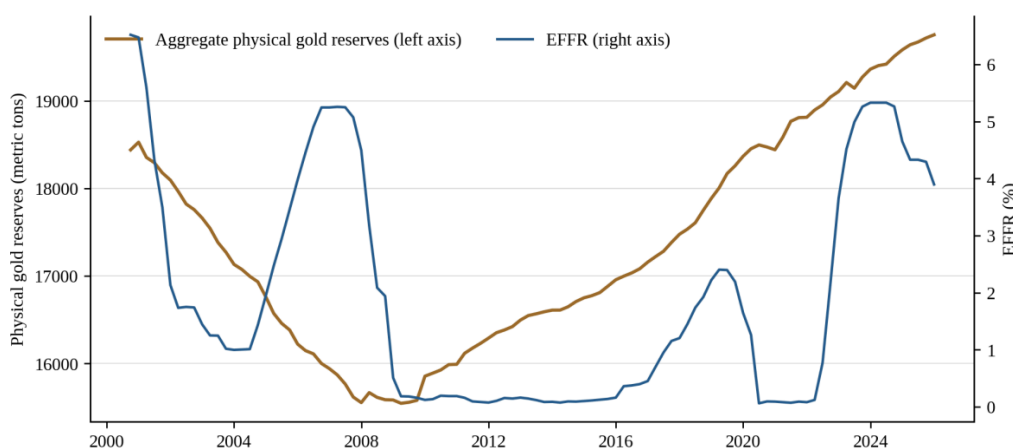


Figure 1. U.S. policy rate and physical gold reserves in the 65-economy sample

Note. Gold reserves are the quarterly sum of physical holdings across the 65 economies included in the baseline estimation and exclude the United States. EFFR denotes the effective federal funds rate.

4. Empirical results and heterogeneity analysis

4.1. Baseline results

Table 3 introduces the controls sequentially. With only country fixed effects, country-specific trends, and seasonal indicators, the EFFR coefficient is -0.0130 ($p = 0.0026$). Adding the global controls produces a coefficient of -0.0149 ($p = 0.0092$). After exports, imports, and foreign exchange reserves are added, the baseline coefficient is -0.0167 , with a Driscoll-Kraay standard error of 0.0059 and a p value of 0.0059. Because the dependent variable is $\ln(1 + \text{physical gold holdings})$, a 1-percentage-point rise in the EFFR is associated with an approximately 1.66% decrease in $1 + \text{physical gold holdings}$ [$\exp(-0.0167) - 1$]. A mechanical conversion at the baseline-sample mean of 298.22 metric tons implies holdings lower by about 4.96 metric tons. This calculation is only an illustration of economic magnitude, it does not mean that a typical central bank immediately sells 4.96 metric tons of gold following a single rate increase. The three specifications yield similar signs and magnitudes, supporting H1 in the static level model.

Table 3. Baseline regression results

Variable/statistic	M1	M2	M3 Baseline
L1.EFFR	-0.01297^{***}	-0.01493^{***}	-0.01670^{***}
DK standard error	(0.00420)	(0.00562)	(0.00593)
p value	0.0026	0.0092	0.0059
Global controls	No	Yes	Yes
Country controls	No	No	Yes
Country fixed effects	Yes	Yes	Yes
Country-specific quadratic trends and seasonal indicators	Yes	Yes	Yes
Observations	5,832	5,832	5,832
Economies	65	65	65
Within R^2	0.0777	0.0796	0.0832

Note. Driscoll-Kraay standard errors are reported in parentheses, with a maximum lag of four. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. All explanatory variables are lagged by one quarter.

The economic interpretation of the coefficient should be treated with caution. First, it describes a difference in reserve levels conditional on the included controls, it does not imply that a particular rate increase immediately triggers gold sales of the same proportion. Second, central bank gold reserves are highly persistent, and transactions in gold reserves are relatively infrequent. A static model may therefore map gradual portfolio rebalancing or omitted trends into the policy coefficient. Third, because the analysis uses physical tonnage, the negative coefficient cannot be explained mechanically by a rate-induced fall in the gold price and a corresponding decline in the dollar value of gold reserves. This strengthens the quantity interpretation, but it does not eliminate common macroeconomic shocks. For example, a simultaneous shift in global risk appetite may affect both the U.S. policy stance and central banks' willingness to purchase gold.

4.2. Robustness and dynamic tests

Table 4 reports several alternative specifications, and Figure 2 plots the policy coefficients and their 95% confidence intervals. Replacing the EFFR with the shadow rate yields a policy coefficient of -0.0160 , significant at the 1% level, suggesting that the zero lower bound is unlikely to drive the main result. Adding GDP growth, exchange-rate changes, and the financial account gives a coefficient of -0.0106 ($p = 0.0329$), while adding the U.S. 10-year real yield gives -0.0118 . The coefficient also remains negative and significant at the 5% level when the foreign exchange reserve ratio is winsorized at the 1st and 99th percentiles and when the sample begins in 2006. Thus, the baseline negative association is not wholly attributable to a single policy indicator, extreme reserve ratios, or the earliest observations.

Table 4. Robustness and dynamic tests

Model	Policy coefficient	DK standard error	p value	Observations
M4 Shadow rate	-0.01596^{***}	0.00386	0.0001	5,832
M5 Additional macro controls	-0.01063^{**}	0.00491	0.0329	4,667
M6 U.S. real yield	-0.01182^{***}	0.00446	0.0095	5,318
M7 Winsorized reserve ratio	-0.01607^{***}	0.00585	0.0071	5,832
M8 Post-2006 sample	-0.01017^{**}	0.00473	0.0345	4,782
M9 Dynamic fixed effects	-0.00046	0.00077	0.5493	5,830
M10 First difference	-0.03609	0.05476	0.5114	4,985

Note. The policy variable in M4 is the shadow rate, all other models use the EFFR. M9 includes the one-quarter lag of the dependent variable. The dependent variable in M10 is $\Delta \ln(1 + \text{physical gold reserves})$.

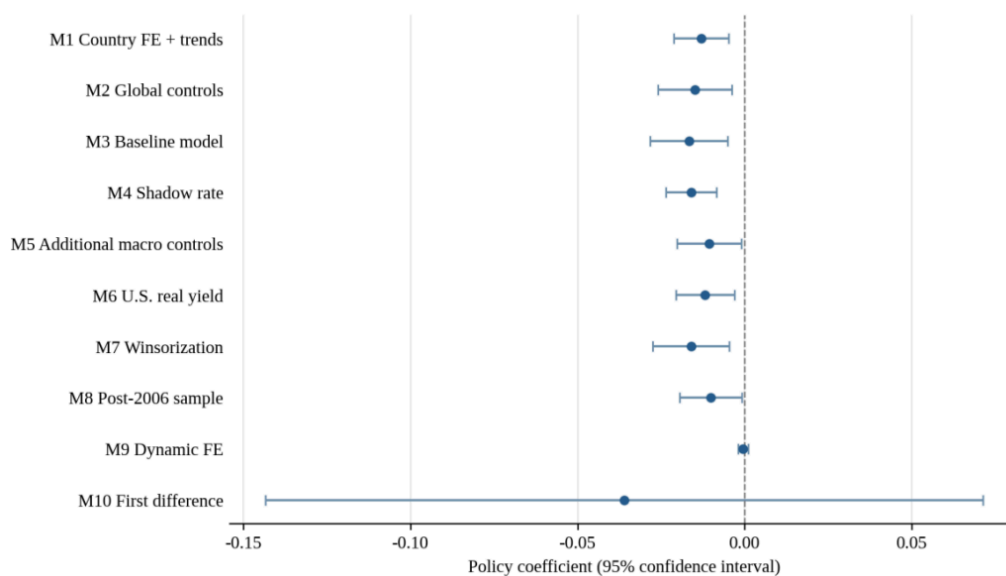


Figure 2. Policy coefficients and 95% confidence intervals across models

Note. Dots indicate policy coefficients, error bars are 95% confidence intervals based on Driscoll-Kraay standard errors. The dependent variable in M10 is $\Delta \ln(1 + \text{physical gold reserves})$, so its coefficient has a different scale and is included only for comparison of direction and interval width.

The dynamic tests, however, substantially narrow the interpretation. After the one-quarter lag of gold reserves is included, the policy coefficient falls to -0.00046 ($p = 0.5493$). When the first difference of log gold reserves is used as the dependent variable, the coefficient is -0.0361 , with a standard error of 0.0548 and a p value of 0.5114. Dynamic fixed-effects estimates may suffer from Nickell bias when the time dimension is limited, while first differencing can amplify measurement error, therefore, neither result provides a simple refutation of the baseline model. Taken together, however, the tests provide no robust evidence that central banks actively reduce their gold holdings in the quarter following a Federal Reserve rate increase. A more defensible conclusion is that U.S. tightening cycles are associated with lower medium-run levels of central bank gold reserves, whereas an immediate adjustment effect cannot be established.

4.3. Heterogeneity by foreign exchange reserves

Table 5 summarizes the heterogeneity results. The policy coefficient is -0.0226 , with a standard error of 0.0064, for the low-reserve group and -0.0117 , with a standard error of 0.0040, for the high-reserve group. In absolute value, the low-reserve point estimate is approximately 1.94 times that of the high-reserve group, which is consistent with the direction predicted by the liquidity-constraint mechanism. However, when the interaction between the EFFR and the high-reserve indicator is included in the pooled sample, its coefficient is 0.0110 ($p = 0.5631$), so the null hypothesis of equal slopes cannot be rejected. H2 therefore receives only directional support and does not pass the formal test of between-group significance.

Table 5. Heterogeneity by foreign exchange reserves

Estimation sample/term	Coefficient	DK standard error	p value	Observations
Low-reserve group: L1.EFFR	-0.02261	0.00643	0.0006	3,007
High-reserve group: L1.EFFR	-0.01166	0.00405	0.0048	2,825
Pooled sample: L1.EFFR $\times$ high-reserve group	0.01102	0.01900	0.5631	5,832

This result has two implications. On the one hand, low-reserve economies may indeed be more vulnerable to a tightening of dollar liquidity. On the other hand, central bank gold allocation is also influenced by exchange-rate regimes, reserve adequacy, geopolitical risk, and long-run diversification objectives [2, 7]. Dividing economies only by foreign exchange reserves as a share of GDP may therefore be insufficient to identify a clear structural difference. Comparing statistical significance across groups without formally testing the interaction would invite the mistaken inference that a significant estimate and an insignificant estimate necessarily differ significantly. The point-estimate gap is therefore not presented as confirmed heterogeneity.

5. Discussion and policy implications

The findings are consistent with the proposition that higher interest rates increase the opportunity cost of holding gold. The dynamic tests nevertheless provide no evidence that central banks trade gold around individual policy meetings in the manner of short-term, transaction-oriented investors. A more plausible interpretation is that U.S. tightening gradually affects annual or medium-term allocation plans through dollar funding costs, foreign exchange liquidity, and the return on reserve portfolios, while safe-haven demand offsets part of the negative effect. The static coefficient is the net result of several opposing mechanisms and should not be treated as a structural parameter for a single channel.

The results have three implications for reserve management. First, gold allocation should be guided by a strategic target range rather than short-run interest-rate signals. Central banks can define upper and lower bounds for gold based on liquidity coverage, external-debt service, and protection against extreme events, with regular rebalancing. Second, economies with limited foreign exchange buffers should improve the liquidity structure of reserves and reduce mismatches between short-term external debt and import payments, rather than being forced to sell gold during stress. Because the between-group difference is not statistically significant, the point estimates should not be used to define mechanical policy thresholds. Third, central banks should disclose physical tonnage, market value, and the reserve share of gold simultaneously. Tonnage indicates whether holdings actually changed, while value shows how the portfolio's market valuation changed, the two measures are not interchangeable.

The study has four limitations. First, the common U.S. policy variable cannot coexist with complete time fixed effects, so residual global shocks may bias the estimates. Future work could use cross-country exposure to dollar liabilities or trade to construct heterogeneous treatment intensities, apply Jordà's local-projection method, or combine external instruments with the panel design to strengthen causal identification [10]. Second, physical tonnage removes price revaluation but does not directly measure gold's weight in total reserves, future research could report tonnage, market value, and portfolio share together. Third, the model does not include structural variables such as geopolitical risk, sanctions exposure, or central bank independence. Prior evidence identifies sanctions risk as an important recent driver of central bank gold purchases [2], so omission of these variables may still matter. Fourth, the data are quarterly, whereas central bank gold transactions may be executed within annual budgeting or strategic review cycles. Higher-frequency data or event-study designs could better identify short-run adjustment.

6. Conclusion

Using a quarterly cross-country panel for 2000–2025, this study examines the relationship between U.S. monetary policy and central banks' physical gold reserves. In the baseline model, a 1-percentage-point increase in the one-quarter-lagged EFR is associated with an approximately 1.66% lower level of $1 +$ physical gold holdings, for large holders, this is approximately equivalent to a 1.66% lower tonnage. The negative association is robust to the use of the shadow rate, additional macroeconomic controls, the U.S. real yield, winsorization, and a post-2006 sample. The point estimate is larger for low-reserve economies, but the between-group difference is not statistically significant. Once lagged holdings are included or the model is estimated in first differences, the policy coefficient is no longer significant. The evidence therefore supports a medium-run level association rather than the claim that higher rates induce active sales in the following quarter. Central banks should respond to the global financial cycle through rule-based and layered reserve management and should monitor gold tonnage, value, and portfolio share separately. Future research can improve causal identification by exploiting cross-country exposure differences, constructing more complete data lineages, and incorporating geopolitical risk.

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