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Macroeconomic shocks and asymmetric gold price responses: evidence from a developing economy

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Abstract

Purpose – This study examines the asymmetric effects of key domestic macroeconomic shocks – inflation, interest rates, exchange rates and economic growth – on domestic gold prices in Vietnam while incorporating world gold prices as the external price anchor of the market.

Design/methodology/approach – The study uses monthly time-series data over the period 2015–2024 and applies the nonlinear autoregressive distributed lag model.

Findings – The empirical results reveal the existence of a long-run co-integration relationship between gold prices and macroeconomic variables. Inflation and exchange rates exhibit significant asymmetric effects. Interest rates are insignificant in the short run but exert a significant negative impact in the long run, whereas economic growth is significant only in the long run and also has a negative effect. World gold prices have a positive and statistically significant impact in both the short and the long run, highlighting the leading role of the international market in shaping domestic gold prices.

Originality/value – This study differs from previous research by developing a nonlinear analytical framework that links gold prices with multiple macroeconomic factors and by extending the model to include key variables such as inflation, interest rates, exchange rates, economic growth and world gold prices. In particular, it focuses on examining asymmetric effects by comparing the responses of gold prices to positive and negative shocks, thereby clarifying the nonlinear transmission mechanism underlying gold price dynamics in the context of Vietnam.

Keywords Asymmetric impact, Developing economy, Gold prices, Macroeconomic factors, NARDL model

Paper type Research article

1. Introduction

Gold has long occupied a distinctive role in international finance as both an inflation hedge and a safe-haven asset (Baur and Lucey, 2010; Baur and McDermott, 2010; Capie *et al*., 2005). However, these properties are heterogeneous across countries, sample periods and investment horizons (Bredin *et al*., 2015; Erb and Harvey, 2013). This heterogeneity is especially important for developing economies, where inflation expectations, exchange-rate pressure and less developed financial markets can alter household portfolio choices. In Vietnam, gold also has a long-standing cultural and savings function. Domestic gold prices therefore do not merely reflect global commodity prices; they also respond to local macroeconomic conditions, investor sentiment and the institutional features of the domestic gold market.

The Vietnamese context is distinctive for at least two reasons. First, gold transactions are strongly linked to the international market because global gold prices are quoted in US dollars, whereas domestic transactions are conducted in Vietnamese dong. As a result, changes in the VND/USD exchange rate can transmit quickly to the domestic price of gold. Second, the domestic market is shaped by regulation, including Decree No. 24/2012/ND-CP on the

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management of gold business activities (Government of Vietnam, 2012). The designation of SJC gold bars as the national benchmark and restrictions in the domestic market can create a persistent wedge between domestic and world prices. This institutional setting makes Vietnam a useful case for studying whether domestic gold prices adjust differently to positive and negative macroeconomic shocks (Do *et al*., 2023).

The theoretical link between macroeconomic variables and gold prices is well established. Inflation can raise gold demand because it erodes the purchasing power of money and strengthens the hedging motive. Interest rates affect gold through the opportunity cost of holding a non-interest-bearing asset. Exchange-rate movements influence domestic gold prices through both purchasing power parity and import-cost channels. Economic growth affects gold demand through changes in income, risk appetite and portfolio allocation. Finally, world gold prices serve as the external anchor for domestic gold prices. However, these channels need not be symmetric. For example, a rise in inflation or a depreciation of the domestic currency may trigger a stronger defensive demand for gold than that generated by an equivalent fall in inflation or appreciation of the currency.

Previous studies provide valuable evidence on gold as a hedge and safe-haven asset, as well as on the effects of inflation, interest rates, exchange rates and world gold prices. Nevertheless, three gaps remain. First, much of the literature relies on linear autoregressive distributed lag (ARDL), vector autoregression (VAR), vector error correction model (VECM) or generalized autoregressive conditional heteroskedasticity (GARCH)-type specifications, which generally impose symmetric responses to positive and negative macroeconomic shocks. Second, the NARDL studies that do exist often examine a single relationship, such as gold-inflation or gold-exchange-rate dynamics, rather than a broader macroeconomic system (Hoang *et al*., 2016; Do *et al*., 2023). Related studies in the *Journal of Economics and Development* have applied asymmetric and nonlinear approaches to other Vietnamese markets, including the asymmetric impact of world oil prices on macroeconomic variables (Pham and Le, 2020) and the asymmetric reactions of Vietnamese stock markets to global energy-price shocks (Aladwani, 2025), yet the domestic gold market has not been analyzed within such a multivariate asymmetric framework. Third, studies on Vietnam rarely integrate inflation, interest rates, exchange rates, economic growth and world gold prices in a single nonlinear framework while also discussing data-frequency issues, especially the use of interpolated GDP and possible feedback among macroeconomic variables.

This study addresses these gaps by examining the asymmetric effects of macroeconomic shocks on domestic gold prices in Vietnam using monthly data from January 2015 to December 2024. The empirical strategy combines a linear ARDL benchmark with a multivariate nonlinear ARDL (NARDL) model. The ARDL model provides a transparent linear comparison requested in robustness assessment, while the NARDL model decomposes selected macroeconomic variables into positive and negative partial sums to estimate asymmetric short-run and long-run effects. Additional robustness checks are conducted by excluding interpolated GDP, using an alternative lag structure, testing whether world gold price pass-through is asymmetric, estimating pre- and post-COVID ARDL benchmarks and examining feedback through a VAR-based diagnostic.

This study contributes to the literature in three ways. Theoretically, it extends hedge and safe-haven theory by linking gold-price responses with prospect theory, adjustment-cost arguments, sticky expectations and exchange-rate pass-through (Kahneman and Tversky, 1979; Ball and Mankiw, 1994; Shin *et al*., 2014). Empirically, it provides evidence from Vietnam, a developing economy with strong household gold-holding behavior and a regulated domestic gold market. Methodologically, it evaluates nonlinear NARDL estimates against a linear ARDL benchmark and explicitly addresses concerns about interpolated GDP and possible endogeneity. The remainder of the paper is organized as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 describes the data and methodology. Section 4 reports the empirical results. Section 5 discusses the findings. Section 6 concludes the paper.

2. Literature review

2.1 Inflation and gold prices

Inflation is one of the most frequently examined determinants of gold prices. According to Fisher (1930), nominal returns incorporate expected inflation, while purchasing power parity implies that asset prices denominated in domestic currency may adjust when the price level changes. Because gold is not a liability of any government, investors often regard it as a hedge against the erosion of purchasing power (Erb and Harvey, 2013). Empirical evidence generally supports the relevance of inflation for gold prices, although the strength and direction of the relationship vary across countries, time horizons and monetary regimes (Ghosh *et al*., 2004; Worthington and Pahlavani, 2007; Beckmann and Czudaj, 2013; Hoang *et al*., 2016). In Vietnam, inflation and macroeconomic policy shocks remain closely intertwined with broader economic dynamics (Le and Finch, 2022).

Recent studies show that the inflation–gold relationship may be nonlinear. Beckmann and Czudaj (2013) find that the hedging property of gold changes over time, while Batten *et al*. (2014) emphasize that the gold–inflation relationship depends on broader economic conditions. In Vietnam, Long *et al*. (2022) and Do *et al*. (2023) report evidence that inflation and gold prices are connected in a nonlinear and time-varying manner. These findings are consistent with the idea that households and investors react more strongly when inflation rises than when it falls because rising inflation directly threatens real wealth.

H1. Inflation has an asymmetric effect on domestic gold prices. Positive inflation shocks are expected to increase gold prices more strongly than negative inflation shocks reduce them.

2.2 Interest rates and gold prices

Interest rates influence gold prices mainly through the opportunity cost channel. Because gold does not generate interest income, higher interest rates increase the relative attractiveness of bank deposits, bonds and other interest-bearing assets. Keynes (1936) and Tobin (1958) provide the theoretical basis for liquidity preference and portfolio allocation under risk, suggesting that investors rebalance their portfolios when the reward for holding liquid or interest-bearing assets changes. In this framework, higher interest rates are generally expected to reduce gold demand.

The interest-rate channel may also be asymmetric. A tightening of monetary policy can be interpreted as a signal of inflation control, which may weaken gold demand. Conversely, a decline in interest rates can reduce the opportunity cost of holding gold and may stimulate speculative or precautionary demand, especially during periods of uncertainty. In emerging markets, this response can be amplified by limited financial alternatives and by household preferences for tangible assets. Consistent with this view, recent asymmetric evidence for emerging economies shows that inflation and interest-rate shocks can affect asset prices unequally (Sia *et al*., 2025).

H2. Interest-rate shocks have an asymmetric effect on domestic gold prices. Negative interest-rate shocks (monetary easing) are expected to raise domestic gold prices more strongly than positive interest-rate shocks (monetary tightening) reduce them.

2.3 Exchange rates and gold prices

Exchange rates are central to domestic gold-price formation because world gold is quoted in US dollars. A depreciation of the domestic currency raises the local-currency cost of internationally priced gold, while an appreciation can reduce it. Theories of purchasing power parity and exchange-rate overshooting (Dornbusch, 1976; Rogoff, 1996) suggest that exchange-rate movements can be transmitted into asset prices both through current import-cost effects and through expectations about future monetary conditions. Empirical studies such

as Capie *et al*. (2005) and Sjaastad (2008) also show that gold prices are closely connected with exchange-rate dynamics.

In Vietnam, exchange-rate movements are especially relevant because the domestic gold market is linked to global prices but operates within a regulated environment. When the VND depreciates, investors may view gold as protection against currency risk, which can increase domestic demand in addition to the mechanical local-currency price effect. When the VND appreciates, however, domestic prices may not decline proportionally because of price stickiness, transaction costs and expectations of future depreciation. Evidence for Vietnam confirms that exchange-rate movements pass through into domestic inflation and prices (Pham, 2019).

H3. Exchange-rate shocks have asymmetric effects on domestic gold prices. Positive exchange-rate shocks, interpreted as VND depreciation, are expected to increase domestic gold prices more strongly than appreciation shocks reduce them.

2.4 Economic growth and gold prices

Economic growth affects gold prices through income, portfolio allocation and risk perception. During expansionary periods, rising income can increase demand for gold as jewelry or savings, especially in economies where physical gold remains part of household wealth accumulation (Starr and Tran, 2008). At the same time, stronger growth can shift investors toward productive or risky assets such as equities and business investment. The portfolio theory of Markowitz (1952) and the liquidity-preference framework of Tobin (1958) imply that investors adjust their asset allocation according to risk-return trade-offs and macroeconomic expectations.

The expected sign of GDP growth is therefore ambiguous. In stable expansions, gold may become less attractive as investors prefer higher-yielding assets. In periods of weak growth, uncertainty and precautionary savings may increase demand for gold as a safe asset. This channel may be particularly relevant in Vietnam, where gold is widely used as a household store of value. At the same time, because official GDP data are not naturally available at a monthly frequency, empirical results involving monthly GDP must be interpreted cautiously.

H4. Economic growth has an asymmetric effect on domestic gold prices. Negative growth shocks are expected to raise domestic gold prices more strongly than positive growth shocks reduce them.

2.5 World gold prices and domestic pass-through

World gold prices are the external anchor for domestic gold prices. Since gold is traded internationally and quoted in US dollars, changes in the world price should be transmitted to domestic prices through arbitrage, import-cost and expectation channels. Studies on gold and exchange rates, including Capie *et al*. (2005), Sjaastad (2008) and Ciner *et al*. (2013), confirm that international gold prices and currency movements are closely connected.

However, the degree of pass-through may vary across markets. In Vietnam, domestic prices can deviate from world prices because of regulation, transaction costs and market segmentation. For the baseline model, this study treats world gold prices as a symmetric external price anchor in order to focus the NARDL decomposition on domestic macroeconomic shocks. A robustness check then decomposes world gold prices into positive and negative shocks to examine whether the assumption of symmetric pass-through is empirically reasonable.

Because world gold prices function as the external price anchor of the model rather than as a behavioral channel specific to Vietnam, they are not framed here as a separate formal hypothesis. Instead, the baseline specification includes the world gold price as a symmetric

regressor, and whether its pass-through is in fact asymmetric is examined later as a robustness check (Section 4) rather than as a core hypothesis of the study.

2.6 Asymmetric transmission mechanism

The theoretical foundation for asymmetry comes from behavioral finance and macroeconomic adjustment frictions. Prospect theory argues that agents react differently to gains and losses, with losses generally receiving greater weight than equivalent gains (Kahneman and Tversky, 1979, 1984). In the gold market, this implies that adverse macroeconomic shocks, such as higher inflation or currency depreciation, may produce stronger reactions than favorable shocks of the same size.

Macroeconomic friction provides an additional explanation. Sticky prices, sticky expectations and adjustment costs (Muth, 1961; Rotemberg, 1982; Carroll, 2003; Ball and Mankiw, 1994) imply that prices and beliefs do not adjust instantly or proportionally. In gold markets, adjustment costs, information frictions and precautionary motives can make the response to macroeconomic shocks nonlinear. These arguments support the use of the NARDL framework developed by Shin *et al*. (2014), which separates positive and negative changes and estimates their short-run and long-run effects within a single co-integration model. In the Vietnamese context, asymmetric and nonlinear decompositions have already proved informative for other markets, including stock-return volatility responding asymmetrically to macroeconomic shocks (Nguyen *et al*., 2024) and domestic markets reacting asymmetrically to global commodity-price movements (Aladwani, 2025).

3. Research methodology

This study uses monthly data for Vietnam from January 2015 to December 2024, yielding 120 observations. The dependent variable is the domestic SJC gold price, transformed into natural logarithms and denoted as $y_t = \ln(GOP_t)$. The explanatory variables are inflation (INF), interest rate (INT), the VND/USD exchange rate transformed into natural logarithms ($exr_t = \ln EXR_t$), economic growth (GDP) and the world gold price transformed into natural logarithms ($wgp_t = \ln WGP_t$). Data are collected from the General Statistics Office of Vietnam, the State Bank of Vietnam, Saigon Jewelry Company, the World Gold Council and international databases where applicable.

Because Vietnam's real GDP is officially available at a lower frequency than monthly financial variables, the GDP series used in the monthly model is constructed from lower-frequency information. This choice is reported transparently because interpolation or temporal disaggregation of low-frequency series can create artificial persistence and distort inference in co-integration analysis (Ghysels and Miller, 2014). To address this concern, the empirical design treats GDP-related results cautiously and includes a robustness model that excludes GDP. If the key findings remain similar without GDP, the results are less likely to be driven by the interpolation procedure.

The empirical analysis proceeds in four stages. First, descriptive statistics and time-series plots are used to examine the behavior of the variables. Second, the order of integration is checked using Augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and KPSS tests. The ARDL and NARDL frameworks require that no variable be of order two, I(2). Third, a linear ARDL model is estimated as a benchmark against which the nonlinear model can be compared. Fourth, the main multivariate NARDL model is estimated to identify asymmetric short-run and long-run effects.

The linear ARDL benchmark follows Pesaran and Shin (1999) and Pesaran *et al*. (2001). Let $z_t = (INF_t, INT_t, exr_t, GDP_t, wgp_t)$ denote the vector of explanatory variables. The benchmark error-correction ARDL can be written as

$$\Delta y_t = c + \rho\, y_{t-1} + \theta' z_{t-1} + \Sigma_i \psi_i\, \Delta y_{t-i} + \Sigma_i \gamma_i'\, \Delta z_{t-i} + e_t. \quad (1)$$

The ARDL model is not treated as the main contribution of the paper. Instead, it provides a linear comparison that helps assess whether allowing for asymmetric responses materially improves the empirical explanation of domestic gold-price movements. The maximum lag length for the multivariate ARDL search was kept conservative to preserve degrees of freedom in a sample of 120 monthly observations.

The main specification is a nonlinear ARDL model, following Shin *et al.* (2014). The NARDL model decomposes selected regressors into positive and negative partial sums. For each variable x_t in the set $\{INF_t, INT_t, exr_t, GDP_t\}$, the partial sums are defined as

$$x_t^+ = \Sigma_{j=1}^{t} \max(\Delta x_j, 0), x_t^- = \Sigma_{j=1}^{t} \min(\Delta x_j, 0). \quad (2)$$

The long-run asymmetric relationship is specified as

$$y_t = \alpha_0 + \beta_1 INF_t^+ + \beta_2 INF_t^- + \beta_3 INT_t^+ + \beta_4 INT_t^- + \beta_5 exr_t^+ + \beta_6 exr_t^- + \beta_7 GDP_t^+ + \beta_8 GDP_t^- + \beta_9 wgp_t + u_t. \quad (3)$$

Equation (3) includes all variables in the proposed macroeconomic model. Inflation, interest rates, exchange rates and GDP are decomposed into positive and negative shocks because the theoretical arguments predict asymmetric domestic responses. The world gold price is retained as a symmetric external anchor in the baseline model, while an additional robustness check decomposes wgp_t into positive and negative components to test whether world-price pass-through is itself asymmetric.

The corresponding NARDL error-correction model is estimated by OLS as follows:

$$\Delta y_t = c + \varphi y_{t-1} + \lambda^+ X_{t-1}{}^+ + \lambda^- X_{t-1}{}^- + \eta wgp_{t-1} + \Sigma_i \psi_i \Delta y_{t-i} + \Sigma_i \delta_i{}^+ \Delta X_{t-i}{}^+ + \Sigma_i \delta_i{}^- \Delta X_{t-i}{}^- + \Sigma_i \kappa_i \Delta wgp_{t-i} + \varepsilon_t. \quad (4)$$

In Equation (4), $X_t{}^+$ and $X_t{}^-$ collect the positive and negative partial sums of INF, INT, exr and GDP. The coefficient φ is the error-correction coefficient and is expected to be negative and statistically significant if a long-run equilibrium relationship exists. Long-run coefficients are obtained by normalizing the lagged-level coefficients by the error-correction coefficient. Short-run effects are captured by the coefficients of differenced variables.

Asymmetry is evaluated through Wald tests. Long-run asymmetry is tested by comparing the coefficients of the positive and negative lagged-level components, such as $\beta INF^+ = \beta INF^-$. Short-run asymmetry is tested by comparing the sums of the positive and negative differenced coefficients. These tests are conducted separately for inflation, interest rates, exchange rates and GDP. The baseline NARDL uses *p*(2), q(2) and an alternative *p*(1), q(1) structure is estimated as a robustness check.

Several diagnostics are applied after estimation. Serial correlation is examined using the Breusch–Godfrey test; heteroskedasticity is checked using the Breusch–Pagan/Cook–Weisberg test; functional form is assessed using the Ramsey RESET test; residual normality is examined using a skewness-kurtosis test; and parameter stability is evaluated using CUSUM-type diagnostics where available. The study also reports a no-GDP robustness model to address the interpolation concern, a world-gold-price asymmetry model to test the symmetric pass-through assumption and pre- and post-COVID linear ARDL benchmarks to assess sensitivity across subsamples.

Finally, the ARDL/NARDL approach is interpreted as a conditional dynamic model rather than as a proof of strict exogeneity. The bounds-testing framework is commonly used under a

weak-exogeneity condition for the regressors (Engle *et al*., 1983; Pesaran *et al*., 2001), while lagged dynamics help reduce but do not eliminate simultaneity concerns. Recent ARDL evidence also motivates the use of additional robustness checks when exogeneity is uncertain (McNown *et al*., 2018). To examine possible feedback among variables, the study reports a Toda–Yamamoto VAR-based causality diagnostic (Toda and Yamamoto, 1995). This diagnostic is used only as a robustness and weak-exogeneity check; the substantive interpretation remains focused on the conditional response of domestic gold prices to macroeconomic shocks.

4. Analysis results

Table 1 reports the descriptive statistics and preliminary unit-root evidence for the variables used in the model. The sample contains 120 monthly observations from January 2015 to December 2024. The mean of lnGOP is 3.879, while the mean of lnWGP is 0.630. Inflation, interest rates, exchange rates and GDP growth display visible variation over the sample period, reflecting the macroeconomic shocks surrounding the COVID-19 period and the global inflation episode that began after 2021.

The ADF, Phillips–Perron and KPSS tests show that the variables are a mixture of I(0) and I(1) processes, but none is of order two. Specifically, lnGOP and lnWGP are nonstationary at levels but become stationary after first differencing, while INF, INT, lnEXR and GDP are stationary or close to stationary at levels depending on the test. This mixed order of integration is appropriate for the ARDL and NARDL frameworks.

Table 2 presents the linear ARDL benchmark. The automatic linear ARDL model selected by AIC is ARDL(3,0,2,0,0,1). The error-correction coefficient is negative and statistically significant (ECT $= -0.0779$, $p = 0.020$), suggesting some adjustment toward equilibrium in the linear specification. However, the Pesaran–Shin–Smith bounds test does not reject the null of no-level relationship ($F = 2.032$) and the decision remains no rejection at the 10%, 5% and 1% levels. This indicates that the linear ARDL model provides only weak evidence of a stable long-run relationship.

The manually estimated linear ARDL-ECM with $p(2)$, q(2) produces a similar adjustment coefficient (ECT $= -0.0849$), but most long-run coefficients are statistically insignificant. In the short run, the world gold price is the only variable with clear joint significance ($p < 0.001$). Diagnostic tests also reveal limitations in the linear model: the Breusch–Godfrey test indicates serial correlation at lag 2 ($p = 0.042$), the Ramsey RESET test suggests possible functional-form misspecification ($p = 0.012$) and residual normality is rejected ($p = 0.008$). These results justify the use of the nonlinear NARDL model as the main specification rather than relying on the linear benchmark alone.

Table 3 reports the main multivariate NARDL estimates. The model explains a substantially larger share of short-run changes in domestic gold prices than the manual

Table 1. Descriptive statistics and unit-root checks

Variable	*N*	Mean	SD	Min	Max	ADF level p	PP level p	KPSS stat	ADF diff. p	Inference
LnGOP	120	3.879	0.320	3.481	4.520	0.349	0.226	0.401	0.000	I(1)
INF	120	0.241	0.416	−1.540	1.520	0.000	0.000	0.034	0.000	I(0)
INT	120	0.218	0.416	−1.145	1.915	0.000	0.000	0.027	0.000	I(0)
lnEXR	120	3.373	0.419	1.607	4.661	0.000	0.000	0.036	0.000	I(0)
GDP	120	6.274	2.052	−1.500	15.840	0.019	0.048	0.093	0.000	I(0)
lnWGP	120	0.630	0.239	0.245	1.195	0.193	0.115	0.143	0.000	I(1)

Note(s): ADF and PP tests use trend at levels and no trend for first differences. KPSS reports the lag-4 statistic; none of the variables are I(2)

Table 2. Linear ARDL benchmark

Panel/Item	Statistic	Value	*p*-value/Decision
Automatic ARDL	Selected model	ARDL(3,0,2,0,0,1)	
Automatic ARDL	Observations/R^2/Adj. R^2	116/0.390/0.325	
Automatic ARDL	ECT	−0.0779	0.020
Automatic ARDL	Bounds test F	2.032	No rejection at 10%, 5%, 1%
Automatic ARDL	Long-run lnWGP	0.942	0.022
Manual ARDL *p*(2),q(2)	Observations/R^2/Adj. R^2	118/0.364/0.255	
Manual ARDL *p*(2),q(2)	ECT	−0.0849	0.022
Manual ARDL *p*(2),q(2)	LR INF/INT/EXR/GDP/WGP	−2.486/−2.484/0.272/−0.001/0.612	All insignificant
Manual ARDL *p*(2),q(2)	Short-run joint WGP	$F = 12.14$	0.000
Manual ARDL diagnostics	BG lag2/RESET/Normality	0.042/0.012/0.008	Diagnostic weaknesses

Note(s): The linear ARDL is reported as a benchmark. Diagnostic weaknesses and weak bounds-test evidence motivate the NARDL specification

Table 3. Main multivariate NARDL estimates

Panel/Variable	Coefficient/Test	Value	*p*-value
Model fit	Observations/R^2/Adj. R^2	118/0.579/0.440	
ECT	Error-correction coefficient	−0.3425	<0.001
Level relationship	Joint lagged-level Wald test	$F = 3.55$	0.0006
Long-run INF+	LR coefficient	2.229	0.113
Long-run INF−	LR coefficient	2.612	0.073
Long-run INT+	LR coefficient	−0.626	0.154
Long-run INT−	LR coefficient	−0.293	0.687
Long-run EXR+	LR coefficient	−2.413	0.015
Long-run EXR−	LR coefficient	−3.155	0.033
Long-run GDP+	LR coefficient	−0.008	0.339
Long-run GDP−	LR coefficient	−0.016	0.013
Long-run WGP	LR coefficient	0.329	0.023
Short-run lnWGP	ΔlnWGP	0.342	<0.001
Short-run EXR+	Lagged ΔEXR+	1.774	0.018
Short-run INF+	Lagged ΔINF+	−1.672	0.027
Asymmetry tests	LR INF/INT/EXR/GDP	0.834/0.458/0.651/0.254	Wald *p*-values
Asymmetry tests	SR INF/INT/EXR/GDP	0.071/0.336/0.106/0.890	Wald *p*-values
Diagnostics	BG lags 1/2/3	0.822/0.935/0.899	No serial corr
Diagnostics	BP/RESET/Normality	0.840/0.170/0.016	Normality weak
Stability	CUSUM-type test	0.660 < 10% critical value	Stable

Note(s): INF, INT, EXR and GDP are decomposed into positive and negative partial sums. WGP is kept symmetric in the baseline model

linear ARDL benchmark (R-squared = 0.579, adjusted R-squared = 0.440). More importantly, the error-correction coefficient is negative and highly significant (ECT = −0.3425, $p < 0.001$), implying that approximately 34.3% of the disequilibrium is corrected within one month. The joint test on the lagged level terms is also significant ($F = 3.55$, $p = 0.0006$), supporting the presence of a long-run relationship in the nonlinear specification.

Because this statistic is an OLS Wald statistic rather than a standard ARDL bound statistic, it is interpreted together with the significant ECT and diagnostic tests.

The long-run NARDL results show that exchange-rate shocks and the world gold price are the most robust determinants of domestic gold prices. Positive and negative exchange-rate components are both statistically significant, with long-run coefficients of −2.413 ($p = 0.015$) and −3.155 ($p = 0.033$), respectively. The world gold price has a positive and significant long-run effect (0.329, $p = 0.023$), confirming that the international gold market remains a key anchor for domestic prices. GDP negative shocks also have a statistically significant coefficient (−0.016, $p = 0.013$), while the negative inflation component is marginally significant at the 10% level ($p = 0.073$).

The short-run estimates reinforce the importance of world gold prices. The contemporaneous change in lnWGP is positive and highly significant (0.342, $p < 0.001$), suggesting rapid transmission from global to domestic gold prices. Some lagged nonlinear components are also relevant: lagged positive exchange-rate changes are significant ($p = 0.018$), lagged positive inflation changes are negative and significant ($p = 0.027$) and positive GDP changes are marginally significant in the short run ($p = 0.079$). These short-run effects indicate that domestic gold prices respond not only to international prices but also to selected domestic macroeconomic shocks.

The Wald tests for asymmetry provide more nuanced evidence. In the full NARDL model, long-run asymmetry is not statistically significant for inflation, interest rates, exchange rates or GDP. In the short run, inflation shows marginal evidence of asymmetry ($p = 0.071$) and exchange-rate asymmetry is close to the 10% threshold ($p = 0.106$), while interest rates and GDP show no short-run asymmetry. Therefore, the results should not be interpreted as strong evidence of asymmetric effects for every variable. Rather, the nonlinear model improves the dynamic specification and reveals selected asymmetric responses, especially when robustness checks are considered.

The diagnostic tests support the adequacy of the main NARDL model. The Breusch–Godfrey tests show no serial correlation at lags 1 to 3 (p-values = 0.822, 0.935 and 0.899). The Breusch–Pagan test does not indicate heteroskedasticity ($p = 0.840$) and the Ramsey RESET test does not reject the correct functional form ($p = 0.170$). The CUSUM-type stability test remains within the critical bounds, suggesting parameter stability. The only remaining weakness is residual normality, which is rejected at the 5% level ($p = 0.016$). Given the small monthly sample and the presence of crisis episodes, this limitation is noted but does not overturn the main dynamic results.

The robustness and feedback checks are summarized in Supplementary Table S1, provided in the online Supplementary File. First, to address the reviewer's concern that interpolated GDP may distort long-run estimates, the model is re-estimated without GDP. The no-GDP NARDL remains well behaved: the ECT is negative and highly significant (ECT = −0.3101, $p < 0.001$), and the joint level-relationship test remains significant ($F = 4.04$, $p = 0.0004$). In this specification, the negative inflation component is strongly significant (4.193, $p < 0.001$), the positive interest-rate component is negative and marginally significant (−0.835, $p = 0.050$), both exchange-rate components are significant and the world gold price remains positive and significant (0.365, $p = 0.020$).

The no-GDP model also provides clearer evidence of long-run asymmetry. The long-run asymmetry test for inflation is marginally significant ($p = 0.052$), while the exchange-rate asymmetry test is significant at the 5% level ($p = 0.017$). Short-run asymmetry tests are not statistically significant in this robustness model. These findings suggest that the main conclusions are not driven by the interpolated GDP variable and that the asymmetric exchange-rate channel is more robust when GDP is excluded.

Second, an alternative NARDL lag structure, $p(1)$, q(1), is estimated. The ECT remains negative and statistically significant, but the asymmetry tests are not significant for inflation, interest rates, exchange rates or GDP. This indicates that the evidence of asymmetry is sensitive to lag structure and should be interpreted cautiously. Third, the world gold price is

decomposed into positive and negative partial sums to test whether the baseline symmetric treatment of lnWGP is appropriate. The long-run symmetry test ($p = 0.650$) and the short-run symmetry tests ($p = 0.127$) fail to reject symmetry, supporting the baseline decision to keep world gold prices symmetric.

Fourth, pre- and post-COVID linear ARDL benchmarks are estimated as additional checks. In the pre-COVID subsample, the ECT is negative and significant and world gold prices remain strongly significant, but the bounds test does not reject the null of no-level relationship. In the post-COVID subsample, the ECT is again negative and significant, exchange rates become more relevant in the long run and world gold prices remain important in the short run; however, the bounds test evidence is still weak or inconclusive. These subsample results reinforce the view that the linear ARDL is useful as a benchmark but does not fully capture the nonlinear dynamics of the Vietnamese gold market.

Finally, the VAR-based feedback diagnostic provides a cautious check on weak exogeneity. Inflation and interest rates jointly help predict changes in LnGOP ($p = 0.033$ and $p = 0.049$, respectively), while exchange rates, GDP and world gold prices do not show significant predictive effects in the LnGOP equation. In the reverse direction, LnGOP significantly predicts GDP ($p = 0.009$), but not inflation, interest rates, exchange rates or world gold prices. These results suggest that some feedback exists, particularly around GDP, so the ARDL/NARDL estimates should be interpreted as conditional dynamic relationships rather than strict causal effects.

Overall, the empirical evidence supports the use of the NARDL framework. The linear ARDL benchmark provides limited evidence of a long-run relationship and shows diagnostic weaknesses, whereas the main NARDL model has a stronger error-correction mechanism, better diagnostics and economically meaningful long-run effects for exchange rates, GDP downturns and world gold prices. The no-GDP robustness check further strengthens the findings by showing that the main results do not depend on the interpolated GDP variable. The evidence for asymmetry is strongest for the exchange-rate channel in the no-GDP model and weaker for other variables, so the results are best interpreted as selective rather than universal asymmetry.

The empirical evidence can now be mapped directly onto the study's hypotheses. H1 (asymmetric inflation effect) receives partial and specification-sensitive support: the negative inflation component is strongly significant once interpolated GDP is excluded ($p < 0.001$) and marginal in the main model ($p = 0.073$), short-run inflation asymmetry is marginal in the main model ($p = 0.071$) and long-run inflation asymmetry is marginally significant only in the no-GDP model ($p = 0.052$). H2 (asymmetric interest-rate effect) is not supported in the main model, where the interest-rate components and the asymmetry tests are all insignificant and receives only weak support in the no-GDP specification, in which the positive interest-rate component is marginally significant ($p = 0.050$). H3 (asymmetric exchange-rate effect) is the best-supported asymmetry hypothesis: both exchange-rate components are significant across specifications, and the long-run asymmetry test is significant in the no-GDP model ($p = 0.017$), although it is not significant in the full model. H4 (asymmetric growth effect) is only partially supported, since the negative long-run GDP component is significant ($p = 0.013$), consistent with a safe-haven interpretation, but the formal asymmetry tests are insignificant and this channel must be interpreted cautiously because monthly GDP is interpolated. Finally, the symmetric treatment of world gold prices is confirmed: decomposing world prices into positive and negative components does not reject symmetry (long-run $p = 0.650$; short-run $p = 0.127$), while the world gold price itself exerts a strong and stable positive effect on domestic gold prices.

5. Discussion

The empirical findings provide a more nuanced picture than the simple claim of universal asymmetry. The linear ARDL benchmark gives only weak evidence of a stable long-run

relationship and shows several diagnostic weaknesses, whereas the NARDL specification produces a stronger error-correction mechanism, better residual diagnostics and economically meaningful long-run effects. This comparison directly supports the use of the nonlinear framework proposed by Shin *et al*. (2014) while also indicating that asymmetry is selective rather than present in every macroeconomic channel.

For inflation, the results are consistent with the view that gold plays a hedging role, but the evidence is not uniformly strong in the full model. The negative inflation component is marginally significant in the main NARDL, and the short-run Wald test for inflation asymmetry is significant only at the 10% level. When GDP is excluded, however, the inflation channel becomes stronger and the long-run asymmetry test is close to conventional significance. This pattern is consistent with Do *et al*. (2023) and Hoang *et al*. (2016), who show that the gold–inflation relationship is nonlinear and context-dependent rather than mechanically stable across all specifications.

The interest-rate channel is weaker than predicted by the simple opportunity-cost theory. In the full NARDL model, interest-rate components are not statistically significant in the long run or short run. In the no-GDP robustness model, the positive interest-rate component becomes negative and marginally significant, suggesting some evidence of an opportunity-cost effect. Overall, the results imply that interest-rate policy may influence gold demand, but this channel is less robust than the exchange-rate and world-price channels. This is plausible in Vietnam, where household gold-holding behavior, regulated gold-market conditions and limited portfolio substitution can dampen the short-run effect of policy rates.

Exchange rates constitute the most robust domestic macroeconomic channel. Both exchange-rate partial sums are significant in the main NARDL model, and the no-GDP model provides significant evidence of long-run exchange-rate asymmetry. The estimated signs should be interpreted as conditional effects after controlling for world gold prices and other macroeconomic variables, rather than as a raw bivariate pass-through coefficient. Economically, the findings confirm that exchange-rate conditions matter strongly for domestic gold-price dynamics in a market where world gold is quoted in US dollars and domestic prices are paid in Vietnamese dong. This supports the argument that currency-market conditions and gold-market regulation jointly shape Vietnam's domestic gold price.

The GDP results should be interpreted with particular caution because monthly GDP is constructed from lower-frequency information. In the full NARDL model, the negative GDP component is significant in the long run, suggesting that weaker real activity is associated with stronger gold-market adjustment. This is consistent with the safe-haven interpretation: when real economic conditions deteriorate, households and investors may rely more on gold as a store of value. However, because the no-GDP model remains stable and produces stronger diagnostics, the paper treats GDP-related findings as supportive rather than central evidence.

World gold prices are the clearest external determinant of domestic gold prices. The world-price coefficient is positive and significant in the main NARDL and remains significant in the no-GDP robustness check. Moreover, decomposing world gold prices into positive and negative partial sums does not reject symmetry in either the long run or the short run. This supports the baseline treatment of lnWGP as a symmetric external anchor and confirms that international price movements transmit rapidly into Vietnam's domestic market, even though regulation and market segmentation may affect the degree and timing of pass-through. This dominant role of external price shocks is consistent with evidence published in the *Journal of Economics and Development*, *which shows* that global commodity-price shocks are transmitted asymmetrically to Vietnamese macroeconomic and asset-market outcomes (Pham and Le, 2020; Aladwani, 2025).

The robustness and feedback checks also qualify the interpretation of the results. The no-GDP specification addresses the reviewer's concern that interpolated GDP may distort persistence and long-run estimates. The alternative p(1), q(1) model shows that the evidence for asymmetry is sensitive to the lag structure, which reinforces the need for caution. The pre- and post-COVID ARDL benchmarks indicate that linear relationships are unstable across

subsamples. Finally, the VAR-based diagnostic reveals some feedback, especially from LnGOP to GDP, so the findings should be read as conditional dynamic relationships rather than strict causal effects.

Taken together, the results refine the theoretical contribution of the paper. Gold-price responses in Vietnam are nonlinear, but the nonlinearity does not imply that all macroeconomic shocks generate strong asymmetric effects. Instead, the evidence points to a hierarchy of channels: world gold prices provide the dominant external anchor; exchange-rate conditions provide the strongest domestic macroeconomic channel; inflation matters but is specification-sensitive; interest rates are comparatively weak; and GDP-related effects are informative but must be treated cautiously because of data-frequency limitations.

6. Conclusion

This study examines the effects of inflation, interest rates, exchange rates, economic growth and world gold prices on domestic gold prices in Vietnam from January 2015 to December 2024. To respond to the limitations of symmetric linear models, this paper compares a linear ARDL benchmark with a multivariate NARDL framework that allows positive and negative macroeconomic shocks to have different effects. The empirical results show that the linear ARDL benchmark provides limited evidence of a stable long-run relationship, while the NARDL model produces a stronger error-correction mechanism and better diagnostic performance.

From a policy perspective, the findings suggest that stabilizing the domestic gold market requires attention to both global and domestic channels. Policymakers should monitor world gold prices and exchange-rate conditions closely because these are the most consistent drivers of domestic gold-price movements. Inflation control remains important, but the evidence indicates that inflation effects are nonlinear and specification-dependent. Interest-rate policy alone is unlikely to stabilize the gold market quickly. In addition, improving transparency in the domestic gold market and reducing frictions in price adjustment may help narrow the wedge between domestic and world prices.

Theoretically, the study contributes to the literature by showing that gold's hedge and safe-haven roles in a developing and regulated market are better understood through a nonlinear dynamic framework. The results support the use of NARDL for distinguishing short-run and long-run adjustments, but they also caution against assuming that all macroeconomic variables exhibit strong asymmetry. The contribution is therefore not merely that asymmetry exists but that asymmetry is channel-specific and sensitive to model specification.

The study has several limitations. First, the sample covers only 2015–2024, so longer data may reveal additional regime shifts. Second, the monthly GDP series is constructed from lower-frequency information and although the robustness check excluding GDP reduces this concern, future research could employ alternative real-activity proxies or formal temporal-disaggregation procedures. Third, the model does not include geopolitical risk, gold-market policy changes, investor sentiment, oil prices or uncertainty indices. Finally, the ARDL/NARDL framework identifies conditional dynamic relationships rather than strict causality. Future research could extend the analysis using structural-break models, time-varying parameter methods, volatility models or alternative identification strategies when richer data become available.

Supplementary material

The supplementary material for this article can be found online.

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