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The gold price – Inflation relation in the case of Vietnam: empirical investigation in the presence of structural breaks

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Abstract

Purpose – This paper investigates the relationship between domestic gold prices and inflation in Vietnam based on the monthly series of the gold price index and consumer price index over the period of December 2001–July 2020.

Design/methodology/approach – The co-integration between the domestic gold price and inflation is examined within the autoregressive distributed lag-error correction (ARDL bounds testing) framework. This paper also applies the vector error correction model (VECM) and impulse response function analysis to explore the causal relationship between these two variables. Moreover, since both gold and inflation series are likely to have structural changes over time, a unit root test controlling for significant breaks is employed in this paper.

Findings – Findings from the ARDL bounds testing model suggest the presence of a co-integration between the underlying variables. The VECM indicates that shocks in inflation lead to a negative response to gold prices in the long run. In the short term, only fluctuations in gold prices impact inflation, and this causality is unidirectional.

Research limitations/implications – Gold is regarded as a critical financial asset to preserve wealth from inflation pressure in the case of Vietnam. These findings propose implications for both investors and policymakers.

Originality/value – Empirical results suggest that inflation has a long-term impact on gold prices in the Vietnamese market. In the existence of a permanent inflationary shock, domestic prices of gold respond negatively to this shock; hence, gold can act as a good hedge against inflation in Vietnam.

Keywords Inflation, Gold prices, Vietnam, Structural breaks, ARDL bounds testing model

Paper type Research paper

1. Introduction

Gold has been treasured for its beauty, durability and rarity for thousands of years. People traditionally consider gold a valuable commodity and keep it to preserve their wealth. The demise of the Bretton Woods System in 1971, in which the U.S. dollar was pegged to gold at a fixed rate, reduced the primary role of gold in the financial system. However, to date, gold has been acting as a popular investment channel for many institutional and individual investors (Shahbaz *et al.*, 2014; Wang *et al.*, 2011; Worthington and Pahlavani, 2007).

The relationship between the prices of gold and consumer price inflation (*inflation* for short) has been widely examined in prior works. Jastram (1977) is one of the pioneers in this line of research. He showed that the prices of bread or bricks in terms of gold were stable in the

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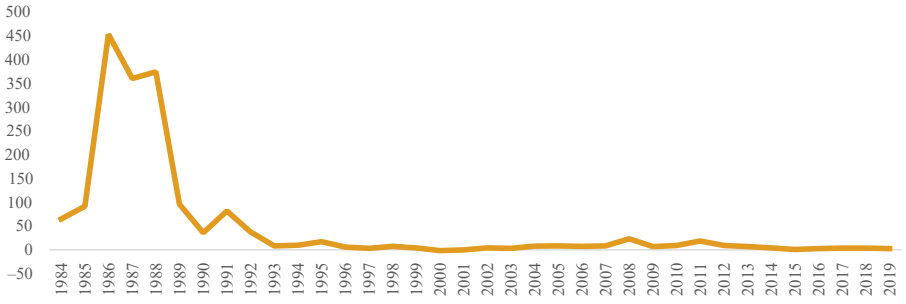
United Kingdom from 1560 to 1976 and in the United States from 1808 to 1976. Recent studies have found various pieces of evidence for the gold price–inflation relation. Ghost *et al.* (2002) provided results in favour of the relationship between the gold prices and the US retail price index in the long term for the period 1976–1999. When Hoang *et al.* (2016) examined the role of gold in six small and large gold markets from 1955 to 2015, they realised the short-run impact of inflation on gold prices in the UK, US and India, but the long-run impacts were not apparent. Shahbaz *et al.* (2014) confirmed that gold was a good investment against inflation in Pakistan in both the short and long terms.

Given the disparity in the aforementioned findings, this study aims to revisit the gold price–inflation linkages in the Vietnamese context. The unique environment of Vietnam is chosen for three main reasons. *First*, Vietnam is one of the largest gold-consuming countries in the world (World Gold Council, 2011/2012/2015). Thus, the impact of inflation on the domestic gold price in Vietnam, if it happens, should be more significant than in smaller gold markets. *Second*, unlike developed countries, an emerging economy like Vietnam has experienced some periods of high inflation. Specifically, the annual growth of the consumer price index (CPI) in Vietnam sharply increased to 23.11% during the 2008 global financial crisis, and then remained at about 10% in the post-crisis period (Figure 1). *Third*, the Vietnamese gold market has witnessed some remarkable co-movements in the gold price index and CPI (Figure 2). It is reasonable to expect a potential relationship between these two underlying variables in Vietnam. This preliminary analysis is further addressed in Section 3 of this article.

This article exhibits the co-integration between gold prices and inflation in Vietnam from December 2001 to July 2020. The ARDL bounds testing model with a break date dummy variable is employed to test if the variables have long-term relationships. The VECM and IRFs are also applied to determine the causality direction of gold and inflation series. From estimated outcomes, the inflation measured by CPI is shown to have a long-term causality to the gold price index. Nevertheless, the short-term impacts stemming from consumer price inflation on gold prices are not apparent in the Vietnamese market. Moreover, the negative response of gold in the presence of permanent shocks from CPI is presented in this article. These findings indicate that gold may act as a good hedge against inflation in the long run, which may offer critical insights for investors and policymakers regarding investment in and management of the Vietnamese gold market.

The rest of the article is structured as follows. Section 2 reviews the related literature and states the study's contribution. Section 3 briefly describes some historical movements of inflation and gold prices in Vietnam. Section 4 discusses the data employed in the study. The empirical method used and the analysis results are provided in Sections 5 and 6. The article ends with some conclusions and policy implications in Section 7.



Source(s): The World Bank data

Figure 1.
Annual consumer price inflation in Vietnam (1984–2019)

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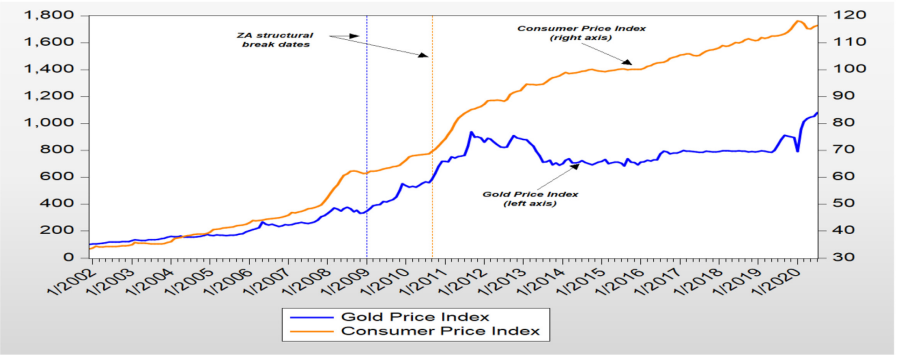

Source(s): The General Statistics Office of Vietnam

Figure 2. Monthly gold price index and CPI in Vietnam (2002–2020)

2. Literature review and study contribution

2.1 Theoretical viewpoint

Some theoretical frameworks confirm the relationship between asset prices (including gold) and inflation. Marx's economic theory played a critical role in the intellectual history of the monetary theory. Marx believes that money has five functions, including a means of hoarding. Marx indicates that "to make the amount of money in actual circulation compatible with the saturability of the circulation domain, the amount of gold and silver available in a country must be greater than the amount of gold and silver that can perform the function of coinage. This condition is realised by the form of the hoarding of money" [1]. Therefore, in history, money in terms of gold and silver was a means to accumulate social wealth and expand one's social rights. This function of money as a hoarding means is considered a hedge against inflation, which decreases the value of money for a long time.

In the classical theory of interest, Fisher (1930) postulates that the expected nominal stock returns should move one for one with the expected inflation. In other words, economic investors will require a nominal return that will compensate for the decline in the purchasing power of money. This so-called Fisher hypothesis is generalised to other investment assets (Fama and Schwert, 1977). It implies that the expected nominal return on any investment asset should be equal to its real return plus the expected inflation rate.

The post-Keynesian theory of asset price inflation suggests that an increase in share market or property values can itself contribute more to general inflationary pressures (through the wealth effect on consumer expenditures), which require a higher base interest rate from the central bank and entail greater economic hardship for those who subsequently lose their jobs (Dalziel, 1999–2000).

Recently, Ghost *et al.* (2002) developed a theoretical framework based on the long-run determinants of the gold price: in a competitive market where gold producers are profit maximisers, the price of gold is equal to the marginal cost of producing gold. If the cost rises due to a rise in the general inflation rate, the price of gold will be at the same rate. Thus, changes in inflation rates have impacts on the domestic gold price.

2.2 Empirical viewpoint

The mutual effects of the gold price and inflation have drawn much interest from international researchers and economists for decades. However, as mentioned in Section 1, the empirical findings on this topic have triggered a controversial debate. These inclusive results depend on the market considered, the time researched and the employed data and method (Wang *et al.*, 2011).

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For the first stream of articles, the impact of inflation on asset prices (including gold) is statistically significant; thus, gold is an inflation hedge. Ghost *et al.* (2002) and Worthington and Pahlavani (2007) applied the co-integration techniques and suggested a long-run relationship between gold prices and the US CPI. Dempster and Artigas (2010) investigated some potential inflation hedges in the US market from 1974 to 2009 and confirmed the role of gold as an efficient hedge and an increase in returns of portfolios. Aye *et al.* (2017) also argued that gold is a good hedge against inflation. Using the UK data from 1257–2016, they showed that co-integration exists between these variables. Greg (2007) analysed whether the gold price is a determinant of inflation in 14 inflation-targeting countries over the 1994–2005 period and suggested the significant impacts of gold price on future inflation in several countries, including Canada. Beckmann and Czudaj (2013) analysed these gold price–inflation linkages in four major countries (US, UK, the Euro area and Japan) from 1970 to 2011. On the basis of the results of the Markov-switching VECM, they emphasised that gold is a long-run inflation hedge. In the case of Pakistan, Tufail and Batool (2013) and Shabaz *et al.* (2014) suggested the short- and long-run impacts of inflation on Pakistan's gold price.

Contrary to the aforementioned studies, the error correction model (ECM) proposed by Magdavi and Zhou (1997) suggested that there was no evidence of co-integration between inflation and London gold prices over the period 1970–1994. In his case study on the US market, Blose (2010) showed results opposite those of the aforementioned articles for the US variables. He used unexpected changes in the CPI to measure inflation and concluded that inflation did not affect the gold prices during the period studied. Similarly, Batten *et al.* (2014) provided estimates from co-integration tests for a sample of data from 1985 to 2012 in the US market and found that there would be no dynamic relationship between inflation and gold prices if the volatile period of the 1980s was excluded from the series. Wang *et al.* (2011) studied the cases of Japan and the US using short- and long-run threshold models and rejected the idea that gold has a role in hedging against inflation in the long run. On the basis of the local monthly gold prices in six small and large gold markets from 1955 to 2015, Hoang *et al.* (2016) analysed the role of gold by conducting non-linear autoregressive distributed lag and showed that there is no long-run equilibrium between gold prices and CPI in China, India and France. Dee *et al.* (2013) conducted quantile and binary probit regression for the case of the China mainland market from 2002 to 2012 and concluded that gold is not a safe hedge against inflation when there are inflation and stock market shocks in the Chinese capital market.

Few Vietnamese studies have been conducted on this issue to date. Vuong (2004) was one of the first to study the inflation and gold prices in Vietnam's transitional economy from 1994 to 2002. However, he analysed the determinants of the domestic gold price (i.e. lagged variables, world gold market) and inflation in Vietnam separately rather than explaining the relationship between gold price and inflation. Long *et al.* (2013) investigated the inflation hedge properties of gold in Vietnam using a sample data set from January 2001 to December 2011. Their regression results support the Fisher hypothesis and suggest that gold is a good hedge against both ex-post and *ex ante* inflation in Vietnam. Using the same time span as that used by Long *et al.* (2013), Nguyen and Siregar (2013) provided different outcomes. They adopted the Markov-switching vector autoregressive framework to estimate the inflationary consequence of gold price with the 2007–2008 global financial crisis as a structural break. They realised that gold price has no impact on inflation during stable periods, but it is a significant determinant of domestic inflation in Vietnam in the post-crisis period.

2.3 Study contribution

This article explores the extent to which the previous studies evaluated the impacts of inflation on the gold price in analysing the case of Vietnam. This article thus contributes to the existing literature in different ways.

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First, most of the previous studies focused on developed countries (e.g. Aye *et al.*, 2017; Batten *et al.*, 2014; Beckmann and Czudaj, 2013; Wang *et al.*, 2011; Worthington and Pahlavani, 2007; Ghost *et al.*, 2002). There have been few studies on developing countries. In fact, in many developing countries, there have been periods of high inflation rates (Schaechter *et al.*, 2000). Thus, the conclusions regarding the gold price–inflation relation in developing economies provide useful implications. Taking the Vietnamese gold market into consideration, this article analyses the price consequences of inflation and fills this literature gap.

Second, economic time series are generally recognised to have a random element or structural break (Patterson, 2000). Estimates not considering the structural break of time series are likely to produce bias (Worthington and Pahlavani, 2007). Unfortunately, not all the previous studies incorporated this important issue when modelling gold prices against inflation (e.g. Dee *et al.*, 2013; Tufail and Batool, 2013). Besides, some previous works for the Vietnamese case (e.g. Long *et al.*, 2013; Nguyen and Siregar, 2013) mentioned structural breaks in series, but no official empirical tests were employed to explain these breakpoints. Thus, there is room for doubt regarding the credibility of these dates. This article applies several structural break tests and the ARDL co-integration model with breakpoints. Hence, the results should be more efficient and reliable.

Last but not least, to the best of the author's knowledge, this article is one of the first attempts to examine the relationship between gold price and inflation in both the short and long terms in Vietnam. Some prior works (e.g. Hoang *et al.*, 2016; Kuma, 2016; Batten *et al.*, 2014) indicated a non-linear relationship between these two variables over time in the international gold markets, but not in Vietnam; thus, this analysis is necessary. The outcomes from the ARDL model show that a co-integration relation exists between the gold price and inflation in Vietnam, but the impacts of inflation on gold are insignificant in the short run.

3. Some stylised facts on inflation and gold trading in Vietnam

3.1 Inflation in Vietnam

In their former planned economy, food, clothes and other essential items were distributed to the Vietnamese people through food stamps and rice books. The failure of the 1985 price–wage–currency adjustment pushed the economy into a severe crisis, resulting in hyperinflation (nearly 500%) in the mid-1980s (Figure 1). To get the country out of the crisis, Vietnam embarked on an economic reform process in 1986. Since then, market competition has steadily increased, with the participation of non-state-owned enterprises. The prices of goods and services are now determined by their demand and supply in the market. The inflation gradually went down and has remained below 10%. However, as a consequence of the 2008 global financial crisis, a price boom occurred in many economies. A large number of countries suffered high levels of financial stress and experienced poor economic performance. Vietnam was not an exception to this. From 2007 to 2011, high volatility in inflation returned to the economy, with annual growth in double-digit rates (except for 2009). Significantly, consumer price inflation grew approximately to 23 and 18.7% in 2008 and 2011, respectively. The high rates of inflation adversely affected the economy (Tuyen, 2018; Vuong, 2004). Hence, in the last few years, the Vietnamese policymakers have focused much more on stabilising prices. Thanks to that, the annual inflation in Vietnam has remained at relatively low rates (2–4%).

3.2 Gold trading and the gold price–inflation relation in Vietnam

Like other Asians, the Vietnamese have a strong preference for gold. Many Vietnamese people preserve gold as a traditional savings mechanism. In Vietnam, gold was even used as a

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unit account for transactions not involving gold, such as real estate, home appliances and automobiles. Understanding this practice, several commercial banks in Vietnam lent gold to the public and mobilised gold in the 2000s. Although these activities are now prohibited by the State Bank of Vietnam [2], keeping gold to preserve one's wealth and investing in gold are still popular among a portion of the population.

Estimates from the World Gold Council show that Vietnam is one of the largest gold-consuming countries in the world. The total consumption demand for gold in Vietnam reached 63.4 tonnes in 2015, the 7th highest globally and the 4th highest in Asia, below only that in China, India and Thailand. As the nation is a large consumer of gold, the Vietnamese gold market has experienced significant fluctuations in gold prices, which had co-movements with changes in inflation. The gold prices and inflation in Vietnam remained relatively stable in the initial period of 2002–2006 (Figure 2), but as mentioned in the previous subsection, the 2008 global crisis brought Vietnam back to the period of high and volatile inflation from 2008 to 2011. In line with the high rates of inflation and the economic volatilities during the crisis period, the gold prices traded in the Vietnamese market witnessed a remarkably increasing trend in the gold price index from 350 to 900 points in 2011. Since then, however, the Vietnamese economy has recovered. Thus, the inflation had been relatively low, with the CPI hovering at around 100 points.

Similarly, the domestic gold prices did not reflect many large fluctuations during this period. The gold price index remained at around 700–800 points before increasing sharply in 2020 due to the global coronavirus disease 2019 pandemic. This upward trend urges the Vietnamese government to implement efficient policies in domestic price stabilisation.

4. Data

This article examines the relationship between gold prices and inflation in Vietnam. The gold prices are measured by the gold price index (Gold). The CPI and its changes represent inflation. Both the gold price index and the CPI are derived from the General Statistics Office of Vietnam for data consistency. Based on the data availability, a monthly data set from December 2001 to July 2020 of these two endogenous variables, for a total of 448 observations, is applied to the model. Given the fact that economic and financial time series are usually non-stable (Fuller, 1996; Phillips and Perron, 1987), the natural logarithms of the series are taken to ensure better properties. These series are seasonally adjusted to remove the influences of seasonal patterns using the X13 procedure in EViews.

The descriptive statistics of the two underlying variables are employed for their natural logarithmic forms and reported in Table A1 of Appendix. The table shows that the mean values for both Gold and CPI are significantly different from zero. In terms of skewness, both series have negative values. This means that the distributions of the Gold and CPI variables have a long left tail around their means. CPI exhibits higher standard deviations and kurtosis than Gold, indicating that consumer prices experienced more fluctuations in the last 18 years than gold prices.

5. Study method

5.1 Unit root and structural break tests

Generally, a stationary time series is defined to have stable probability distributions (Wooldridge, 2016). The order of integration among the variables is determined by the stationarity properties of the data. The stationarity tests are conducted on the natural logarithms of the variables (X_t) in their level and differenced forms. The differenced form for each variable is generated by taking the difference of the variable in the natural logarithm (i.e. $\Delta \ln X_t = \ln X_t - \ln X_{t-1}$).

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The tests for the variable stationarity can be conducted using various methods. However, most of them fail to take into account the possible structural breaks in the data; hence, they may generate biased estimates (Phillips and Perron, 1987). This article employs the unit root test based on Zivot and Andrews's (1992) approach (ZA). The ZA model endogenises a single structural break with the null hypothesis, which is that the investigated variable contains a unit root with a structural break in intercept, trend or both. For comparison purposes, two other unit root tests, the augmented Dickey–Fuller unit root test (ADF) (Dickey and Fuller, 1979) and the Phillips–Perron test (PP) (Phillips and Perron, 1987), which do not consider the structural break issues, are used.

Another merit of the ZA unit root test is that a potential structural point in each series can be provided. As these breakpoints may be important in the gold price–inflation relation, in the next step, further examination is done to check the credibility of these breakpoints. One popular method used in time series to test for a known structural break is the Chow test (Chow, 1960). The null hypothesis in this test is that there is no break at specified breakpoints, which implies that the coefficients of the model do not change with respect to time. The F-statistics can be applied to test this hypothesis. This test requires the homoskedastic error term as the underlying assumption.

5.2 Autoregressive distributed lag error correction model

This article aims to investigate the gold price–inflation relation in the case of Vietnam. As an equilibrium among co-integrated series converges over time, the long-run relationship among the underlying time series can be investigated through co-integration tests. Some co-integration tests are popular in the literature, such as Engle and Granger (1987), Johansen (1991), Stock and Watson (1993) and recently, the ARDL bounds testing model developed by Pesaran *et al.* (2001). The ARDL bounds testing approach has been found to have some merits over other traditional co-integration techniques. First, the former three tests can be applied only if the series are integrated in the same order of integration; the ARDL model, on the other hand, relaxes this condition and can estimate relationships between the series of I(0) and/or I(1). Second, if one co-integration vector is identified, the ARDL model is re-parameterised into ECM, and then the short- and long-run impacts are simultaneously estimated. Third, this procedure has been found to provide more efficient estimates when dealing with small and finite sample data sizes.

Given the numerous advantages of the ARDL model, the impacts of inflation on the gold prices in Vietnam are estimated by applying such a model to the monthly time series from December 2001 to July 2020. The ARDL model requires exogeneity as a precondition (Batten *et al.*, 2014). As gold is not included in the CPI basket measure in Vietnam, this assumption is likely to be satisfied when investigating the Vietnamese series. A limitation of the ARDL procedure, however, is that it cannot accommodate the possible structural breaks in the series. Thus, the dummy variables of structural breaks are added to the models to address this issue.

The presence of co-integration between variables is determined by the ARDL (p, q_1, q_2) specifications without intercepts and trends in Equation (1), as follows:

$$\Delta\ln(\text{Gold})_t = \delta_1 \ln(\text{Gold})_{t-i} + \delta_2 \ln(\text{CPI})_{t-i} + \eta_1 \text{DUM}_{t-\text{i}} + \sum_{i=1}^{p} \alpha_{1i} \Delta\ln(\text{Gold})_{t-i} + \sum_{i=1}^{q_1} \alpha_{2i} \Delta\ln(\text{CPI})_{t-\text{i}} + \sum_{i=1}^{q_2} \eta_{2i} \Delta\text{DUM}_{t-\text{i}} + \text{u}_t \quad (1)$$

where Δ is the difference operator; subscripts $i = 1,2, \ldots, p$, q_1 and q_2 represent the lag orders selected on the basis of the Schwarz information criterion (SIC); subscript t is the month; δ_1, δ_2

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and η_1 correspond to the long-run relationship while α_1, α_2 and η_2 measure the short-run dynamics; u_t is the error term that must be white noise and *ln(Gold)* and *ln(CPI)* are the gold price index and CPI in logarithm forms, respectively. *DUM* is a dummy variable, which is 1 if $t = T_0$; otherwise, 0. T_0 indicates the structural breakpoint provided by the ZA and Chow tests.

The null hypothesis is that the coefficients of the lag level variables are zero, which implies the non-existence of a long-run relationship:

H0. $\delta_1 = \delta_2 = \eta_1 = 0$ (the co-integration relationship does not exist).

against

H1. $\delta_1 \neq \delta_2 \neq \eta_1 \neq 0$ (the co-integration relationship exists).

As the *F*-statistic in this approach is non-standard, Pesaran *et al.*'s (2001) critical bounds are used to test the null hypothesis. If the calculated *F*-statistic falls below the lower critical bound, the null hypothesis of no co-integration cannot be rejected; hence, there is no co-integration between the underlying variables. In contrast, the null hypothesis is rejected if the calculated *F*-statistic is higher than the critical upper bound. If the *F*-statistic lies between the lower and upper critical values, then the outcome is inconclusive.

If there is a long-run relationship between the variables, the ARDL long-run form is estimated using Equation (2):

$$\ln(\text{Gold})_t = \sum_{i=1}^{p} \delta_{1i} \ln(\text{Gold})_{t-i} + \sum_{i=1}^{q_1} \delta_{2i} \ln(\text{CPI})_{t-i} + \sum_{i=1}^{q_2} \eta_{1i} \text{DUM}_{t-i} + \text{v}_t \tag{2}$$

In the last stage, the short-run dynamics are examined by ECM equation:

$$\Delta\ln(\text{Gold})_t = \sum_{i=1}^{p} \alpha_{1i} \Delta \ln(\text{Gold})_{t-i} + \sum_{i=1}^{q_1} \alpha_{2i} \Delta\ln(\text{CPI})_{t-i} + \sum_{i=1}^{q_2} \eta_{1i} \Delta\text{DUM}_{t-i} + \eta_2 \text{ECT}_{t-1} + \theta_t \tag{3}$$

where the lagged error correction term ECT_{t-1} indicates the speed of the adjustment back to long-run equilibrium after a short-run shock. The permanent adjustment requires the estimated coefficient of this term to be statistically significant and negative, implying the existence of a long-run relationship between the variables.

The stability of the ARDL estimates is checked using the Breusch–Pagan–Godfrey test proposed by Breusch and Pagan (1979) and Godfrey (1978) for heteroskedasticity; the Breusch–Godfrey test proposed by Breusch (1978) for autocorrelation; and the cumulative sum (CUSUM) and cumulative sum of squares (CUSUM square) tests proposed by Chow (1960) and Brown *et al.* (1975), respectively, for recursive estimates.

5.3 Causality analysis

It is suggested that at least unidirectional causality occurs between variables if there is a co-integration between them (Morley, 2006). As ARDL does not provide estimates for the causality effects of series, the VECM causality approach (Engle and Granger, 1987) is employed in the next step to estimate the short- and long-run causality linkages between gold prices and inflation in Vietnam. The VECM approach prerequisites the presence of co-integration equations in the models; thus, the method can be employed after the ARDL procedure.

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The causality running from consumer price inflation to gold price inflation is estimated in VECM using the following equation:

$$\Delta \ln(\text{Gold})_t = a_1 + \sum_{i=1}^{p} \alpha_{1i} \Delta \ln(\text{Gold})_{t-i} + \sum_{i=1}^{q_1} \alpha_{2i} \Delta \ln(\text{CPI})_{t-i} + \mu_1 \text{ECT}_{t-1} + \varepsilon_{1t} \quad (4)$$

where Δ, t, *ln(Gold)* and *ln(CPI)* are defined as in Equation (1). The long-run causality associations are provided from estimated parameters μ_1 attached to the error correction terms, ECT_{t-1}. The short-run causality relationship is derived from the parameters α_{1i} and α_{2i} of the lagged variables in differenced forms. The Wald test can be used to determine the joint significance of the short-run relation. The impulse response analysis based on VECM is conducted to determine the direction of movements in the series in the presence of a permanent shock.

6. Empirical findings and discussion

6.1 Results of the unit root tests and structural break tests

SIC is used to select the optimal lags in the ADF and ZA tests. SIC indicates that the appropriate lag length is one and two lags for the *ln(Gold)* and *ln(CPI)* series, respectively. The bandwidth in the PP test is selected according to the Newey–West bandwidth. The unit roots in both the intercept and the trend are taken in these methods. The estimates from the ZA, ADF and PP unit root tests are reported in Table 1.

From Table 1, all the tests suggest that the series of CPI and gold price index have a unit root in the log-level form but are stationary in the first differences. In other words, these variables are integrated of order one, I(1). With this order of integration, this study proceeds with co-integration examination in the ARDL model in the next subsections. The break dates derived from the ZA test suggest that the most significant structural changes for the gold series (in levels) occurred in January 2009 while those for CPI occurred in September 2010. These fluctuations, which are plotted in Figure 2, coincided with the post-crisis period. These breakpoints are re-examined through the Chow test. The outcomes of the Chow test can be seen in Table A2 of Appendix. Chow test results show that the null hypothesis of no structural break for the respective break dates is rejected in both series at a 1% significance level, and that there is no heteroskedasticity in these outcomes. Thus, the results of the ZA *test*

Variables	ADF *t*-statistics	Result	PP *t*-statistics	Result	ZA *t*-statistics	Result	Break point
Logarithm transformed variables							
ln(Gold)	−1.140 (1)	NS	−1.224	NS	−3.666 (1)	NS	January 2009
ln(CPI)	−0.530 (2)	NS	−0.174	NS	−4.994 (2)	NS	September 2010
Differenced transformed variables							
Δ ln(Gold)	−13.290*** (1)	SS	−13.305***	SS	−14.627*** (1)	SS	October 2011
Δ ln(CPI)	−5.808*** (2)	SS	−5.808***	SS	−5.433** (2)	SS	September 2008

Note(s): This table represents *t*-statistics in unit root tests. *** and ** depict the significance at 1% and 5% levels, respectively. ADF refers to the augmented Dickey–Fuller test; PP stands for Phillips–Perron stationary tests; ZA is Zivot–Andrews structural break unit root test. All these tests apply for both Intercept and Trend. The optimal lag is shown in parentheses
NS = non-stationary; *SS* = stationary
$\Delta \ln X = \ln X_t - \ln X_{t-1}$
Source(s): Author's calculation

Table 1. Results of unit root tests

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are reliable. This article uses these break dates to generate the dummy variable in the ARDL model investigating the gold price–inflation co-integration.

6.2 Results from the ARDL bounds testing model

The ARDL model is used based on Pesaran *et al.*'s (2001) approach to examine co-integrated variables, with the gold price index as the dependent variable. The SIC indicates that the optimal lag length is 1 lag for the dependent variable ln(Gold) and 2 lags for the regressors.

The results obtained from the ARDL model are presented in Table 2. From Table 2, when gold is the dependent variable, the calculated F-statistic = 7.774 is higher than the critical upper bound at the 1% level obtained from Pesaran *et al.* (2001). This estimate indicates that there is a co-integration between the gold price index and the CPI in Vietnam for the whole study period. The coefficient of $ln(CPI)_{t-1}$ is 1.580, which is statistically significant at the 1% level, suggesting a long-run effect of inflation on the domestic gold price. Moreover, in the ECM, the error correction coefficient (ECT_{t-1}) of −0.016 shows a low speed of adjustment to equilibrium after a shock. These outcomes confirm the long-term relationship between these two variables. This result is consistent with the view reported by many previous works for international gold markets, such as Ghost *et al.* (2002) for the US; Aye *et al.* (2017) for the UK; Beckmann and Czudaj (2013) for the US, the UK, the Euro area and Japan; and Long *et al.* (2013) for Vietnam.

The short-run analysis in Table 2 reveals that the estimated coefficient of inflation, $\Delta ln(CPI)$, is statistically insignificant (p = 0.159). Thus, inflation has no apparent impact on gold price inflation in the short run. The estimated coefficient of ΔDUM is statistically significant at the 10% level; it confirms the importance of considering the structural breaks in the ARDL model. The results of the stability diagnostic tests for the ARDL model are reported in the lower parts of Table 2. The results of the Breusch–Pagan–Godfrey and LM tests show that the estimates in the ARDL model do not suffer from autocorrelation and heteroscedasticity problems as their F-statistics are both statistically insignificant.

Panel I: bounds testing co-integration results	
Optimal lag structure	ARDL(1,0,0)
Dependent variable	ln (Gold)$_t$
F-statistic	7.774***
1% critical lower bound	3.88
1% critical upper bound	5.3
ln(CPI) $_{t-1}$	1.580***
Panel II: ARDL-ECM analysis	
Optimal lag structure	ARDL(1,0,0)
Dependent variable	Δ ln(Gold)t
Δ ln(Gold)$_{t-1}$	0.984*** (0.000)
Δ ln(CPI) $_{t-1}$	0.025 (0.159)
Δ DUM $_{t-1}$	0.128* (0.092)
ECT$_{t-1}$	−0.016*** (0.000)
Panel III: diagnostic tests	
R^2	0.998
Adjusted R^2	0.998
Breusch–Pagan–Godfrey for heteroscedasticity F-stat	0.422 (0.737)
Breusch–Godfrey for serial correlation (LM test) F-stat	2.079 (0.128)

Note(s): Lower- and upper critical bounds are taken from Case I (no intercept and no trend) of Pesaran *et al.* (2001). ***, ** and * depict the significance at 1%, 5% and 10% levels, respectively. The p-value is shown in parentheses
Source(s): Author's calculation

Table 2. The ARDL regression results

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Moreover, the stability of the estimates from the ARDL model is confirmed by the CUSUM and CUSUM square plots shown in Figure 3. The results suggest that the estimates in the ARDL model are largely between the critical boundaries at 5% significance levels. Thus, the ARDL estimated coefficients can be said to be stable across the researched periods, and the results are reliable.

6.3 Results of the VECM causality approach

The presence of co-integration between the gold price index and the CPI sets the stage for investigating the causal linkages between them. The short- and long-run causality estimates from the VECM estimation are reported in Table 3. As per Table 3, the estimated coefficient of error correction term is negative and statistically significant at the 1% level ($ECT_{t-1} = -1.747$), implying a long-run causality from CPI to the gold price.

The short-term causality is determined by the Wald test. The null hypothesis in the Wald test of the joint insignificance of the short-run parameters is rejected at the 1% significance level as *Δln(CPI)* is the dependent variable, but it is not rejected when *Δln(Gold)* acts as a dependent variable. These indicate a unidirectional short-run causality between inflation in consumer prices and that in gold prices. This shows that inflation causes significant

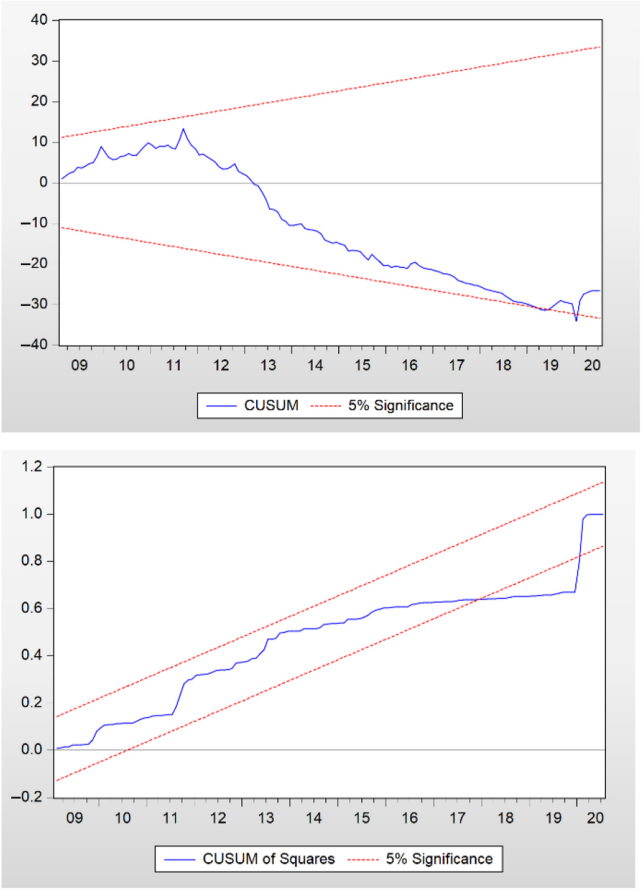

Figure 3.
CUSUM and CUSUM of squares plots of ARDL coefficients

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fluctuations in gold prices in the long term rather than in the short term. This further supports the findings from the ARDL co-integration approach in the previous subsection. The LM test for VECM shows that the model has no serial correlation at lagged variables.

The results of the IRFs analysis are plotted in Figure 4. IRFs reveal the way that the dependent variable (in the level form) responds to permanent shocks occurring in the

Table 3. The VECM causality results

Dependent variables	Wald test for short-run causality (Chi-square)		Long-run causality		LM test for autocorrelation	
	Δ ln(Gold)$_{t-1}$	Δ ln(CPI)$_{t-1}$	ECT$_{t-1}$	t-statistic	LM-stat	Prob. value
Δ ln(Gold)t	–	2.554 (0.110)	−1.747***	−18.863	2.471	0.650
Δ ln(CPI)t	3.768* (0.052)	–				

Note(s): ***, ** and * depict the significance at 1%, 5% and 10% levels, respectively. The p-value is shown in parentheses
Source(s): Author's calculation

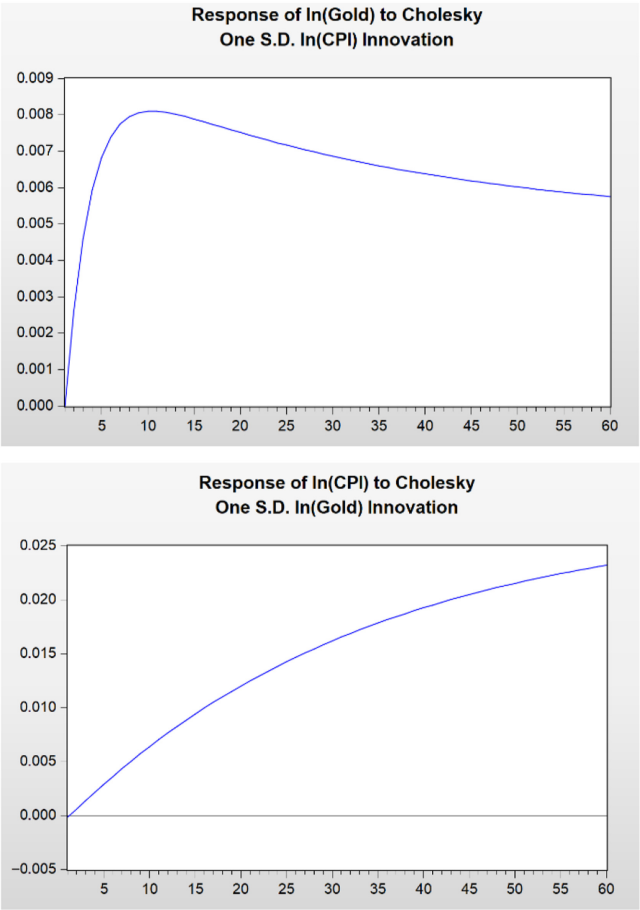

Figure 4. Impulse response function in VECM models

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independent variable. Figure 4 indicates that a hike in CPI leads to a negative response of the gold price index in the long run. More precisely, after an increase in initial periods, the gold price index gradually decreases until the 60th-period limit. The negative long-run causality from the CPI fluctuations to the gold price index confirms the property of gold as an asset that protects investors from devaluing the portfolio returns due to the rising prices of goods and services in the long run. Hence, gold investment can be used as a hedge against the inflation pressure in Vietnam for the study period.

In contrast, the response in the CPI series due to a permanent increase in gold prices is positive for all the limited time horizons. This may stem from the diminishing confidence in holding fiat money as gold prices continuously increase for a long time.

7. Concluding remarks and policy implications

The high volatility of inflation caused by economic uncertainties in recent decades has drawn the interest of economists and policymakers in the relationship between inflation and financial assets such as gold. This article contributes to the existing economic literature by investigating both the short- and long-run relationships between gold prices and inflation in Vietnam. A monthly data set of the gold price index and CPI and their changes for the period from December 2001 to July 2020 is used in this article. Break dates corresponding to the 2008 global financial crisis are empirically investigated using the ZA and Chow tests. The ARDL co-integration approach is applied in the presence of these structural breaks in the time series. The VECM causality approach and IRFs are employed following the ARDL procedure to determine the causal linkages between the variables.

The results of the ARDL approach suggest that consumer price inflation has no impact on gold price inflation in the short run, but a long-run equilibrium exists between these two variables. VECM causality analysis indicates a unidirectional causality between gold price inflation and consumer price inflation in the short run. This means that gold price inflation temporarily causes consumer price inflation, but the impact of CPI on the gold price index is permanent and negative. These outcomes confirm the robustness of the findings from the ARDL model. Thus, investment in gold is considered an effective tool for preserving the value of assets as the real value of money decreases. In other words, gold is a good hedge against inflation in the Vietnamese market for the study period. These outcomes are realistic considering the traditional aspects of gold in Vietnam. The Vietnamese have a strong preference for gold and reserve it to protect their wealth for years rather than considering it a speculative asset. The results of the stability tests indicate that the estimates in this article are reliable.

The findings in this article have important implications. For Vietnamese policymakers, although gold is not measured in the CPI basket in Vietnam, the long-run relationship between these two series suggests that inflation should be controlled well since it affects gold market management, especially during periods of economic turmoil. Moreover, the Vietnamese gold market is largely determined by the psychological factor; that is, Vietnamese people prefer using gold as a hoarding means to an investing channel. This preference may largely reduce the financial resources within the economy and harm economic development in the long term. Thus, gold hoarding should not be encouraged. The Vietnamese government should promote more efficient investing channels to mobilise the gold resources accumulated in the population and stabilise the domestic gold market.

From the perspective of investors, gold can be a good tool for investors to protect their wealth against high volatility in inflation, and investors should care about periods of high inflation as these may lead to fluctuations in gold prices. The strong link between gold price and inflation indicates that investors should diversify their investment portfolios to reduce risks and obtain more returns. From an academic perspective, this article contributes to a

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better application of econometric techniques in the existence of structural breaks in time series to address the co-integration and causality relation between variables.

This article could have provided a more efficient analysis if the historical trading prices of gold rather than the gold price index were employed in the model. However, this kind of data has been unavailable for such a long time in the Vietnamese market. As part of the future work, this article can be extended to investigate the economic determinants of the gold price–inflation relation to suggest further macro policies for managing the gold prices and inflation in Vietnam.

Notes

1. Cited in Wang (2019, p. 187).
2. Pursuant to Circular No. 11/2011/TT-NHNN of the State Bank of Vietnam dated 29 April 2011, commercial banks have been prohibited from lending and depositing gold since 1 May 2011, for gold market management and economy stabilisation.

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Appendix

	ln (Gold)	ln (CPI)
Mean	4.235	6.085
Median	4.362	6.545
Maximum	4.769	6.985
Minimum	3.518	4.612
Standard deviation	0.427	0.711
Skewness	−0.382	−0.640
Kurtosis	1.583	1.868
Number of observations	224	224

Note(s): The summary statistics for a full data set. *ln(Gold)* and *ln(CPI)* stand for Gold price index and Consumer price index in natural logarithmic forms, respectively

Table A1. Descriptive statistics for ln(Gold) and ln(CPI) from December 2001 to July 2020

	Break point	Chow-*F* value	Log likelihood ratio
ln (Gold)	January 2009	988.64***	380.10***
ln (CPI)	September 2010	989.40***	379.95***
Heteroskedasticity test			
F-statistic		2.16	

Note(s): The summary statistics for a full data set. *** depicts the significance at 1%
Source(s): Author's calculation

Table A2. Chow test results for a full sample

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