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Gold investment as an inflationary hedge: Cointegration evidence with allowance for endogenous structural breaks

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Keywords

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Gold investment as an inflationary hedge: Cointegration evidence with allowance for endogenous structural breaks

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Abstract

This note tests for the presence of a stable long-run relationship between the monthly price of gold and inflation in the United States from 1945 to 2006 and from 1973 to 2006. Since both the price of gold and the consumer price index have been subject to structural change over time, a novel unit root testing procedure is employed which allows for the timing of significant breaks to be estimated, rather than assumed exogenous. After taking these endogenously determined structural breaks into account, a modified cointegration approach provides strong evidence of a cointegrating relationship between gold and inflation in both the post-war period and since the early 1970s. The results lend support to the widely held view that direct and indirect gold investment can serve as an effective inflationary hedge.

JEL classification: C22; E31; G11
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1 Introduction

Since breaking through the US$500 per oz. barrier in December 2005 – the first time since 1981 – gold has continued its rise towards US$600 per oz., with long-dormant gold bulls forecasting US$1,000 by 2010 (Charles Schwab 2006). Strong supply and demand fundamentals appear the cause, with the most frequently cited factors being a dollar weakened by high current and capital account deficits and concerns about the escalating cost of the war in Iraq. On the supply side, other factors include the decade-long reduction in global production, exploration expenditure and sales by central banks, while on the demand side, there is booming user demand for jewellery in India and China and asset demand for gold's traditional hedge status to counter global currency and inflation risks.

In response, investors of all ilks have increasingly sought to add gold, both directly and indirectly, to their strategic asset allocation. In the US, for instance, investors can purchase

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coins in the form of American Eagles, Canadian Maple Leafs and South African Kruggerrands or invest in exchange-traded funds like State Street Global Advisors' (2006) US$6 billion StreetTRACKS Gold Shares or iShares (2006) US$690 million Comex Gold Trust (2006) to avoid the buying, storage and insurance problems of bullion. More indirectly, investors can diversify with mutual funds investing in precious metals like US Global Investors' (2006) Gold Shares or World Precious Minerals Fund, Fidelity Select Gold, American Century Global Gold and Vanguard Precious Metals and Mining or take a position in one of the many US and foreign gold mining stocks such as Freeport-McMoRan Copper & Gold, Newmount Mining, Newcrest Mining, Stillwater Mining and Barrick Gold. In Australia, the Australian Stock Exchange (2006) provides an overview of domestic exchange-traded investment opportunities, including Gold Bullion Securities and Perth Mint Gold warrants, while the Perth Mint (2006) has information on holding certificates, depository services and physical delivery opportunities.

A range of benefits are thought to accrue from investing in gold, and these have duly received attention in the literature. Sherman (1986), Jaffe (1989) and Chua et al. (1990), for example, have pointed out the diversification benefits for portfolios including gold investments; Ariovich (1983), Aggarwal et al. (1992), Dooley et al. (1995), Ghosh et al. (2002) and Capie et al. (2005) its efficiency as a hedge against inflation, political unrest and currency risk; and Kolluri (1981), Tschoegl (1980) Solt and Swanson (1981), Ho (1985) and Smith (2002) its market behaviour and forecastability. Koutsoyiannis (1983), Basu and Clouse (1993), Laurent (1994), Levin et al. (1994), Mahdavi and Zhou (1997), Ciner (2001) and Lucey et al. (2004) discuss other investment-related dimensions of this precious commodity.

But it is the view that gold provides an effective hedge against inflation which is the focus of this note, and indeed much of the current hype surrounding gold investment. The conventional wisdom is that because commodities are physical assets, they are the best way to hedge against rising prices which reduce the returns of purely financial assets like stocks and bonds. However, unlike most commodities, gold is durable, relatively transportable, universally acceptable and easily authenticated. Figure 1 plots the monthly US price of gold, the US consumer price index and the 'inflation hedge' price of gold [the price of gold holding constant its 1875 purchasing power] from 1875 to 2006. By breaking through US$562 in January 2006, the average monthly increase in the gold price over the period 1875-2006

(0.2024 percent) has in fact exceeded the average monthly increase in the CPI over the same period (0.2022 percent), providing tantalising support for an effective inflationary hedge over the past one hundred and thirty-one years, at least in the United States [technically gold is only a perfect inflationary hedge when its dollar price rises at the same rate and time as the domestic price index].

Critics would argue, however, that the price of gold has actually only exceeded the inflation hedge price on a small number of occasions - 1875-1879, 1884-1889, 1892-1899, 1974-1975, 1977-1991 and 2006 – and that the bear market since 1992 proved gold was not a good short-run inflation hedge. This is countered by the argument that gold is most effective as a hedge with extremely uncertain inflationary conditions, as during the 1970s and early 1980s. For example, the price of gold peaked at $US825 per oz. during 1979/80 and was immediately followed by a 14.7 percent inflation rate, while in the mid-1980s gold briefly topped $US500 when inflation hit 5 percent.

Unfortunately, extending anecdotal evidence like this to more formal analyses of data over longer periods remains problematic. Part of the problem lies in the fact that while the price of gold "…can quickly incorporate news and events which might affect the expected inflation rate…[the] prices of goods and services included in the CPI-basket, on the other hand, generally adjust more slowly as sellers gradually react to changing market conditions" (Mahdavi and Zhou 1997: 477). For this reason, the price of gold can exhibit movements which are significantly more volatile than the general price level. Nevertheless, although short-run changes in gold price may not necessarily be associated with a change in the price level, the level of these two variables may not drift too far apart in the long-term: that is, they may be cointegrated. However, empirical evidence of a stable long-run relationship has been mixed, with Mahdavi and Zhou (1997: 477) summarising the early literature as follows: "These studies yielded somewhat mixed results regarding the degree of integration of the CPI and the existence of a cointegrating relationship, depending on the stationarity test and the sample period employed". Among the most recent work, Mahdavi and Zhou (1997) concluded that there was no evidence of a cointegrating relationship between gold and inflation over the period 1970-1994, while Ghosh et al. (2002) were unable to establish fully either the order of integration or the presence of a cointegrating relationship.

It is the contention of this note that conventional cointegration techniques such as these are unable to prove the existence of a stable long-run relationship between gold and inflation because they ignore the substantial structural changes associated with the transition of gold from being the basis of the global monetary system, with often heavy official intervention, to a commodity like any other. For much of the nineteenth and the early part of the twentieth century, gold was the standard measure of value (initially as part of a bimetallic standard with silver). Following WWI, the international gold standard, whereby economies fixed an exchange rate between their currencies and gold, gradually crumbled in the face of unrelenting political, social and economic forces. Resurrected under Bretton Woods following WWII, the system again became under pressure with the dollar expressed in terms of a fixed gold price of US$35 per oz. In 1968 a two-tiered gold system was instituted under which the private commodity price of gold was permitted to fluctuate without official intervention, but this system was terminated in 1973 because of the wide variation between ‘official’ prices and market prices, leading to the gold price since then being determined by open market forces.

The purpose of this note is then to assess the long-run inflation hedging properties of gold while taking account of these structural changes to the gold market and its relationship with inflation. The paper itself is divided into four main areas. Section 2 presents the data employed in the analysis. Sections 3 and 4 explain the empirical methodology and present the results. The paper ends with some brief concluding remarks in the final section.

2. Data

The data used are monthly observations on the price of gold, quoted in US dollars per troy ounce, and the monthly US inflation rate over the period January 1875 to February 2006. All information on gold prices and the Consumer Price Index (1982-84=100) used to calculate the inflation rate are from Global Financial Data (2006). The long-term gold price and inflation index series represent composite series with data drawn from a number of official sources, details of which may be found at the data provider’s site. Over the entire sample period the end-of-month price of gold averages $US108 per oz. with a range between $US20 and $US728 per oz. The monthly inflation rate averages 0.20 percent per month, with a range between -3.21 percent and 5.71 percent. The longest time-series used to construct Figure 1 are purely for expositional purposes.

The computational analysis itself is undertaken with respect to two overlapping sub-samples: the first from January 1945 to February 2006 (734 observations), the second from January 1973 to February 2006 (398 observations). The former corresponds to a period coinciding with the formation and eventual breakdown of Bretton-Woods, while the second roughly corresponds with the beginning of the flexible-price period for the price of gold. During the entire post-war sample, the gold price averages $US207 per oz. and monthly inflation averages 0.33 percent; in the smaller sample, the price of gold averages $US349 per oz. and the inflation rate averages 0.39 percent per month. The analysis is undertaken with respect to the natural logs of both series.

3. Unit root tests with endogenous structural breaks

Structural change occurs in many time series for any number of reasons, including economic crises, changes in institutional arrangements, policy changes and regime shifts. An associated problem is that of testing the null hypothesis of structural stability against the alternative of a one-time structural break. Most importantly, if such structural changes are present in the data generating process, but not allowed for in the specification of an econometric model, the results may be biased towards the erroneous non-rejection of the non-stationarity hypothesis (Perron, 1989, 1997; Leybourne and Newbold, 2003).

Zivot and Andrews (1992) propose a testing procedure where the time of the break is estimated, rather than assumed as an exogenous phenomenon. The null hypothesis in their method is that the variable under investigation contains a unit-root with a drift that excludes any structural break, while the alternative hypothesis is that the series is a trend stationary process with a one-time break occurring at an unknown point in time. By endogenously determining the time of structural breaks, Zivot and Andrews (1992) argue that the results of unit root hypotheses previously suggested by earlier conventional tests, such as the widely-employed Augmented Dickey-Fuller test, may be changed.

In this methodology, T_b (the time of break) is chosen to minimize the one-sided t-statistic of α=1. In other words, a break point is selected which is the least favourable to the null hypothesis. The Zivot and Andrews (1992) model endogenizes one structural break in a series (such as y_t) as follows:

$$H_0: \quad y_t = \mu + y_{t-1} + e_t \tag{1}$$

$$H_1: \quad y_t = \hat{\mu} + \hat{\theta}\ DU_t(\hat{T}_b) + \hat{\beta}\ t + \hat{\gamma}\ DT_t(\hat{T}_b) + \hat{\alpha}\ y_{t-1} + \sum_{j=1}^{k} \hat{c}_j \Delta y_{t-j} + \hat{e}_t \tag{2}$$

As can be seen, this model accommodates the possibility of a change in the intercept as well as a broken trend. DU_t is a sustained dummy variable capturing a shift in the intercept, and DT_t is another dummy variable representing a break in the trend occurring at time T_b where

DU_t=1 if $t > T_b$, and zero otherwise and DT_t is equal to (t-T_b) if (t > T_b) and zero otherwise. The null hypothesis is rejected if the α coefficient is statistically significant. The computations were done with RATS program.

Table 1 summarizes the result of the Zivot and Andrews (1992) test in the presence of structural break allowing for a change in both the intercept and trend. In this model, T_b is endogenously determined by running the model sequentially allowing for T_b to be any year within a 15 percent trimming region. The optimal lag length is determined on the basis of the Schwartz-Bayesian Criterion. Using the Zivot and Andrews (1992) procedure, the time of the structural changes (impacting on both the intercept and the slope of each series) for each of the variables is detected based on the most significant t ratio for $\hat{\alpha}$, that is $t_{\hat{\alpha}}$ and the results are presented in Table 1 and Figure 2 for the two different sample periods: 1973m1-2006m2 and 1945m1-2006m2. As shown, the most significant structural breaks for gold occur in January 1973 and December 1978, while those for inflation coincide with some lag in February 1973 and January 1979. These correspond broadly to the pronounced structural change associated with the 1973 and 1979 oil crises.

4. Cointegration analysis with endogenous structural breaks

As noted as early as Perron (1989), ignoring the issue of potential structural breaks can render invalid the statistical results not only of unit root tests, but of cointegration tests as well. Kunitomo (1996) explains that in the presence of a structural change, traditional cointegration tests may thereby produce spurious evidence concerning cointegration or the lack of cointegration.

Saikkonen and Lütkepohl (2000a; 200b; 2000c) propose a test for cointegration analysis that allows for possible shifts in the mean of the data-generating process. Saikkonen and Lütkepohl (2000b: 451) argue that "…structural breaks can distort standard inference procedures substantially and, hence, it is necessary to make appropriate adjustment if structural shifts are known to have occurred or are suspected". According to Saikkonen and Lütkepohl (2000b) and Lütkepohl and Wolters (2003), an observed n-dimensional time series $yt = (y_{1t},…., y_{nt})$, y_t is the vector of observed variables (t=1,…, T) which are generated by the following process:

$$y_t = \mu_0 + \mu_1 t + \delta_0 Dt_{0t} + \delta_1 Du_{1t} + x_t \qquad (3)$$

where DT_{0t} and DU_{1t} are the respective impulse and shift dummies which account for the existence of structural breaks, DT_{0t} is equal to one when t=T_0 and zero otherwise and the step (shift) dummy (DU_{1t}) is equal to one when (t>T_1), and zero otherwise. The parameters μ_0, μ_1 δ_0 and δ_1 are associated with the deterministic terms.

The possible options in the Saikkonen and Lütkepohl (2000a; 200b; 2000c) procedure, as for Johansen's approach, are threefold: a constant, a linear trend term, or a linear trend orthogonal to the cointegration relations. In this methodology, as in Johansen, the Schwartz-Bayesian Criterion, Akaike Information Criterion and Hannan-Quinn selection criteria are available for making appropriate decisions on the order of the VAR. In this research, the optimal number of lags to be included is searched up to 10 lags and determined by the Schwartz Baysian information criterion.

The maximum likelihood approach based on Saikkonen and Lütkepohl (2000a; 200b; 2000c) is used for testing and determining the long-run relationship between the price of gold and inflation. The timing of the most significant structural breaks has been determined earlier using Zivot and Andrews' (1992) procedure. The timing of the breaks is consistent with long-term changes in the gold market and/or rapid acceleration in the inflation rate. We now consider three cases: dummies with an intercept included; dummies with trend and intercept included; and finally, dummies with a statistically independent trend (orthogonal) to the cointegration relation.

The computations in this section were done with Gauss program. The three null hypotheses of a no long-run relationship between gold and inflation are tested and the results presented in Table 2. The upper panel includes the three tests for the period 1945-2006 and the lower panel for the period 1973-2006. Critical values are provided for the 90, 95 and 99 percent levels of significance. The empirical results indicate that the null hypothesis of no cointegration (r =0) is rejected at the 1 percent level of significance for both sample periods and the three cases considered: intercept, intercept and trend and trend orthogonal to the cointegration relation. In sum, there is abundant evidence of a stable long-run relationship between the price of gold and inflation in both the post-war and post-1970s period as long as allowance is made for significant structural changes in the US gold market and US inflationary regimes in 1972/73 and 1978/79. Put differently, since the long-run price of gold and inflation move together, investment in gold can serve as an inflationary hedge.

5. Concluding remarks

The inflation hedging quality of gold depends on the presence of a stable long-term relationship between the price of gold and the rate of inflation. Because of significant structural changes in both the gold market and consumer prices, this analysis uses the Zivot and Andrews (1992) test procedure to endogenously determine the most significant structural breaks impacting upon this relationship. The results suggest the most significant structural breaks in both markets correspond to the gold market moving to purely open market operations and the acceleration of inflation in the 1970s. A modified cointegration method incorporating these breaks indicates that a strong cointegrating relationship exists between gold and inflation suggesting that gold is a useful inflation hedge in the post-war and post-1970s period.

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Figure 1
Monthly price of gold required for an inflation hedge in the United States, January 1875 – February 2006

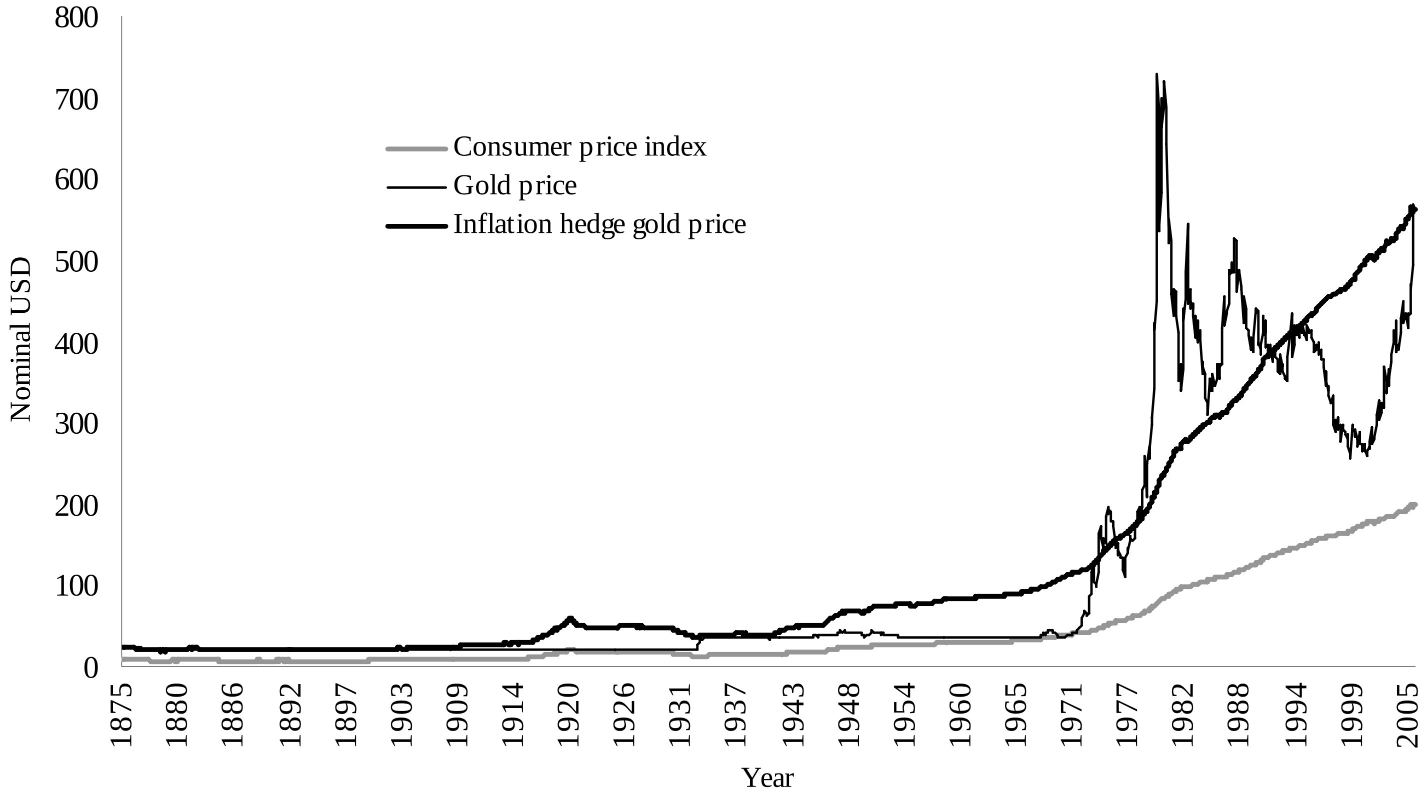


Table 1
Zivot-Andrews test results with break in intercept and trend

$$\Delta y_t = \mu + \beta t + \theta DU1_t + \gamma DT1_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \varepsilon_t$$

Period	Variable	Break	K	$t_{\hat{\alpha}}$
1945:1-2006:2	Gold	1972:01	1	-4.541
	Inflation	1973:02	4	-3.324
1973:1-2006:2	Gold	1978:12	1	-4.321
	Inflation	1979:01	4	-6.486

Notes: Critical values at 1, 5 and 10 percent levels are -5.57, -5.08 and -4.82, respectively. Critical values tabulated in Zivot and Andrews (1992)

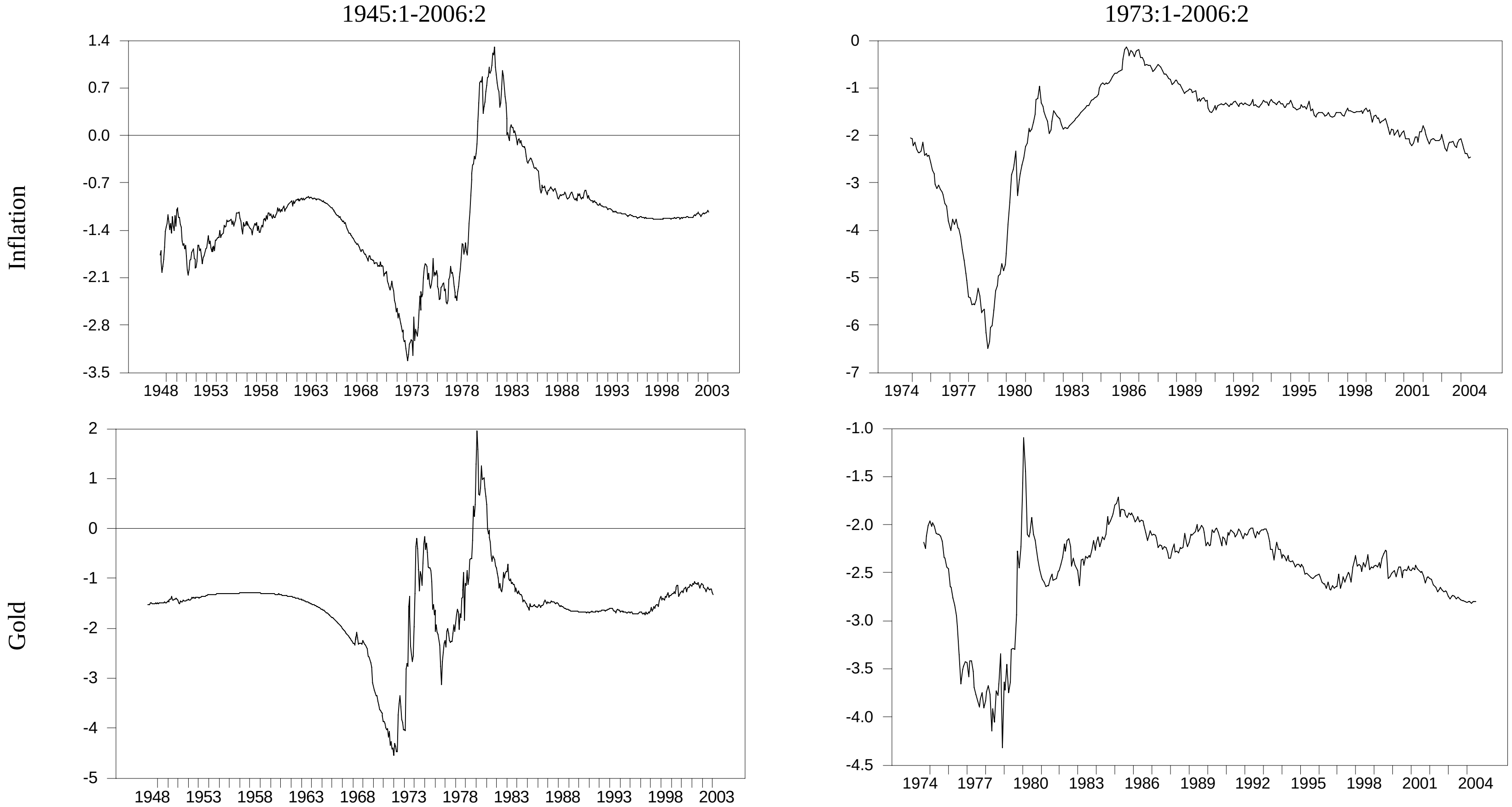
Table 2
Saikkonen and Lutkephol cointegration test results

	Intercept included (C)					Intercept and trend included (C/T)					Trend orthogonal to cointegration relation (C/O)				
r_0	LR	p-value	90%	95%	99%	LR	p-value	90%	95%	99%	LR	p-value	90%	95%	99%
0	54.82	0.00	10.47	12.26	16.10	39.31	0.00	13.88	15.76	19.71	24.84	0.00	8.18	9.84	13.47
1	1.88	0.20	2.98	4.13	6.93	1.06	0.77	5.47	6.79	9.73	–	–	–	–	–
0	67.17	0.00	10.47	12.26	16.10	57.96	0.00	13.88	15.76	19.71	44.11	0.00	8.18	9.84	13.48
1	0.00	0.98	2.98	4.13	6.93	5.98	0.07	5.47	6.79	9.73	–	–	–	–	–

Note: cointegration results indicate that the corresponding null of no cointegration is rejected at the 1% level. Critical values are tabulated by Saikkonen and Lutkephol (2000b). The optimal number of lags (searched up to 10 lags) is determined by the Schwartz Baysian information criterion.

Figure 2

Zivot-Andrews unit root tests of natural logarithm of inflation and gold prices



Note: Numbers on the vertical axes are *t* ratios for $t_{\hat{\alpha}}$