Politická ekonomie
2024, Volume 72, Issue 6
https://doi.org/10.18267/j.polek.1443
Open Access

PRAGUE UNIVERSITY OF ECONOMICS AND BUSINESS

Reevaluating the Time-varying Safe Haven Status of Precious Metals: Novel Insights from Economic Policy Uncertainties in the USA and China

Ahmet Tunc

Sirnak University, Department of Economics, Sirnak, Turkey, e-mail: ahmettunc@sirnak.edu.tr

Abstract

This study aims to examine whether the price exuberances in the prices of four main precious metals stem from their status as safe havens against economic uncertainty (proxied by the US EPU and Chinese CEPU indices). The findings reveal that the effects of both uncertainty measures on gold and silver prices, notably more pronounced in the case of the CEPU, persist for longer, particularly during the surge of uncertainty triggered by the COVID-19 pandemic. This finding highlights the safe-haven status of these metals, with a notable dominance of the CEPU in influencing the price dynamics of the gold and silver markets. However, as the observed price exuberances in gold and silver more closely align with periods of supply and demand imbalances, it is less likely that these movements are driven solely by investors seeking safe havens during times of uncertainty. Furthermore, the effect of the EPU on platinum and palladium prices is particularly pronounced during economic turmoil, whereas the effect of the CEPU is confined to the periods that coincide with price exuberances in these metals. In sum, this paper argues that the safe-haven status of individual precious metals is dynamic, and that price exuberances do not consistently originate from their safe-haven status.

Keywords: Precious metals, economic uncertainty, Granger causality, time-varying parameters, COVID-19

JEL Classification: C32, D81, Q02

Citation: Tunc, A.: Reevaluating the Time-varying Safe Haven Status of Precious Metals: Novel Insights from Economic Policy Uncertainties in the USA and China. *Politická ekonomie*, 2024, 72 (6), 958–984, https://doi.ogr/10.18267/j.polek.1443

1. Introduction

Commodity prices are traditionally recognized as a leading indicator of economic activity and are therefore strictly associated with economic uncertainty (Wang *et al*., 2015; Bannigidadmath and Narayan, 2021). There are at least two reasons behind this fact. Firstly, as commodities (especially primary ones) are inputs and crucial components in the production process, the price level of these inputs directly affects production costs. Secondly, as many basic commodity prices are determined by demand and supply conditions, they react to changes in supply and demand more quickly than manufactured goods and services (Kaldor, 1987; Garner, 2017). Hence, the drivers of global economic activity are significantly shaped by commodity price movements (Ding *et al*., 2021) and, consequently, commodity prices may serve as early signals of the future path of global economic activity[1] (Duarte *et al*., 2021). However, the story is somewhat different for the precious metal commodities. Because gold, for example, has a money-like characteristic regardless of whether it is kept in physical form or through the financial system (Narayan and Liu, 2011; Jones and Sackley, 2016) and in line with this fact, approximately half of the gold mined is utilized as a store of value and in bank transactions (Shafiee and Topal, 2010). Furthermore, with the advent of financial derivatives in the early 2000s, the precious metal markets, along with the rest of the commodity markets, became investable assets (Brooks *et al*., 2015). For all these reasons, economic agents tend to use precious metals as hedges against stocks (Baur and Lucey, 2010; Baur and McDermott, 2010; Coudert and Raymond-Feingold, 2011; Hasan *et al*., 2021) and exchange rates (Li and Lucey, 2017), as well as safe havens during economic and financial turmoil (Li and Lucey, 2017; Bilgin *et al*., 2018; Huynh, 2020; Yilanci and Kilci, 2021; Umar *et al*., 2021; Chen *et al*., 2022; Chebbi, 2021).

The unprecedented spike in economic uncertainty caused by COVID-19 has prompted the need for further research into the interactions between economic uncertainty and precious metal prices. While the prevailing literature strongly highlights the safe haven status of precious metals, a notable tendency in studies within the field links the price exuberance of their prices to their perceived safe haven status, often without robust empirical evidence. To fill this gap, this study aims to identify the price exuberance of precious metals and then questions whether economic uncertainty accounts for these exuberances for the period from January 1992 to July 2022. To this end, we follow a two-step estimation procedure. In the first step, we employ the SADF

1 This function of commodity prices also underpins the “commodity price rule” argument, which contends that commodity prices and the general price level are tightly correlated, so achieving a targeted commodity price level would also control the overall inflation rate (Garner, 2017). Increasing commodity prices, for instance, indicate that the real economy is expanding so quickly that the general price level is in danger of accelerating (Cody and Mills, 2014). Therefore, many studies have argued the use of commodity prices as an information variable in the shaping and implementation of monetary and fiscal policies (Cody and Mills, 2014; Sephton, 2016; Garner, 2017).

and GSADF approaches proposed by Phillips *et al*. (2011, 2012, 2015) to detect periods when precious metal prices exhibit signs of price exuberance. However, it is important to highlight that this method does not provide any hints as to the role of economic uncertainty in these instances of exuberance, leaving the results ambiguous with respect to the safe haven status of precious metals. Therefore, in the second step, we utilize the time-varying Granger causality (TVGC) approach proposed by Shi *et al*. (2018, 2020) to ascertain whether economic uncertainty[2] contributes to the formation of price exuberance of precious metals.

Our study is innovative in several respects. Firstly, this paper extends its focus to a relatively longer sample period spanning the last three decades, covering significant events such as the 1997 Asian Financial Crisis, the Global Financial Crisis (GFC), the Eurozone debt crisis, the 2014 oil price crash, China-US trade wars, COVID-19 pandemic and the Russo-Ukrainian War. Combined with the use of a methodology based on time-varying parameters, this enables us to capture whether the predicting power of economic uncertainty on precious metals would be heterogeneous during these events. Secondly, despite the dearth of empirical evidence, the literature tends to attribute the formation of price exuberance coinciding with periods of heightened uncertainty to the safe haven role of precious metals (Zhao *et al*., 2015; Ozgur *et al*., 2021). However, this paper contributes to the literature by testing the validity of this tendency, offering evidence of the potential predictive power of economic uncertainty on precious metal prices. To this end, we focus specifically on the US and Chinese economic policy uncertainties, considering their effect on commodity prices (Georgiadis, 2016; Trung, 2019; Bhattarai *et al*., 2020; Gai and Tong, 2022; Chen *et al*., 2022). Thirdly, unlike previous studies, the paper investigates the roles of both US and Chinese economic policy uncertainties (EPUs) on precious metal prices in a comparative manner. This aspect adds novelty to the research as it explores the differential impacts of economic uncertainty from two major economies on precious metal markets. Lastly, the present study employs the time-varying Granger causality (TVGC) approach introduced by Shi *et al*. (2018, 2020). Unlike constant coefficient models, the time-varying parameter models have the advantage of allowing time variation in the structural changes of the variable under consideration and thus provide a dynamic perspective in capturing the potential heterogeneity of the effects of exogenous shocks. Hence, these models are increasingly being adopted by the relevant literature examining the nexus of economic uncertainty and commodity prices (Tunc *et al*., 2022; Lyu *et al*., 2021; Ding *et al*., 2021; Gu *et al*., 2021; Huang *et al*., 2021). In addition, the existence and directions of causal links may change over time (Karabulut *et al*., 2020; Shafiullah *et al*., 2021), which further justifies the use of a methodology based on time-varying parameters.

2 Since the EPU index is an economy-wide uncertainty measure and reflects policy-related uncertainty as well as macroeconomic uncertainty (for detailed information, see Baker *et al*., 2016), we use the terms "economic uncertainty" and "economic policy uncertainty" interchangeably.

The structure of this study is constructed as follows: The review of the literature covering both the pre- and post-COVID-19 pandemic periods is presented in Section 2. Section 3 provides the methodology and introduces the data. Section 4 presents the empirical findings and Section 5 concludes the study.

2. Literature

In addition to their industrial applications, precious metals function as investment instruments due to their money-like characteristics and safe-haven roles, and therefore the price exuberance of their prices has attracted increasing attention in the relevant literature. Since our primary objective is to detect the price exuberance in these prices and explore whether economic uncertainty accounts for in these instances of exuberance, our investigation holds particular relevance to two key strands of the literature.

The first strand of the literature comprises studies that focus on incidents of exuberance in precious metals prices. For example, Figuerola-Ferretti and McCrorie (2016) investigate incidents of exuberance in four main precious metals prices for the pre- and post-GFC periods. Their findings indicate short-lasting common exuberance in gold and silver prices in the second quarter of 2006 and in 2011. The exuberance in platinum prices coincides with the beginning of the GFC while that in palladium prices aligns with the post-GFC period. Employing the SADF and GSADF tests on monthly data spanning from 1973 to 2014, Zhao *et al.* (2015) explore periods of price exuberance in gold. In addition to the one-and-a-half-year period of exuberance in late 1979, they reported two short-lasting episodes at the beginning of the GFC and a long-lasting period of exuberance from late 2009 to mid-2013. In line with these findings, Ozgur *et al*. (2021) reported longer-lasting periods of price exuberance for gold prices during the periods of 1997–1999, 2003–2006 and 2007–2013. Compared to the exuberance in gold prices, periods of exuberance in palladium, platinum, and rhodium prices are typically short-lasting, with nine months on average. The longest-lasting period of exuberance in palladium prices coincides with price increases in 1998 caused by concerns about the supply disruption by Russia. Pan (2018) investigated the link between precious metals exuberance and market sentiments from 1990:01 to 2017:10. The results reveal evidence of price exuberance in both gold and silver prices during the GFC and Eurozone debt crises. Moreover, the results of logistic regression show that periods of price exuberance are more common when the volatility increases. Wahab and Adewuyi (2021) employed weekly data on copper prices as well as four precious metals prices for the period spanning from 1990 to 2021. The exuberance in gold prices they detected coincide with the 1997–1999, 2006, 2013 and 2020 periods while exuberance in silver prices is quite short-lasting and coincide with 2004, 2006 and 2013. Periods of exuberance in palladium prices, on the other hand, intensified during the 1997–1998 period, when palladium prices recorded highs due to the Russian supply crisis, and during the GFC period. Similarly, periods of exuberance in platinum prices coincide with the periods when palladium was increasingly being substituted by platinum. Gharib *et al*. (2021) investigated whether gold and WTI oil prices display similar behaviors of price exuberance during the COVID-19 pandemic and report that both commodities' prices exhibit common exuberance behaviors at the beginning of the outbreak of the pandemic. Employing the GSADF test, Khan and Köseoğlu (2020) focused on palladium prices for the period 1994:01-2020:01 and reported multiple periods of exuberance in palladium prices. The increasing substitution of palladium due to the switchover of the automobile manufacturers to palladium in 1998 caused the first period of exuberance, while the second was related to the supply disruptions by Russia. The last period of exuberance coincides with the 2019–2020 period which is characterized by supply deficits on palladium due to low production.

Despite this abundant literature on the hedge functions of precious metals against stocks (Baur and Lucey, 2010; Baur and McDermott, 2010; Coudert and Raymond-Feingold, 2011; Lucey and Li, 2015, 2017; Burdekin and Tao, 2021; Hasan *et al*., 2021) and bonds (Li and Lucey, 2017), the literature on their status as safe havens against uncertainty is extremely scarce. Employing the NARDL approach, Bilgin *et al*. (2018) focused on the asymmetric effects of various uncertainty proxies on gold prices. The findings revealed that although the price of gold rises in response to heightened uncertainty, this rise is unlikely to be followed by a fall when uncertainty conditions improve due to the asymmetry in responses. Using the EPU and VIX indices, Huynh (2020) analysed the causality between the four main precious metals and economic uncertainty. Based on the evidence on the existence of causality from economic uncertainty to precious metals, their results indicate the safe haven function of these metals to protect against uncertainty. However, as gold is more resistant to uncertainty shocks, the author concluded that it shows a leading safe haven status against uncertainty. Mokni *et al*. (2021) examined the effect of the EPU on the connectedness among precious metals during the COVID-19 pandemic using the quantile VAR methodology. They reached the conclusion that gold functions as the most dominant safe haven, whereas others exhibit heterogeneous responses to COVID-19. Shah *et al*. (2021) indicated that longer horizons are what really drives the cross-spillovers between policy uncertainty and precious metals. Because of their greater immunity to policy shocks compared to equity markets, the safe haven status of precious metals is more pronounced.

In light of the above findings, it is clear that the empirical literature is aware of the status of precious metals as safe havens. Few studies, however, draw attention to the time-varying dynamics. Based on a time-varying SVAR model, a study by Chai *et al*. (2019) investigates the effects of country-specific EPU measures on gold prices and provides evidence in favor of the time-varying dynamics. More specifically, the EPU exerted positive responses of gold prices during the GFC; however, these responses are negative in most countries during the Eurozone debt crisis. In other words, the safe-haven function of gold is not stable but dependent on economic and political conditions. Huynh (2020) reported significant causality episodes to precious metals, and these episodes coincide with times of heightened uncertainty, such as the GFC, the Eurozone debt crisis, and the pandemic. Focusing on the China-US trade war period, Chen *et al*. (2022) examined the spillovers and time-varying dynamics on the nexus of Chinese and US trade policy uncertainties (TPU) and precious metals. The findings point to the existence of spillover impacts from both uncertainty measures to the precious metal markets; however, the US TPU dominates the market. Yilanci and Kilci (2021) analysed the causation from global EPU (GEPU) to precious metals and report evidence of the existence of time-varying dynamics. They found that precious metals responded to GEPU during the GFC, the 2016 US elections, and the Brexit referendum. Focusing on the COVID-19 period, Umar *et al*. (2021) examined the nexus between the global panic index (GPI) and precious metals. Their findings reveal that GPI acts as a shock transmitter while precious metals act as a net receiver. Silver has the strongest shock resistance, whereas platinum and palladium display a transmission form that changes over time.

3. Methods and Data

3.1 SADF and GSADF tests

To detect the period of exuberance in precious metals prices, we employ the supremum augmented Dickey–Fuller (SADF) and generalized supremum augmented Dickey–Fuller (GSADF) tests. In these methodologies, the unit root test employs a forward recursive algorithm to identify the repeated behavior of the unit root concerning explosive. A forward recursive test procedure that employs a right-side ADF test and a sup test is as follows:

$$\Delta m_t = \alpha + \beta_{y_{t-1}} + \sum_{i=0}^{n} \gamma_i \Delta m_{t-1} + \varepsilon_t,\ \ \varepsilon_t \sim NID(0,\ \sigma^2) \tag{1}$$

where m_{t-1} is the price of interest and n is the lags. The null hypothesis is $\beta = 1$, and this hypothesis suggests that m_{t-1} is unit root procedure. The alternative hypothesis, on the other hand, $\beta > 1$ indicates that m_{t-1} is explosive. At this point, Phillips and Yu (2011) recommend determining the ADF test statistic recursively. Therefore, the SADF test is obtained as the supremum value of the ADF statistic and is dependent on the repeated estimate of the ADF model on a forward-expanding sample sequence. The SADF statistic can be estimated as follows:

$$SADF(r_0) = sup_{r_2 \in (r_0,1)} \left\{ ADF_{r_2} \right\} \tag{2}$$

where r_0 and r_2 is the smallest window width and the termination point of each sample, respectively. However, the SADF is suitable if the series exhibits only one exuberance. To defeat this shortcoming, Philips *et al*. (2012, 2015) suggest the GSADF test, which proposes a flexible window width, for cases when the series exhibits multiple exuberance. By shifting the initial and final recursion levels in the variable window range to the viable range, the GSADF modifies the regression's r_2 termination from r_0 to 1 and increases the sample size. One key feature of the GDSAF is that it allows r_1 to change from 0 and $r_2 - r_0$.More sub-samples of the data and a broader window help to improve the accurate identification of the explosive behavior for multiple exuberance. The GSADF statistic can be described as follows (Philips *et al*., 2015):

$$SADF\left(r_0\right) = sup_{r_2 \in (r_0,1), r_1 \in (0, r_2 - r_0)} \left\{ ADF_{r_1}^{r_2} \right\} \tag{3}$$

The limit distribution of the test statistic can be constructed as below;

$$sup_{r_2 \in (r_0,1), r_1 \in (0, r_2 - r_0)} \left\{ \frac{\frac{1}{2} r_w \left[w\left(r_2\right)^2 - w\left(r_1\right)^2 - r_w \right] - \int_{r_1}^{r_2} w\left(r\right) d_r \left[w\left(r_2\right) - w\left(r_1\right] \right.}{r_w^{1/2} \int_{r_1}^{r_2} w\left(r\right) d_r \left. \right] \left[\int_{r_1}^{r_2} w\left(r\right) d_r \right] \left[\int_{r_1}^{r_2} w\left(r\right) d_r \right]^2 \left. \right\}^{1/2}} \right\} \tag{4}$$

where $r_w = r_2 - r_1$window size and W is the Wiener process. Phillips *et al.* (2015) claim that the GSDAF settled into a normal distribution if the procedure was a random walk. Starting with a conventional Wiener technique that exhibits continuous and stochastic characteristics, the simulation may generate just a path sampled from a finite set of locations. The GSADF statistics have a higher critical value than the right tail of SADF. Each exuberance's starting and terminating dates can be calculated using BASDF statistics, which are as follows:

$$BSADF_{r_2}\left(r_0\right) = sup_{r_1 \in (0, r_2 - r_0)} \left\{ ADF_{r_1}^{r_2} \right\} \tag{5}$$

Numerical simulation is used to determine asymptotic critical values (*cv*), while the bootstrap method represents an average of the distribution across a finite set of data. The exuberance starts when this statistic exceeds the critical value and terminates when the statistic is less than the critical value (Phillips *et al*., 2015). The starting and terminating points of an exuberance are determined by the respective equations:

$$\widehat{r_e} = inf_{r_2 \in [r_0,1]} \left\{ r_2 : BSADF_{r_2}\left(r_0\right) > cv_{r_2}^{SADF} \right\} \tag{6}$$

$$\widehat{r_f} = inf_{r_2 \in \left[\widehat{r_e} + \eta log(T)/T, 1\right]} \left\{ r_2 : BSADF_{r_2}\left(r_0\right) > cv_{r_2}^{SADF} \right\} \tag{7}$$

where $\widehat{r_e}$ and $\widehat{r_f}$ are the starting and terminating points, respectively. $cv_{r_2}^{SADF}$ is the critical value of the SADF statistic when the sample size is equal to r_2T and $\eta\log(T)$ is the minimum exuberance length. Accordingly, the starting point is determined as the point on which the BSADF statistic exceeds the critical value.

3.2 Time-varying Granger causality test (TVGC)

The time-varying dynamic effects of the US and Chinese economic policy uncertainty indices on precious metals are examined in the study by employing the recent approach suggested by Shi *et al*. (2018, 2020). The test utilizes three algorithms including forward (FO), rolling window (RO) and recursive evolving (RE). Assume a *k*-vector time series (y_t) such as:

$$y_t = \beta_0 + \beta_1 t + u_t \tag{8}$$

where the error term u_t follows a VAR(p) process:

$$u_t = \alpha_1 u_{t-1} + ... + \alpha_p u_{t-p} + \varepsilon_t \tag{9}$$

where ε_t is the error term. Substituting $u_t = y_t - (\beta_0 + \beta_1 t)$ from Eq. (9) into Eq. (8) yields:

$$y_t = \delta_0 + \beta\delta_1 t + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \varepsilon_t \tag{10}$$

where δ_i is a function of β_{i} and α_i in which $i = 0$, 1 and $j = 1, \ldots, p$.

Relying on the lag-augmented VAR (LA-VAR) model of Toda and Yamamoto (1995) and Dolado and Lütkepohl (1996), a Granger causality test for an integrated variable, y_t, can be conducted utilizing a compacted form of the LA-VAR model outlined below.

$$Y = \eta\Gamma' + X\Theta' + B\Phi' + \varepsilon \tag{11}$$

where $Y = \left(y_1,\, y_2,\, \ldots,\, y_T\right)_{T\times n'}$, $\eta = \left(\eta_1,\, \eta_2,\, \ldots,\, \eta_T\right)_{T\times 2'}$, $\eta_t = \left(1,\, t\right)_{2\times 1'}$,

$X = \left(x_1,\, x_2,\, \ldots,\, x_T\right)_{T\times np'}$, $x_t = \left(y_{t-1'},\, y_{t-2'},\, \ldots,\, y_{t-p'}\right)_{np\times 1'}$, $\Theta = \left(\alpha_1,\, \alpha_2,\, \ldots,\, \alpha_p\right)_{n\times np}$,

$B = \left(b_1,\, b_2,\, \ldots,\, b_T\right)_{T\times nd'}$, $b_t = \left(y_{t-p-1'},\, y_{t-p-2'},\, \ldots,\, y_{t-p-d'}\right)_{nd\times 1'}$

$\Phi = \left(\alpha_{p+1},\, \alpha_{p+2},\, \ldots,\, \alpha_{p+d}\right)_{n\times nd}$, $\varepsilon = \left(\varepsilon_1,\, \varepsilon_2,\, \ldots,\, \varepsilon_T\right)_{T\times n'}$ and d is the lag addition parameter.

Based on the restriction imposed by the null, H_0: $\mathbf{R}\boldsymbol{\theta} = 0$, the Wald test is given by:

$$w = \left[\mathbf{R}\hat{\boldsymbol{\theta}}\right]' \left[\mathbf{R}\ \{\Omega \otimes (X'QX)^{-1}\}\ R^{1}\right]^{-1} \left[R\hat{\theta}\right] \tag{12}$$

where $\hat{\boldsymbol{\theta}} = vec(\widehat{\Theta})$, stands for the row vector, $\widehat{\Theta}$ is the OLS estimator of $\widehat{\Theta} = X'QX(X'QX)^{-1}$, $\widehat{\Omega} = \frac{1}{T}\hat{\varepsilon}'\hat{\varepsilon}$ and $\otimes$ is the Kronecker product. $\mathbf{R}$ is m $\times$ n^2p matrix where m is the number of estrictions. The Wald statistic is asymptotically χ_m^2 under the assumptions of null and the conditional homoscedasticity (Toda and Yamamoto, 1995; Dolado and Lütkepohl, 1996). The methodology of Shi *et al*. (2018, 2020) uses supremum (sup) Wald statistic sequences. $W_{f2}(f_1)$ provides the Wald statistic over $[f_1, f_2]$, with a sample size proportion of $f_w = f_2 - f_1 \geq f_0$. The sup Wald statistic is expressed as

$$SW_f(f_0) = \frac{sup}{(f_1, f_2) \in \wedge_0, f_2 = f} \left\{ W_{f_2}(f_1) \right\} \tag{13}$$

where $\wedge_0 = \{(f_1, f_2): 0 < f_0 + f_1 \leq f_2 \leq 1$, and $0 \leq f_1 \leq 1 - f_0\}$ and $f_0 \in (0, 1)$ stands for the reduced sample size for the estimation of the VAR system. Based on alternative simulations, Shi *et al*. (2018) concluded that when f_0 takes a value ranging between 0.18 and 0.24, the RO and RE algorithms become more powerful. Following Shi *et al.* (2018), we choose the minimum window size, $f_0 = 0.2$, as an optimal choice. In a switch scenario, the procedures for establishing dating rules are outlined through the below procedures:

- *rolling*

$$\hat{f}_e = \frac{inf}{f \in [f_0, 1]} \left\{ f : W_f(f - f_0) > cv \right\}, \ and \ \hat{f}_f = \frac{inf}{f \in \left[\hat{f}_e, 1\right]} \left\{ f : W_f(f - f_0) < cv \right\} \tag{14}$$

- *recursive evolving*

$$\hat{f}_e = \frac{inf}{f \in [f_0, 1]} \left\{ f : SW_f(f_0) > scv \right\}, \ and \ \hat{f}_f = \frac{inf}{f \in \left[\hat{f}_e, 1\right]} \left\{ f : SW_f(f_0) < scv \right\} \tag{15}$$

where $\hat{f}_e$ and $\hat{f}_f$ stand for the first chronological estimation of observations where the test statistic surpasses or falls below the critical values, respectively. *cv* stands for the critical value of W_f and *scv* stands for the critical value of SW_f statistics.

Since the LA-VAR models, on which the time-varying Granger causality methodology is based, are designed to be robust for integrated and trending data, they can be applied without prefiltering, de-trending and differencing (Shi *et al*., 2020). With a comprehensive simulation study, Shi *et al.* (2020) compared the results of the forward, rolling window and recursive evolving algorithms. They reported that the power of the FO algorithm is far below the RO and RE algorithms. Although the RE algorithm offers higher power compared to the RO algorithm, both algorithms have good size control (Shi *et al*., 2020).

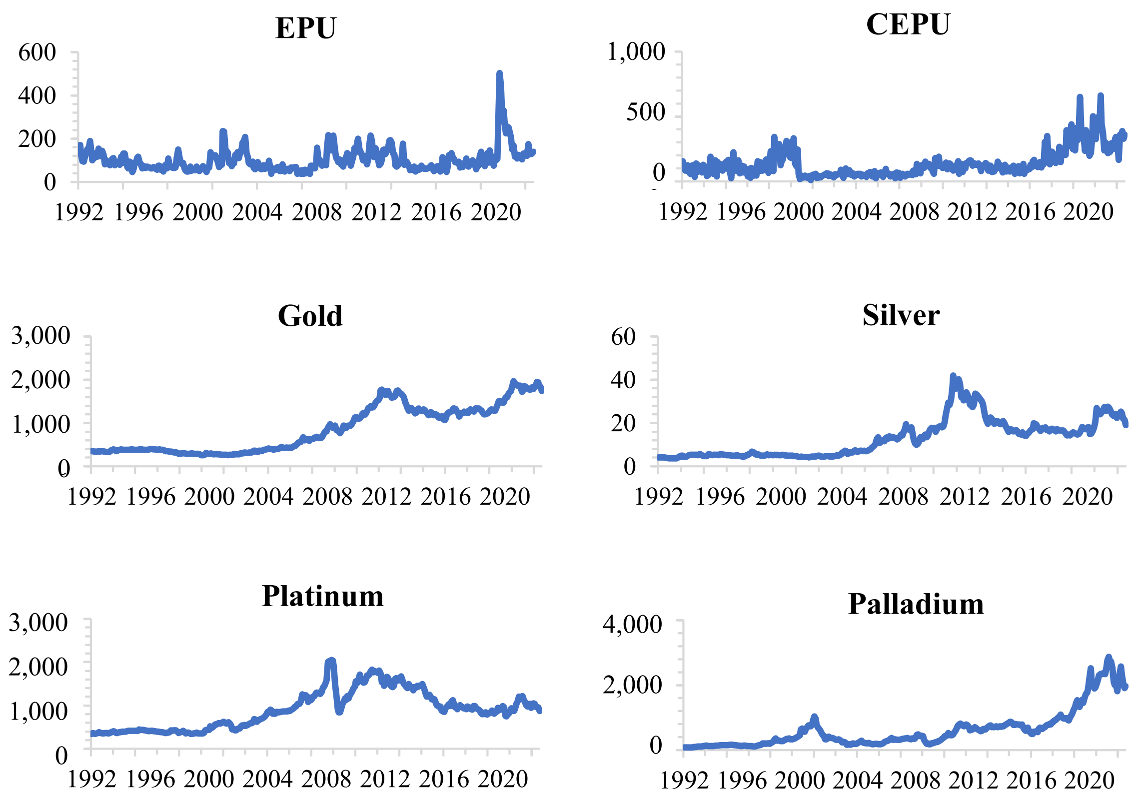
3.3 Data

We utilize monthly data on the spot prices of four main precious metals, *i.e.* gold, silver, platinum and palladium, retrieved from the International Monetary Fund (IMF) database. In the analysis, economic uncertainty is represented by the US and Chinese EPU indices retrieved from the website https://www.policyuncertainty.com. All the time series span from January 1992 to July 2022. The overall performances and descriptive statistics of the series are given in Figure 1 and Table 1, respectively. While some of the major events during our sample period were directly associated with commodity markets, others evolved mainly independently of these markets. Therefore, combined with the use of a methodology based on time-varying parameters, this enables us to capture whether the influence of economic uncertainty on precious metals would be heterogeneous during these events that have diverse origins.

During the last three decades, the world economy has experienced a period full of a variety of shocks in both commodity prices and economic uncertainty conditions. As evident in Figure 1, precious metals prices, which had remained relatively steady until 2002, rose sharply between 2002 and 2008. Though gold and silver prices moved together to a large extent throughout the period, notable peaks were seen in silver prices during the GFC and in gold prices during the pandemic period. With the exception of the significant decline during the GFC, platinum prices remained high throughout the 2002–2016 period as a result of the steady increases in demand for catalytic converters. As of the last quarter of 2018, palladium prices had risen to an all-time high, driven by a combination of factors including the automotive industry's switch from platinum to palladium and a market shortage led by low production and strict environmental regulations.

With the outbreak of COVID-19, the US and Chinese EPUs exhibit unprecedented highs. However, based on its standard deviation, as well as the minimum and maximum values, we observe that the CEPU stands out as more volatile than the EPU (see Table 1). All variables are positively skewed, except for platinum. While most series exhibit a platykurtic distribution, only the EPU exhibits a leptokurtic distribution. Taken together with skewness and kurtosis, the JB test indicates that none of the series are normally distributed.

Figure 1: Original time series of variables



Source: Authors' own elaboration

Table 1: Descriptive statistics

	Median	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J–B	Obs.
EPU	4.474	4.526	6.221	3.618	0.432	0.617	3.585	0*	367
CEPU	4.661	4.657	6.495	2.314	0.715	0.075	2.703	0*	367
Gold	6.500	6.526	7.585	5.548	0.686	0.042	1.344	0*	367
Silver	2.534	2.330	3.737	1.294	0.695	0.093	1.540	0*	367
Platinum	6.775	6.667	7.627	5.832	0.524	−0.151	1.730	0*	367
Palladium	5.927	6.047	7.963	4.390	0.875	0.210	2.282	0*	367

Notes: This table displays the descriptive statistics of each variable (in log), namely the US economic policy uncertainty index (EPU), the Chinese economic policy uncertainty index (CEPU) and precious metals commodity prices (gold, silver, platinum and palladium). The data span from January 1992 to July 2022. * indicates significance at the 1% level.

Source: Authors' own calculations

4. Results and Discussion

4.1 Identifying price exuberance in precious metals

Our first step in this empirical investigation is to identify the periods of exuberance in the four price series. To this aim, we employ the supremum Augmented Dickey–Fuller (SADF) test proposed by Phillips *et al*. (2011) and the generalized supremum augmented Dickey–Fuller (GSADF) test proposed by Phillips *et al*. (2015). These results are obtained by 2 000 replications and test statistics and the corresponding critical values are displayed in Table 2. Since the 1% right-tail critical values exceed the bootstrap critical values, we conclude that each precious metal exhibits periods of price exuberance for the period spanning from 1992:01 to 2022:07.

Table 2: Results of SADF and GSADF tests

Metal group	Test statistics		Bootstrap critical values					
			99		95		90	
	SADF	GSADF	SADF	GSADF	SADF	GSADF	SADF	GSADF
Gold	5.096*	5.096*	2.039	2.602	1.417	2.136	1.137	1.895
Silver	4.235*	4.235*	2.039	2.602	1.417	2.136	1.137	1.895
Platinum	4.148*	4.148*	2.039	2.602	1.417	2.136	1.137	1.895
Palladium	3.477*	3.926*	2.039	2.602	1.417	2.136	1.137	1.895

Notes: We used a lag order of 1 and the corresponding critical values obtained from 2,000 replications.
* indicate significance at the 1% level.
Source: Authors' own calculations

In order to identify the periods of exuberance in the series, we also compute the BSADF statistics[3]. The start and termination dates of these periods of exuberances are displayed in Table 3. Accordingly, we detect three main periods of price exuberance for gold prices. The first period is short and mild, starting in mid-1997 and terminating in early 1998. The gold price fluctuations during this period are mainly attributed to the Taxpayer Relief Act of 1997 in the USA (Wahab and Adewuyi, 2021). Aside from a few brief breaks (from October to November 2006 and from November 2008 to January 2009), the second period of exuberance encompasses the whole period

3 The computed BSADF statistics are plotted in Appendix. In addition to the BSADF statistics, we reported the 95% finite sample critical values and the original time series of the variables on the same graphs for easy comparison.

spanning from December 2005 to the first quarter of 2013. This long-lasting period of exuberance matches perfectly a series of events. For example, in 2006, in addition to the strong demand originating from China, the weakening dollar, the rising oil prices and the political tensions over Iran's nuclear activities caused gold to settle at the peak of the last two decades. With the outbreak of the GFC, in response to the economic downturn and loosening monetary policy, investors shifted their assets from the depreciating dollar to gold, further increasing gold's value (Hergt, 2013). For the first time in years, gold prices dropped in 2013 as central banks reduced their net purchases and investor demand weakened. The stronger dollar also played an important role in pushing gold prices lower (Street *et al*., 2014). All these reasons contributed to the end of the long-lasting period of exuberance in gold prices in the second quarter of 2013. The third period of price exuberance we detected is short-lived and covers the period from July to September 2020 overlapping with the peak of the COVID-19 pandemic. Moreover, the collapse in oil prices and global stock markets have also contributed to the increase in gold prices during the pandemic (Wahab and Adewuyi, 2021; Gharib *et al*., 2021). It should be noted that our findings on gold price exuberance are generally similar to the studies of Ozgur *et al.* (2021), Gharib *et al*. (2021) and Wahab and Adewuyi (2021).

Table 3: Periods of exuberance of precious metal prices

	Starting date	Terminating date	Duration (months)
Gold	1997:07	1997:09	3
	1997:11	1998:02	4
	2004:01	2004:02	2
	2005:12	2006:09	10
	2006:12	2008:10	11
	2009:02	2013:04	51
	2020:07	2020:09	3
Silver	2004:01	2004:05	5
	2006:03	2006:07	5
	2008:02	2008:09	8
	2010:11	2011:11	13

	Starting date	Terminating date	Duration (months)
Palladium	1998:02	1998:07	6
	1999:12	2000:05	6
	2000:07	2001:03	9
	2019:03	2019:05	3
	2019:08	2020:03	8
	2020:09	2021:09	13
Platinumm	2004:01	2004:05	5
	2006:02	2006:11	10
	2007:02	2008:09	20

Source: Authors' own calculations

We detect only four mild periods of exuberance in the price of silver. The first and second periods are short-lasting from January to May 2004 and from March to July 2006. The first period coincides with the time when the price of silver surged by 36% driven by the launch of the first silver exchange-traded funds (ETFs) by Barclays[4]. These rises persisted through the first three quarters of 2008 which coincided with the third period of exuberance, but the economic outlook deteriorated dramatically at the end of the year, causing silver and other metal prices to fall. The price of silver rebounded throughout 2009, and this recovery continued as net investment in silver in 2010 nearly doubled from the level seen in 2009, leading to the last period of exuberance we detected, which began in November 2010 and terminated in November 2011. In addition, we detect six mild periods of exuberance in palladium prices, the first three of which are from February to July 1998, from December 1999 to May 2000, and from July 2000 to March 2001. The first two periods were driven by the rise in the prices of palladium due to rising demand from the automotive sector. However, in 2001, delays in Russian platinum group metals (PGM) shipments disrupted supplies, pushing palladium prices to historical highs. The high cost of palladium led to a decline in demand as car manufacturers switched to using less expensive platinum in catalytic converters for gasoline engines (US Geological Survey, 2012). Therefore, platinum prices had grown steadily till the end of 2007. This steady increase in platinum demand is responsible for the three main periods of exuberance in platinum prices between 2004 and 2008 (see Table 5). Due to its much lower cost compared to platinum, manufacturers switched back to palladium. The last three periods of exuberance detected in palladium prices correspond to the periods from March to May 2019, from August 2019 to March 2020, and from September 2020 to September 2021. As a result, the price of palladium increased by roughly 60% in 2019 alone, making it the best-performing precious metal (Khan and Koseoglu, 2020). Despite the disruption in industrial demand driven by the COVID-19 pandemic, the palladium market deficit has also increased in 2020, with an increase in auto catalyst demand due to tightening emissions regulations (Bloxham *et al*., 2020). The main difference between the platinum and palladium price dynamics over the last three years is platinum's stable position and its low price, and palladium's sustained deficits and record high price (Chigumira, 2020).

In sum, the GSADF results indicate more persistent and long-lived periods of exuberance in gold among precious metals. In line with Figuerola-Ferretti and McCrorie (2016), our findings seem to imply that silver price exuberance largely coincided with gold price exuberance during the 2004–2012 period and thus the price of these two metals was tied to each other during this period. It should also be noted that except for minor deviations in the start and termination dates of exuberant periods due to differences in sample selection and data frequency, our findings

4 https://www.silverinstitute.org/silverprice/2000-2010/

on gold, silver, platinum and palladium price exuberance are generally similar with the studies of Zhao *et al*. (2015), Ferretti and McCrorie (2016), Khan and Koseoglu (2020), Ozgur *et al*. (2021) and Wahab and Adewuyi (2021).

4.2 Results of the time-varying Granger causality

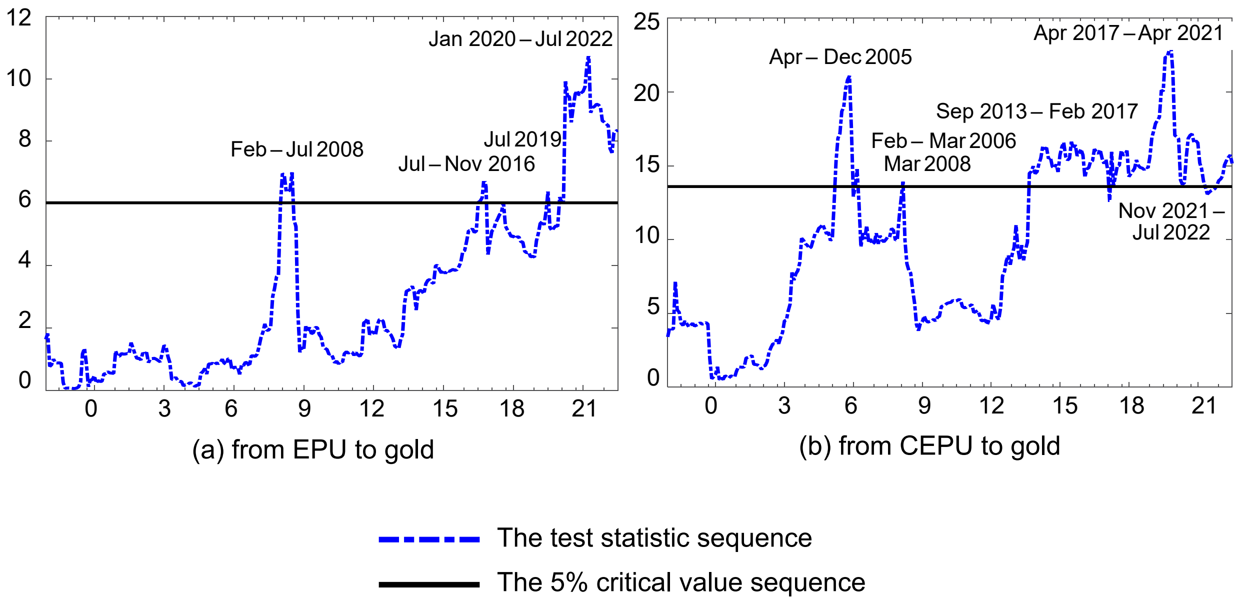
To examine the dynamics of Granger causality running from both the EPU and CEPU to four precious metals prices, *i.e*. gold, silver, platinum and palladium, we utilize the TVGC approach proposed by Shi *et al*. (2018, 2020). As already stated in the methodology section, the TVGC test utilizes three algorithms, *i.e*. forward (FO), rolling window (RO) and recursive evolving (RE) algorithms. In empirical applications, the results of these algorithms show some heterogeneities. The reason is that the FO and RO algorithms are based on Wald statistics whereas the RE algorithm is based on the recursive computation of the test statistics for a sequence of backward-expanding samples. In addition, the RE algorithm endogenously determines the origination and termination points in Granger causality and allows for potential heteroscedasticity (see Shi *et al*., 2018, 2020). Considering all of these advantages, it is worth noting that the RE algorithm produces results that are more closely related to economic expectations than the FO and RO algorithms. Therefore, we prefer to report the results of the RE algorithm[5]. Figures 2–5 show graphical representations of the TVGC results using the RE algorithm, with panels (a) Granger causality running from the US EPU (EPU), and panels (b) Granger causality running from the Chinese EPU (CEPU).

Figure 2a shows the results of TVGC from the EPU to gold prices. The RE algorithm determines four main episodes of Granger causality; the first lasts 6 months from February to July 2008; the second from July to November 2016; the third in July 2019; and the fourth from January 2020 to July 2022. The first and second episodes coincide with periods characterized by heightened uncertainty, such as the GFC and the US presidential election in November 2016. In addition, the last episode is the longest-lasting episode starting from the early phase of COVID-19 to the end of the sample period. The plot in Figure 2b reveals that there are three main episodes in which Granger causality runs from the CEPU to gold prices. The first episode lasted approximately one year from April 2005 to March 2006; the second in March 2008; the third from September 2013 to the end of the sample period (with the exception of two small breaks in March 2017 and from May to October 2021). In fact, this first episode is one of the two most notable differences between panels (a) and (b). To put it more clearly, in contrast to the EPU, the CEPU has significant predicting power on gold prices during the period 2005–2006. Similar to the case of the EPU, the second episode coincides with the GFC period during which the CEPU experi-

5 The results of the FO and RO algorithms are available upon request.

enced moderate increases. Another difference between panels(a) and (b) is that the Granger causality channel from the CEPU to gold prices opened much earlier, specifically in 2013, compared to the channel from the EPU to gold prices, which opened with the early phase of COVID-19. The main implication is that the CEPU appears to have had an earlier and potentially more significant impact on gold prices compared to the EPU.

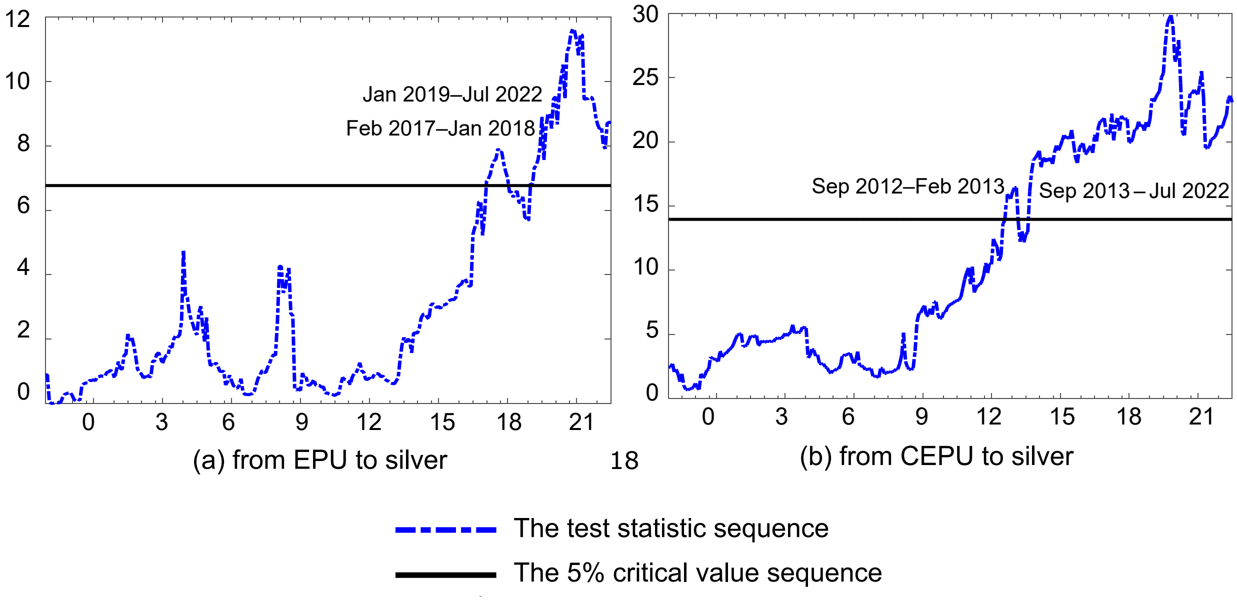
Figure 2: TVGC running from economic uncertainty to gold



Source: Authors' own elaboration

Figures 3a and 3b display the results of TVGC running from the EPU and CEPU to silver prices, respectively. In both cases, the RE algorithm detects two main Granger causality episodes. For the EPU, the first episode lasts one year from February 2017 to January 2018 and the second from January 2019 to the end of the sample period. For the CEPU, the first episode lasts six months from September 2012 to February 2013; the second from September 2013 to the end of the sample period. It is noteworthy that these channels have been quite similar to the channels in which Granger causality runs from the EPU and CEPU to gold prices (see Figures. 2a and 2b). The most striking point here is that, just as in the case of gold prices, the channel from the CEPU to silver prices opens much earlier than the EPU channel, that is, in late 2012.

Figure 3: TVGC running from economic uncertainty to silver

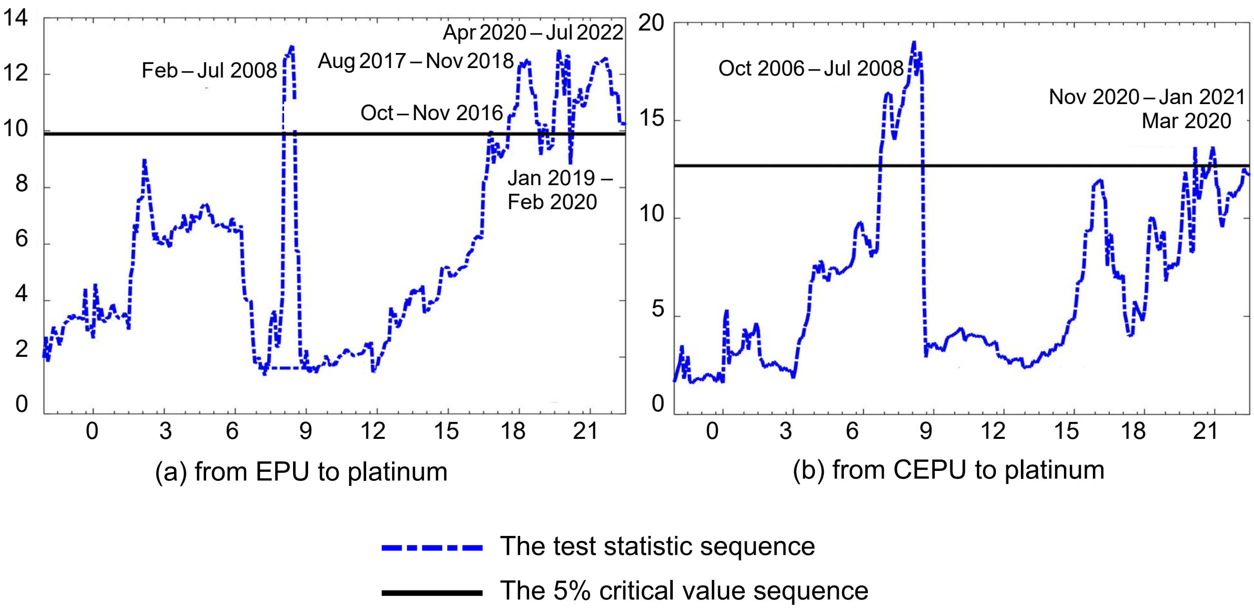


Source: Authors' own elaboration

Three specific points stand out from the above findings. Firstly, in contrast to the moderate increases during the GFC period, both the EPU and CEPU have experienced unprecedented historical peaks throughout the 2020s due to the spread of COVID-19 variants and the Russo-Ukrainian War (see Figure 1). Combined with this fact, the longer-lasting episodes at the end of the sample period confirm the well-known fact that gold and silver act as safe investment havens during times of heightened uncertainty (Joëts *et al.*, 2017; Bilgin *et al.*, 2018; Bakas and Triantafyllou, 2020; Chen *et al.,* 2022; Dinh *et al.*, 2022). Moreover, the effect of a prolonged uncertainty shock on these prices is more persistent and longer-lasting than that of a shorter one. Secondly, the current literature focusing on the emergence of exuberance in precious metals prices tends to attribute these price movements to the safe-haven roles of these metals against economic uncertainty (Zhao *et al.*, 2015; Ozgur *et al.*, 2021). Our findings do not support this tendency, as we found no evidence of Granger causality from both the EPU and CEPU to gold and silver prices during these periods of exuberance. Instead, we argue that exuberance in gold and silver prices may have resulted from supply/demand imbalances, not due to their role as safe havens against economic uncertainty. Thirdly, beyond historical peaks of economic uncertainty, the significant predictive power of the CEPU on gold and silver prices becomes particularly apparent during periods of heightened demand for these metals in China. This observation highlights China's increasing influence in these markets and underscores the heightened sensitivity of these markets to uncertainty dynamics in China. Consequently, we assert that the CEPU exerts a greater influence on the gold and silver markets compared to the EPU.

The TVGC running from the EPU and CEPU to platinum prices are illustrated in Figures 4a and 4b, respectively. The RE algorithm determines two episodes in which Granger causality runs from the EPU to platinum prices; the first from February to July 2008; and the second from October 2016 to the end of the sample period (with the exception of small breaks). The first episode coincides with the GFC, while the second covers important historical events such as the US-China trade war, COVID-19 and the Russo-Ukrainian War. Fig. 4b, on the other hand, detects a long-lasting episode from October 2006 to July 2008, as well as two short episodes in March 2020 and from November 2020 to January 2021. One specific point stands out from these findings. The EPU has a significant predicting power on platinum prices during periods of economic turmoil, such as the GFC, the US-China trade war, COVID-19, and the Russo-Ukrainian War, indicating the role of platinum as a safe haven against economic uncertainty in the USA. The CEPU, on the other hand, has significant predicting power on platinum prices during the periods when platinum prices exhibited the longest-lasting period of exuberance (see Table 3). In other words, CEPU becomes particularly influential in shaping platinum prices when there are upward price movements characterized as price exuberance.

Figure 4: TVGC running from economic uncertainty to platinum



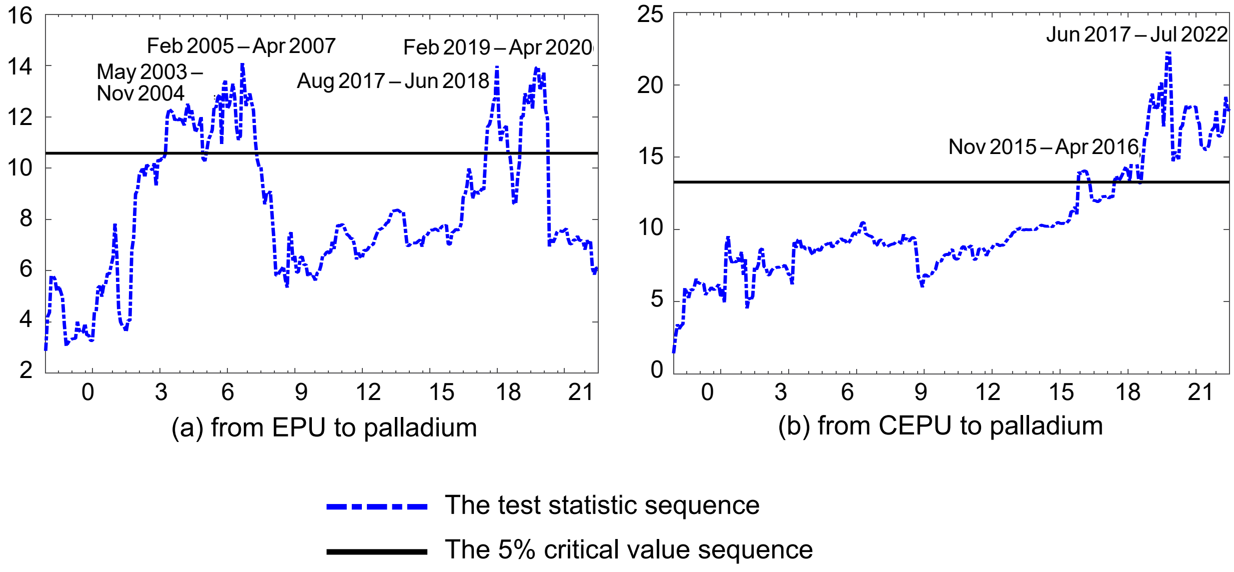
Source: Authors' own elaboration

Figures 5a and 5b display the results of TVGC running from the EPU and CEPU to palladium, respectively. The algorithm determines three main episodes: the first from May 2003 to April 2007; the second from August 2017 to June 2018; and the third from February 2019 to April 2020

(Figure 5a). Interestingly, the first episode coincides with the 2003–2007 period characterized by the sharp declines in global palladium demand due to the increasing substitution of platinum in catalytic converters. The other two episodes coincide with the post-2016 period when palladium prices began to experience unprecedented increases due to the increasing demand for palladium, and the last episode terminates in mid-2020 when palladium prices began to decline. For the CEPU-palladium pair, on the other hand, the RE algorithm detects only two episodes from November 2015 to April 2016 and from June 2017 to the end of the sample period (Figure 5b). Compared to the post-2016 channel from the EPU, the Granger causality channel from the CEPU opens earlier in April 2016, at the beginning of the unprecedented increases in prices, and it lasts until the end of the sample period. Note that the Granger causality episodes from the EPU and CEPU corresponding to the end of the sample period cover the long-lasting period of exuberance in palladium prices we detected (see Table 5).

Aug 2017 – Nov 2018

Figure 5: TVGC running from economic uncertainty to palladium



Source: Authors' own elaboration

The most striking finding is that significant Granger causality episodes from the CEPU to both platinum and palladium coincide with observed periods of their price exuberance. In other words, the majority of the price exuberances that we detected in platinum and palladium prices overlap with the periods during which the CEPU has significant predicting power on these metal prices. This raises intriguing implications, particularly considering China's pivotal role as a major consumer of platinum group metals (PGM), accounting for approximately 30% of global demand in 2021, a significant increase from about 5% in 1998 (Mattley, 2021). This surge in China's demand for PGM offers a plausible explanation for the dominance of the CEPU in influencing the prices of these metals during episodes of exuberance. The ever-growing demand for PGM positions the CEPU as a key influencer on the prices of platinum and palladium during episodes of significant price surges.

In sum, it is obvious from the above findings that the effects of both the EPU and CEPU on individual precious metals are time-varying. This result is consistent with the literature that has highlighted the time-varying dynamics (Chai *et al*., 2019; Huynh, 2020) and provides complementary evidence to the literature focusing on the effects of other uncertainty and risk measures on precious metals (Chen *et al*., 2022; Yilanci and Kilci, 2021; Umar *et al*., 2021). As a result, we conclude that the role of individual precious metals as safe havens against economic uncertainty cannot be considered regardless of existing economic and political conditions. Additionally, in contrast to the literature that emphasizes the dominant role of gold as a safe haven (Huynh, 2020; Mokni *et al*., 2021), we find that the role played by individual precious metals as safe havens against economic uncertainty changes over time. This result is in line with Lucey and Li (2015), Li and Lucey (2017) and Hasan *et al*. (2021).

5. Conclusion

Precious metal commodities have historically functioned independently from other commodity classes, especially during turbulent periods, due to their safe-haven roles. Consequently, the notable exuberance in their prices and their safe haven status against economic uncertainty have attracted increasing attention in the relevant literature. However, the prevailing tendency within this body of literature leans towards attributing these exuberances that coincide with periods of heightened uncertainty to the safe-haven role of precious metals, even in the absence of empirical evidence. To test the validity of this tendency, this study aims to identify the periods of exuberance in precious metals prices and question the extent to which economic uncertainty contributes to these price exuberances.

The key question we addressed was whether precious metals, namely gold, silver, platinum and palladium, tend to exhibit price exuberances during the period from January 1992 to July 2022 and, if so, to what extent economic uncertainty contributes to these price exuberances. Economic uncertainty was proxied by the economic policy uncertainty index (EPU) constructed by Baker *et al*. (2016). Since the US and China are the largest consumers of precious metals, we comparatively concentrated on the US and Chinese EPUs in this study. To this end, we followed a two-step estimation procedure. In the first step, we employed the SADF and GSADF methodologies proposed by Phillips *et al*. (2011, 2012, 2015) to detect the periods of exuberance of precious metal prices. We then utilized the time-varying Granger causality (TVGC) approach of Shi *et al*. (2018, 2020) in the second step.

The estimation results reveal that all precious metals prices – gold, silver, platinum, and palladium – display exuberant behavior. Specifically, gold and silver experienced their most prolonged periods of price exuberance during the Global Financial Crisis (GFC) and the Eurozone debt crisis. Platinum showed similar behaviors from 2004 to 2008, while palladium's main periods of exuberance occurred from 1998 to 2001 and from 2019 to 2021. Moreover, our results provide strong evidence in favor of the time-varying Granger causal effect of both economic uncertainty measures on individual precious metals. More specifically, the predicting powers of the EPU and CEPU on gold and silver prices are more pronounced and persist for longer at the end of the sample period, particularly during the great spike of uncertainty brought about by the pandemic and the Russo-Ukrainian War. Moreover, the effect of the EPU on these metals becomes more pronounced during periods of heightened uncertainty, whereas the effect of the CEPU becomes noticeable when demand for these metals from China is increasing. Therefore, we argue that the CEPU is more dominant in the gold and silver markets compared to the EPU. However, it should also be noted that the EPU and CEPU have no predicting power on gold and silver prices during the periods of exuberances we detected. This suggests that not all price exuberances in precious metal prices can be attributed to heightened uncertainty. Instead, the exuberances in gold and silver prices are more likely due to imbalances in supply and demand, rather than being driven by investors seeking a safe haven during times of uncertainty. On the platinum and palladium side, the EPU has a significant predicting power on these prices during periods of economic turmoil, indicating their safe haven roles against economic uncertainty in the USA. Conversely, the CEPU has a significant predicting power on platinum and palladium prices during the periods when these prices exhibited the longest-lasting periods of exuberances. In other words, the CEPU becomes particularly influential in shaping these prices when there are upward price movements characterized as price exuberance.

In sum, our findings clearly demonstrate that the effects of both the EPU and CEPU on individual precious metals are time-varying. Therefore, in contrast to the literature that emphasizes the dominant role of gold as a safe haven, we conclude that the role of individual precious metals as safe havens against economic uncertainty changes over time. Given that precious metals have money-like characteristics and serve as crucial inputs into production processes, these findings have important policy implications. By identifying periods of price exuberance for precious metals, we can better understand the underlying causes of these fluctuations. Furthermore, exploring how this price behaviour interacts with economic uncertainty can deepen our comprehension of their attributed safe haven status. Therefore, one of the critical implications of this study is that investors, policymakers and other relevant stakeholders may closely monitor the uncertainty conditions of global players on these metal markets, as well as the supply and demand conditions for these metals. For future research, broadening this analysis to comprise other commodity classes may yield further policy implications and improve our knowledge of market dynamics.

Acknowledgement

Funding: There was no funding, either externally or internally, towards this study.

Conflicts of interest: The authors hereby declare that this article was not submitted no published elsewhere.

References

Bakas, D., Triantafyllou, A. (2020). Commodity price volatility and the economic uncertainty of pandemics. *Economics Letters*, 193, 109283. https://doi.org/10.1016/j.econlet.2020.109283

Baker, S. R., Bloom, N., Davis, S. J. (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics*, 131(4), 1593–1636. https://doi.org/10.1093/qje/qjw024

Bannigidadmath, D., Narayan, P. K. (2021). Commodity futures returns and policy uncertainty. *International Review of Economics and Finance*, 72, 364–383. https://doi.org/10.1016/j.iref.2020.11.009

Barclays (2024). *Silver Price History / 2000–2010*. [Retrieved 2024-03-06] Available at: https://www.silverinstitute.org/silverprice/2000-2010/

Baur, D. G., Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review*, 45(2), 217–229. https://doi.org/10.1111/j.1540-6288.2010.00244.x

Baur, D. G., McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking and Finance*, 34(8), 1886–1898. https://doi.org/10.1016/j.jbankfin.2009.12.008

Bhattarai, S., Chatterjee, A., Park, W. Y. (2020). Global spillover effects of US uncertainty. *Journal of Monetary Economics*, 114, 71–89. https://doi.org/10.1016/j.jmoneco.2019.05.008

Bilgin, M. H., Gozgor, G., Lau, C. K. M., *et al*. (2018). The effects of uncertainty measures on the price of gold. *International Review of Financial Analysis*, 58, 1–7. https://doi.org/10.1016/j.irfa.2018.03.009

Bloxham, L., Cowley, A., & Shao, E. (2020). PGM Market Report May 2020. May.

Brooks, C., Prokopczuk, M., Wu, Y. (2015). Booms and Busts in Commodity Markets: Bubbles or Fundamentals? *Journal of Futures Markets*, 35(10), 916–938. https://doi.org/10.1002/fut.21721

Burdekin, R. C. K., Tao, R. (2021). The golden hedge: From global financial crisis to global pandemic. *Economic Modelling*, 95, 170–180. https://doi.org/10.1016/j.econmod.2020.12.009

Chai, G., You, D.-M., Chen, J.-Y. (2019). Dynamic response pattern of gold prices to economic policy uncertainty. *Transactions of Nonferrous Metals Society of China (English Edition)*, 29(12), 2667–2676. https://doi.org/10.1016/S1003-6326(19)65173-3

Chebbi, T. (2021). The response of precious metal futures markets to unconventional monetary surprises in the presence of uncertainty. *International Journal of Finance and Economics*, 26(2), 1897–1916. https://doi.org/10.1002/ijfe.1885

Chen, J., Huang, Y., Ren, X., *et al*. (2022). Time-varying spillovers between trade policy uncertainty and precious metal markets: Evidence from China-US trade conflict. *Resources Policy*, 76, 102577. https://doi.org/10.1016/j.resourpol.2022.102577

Chigumira, D. (2020). Platinum Essentials. World Platinum Investment Council, March, 1–7. [Retrieved 2023-12-06] Available at: www.platinuminvestment.com

Cody, B. J., Mills, L. O. (2014). The Role of Commodity Prices in Formulating Monetary Policy. *The Review of Economics and Statistics*, 73(2), 358–365.

Coudert, V., Raymond-Feingold, H. (2011). Gold and financial assets: Are there any safe havens in bear markets? *Economics Bulletin*, 31(2), 1613–1622.

Ding, Q., Huang, J., Zhang, H. (2021). The time-varying effects of financial and geopolitical uncertainties on commodity market dynamics: A TVP-SVAR-SV analysis. *Resources Policy*, 72, 102079. https://doi.org/10.1016/j.resourpol.2021.102079

Dinh, T., Goutte, S., Nguyen, D. K., *et al*. (2022). Economic drivers of volatility and correlation in precious metal markets. *Journal of Commodity Markets*, 100242. https://doi.org/10.1016/j.jcomm.2021.100242

Dolado, J. J., Lütkepohl, H., (1996). Making Wald tests work for cointegrated VAR systems. *Econometric Reviews.* 15(4), 369–386.

Duarte, A. M., Gaglianone, W. P., de Carvalho Guillén, O. T., *et al*. (2021). Commodity prices and global economic activity: A derived-demand approach. *Energy Economics*, 96. https://doi.org/10.1016/j.eneco.2021.105120

Figuerola-Ferretti, I., McCrorie, J. R. (2016). The shine of precious metals around the global financial crisis. *Journal of Empirical Finance*, 38(B), 717–738. https://doi.org/10.1016/j.jempfin.2016.02.013

Gai, P., Tong, E. (2022). Information spillovers of US monetary policy. *Journal of Macroeconomics*, 72, 103401. https://doi.org/10.1016/j.jmacro.2022.103401

Garner, A. (1989). Commodity Prices: Policy Target or Information Variable? *Journal of Money, Credit and Banking*, 21(4), 508–514.

Georgiadis, G. (2016). Determinants of global spillovers from US monetary policy. *Journal of International Money and Finance*, 67, 41–61. https://doi.org/10.1016/j.jimonfin.2015.06.010

Gharib, C., Mefteh-Wali, S., Jabeur, S. B. (2021). The bubble contagion effect of COVID-19 outbreak: Evidence from crude oil and gold markets. *Finance Research Letters*, 38, 101703. https://doi.org/10.1016/j.frl.2020.101703

Gu, X., Zhu, Z., Yu, M. (2021). The macro effects of GPR and EPU indexes over the global oil market—Are the two types of uncertainty shock alike? *Energy Economics*, 100(24), 105394. https://doi.org/10.1016/j.eneco.2021.105394

Hasan, M. B., Hassan, M. K., Rashid, M. M., *et al*. (2021). Are safe haven assets really safe during the 2008 global financial crisis and COVID-19 pandemic? *Global Finance Journal*, 50, 100668. https://doi.org/10.1016/j.gfj.2021.100668

Hergt, B. (2013). Gold prices during and after the Great Recession. *US Bureau of Labor Statistics*, 2(4), 1–8.

Huang, J., Li, Y., Zhang, H., Chen, J. (2021). The effects of uncertainty measures on commodity prices from a time-varying perspective. *International Review of Economics and Finance*, 71, 100–114. https://doi.org/10.1016/j.iref.2020.09.001

Huynh, L. D. T. (2020). The effect of uncertainty on the precious metals market: New insights from Transfer Entropy and Neural Network VAR. *Resources Policy*, 66, 101623. https://doi.org/10.1016/j.resourpol.2020.101623

Joëts, M., Mignon, V., Razafindrabe, T. (2017). Does the volatility of commodity prices reflect macroeconomic uncertainty? *Energy Economics*, 68, 313–326. https://doi.org/10.1016/j.eneco.2017.09.017

Jones, A. T., Sackley, W. H. (2016). An uncertain suggestion for gold-pricing models: the effect of economic policy uncertainty on gold prices. *Journal of Economics and Finance*, 40(2), 367–379. https://doi.org/10.1007/s12197-014-9313-3

Kaldor, N. (1987). The role of commodity prices in economic recovery. *World Development*, 15(5), 551–558. https://doi.org/10.1016/0305-750X(87)90002-7

Karabulut, G., Bilgin, M. H., Doker, A. C. (2020). The relationship between commodity prices and world trade uncertainty. *Economic Analysis and Policy*, 66, 276–281. https://doi.org/10.1016/j.eap.2020.05.001

Khan, K., Derindere Köseoğlu, S. (2020). Is palladium price in bubble? *Resources Policy*, 68. https://doi.org/10.1016/j.resourpol.2020.101780

Li, S., Lucey, B. M. (2017). Reassessing the role of precious metals as safe havens–What colour is your haven and why? *Journal of Commodity Markets*, 7, 1–14. https://doi.org/10.1016/j.jcomm.2017.05.003

Lucey, B. M., Li, S. (2015). What precious metals act as safe havens, and when? Some US evidence. *Applied Economics Letters*, 22(1), 35–45. https://doi.org/10.1080/13504851.2014.920471

Lyu, Y., Yi, H., Hu, Y., *et al*. (2021). Economic uncertainty shocks and China's commodity futures returns: A time-varying perspective. *Resources Policy*, 70, 101979. https://doi.org/10.1016/j.resourpol.2020.101979

Matthey, J. (2021). PGM market report. PGM Market Report May 2021, May, 1–48. http://www.platinum.matthey.com/services/market-research/pgm-market-reports

Mokni, K., Al-Shboul, M., Assaf, A. (2021). Economic policy uncertainty and dynamic spillover among precious metals under market conditions: Does COVID-19 have any effects? *Resources Policy*, 74, 102238. https://doi.org/10.1016/j.resourpol.2021.102238

Narayan, P. K., Liu, R. (2011). Are shocks to commodity prices persistent? *Applied Energy*, 88(1), 409–416. https://doi.org/10.1016/j.apenergy.2010.07.032

Ozgur, O., Yilanci, V., Ozbugday, F. C. (2021). Detecting speculative bubbles in metal prices: Evidence from GSADF test and machine learning approaches. *Resources Policy*, 74, 102306. https://doi.org/10.1016/j.resourpol.2021.102306

Pan, W.-F. (2018). Sentiment and asset price bubble in the precious metals markets. *Finance Research Letters*, 26, 106–111. https://doi.org/10.1016/j.frl.2017.12.012

Phillips, P. C. B., Yu, J. (2011). Dating the timeline of financial bubbles during the subprime crisis. *Quantitative Economics*, 2(3), 455–491. https://doi.org/10.3982/qe82

Phillips, P. C. B., Shi, S., Yu, J. (2012). *Testing for Multiple Bubbles*. Cowles Foundation Discussion Paper No. 1843.

Phillips, P. C. B., Shi, S., Yu, J. (2015). Testing for multiple bubbles: historical episodes of exuberance and collapse in the S&P 500. *International Economic Review*, 56, 1043–1078. https://doi.org/10.1111/iere.12132

Phillips, P. C. B., Wu, Y., Yu, J. (2011). Explosive behavior in the 1990s NASDAQ: when did exuberance escalate asset values? *International Economic Review*, 52, 201–226.

Sephton, P. S. (2016). Commodity Prices: Policy Target or Information Variable. *Journal of Money, Credit and Banking*, 23(2), 260–266.

Shafiee, S., Topal, E. (2010). An overview of global gold market and gold price forecasting. *Resources Policy*, 35(3), 178–189. https://doi.org/10.1016/j.resourpol.2010.05.004

Shafiullah, M., Chaudhry, S. M., Shahbaz, M., Reboredo, J. C. (2021). Quantile causality and dependence between crude oil and precious metal prices. *International Journal of Finance and Economics*, 26(4), 6264–6280. https://doi.org/10.1002/ijfe.2119

Shah, A. A., Dar, A. B., Bhanumurthy, N. R. (2021). Are precious metals and equities immune to monetary and fiscal policy uncertainties? *Resources Policy*, 74, 102260. https://doi.org/10.1016/j.resourpol.2021.102260

Shi, S., Hurn, S., Phillips, P. C. B. (2020). Causal change detection in possibly integrated systems: Revisiting the money-income relationship. *Journal of Financial Econometrics*, 18(1), 158–180. https://doi.org/10.1093/JJFINEC/NBZ004

Shi, S., Phillips, P. C. B., Hurn, S. (2018). Change Detection and the Causal Impact of the Yield Curve. *Journal of Time Series Analysis*, 39(6), 966–987. https://doi.org/10.1111/jtsa.12427

Street, L., Grubb, M., Hewitt, A., *et al.* (2014). *Gold Demand Trends Full Year 2013*. London: World Gold Council.

Toda, H. Y., Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Economics*, 66(1–2), 225–250. https://doi.org/10.1016/0304-4076(94)01616-8

Trung, N. B. (2019). The spillover effects of US economic policy uncertainty on the global economy: A global VAR approach. *North American Journal of Economics and Finance*, 48, 90–110. https://doi.org/10.1016/j.najef.2019.01.017

Tunc, A., Kocoglu, M., Aslan, A. (2022). Time-varying characteristics of the simultaneous interactions between economic uncertainty, international oil prices and GDP: A novel approach for Germany. *Resources Policy*, 77, 102658. https://doi.org/10.1016/j.resourpol.2022.102658

US Geological Survey (2012). *Metal Prices in the United States Through 2010*. Reston: United States Geological Survey.

Umar, Z., Aziz, S., Tawil, D. (2021). The impact of COVID-19 induced panic on the return and volatility of precious metals. *Journal of Behavioral and Experimental Finance*, 31, 100525. https://doi.org/10.1016/j.jbef.2021.100525

Wahab, B. A., Adewuyi, A. O. (2021). Analysis of major properties of metal prices using new methods: Structural breaks, non-linearity, stationarity and bubbles. *Resources Policy*, 74, 102284. https://doi.org/10.1016/j.resourpol.2021.102284

Wang, Y., Zhang, B., Diao, X., *et al*. (2015). Commodity price changes and the predictability of economic policy uncertainty. *Economics Letters*, 127, 39–42. https://doi.org/10.1016/j.econlet.2014.12.030

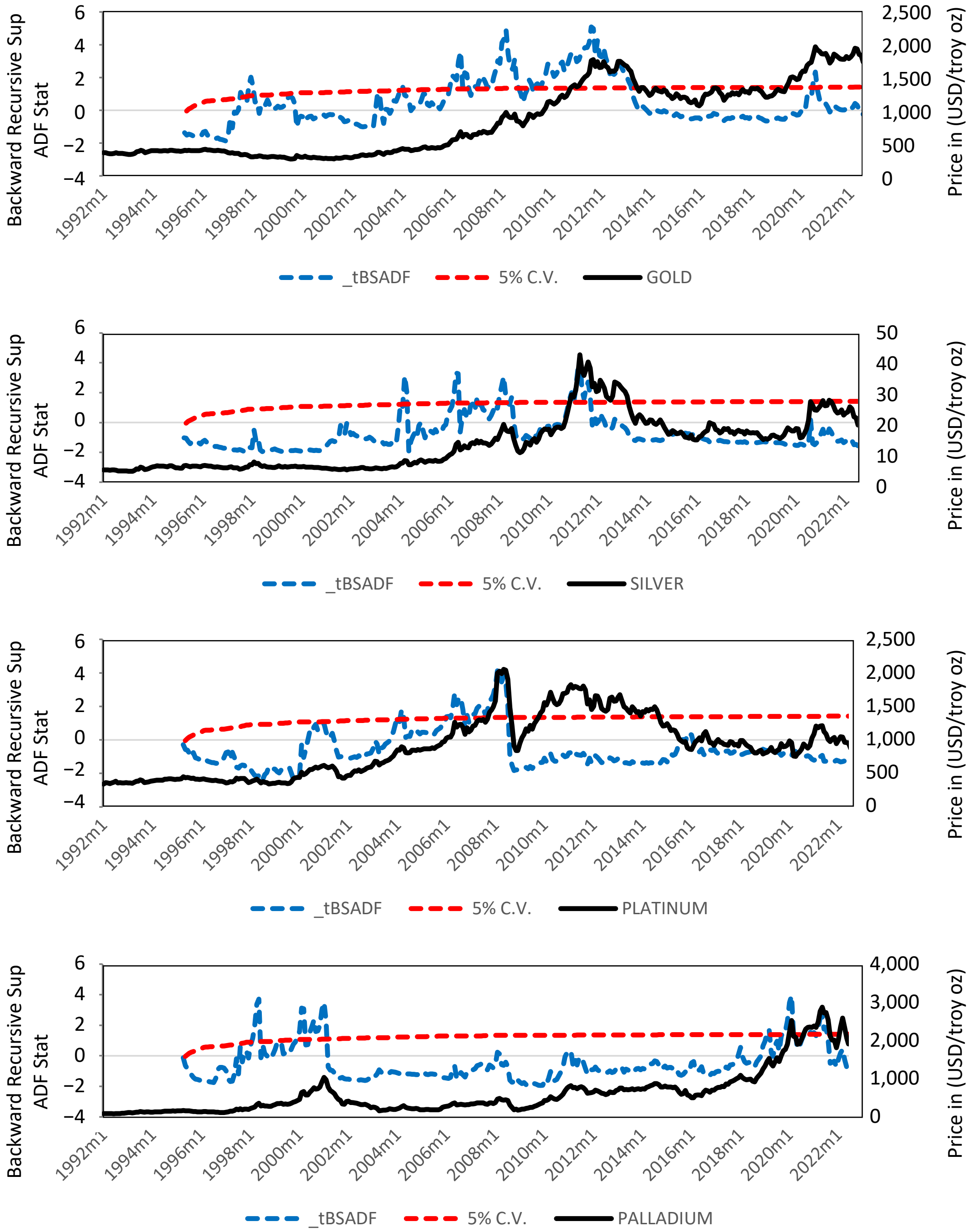
World Gold Council (2009). *China Gold Report: Gold in the Year of the Tiger*. London: World Gold Council.

Yilanci, V., Kilci, E. N. (2021). The role of economic policy uncertainty and geopolitical risk in predicting prices of precious metals: Evidence from a time-varying bootstrap causality test. *Resources Policy*, 72, 102039. https://doi.org/10.1016/j.resourpol.2021.102039

Zhao, Y., Chang, H.-L., Su, C.-W., *et al*. (2015). Gold bubbles: When are they most likely to occur? *Japan and the World Economy*, 34–35, 17–23. https://doi.org/10.1016/j.japwor.2015.03.001

Appendix

Figure A: BSADF sequence: periods of exuberance in precious metals prices



Notes: The original time series are depicted by the solid black line on the right vertical axis, whereas BSADF sequences and 95% finite sample critical values are depicted by the dashed blue and red lines on the left vertical axis, respectively. An exuberance phase is identified whenever the BSADF sequence heightens over the corresponding critical value.

Source: Authors' own elaboration