Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

The double nature of the price of gold—A quantitative analysis based on Ensemble Empirical Mode Decomposition

Lei Ming, Shenggang Yang, Cheng Cheng *

School of Finance and Statistics, Hunan University, Changsha, People's Republic of China

A R T I C L E   I N F O

A B S T R A C T

The research perspective of gold is either as a commodity or as a financial asset in most previous research. This paper initially examines the double nature of the price of gold both as a commodity and money from 1969 to 2014 by a statistics model, namely the Ensemble Empirical Mode Decomposition (EEMD). We decompose and categorize the gold price by time frequency into three different series: high frequency series, low frequency series and trend series, which takes 4.17%, 25.68%, 70.15% of the total variability, respectively. The high frequency series is consistent with the reaction of gold price to the influence of speculation and economic events, while the low frequency series is changing simultaneously with gold's varying role in world currency and as a safe haven asset. The trend series of gold grows steadily because of scarcity and increasing volume of jewelry purchases. Therefore, we interpret the high frequency series and trend series as a reflection of gold's commodity property, and the low frequency series is associated with gold's monetary property. This technology of EEMD sheds light on the double nature and price change of gold in the past.

1. Introduction

The double character of gold as a commodity and as money has been discussed in economics for centuries. As Ricardo (1817) has pointed out, gold not only is the measure of value but also the thing valued (pp. 42–43). Marx (1867) has summarized that "gold and silver are not by nature money; money is by nature gold and silver" (pp. 183–184). Pinney (1958) has explicitly clarified the duality of gold: gold is the ideal medium of exchange because of its acceptability, durability, portability, etc. On the other hand, gold is also a commodity. Its supply varies considerably based on new discoveries, and its demand is subject to commercial use from time to time. Although after the collapse of the Bretton Woods System in 1971, currencies are no longer connected to gold, many scholars have begun to discuss gold's other features such as: the stock market diversifier in Sherman (1982) and Davidson et al. (2003); the inflation hedge in Ghosh et al. (2004) and Blose (2010); the exchange rate hedge in Capie et al. (2005), Sjaastad (2008), Joy (2011), Wang and Lee (2011); the safe haven asset in McCown and Zimmerman (2006), Baur and Lucey (2010), Baur and McDermott (2010), Reboredo (2013), etc. However, all of those discussions are based on the assumption that gold can hold its

purchasing power steadily over many years (Capie et al., 2005), it is value-preserving and still universally accepted in the world market (Wang and Lee, 2011). Rockerbie (1999) also divides the demand of gold into monetary factors and non-monetary factors. Therefore, we consider gold's characteristics of hedge, value preservation, and inflation resistance as gold's monetary property. And we interpret gold's industrial and private consumption needs as commodity property for the convenience of our further discussion in this paper.

In the last ten years, with the prosperity in emerging market economies, the demand for gold's consumption as jewelry and luxury goods keeps rising. For example, gold jewelry consumption increased from 224 t in 2004 to 669 t in 2013 in China, nearly tripling over the past decade[†]. In India, the importation of gold has increased from 492.3 t in 2001–2002 to 838.3 t in 2011–2012, making India the world's largest gold importer (Kanjilal & Ghosh, 2014). However, with the advent of electronic payments and new money forms (for example, Bitcoin), the demand for gold as a standard of value and a means of exchange could shrink. Therefore, the double role of gold as a commodity and as money could possibly make different impacts on the price of gold. Thus, distinguishing and evaluating the different impacts of gold's

* Corresponding author.
    E-mail addresses: minglei@hnu.edu.cn (L. Ming), sgyang@hnu.edu.cn (S. Yang), ccheng@hnu.edu.cn (C. Cheng).

† Data Resource: World Gold Council, 2014, *China's gold market: progress and prospects,* http://www.gold.org/supply-and-demand/chinas-gold-market-progress-prospects.

commodity and monetary property is a promising starting point for us to analyze the dynamics of the price of gold.

Numerous literatures have analyzed gold prices by different methods. However, none of them has attempted to disentangle gold's dual property quantitatively. By the research perspective, they can be divided into two groups: one regards gold as a precious metal and an important commodity, those studies mainly focus on deciphering the relationship between the gold price and crude oil price (see Baffes, 2007; Soytas et al., 2009; Narayan et al., 2010; Zhang and Wei, 2010) and introduce other macroeconomic variables, for example, interest rate (Hammoudeh and Yuan, 2008; Wang and Chueh, 2013) and exchange rate (Sari et al., 2010). Some of them analyze the gold price from the supply and demand framework, including the influence of production (Rockerbie, 1999), mining (Ndiaye and Armstrong, 2013). The other studies only consider gold's role as a financial asset and mainly discuss the reaction of gold price to stock markets (see, e.g., Sherman, 1982; Davidson et al., 2003), exchange rate markets (see, e.g., Capie et al., 2005; Sjaastad, 2008; Joy, 2011; Wang and Lee, 2011), or asset price bubbles (see, Baur & Glover, 2014; Białkowski et al., 2014). Some of these studies test gold's ability as inflation-hedging (see Ghosh et al., 2004; Blose, 2010) and a safe-haven asset (McCown and Zimmerman, 2006; Baur and Lucey, 2010; Baur and McDermott, 2010; Reboredo, 2013), etc.

Thus, the research perspective of gold is either as a commodity or as a financial asset for most of the previous research. However, there is no quantitative analysis on both property of gold now. Therefore, this is a first attempt to explore the dynamics of the gold price from the view point of the double nature of gold by taking advantage of a new statistical model, Ensemble Empirical Mode Decomposition (EEMD). It was extended from Empirical Mode Decomposition (EMD) which was first introduced by Huang et al. (1998). EMD assumes that the data may have several different coexisting modes of oscillations simultaneously. It can extract those intrinsic modes from the original time series and generate intrinsic modes functions (*imfs*) with the same numbers of extrema and zero-crossings or differing at the most by one. Each *imf* is symmetric with local zero mean. Therefore, EMD can help to interpret the data with different nearly periodic functions with different time ranges and fluctuation frequencies. EMD was initially applied to the study of ocean waves, and then successfully used in many research areas. Huang et al. (2003) first introduced this method into financial time-frequency analysis. Next, Wu and Huang (2004) extended EMD, and proposed EEMD. Zhang et al. (2008) used EEMD and fine-to-coarse reconstruction to decompose and reconstruct crude oil price into three components: the short term fluctuation, the effect or shock of supply-demand change, and the long term trend.

With identical methodology, we apply EEMD and fine-to-coarse reconstruction to decompose and reconstruct the price of gold into three components with different time frequency, which can be interpreted as different aspects of gold's double nature quantitatively. The organization of this paper is given as below: Section 1 describes our purpose and previous research on the price of gold. Section 2 discusses the general trend of the gold price and its dual property. Section 3 outlines the research methodology and EEMD. Section 4 presents the result of decomposition on the gold price. Section 5 offers our interpretation for the reconstruction of gold price. Finally, the last section is discussion and conclusion.

2. General trend of the gold price and its dual property

2.1 Gold demand and supply

Gold has come and gone as an anchor to the global monetary system. The change in gold's role in the monetary system exerts an influence on its price.

As shown in Fig. 1, the price of gold increased substantially from 1969 to 1978. However, since the "Nixon shock"[‡], the US government unilaterally canceled the direct convertibility of the United States dollar to gold in 1971, and the International Monetary Fund delivered a collective decision to cease the monetary uses of gold in 1978, which triggered a substantial decline in the price of gold. After that, the price was relatively stable from the 1980 s to 2005. In 2005, the gold price started another round of increases until August, 2011. After several months' fluctuation in 2012, the price of gold suddenly reversed and declined until the third quarter of 2014.
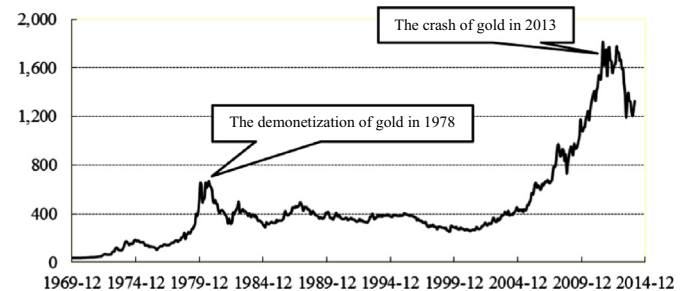

Fig. 1. The nominal gold prices from Dec. 1969 to Feb. 2014 (USD/troy ounce). **Source:** Authors' construction from World Gold Council. Note: The troy ounce (oz t) is a unit of imperial measure to gauge the mass of precious metals. One troy ounce is currently defined as exactly 31.1034768 g of 0.996 purity.

Table 1
The world gold flow from 2004 to 2013 (metric tons). **Source:** World Gold Council (2014).

	Jewelry[a,b]	Total bar and coin invest[b]	ETFs[⊕] and similar[b]	Technology[a]	Central banks[b]	Total
2004	2, 619	361	133	418	− 479	3, 052
2005	2, 721	412	208	440	− 663	3, 118
2006	2, 302	428	260	471	− 365	3, 095
2007	2, 425	442	253	477	− 484	3, 114
2008	2, 306	916	321	464	− 235	3, 771
2009	1, 817	826	623	414	− 34	3, 647
2010	2, 034	1, 229	382	469	77	4, 192
2011	2, 029	1, 569	185	458	457	4, 698
2012	1, 998	1, 358	279	415	544	4, 595
2013	2, 361	1, 781	− 880	409	409	4, 080

[a] denotes gold's use as a commodity,
[b] denotes gold's use as financial asset.

Table 1 shows world gold flow from 2004 to 2013. Gold purchases were around 3,100 t per annum from 2004 to 2007. Jewelry use of gold fluctuated during 2004 to 2013, while center bank purchases moved from negative to positive during this period. The technology demand rose from 2006 to 2011. However, the demand for gold by ETFs and similar[§] declined substantially in 2013.

Table 2 illustrates the estimated world mine production of gold from 2004 to 2013. The world total production of gold decreased from 2,440 t to 2,280 t during 2004–2008 and continuously increased from 2008 until 2013, when its maximum was reached. As can be seen from Table 2, all 13 countries provide more than 70% of world mine production of gold.