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The synchronized and exceptional price performance of oil and gold: Explanations and prospects

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ABSTRACT

This paper compares the global markets for gold and oil so as to explain the surprisingly high correlation of the two materials' prices since 1970, and the exceedingly impressive rise of both price series compared with that of virtually all other primary commodities. We propose that developments in the oil market, and the resulting effects on the macroeconomy, influenced investment activity in gold, thus providing the most plausible explanation for the two commodities' price synchronization. Our view on the extraordinary price increases of oil and gold, compared to a broad category of metals and minerals, is that oil prices rose first based on above-ground hurdles that restrained the capacity to produce, and gold prices then reacted as they were pushed up by rising safe-haven investment to store value – an attribute not shared by other metals and minerals. The paper also comments on the likely future price evolution of these important materials, arguing that oil prices will stagnate at levels observed from late 2014, or even weaken in the coming decades, but that gold prices will continue to ride relatively high – thus leading to a collapse of the oil/gold price connection.

1. Introduction

Fig. 1 shows the price performance, in constant money, for oil and gold, along with an index of metals and minerals prices, over 46 years. Two observations stand out from the graph. *First*, it appears that the prices of oil and gold are highly correlated (correlation coefficient 0.83, but only 0.72 for oil and metals, and 0.66 for gold and metals) over the period studied. This is astonishing, given the very differing characteristics of the two materials and their markets (see Section 2). And *second*, the two commodities have recorded quite extraordinary price increases, compared to an aggregate of exhaustible materials, represented here by a broad metals and minerals index. The price of oil recorded an impressive increase of 759% from 1970–72 to 2012–14. Over the same period, the gold price rose by 580%, while the metals and minerals index increased by a mere 38%.[1] These two observations dominate the agenda for our study of oil and gold, two mineral commodities with crucially important roles in human civilization. A *third* objective, addressed at the end of the paper, is to assess the likelihood or otherwise, that the price correlation of the two materials and their exceptional price performance will persevere into the future.

There is considerable literature on the economics of oil and gold and some on the relationships between the two, and this literature is quoted and drawn upon in the pages which follow. We feel, however, that the main issues comprised in the present paper's agenda have not been adequately treated in earlier work. This provides a rationale for our effort. Moreover, it is worth underlining at this stage that our objective is not to make further theoretical or statistical advances in the subjects of focus, but instead to lean heavily on institutional conditions in deriving our findings and conclusions.

The discussion proceeds as follows. Section 2 elaborates briefly on the significance and market characteristics of the two products. In Section 3 we analyze the fundamental price determinants for oil and gold with the ultimate objective to identify the causes of the high correlation between the two. Section 4 addresses the reasons for the extraordinary price performance of both oil and gold over the past 46 years, compared to the lackluster price evolution of other exhaustible raw materials. Section 5 looks into the future and explains our view of a weakening oil-gold price correlation, and of a stagnant or falling price trend for oil compared to a more dynamic one for gold.

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[1] A comparison of individual mineral commodities with oil and gold does not alter the exceptionality in the price performance of the latter two up to 2014 (see Aguilera and Radetzki, 2016). By 2016, the price changes from 1970 to 72 had been reduced, but still amounted to an impressive 300% for oil and 551% for gold. Over the same years, the increase in the metals and minerals index amounted to just 1%.

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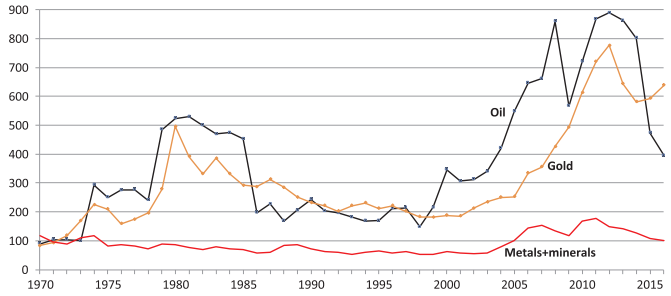

Fig. 1. Real prices* of oil, gold and metals + minerals 1970–2016. Index, 1970–72 = 100.
*UN's Manufactured Unit Value (MUV) Index in US$ used as deflator.
Sources: UNCTAD, UNSTAT and IMF

2. The significance of oil and gold and the market characteristics for the two products

Oil and gold are both of great importance to the world economy, though this importance manifests itself in different ways. Oil is by far the most sizable source of energy use, with applications throughout the modern economy, and its economic weight has been so great that its price changes are believed to affect global growth and inflation. Gold has for millennia played crucial roles in decoration activities while its holdings have been regarded as a safe haven particularly but not exclusively during unruly times. In more recent centuries, gold has additionally been a fundamental factor in global financial and monetary affairs. In terms of quantities and values, oil is much bigger than gold, but they both belong to the top tier among primary commodities in terms of value of production and trade.

Table 1 characterizes some major features of the markets for the two products, and reveals several stark differences between them. Secondary supply plays no role at all in the oil market. In contrast, gold scrap, gold being virtually indestructible, accounts for almost a third of overall supply. Usage is quite concentrated in both materials, with 56% of oil consumption in transport and 53% of gold employed to manufacture jewelry. But while all of oil is irrevocably consumed, more than a third of gold demand in 2016 was set aside for holding by private investors and central banks. As noted above, the economic weight of oil is much greater than that of gold – the 2016 oil supply valued at some 2.06% of global GDP, compared to only 0.24% for gold. Finally, there is a huge difference in inventory holdings, those of oil (7% of supply) representing the need to even out short-run demand (and supply) fluctuations, while in gold, private and official holdings maintained as a safe store of value amount to more than 20 times annual supply. As seen in Table 1, supply of 4511 t in 2016 alone exceeded demand of 3559 t, resulting in a surplus of 952 t in that year. We surmise that the discrepancy, to which neither the World Gold Council nor Thomson Reuters (the two lead agencies producing gold statistics) have been able to provide a full and clear-cut account, implies a further addition to inventories over and above the amounts demanded by private investors (1057 t for bars and coins) and central banks (257 t), mainly in exchange-traded funds (ETF)[2] and in less visible areas like over-the-counter markets and fabrication sites (private communication with World Gold Council and Thomson Reuters).

Table 1
Oil and gold in 2016 – distinguishing characteristics.
Sources: IEA (monthly, annual); Thomson Reuters (annual); World Gold Council (on the web)

	Oil		Gold	
Total supply, tons	**4850 m**		**4511**	
Primary supply	4850 m		3222	Mine
Secondary supply	0		1268	Scrap
			21	Hedging + ETF net
Total demand, tons	**4830 m**		**3559**	
	2700 m	Transport	1891	Jewelry
	870 m	Industry	354	Industrial
	390 m	Buildings	1057	Private investments (bars & coins)
	290 m	Power	257	Central Banks
	580 m	Other		
Price, $/ton	**318**		**40.2 m**	
Value of supply, $ bn	**1542**		**181**	
Value as % of world GDP*	**2.06**		**0.24**	
*$75 tr at market prices				
Visible inventories, Dec, tons, total	**337 m**	Only OECD	**99000**	
	177 m	Government	31000	Central banks
	160 m	Industry	38000	Bars and coins
			30000	Other
Inventories as % of supply	**7**		**2195**	

3. The fundamental price determinants for oil and gold

3.1. The pricing conventions employed in the two markets

A variety of pricing conventions prevail in primary commodity markets, the dominant ones being posted prices, bilateral contract prices, producer dictated prices, user driven prices, and prices set by auctions and by commodity exchanges – with the latter assuming widening application in international commodity trade (Radetzki and Wårell, 2017). While the conventions used in oil and gold are unlikely to explain the price correlation between the two materials nor their extraordinary price rise since the early 1970s, a proper understanding of how the two markets function warrants a brief description of the conventions used and their evolution over time.

The formation of the Organization of the Petroleum Exporting Countries (OPEC) in 1960, combined with the oil glut through most of that decade and the many nationalizations of the 1970s, enabled the OPEC governments by the mid-1970s to exercise control by establishing a system of producer determined prices. This was centered on a "reference price" set on Saudi Arabia's Light Arabian oil. Other oil qualities produced by OPEC nations were priced with premiums or discounts to this price (Fattouh, 2011). The system of reference prices lasted for almost a decade. Its eventual demise about 1985 was primarily caused by an extraordinary production expansion outside of OPEC, induced by the high prices that prevailed between 1975 and 1985 (Mabro, 2000). Saudi Arabia and the rest of OPEC abandoned the producer administered pricing formula and accepted a more market related system of pricing. At the time, the New York Mercantile Exchange (NYMEX) had already operated a crude oil futures contract for a few years. This trade outlet helped in pricing arm's length sales conducted by the independent producers in non-OPEC countries. Oil prices determined by exchanges have prevailed since that time.

In gold, the shift in pricing conventions has been less dramatic. Shafiee and Topal (2010) report that gold prices were basically flat at about $20 per ounce from 1833 to 1933, when producer-dictated prices were the dominant convention. Back then, a relatively small number of producers and refiners, and their home governments, had sufficient market power to set prices for extended periods of time. In 1933, the gold price was fixed at approximately $35 – following an executive order by US President Roosevelt – and remained at that level until 1967. A year later, prices were permitted to deviate from official prices, and in 1975 gold became a new arrival on the commodity exchanges. Since then, gold prices have been basically determined by the forces of supply and demand, just like any commodity prices traded in unregulated and reasonably competitive markets.

[2] The World Gold Council (on the web) defines ETFs as "financial products physically backed with allocated gold bullion, listed on a stock exchange, and bought and sold in the form of shares."

3.2. The structure and determinants of demand and supply in oil and gold

The dominant market segment for *oil* – as a fuel for transport on roads, in the air and across the seas – continues to persevere despite the past price rises. Until the mid-2010s, large-scale substitutes to oil in these markets are conspicuous by their absence. The dependence on oil in the transport sector makes the global economy highly vulnerable to oil supply disruptions.

The power producing sector constitutes a sharp contrast in this respect. The price increases experienced in the past have resulted in sharply shrinking demand, as oil was successfully replaced by expanded usage of coal, gas, nuclear and renewables. By the time of the first oil crisis in the 1970s, the power sector absorbed quite a sizable share of oil usage. In 1980, the share of oil consumption absorbed by power producers still accounted for approximately 20% of the total. By 1995, that share had declined to around 10%, and to no more than 5% by 2010. For all practical purposes, power output has detached itself from its earlier dependence on oil.

OPEC accounted for about half of global supply in 1973, but that share declined to about a third in the 2010s. The group's contribution of less than a quarter to global output growth since 1973 is low, given that almost three-quarters of global reserves are located in OPEC countries, and that they comprise the huge and economically exceptional ones of the Middle East (Radetzki and Wårell, 2017).

Other major oil producers include the United States, Russia, Canada, China, Brazil, Mexico and Norway – this group of countries accounted for over 42% of world oil output in 2016 (BP, annual), while the group's share of proved reserves represented no more than some 22% of the global total.

Due primarily to the extraordinary production expansion associated with the shale oil revolution in the US (output stood at about 4.5 mbd in mid-2017 and is rising despite the relatively low price environment; it currently represents roughly half of total US production) the oil market has been clearly characterized by oversupply since 2014, and the global stock levels have been well above the averages of five preceding years (Bloomberg, 2017).

Total *gold* demand is geographically skewed, with India and China accounting for around half of the current global total. Fig. 2 shows the trends in demand by sector from 1970 to the present, revealing some intricacies in the relationship between demand and price. A "conventional" inverse relationship between demand (grey shaded areas) and price (solid line) is particularly evident for jewelry. The quantitatively very important demand in the form of private investment, however, appears to have "unconventionally" increased along with the gold price, both reaching maximums in the early 2010s, while official gold holdings rose too in those years. This suggests not only that inventory change must have a direct and significant impact on price, but that rising prices are likely to have a positive impact on inventory buildup.

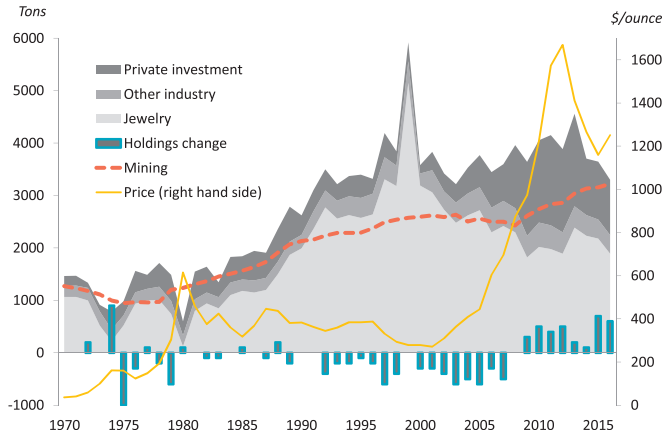

Fig. 2. Gold demand (jewelry, other industry, private investment), holdings change, mining supply, and price (1970–2016).
Sources: World Gold Council (on the web); Thomson Reuters (annual)

Gold is exceptional among metals in that only a small share of demand is generated by industry proper (e.g. electronics, dentistry), as distinguished from the jewelry industry. The latter, characterized by a high price and income elasticity, dominates total demand. In 2016, jewelry demand was recorded at 1891 t out of a world total of 3559 t (Table 1). Marriages in the emerging nations of China and India represent a substantial proportion of jewelry purchases.

The decisions of countries' central banks to buy and sell can be of instrumental importance for the gold market but we have failed to reveal uniform and stable bases for such decisions. On purely economic grounds, no strong rationale can be found for central banks to purchase and hold gold for inventories, as it has lost its ancient role as a reserve for the issue of money. The reasons that they continue to do so, and in fact increase their holdings over time in some measure, must be sought in political considerations, along with tradition and taste. Central banks have gold inventories of more than 33000 t, corresponding to 10 years of mine output at 2016 levels. As shown in Table 1, 257 t were added to official holdings in 2016.

Visible private investments in bars and coins, some 1057 t in 2016, commonly make up a considerable share of gold demand. Although some coins and bars may be bought for their decorative properties, most such purchases constitute investments, purportedly for the purpose of preserving or increasing value.

Since the turn of the century, ETFs – which, as noted earlier, are thought to have accounted for most of the overhang in the supply-demand balance of 2016 – have allowed investors to purchase gold without the need to store or insure it. As observed, such investments are less visible and not easy to fully identify. These investments, like investments in bars and coins, have two basic motivations (Radetzki, 1990). The *first* is a belief that gold holdings provide a safety in times of distress. Gold is easy to transport, does not burn and is harder to confiscate than many other assets. The *second* motivation is the expectation that gold prices will rise so as to provide a better return than alternative placements.

Analyzing the period 1976–1999, Ghosh et al. (2004) conclude that the gold price has in fact risen over time with the rate of inflation, and has thus constituted an effective inflation hedge. The first motivation should make gold holdings relatively inelastic to price or to price expectations. The second, however, is based precisely on such expectations. Intriguingly, many holdings have been built up with both motives simultaneously in view.

On the supply side, gold mining is led by China, with production of around 454 t in 2016 out of a world total of 3222 t (Thomson Reuters, annual). Australian gold production was about 291 t in the same year, making it the second biggest producer, followed by Russia at 254 t and the United States at 236 t.

A number of studies quantitatively assess the correlation between the costs of the marginal gold projects and the market price (e.g. CB Capital Research Inc, 2014), asserting, unsurprisingly, that cost plays a crucial role for price evolution. Despite mine production accounting for a minor proportion of overall supply, the analyses indicate that costs of new supply are strongly linked to price levels. The studies observe the correlation over the past four decades, including the years where prices spiked – around 1980 and 2010.

It should be mentioned that while economists usually focus on the established determinants of demand and supply to explain price developments, some commodity analysts do not regard these as the most accurate drivers for near term gold price movements. A somewhat unconventional view on the link is presented by O'Connor et al. (2016), who find evidence of causation running from gold prices to production costs. A study by Tilton (2014), though dealing only with hard rock minerals, provides support to O'Connor et al.'s view by quoting a number of reasons why productivity declines and costs are pushed up during periods of boom and high prices in resource industries, and vice

versa during recessions with suppressed price levels.

A further perspective revealed from reading the trade press, research reports by investment banks, news articles, and also some academic papers, sees gold price evolution as primarily a function of macro-economic and geopolitical factors.

Old scrap, totaling 1268 t in 2016, is another crucial component of gold supply. Price is a particularly important factor behind the volume of scrap availability, in gold as well as in other metals. The discarded industrial products ordinarily constitute the major source of metal scrap. In gold, however, by far the most important source of scrap is jewelry. The importance of scrap in the gold market can be deduced from Fig. 2 by comparing total gold demand over the decades with the production path of mine supply. Most of the difference can be attributed to old scrap supply.

The populations of India and several nations in the Middle East are particularly intensive holders of gold in the form of jewelry and other decoration pieces. Severe recessions in these countries can strongly expand scrap supply by forcing the groups economically hit to offer their fabricated gold for re-melting.

3.3. Major pricing events since 1970

This sub-section briefly describes events that had major impacts on the oil and gold markets, thus helping to explain the price reactions in Fig. 1 over the past 46 years.

In the case of *oil*, we draw heavily on Hamilton (2011), whose study provides a broad historical overview of local and global events that caused important, but often short-run shifts in the oil price. In 1973–1974, some Arab members of OPEC implemented an embargo on oil exports to selected countries, followed by significant production cutbacks. The price of oil doubled in consequence. In the late 1970s, sizable output reductions resulted from the Iranian revolution, soon followed by the Iran-Iraq War in the early 1980s, suppressing production in both. The historical price collapse of 1985–1986 occurred as Saudi Arabia and other OPEC members gave up their defense of high prices to preserve their market share. In 1990–1991, Iraq invaded Kuwait, thus reducing oil output in both countries. The East Asian crisis hit in 1997–1998, with recession in Thailand, Korea and other East Asian countries reducing oil demand and sending the oil price to its lowest level in real terms since 1974. Through 2004–2008, global and especially Chinese economic growth was quite impressive, and demand for oil expanded rapidly while supply was stalling, prompting the most recent oil (and general commodity) boom. As 2014 drew to a close, the oil price plunged suddenly and unexpectedly, primarily in consequence of rapidly expanding supply from the US shale oil sector that overwhelmed the market. The supply glut has endured, with low prices and high inventory levels persevering since.

While Fig. 1 visibly illustrates that the price evolution of *gold* has been highly synchronized with that of oil, and thus might be partially influenced by the same events outlined for the oil market, the following provides a summary of the circumstances associated with gold's price movements (The Guardian, 2010). The remarkable price rise over the 1970s was prompted early in the decade by President Nixon's cancellation of the fixed link between the US dollar and gold. This resulted in a devaluation of the dollar and a boost for nominal gold prices, as gold continued to be denominated in dollars. In 1980, geopolitical turmoil, including the Soviet intervention in Afghanistan, and rising inflation prompted by rising oil prices boosted investor demand for gold. Gold prices fell throughout most of the 1980s, partly as a result of aggressive US monetary and fiscal policies intended to raise interest rates and curb inflation. Governments somewhat reduced their gold holdings in the 1990s, further depressing prices, while gold producers increased sales in the futures markets to hedge against further falls in the gold price. In 2003, the price rallied as demand rose, prompted by safe-haven motivated investments ahead of the US invasion of Iraq. Subsequently, in line with oil and most commodities, demand for gold continued to rise on account of brisk economic expansion in both rich and emerging nations. According to The Economist (2017), the sustained price rise that lasted until 2011 was accentuated by central banks' use of quantitative easing intended to increase money supply and raise inflation. Additionally, the euro crisis worried investors about the potential dissolution of the single currency and the safety of banks in Europe. But by 2013, concerns about the euro-zone were subsiding and the anticipated inflation did not materialize. The gold price fell sharply, depressed further by slowed economic growth and demand, and has remained in a lower band since then.

3.4. The high correlation explained

Table 1 reveals the significant differences in key factors between the oil and gold markets, and yet, the price developments have been strongly synchronized. The following paragraphs quote major findings in the academic literature related to the correlation, before we formulate our own views on the issue.

Though our considered time horizon goes back only to 1970, Rafiq and Bloch (2016) show the positive correlation between oil and gold prices ever since 1900. Focusing on the years 2000–2008, as all commodity prices surged, Zhang and Wei (2010) observe significant cointegration between the prices of oil and gold and assert that the rising oil price pushed up the gold price in turn.

Kumar (2017) finds that oil and gold prices are 'stickier' when rising, which suggests the correlation is somewhat asymmetric. A similar result is presented in Tiwari and Sahadudheen (2015). This finding is not readily apparent through a visual inspection of the long-term price relationship of the two commodities seen in Fig. 1, and is contradicted by Le and Chang (2012). The latter also provide evidence that gold prices follow oil prices with a lag of a few months.

As noted earlier and described in the literature, the demand for certain commodities may be partially motivated by investors seeking to hedge against the inflationary effects of macroeconomic shocks (e.g. Ahmadi et al., 2016; Pindyck and Rotemberg, 1990). In this context, gold – used as a store of value, particularly during episodes of economic and political turmoil – is often referred to as a safe haven for investors who hedge against inflation caused by oil price increases (Bildirici and Turkmen, 2015; Narayan et al., 2010; Shafiee and Topal, 2010). This conceptual framework appears to have general support in the literature, though results vary according to the time period in question (Smiech and Papiez, 2017). Before the most recent commodity boom, Mahdavi and Zhou (1997) concluded that commodity prices as a whole were better indicators of inflation than the price of gold. Studying the period 2000–2011, which covers much of the recent boom, Reboredo (2013) indicates that gold does indeed act as an effective safe haven against oil price movements.

Natanelov et al. (2011) also base their study on the idea that crude oil market developments encourage investment decisions on other commodities like gold. Melvin and Sultan (1990), among others, note that gold represents a considerable share of the asset portfolios of some oil-exporting countries and that demand for gold increases in these countries when the oil price rises – as government revenues rise too, since many prominent oil-exporting nations have a strong economic dependence on oil. The gold price thus increases in turn. In addition, demand for jewelry in the Middle East – the third largest consumer, behind China and India – explodes during periods of elevated oil prices.

Beckmann and Czudaj (2013) and Sari et al. (2010) summarize the research on the inverse link between the US dollar exchange rate and the prices of oil and gold, as both commodities are denominated in dollars. In this case, the relation between oil and gold prices would be one of correlation and not causality. On a related subject, Ciner et al. (2013) find that gold can be considered a safe haven again exchange rate volatility.

Despite the many academic studies that we have read and quoted, the price correlation between oil and gold remains opaque, and further

work on the issue is warranted. Though we too remain uncertain, here is our attempted explanation to the observed price correlation between the two.

Oil is a dominant commodity whose movements impacts macroeconomic factors like inflation and growth. Gold is very special among primary commodities with investments in inventory holdings to safeguard against macroeconomic vagaries playing a major role in overall demand. We take serious note of the finding in several of the studies quoted that gold price changes follow the lead of oil prices, with a lag. We see rising oil prices stimulating the demand for gold and hence exerting an upward pressure on the gold price mainly through two interrelationships. First, ceteris paribus, increased oil prices will exacerbate inflationary pressures and so inspire added private investments in gold inventories as a safe haven. And second, higher oil prices will add to income in major oil producing countries, and the Middle East in particular, resulting in expanded demand for official gold holdings, as well as for privately held jewelry. The obverse will hold when oil prices fall. We repeat again that further work is needed to bring about a fuller understanding of the relationship.

4. The causes to the exceptional price performance of oil and gold

So why did the real prices of oil and gold increase by some 600–800% between 1970–72 and 2012–2014 while those for minerals in general rose by less than 40% (Fig. 1)?

Recent research (Aguilera and Radetzki, 2016) provides some leads, at least for oil. It discards the interventions of OPEC – most of whose actions have had a short-term and shallow price impact – as an important long-run price influence. In a similar vein, we do not see depletion as driving oil prices upward. For depletion to play this role, it should have pushed costs upwards, but our investigations fail to find cost-increasing oil trends.

A summary assessment of conventional and unconventional oil resource quantities and the costs of their exploitation in 2008, a year well suited to represent average total cost levels of the past decade, reveals that the global volume consumed in that year amounted to some 86.6 million barrels per day. Consumption at that level is possible for some 65 years without exceeding $30 per barrel costs. Even that finding is conservative, considering that it does not take into account the recently identified vast shale resources, which currently become economic at oil prices of around $30 to $50, with falling cost levels year by year (Aguilera and Radetzki, 2016).

The unimportance of depletion applies to gold as well. A review of cost data for oil and gold (e.g. Aguilera et al., 2009; Thomson Reuters, annual) reveals the high profitability of both industries; costs, even at the margin, were substantially below simultaneous price levels most of the time in the course of the past decades – providing ample space for fiscal cream off. For gold, a comparison of the total cost curves between 2010 and 2016 with price levels shows that approximately 90% of gold production (an exceptionally high level for extractive industries) had costs substantially below market prices. In 2016, average production costs for the world were reported at $818 per ounce, while the gold price averaged $1251 (Thomson Reuters, annual).

South African gold may constitute an exception to our view that depletion played no important role in the industry, but the verdict is far from certain. Having heavily dominated global mine production for decades, South Africa began to lose market share in the 1980s, a decline that has yet to be reversed. A combination of low prices through the early 1980s to early 2000s, above-ground policies that constrained capacity expansion, and ageing mines provide plausible explanations for waning output (Thomson Reuters, annual). Depletion as a cause to South Africa's declining role in gold is countered by the country's large proved gold reserves. In 2016, these were estimated at 6000 t, behind only Australia at 9500 t and Russia at 8000 t (USGS, annual), two countries with lead roles in replacing South Africa as producers. Depletion may nevertheless have played a role, given that the country's all-in sustaining costs[3] have been reported at above $1000 per ounce over the past decade (Thomson Reuters, annual), the highest in the world and not far below prices over the period. Hence, although gold prices experienced a sharp rise in the mid-2000s, it is likely that companies looked to more favorable economic prospects elsewhere in the world. Despite South Africa's decline, a 19% global output increase in mined gold between 2010 and 2016 has been reported with leading roles for China (351–454 t), Australia (261–291 t), the US (195–254 t), Russia (230–236 t) and Peru (104–165 t). South Africa has seen a 9% decline over the period, from 184 to 168 t (Thomson Reuters, annual).

Some important leads to the oil price evolution over 40 years are provided in Aguilera and Radetzki (2016). It is asserted there that an inability to expand capacity in line with demand growth provides the main reason for exploding oil prices. This inability had several causes comprising widespread inefficiencies in the newly established dominant state-owned sector, excessive fiscal extraction that left insufficient resources for investment, and, in particular, the conflicts arising from the resource curse. We see the latter, characterized by often violent domestic and international strife over the high oil rents which not only arrested capacity growth but in many cases led to sharp reductions in the ability to produce, as the main explanation to the oil price performance. In these respects, oil appears as an exceptional case among primary commodities.

Our supposition for the extraordinary price increases of oil and gold, compared to the broad category of exhaustible primary commodities, is that oil prices rose first, triggered by the above-described factors that restrained the capacity to produce. Gold prices then reacted in response, triggered by the correlation between the two materials, and pushed upwards in response by a desire for safe-haven investments to store value – a characteristic not shared by other metals and minerals.

5. The future: prospects for oil and gold prices – is a de-linkage in sight?

A crucial follow-up question that we investigate is whether the exceptional price performance in oil and gold observed over the past four decades is likely to persevere in the future. Our thinking is that gold prices will continue to perform relatively strongly, not much below the $1200 per ounce average recorded in 2014–2016, but that forceful reasons exist to suggest stagnant at best and more likely falling oil prices from the levels that have prevailed after the dramatic price fall of 2014. These views also imply that the price correlation between the two materials will weaken or even disappear.[4] The paragraphs which follow justify the positions we have taken.

Our view on stagnant oil prices at levels observed from late 2014 importantly follows the conclusions in recent works (Aguilera and Radetzki, 2013, 2014, 2016). Those studies point to the shale oil revolution leading to a fundamental turnaround in the oil market. The revolution has so far been limited by and large to the US, where oil output rose by 78% between 2008 and 2016. At the same time, an unprecedented technological and productivity improvement has steadily suppressed shale production costs, and continues to do so. In 2016, most of the shale output in the US becomes economical to exploit at or below $50 per barrel, and the cost levels are falling. Wells require ever shorter time to be drilled, while the area covered by the horizontal extensions increases in size, and the output from each well is continually expanded. Although there have been many other technological revolutions in oil production over the past half century (e.g. the tapping of deep offshore fields), there is a vast difference between this continuous change and the shale revolution, as is clearly evident from the

[3] All-in sustaining costs consist of capital costs, operating costs, and also royalties and production taxes (World Gold Council, 2013).

[4] A divergence between oil and gold prices has already been observed, since 2014, and is primarily explained by the shale revolution's impact on oil supply. However, we see the divergence accentuated as shale supply continues to expand.

Table 2
Speculative rest of world shale oil supply in 2033, mbd.
Sources: BP (annual); **An update from** Aguilera and Radetzki (2016)

Global 2016 oil output	Global rise, 16 years until 2016	US share of shale oil resources, EIA (2015)	US shale production rise, 8 years (2008–2016)	ROW shale production rise, 16 years (2017–2033)
92.1	17.2	19%	3.7	16.2

US production explosion since the mid-2000s. One difference between past technology developments and the shale revolution is the very short lead times associated with the latter, meaning speedy output reactions to price changes. In the past, it took 5–10 years for new supply sources to come onstream; e.g. from oil sands, offshore reservoirs or even conventional oil formations.

This exceptionality of the shale oil revolution will be even more evident as shale expands internationally: the US is not exceptionally endowed with shale resources, so we expect an impending international spread of the revolution as other nations venture into the business. Assessments of extractable resource volumes in the rest of the world (ROW) have begun recently and the quantities are subject to growth as further exploration proceeds. The most recent data point to an 19% US share of the global total (EIA, 2015), a number likely to fall with the progress of exploration in other countries.

Table 2 provides a fascinating thought experiment. It reveals an actual US shale achievement of 3.7 mbd in the 8-year period 2008–2016. Assuming the ROW is equally successful as the US in its shale exploitation, though beginning seriously only in 2017, and progressing at half the recorded US pace, its contribution to global oil supply in 2033 would work out at 16.2 mbd, similar to the global oil supply rise in the 16 preceding years. And this is all a conservative assessment of global shale supply, given that future US increases are ignored, and that, as argued above, the US share of global shale resources will prove smaller over time.

There is an additional potential impact of horizontal drilling and fracking, technologies used in shale exploitation, evolving so recently that it has barely been reported by media so far. In our research, we refer to it as the conventional oil revolution, where these technologies are applied to old and tired conventional fields to extract the oil left behind, much like, but cheaper than, traditional enhanced oil recovery efforts (Aguilera and Radetzki, 2016). In a similar fashion to the output projections for shale oil, we project the global supply contributions of the conventional revolution to be of a similar magnitude as those of shale oil.

Thus, we see oil prices in the future coming closer to production costs because of the geographical diversification of output reducing the impact of resource curse disturbances, and, with ample, cheaper and widely distributed supply, a lesser role for price-increasing output manipulation.

There are a few further arguments to our assertion of stagnant or falling oil prices in the next decade and beyond. *First*, as is clear from Fig. 1, the prices of 2015 and 2016, often referred to as depressed, are quite high in a longer perspective; in fact, about the same as the extreme peak experienced in the 1980s, when measured in real terms. *Second*, the successfully implemented output restrictions by OPEC and major non-OPEC producers since late 2016 have failed to make a significant impact on price. And *third*, stagnant and plausibly even falling demand over the longer term due to oil-saving technological change and climate stabilization efforts is a further reason for prices not to exceed the levels of the recent past.

Our view on persevering high gold prices hinges on the dominant role of jewelry in gold demand, and our belief that this demand will expand by leaps and bounds. Two factors are involved. First, the income elasticity of gold for jewelry, a luxury usage, is bound to be high, so continued steady growth of the world economy will support future gold demand. Superimposed on this is an intriguing gender aspect. A dominant share of gold for jewelry is consumed by women, and a significant proportion of the global female population lives in emerging economies, where, due to changing social attitudes and rising employment, women experience widespread and fast economic emancipation. This gender factor is bound to provide a further boost to gold demand for jewelry. Jewelry light-weighting – resulting from shifting preferences, where consumers tend to purchase lighter and less expensive items – represents an opposing driver of demand, which is thought to be a recent cause of slowing demand in year-on-year percentage terms (private communication with Citigroup Commodities Research). In addition, the Middle East will presumably be deprived of the huge profits from high oil prices that have contributed to rising gold prices. We believe, however, that these relatively new developments will be overwhelmed by the high income elasticity of gold combined with fast growth of emerging nations and the gender factor referred to above.

An important consideration in determining gold prices is what the owners of the huge official and private gold inventories do with their holdings. As referred to earlier, the world's central banks, irrationally in our view, hold a huge gold inventory, equal to about 10 years of global mine production. Our conclusion about gold's price prospects is therefore critically dependent on a belief that the banks will not sell out their gold holdings. This is not a very daring proposition. Official gold holdings have been quite stable over the past several decades. They were maintained at around 35000 t between 1970 and 1990 (Gold Fields, 1991), then declined slowly to some 30000 t by 2008, only to rise again to more than 33000 t in 2016 (World Gold Council, on the web).

There remain the incompletely recorded private investments and holdings of gold in bars, coins and ETFs, on whose development we are highly uncertain. On the basis of two considerations we argue that the private holdings, like the official ones, will not undergo any dramatic change and so will not importantly impact gold prices in future years. The first has to do with a weakened link between oil and gold prices, which should suppress the demand for private gold inventories. The second surmises that the very low interest rates of the 2010s may be here to stay, so reducing the cost and enhancing the attractiveness of gold holdings (historically low interest rates, remaining suppressed despite years of energetic central bank efforts to bring about an increase, are leading to increasingly widespread beliefs that the low interest environment will persevere for the foreseeable future). We infer that the impact of the two factors on gold holdings might cancel out.

Earlier in the paper we assert that rising oil prices since the early 1970s drove gold prices upwards and so established a correlation between the two price series. This is because oil price changes impacted on global growth and inflation, given the dominance of oil in the world economy, and changing growth and inflation had an impact on the price of gold. With a less dominant role of oil in the world economy after the 2014 price fall, this correlation is likely to weaken, with oil providing a reduced support to the price of gold.[5]

The weakened oil/gold price link argued above implies that future gold prices will not benefit much from rising oil prices. But then, we anticipate future oil prices to be falling or stagnant at best. The gold price-boosting future of persevering low interest rates, on the other hand, will remain. These two considerations in combination lead us to project an historically relatively high gold price that remains close to that recorded in the recent past, plausibly in a range of $1000–1200 per ounce over the next ten years. From the producers' perspective this is a

[5] In an article published by S & P Global Platts, Kingston (2017) comes to the same conclusion, though with a different line of reasoning. Intriguingly, Kingston sees the collapse of the oil/gold price correlation explained primarily by the shale oil revolution. The author draws a possible analogy with the de-linkage of oil and natural gas prices caused by the shale gas revolution.

much more optimistic projection than our outlook of increasingly subdued oil prices due to impressive oil supply increases in coming years.

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