A review on the determinants of the price of gold

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Abstract

As gold has been a liquid asset for centuries with the property to hedge against inflation, in times with and without the Gold Standard, much has been written about the price of gold. Despite the attention gold has to investors, it still is not completely clear what drives the price of gold exactly. To date, no theory exists which shows how inflation and exchange rates and other variables affect the price of gold. This paper seeks to give a review of papers about the structure of the gold market; the determinants of the gold price and to use this literature on the influences on the gold price to test if such relations are still present today. The multivariate model explains 4.00% of the price of gold over the last twenty year. The variables used include: the London Interbank Offered Exchange Rate (LIBOR), the physical gold rate, the inflation rate, the amount of economic and political instability and US Dollar exchange rate to the Great Britain Pound, the Indian Rupee and the Chinese Yuan.

As gold has been a liquid asset for centuries with the property to hedge against inflation (Christie-David et al., 2000; Faugere and Van Erlach, 2006; Kaufmann and Winters, 1989; Mani and Vuyyuri 2005; Sjaastad and Scacciavillani, 1996; Starr and Tran, 2008; Theal, 2009; Tkacz 2007), in times with and without the Gold Standard, much has been written about the influences on the price of gold. The precious metal has been accepted as a universal means of exchange for many reasons. Characteristics of gold are its indestructibility, beauty and rareness relatively to other metals (Mani and Vuyyuri 2005). Also the existence of vast aboveground inventories make gold a unique metal, for it can be easily brought to the market to counter excess demand or supply shocks. Another feature of gold is that it can be stored against relatively low costs (Theal, 2009).

After the termination of the Bretton Woods system in 1973[1], there was no way to maintain an official price of gold (Warwick-Ching, 1993, p. 246). Despite the attention gold has to investors, it is still not completely clear what drives the price of gold exactly. To date, no theory exists which shows how inflation and exchange rates and other variables affect the price of gold (Faugere and Van Erlach 2006; Theal, 2009). This paper seeks to give a review

[1]The Bretton Woods system allowed countries to exchange their currency at a fixed price of gold.

of papers about the structure of the gold market; the determinants of the gold price and to use this literature on the influences on the gold price to test if such relations are still present today.

Section 1 'The structure of the gold market' explains the structure of the gold market to give the reader a clear indication of how market participants interact. Subsequently, section 2 'Influences on the price of gold' gives a review of research which focuses on the influences on the price of gold. This review is divided in research focused on influences on the demand of gold and studies focused on determinants of the gold quantity supplied. Next, some of these relations are tested with recent data to see if these relations still exist. This will be done in section 3 'Methods and findings'. Section 4 'Conclusion' will discuss the results and explain if the results agree with the hypothesis.

The multivariate model explains 4.00% of the price of gold over the last twenty year. The variables used include: the London Interbank Offered Exchange Rate (LIBOR), the physical gold rate, the inflation rate, the amount of economic and political instability and US Dollar exchange rate to the Great Britain Pound, the Indian Rupee and the Chinese Yuan.

1 The structure of the gold market

O'Callaghan (1993) divides the gold market in to the physical gold market and the market of gold claims. The latter market consists of a paper gold market that trades claims on physical gold, instead of trades in physical gold itself. Both these markets are closely linked by arbitrage since the underlying value of the claims equals the physical gold value. The markets are mainly influenced by the same fundamentals; however each of them is influenced by other market participants. For example, the physical gold market is mainly influenced by the demand of participants which deal with physical trades. Examples of these agents are: gold producing firms, central banks and gold jewellery firms. The gold claim market however, is largely determined by the demand of investors which use the claims to obtain gold exposure. Nevertheless, also gold jewellery firms and gold producing firms use gold claims to hedge gold price risk. To give an overview of the structure of the gold market, first the agents which participate in the physical trade of gold will be explained. These agents consist mainly of the gold producing firms, central banks and gold jewellery firms. Also recycling and fabrication firms are involved in physical gold traded. However, as the latter agents are smaller participants on the gold market this section will limit itself to the former agents (WGC, 2010).

The last part of this section focuses on the claims of gold which mainly consists of institutional investors and retail investors.

1.1 Gold Producing Firms

There are two ways on how gold producing firms can acquire their gold. First, gold producing firms can extract gold from gold mines and sell the stocks on the spot market. Second, they can borrow gold from central banks and sell the borrowed gold on the spot market. The extracted gold from gold mines mainly comes from South Africa, the U.S. and Australia (Christie-David et al., 2000). The leased gold primarily is borrowed from central banks.

This second method to acquire gold is conducted as following. Mining companies lease gold and sell the amount on the spot market to gain cash at time t_0. The cash is used to excavate gold mines and further explore new sources of gold and at the same time obtain a hedge against adverse price movements. In return they use the cash gained by the sale of their own extracted gold stocks to pay the required interest and return the physical gold amount at t_1. This can all be done at a relatively low interest rate, which is called the physical gold rate. The above transactions of borrowing and selling gold at $t_0$and selling gold and paying back the principal amount at $t_1$at the spot price is a convenient way for producers to manufacture their products (O'Callaghan, 1991) and can be compared to the purchase of a short forward contract which obliges the gold producing firm to sell the hedged gold at the forward price. This is true, since the forward matches the corresponding replicating portfolio which is a short position in a gold loan and a short position in the gold spot market. The above described cash flows can be shown in figure 1.

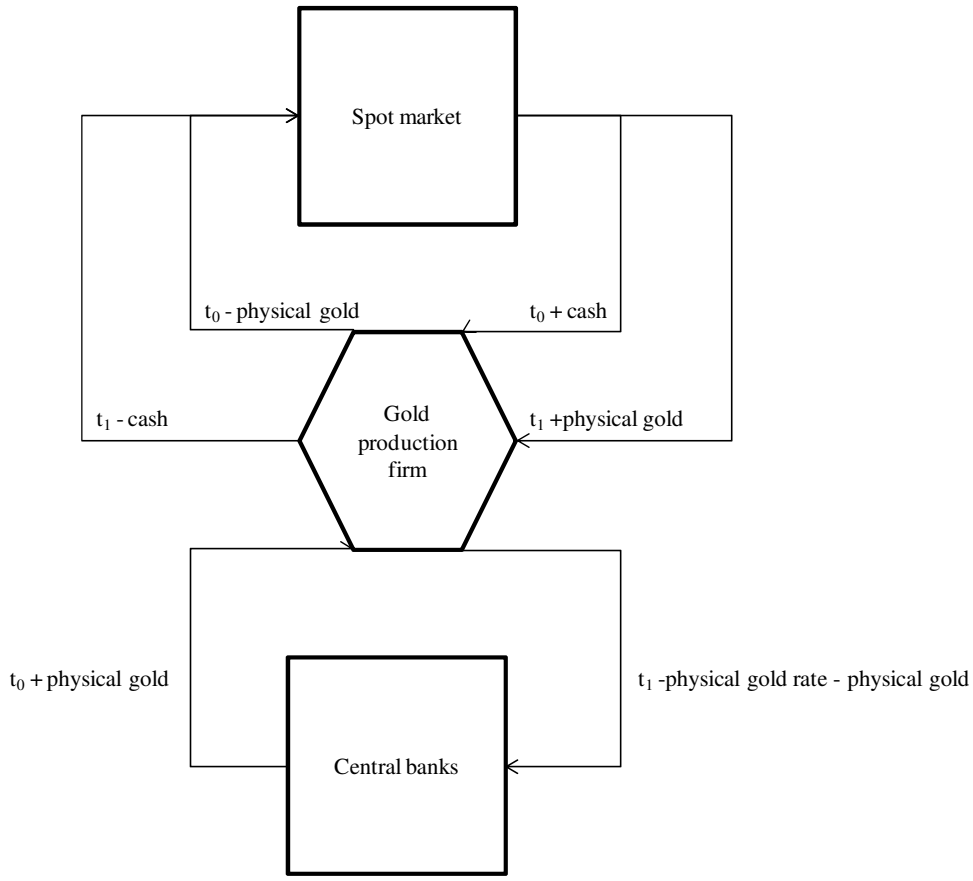

Figure 1 Lease structure of gold production firms

1.2 Central Banks

In contrast to bonds, gold does not bear interest. Since central banks are restricted in their freedom to sell stocks of gold[2], but on the other hand still wish to have a return on gold stocks, they developed lease transactions. These transactions, mainly consisting of gold loans, involve a transfer of gold to the borrower which in turn bears interest to the central banks. At maturity the face value contains the physical amount of gold borrowed. This way, central banks still get around the constraint which is inherent to the nature of central banks and still make a return on their gold holdings.

Central banks lend their gold against the physical gold rate to the market (e.g. to gold producing firms and gold jewellers). Central banks can earn a yield on gold by using the following two types of transactions. The first way of earning a yield on gold by central banks is to simply lease the physical amount of gold at t_0 and to receive the face value incremented by the physical gold rate at t_1. This can be shown in the following figure 2.

[2] Central banks need to hold ownership on gold stocks.

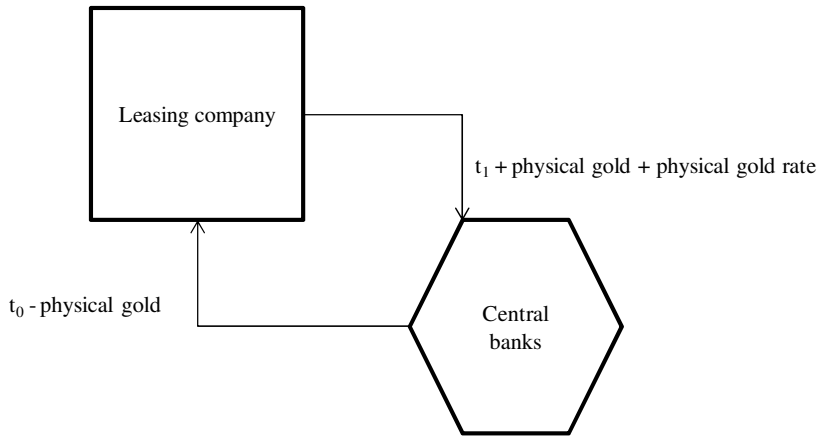

Figure 2 Lease structure of central banks

The lend gold from central banks can be sold at the spot price by dealers and the resulting proceeds can be invested at the LIBOR rate or in treasury bills. If the gold spot price does not move significantly this can be a profitable strategy which earns the firm the difference between the LIBOR and the physical gold rate. The difference between the LIBOR and the physical gold rate is called the Gold Offered Forward rate (GOFO). This is summarized in the following equation:

$$Physical\ Gold\ Rate = LIBOR - GOFO \quad (1)$$

The second strategy to earn money on gold holdings by central banks is by the use of a swap against US Dollars. As with the leasing transaction, with a swap the ownership title of the gold is transferred to the lending firm but with the added condition that the central bank has the right to repurchase the gold at a future time. In selling the gold, the central bank receives US dollars at t_0. In addition to agreeing to the repurchase at t_1, the involved central bank also pays the GOFO rate to the leasing-organisation at t_1. The received US Dollars by central banks are invested at LIBOR at t_0 and retrieved at t_1. The central banks then earn the physical gold rate at t_1. This is summarized in the following in figure 3.

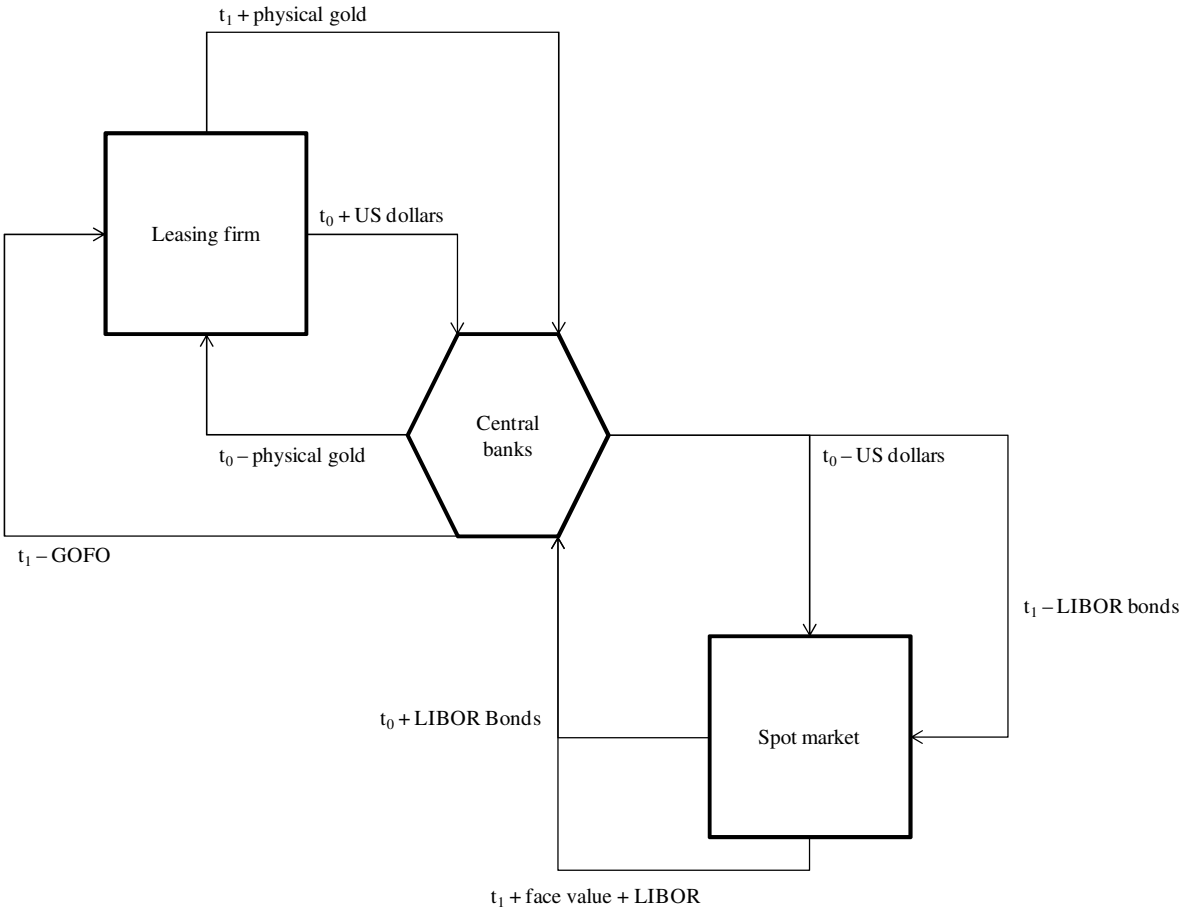

Figure 3 Gold swap construction of central banks

Since the GOFO is the interest rate charged on central banks by the leasing firms on a loan with a gold-collateral, this implies that the GOFO rate is the rate at which the spot price rises relative to the future price (Theal, 2009). The derived GOFO rate is set by a group of market making members of the London Bullion Market Association (LBMA) which are mostly banks. The rate can therefore be thought of as a signal from participating banks. If the LIBOR and GOFO are unequal to each other this results in a physical unequal to zero. When the GOFO is smaller than the LIBOR the central banks earn the physical gold rate, which makes it attractive to perform the above described swap and thus stimulate supply by central banks.

1.3 Gold Jewellery

About half of the annual demand of gold is coming from gold jewellery demand and it would be reasonable to assume that about half the world gold pool is used by consumers for personal adornment (Kaufman and Winters, 1989). Especially government restrictions against bullion holdings in India stimulate Indian consumers to buy gold jewellery as a substitute of pure gold holdings, so they can still use gold as a store of wealth. Gold plays a central role in the Indian

culture which nowadays has the largest demand of world gold jewellery (Mani and Vuyyuri 2005; Starr and Tran, 2008). It is useful in the sense that it can be enjoyed in times of wealth and can be liquidated in times of adverse shocks.

The jewellery industry can buy gold on consignment, meaning that they buy the gold only when they already fabricated the goods and priced them to retailers. This allows the jewellery industry to not first seek capital to pay for the gold, and to hedge their bullion transaction while guaranteeing a profit margin (O'Callaghan, 1991).

The demand of industrial use includes the fabrication of electronics, as telecommunications and information technology, dentistry and chemical industries (O'Callaghan, 1991; Christie-David et al., 2000). It has also become important in biomedical applications, as it possesses thermal and electrical conductivity and it is very resistant to corrosion (Tully and Lucey, 2005).

1.4 Investors

The above three paragraphs described the involved transactions within the physical gold market. This paragraph explains the workings of the paper gold market, and is put here mainly because it is most used by institutional investors and retail investors. It allows retail investors to gain exposure to gold by using gold futures and gold ETF's, without actually holding physical gold. Also, institutional investors have interest in claims on the price of gold to hedge the value of their gold holdings.

To gain exposure to price movements of gold, mainly two types of products are used: futures and ETF's. Albeit, futures oblige the owner to purchase or sell the underlying value at maturity, the investor can liquidate his position before the future matures. This can be done by using offsetting trades, which means that the holder of the future buys or sells another future which neutralizes the original position (Ederington, 1979).

In 1990, Exchange Traded Funds (ETF's) were introduced, (Deville, 2008), which allow the investor to directly trace the price of the underlying index and thus to gain exposure to price movements in the underlying value. Exchange Traded Commodities (ETC's) however, were developed almost thirteen years later, which now make it possible for retail investors to obtain exposure to price movements in commodities of which gold is the most popular one (Bienkowski, 2007).

2 Influences on the gold price

Next, a literature review is given on the influences on the price of gold. To structure the research about the determinants on the price of gold, first research on influences on the supply of gold (section 2.1) is discussed. Section 2.1 is divided into three paragraphs, which each focus on influences on the quantity supplied by agents in the gold market. Subsequently, research on the determinants on the demand (section 2.2) of gold will be considered. This section is separated into three paragraphs which also each focus on the determinants of the quantity demanded by the participating agents in the gold market.

2.1 Supply

To give a summary of the papers which focus on the factors that influence the amount of gold supplied, first a section about the mine production firms is considered. Next, the determinants on the supply of central banks are regarded and at last the recycling industry is covered. The section about the central banks is taken into account in the supply section, as for the last five years central banks are net suppliers. More specifically, they sold more gold to the market than they purchased. (WGC, 2010).

2.1.1 Gold Producing Firms

Ghosh et al. (2004) argue that the amount of gold supplied is positively related to the price of gold from period t_0 since there may be a substantial time lag before mines react to price changes at t_1. However, the amount of gold supplied on the gold spot market at t_1 is negatively related to the amount of leased gold and the physical gold rate at t_0, since the amount of leased gold has to be returned to the central banks along with the interest paid on the leased gold at t_1. Banks do forego the convenience yield when leasing gold. The convenience yield represents the opportunity costs of not holding gold. These opportunity costs mainly occur in times of temporary shortages so that firms cannot meet short-term demand changes, which results in lost sales. In return for leasing physical gold, central banks receive interest from the physical gold lease rate. The empirical research of Ghosh et al. suggests that both the convenience yield and the physical gold lease rate in equilibrium tend to be equal. Also, Theal (2009) find that the physical lease rate can be thought of as a proxy for the convenience yield. The above is summarized in the following equation:

$$Convenience\ Yield = Physical\ Gold\ Rate = LIBOR - GOFO \quad (2)$$

Fama and French (1988) explain the characteristics of the convenience yield from the theory of storage, which hypothesizes that the marginal convenience yield declines at higher inventory levels but at a decreasing rate. The original theory was developed to explain the seasonal behaviour of agricultural products, but the authors extended the theory of storage for product of which inventories are determined by business cycles. The theory suggests that at high inventory levels the marginal convenience yield decreases. Since global gold inventories are relatively high, when compared to other commodities, this inclines that the convenience yield is relatively stable and thus leads to equal changes in spot and future or forward prices.

For gold producing firms depend on the total quantity extracted and, the gold lease rate incremented by central banks, the total supply depends on the gold lease rate, the price of gold of the previous and actual period and the amount leased from previous periods. The empirical data analysis of Ghosh et al. (2004) supports that short run movements are influenced by the gold lease rate, the convenience yield and the LIBOR. Also, Kaufmann and Winters (1989) researched the relation of the total global gold quantity on the price of gold. They found a negative relation which means that a larger global inventory, forthcoming from extracted gold of mining companies, has a downwards pressure on the price of gold. However, as global gold inventories are high this downward pressure should be relatively low.

Moreover, as gold producers extract gold from mines and lease from central bank, and assuming that gold mine firms are profit maximizers, they will substitute between the two alternatives to the point where both marginal costs are equal. As the marginal costs in a perfect competitive market are equal to the cost price of producing gold it is assumed that these costs equal the price of gold (Ghosh et al., 2004). More precisely, the price of borrowing from a central bank, which is the interest on the leased gold plus the principal amount of gold, should be the same as the present value of mining one ounce of gold, plus the gold lease rate to be returned to central banks. In their long term model they argue that as long as extraction costs rise at the general rate of inflation then the price of gold also increases at this rate. Even if gold mine firms have market power, the price of gold will be proportional to the marginal costs of extraction and the price of gold will still rise at the general rate of inflation. Faugère and Van Erlach (2005) state that in the long run the gold mining industry's real profit margin is constant which suggests that the price of gold on average is constructed by the marginal costs plus a small mark-up.

The above described relations are summarized as following: the supply of gold producing firms at t_1 depends positively on the price of gold at t_0; negatively relates to the amount of leased gold at t_0; negatively relates to the physical gold rate at t_0; positively relates to the price of gold at t_1 and, as part of the physical gold rate, negatively relates to LIBOR at period t_0. Each of these relations inversely does affect the price of gold as an increase of gold supply decreases the price of gold. On the long term the price of gold is negatively related to the total world stocks and, assuming the cost price of extracting gold increases with the inflation rate, positively related to the inflation rate. The above is summarized in table 1.

Table 1. Influence on the price of gold by gold producing firms.

Influence	Relation
Short term	
• Price of gold at t_0	-
• Amount of leased gold at t_0	+
• Physical gold rate at t_0	+
• Price of gold at t_1	-
• LIBOR at t_0	+
Long term	
• Total world stocks	-
• Inflation rate	+

2.1.2 Central Banks

Before the increase in investor interest in gold bullion and the creation of the nowadays popular gold ETF's, central banks and bullion banks were the main operators in the gold future market, because of the attractiveness of leasing gold to earn a small yield on their reserves. Indeed, prior to the Washington Agreement on Gold sales in 1999[3], central banks bought and sold significant quantities of gold which directly or indirectly influenced the price of bullion (Theal, 2009; Tully and Lucey, 2005; Salent and Henderson, 1976).

Central banks hold a large proportion of the above ground stock of gold, which they hold for several reasons: diversification; economic security since gold is observed by investors as an inflation hedge; it is a liquid asset; it maintains its value in times of financial turmoil and it can be leased (Tully and Lucey, 2005).

[3] This agreement constrained central banks with an annual cap on purchases and the sales of gold.

As already explained, the amount of gold sales and purchases is influenced by the physical gold rate. They can acquire money by using this rate by executing the two types of transaction explained in chapter 1.2. As the physical gold rate equals the convenience yield[4], which on its own positively relates to the LIBOR, the LIBOR positively relates to the supply of gold by central banks. Ghosh et al. (2004) state that an increase in the convenience yield, caused by an increase of the real interest rate, suggests a reduction in the price of gold. More specifically, a rise in the real interest rate, which they calculate as $LIBOR - GOFO$, would cause central banks to lower their inventories because the convenience yield is now lower than the foregone real interest rate. This motivates central banks to sell gold and convert the acquired cash in interest bearing bonds. This results in a tighter supply of gold which as a consequence increases the convenience yield on gold to the point at which both the physical gold rate and the convenience yield are in equilibrium. Levin and Wright (2006 p. 24) argue that in theory, because of the no-arbitrage relationship between the convenience yield and the physical gold rate, a mine is indifferent between "extracting gold now, and selling the mined gold now, and leasing gold now, selling the leased gold now, investing the proceeds of the sale and take a long position in a bond, selling the bond in one year and using the proceeds including the interest to pay for extracting the gold plus the physical interest rate." If the cost of extraction rises at the general rate of inflation, the gold lease rate is equal to the real interest rate. However, the data analysis of Ghosh et al. (1994) does not support the above theory as the UK interest rate, which they used to test the relation, might not reflect the world interest rate.

In addition to the stimulus of the physical gold rate to lend or to borrow gold, central banks are also influenced by the fact that they regard gold as a monetary cushion. This counts especially for countries with debt problems, which tend to buy gold as collateral for issued loans (Christie-David et al., 2000).

The above relations can be outlined as following: the real interest rate is negatively related to the price of gold, the physical gold rate is negatively related to the price of gold, and the amount of countries with debt problems is positively related to the price of gold. Each of these relations is shown in table 2.

[4] See chapter 2.2.1.

Table 2. Influence on the price of gold by central banks.

Influence	Relation
Short term	
• The real interest rate	-
• Physical gold rate	-
• Amount of countries with debt problems	+

2.1.3 Recycling Firms

The input of gold scrap for recycling firms mainly comes from melting coins and gold jewellery (O'Callaghan, 1991), and is the second largest source of supply of gold. The supply of scrap gold is dependent on the price of gold. Also, the economic situation of the Middle East and India is noteworthy. These economies use gold for many purposes of which 'the store of value' is one of the main features. When these economies are in financial distress (e.g. by harvest failures), owners of gold tend to sell their gold to recycling firms which in turn increases recycling supply (Tully and Lucey, 2005). However, since it is hard to acquire data of recycled jewellery gold, it is difficult to test relations between recycling behavior and the price of gold (Kaufmann and Winters, 1989). Nevertheless, the above theoretical relations can briefly be described as following: the price of gold at t_0 positively relates to the amount of recycled gold at t_1 and thus negatively relates to the price of gold; the amount of financial distress positively relates to the amount of recycled gold and as a result negatively affects the price of gold. Both these relations can be shown in table 3.

Table 3. Influence on the price of gold by recycling firms.

Influence	Relation
Short term	
• The price of gold at t_0	+
• The amount of financial distress	-

2.2 Demand

The demand of gold is divided into three categories of which the first one is the jewellery demand, which includes gold jewellery, medals and coins. The second one is the industrial demand as the fabrication of electrical components. The jewellery demand and the industrial demand are also categorized as 'use demand'. The third one is called the 'asset demand'

which is the demand of gold used by governments, fund managers and individuals as investment.

2.2.1 Gold Jewellery

According to Ghosh et al. (2004) the demand of gold jewellery at t_1 is negatively related to the price of gold at t_0 as it becomes more expensive to purchase gold. This in turn leads to adverse movements in the price of gold. The gold jewellery demand movements depend on the price elasticity of gold jewellery demand (Batchelor and Gulley, 1995). They authors measure this by using data of developed countries. The use of data from developed countries, rather than emerging countries, is because of the exclusion of the motivation that consumers buy gold jewellery as a store of value. They found results of price elasticity between -0.5 and -1, which inclines that a one percentage increase of the gold price results in a 0.5% decline of demand. The evidence strengthens the statement that the gold price of the former period negatively relates to the gold price of the latter period.

2.2.2 Industrial demand

Ghosh et al. (2004) state that the industrial gold demand is negatively related to the price of gold, as it also becomes less attractive to purchase gold. Unfortunately, the literature and available data about industrial demand is not very extensive which constrains the possibility to research relations between movements in de demand of gold and movements in the price of gold.

The above relations of paragraph 2.2.1 and 2.2.2 are summarized in table 4.

Table 4. Influence on the price of gold by 'use demand'.

Influence	Relation
Short term	
• The price of gold at t_0	-

2.3 Asset demand

The 'asset demand' relates to several factors including, inflationary expectations, the expected real interest rate the dollar exchange rate expectations, the beta of gold, the price of silver and other variables as 'fear' and public announcements. Each of these will be considered hereafter.

Investors and central banks view gold as an inflation hedge (Christie-David et al., 2000; Faugere and Van Erlach 2006; Kaufmann and Winters, 1989; Mani and Vuyyuri 2005; Sjaastad and Scacciavillani, 1996; Starr and Tran, 2008; Theal, 2009; Tkacz 2007). These gold holdings are especially useful in emerging countries of which the economic situation of the corresponding country can be highly uncertain. Empirical research supports this hypothesis (Starr and Tran, 2008). Faugere and Van Erlach (2006) hold that the yield of a gold must vary inversely to the yield of a portfolio of other assets, to provide a hedge against price fluctuations of other assets. The data of Ghosh et al. (2004) support the idea of gold being a long run inflation hedge. While rising income could indicate expected inflation and an increase in gold prices, Starr and Tran (2008) did not find a significant relation between the two. Christie-David et al. (2000) studied the effects of announcements on the price of gold. Their results suggest that the Gross Domestic Product and the Producer Price Index are positively related to the price of gold, which might be the result of investors looking for an inflation hedge;

Fortune (1987) relates the expected interest rate to the price of gold, assuming that interest-bearing bonds are a substitute for gold. An expected increase of interest rates causes a negative adjustment of the price of gold, since it is relatively more worthwhile for individuals to sell gold and obtain assets with higher interest rates. This hypothesis is supported by their results. While central banks can circumnavigate this problem of foregone interest on gold, by using lease constructions, the author finds a significant negative relation between the expected interest rate and the price of gold.

Sjaastad and Scacciavillani (1996) looked into the effects of exchange rate movements in accordance with the gold price which is usually denominated in US dollars. They found significant price movements of gold as an effect of exchange rate movements. Also gold demand tends to be negatively related to US dollar exchange rates. This, since gold becomes less expensive to non-US denominated countries when the US Dollar depreciates against other currencies (Tully and Lucey, 2005).

According to Ghosh et al. (2004), Mani and Vuyyuri (2005), and Tully and Lucey (2005) gold can be considered a tool for the reduction of risk, for their empirical analyses suggest that gold has a negative beta. As institutional investors have to diversify their portfolio to reduce risk, holdings of gold are attractive, as it tends to show a negative beta when compared to the

market portfolio. Better diversification can be obtained by a more negative beta, which increases gold demand and thus the price of gold.

Throughout history, gold and silver have been closely related as preciously metals and are often considered as substitutes to reduce similar types of risk in portfolios (Ciner, 2001; Escribano and Granger, 1998; Ma, 1985; Mani and Vuyyuri 2005). Like gold, silver has many uses and sometimes serves as a hedge against inflation. Demand for silver primarily comes from sterling ware, photographic, and electrical industries. Metal traders consider silver to be more volatile than gold. However, the commodities do have distinct characteristics and uses. Whereas silver has been transformed into a metal of electronics, X-rays and photography, because of its unique physical and chemical properties, the demand for gold mainly depends on the actions of central banks and jewellery demand (Ciner, 2001; Escribano and Granger, 1998). This suggests that both the precious metals are not substitutes and that the two markets should be separated. On the other hand, they do act as quite close substitutes to jewellers and to investors, as a reduction of risk. Escribano and Granger (1998) found evidence that indeed the markets are becoming separated. The empirical results of Ciner (2001) tie up with the hypothesis that on the long term no relation exists between the prices of gold and silver.

Also the role of gold amongst times of financial or political turmoil is significant. Investors tend to buy gold when there is financial or political instability, since the commodity is seen by investors as a safe haven, with a low credit risk which at times of turmoil is very liquid. Mani and Vuyyuri (2005) suggest that this has to do with the low credit risk of gold holdings of central banks. Also Cristie-David et al. (2000) found a positive relation between the announcement of the unemployment rate to the price of gold. This, as it can be hypothesized that investors will look for a safe haven when signals of economic distress occur, of which a higher unemployment rate is one indicator.

All the influences on the price of gold from an investors' perspective are shown in table 5.

Table 5. Influence on the price of gold by asset demand.

Influence	Relation
Short term	
• Expected inflation rate	+
• Expected interest rate	-
• USD exchange rates	-
• The beta of gold	+
• Amount of economic distress	+

3 Data description

As the literature on gold price influences clarifies, many factors do determine the price of gold. This study however, does focus on the effects of the LIBOR; the physical gold rate; the inflation rate; the USD exchange rate; and the amount of economic and political distress on gold price movements. Although the relations have already been tested in other studies, they are investigated again with recent data to see if the relations are still present today. The period used for this study is from 3-12-1990 to 31-12-2010 with a daily time interval.

The physical gold rate is calculated as the GOFO subtracted from the LIBOR. To obtain daily inflation rate, US T-bills are used as a representative, for the discount rate is a good approximation of the inflation rate[5]. At first sight, the Euro to the US Dollar exchange rate should be a good representative as a world exchange rate. However, no data exists before 1999 at which the Euro was introduced. Therefore the Great Britain Pound to the US Dollar (GBP/USD) is used as a substitute. Also the Indian Rupee to the US Dollar (INR/USD) and the Chinese Yuan to the US Dollar (CNY/USD) exchange rates are used, as the Indian and Chinese gold jewellery markets are the prime demanding players in the gold world market (WGC, 2010). The amount of political turmoil and economic distress is approached by the Volatility Index (VIX). Since the value of the index is dependent on the implied volatility of S&P 500 options, the index will increase in value when the implied volatility on the index increases. The implied volatility, in turn represents the amount of expected distress in the world economy. The VIX is therefore used as a representative of global economic distress and political turmoil.

[5] US T-bills are used here instead of GDP data, since the latter is only available on an annual base. When smoothed within years the GPD data will probably underestimate inflation volatility.

The 1-Month LIBOR; the 1-Month GOFO; the exchange rates and the VIX data are acquired from *Reuters DataStream*. As the 3-month US T-bill data acquired from *Reuters DataStream* did not deliver accurate data from October 2006, another source is used which is *wfhummel.cnchost.com*. Since the data of the latter source misses some daily observations, the amount of observations depends on the amount of observations of the 3-month US T-bills. All daily data is transformed into daily relative returns to be able to compare the variables on equal bases.

For each of the studied variables the summary statistics are provided in table 1, which include the mean daily return; the daily standard deviation and the correlations of each variable with gold price returns.

Table 6. Correlations of used variables between 1990 and 2010.

Variable		Mean	Std. Deviation	Correlation
Gold price	Dependent	.00030	.0096	1.000
LIBOR	Independent	-.00040	.0211	-.010
Physical gold rate	Independent	-.00136	.1645	.037**
3-Month T-Bill	Independent	.00429	.1754	.017
VIX	Independent	.00165	.0591	.046**
GBP/USD	Independent	.00006	.0062	-.175**
INR/USD	Independent	.00018	.0044	-.075**
CNY/USD	Independent	.00006	.0068	-.002

**. Correlation is significant at the 0.01 level (2-tailed).

The correlations of the LIBOR; the 3-Month T-bill and the CNY/USD exchange rate daily returns appear to be insignificant. As the LIBOR is an important variable for different gold market participants with contrasting interests, the insignificant correlation is not surprising. The insignificance of the 3-Month T-bill on the other hand, is striking, as a positive correlation is suggested between the inflation rate and the price of gold within many studies (Christie-David et al., 2000; Faugere and Van Erlach 2006; Kaufmann and Winters, 1989; Mani and Vuyyuri 2005; Sjaastad and Scacciavillani, 1996; Starr and Tran, 2008; Theal, 2009; Tkacz 2007). Also, no correlation has been found between the Chinese Yuan and the

United States Dollar. This is probably because the currencies have been pegged, which means that almost no change in the exchange rate took place. The physical gold rate and the VIX tend to move positively with movements in the gold price. To explain the found positive correlation of the physical gold rate and the price of gold, it appears that central banks use the earlier described lease constructions relatively more than gold producing firms. Also, the GBP/USD and the INR/USD exchange rate do move negatively with movements in the gold price which matches with the expectations of the above literature study (Sjaastad and Scacciavillani, 1996; Tully and Lucey, 2005). A depreciation of US Dollar denominated exchange rates will increase demand of gold as gold becomes less expensive. Hence, a negative coefficient does agree with our expectations.

4 Empirical results

For each variable the influence on gold price movements will be determined by using cross-sectional simple regressions. Also, a multivariate regression is used, wherein all variables are included. This results in the following multivariate regression model:

$$GP = \beta_0 + \beta_{LIBORR} + \beta_{PGRR} + \beta_{TBILLR} + \beta_{VIXR} + \beta_{GBPR} + \beta_{INRR} + \beta_{CNYR} + \epsilon$$

The multivariate model explains price movements by an adjusted R-square of 0.04, and thus significantly explains price movements of gold. The results, reported in table 7, show that the physical gold rate; the VIX, the GBP/USD exchange rate and the INR/USD exchange rate indeed do significantly, at a confidence level of 99%, influence gold price movements. In addition, the results of the coefficients of the amount of political turmoil and economic distress, and the US Dollar denominated exchange rate do match our expectations (Sjaastad and Scacciavillani, 1996; Tully and Lucey, 2005; Cristie-David et al., 2000; Mani and Vuyyuri, 2005). These outcomes hold both for the simple regression models as for the multivariate model. Nevertheless, the LIBOR; the 3-Month US T-bills and the CNY/USD exchange rate do not significantly influence gold price movements. The results of the LIBOR can be explained with the same reasoning as stated in the descriptive statistics section.

Table 7. Cross-sectional tests (t-statistics in parentheses).

R-square	Intercept	LIBOR	Physical gold rate	3-Month T-Bill	VIX	GBP/USD	INR/USD	CNY/USD
.000	.000	-.0048						
	(2.2233)	(-0.7574)						
.001	.000		0.0021**					
	(2.2612)		(2.6655)					
.000	.000			.0009				
	(2.3453)			(1.157)				
.002	.000				0.0075**			
	(2.1456)				(3.3625)			
.031	.000					-0.2716**		
	(2.3941)					(-12.8831)		
.006	.000						-0.1637**	
	(2.4667)						(-5.4725)	
.000	.000							-.0028
	(2.239)							(-0.1447)
.041	.000	-.0042	0.0027**	.0010	0.0088**	-0.2718**	-0.1438**	-.0005
	(2.5646)	(-0.6679)	(3.2807)	(1.294)	(3.8136)	(-12.2253)	(-4.6646)	(-0.0278)

**. Variable is significant at the 0.01 level (1-tailed).

The results of the 3-Month US T-bills are contrary to expectations. This might be the result of two reasons. First, US T-bills may not be a good representative of inflation as it does not account for global inflation. Second, the results might indicate that gold is not a good inflation hedge as expected anymore. The insignificance of the CNY/USD exchange rate relation with gold price movements can be explained by the fact that the Chinese Yuan is pegged with the US Dollar. CNY/USD exchange rate movements will rarely occur, and will thus have almost no influence on the gold price.

Although most of the results of the model do agree with the expectations of the literature study, the multivariate model does not explain gold price movements as well as expected, for the R-square of the multivariate regression model has a value of 0,041. Further investigation to the determinants of gold price movements is therefore needed to understand which other factors do affect price movements of gold.

5 Conclusion

Most of the examined variables within this study still turn out to have a significant impact on the price movements over the last twenty years. These variables are: the physical gold rate; the amount of political turmoil and economic distress and the USD exchange rates. Conversely, the LIBOR and the inflation rate did not statistically affect gold price movements within the last twenty years. As the LIBOR does affect market participants with contrary interests, this might have led to the insignificance of the influence of the LIBOR on gold price movements.

However, the fact that the inflation rate, in the last twenty years, did not affect gold price movements is striking and contrary to expectations forthcoming from the literature review (Christie-David et al., 2000; Faugere and Van Erlach 2006; Kaufmann and Winters, 1989; Mani and Vuyyuri 2005; Sjaastad and Scacciavillani, 1996; Starr and Tran, 2008; Theal, 2009; Tkacz 2007). This is may be caused by using the US T-Bill rate as a representative. It is therefore recommended to use a better substitute of the global inflation rate. An example might be to use Treasury bill rates of a delegation of countries, weighted by the country's GDP, to get a better approximation of the global inflation rate. However, GDP figures are produced on annual base, which was the reason in the first place to use T-bill rates instead of GPD numbers. Also, instead of GDP information, the daily net gold sales per country could

be used to add weight to the countries T-bill rates. Nevertheless, it is probably very hard, if not impossible, to get the required data to come to this weighted average inflation rate.

A last remark is made about the low explanatory power of the multivariate model. Even though, most of the results of the variables can be explained, still almost 96% of gold price movements are not explained. This may challenge students to further investigate what really moves the gold price. Clearly, there are many other influences that drive the price of gold, either rational or emotional.

6 References

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