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Ekaterina Antonova, BSc

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ABSTRACT

The master thesis entitled “Gold: Investments, Gold Price Analysis and its Short-term Projections“ is both theoretical and practical analysis of gold’s distinctive qualities as an investment. The objective of this thesis is to provide a source of insight into the investment possibilities of private investors who wish to enter the gold market. It reiterates existing literature on the role of gold in financial markets from both historical and contemporary perspective. It presents options on how investors can obtain exposure to gold as a long-term investment asset class on current financial markets, in particular distinguishing between direct and indirect form of investments. It also examines the various features, structure, and common trends of demand and supply dynamics of the gold market, where demand and supply of gold are identified as significant driving forces in the determination of the price of gold. This contributes to a further discussion of the trends in the price of gold, whereby the underlying factors that dictate gold’s value are further examined by the empirical analysis, which is intended to introduce the reader to the possible evaluation and prediction of future outcomes of the price of gold.

The practical part includes econometric analyses and forecasts based on monthly observations. Two models “A model of the average price of gold and “A model of the monthly closing price of gold” were built using selected statistical tools such as Granger causality tests and the method of least squares. The quality of the model was examined by testing the residuals on the likeliness of its characteristics with the characteristics of white noise. To describe models shortly, it is appropriate to mention that correlation between the actual and fitted values is between 55 - 65 %; and therefore models are effective tools in the process of prediction. Since, the results are satisfactory, constructed models are recommended to be applied as an addition and extension of a deeper fundamental analysis.

Introduction

Gold has been appreciated dating back for thousands of years ago up until now for its variety of attributes: as an element portraying beauty, a world currency, a measurable unit of value, a commodity, an article of trade, and an investment. Recent years have experienced gold as a subject of increasing investor interest and opportunity, especially since the price has been consistently rising and, consequently, a massive upswing in gold has been predicted by many gold experts. Investor of gold is considered to be individual investors, institutions, and governments across the globe. Likewise, the tumultuous years in the financial crisis of 2007-2009 around the world reinforced gold's long-standing role as a store of value and insurance asset.

Apart from the industrial attributes of gold, gold has certain investment roles that make it desirable. Gold's role is believed to be a vehicle for portfolio performance management, as well as for portfolio diversification, regardless of how the economy is currently performing. According to Hillier et al., gold's diversification benefits are particularly legitimate when markets are in a state of high volatility and poor performance.¹ The World Gold Council emphasizes that, true to its roles, gold has outperformed all major other asset classes, such as oil, in the latest times of sustained economic uncertainty and higher volatility in the financial markets.² Gold's role in portfolio performance management is justified, especially due to its low correlations to most of the mainstream assets like equities and fixed income investments held by institutional and individual investors when sustaining or even enhancing expected portfolio returns. Historically, gold has also played a role of longer-term inflation and currency devaluation hedging instrument. Moreover, gold has a function to appreciate in currency terms. Gold tends to keep its value constant in terms of currency, as it has restricted supply from mining production and additional units can't be that simply injected by the government into an economy, causing its eventual depreciation.

The goal of the thesis is to better understand how to gain a source of insight into the dynamics of investing in gold. The thesis examines gold in the context of the increasing relevance as a long-term investment asset class.

¹ See Hillier, et al., 2006, p. 101

² See The World Gold Council, 2012b, p. 2

The whole thesis can be divided into two parts, theoretical and practical. The theoretical part will focus on the investment role of gold in financial markets from both a historical and contemporary perspective. Investor's interest in investing in gold is to a large extent affected by the fluctuations and trends in the price of gold. Clearly, discussion of the topic is of crucial importance for investors, because the price of gold is one of the most controversial issues, where trading with precious metal and other commodities on the financial markets is part of the investor's investment portfolio. Therefore, theoretical considerations will be devoted to the historical and current changes of gold prices in the first part of the thesis, followed by the empirical portion of analysis of market price formation with the help of the construction of applicable econometric models.

More specifically, the empirical part will be dedicated to the analysis of the underlying factors that dictate gold's value in the financial markets. As a primary instrument for constructing an applicable econometric model, Granger causality tests and the method of least squares will be applied. The examined determinants of gold will include: the US dollar exchange rate, credit risk, US inflation rate, lagged gold price, Standard and Poor 500 stock price index, Europe Brent crude oil price, volatility of Standard and Poor 500 Index (VIX) and oil price volatility. The research deals with developing an econometric model that can be finally implemented for both evaluation and prediction of the future outcomes of price of gold.

1. About Gold in General

Historically, gold has been always recognized as a symbol of wealth and power. It has been known for its many and various attributes and applications such as an object portraying beauty, a world currency, a measurable unit of value, a commodity and an investment. Economically, gold has experienced a whole series of transformations and has not only developed in its unique properties, but also has changed its functions under world economic conditions. In the timeline of 1980s and 1990s financial world changed rapidly, what caused stagnating demand for gold with many investors. However, an event such as the financial crisis raises the profile of gold as a store of value, an insurance asset and a hedge against inflation. Mundell points out that the importance of gold in the international monetary system is now well demonstrated by the fact that gold is the only commodity used as a reserve by the monetary authorities, and it amounts to the largest section after the world's reserve currency holdings of U.S. dollar in the total reserves of the international monetary system.³

1.1 History of Gold

Gold belongs to a category of precious metals. Due to its bright yellow color, luster, permanence and great resistance, gold has been valued starting back to the earliest history of civilization. From ancient times, gold has been a viable representative of beauty, power, wealth and cultural elite. As far back to the early beginnings of civilization, gold has been powerful metal, associated with gods, and the glory of immortals and royalties. Gold has gained an important part in social and religious customs, especially in jewellery making and ornaments.

Throughout ancient and modern civilizations and cultures, gold has been accepted as a store of value. Gold played a central role in currencies, and gave rise to the concept of money itself. Consequently, gold became a natural trading medium in form of standardized coins.

Its beginnings go back to the times of ancient Egypt around 5000 years ago. Thousands of years later (1500 BC), in times of evolving international trade gold has developed its characteristic of an internationally traded currency in the Middle-East.⁴ In 1901 B.C., around 400 years later, gold became also legally recognized in China as a form of money. As next, another 450 years later, Lydia started to mint own first coins in gold. In 58 B.C. Romans

³ See Mundell, 1997, p. 1

⁴ National Mining Association, n.d., p. 2

started to issue gold coins, and around 1340 years later in 1284 A.D. Great Britain issued its “first major gold coin”, and later in 1377 A.D. adopted “a monetary system based on gold and silver.”⁵ In 1717 A.D. Great Britain switched to the gold standard and fixed their currency to gold at a constant rate.⁶

The history of gold from the point of time when gold has been used as a commitment mechanism highlights the importance of gold throughout the most dramatic points in time in the history of gold as a monetary asset, and allows a more useful insight into the composition of gold demand and supply fundamentals. According to Harmston, the use of gold as a commitment instrument can be broken down into three main periods: pre-1914; the interwar years, and the Bretton Woods years.⁷ The monetary system gold standard which preceded World War I was maintained by the authorities by holding the price of currency in terms of gold fixed, except of the interwar times. After World War II under the Bretton Woods system, the United States was the only one required to peg its currency to gold; meanwhile other countries pegged their currencies to the dollar. From this follows that a specific amount of currency was kept at equal value to the quantity of gold. The relationship between the quantity of gold in an economy and the quantity of money holds already from that time.

2. Investments in Gold

In order to examine the economic nature of gold in the global economy, this chapter discusses in more detail the various roles of gold as an investment. Hillier et al. reiterate “the literature on the role of gold and other precious metals in financial markets”, where they identify five main types of these roles.⁸ The first classification is the role of precious metals as a diversifier in the combination with stocks in financial portfolios.⁹ Gold is considered to be an effective tool for diversification and risk management due to its low correlations to the most of mainstream asset classes like equities and fixed income investments held by institutional and individual investors. The World Gold Council reports that gold’s volatility is usually lower than one of the other commodities, real estate indices and equity indices such as the developed market equity indices (S&P 500, FTSE or DAX) and particularly emerging

⁵ National Mining Association, n.d., p. 3

⁶ The World Gold Council, n.d.

⁷ See Harmston, 1998, p. 31

⁸ Hiller, et al., 2006, p. 98

⁹ See Hillier, et al., 2006, p. 98

markets equity indices.¹⁰ Additionally, as shown in the other study of The World Gold Council, the role of gold as a needed diversifier reveals itself not only in the normal economic periods, but especially during periods of financial turmoil, in which equity is inclined to plunge and volatility increase, while gold's volatility stays much lower.¹¹ This all contributes to enhanced investment performance of portfolios and makes gold an effective vehicle in investing activities.

Secondly, Hillier et al. in their research of existing literature stress “the role of gold as a potential hedging variable in inter-temporal asset-pricing models.”¹² The role of gold as a hedging instrument can be examined from the two aspects: gold as a hedge against the US dollar or as a hedge against inflation. A research study of Capie et al. explores the relationship between gold and the US dollar. This study reveals motives for why is gold a hedge against fluctuation in the US dollar. Among these motives are statements that “gold is a homogeneous asset”, “easily traded in a continuously open market”, which “cannot be produced by the authorities who produce currencies”, what in turn conveys “certain amount of trust in its long-run wealth preserving properties.”¹³ Another way of looking at the hedging properties of gold is the view that gold is a valuable hedge against inflation. This was well demonstrated by Levin and Wright research study, where authors prove that there is “a long-term relationship between the US price level and the price of gold.” They say that “the price of gold and the general US price level move together in a statistically significant relationship supporting the view that a one percent increase in US inflation raises the price of gold by one percent.” On the other hand, Levin and Wright found evidence for “short-run deviations from the long-run relationship between the price of gold caused by short-run changes in the US inflation rate, inflation volatility, credit risk, the US dollar trade-weighted exchange rate and the gold lease rate.”¹⁴

In addition, Hillier et al.'s three further classifications of the role of gold in financial markets also incorporate: “the properties of the return distribution and the possibilities for earning excess returns in the gold and silver markets, i.e. the efficiency of these markets”; “the relationships of gold (and silver) to macroeconomic variables and government policy”; and

¹⁰ See The World Gold Council, 2011c, p. 8

¹¹ See The World Gold Council, 2010, p. 13

¹² Hillier, et al., 2006, p. 98

¹³ Capie, et al., 2004, p. 26

¹⁴ Levin & Wright, 2006, p. 44

“the particular features and characteristics of gold (and silver) production and market processes.”¹⁵

2.1 Gold as an Investing Commodity

The financial market for gold as an investing asset is considered to be broad and liquid, especially due to the increasing number of ways and opportunities on how to approach this commodity trading. In the first instance, investor can choose either to acquire physical gold, or to hold gold, without taking any physical delivery, thus, in the second case, investing into gold security certificates, whose price is directly dependent on the market price of gold.

This chapter summarizes individual forms of investments in the market of gold, distinguishing between direct and indirect forms of investments, where the former includes investing in gold in forms of gold coins or bars, and the latter involves gold stocks, gold futures or options, gold funds (ETFs) and gold certificates (securities based on obligations).

2.2 Direct Forms of Investment

A direct form of investment in gold deals exclusively with physical ownership, available in world gold bullion, and a wide range of gold coins and mints; and is one of the ways how to gain exposure to this precious metal. In addition, there is gold used for jewellery hereinafter also being referred to as physical gold, however, this kind of purchasing gold for investment purposes is not legally recognized. Gold bullion has two popular options: bullion coins and bullion bars. These two types of gold bullion provide an opportunity for investors to put in a smaller amount of spending in order to acquire gold.

By means of purchasing physical gold, the main goal of investors is to ensure a protection against uncertainty in the future, rather than aimed at realizing some type of profit from investment. Typically, this kind of investment is accounted for long term investment. Investing in physical gold in a tradition manner is generally associated with higher costs due to insurance, storage, security and higher mark-ups concerns.¹⁶ One must also not forget that physical gold is less liquid investment, when the selling price turns to be naturally lower than the current market price, and willing buyers cannot normally be found at all times. In terms of

¹⁵ Hillier, et al., 2006, p. 98

¹⁶ See United States Geological Survey, 2011, p. 67

higher cost- efficiency and higher liquidity, gold bullion is considered to be a more favorable form of investment as compared to other forms of physical gold.

Generally, investors have no expectations for gold to provide regular return when investing in physical gold. Gold in bullion form is usually sold by dealers at the latest gold trading price plus a markup, or a premium which tend to fall as the bar weight increase, or dollar value rise.¹⁷ The premium normally may take account of costs for production, refining, shipping, handling, insurance, or transaction-related processing for example. Besides that, the premium may be subject to the variation affected by the availability of gold on the market, and by the extent to which the gold price is either relatively stable or volatile. In case if the price is rather volatile than stable, the higher premium is to be expected, in return of the greater degree of risk.¹⁸

Those who are interested in physical gold can buy from government mints, private refiners, bullion banks, precious metal brokers and private individuals. Investors are provided with access to a larger number of reputable national and especially international gold dealers to choose from when intending to buy gold bullion bars. More specifically, Gold Bars Worldwide website also points out the major dealers that supply international gold bullion market: Commerzbank, Credit Suisse, JP Morgan Chase Bank, Standard Bank and UBS. Investors can look up, among others, the members of LBMA (London Bullion Market Association), most of which are accredited gold bullion dealers, refiners and major international banks.¹⁹

Gold accounts are another bullion option, where two kinds of gold accounts can be distinguished: allocated and unallocated. The former is an account where investor has gold stored and managed in the bullion dealers' vault and, besides the price of gold, also pays insurance and storage charges, while the latter is an account where the owner has gold stored in the dealer's vault, however with a less direct claim of ownership, and no obligation to pay any storage or insurance fee, since the bullion bank has the right to lease gold accounts to other intermediary. One of the disadvantages for the owner of the unallocated is the exposure to the counter-party risk of bankruptcy.²⁰

¹⁷ See Goodman & Downes, 2003, p. 64

¹⁸ See Gold Bars Worldwide, 2012, p. 3.

¹⁹ See Gold Bars Worldwide, 2012, p.1

²⁰ See The World Gold Council, 2011a, p. 45- 46

2.3 Indirect Forms of Investment

Investors who have made a decision to invest in gold have more options to acquire gold via indirect than direct investing. In case of indirect investing, private investor is not interested in physical ownership of gold, but gears towards return by taking a speculative position on gold. Investor purchases security the value of which changes in response to changes in the gold price on the market. One of the most preferred products in this category is gold stocks, gold futures or options, gold funds (ETFs) and gold certificates.

2.3.1 Gold Mining Stocks

Instead of owning physical gold, investors can choose to buy shares of gold mining companies. These in turn partially reflect the movement of gold market prices, and behave as leveraged gold. However, there is a combination of other factors rather than the price of gold only that set the stock pricing of a gold mining company. Gold mining shares have been often highly volatile, meaning that they tend to rise and fall more sharply than the price of gold, hereafter referred to as the “gearing effect of mining shares” - by Coulson.²¹

Gold mining equities offer investors to profit from either rising prices, or the firm’s market over- performance. But, of course, ownership equity of any company is also subject to the investment risk possibly arising from the decline in value of that stock and the failure of the economic performance of the company.

One of riskier investments is stocks of smaller mining companies with limited exposure to geographic reach of mining projects, advances in mining processing and sites for continuous as well as new mining of gold. Besides that, the discerning investor needs to look for the company with strong balance sheets, and preferably aim for stocks of large mining companies like, for example, Barrick Gold and Goldcorp. After all, larger companies tend to be better off amid market risk and volatility times due to the efficiencies of management.

The gold mining sector is typically referred to as large. According to The World Gold Council, more than 750 gold mining companies are publicly held across the world, with consolidated market capitalization of around US\$400 billion. Global gold mining share performance can be widely tracked by equity benchmarks – “stock market indices including,

²¹ See Coulson, 2004, p. 84

for example, FTSE Gold Mines Index, S&P/TSX Capped Gold Index, Philadelphia Gold and Silver Index, AMEX Gold Bugs Index.”²²

2.3.2 Gold Derivative Products

There are many different types of derivative products; in gold for example they comprise “futures contracts, forward contracts of various designs, gold loans, options with more or less exotic features and gold-denominated bonds”, which trade on several stock exchanges around the globe and the over-the-counter market (OTC).²³ The largest stock exchanges, on which the gold future contracts are traded, are the New York Mercantile Exchange Comex Division (CMEX), the Chicago Board of Trade (CBOT), the Tokyo Commodity Exchange (TOCOM), Europe (EUREX), India, Dubai and in China on the Shanghai Futures Exchange.²⁴

Cross describes some of the most in active use risk management products, gold derivatives, as following:²⁵

Forwards

- *Fixed forward*

“The most basic forward contract that allows the seller to deliver an agreed volume of gold for an agreed price at a future agreed date.” (Cross, 2000, p. 106)

- *Floating gold rate forward*

“Standard forward contract in which the gold price and interest rates are pre-agreed and locked-in. The gold lease rate is allowed to float and is calculated at maturity based on its performance during the life of the contract.” (Cross, 2000, p. 107)

- *Floating forward*

“Forward contract in which the gold price is pre-agreed but the interest rates and gold lease rates are allowed to float and are calculated at maturity based on their performance during the life of the contract.” (Cross, 2000, p. 108)

²² See The World Gold Council, 2011a, p. 49

²³ Neuberger, 2001, p. 87

²⁴ See The World Gold Council, 2011a, p. 50

²⁵ Cross, 2000, p. 106- 121

- *Spot deferred*

“Forward contract in which the gold price is pre-agreed; interest rates and gold lease rates are allowed to float. The maturity date is deferrable.” (Cross, 2000, p. 109)

- *Participating forward*

“Forward contract with a purchased call option attached.” (Cross, 2000, p. 110)

- *Advance premium forward*

“A forward contract in which the contango is partly payable in advance. Also known as the flat rate forward or the stabilised contango” (Cross, 2000, p. 111)

- *Short-term averaging forward*

“A forward contract locking in an average, not the spot price.” (Cross, 2000, p. 112)

Options

- *Put option*

“A contract that gives the buyer the right but not the obligation to sell gold at a pre-agreed price at an agreed date. There is an obligation on the part of the option writer to take delivery of gold at the agreed price on the agreed date should the option be exercised.” (Cross, 2000, p. 113)

- *Call option*

“A contract that gives the buyer the right but not the obligation to buy gold at a pre-agreed price at an agreed date. There is an obligation on the part of the option writer to deliver gold at the agreed price on the agreed date should the option be exercised.” (Cross, 2000, p. 114)

- *Down and out barrier option*

“An option strategy (can be either calls or puts) in which the options cease to exist if a pre agreed price level is broken at any stage of the contract life. A rebate is usually payable if the option is knocked-out, the amount depending on the remaining life of the contract.” (Cross, 2000, p. 118)

- *Up and in barrier option*

“An option strategy in which the options (either calls or puts) are triggered and come into being if a pre-agreed price level is broken at any stage of the contract life.” (Cross, 2000, p. 116)

Swaps

- *Basic lease rate swap*

“A basic agreement in which gold is lent at a pre-agreed lease rate for a pre-agreed period (usually 3 months). At the end of the period the average lease rate is compared to the contract rate and the differential is paid by the party in debit. The contract is then usually rolled for a further period.” (Cross, 2000, p. 120)

The gold derivative market is liquid, thus has been also very active on the back of the large market for physical gold, especially in contrast to other commodities market, although it is relatively small compared to the total financial derivative market. Unfortunately, there is not much consistent information to be found on the current size of the gold derivative market. However, in 2001 Neuberger reported that gold had 45 % weight in banks' commodity derivative baskets, but of all derivatives its share accounted for just 0.3 %.²⁶ According to the Bank for International Settlements, in 2012 gold had less than 19 % of all the commodity contracts and was just 0,07 % of all derivatives.²⁷

In approaching the issue of the market impact of gold derivatives, Neuberger also pointed out that from 1990 until the end of the decade worlds' gold derivative market was growing at a robust rate, where central banks pumped their lending of gold into the markets by a total of an estimate of 4000 tonnes, for the purpose to make physical supply meet demand of the derivative markets. Next he has made a comparison of this enormous increase in size with 12 % of non-investment demand for gold, and estimated 140,000 tonnes of the stock of existed gold over the same period.²⁸

An additional aspect, which has to be taken into account when speaking about the gold derivative market is that its rapid growth has brought significant gains to each class of its

²⁶ See Neuberger, 2001, p. 9

²⁷ See Bank for International Settlements, 2013, p. 1

²⁸ See Neuberger, 2001, p. 10

users by taking up a position in this market. Among these users are, for example, central banks with their significant increase in current income from their gold reserves; gold refiners, fabricators and distributors hedge to lock in a gold price future fall for ongoing inventories; speculators hold long or short positions in earning a trading profit in the gold market.²⁹ In general, holders of this precious metal can anticipate additional profit from their possessions of hold by participating in the derivative markets. What derivatives do is, to a large extent, provision of broad selection of appropriate products and strategies, predominantly attributable to the managements' view of large ownership of gold reserves. Certainly, derivatives enable investors to benefit from the flexibility and extra income, and as a whole add more support in the argument of gold is being an even more attractive investment asset to seize.³⁰

2.3.3 Gold Funds

Investors can decide to take the lead by investing in gold funds either through mutual funds or exchange traded funds (ETFs), which offers investors to obtain a proportionate share in the fund's pool of assets. While mutual funds are not listed, ETFs provide investors an opportunity to buy and sell shares on a stock exchange through a broker-dealer system, tracking the selected index. In case of exchange traded gold or gold exchange traded funds (GETFs), funds contain only one principal asset which is gold, thus are 100 % backed by gold, and are successful in tracking and reflecting the price of gold. By investing in gold ETF, investor can gain exposure to the performance of gold without actually owning the precious metal.

For investor who would like to include gold as part in the investment portfolio, an appropriate alternative to gold exchange traded funds (ETFs) would be gold exchange traded commodities (ETCs). The World Gold Council reports that ETCs are obligations or, in other words, claims against the issuer.³¹ The most globally prominent ETFs are SPDR Gold Shares or iShares Comex Gold Trust.

3. Analysis of the Gold Market

Gold markets – is a center for trading gold, where demand meets supply for this precious metal and its buying and selling regularly take place. The world gold market comprises a

²⁹ See Neuberger, 2001, p. 9

³⁰ See Neuberger, 2001, p. 12

³¹ See The World Gold Council, 2011a, p. 48

complete circulation of this precious metal, namely its production, distribution, and consumption.

Economically, gold experienced a whole series of transformations and has not only developed in its specific characteristics and attributes, but also has changed its functions under world economic conditions. As the next step in the discussion of gold as a commodity and possibilities of gold trading for prospective investors, gold's functions must be acknowledged and will be taken into account in the assessment of gold's actual value.

From the moment, when gold has become popular as common equivalent of value, it has outlined its distinguishing features from other commodities and has been valued as a highly precious and multifunctional metal. Throughout most of the last millennium, we have followed a bimetallic monetary standard. However, in the last two hundred years monetary standards differed in their detail. Mono- metallic or multiple- metallic monetary standards were one of the varieties of monetary standards which were based on silver, gold, or on a tender of these two metals, or other metals too, such as bronze and copper.

The use of gold as a monetary measure dates back thousands of years when first international gold currency in 564 BC was created, and in later years gold has served as the basis for the gold standard system, what was essential for economic development of many countries in the 19th and 20th centuries. Until the 1970s gold has performed its prior function as a medium of the common monetary exchange system. From the 1870s until 1900s most of the world's gold in circulation at that time was at national level, intergovernmental level, or between international financial institutions. The private sector was abandoned from this sort of activity though.

Conflicts in the monetary system of the world have led to qualitative changes. Gold was excluded from the world monetary system as a natural trading medium. Afterward, the world market received substantial initiative in more liberalized trading. As a result, gold market has changed substantially, especially in its structure, participants, and trading volume in precious metals.

This chapter brings five sub-chapters together. The first sub-chapter introduces the reader to the fundamental gold price determinants such as demand and supply of gold. The structure of both sides of the market is discussed with a closer look at the trends and factors affecting these. Before touching the major topic of gold price development, the next two sub-chapters will discuss the size and liquidity of the gold market. Concluding part will talk about the

historical and current changes of gold prices, referring back to demand and supply aspects of the gold market.

3.1 Demand for Gold

Demand for gold can be distinguished across two categories: physical demand and investment demand for gold. Demand for physical gold can be furthermore distributed across jewellery, coins or other alternative industrial purposes. In the industry gold finds its use in technological applications, especially in electronics, computers and medicine sectors. In turn, investing in gold can be either done by physical possession of gold, or by investing in trading securities. Investment demand for gold stems from governments, institutional and private investors. Most definitely the highest demand for gold stems from the fabrication of jewellery, which accounts for almost a half of the overall demand. However, investors account for not less important contribution, namely a quarter less than the jewellery producers.³² Investing activities comprise mostly direct forms of investments, especially bar and coin demand. It is important to add that the central banks play a significant role in the flow of gold in the financial market. Central banks demand a larger amount of gold particularly in the emerging markets in order to reduce dependence on the single or several currencies.

3.1.1 The Structure of Demand

A change has taken place since the 1970s, especially after the gold peg was entirely removed one year later. There is a common false impression that the demand for gold is mostly driven by Western institutional investors. The World Gold Council reports dramatic shift in the structure of gold demand, especially how North America and Europe share of 47 % of the global gold market in 1970 fell to 27 % in 2010.³³ On the world gold market scale this plunge was offset by the Indian Sub Continent and East Asia, whose share climbed from 35 % in 1970 to 58 % by 2010 (Figure 1).

Important to note is that the chart excludes the notion of demand of central banks. Even though, the majority of central bank reserves are held in North America and Europe, emerging markets have managed to build up a growing amount of gold reserves in the past years as well.

³² See The World Gold Council, 2011a, p. 27

³³ See The World Gold Council, 2011d, p.3

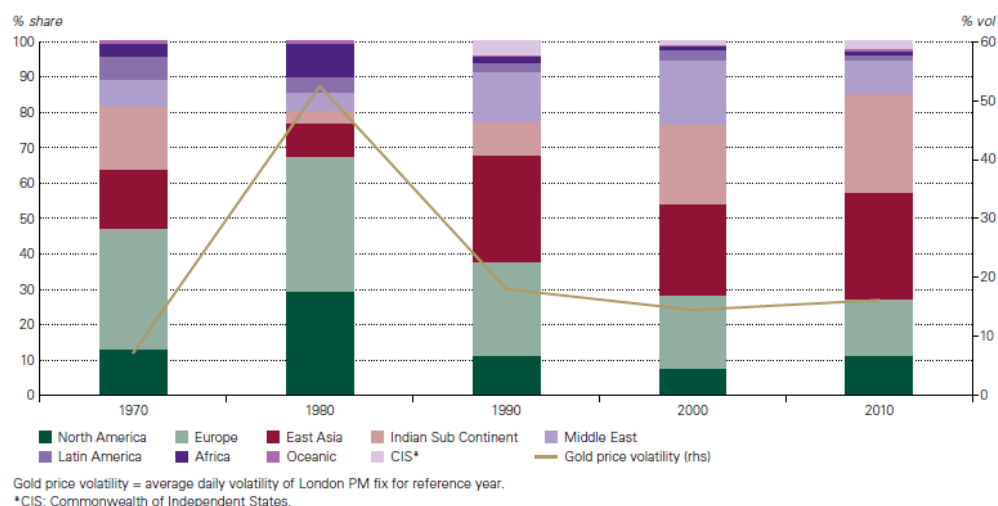


Figure 1: Distribution of gold demand by region³⁴

Equally relevant to the issue of demand is the notion of distribution of gold demand by categories (Figure 2). As already revealed, the major three categories have been jewellery, technology and investment. Firstly, jewellery demand has been a key force of the reallocation from west to east. The World Gold Council states “as North America and Europe’s dominance of the sector has diminished from 44 % share in 1970 to just 14 % in 2010, the Indian Sub Continent and the Far East have grown to represent 66 % of demand from 36 % in 1970.”³⁵ Secondly, from 1980 to 2010 investment demand in North America and Europe dropped from 74 % to 45 % share. On the other hand, we can observe that Indian Sub Continent and East Asia accounted for 43 % share of the market in 2010 referred to China being one of the fast-breaking investment markets. Thirdly, technology demand has managed to remain stable slightly over 10 % of the market over a period from 1980 to 2010. By looking in the distribution of technology demand by region a sharp increase from 17 % in 1970 to 67 % in 2010 in countries such as Japan, China and South Korea can be observed mainly due to the general trend of increasing use of electronics and regional shifts from higher-cost to lower-cost electronics manufacturers.³⁶ Due to the unique features of gold it has become one of the seeking drivers within technology development.

According to The World Gold council, gold as a precious metal commodity has both similarities and distinctive features with any of the other classes of commodities such as energy, metals (whereby gold is included here), agriculture, and livestock commodities, but the other metals, including silver account for a larger demand in technology and industrial

³⁴ See The World Gold Council, 2011d, p.3

³⁵ The World Gold Council, 2011d, p.3

³⁶ The World Gold Council, 2011d, p.5

sectors.³⁷ This notion makes gold less exposed to economy changes and the idiosyncratic risks, and thus less vulnerable to business cycles.

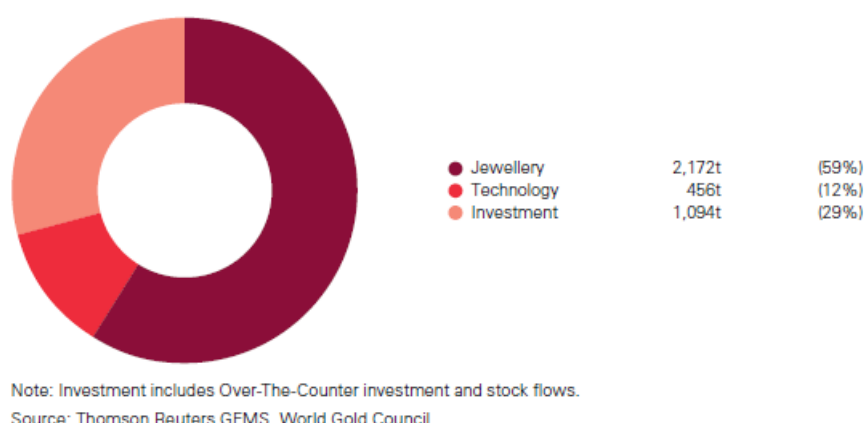


Figure 2: Average annual demand in tones from 2006 to 2010³⁸

3.2 Supply of Gold

Meanwhile the demand side comprises a large amount of key players; the supply of gold is generally associated with gold producers, namely mining corporations. According to The World Gold Council, mining companies account for almost 60 % overall gold supply.³⁹ As an example of the world biggest gold mining companies are Barrick Gold Corporation, Newmont Mining Corporation, AngloGold Ashanti Ltd., GoldCorp Inc., etc. Apart from the most essential supply of gold is considered to be mine production, recycled gold and the net official sector supply are also thought of as other forms of supply. Since gold is almost indestructible, all of the ever mined gold stocks are still in use in a variety of different forms. Therefore, reused or so called recycled gold covers a larger contribution of the supply compared to any other metal, enabling the market to react to main production shocks and shortages in a more efficient manner. In order to be more precise, recycled gold accounted for 36 % of the overall annual supply in gold.⁴⁰ The gold recycling supply is vulnerable to changes in global economic conditions and prices. One of the advantages of reused or recycled gold as a means of additional gold supply is that it enables matching increasing demand for gold in a short period of time, and is not harmful for the environment.

³⁷ See The World Gold Council, 2011b, p. 5

³⁸ The World Gold Council, 2011a, p. 27

³⁹ See The World Gold Council, 2011a, p. 34

⁴⁰ See The World Gold Council, 2011b, p. 6

Equally relevant to the supply of gold is the extent of distribution of the production of gold. Unlike the production of other commodities, a viable example of which is the regional concentrated production of oil, gold is said to be distributed evenly, with no region contributing for more than 20 % of aggregate production in 2009. In connection to this, The World Gold Council explains lower volatility of gold with its favorable production diversification properties.⁴¹

Furthermore, the official sector of gold reserves supply comprising central banks and international monetary fund as key flow players accumulating a large amount of gold injects gold into the financial market, thus also influencing the price of gold. Central banks and international monetary fund take role account for 6 % supply (Figure 3).

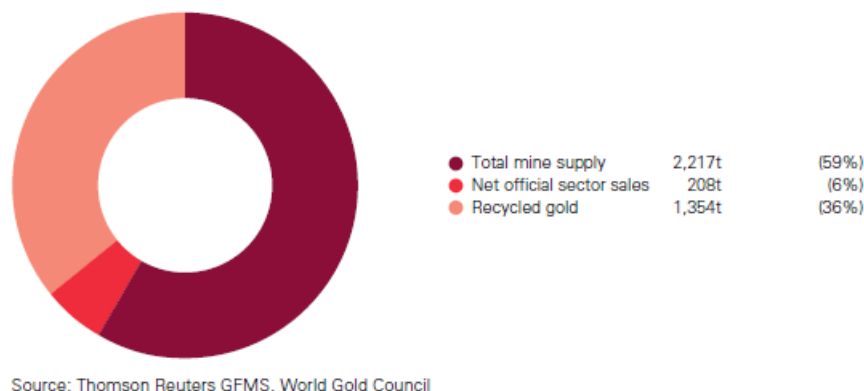


Figure 3: Supply flow 5-year annual average in tones from 2006 to 2010⁴²

3.3 Liquidity in the Gold Market

This part will deal with the gold reserve management, paying particular attention to the size and liquidity of the financial market of gold. Throughout the discussion on the liquidity in the gold markets, I will reveal the size of the gold market.

With the help of literature, the size of the gold market can be compared to the sovereign debt market, which is considered to be most attractive for investors due to its depth and the size of the equities. Apart from the two major uses of gold such as adornment and technological applications, whereby gold as jewellery accounts for 50 % and technological applications in sectors such as mobile, computer and medical industries account for 12 % of the total gold ground stocks, gold finds its use also in the financial market as private investment and official

⁴¹ The World Gold Council, 2011b, p. 6

⁴² The World Gold Council, 2011a, p. 35

sector holdings. Overall, Bhatia et al. valued the market for gold as a financial asset at US\$2.4 trillion, the amount derived from 36 % accounted gold for private investment and official sector holdings multiplied by the average price of gold. After quantifying the gold market to the sovereign debt market, the gold market is actually bigger in size than all European sovereign debt markets and is behind only US Treasuries and Japanese government bond markets. This leads us to think that central banks must hold considerable amounts of gold reserves, which is proved by the fact that gold is the third largest reserve asset after the U.S. dollar and Euro.⁴³

In connection with estimating the size of the gold market, it is important to understand the annual gold supply. Apart from the most essential supply of gold is considered to be mine production, recycled gold and the net official sector supply are also thought of as other forms of supply. Gold mining production accounts for 59 % of the overall gold supply at annual basis, while recycled gold accounts for 36 % (Figure 3).

Liquidity of the gold market is characterized by the over-the-counter (OTC) nature of gold trading which accounts for the most traded place for market participants on the global scale. The OTC wholesale markets are the most liquid ones, but at the same time are nontransparent. According to Bhatia et al., the trading volume in the gold market is substantially larger than trading with other assets.⁴⁴ In connection with the trading volume in gold, the bid-ask spreads are said to be narrow contributing to strong market liquidity.

3.4 Gold and Volatility

Volatility is not only an important phenomenon in markets in general but also it is a perceived source of concern raised by all of the short-term and long-term investors. The public tends to equate gold prices with the prices of other commodities. Compared to the gold prices, the spot prices of other commodities such as oil, copper, tin, oil, palladium, silver, lead, nickel, or copper are regarded to be very volatile. The Figure 4 provides a comparative overview of the volatility of gold and selected commodities over the time period from 2002 to 2004. More precisely, the chart shows that the gap between gold volatility and that of the other major commodities moves in an almost constant pace. Likewise, The World Gold Council concluded on the whole that gold volatility was about 6 % points less volatile than that of the

⁴³ See Bhatia, et al., 2011, p. 2

⁴⁴ See Bhatia, et al., 2011, p. 8

equity market over the past twenty years.⁴⁵ Pulvermacher explains that commodity spot prices show a discrepancy in volatility shaped by short-term supply and demand dynamics in the markets.⁴⁶

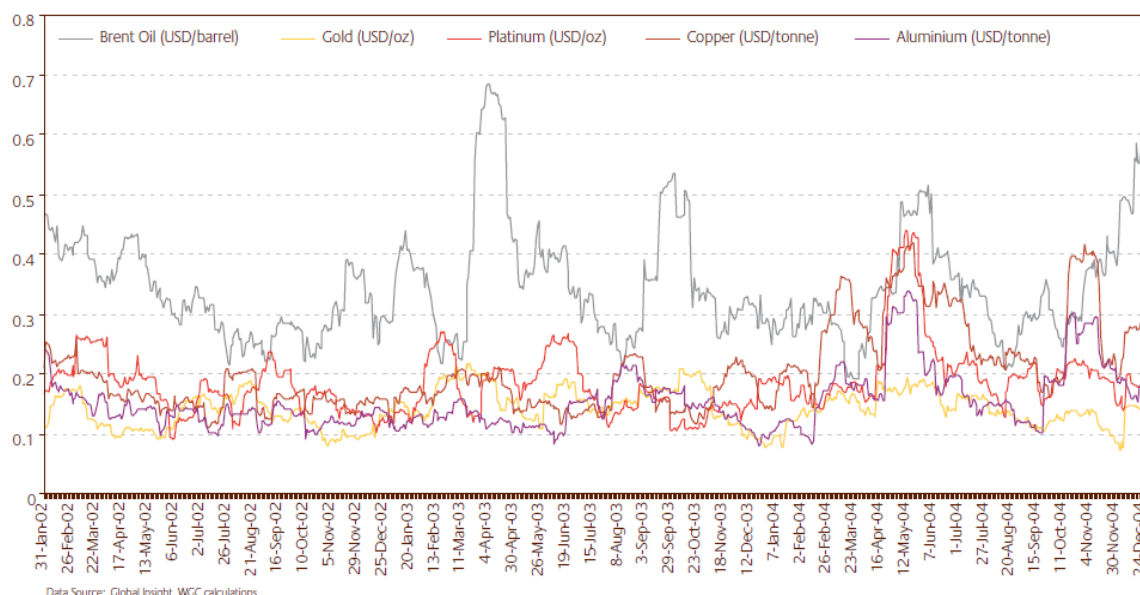


Figure 4: Historical volatility of certain commodities⁴⁷

The World Gold Council emphasizes the number of convincing reasons for why gold is less volatile compared to other commodities. Firstly, the gold market is said to be deep and liquid, what in turn is supplemented by the handiness of the on-ground gold stock and the market for recycled gold. Thus, recycled gold can cater for the rapid increase in demand for gold and limit the possible scope of some price spike. In the same way, trading in gold is usually carried out in the form of physical transactions due to the handiness of the on-ground reserves. Thus, gold trading and investments have limited exposure to leverage - something what cannot be usually also said about the other commodities, because they lean to exceedingly leveraged futures-based contracts, which are automatically conceived with an increased volatility in commodities.⁴⁸

Secondly, the other reason explains the volatility of gold compared to other major commodities by the worldwide mine production distribution. It is worth reiterating what has been already discussed in the previous chapter “supply of gold” that gold reserves are significantly more scattered globally unlike most of major commodities. Accordingly, this makes gold to a less subject matter of geopolitical or other country-specific shocks. In

⁴⁵ See The World Gold Council, 2011a, p. 10

⁴⁶ See Pulvermacher, 2005, p. 6

⁴⁷ Pulvermacher, 2005, p. 2

⁴⁸ See The World Gold Council, 2011a, p. 10

addition, apart from the other major commodities, which have been about 6 % points more volatile than gold as of the last twenty years, stock indices such as, for instance, the STOXX Europe 600 index has performed also to some extent more volatile than gold (18,7 % vs. 16 %).⁴⁹ Overall, it is clear that gold embraces evident characteristics to resist motion of shocks and evolve at a more deliberate rate than many other commodities and stock market indices too.

Equally relevant to the issue of gold and volatility is that gold is an effective diversifier in particular when markets are in a state of high volatility and poor performance. This was examined by the research of Hillier et al., where authors used data from 1976 to 2004 for Standard & Poor's 500 and EAFE and found that gold, in fact, has predominantly effective diversifying effects in periods of high volatility and poor performance.⁵⁰

3.5 Gold Price Trends

With regard to the US dollar currency terms, the gold price stood at \$ 1,657 per ounce in the fourth quarter of 2012. Even though, with a drop in the spot price of 6.7 % since the last quarter of 2011, gold has experienced twelve consecutive annual growth in US dollar terms.⁵¹ Erb & Harvey mention the gold prices appreciation of more than 15.4 % per annum in the U.S. dollar terms, and U.S. inflation gain by 2.5 %, in comparison with U.S. stock and bond markets etched out an annual 1.5 % and 6.4 % increase, respectively, over a period from 1999 to 2012.⁵² In the period from the end of 2001, the gold price increased from US\$276.50 per ounce to US\$1,813.50 per ounce, a cumulative annual rise of 556 %.⁵³

On 6 September 2011 gold prices have reached its nominal high of US\$1,895, followed by a pullback of 16 % when gold traded near US\$1,600 per ounce by the end of Q1 2013. The chart below shows how spot gold prices have developed since 1970 up to the end of the first quarter 2013, demonstrating particularly well the gold bull run since 2001 up until 2011 (Figure 5).

⁴⁹ See The World Gold Council, 2011a, p. 10

⁵⁰ See Hillier, et al., 2006, p. 101

⁵¹ See The World Gold Council, 2012a, p. 6

⁵² Erb & Harvey, 2013, p. 2

⁵³ See The World Gold Council, 2011a, p. 8

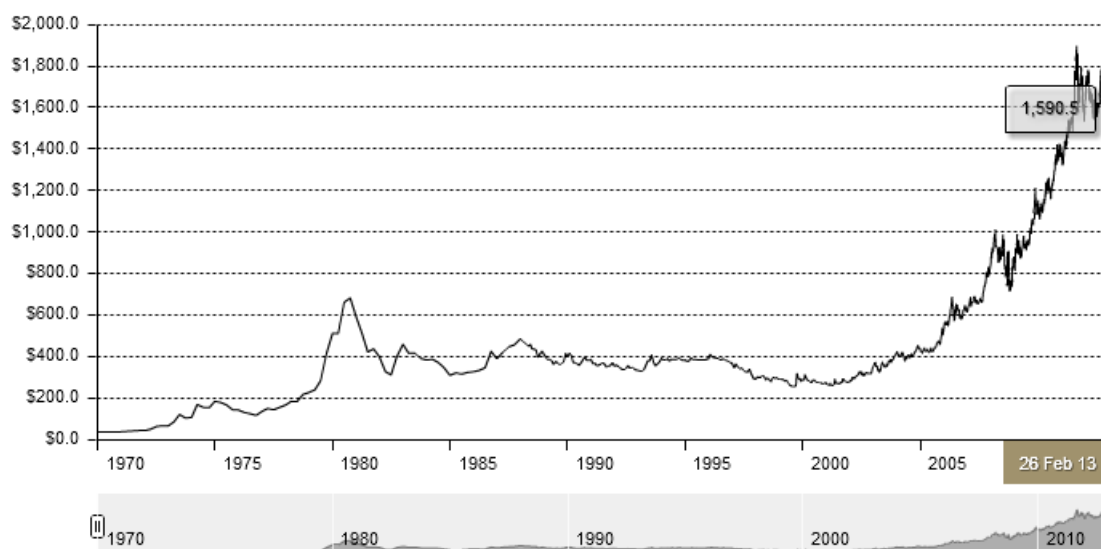


Figure 5: Spot gold price in USD in oz (01/1970-03/2013)⁵⁴

Nevertheless, one cannot ignore the fact that despite gold price has soared to its nominal high of US\$1,895 per ounce on September 2011, gold has recently experienced significant pressure, and raised concerns of whether this is the end of gold's bull run period. The gold market recorded a pullback of 16 % from its high, when gold price reached the bottom of close to US\$1,600 per ounce during the first quarter of 2013, followed by further price drop of 10 % in the middle of April 2013 (Figure 5). In view of these facts, it is quite reasonable to pose two relevant questions: why have been prices pushed that rapidly up to US\$1,900 per ounce in 2011, and what is the most precise interpretation of the price pullback in 2013?

The price of gold as well as also the price of all other investment goods or services is determined by the demand and supply interaction in any specific market. In addition to the supply and demand for gold, the resultant gold market price also happens to be dependent upon the dynamics of inflation, the U.S. dollar exchange rate, financial crisis, profit margins of mining companies (the miners' production costs), multiple structural changes in the gold market (especially on how to access the gold market such as the development of the Exchange Traded Funds (ETFs)), and official sector reserve management activity (central banks readjusting their gold holdings).

From 2001, the gold mining supply started to shrink by means of declining availability of gold resources and falling efficiencies in the production; as well from 2001 to 2010 gold production corporations were disallowing their performance on the forward sale contracts. In the last three years, market has experienced bullish gold supply, where, conjointly expansion

⁵⁴ The World Gold Council, 2013b

of already existing projects and new project start-ups has accelerated mine supply. Over the period of falling supply, mining companies' production costs were growing, setting a higher price level prerequisite. The World Gold Council mentions that the overall expenses of substituting, exploring and mining new ores climbed to US\$928 per ounce in 2010 from US\$282 per ounce in 2001, and now rise even further. The same period experienced a major change in the official sector, started with central banks putting limits to their contribution to supply by selling gold, and for the first time in the last two decades have started purchasing gold.⁵⁵

In the meantime, when observing the gold price changes from the demand side, it is worth noting that over the past decade, rapid GDP growth and an increase in emerging markets disposable income, especially in jewellery demanding markets such as India and China, were leading to an even higher price floor. It is important to add that the introduction of "Shanghai gold exchange and the legalization of gold investment purchases" were viable examples of changes in the gold market in China, where "consumer demand increased from 200 tonnes per year in 2002 to over 750 tonnes per year in 2011 and 2012."⁵⁶

In 2003/2004 The World Gold Council launched the gold-backed ETFs for investors to purchase gold on exchange markets. As a matter of fact, trading gold through ETFs became more reachable and transparent to a wider portion of the addressees. This has affected interest for owning gold in general, and has made gold's diversification properties better known to investors.⁵⁷ The World Gold Council presents the data on the ETFs, "that there were 2,600 tonnes of gold held in the form of ETFs, corresponding to just 8 % of on-ground stock held by private investors, and 10 % of average annual demand."⁵⁸

Between the second half of 2008 and first half of 2011, when the U.S. dollar currency weakened and inflation was expected to creep up, gold has been preserving its properties of a sought-after asset, whereby investors were purchasing gold. Concerns about depreciation with regard to currencies have spread to euro too, buffeted by the European sovereign debt crisis and possible financial contamination in the euro zone.⁵⁹ The World Gold Council contends that the 2008- 2009 financial crises contributed to various structural transformations in the way investors dealt with risk. Central banks involved in the economies of the developed

⁵⁵ See The World Gold Council, 2011a, p. 8

⁵⁶ The World Gold Council, 2013a, p. 7

⁵⁷ See The World Gold Council, 2011a, p. 8

⁵⁸ The World Gold Council, 2013a, p. 7

⁵⁹ See The World Gold Council, 2011a, p. 6

markets by means of changing monetary policies settings. Central banks have switched their position as market participants from sellers to buyers of gold, what in turn has provoked western participants to acquire gold as a hedging practice against prospect inflation, currency devaluation and disaster protection. Furthermore, it has been observed that government securities such as bonds of the world economies of the U.S., Germany, UK and Japan have revealed their weakness in the times of weak financial environment, whose credit rating has been downgraded, and, thus, raising concerns of their credit worthiness, and their excessive correlation.⁶⁰

Following the period from 2001 to 2010, year 2011 has brought all-time record high of gold price. The force behind the rapid price acceleration is described by The World Gold Council as escalating “concerns over economic health of the US and Europe and the aggressive monetary policies that followed (Western demand) coupled with strong emerging market growth (Asian demand) boosted gold price.” The World Gold Council suggests another way of looking at the price pullback in 2011, that “the pullback has not been the first, and over the course of 12-years bull run, gold prices have fallen by more than 10 % (peak-to-trough) on several occasions and by more than 20 % on three since 2011.” And “after each of those occasions, gold prices made new highs supported by healthy demand.”⁶¹ One can agree up to a certain point that by the gold price sharp increase, it is difficult for demand-side to adjust accordingly in the short time, and it would be reasonably well justified to anticipate the price of gold to rise again.

4. Criticism

A number of key criticism issues arise from the topic of investment in gold recently. Whereas a vast majority of literature highlights the appealing side of the investment in the precious metal, perhaps it would also be interesting to look at the literature that disagrees to some point or other with the effectiveness of gold and its roles in portfolio allocation. As already captured in the previous chapter of “Price trends”, the rampant pullback in gold prices to below US\$1,400 in April 2013, a number of concerns have been identified in the minds of investors, who perceive gold as the ultimate portfolio protection tool against inflation and currency debasement or financial instability. In order to approach the other side of the coin, this chapter will mostly deal with the literature based on an article “The Golden Dilemma” from Erb and

⁶⁰ See The World Gold Council, 2013a, p. 7

⁶¹ The World Gold Council, 2013a, p. 4-5

Harvey (2013), who convincingly reject the 6 major arguments for which investors decide whether or not to invest in the precious metal:

- “gold provides an inflation hedge”
- “gold serves as a currency hedge”
- “gold is an attractive alternative to assets with low real returns”
- “gold is a safe haven in times of stress”
- “gold should be held because we are returning to a de facto world gold standard”
- “gold is “under owned” ”⁶²

In the research results, Erb and Harvey come to an insightful bottom line that the majority of these myths are rather spurious, whereas none of them can justify the current price. The authors go so far as to suggest that sooner or later the gold price is inclined to slump even further, when looking at the historical ratio of gold prices and inflation. This argument has been reasonably well portrayed in their different scenarios of the real price of gold based on the next 10 year inflation forecasts and the current real price of gold (the current gold price/current CPI Index), whereby the authors estimate the negative ending real price of gold of around -6 % per annum for the next 10 years just in the case if the real gold price ratio reverts to its historical median of 3.2 % (7.3 % in March 2012). Therefore, in the sense that real prices are mean reverting, the long-term returns are supposedly not to be expected as in the case if gold is purchased at this point of time. In the first place, Erb and Harvey manage to object the widely stated claim that gold as a store of value is effective in hedging against inflation neither in the short nor in the intermediate run, and that the real price of gold are staying roughly unchanged. According to the authors, the “gold as an inflation hedge” case seems to confirm the idea that “the price of gold should at present be about \$780.” They also suggest that gold has been an attractive inflation hedge in the long run of a time span of approximately a century.⁶³

Secondly, the authors are objectively and reasonably well justified in opposing the “gold as a currency hedge” argument, for which they note here that it is just another variant of outlining the “gold as inflation hedge” explanation. For this Erb and Harvey define how the real home currency price of gold has varied over time from 1975 to 2012 in the following eight countries: Australia, Canada, Germany, Japan, New Zealand, Switzerland, the U.K. and the

⁶² Erb & Harvey, 2013, p. 3

⁶³ Erb & Harvey, 2013, p. 5

U.S. In this connection, the real price of gold tends to rise and fall in unison in different countries and in different currencies, thus in the principal seems to be independent of the currency movements. All of this suggests that the local currency movements in the real price of gold give relatively little of the currency hedging explanation.⁶⁴

Thirdly, Erb and Harvey approach the next pro-gold argument that “gold is an attractive alternative to assets with low real returns”, suggesting the most frequently encountered inverse connection between the real price of gold and the level of interest rates. The authors support this view with the data such as, for example, the historical relationship between the real price of gold in U.S. dollars and the real yields, when in the late 1990s in the U.S., the real interest rates were high, gold’s price was low. In recent times, there has been a continuing trend when the yields are almost close to zero, the real price of gold is high.⁶⁵ However, Erb and Harvey manage to disagree with the robustness of these observations by looking at the longer period data sample for the United Kingdom, when there was a relatively low correlation of -0.31 % (compared to -0.82 % in the U.S.) between real yields and the real price of gold, explaining only 9 % of the change in the price of gold.⁶⁶

The authors carry on indicating the possibility of a higher relevance of a time trend over the real interest rate on gold’s real price in the U.S. experience over the period of 1997 to 2012 by means of supporting their argument with the correlation sets of 0.87 between the real price of gold and a time trend being highly positive and substantially closer to 1 than the correlation of -0.90 between real yields and the time trend. Erb and Harvey caution “the highly positive correlation between the real price of gold and a time trend suggests that the real price of gold increases with the passage of time, without limit.” On reflection, the counter argument of the authors is that the infinite story of the real price of gold can never be actually claimed. The most satisfactory conclusion to be drawn based on the arguments presented by Erb and Harvey, is that there is no evidence that that gold is an attractive investment to other competing assets with low real returns.⁶⁷

Furthermore, Erb and Harvey are raising some uncertainty about the fourth belief by claiming that gold may not be “a reliable safe haven asset” with respect to extreme financial and economic stress. Even though, recent events when the price of gold has climbed from US\$743

⁶⁴ See Erb & Harvey, 2013, p. 19

⁶⁵ See Exhibit 13: “The Real Price of Gold and the Real Interest Rate, 1997-2012” from Erb & Harvey, 2013, p. 21

⁶⁶ See Erb & Harvey, 2013, p. 21

⁶⁷ See Erb & Harvey, 2013, p. 21

as of September 2007 to US\$1,940 as of September 2011 in the series of events such as severe global financial crises, followed by Euro zone crises, with Spain and Greece filling for bail outs seem to be most reasonable for the “gold as a safe haven” argument, Erb and Harvey manage to prove the opposite by the fact that 17 % of total observations of the U.S. stock and gold returns represent negative monthly equity returns (financial market) matching with negative gold’s return performance in the period from 1975 to 2012. In case if we were to consider gold as a “safe haven asset“, then there would be access to few, if any, observations under this condition. After all, the authors emphasize the fact that what matters is how we define financial stress.⁶⁸

Equally relevant to the issues of “gold as a haven asset“ and “gold as an inflation hedge“ the researchers decide to discuss the question of how well does gold provide a hyperinflation hedge. They describe an example of an average annual inflation rate of about 250 % in Brazil from 1980 to 2000, when the price of gold in inflation-adjusted terms plummeted 70 %. So, if the price dropped 70 %, the Erb and Harvey define to what extent they consider gold to be a successful hyper-inflationary tail risk protection by referring to a number of issues arising from this statement. The first argument suggests that if the price would move one-to-one with the Brazilian inflation as expected, then gold was not a successful hedge against hyperinflation, whilst the second suggests that in comparison with bonds or cash which have lost about 100 % in value, a drop of 70 % of gold prices reveals gold as a relatively better hedge alternative in a period of hyperinflation. However, after the detailed discussion the authors came to the conclusion that irrespective of the country specific hyperinflationary experience, there is no motive to think that the inflation-adjusted return of gold will be positive.

The researchers see “gold is under owned” as a further strong pro-gold argument in favor of driving current gold market prices to the upside. The argument of under-ownership is supported by the fact that the value of gold held by most investors such as institutions do not reach even 2 % of their portfolios. Accordingly, an increasing urge to own more gold in well diversified portfolios would lead to resulting stepped up upward pressure on prices. Moreover, Erb and Harvey (2013) believe that the emerging market demand, and the fact that

⁶⁸ See Exhibit 14: “Gold and the S&P 500, 1975-2012” from Erb & Harvey, 2013, p. 24

only 20 years lasting under-ground gold reserves are yet remaining, is a continuing upward momentum in gold prices.⁶⁹

The value of gold held by private investors is about 2 % of the aggregate value of stocks and bonds, but most investors – such as institutions – have nowhere near 2 % of their portfolios in gold, since a subset of investors hold a disproportionately large amount. The argument is that they therefore under-own it, and once there is a general realization of this under-ownership, and a scramble to buy more, the price will surge upward still further.

What conclusion can be drawn from all this? Erb and Harvey conduct comprehensive academic research on gold, deriving the real measurements of the “fair price” of gold with respect to a number of popular stories that are conjointly working to formulate a pro-gold argument. Of course, it is worth stating at this point that all of the discussed arguments for and against gold are not the ultimate word on this matter. The researchers, Erb and Harvey, raise investors’ awareness of the factors, beyond the standard ones, having the potential for great impact on their financial returns. Erb and Harvey stress the importance of not always relying on the commonly held argument that gold can hold its value over extensively longer terms to find good reasoning for gold price shorter term outlook.

⁶⁹ See Erb & Harvey, 2013, p.44

5. Introduction to the Empirics

The main objective of the empirical part of this paper is the construction of applicable econometric models of gold market price formation, which can be used to predict future outcomes of the price of gold. The variables of the model will be derived from theoretically based determinants or factors, which will be used in the later analysis according to the author's own assumptions. All statistical analyses and forecasts will be based on monthly prices, whereby the monthly average price, as well as the monthly closing price (quote on the last trading day in the month) will be taken. Primary determinant's lags will be chosen with help of test for Granger causality and Vector Autoregressive (VAR) models for each of the confirmed determinants of gold. Due to a large amount of data and in order to avoid unnecessary information in the text of this part of the paper, the results of the above models and tests are given in the appendix. The final models will be chosen by the statistical significance of each of the exogenous variables and of the adjusted coefficient of determination, hereinafter referred to as R^2 . A major part of the process of econometric model building is the analysis of the residuals on their resemblance with the white noise error terms. This will serve us an important criterion for the selection of the final models' construction. The conclusion of a whole study will contribute to the assessment of the actual application of the constructed models.

Examined determinants of the gold price are listed below:

- the US dollar exchange rate
- credit risk
- US inflation rate
- lagged gold price
- Standard and Poor 500 stock price Index
- Europe Brent crude oil price
- price volatility of Standard and Poor 500 Index
- oil price volatility

It is important to note here the reason for the selection of the above listed potential exogenous variables. Gold has been unofficially called the “anti-dollar” because of the strong negative correlation between the US dollar and gold. Since the major stock exchange currency of gold

listings is the US dollar, its weakening against other currencies makes gold cheaper to purchase for investors as well as for producers outside the US dollar zone. As a result, the rising demand for gold drives up the price in US dollars.

The level of credit risk reflects the extent to which economy is currently destabilized, as well as the widespread of uncertainty among economic actors. It is common to judge that in periods of high credit risk, investors will resort to the most traditional and presumably the least risky investments, one of which has historically been gold. A positive correlation of gold price and the level of credit risk is thoroughly justified.

Moreover, high inflation represents certain risk to investors, whereby gold as an asset reduces this risk - statement proved in a statistical study of Levin and Wright.⁷⁰ Thus, we should expect higher demand for gold followed by the rise in the price of gold at the periods of high inflation.

The Standard & Poor's 500 stock market index is considered to be one of the best indicators of the state of the world economy. It is generally agreed today and particularly discussed in the research report by Dempster that gold as a serve of long-term sustainable value will be more in demand during economic recessions and less in times of economic growth.⁷¹ All of this points to the assumption of the expected negative correlation relation between stock index quotes and gold prices.

The volatility index (VIX) is an analogue indicator of credit risk of default, which also indicates the level of economic destabilization as a result of investors' uncertainty. Nevertheless, one should also consider that VIX, in contrast to the credit risk, is a better and more accurate representation of the equity market, since VIX shows volatility of S&P500 stock market index. In case of credit risk it is debt securities and obligations. Since there have been two determinants found with similar points of interpretation, namely credit risk and volatility index, it is possible that one of the two determinants will be dismissed from the model in case of strong pairing correlation.

Historically, the price of oil was significantly correlated with the price of gold. One of the investigations on this topic has been made by Kim and Dilts, where the main findings of their

⁷⁰ See Levin & Wright, 2006, p. 10

⁷¹ See Dempster, 2008, p. 7

research imply that “gold and oil represent safe havens from fluctuations in the value of the dollar.”⁷²

On reflection, price volatility may turn out to be a more accurate factor than the oil price itself. Oil prices are one of the most influential and powerful factors for many economies, whose sharp increase depicts severe supply-side economic shocks. Historically, an increase in price of gold tends to reflect political tension in the world. An inflow of investment activity in the gold market in a time of high oil price volatility happens as a result of the perceived fear from political conflicts and prospect economic instability.⁷³

The final models will be evaluated for the period from March 1990 to September 2012. Despite the fact that data on many quotes, including the price of gold itself goes much further into the past (data for the price of gold is known from 1970s), this period was chosen for two reasons. First, evaluation of the model requires data for each of the determinants, whereby the youngest available data will serve as a lower boundary of the period. For example, the VIX Index which corresponds to the volatility index of S&P 500 is listed only from the beginning of the 90th, what makes it impossible to build a model based on the data from 1970 till 1990s. The second reason serves the confirmation of the validity of the accepted solution, rather than being a root cause. It is essential to consider that in the meantime of examining the period, it is necessary to address the assumption that behind each of the time series stands an unchanging stochastic process. In the nineties, mankind has survived the information revolution. The sharp increase in the rate of information transfer and radical change in the form of investments may serve a cause in terms of serious changes in the stochastic processes of formation of asset prices. It would be legitimate to question the accurateness of applying the mechanism of gold price formation which has been observed up until the 1990s for the year 2000. For this reason, the use of longer time series can distort the actual stochastic processes that are the subject of this study.

6. A Model of the Average Gold Price

The first aspect to point out is that this part of the work will present the variables, which were included in the final model, as well as will show the structure of these variables, using derived

⁷² Kim & Dilts, 2011, p. 1151

⁷³ See Sujit & Rajesh Kumar, 2011, p. 148

data. In the second place, evaluation of the model by the method of least square, followed by the interpretation of results and testing of residuals for the white noise will be conducted.

6.1 Determinants of the Gold Price

The model includes variables on the following determinants:

- lagged values of the gold price
- the US dollar exchange rate
- credit risk
- Europe Brent crude oil price
- volatility index (VIX)

Due to the large majority of the time series of asset prices are found as non-stationary, the time series of variables representing asset prices will be further transformed to a stationary form. Generally, a stationary nature of random process means time constancy of its parameters, whereby two types of stationary processes should be noted: strict/strong stationarity and weak sense/ wide-sense stationarity. The case of a strict stationary process refers to the constant average value and dispersion of the process with respect to time. The wide-sense stationary process requires an additional condition of invariability in autocorrelation function in time.⁷⁴ In this study, investigation will be restricted to the weak stationary process and the satisfaction of its conditions will be achieved through the logarithmic difference of two values. Therefore, when considering for example the price of gold, the time series is not the absolute value of the price at a certain time, and its percentile change is relative to the previous quote. The advantage in the application of the logarithmic differences over the percentage change is its constant nature in terms of time. At the level of up to 10 per cent, the difference in the results of these methods of calculation is considered to be not statistically significant.

6.1.1 The Price of Gold

In this statistical model, the price of gold is represented by two variables – log returns of the average price and log returns of the price on the last day of the month. The gold price is taken from The World Gold Council. Both variables are incorporated as their own primary lags.

⁷⁴ See Cipra, 2008, p. 328

$$\Delta \ln G_{av_t} = \ln \left(\frac{\sum_{n1=1}^{m_1} g_{n1}}{m_1} \right) - \ln \left(\frac{\sum_{n0=1}^{m_0} g_{n0}}{m_0} \right),$$

$\Delta \ln G_{av_t}$ – logarithmic return of the average price of gold

g_{n1} – daily closing gold price for the month $t + 1$

g_{n0} – daily closing gold price for the month t

m_1 – number of days in the month $t + 1$

m_0 – number of days in the month t

$$\Delta \ln G_{cl_t} = \ln(g_{t+1}) - \ln(g_t),$$

$\Delta \ln G_{cl_t}$ – logarithmic return of the closing price of gold

g_{n1} – closing gold price on the last trading day of the month $t + 1$

g_{n0} – closing gold price on the last trading day of the month t

6.1.2 The U.S. Dollar Exchange Rate

In the model, the U.S. dollar exchange rate is represented by the logarithmic difference of the closing prices on the last day of the next two months.

$$\Delta \ln USD_{cl_t} = \ln(usd_{t+1}) - \ln(usd_t),$$

$\Delta \ln USD_{cl_t}$ – logarithmic difference of the closing price

usd_{n1} – closing quote of the U.S. dollar index on the last trading day of the month $t + 1$

g_{n0} – closing gold price on the last trading day of the month t

6.1.3 Credit Risk

The level of the credit risk is determined by the difference in the profitability of bonds with AAA rating and bonds with one notch below the credit rating of AAB. The monthly return quotes data on the Moody's bonds will be included in the calculations. The variable, which is responsible for this particular factor, is represented as the ratio of profitability of higher-rated bonds over profitability of lower-rated yield bonds. In other words, variable is used as multiplicative inverse or reciprocal for the level of credit risk, meaning that fewer the value of the variable, the higher the level of credit risk in the particular month.

$$CRgap_t = \frac{Yield_{AAA_t}}{Yield_{AAB_t}},$$

$CRgap_t$ – credit risk level, multiplicative inverse or reciprocal

$Yield_{AAB_t}$ – profitability of Moody's bonds with an AAB rating

$Yield_{AAA_t}$ – profitability of Moody's bonds with an AAA rating

6.1.4 Europe Brent Crude Oil Price

This given factor is proved to be statistically significant in the model presented as the difference of monthly average price changes and the changes in the closing gold prices in the next two months. The value of the variable can be interpreted as an amount of dramatic changes within a month with an increase in value of these changes as they approach the end of the period. Accordingly, the higher the value of the variable, the more dramatic is the change in the trend of the oil prices from positive to negative, and the closer it is to be found towards the end of the month. A more clear construction of the variable may be expressed by the formula below:

$$\Delta\Delta Oil_t = \Delta\ln Oil_{av_t} - \Delta\ln Oil_{cl_t}$$

$$\Delta\ln Oil_{av_t} = \ln\left(\frac{\sum_{n1=1}^{m1} oil_{n1}}{m_1}\right) - \ln\left(\frac{\sum_{n0=1}^{m0} oil_{n0}}{m_0}\right),$$

$$\Delta\ln Oil_{cl_t} = \ln(oil_{t+1}) - \ln(oil_t),$$

$\Delta\Delta Oil_t$ – difference in the average monthly change in oil prices and the change in the closing oil prices

$\Delta\ln Oil_{av_t}$ – logarithmic return of average monthly oil price

$\Delta\ln Oil_{cl_t}$ – logarithmic return of closing oil price

oil_{n1} – daily closing oil price in the month t +1

oil_{n0} – daily closing oil price for the month t

m_1 – the number of days in the month t +1

m_0 – the number of days in the month t

oil_{n1} – closing oil price on the last trading day of the month t +1

oil_{n0} – closing oil price on the last trading day of the month t

6.1.5 Volatility Index (VIX)

Given index is derived from the volatility of the index S&P 500, and is presented in the model as a logarithmic difference in the average monthly quotes.

$$\Delta \ln Vix_{av_t} = \ln \left(\frac{\sum_{n1=1}^{m1} vix_{n1}}{m_1} \right) - \ln \left(\frac{\sum_{n0=1}^{m0} vix_{n0}}{m_0} \right),$$

$\Delta \ln Vix_{av_t}$ – logarithmic return of average monthly quotes

vix_{n1} – daily closing quote for the months t+1

vix_{n0} – daily closing quote for the months t

m_1 – the number of days in the month t+1

m_0 – the number of days in the month t

6.1.6 Auxiliary Binary Variables

In order to adapt statistical characteristics of random components to the characteristics of white noise using binary (dummy) variables, three periods were dismissed: October 1999, June 2006 and August 2008. It is very possible that the change in average prices in these periods was caused by the factors that are not presented in the model: that is, exogenous shocks in relation to the studied system.

Binary variables are unit vectors, i.e. the numerical values 0 with the only one value of 1 in the period. Therefore, one variable is attached to the only single value of the price of gold, and its coefficient value can cancel a random component in the given period.

6.2 Model

This part of this paper presents the overall evaluation results for the period from March 1990 to September 2012. There is a total number of observations of 271.

$$\begin{aligned} \Delta \ln G_{av_t} = & 0.13 + 0.459 \Delta \ln G_{cl_{t-1}} - 0.233 \Delta \ln G_{av_{t-1}} + 0.029 \Delta \ln USD_{cl_{t-1}} \\ & - 0.13 CRgap_{t-1} - 0.00066 \Delta \ln Vix_{av_{t-1}} - 0.0369 \Delta \Delta Oil_{t-1} + dummy \end{aligned}$$

6.3 Properties of Mathematical Expectation

R-squared	0.47
Adjusted R-squared	0.45
Correlation	0.66

Table 1: Average gold price model characteristics of the accuracy in the prognosis

With regard to the properties of mathematical expectation showed in the figure above, the idea seems to be that general features of the model have exceeded expectations. The coefficient of determination, showing to what extent mathematical expectation model coincides with the real data, is just over 0.47.

Given the logarithmic form of the model and the fact that the exogenous variables are only lags, the result can be considered to be good. Moreover, the adjusted coefficient of determination in terms of its value accommodates a kind of cost referring to the number of variables used. Due to the immense level of autonomy (referred to as how to distinguish the number of observations and the variables in the model), the adjusted coefficient of determination, $\bar{R}^2$, is not much different from the standard R-squared value and is over 0.45. The correlation between the mathematical expectation and the real data was slightly higher than 0.66. This appears to confirm the idea, that the model has the potential for the future prediction.

6.4 Characteristics of Variables

The table below (estimations were derived and reproduced with the econometrics software EViews) is a good tool for a visual description of the characteristics of the variables.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
<i>intercept</i>	0.130722	0.031228	4.186071	0.0000
$\Delta \ln G_cl_{t-1}$	0.459477	0.047139	9.747321	0.0000
$\ln G_av_{t-1}$	-0.233110	0.058980	-3.952348	0.0001
$\Delta \ln USD_cl_{t-1}$	0.029482	0.011396	2.586952	0.0102
$CRgap_{t-1}$	-0.130083	0.032315	-4.025420	0.0001
$\Delta \ln Vix_{av_{t-1}}$	-0.000664	0.000247	-2.690989	0.0076
$\Delta \Delta Oil_{t-1}$	-0.036940	0.021707	-1.701764	0.0900
$D2006M06$	-0.107697	0.027073	-3.978056	0.0001
$D2008M08$	-0.103014	0.026876	-3.832921	0.0002
$D1999M10$	0.098076	0.027455	3.572258	0.0004

Table 2: Description of variables in the average gold price model

On the basis of the characteristics of variables, the first column of the table above sets out the name of the variable, and the second column lists its coefficient originating from the primary

model. However, new information is obtained in the next two columns: the standard error of the estimate of each variable and the probability of the variables incurred insignificance. The probability in the third column is the result of testing the null hypothesis, that the coefficient of the variable is equal to zero, against an alternative (symbolized as H1) hypothesis testing for the deviation of the coefficient value from zero. The statistical testing is conducted using T-statistics, which is the ratio of the coefficient of the variable to its standard error. Moreover, following relation can be observed from the table: the greater the absolute value of the statistics, the higher is the level of significance based on which the null hypothesis will be denied and at the same time an alternative H1 hypothesis confirmed.

In view of the testing results, one may conclude that all the variables in the model are determined to be statistically significant with a probability of over 90 per cent. In addition, all variables except for the oil variable are significant with a probability nearly equal or over 99 per cent.

In case of the absence of the coefficients of dummy variables, they can be considered as the approximate value of the random error in the given period. Furthermore, the partial price change will be expressed by other variables in the model, and the random error will be slightly smaller in its magnitude, but with the same sign as the binary variable in the given period.

Unfortunately, at this stage it is impossible to make a comprehensive conclusion about the impact of each of the exogenous variables on the predicted price of gold ($\Delta \ln G_{av_t}$), for the reason that the conclusion requires the investigation of the linear dependence relation among all the variables. More details on this issue will be given in the next section.

6.5 Analysis of the Model's Performance and Quality

The first aspect to point out is that this stage is not less important than the construction process of the model itself. So, in the event of not fulfilling certain criteria related to the characteristics of random errors, the results of the model may not reveal information, or, in turn, information may be distorted. The resulting model will be tested for the presence of auto-correlation in random error terms. Based on these considerations, and taking into account the fact that the subject of this study is the time series; residuals (as representatives of random errors) will be tested and approved for the non-presence of the autocorrelation process and determined whether the data is normally distributed. Finally, variables of the model will be

checked for multicollinearity, whereby it should be noted that in the case of positive result, the question of its acceptability has to be addressed and accordingly examined.

6.5.1 Autocorrelation

Autocorrelation process means dependence of random components in the model on its own lags. In the case of negative consequences, autocorrelation can be explained by distortion of mathematical expectation of dispersion of random components and can cause a distortion of the estimated regressors. When using standard techniques that match serial independence of random errors, the coefficient of determination turns out to be overvalued, and standard errors of the estimated coefficients of the variables undervalued.

The characteristic of this model embodies a common cause for autocorrelation due to the use of lags and evaluation of the model based on the data containing mean values. Therefore, one is justified to ensure that special attention is paid to the autocorrelation test.

Autocorrelation will be tested using Q-test (Portmanteau - test) and LM-test (Breusch-Godfrey Serial Correlation Lagrange Multiplier Test). Both of these tests are used to test the null hypothesis on the lack of autocorrelation, and an alternative H1 hypothesis on the presence of the autocorrelation process, the correlation matrix of the random component in time. The Q-test tests the overall statistical significance of the first k autocorrelations of residuals. According to the recommendations of literature, constant K will be determined as $k = \sqrt{n}$, where n is the number of observations, which in this case is around 400.⁷⁵ Further, the LM-test investigates whether there is a serial dependence, on the basis of evaluation of residuals with the help of its own lags and exogenous variables.

6.5.2 Q-test

Lag	AC	PAC	Q-Stat	Prob
1	-0.027	-0.027	0.1930	0.660
2	-0.004	-0.005	0.1970	0.906
3	-0.028	-0.028	0.4081	0.939
4	-0.002	-0.004	0.4092	0.982
5	-0.007	-0.007	0.4215	0.995
6	0.032	0.031	0.7077	0.994
7	0.019	0.020	0.8063	0.997
8	-0.032	-0.031	1.0990	0.998
9	-0.051	-0.051	1.12	0.994

The second column shows the correlation coefficient between the actual mathematical expectation of white noise and its lags n . Furthermore, the third column shows the coefficient of the partial autocorrelation function, which is different to the previously presented coefficient, as it does not include the value of correlation, which is based on a

⁷⁵ See Cipra, 2008, p. 348

10	0.078	0.077	3.64	0.965
11	0.047	0.050	4.1738	0.965
12	-0.049	-0.050	4.68	0.963
13	-0.096	-0.098	7.15	0.876
14	0.017	0.017	7.46	0.911
15	0.022	0.029	7.36	0.935
16	-0.026	-0.034	7.46	0.952
17	0.052	0.039	8.00	0.950
18	0.011	0.018	8.47	0.966
19	-0.016	0.003	8.22	0.977
20	0.082	0.084	10.753	0.952

Table 3: Q-test indicating a lack of autocorrelation

linear dependence of the values between the current and the examined lag. The following table shows that both coefficients are approximately equal, and this proves a lack of autoregressive processes. The last column is composed of the probability of accepting the null hypotheses on the absence of autocorrelation. It shows that the probability systematically increases up to 95 per cent in the 20th lag. This test points to the conclusion that autocorrelation is not statistically significant with the probability of 95 per cent.

6.5.3 LM-test

F-statistic	0.68296	Prob. F(2,247)	0.4093
Obs*R-squared	0.709993	Prob. Chi-Square(2)	0.3994

Table 4: LM-test indicating a lack of serial autocorrelation

In the above table, the results of testing serial dependence of residuals are shown. The test applied here is based on the data including only the first lag of residuals. The result of this test implies that there is no serial correlation with the probability of 40 per cent, and one should accept that this result is fully satisfactory.

This test leads to the conclusion that serial autocorrelation of residuals is not present in the model.

6.5.4 Normal Distribution

Since all the tests to evaluate the model by the method of least square are based on the assumption of normal distribution of random errors, the testing of this fact will not be superfluous, while at the same time though is not considered to be a necessity in most of the econometric literature.⁷⁶ In order to determine normal distribution, three most commonly used methods will be implemented: a comparison of statistical characteristics based on the residuals with characteristics of normal distribution, Jarque- Bera test and the histogram serve representation for visual comparison.

⁷⁶ See Husek, 2007, p. 71

6.5.5 Statistical Characteristics of Residuals and Jarque - Bera Test

Mean	0
Median	-0,0016
Skewness	0,21
Kurtosis	3,078
Jarque - Bera	2,069
Probability	0,355

Table 5: Empirical distribution and J-B Test

Arithmetic mean and the median value correspond to a normal distribution and both are equal to zero. An asymmetry coefficient is slightly positive indicating a rather larger number of absolute (positive) values, as well as many negative, medium and weakly negative random errors. Of particular importance is the strongly positive kurtosis of 3.08.

Compared to normal distribution, distribution of residual values of the given model is determined as leptokurtic distribution. It is more peaked in the center and has fatter tails. As a result, the number of minimum and extremely large errors with respect to the number of average errors is much greater, than in a normal distribution. Besides, positive kurtosis is regarded to be characteristically descriptive for the financial time series, and is an actual topic issue for financial statisticians.

The Jarque - Bera test examines normal distribution based on the second and third moments of distribution. The null hypothesis tests if the distribution is indeed normal against the alternative hypothesis of non-normal distribution. According to the results of this test, normal distribution of residuals is confirmed.

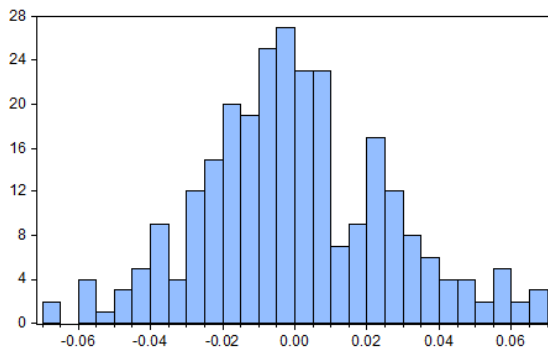


Figure 5: Histogram of residuals of the average gold price model

Histogram shows the empirical distribution of residuals and clearly confirms the above described statistical characteristics. From the illustration on the left, the peak of distribution seems to be shifted to the left, as well as the curve extended to the right. Also, the curve is significantly sharper than the Gaussian symmetrical curve. Despite of some flaws, this

distribution remains within the normal range and the graph corresponds to the outline of normal distribution. Moreover, the original data had a much worse performance in comparison with the above distribution. In the view of this test, an adequacy of the model can be confirmed.

The conclusion of this part is that the distribution of mathematical expectations of random errors is normal.

6.5.6 Multicollinearity

Since a common cause of multicollinearity is the use of different time series lags in the model, it is worth paying special attention to this topic. Moreover, the LM test result discussed earlier shows an evidence of strong multicollinearity. In case of econometric model building for the purpose of future forecasting, the most negative consequence is considered to be strong sensitivity of the estimated coefficients, when a slight change in the observation matrix happens. This could mean that the parameters that are estimated to be statistically significant in this period may actually turn to be not statistically significant when using the new observations. Accordingly, this observation significantly reduces the quality of forecasts and the due dates of the possible use of models. So, auxiliary regression will be used in order to assess the strength of multicollinearity. Afterward, we will assume that multicollinearity is seen to be problematic in case if the adjusted coefficient of determination in auxiliary model is higher than the one in the original model. This condition can be expressed using formula as follows:

$$\bar{R}^2 < \bar{R}_j^2, \quad j = 1, 2 \dots k,$$

where

- $\bar{R}^2$ – adjusted coefficient of determination of an original model,
- $\bar{R}_j^2$ – adjusted coefficient of determination of the auxiliary regression

Firstly, the auxiliary regression method suggests a model in which one of the exogenous variables is valued by other variables. For example, the auxiliary regression for the lagged values of the log difference of the gold price will be constructed as follows:⁷⁷

$$\begin{aligned} \Delta \ln G_{clt-1} = & \beta_0 + \beta_1 \cdot \Delta \ln G_{avt-1} + \beta_2 \cdot \Delta \ln USD_{clt-1} - \beta_3 \cdot CRgap_{t-1} - \beta_4 \cdot \Delta \ln Vix_{avt-1} \\ & - \beta_5 \cdot \Delta \Delta Oil_{t-1} + dummy \cdot \varepsilon_{t-1} \end{aligned}$$

This way, the endogenous variable is represented by the lagged value; next, for the purpose of clarity the model is transformed to the following form:

$$\begin{aligned} \Delta \ln G_{clt} = & \beta_0 + \beta_1 \cdot \Delta \ln G_{avt} + \beta_2 \cdot \Delta \ln USD_{cle} - \beta_3 \cdot CRgap_t - \beta_4 \cdot \Delta \ln Vix_{avt} - \beta_5 \cdot \Delta \Delta Oil_t \\ & + dammy + \varepsilon_t \end{aligned}$$

⁷⁷ See Husek, 2007, p. 97

In a similar way, the model is developed and evaluated for each of the regressors. The results of adjusted coefficients of determination are given in the table below.

Variable	$\bar{R}_j^2$
$\Delta \ln G_{clt}$	0,38211
$\Delta \ln G_{avt}$	0,476034
$\Delta \ln USD_{cle}$	-0,02691
$CRgap_t$	0,322068
$\Delta \ln Vix_{avt}$	0,291177
$\Delta \Delta Oil_t$	0,03342

Figure 6: R-squared of the auxiliary regressions

From the table above, the critical value of the adjusted coefficient of determination of the original model has been exceeded only in one auxiliary regression of the first lagged value of the average price of gold. $\bar{R}^2(0,45) < \bar{R}_j^2(0,476)$.

The model has undergone the test of residuals, including the autocorrelation test and the test of normal distribution. The assumption of multicollinearity has been confirmed in the last

topic. The resulting model will be sensitive to the new observations of exogenous variables. As a consequence, its effectiveness will be reduced over time, and the estimation of the coefficients will be required. In particular, predictions of the model will not only depend on the constancy of the linear relationships of exogenous variables and predicted gold prices, but also on the constancy of the links between these exogenous variables.

7. A Model of the Monthly Closing Price of Gold

As the first step on this part of the work the variables included in the final model will be presented showing their construction structure from the data available. Furthermore, evaluation of the model by the least squares method, interpretation of results and residuals testing will follow next.

7.1 Determinants of the Gold Price

The model includes variables representing the following determinants:

- lagged values of the price of gold
- the U.S. dollar exchange rate
- credit risk
- Europe Brent crude oil price
- the volatility of Europe Brent crude price
- volatility index (VIX)

7.1.1 The Price of Gold, the U.S. Dollar Exchange rate, and the Level of Credit Risk

The construction of the variables representing the following determinants is identical to the previously presented variables of the average price of gold - $\Delta \ln G_{cl_t}$, $\Delta \ln USD_{cl_t}$, $CRgap_t$.

7.1.2 Europe Brent Crude Oil Price

The percentage change in the price of oil in the next two months will be calculated as the logarithmic difference of the closing price on the last trading day of the month. Since, the price of oil and the price of gold are historically correlated; it is permissible to expect a positive coefficient of the given variable in this model. It is important to add that this variable appears in the model as the first lag.

$$\Delta \ln Oil_{cl_t} = \ln(oil_{cl_{t+1}}/oil_{cl_t}),$$

$\Delta \ln Oil_{cl_t}$ – logarithmic return of the closing oil price

oil_{cl_t} – closing oil price on the last day of the month t

$oil_{cl_{t+1}}$ – closing oil price on the last day of the month t +1

7.1.3 The Volatility of Europe Brent Crude Prices

The volatility in oil prices may provoke negative shocks in both financial markets and the real economy. Gold is regarded to be a preferred asset in times of instability, therefore it is acceptable to expect positive values of variables in the early lags and negative in the later ones. Also, history proves that with particular constancy, periods of instability are followed by periods of investment optimism. Variable is represented as the difference in volatility in the next two months. After all, this variable turned out to be statistically significant in the fourth and the fifth lagged value.

$$Oil_{av_t} = \frac{\sum_{n=1}^{m1} oil_n}{m},$$

$$VolOil_t = \frac{12 \cdot VAR(Oil_t)}{\sum_{i=t-12}^{12} Oil_i},$$

$$\Delta VolOil_t = VolOil_t - VolOil_{t-1}$$

$\Delta VolOil_t$	– changes in the volatility in the current month compared to the previous month
$VolOil_t$	– volatility of oil prices, calculated as the dispersion of average monthly price divided by the arithmetic mean of the price
Oil_{av_t}	– average price of oil
oil_n	– daily closing price on a day n
m	– the number of days in the month t

7.1.4 Inflation in the United States

Variables are represented by the means of change in inflation in the current month compared to the previous in the second lagged value.

$$Pi_{US_t} = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}},$$

$$\Delta Pi_{US_t} = Pi_{US_t} - Pi_{US_{t-1}}$$

7.1.5 Auxiliary Binary Variables

Just as in the previous model, in order to match statistical characteristics of residuals on the characteristics of the white noise using binary variables, or so called dummies two following periods were eliminated: October 2008 and September 1999. Most likely the change in average prices in these particular periods was caused by the factors that are not included in the model, that is, exogenous shocks compared to the examined system.

7.2 Model

In this part of the paper, the evaluation result for a period from November 1988 to September 2012 with a total number of 287 observations will be concluded.

$$\begin{aligned} \Delta \ln G_{cl_t} = & 0.15 - 0.123 \Delta \ln G_{cl_{t-1}} + 0.048 \Delta \ln USD_{cl_{t-1}} - 0.055 \Delta \ln USD_{cl_{t-2}} \\ & - 0.069 \Delta \ln USD_{cl_{t-5}} + 0.04 \Delta \ln USD_{cl_{t-6}} - 0.163 CRgap_{t-1} + 0.036 \Delta \ln Oil_{cl_{t-1}} \\ & - 0.024 \Delta VolOil_{t-4} + 0.018 \Delta VolOil_{t-5} + -1.9 \Delta Pi_{US_{t-2}} + dummy \end{aligned}$$

7.3 Characteristics of Variables

The table below (estimations were derived and reproduced with the econometrics software EViews) is a good tool for a visual description of the characteristics of the variables.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
intercept	0.147520	0.033592	4.391489	0.0000
$\Delta \ln G_{cl_{t-1}}$	-0.122709	0.053761	-2.282482	0.0232
$\Delta \ln USD_{cl_{t-1}}$	0.048060	0.016218	2.963347	0.0033
$\Delta \ln USD_{cl_{t-2}}$	-0.055247	0.016461	-3.356145	0.0009
$\Delta \ln USD_{cl_{t-5}}$	-0.069270	0.016216	-4.271767	0.0000
$\Delta \ln USD_{cl_{t-6}}$	0.039605	0.016510	2.398896	0.0171
CRgap_{t-1}	-0.162999	0.038467	-4.237392	0.0000
$\Delta \ln Oil_{cl_{t-1}}$	0.036009	0.021168	1.701097	0.0901
VolOil_{t-4}	-0.023770	0.006757	-3.517624	0.0005
VolOil_{t-5}	0.017797	0.006734	2.642995	0.0087
$\Delta Pi_{US_{t-2}}$	-1.925259	0.662047	-2.908038	0.0039
D2008M10	-0.206053	0.038599	-5.338361	0.0000
D1999M09	0.162020	0.037540	4.315985	0.0000

Table 6: Description of variables in the closing gold price model

For the convenience of interpreting the results of the table, once again the description identical to the one described in the above section “Model of the average price of gold” will be recapitulated. The first column of the table above sets out the name of the variable, and the second column lists its coefficient originating from the primary model. However, new information is obtained in the next two columns: the standard error of the estimate of each variable and the probability of the variables incurred insignificance. The probability in the third column is the result of the testing the null hypothesis, that the coefficient of the variable is equal to zero, against an alternative (symbolized as H1) hypothesis testing for the deviation of the coefficient value from zero. The statistical testing is conducted using T-statistics, which is the ratio of the coefficient of the variable to its standard error. Moreover, following relation can be observed from the table: the greater the statistics, the higher the level of significance, based on which the null hypothesis will be denied and an alternative H1 hypothesis confirmed.

The vast majority of the variables are significant with a probability of over 99 per cent. Only two variables, namely $\Delta \ln G_{cl_{t-1}}$ and $\Delta \ln USD_{cl_{t-6}}$ are significant with a probability of 95 per cent, and only one variable of $\Delta \ln Oil_{cl_t}$ with a probability of 90 per cent. In case of the absence of the coefficients of dummy variables, they can be considered as the approximate value of random errors in the actual given period. Furthermore, random errors are slightly larger in their magnitude, but with the same sign as the binary variables.

7.4 Analysis of the Model's Performance and Quality

Similarly to the average price model, the model of the monthly closing price of gold will be tested for the presence of auto-correlation and normal distribution of residuals. Additionally, variables of the model will be checked for the presence of multicollinearity.

7.4.1 Autocorrelation

Autocorrelation will be tested using Q-test (Portmanteau - test) and LM-test (Breusch-Godfrey Serial Correlation Lagrange Multiplier Test). Both of these tests are used to test the null hypothesis on the lack of autocorrelation, and an alternative H1 hypothesis on the presence of the autocorrelation process, the correlation matrix of the random component standby time. The Q-test tests the overall statistical significance of the first k autocorrelations of mathematical expectations of white noise. According to the recommendations of literature, constant K will be determined as $k = \sqrt{n}$, where n is the number of observations, which in this case is around 400. Further, the LM-test investigates whether there is a serial dependence, on the basis of evaluation of residuals with the help of its own lags and exogenous variables.

7.4.2 Q-test

Lag	AC	PAC	Q-Stat	Prob
1	0.030	0.030	0.2677	0.605
2	-0.059	-0.060	1.50	0.526
3	0.063	0.067	2.99	0.484
4	0.011	0.003	2.41	0.647
5	-0.104	-0.097	5.35	0.342
6	-0.063	-0.060	6.20	0.338
7	0.002	-0.007	6.29	0.448
8	-0.009	-0.003	6.75	0.553
9	-0.043	-0.034	7.52	0.596
10	0.085	0.080	9.77	0.480

The first column of the table shows the lag until which the hypothesis is tested on the statistical significance of all previous autocorrelation of the lags, including also the very last lag. The second column shows the correlation coefficient between the actual mathematical expectation of white noise and its lags n .

Table 7: Q-test indicating a lack of autocorrelation

The third column shows the coefficient of the partial autocorrelation function, which is different to the previously presented coefficient, as it does not include the value of correlation, which is based on a linear dependence of the values between the current and the examined lag. Moreover, in the above table both coefficients are approximately equal and this proves lack of autoregressive processes. The last column is composed of the probability of accepting

the null hypotheses on the absence of autocorrelation. According to the results of Q- Test, the hypothesis of the autocorrelation was rejected.

7.4.3 LM-test

F-statistic	1.346353	Prob. F(2,247)	0.2619
Obs*R-squared	2.813350	Prob. Chi-Square(2)	0.2450

Table 8: LM-test indicating a lack of the serial autocorrelation

The most satisfactory conclusion of the LM- test is that the serial autocorrelation of residuals is not part of the testing results.

7.4.4 Statistical Characteristics of Residuals and Jarque - Bera Test

Mean	0
Median	-0,001
Skewness	0,04
Kurtosis	3,18
Jarque - Bera	0,44
Probability	0,80

Table 9: Empirical distribution and J-B test

According to Jarque - Bera test, arithmetic mean and medial values correspond to a normal distribution and are equal to zero. An asymmetry coefficient is slightly positive indicating a rather larger number of positive values, as well as many negative, medium and weakly negative random errors. Of particular importance is strongly positive kurtosis of 3.18.

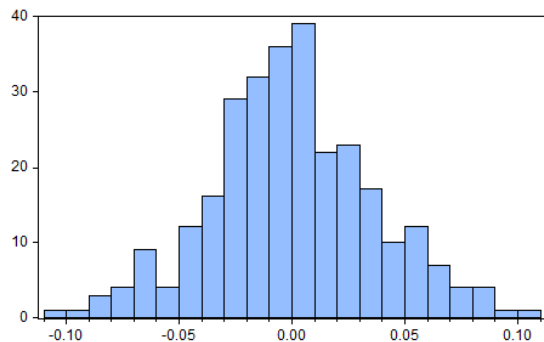


Figure 7: Histogram of residuals of the average gold price model

The histogram illustration is confirming above listed characteristics, and is visually correspondent to the idea of normal distribution. To sum up, in view of this part, the distribution of residuals is defined to be normal.

7.4.5 Multicollinearity

The strength of multicollinearity will be assessed with help of the auxiliary regressions. To refresh on the condition of the satisfactory result of the following testing, based on the assumption that multicollinearity is seen to be problematic in case if the adjusted coefficient of determination in auxiliary model is higher than the one in the original model. And again, the above described condition can be expressed using a formula as follows:

$$\bar{R}^2 < \bar{R}_j^2, \quad j = 1, 2 \dots k,$$

where

$\bar{R}^2$ – adjusted coefficient of determination of the original model,

$\bar{R}_j^2$ – adjusted coefficient of determination of the auxiliary regression

As follows, the auxiliary regression method suggests a model in which one of the exogenous variables is valued by other variables. The auxiliary regression for the lagged values of the log return of the gold price will be constructed as follows:

$$\begin{aligned} \Delta \ln G_{cl_{t-1}} = & \beta_0 + \beta_1 \Delta \ln USD_{cl_{t-1}} - \beta_2 \Delta \ln USD_{cl_{t-2}} - \beta_3 \Delta \ln USD_{cl_{t-5}} + \beta_4 \Delta \ln USD_{cl_{t-6}} \\ & - \beta_5 CRgap_{t-1} + \beta_6 \Delta \ln Oil_{cl_t} - \beta_7 \Delta VolOil_{t-4} + \beta_8 \Delta VolOil_{t-5} - \beta_9 \Delta Pi_US_{t-2} \\ & + dummy \end{aligned}$$

This way, the endogenous variable represented by the lagged value is not fully correct; therefore the model is transformed to the following intuitive form:

$$\begin{aligned} \Delta \ln G_{cl_t} = & \beta_0 + \beta_1 \Delta \ln USD_{cl_t} - \beta_2 \Delta \ln USD_{cl_{t-1}} - \beta_3 \Delta \ln USD_{cl_{t-4}} + \beta_4 \Delta \ln USD_{cl_{t-5}} - \beta_5 CRgap_t \\ & + \beta_6 \Delta \ln Oil_{cl_t} - \beta_7 \Delta VolOil_{t-3} + \beta_8 \Delta VolOil_{t-4} - \beta_9 \Delta Pi_US_{t-1} + dummy \end{aligned}$$

In a similar way, the model is developed and evaluated for each of the regressors. The results of adjusted coefficients of determination are given in the table below.

Variable	$\bar{R}_j^2$
$\Delta \ln G_{cl_{t-1}}$	0.230295
$\Delta \ln USD_{cl_{t-1}}$	0.025339
$\Delta \ln USD_{cl_{t-2}}$	0.024178
$\Delta \ln USD_{cl_{t-5}}$	0.011382
$\Delta \ln USD_{cl_{t-6}}$	0.131578
$CRgap_{t-1}$	0.130733
$\Delta \ln Oil_{cl_{t-1}}$	0.089251
$VolOil_{t-4}$	0.674978
$VolOil_{t-5}$	0.005728
ΔPi_US_{t-2}	0.033119

Table 10: R-squared of auxiliary regressions

From the table above, the critical value of the adjusted coefficient of determination of the original model has been exceeded only in one auxiliary regression of the first lagged value of the average price of gold ($\bar{R}^2 (0,45) < \bar{R}_j^2 (0,67)$). In the examined model, a strong evidence on multicollinearity can be concluded.

The model was tested on residual autocorrelation and test of normal distribution. The assumption of multicollinearity has been confirmed in the last topic. The resulting model will be sensitive

to the new observations of exogenous variables. As a consequence, its effectiveness will be reduced over time, and the estimation of the coefficients will be required. In particular, predictions of the model will not only depend on the constancy of the linear relationships of exogenous variables and the predicted ones, but also on the constancy of the links between these exogenous variables.

8. Conclusion of the Empirics

In view of the empirical part, two models have been depicted and evaluated by the method of least squares to predict the price of gold: a model of the average price of gold, and a model of the monthly closing price of gold. In both cases, an analysis of residual values for compliance with the white noise was conducted, from which it can be concluded that there is no reason to doubt the quality of the model from an econometric point of view.

By means of assessing the quality of the model by the value R-squared, the forecasts of the first model of the average price of gold can be considered to be more accurate $R^2 = 0.47$, than the forecasts of the closing price in the second model with $R^2 = 0.32$. As a matter of observation, both models show a good linear relation between the predictions and the data. The correlation for the first model and the second model is 0.66 and 0.56 respectively. Despite relatively high statistics results, it is clear from the empirical observations that an investment or trading decision, based on the results of these models only, cannot be justified. This can be explained by the presence of exogenous shocks such as political instability or environmental disasters, which may cause even bigger influence on the gold price than historically constant determinates. One should also pay attention to the fact that in order to make an investment decision based on constructed models, requires that the relation of the variables in the model stays the same. On the other hand, the predictions of the model can make a qualitative contribution to a deeper fundamental analysis. I would like to make a reference to artificial neural networks, where this model has the potential to become a significant neuron in the system to predict the price of gold.

We cannot ignore the weakness of the models resulting from the origin of multicollinearity, which is a source of additional conditions for applying the models in the future. As such, the most important condition is the constant statistical behavior of the relation between the actual determinants. Perhaps I should also point out that with new data available, it is recommended to re-estimate the model prior to the application. Since, one of the most useful results of this work is not the determinant's coefficients, but the structure of the model, application of the paper may stay relevant for a longer period of time.

As a suggestion for possible improvements of the quality of the constructed models, I would like to draw attention to the volatility of prices of gold and recommend including it in the mathematical expectation in the given models. If the goal of further research is set to obtain the most accurate prediction of the price of gold, instead of just delivering improvements in

the models, we can substitute the evaluation method of least squares with the maximum likelihood method.

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APPENDIX

A. Verpflichtende deutsche Zusammenfassung der Arbeit

Diese Master-Thesis mit dem Titel "Gold: Investments, Gold Preis Analyse und dessen kurzfristige Prognosen" ist sowohl eine theoretische, als auch praktische Analyse der speziellen Eigenschaften von Gold als Investition. Das Ziel dieser Arbeit ist es, einen wertvollen Einblick in die Investitionsmöglichkeiten auf dem Goldmarkt für private Investoren zu geben. Sie beschreibt die bestehende Literatur über die Rolle des Goldes in den Finanzmärkten aus historischer und aktueller Perspektive. Es werden verschiedene Möglichkeiten aufgezählt, wie Investoren Gold langfristig auf den Finanzmärkten anlegen können, insbesondere mit der Unterscheidung zwischen direkter und indirekter Form von Investitionen. Die Thesis untersucht auch die verschiedenen Funktionen, Struktur und gemeinsamen Trends des Goldmarkts, auf dem Angebot und Nachfrage von Gold als wesentliche Triebkräfte für die Bestimmung des Preises identifiziert werden. Dies trägt zu einer weiteren Diskussion über die Trends des Goldpreises, seine zugrunde liegenden Faktoren, die den Goldwert bestimmen durch empirische Analyse. Des Weiteren wird die mögliche Bewertung und Vorhersage Goldpreise untersucht wird.

Der praktische Teil umfasst ökonometrischen Analysen und Prognosen auf monatlichen Beobachtungen. Zwei Modelle "Modell des durchschnittlichen Preises von Gold" und "Modell des monatlichen Schlusskurses des Goldes" wurden mit geeigneten statistischen Instrumenten wie dem Granger-Kausalität Test und Verfahren der kleinsten Quadrate entwickelt. Die Qualität der Modelle wurde durch Vergleich der Eigenschaften des Residuums mit den Eigenschaften des weißen Rauschens geprüft. Um Modelle zu beschreiben, empfiehlt es sich darauf hinzuweisen, dass die Korrelation zwischen den tatsächlichen und angepassten Werten zwischen 55 - 65% liegt, womit gezeigt wird dass die Modelle effektive Instrumente zur Vorhersage des Goldpreises dienen. Da die Ergebnisse zufriedenstellend sind, wird empfohlen, die konstruierten Modelle als Ergänzung zu einer tieferen fundamentalen Analyse anzuwenden.

B. Curriculum Vitae

EDUCATION

MSc. IN BUSINESS ADMINISTRATION

09/01/20011 – now

Specialization: Corporate Finance and Financial Services

UNIVERSITY OF VIENNA, VIENNA, AUSTRIA

BSc. IN INTERNATIONAL BUSINESS ADMINISTRATION

10/01/2007 – 06/01/2010

Specialization: CFM – Cross Functional Management

WU - VIENNA SCHOOL OF ECONOMICS AND BUSINESS ADMINISTRATION, VIENNA, AUSTRIA

EXPERIENCE

STOEHR INTERACTIVE GMBH, VIENNA, AUSTRIA

01/01/2012 – 07/31/2012

KEY ACCOUNT MANAGER

Stoehr Interactive GmbH - on line marketing and promotion agency as well as IT and web infrastructure development.

- Responsible for managing and developing key accounts as well as attaining new clients.
- Created and presented bilingual presentations to potential clients on services and innovative solutions of the firm as well as updates and newsletters to the existing clientele.
- Analyzed online marketing feedback, technical analysis of marketing campaigns, created scoring systems for valuating online promotions.
- Compiled and analyzed client surveys on industry sectors including auto, logistics, real estate, retail, banks and insurance firms.

STOEHR INTERACTIVE GMBH, VIENNA,

11/01/2009 – 12/31/2011

ACCOUNT MANAGER

- Developed and executed diverse ad placements and algorithm formats to enhance and promote search engine results for advertising campaigns and to gain more internet traffic for customers.
- Citation network – search term distribution over all major search engines and directories to optimize and increase web presence and brand awareness for web campaigns and web presence.
- Provided customer service support, client specific performance monitoring and gap analysis for improvement recommendation on various ecommerce tasks and projects.
- Participated in company's business planning, financial forecasting, budgeting and expense monitoring processes.

CAPITAL INTELLIGENCE GROUP GMBH, VIENNA,

03/01/2009 – 10/31/2009

INTERNSHIP, CENTRAL AND EASTERN EUROPE REGION

CIG – Capital Intelligence Group GmbH – Investment Banking and Corporate advisory.

- Participated in financial and managerial projects including profit and forecasting, competitive analysis, product/strategy feasibility analysis, business planning and strategic market reviews presented to senior management.

- Conducted financial data analysis including bilingual assessment of Financial Statements of prospective clients such as banks in the CIS region.
- Participated in client meetings, team member of working group organizing product training and product description for Central and Eastern European clients.
- Received training in Compliance and best practices in internationally accepted Anti Money Laundering standards and procedures for financial institutions.

LANGUAGES

FLUENT IN ENGLISH, GERMAN, RUSSIAN, CZECH, SLOVAKIAN