AMERICAN UNIVERSITY OF BEIRUT

GOLD AND OIL PRICES INTERRELATION AND REACTION TO CRISIS

by
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AMERICAN UNIVERSITY OF BEIRUT

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AN ABSTRACT OF THE PROJECT OF

Tamara Halim Abou Fakhreddin for Master of Arts in Financial Economics
Major: Financial Economics

Title: Gold and Oil Prices Interrelation and Reaction to Crisis.

This project examines the interrelationships between highly internationally traded commodities and their reaction to crisis. Given that the gold market and the oil market are the main representatives of the large commodity markets, it is of practical significance to analyze their co integration relationship and causality. It is also interesting to examine how these commodities are affected by crisis. The relationship of these commodities with crisis can be studied by comparing their prices to relevant equity index and exchange rate. These relationships are explored using weekly time series from April 1983 to March 2012.

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To My

Beloved Family

CHAPTER 1

INTRODUCTION

In the financial markets worldwide, economists observe more and more interdependence among several asset classes. For instance due to the globalization of traded goods and services, equity markets in different countries tend to move correspondingly. Similar behavior is noted between asset returns volatilities in different markets. When it comes to commodities, analysts have long recognized that their prices tend to move in harmony. This is because they are affected by common macroeconomic factors including inflation, interest rates and the exchange rate. Gold and oil particularly have been given special interest, mainly because of the consistent increase in their economic uses, the situational and quick swell of their prices and the intriguing synchronization of their behaviors.

Crude oil is the most frequently traded commodity in the world and its price is the most volatile in the commodity market. The impulsive and unexpected increase in oil prices and their very high volatility often have serious impact on other macroeconomic variables. Hence policy makers, oil producing countries and oil-related businesses confer serious concerns about it. In addition to that, the price of oil, similarly to that of gold, is denominated in U.S. dollars linking its price directly to the value of the currency. Furthermore its characteristics of a major input in virtually every industry, and as a raw material crucial to human survival all around the globe, make of oil a strategic investment.

Since the Gold holds an intrinsic value and is priced in US dollars, investors have conventionally used gold as a hedge against a depreciating dollar or against inflation. Not only is it a key element of diversification for a commodity portfolio, but gold is also considered as a safe haven towards which investors flee in a stressful environment and during periods of uncertainty and increasing risk. An environment of high inflation or inflationary expectations causes a move towards precious metals, and particularly gold, as a safe haven to avoid risk. Because of its direct link to the green currency, the nominal price of gold will tend to rise whenever the dollar loses value, hence safeguarding the real value of gold. From this perspective, investors with dollar holdings gladly hold gold as a hedge against exchange-rate risk. Up till now, in order to support the value of their currencies central banks in most of the countries around the world continue to embrace gold as one of their forms of reserves.

The above features of oil and gold justify the economic importance of examining the interrelation between these two commodities, and that of seeing whether the markets (equity markets) or the U.S. dollar value (exchange rate) explain movements in prices of both commodities. More importantly, I wanted to explore how these commodities react in periods of crisis, i.e. to a fall in the equity markets or to a fall in the US dollar value. This topic is of great relevance to investors, traders, policy makers and producers who seek to maximize their utility when taking decisions in an uncertain environment.

Chapter two of this project introduces the topic by presenting an overview of gold and oil. It contains a description of the uses of these commodities in terms of investments and investment vehicles, as well as an account of the different factors that may affect their performance. Chapter three summarizes the existing literature review related to the topics analyzed in the project, and chapter four reveals the empirical study, in which the methodological framework and data are described, and in which the empirical results are reported. Finally, some concluding statements are set forth in the last chapter.

CHAPTER 2

GOLD AND OIL OVERVIEW

2.1. Gold

2.1.1. Facts about Production

It is believed that the current stock of gold stands at 171,300 tons. About half of it, i.e. 50% of all gold ever produced comes from South Africa. In fact since 1905 South Africa has been the world's largest producer of gold, dethroned by China only in 2007. Other most important producers include Russia, the United States, Australia and Peru.

Figure 1 shows the evolution of gold spot price and the light, sweet crude oil (West Texas Intermediate) over a 30 year sample period from March 1983 until March 2012 (weekly data)

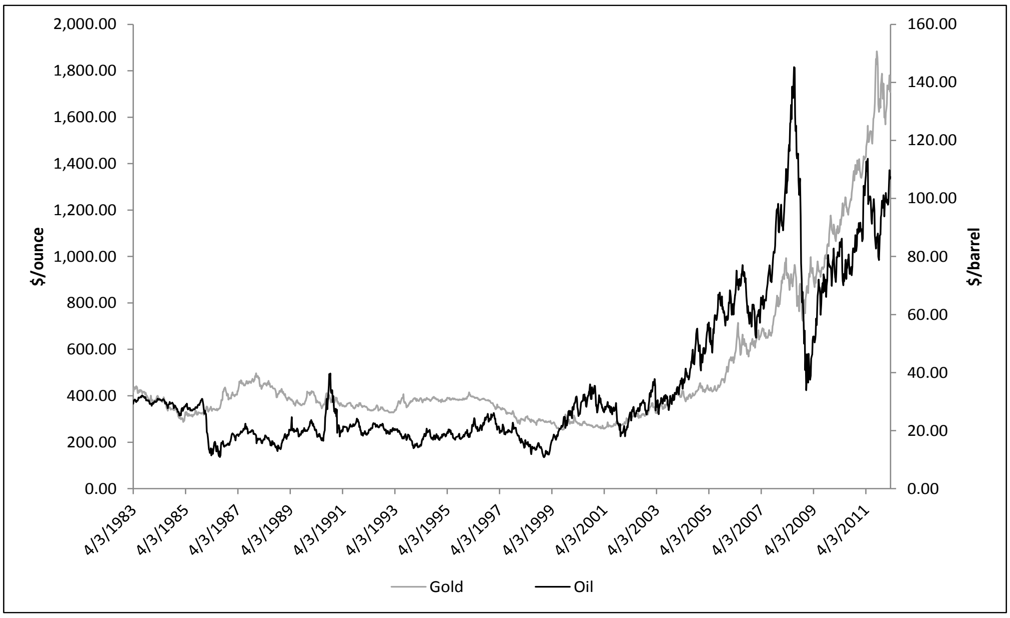

Fig. 1. The evolution of gold spot price and the light, sweet crude oil over a 30 year

In recent years the African country witnessed a decline in production of more than two-thirds; from 1,000 metric tons to 272 metric tons of gold per year. This drastic drop in South African gold production is due to several factors unrelated to the quantity still available for extraction, such as evolving local economic problems, new more stringent controls on the industry and the mining of the country's gold ores that has become more difficult. Moreover the Gold mining industry, like any other mining business, faces increasing rigid costs related to the extraction of gold from the earth.

2.1.2. Facts about Consumption

When it comes to gold consumption India stands at the top of the list buying approximately 25% of the gold in the world, purchasing about 800 tons of gold every year, mainly for jewelry. India is then followed in the ranking by China, the United States, Turkey, Saudi Arabia and Russia. The use of the gold consumed worldwide can be depicted the following way:

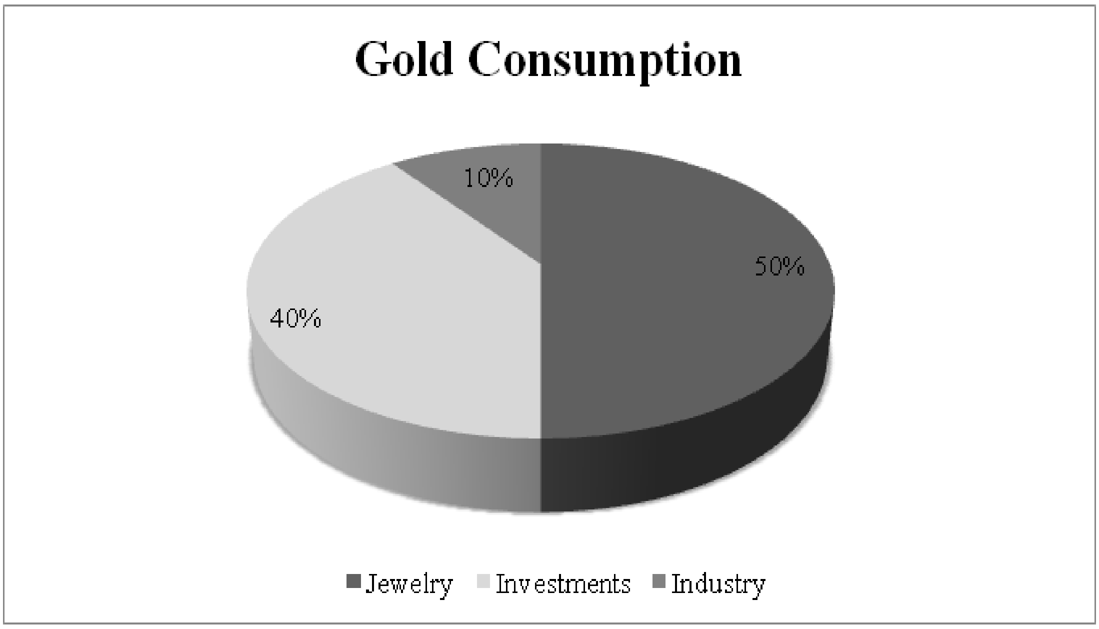

Fig. 2. Gold consumption

Since its discovery (thousands of years ago) gold has been used as a medium of exchange. Also, historically linked to money, Gold's picture has become culturally embedded as an undeniable store of value. For example in India, the world's largest consumer of gold, the yellow metal holds a distinctive socio-cultural connotation as a symbol of a family's wealth and status. On western lands, the British Mercantilist economist Sir William Petty described gold back in the 17th century as "wealth at all times and all places".

Until now, in order to support the value of their currencies, central banks in most of the countries around the world continue to embrace gold as one of the forms of reserves, although the level has generally been declining. For instance, the United States Federal Reserve Bank in New York holds about 3.5% of the world gold ever mined, making it the largest gold depository in the world.

Let us not forget that not a long time ago, in the 20th century, the gold standard scheme implied linking the value of currencies straightforwardly to gold.

2.1.3. Investment Vehicles

Since the Gold is priced in dollars, investors have conventionally used gold as a hedge against a depreciating dollar or against inflation. Because of its direct link to the green currency, the nominal price of gold will tend to rise whenever the dollar loses value, hence safeguarding the real value of gold. From this perspective, investors with dollar holdings gladly hold gold as a Hedge against exchange-rate risk.

As a material asset, gold has an intrinsic value in itself. Its most important use, as discussed above, is in the jewelry business. But it has industrial and dental employments as well. However we are particularly interested in the second main use of gold, which is investment.

Gold served to a multitude of purposes and in different ways throughout human history, and a lot of these remained until nowadays. This is the main reason why one is faced to several options when considering an investment in gold.

2.1.3.1. Bars

One of the oldest ways of investing in gold is by buying gold ingots, or gold bars. These can be found and bought or sold without any troubles at major banks. Especially in countries such as Switzerland, Austria, Canada, Liechtenstein or Argentina, where gold bars are provided with trusted certificates reducing any risk of forgery. In fact large bars have a great volume in which it is possible to embed a partial forgery using a tungsten-filled cavity and which might go through an assay undetectable.

2.1.3.2. Coins

Another common way of owning gold is by purchasing gold coins. There are two types of coins each priced differently. Bullion coins are gold coins that have been minted after 1800 and are valued according to their pure gold content. Their price includes a small premium over the market price of gold which is due to the costs related to manufacturing, storage and distribution, and to their relatively small size. The premium is also affected by supply and demand. Numismatic gold coins are very old coins that have historical and anthropological value. Therefore in addition to their naked gold value a very large "collector" premium is added to represent their price. This premium is determined by the supply and demand based on the condition and the rarity of the coin.

Clearly bullion coins represent the largest share of gold coin investments; they can be obtained from a variety of large and small dealers. The most commonly-used gold bullion coin is the South-African "Krugerrand" with 1400 tons in circulation. But fake gold coins are not rare, and are typically made of gold-plated lead.

2.1.3.3. ETFs

Probably one of the most popular ways of investing in gold on the regulated markets is through gold exchange-traded products, particularly through ETFs. An exchange-traded fund is a security that trades like a stock on an exchange, but that tracks a commodity, an index or a basket of assets. Therefore the content of an ETF is usually diversified, the same way index funds are for example. The advantages of owning an ETF include the ability to buy on margin, to sell short and to purchase small quantities, as little as one share.

Gold ETFs are exchange traded funds concerned only in gold-related investments and where gold is the only traded commodity. The price of ETF shares is supposed to correlate narrowly with the spot price of gold.

2.1.3.4. Derivatives

Finally, other than through traditional gold certificates or gold accounts, it is nowadays possible to invest in gold through numerous derivatives such as gold forwards, futures or gold options. They are traded on a multitude of exchanges around the world (ex: COMEX- New York commodity exchange) and straight into the private market through over-the-counters.

Because of its intrinsic value and because of the unique properties and the scarcity of this yellow metal, Gold as an investment carries some obvious and attractive characteristics; it holds no risk of default and its assessment is not dependent on future earnings or debt. One might think that there are other commodities that may share these eye-catching properties. However what differentiates gold from all of them is its behavior during difficult times and in periods of falling asset values. Recent observations on historical experience hint that, unlike other financial assets, the price of gold has a tendency to rise in retort to negative market shocks and happenings. Hence, a recovery is bad news for the gold price. However, the decline of the price of gold will be gradual because recoveries are never rapid, which gives the investors an ample time to exit. This behavior is contrary to that of stocks and the majority of other markets that act in the opposite way. In fact they rise slowly and collapse quickly. Gold prices rise quickly and decline slowly.

There is no doubt about the fact that the utility of gold, aside from its practical uses, derives from this very atypical property. Nevertheless the real question remains: what explains the price behavior of this precious metal.

2.1.4. Factors Influencing the Price of Gold

Similarly to other commodities, the price of gold is determined by supply and demand as well as by speculative activities. However as opposed to the rest, gold's price is affected by savings and by disposal much more than by its consumption. This is because the largest part of the gold ever mined is prospectively able to return onto the gold markets for the right price, since it is still present in reachable form such as bullion and mass-produced jewelry.

In the past few years the annual mine production of gold has been around 2400 tons (according to the World Gold Council), from which around 1900 tons is consumed in jewelry or used in industrial and dental production, and about 500 tons goes to exchange traded funds and retail investors. Compared to the huge quantity of gold stored above-ground (around 170,000 tons) the annual gold production is clearly very small; which explains why gold's price is mostly influenced by changes in demand (sentiment) rather than by alterations in supply.

2.1.4.1. The Jewelry and Industrial Demand

The most important factor that affects the price of gold is the demand for jewelry and the industrial demand for the metal (including dental and medical uses) which account for approximately two-thirds of the annual gold production. Because of its high resistance to corrosion, to bacterial colonization and to its strong thermal conductivity, Gold is an admired input in the industry. Industrial and jewelry demand has been oscillating due to the economic slowdown following the crises, and to the solid expansion in the emerging markets of the middle class desiring western technology and western lifestyle. Countries like India (purchases 25% of gold in the world), China and many others in the Middle East.

2.1.4.2. Central Banks and IMF

Among the factors that influence the price of gold on the markets, Central Banks and the International Monetary Fund have a significant effect. Around 20% of the gold above the surface of the earth is held as official reserves by central banks and certified organization. In fact when there are double-digit changes in the price of gold, it frequently means that big buyers and sellers have been intervening in the market; mainly Central banks. Although they generally do not declare gold purchases beforehand.

Besides affecting the gold price by means of buying and selling, Central Banks have a power over the gold price by influencing the interest rates. Since gold does not earn any "interest", when interest rates in the economy rise, investors have less incentive to hold the metal and usually opt to redirect their portfolio towards interest-earning assets causing the price of gold to fall. Similarly as rates drop, gold price climbs. This reasoning clearly unveils the way gold prices are influenced by central banks' actions; namely by the use of monetary policy in order to manipulate interest rates. For example if the economy is showing signs of possible extended inflation, the Central bank would want to intervene through appropriate policies to raise interest rates in order to control inflation; that would have a depressing effect on the price of gold.

2.1.4.3. Hedge against Financial Stress and Speculation

Economic unrest often leads to high inflation and investors have been aware, for a long time now, of the advantages of using gold as a hedging instrument. In fact like many precious metals, gold can be used as a hedge against inflation, deflation and currency depreciation/devaluation. This is because gold preserves its wealth as currencies depreciate. Gold is priced in dollar which, as explained earlier, justifies the yellow metal's historical inverse relationship to the dollar. This unique converse property of gold makes it an unavoidable cushion for any investment portfolio.

Because of gigantic government deficits, the currencies of all major nations, including the USA, are undergoing ruthless pressures. When huge amounts of money are pumped into these economies in order to keep them on track, it is only natural that these currencies become less valuable. Hence, if the returns on common investments such as equities, real estate or bonds are not a satisfying compensation for inflation and for their risk, then the appetite for alternative investments such as commodities and particularly gold augments.

Other speculating activities such as short selling or using derivatives such as futures and options often benefit investors who take advantage of falling gold price and affect its price even further.

2.1.4.4. War, Invasion and National Emergency

Finally, one more factor is capable of influencing the price of gold, and it is related to wars, invasions and national emergencies. A war can seriously deteriorate the purchasing power by causing individuals to have less disposable income, and hence less incentive to invest in gold. Although in such difficult circumstances, gold can carry a stable value into the portfolio. However in periods of violence and troubles, people are usually preoccupied by other priorities such as struggles of survival. Other issues also include countries with corrupt dictators. These tend to nationalize the mining companies and the mines; they also limit the exports of gold, or simply steal straightforwardly from the reserves of the central bank, thus affecting the price of gold.

2.2. Crude Oil

2.2.1. Classification and Benchmarks of Crude Oil

Crude oil is an unrefined petroleum product. It can be refined to produce usable products such as gasoline, diesel and other various forms of petrochemicals.

Crude oil is classified by the geographic location it is produced (for example West Texas Intermediate, Brent or Oman), its density (measured by the API gravity), and its sulfur content. Crude oil is said to be “light” when its density is low and “heavy” when its density is high. It is considered sweet if it contains little sulfur or sour if it contains a large amount of sulfur.

The geographic location of the extraction of this crude oil is important because it affects the transportation cost to the refinery. Light crude oil is superior to the heavy oil because it produces a higher yield of petrol. Sweet crude oil is more expensive than the sour crude oil because it necessitates less refining to meet sulfur standards imposed on fuels in consuming countries, and thus produces less problems for the environment.

In the petroleum industry, each crude oil has its own unique chemical characteristic. Barrels of crude oil with determined chemical characteristics and specific geographical area are classified and are used as pricing references around the world. Some of the crude oil references are the West Texas Intermediate (North American oil), Brent (oil from the North Sea), Dubai-Oman crude, Tapis (oil from Malaysia), Minas (oil from Indonesia) and the OPEC Reference Basket (weighted average of oil blends from different OPEC countries). It is worth noting that the Energy Intelligence Group identifies 161 different blends of crude oil.

As for the crude oil benchmarks used throughout the world, also known as oil markers, they were first introduced in the mid-1980s. There are three major benchmarks, WTI, Brent and Dubai-Oman, and the fourth one is the OPEC Reference Basket, which is a weighted average of different crudes.. Benchmarks are used because there are many different types and grades of crude oil. These benchmarks are used to make easier the referencing of crude oil types for sellers and buyers. It is worth noting that there is always a spread among prices of WTI, Brent and other existing blends due to the transportation cost.

The three primary benchmarks of crude oil are defined in more details below. And, given that the WTI is the proxy for oil that is considered in the empirical study of this project, more importance will be given to this specific benchmark.

2.2.1.1. West Texas Intermediate

West Texas Intermediate (WTI) is a benchmark in oil pricing and is mainly used in the United States of America. It is also known as Texas light sweet. West Texas Intermediate is a very high-quality, sweet, light oil delivered at Cushing, Oklahoma for North American oil. This grade of crude oil is light (because of its low density) and sweet (because of its low sulfur content) making it the best choice for the production of low-sulfur gasoline and low-sulfur diesel. WTI is refined mostly in the Midwest and Gulf Coast regions in the U.S., since it is high quality fuel and is produced within the country.

2.2.1.2. Brent Blend

Brent Crude is another major trading classification of sweet light crude oil. Brent is not as light or as sweet as West Texas Intermediate but it is still a high-grade crude. The Brent Crude oil marker is also known as Brent Blend, London Brent and Brent petroleum. Brent Crude is used mainly in Europe and the OPEC market basket, which is used around the world. This benchmark is a mix of crude oil from 15 different oil fields in the North Sea.

2.2.1.3. Dubai and Oman

Dubai-Oman is used as benchmark for Middle East sour crude oil exported to the Asia-Pacific region. Dubai Crude, also known as Fateh, is produced in the United Arab Emirates, in the Emirate of Dubai, refined at Dubai's only refinery at Jebel Ali, and all exported. For many years it was the only freely traded oil in the Middle East, but gradually a spot market has developed in Omani crude as well.

Indeed, for a long time, monthly spot price average of Dubai and Oman crude was used by the majority of oil producers in the Middle East as a benchmark for sales to the Far East (the same as WTI and Brent futures price are used for exports to the

Atlantic Basin). However, in 2007, a potential new mechanism arose in the form of the Dubai Mercantile Exchange, which offers Omani crude futures contracts. Whether the DME will be successful, and whether Omani futures prices will be adopted by producers and buyers as a benchmark, remain to be seen.

2.2.1.4. <u>OPEC Reference Basket</u>

Another important benchmark for crude oil prices is the OPEC Reference Basket (ORB), also referred to as the OPEC Basket. It is a weighted average of prices for petroleum blends produced by OPEC countries.

In June 2005, the OPEC basket was changed to reflect the characteristics of the oil produced by OPEC members. The Reference Basket currently consists of a weighted average of the following blends of oil: Saharan Blend (Algeria), Ecuador oil, Iran Heavy (Islamic Republic of Iran), Basra Light (Iraq), Kuwait Export (Kuwait), Es Sider (Libya), Bonny Light (Nigeria), Qatar Marine (Qatar), Arab Light (Saudi Arabia), Murban (United Arab Emirates), and BCF 17 (Venezuela).

It is worth noting that OPEC tries to keep the price of the OPEC Basket within a certain range, with upper and lower limits, by increasing and decreasing production. This is the reason why the OPEC Basket measure is important for market analysts, traders and investors. The OPEC Basket, comprising a mix of light and heavy crude oils, is heavier than both Brent crude oil, and West Texas Intermediate crude oil.

2.2.1.5. <u>Price Differential among Crude Oil Blends</u>

Various types of crude oil blends are produced around the world. The differences in quality and location of extraction result in price disparities. The OPEC basket is a little heavier and more-sour than Brent. As a result of these density and sulfur differences, WTI normally trades at a premium of a dollar or two to Brent and another premium of a dollar or two to the OPEC basket.

Even though, there exist a price variance between different types of crude oils (due to density, sulfur content...), prices tend to move together because oil markets are globally integrated (see Fig. **3**.).

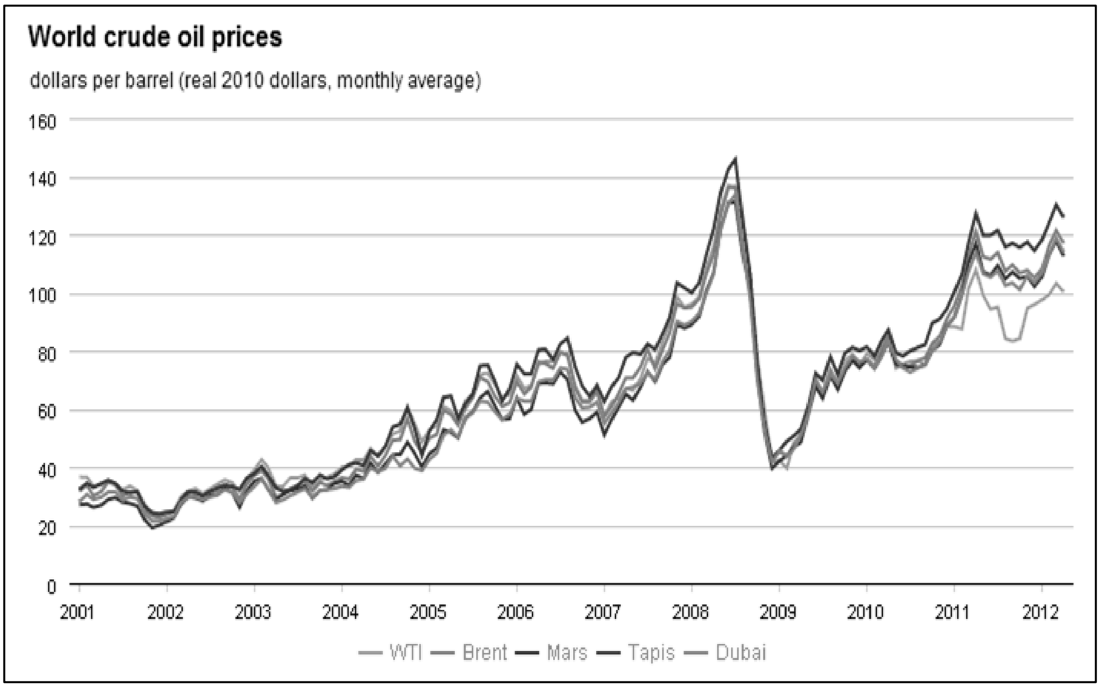

Fig. 3. World crude oil prices – World oil prices move together due to arbitrage
Source: Bloomberg. Thomson Reuters. U.S. Energy Information Administration.

The observation of historical crude oil prices made above is true in general, however some anomalies exist. Indeed, due to certain events, prices break the general rules set above. Two examples of these anomalies can be given.

The first example is the May 2007 anomaly when Brent price exceeded the price of WTI. On May, 24, 2007, Brent was priced at 71.39 U.S. dollars per barrel against 63.58 U.S. dollars for WTI (i.e. nearly 8 U.S. dollars premium), whereas normally, WTI should exceed the price of Brent. The reason behind this is believed to be the temporary shortage of refining capacity of WTI. Mainly due to a refinery shut down, a large build up stock of oil at the Cushing, Oklahoma storage and pricing triggered an artificial depression in prices at the Cushing pricing point. When stockpiles decreased, WTI recovered its price and had exceeded the price of Brent once again.

The second example is the February 2011 anomaly. This example once again shows a situation where the WTI was trading at a lower price than Brent. Indeed, it was trading at approximately 85 U.S. dollars per barrel whereas Brent was at 103 U.S. dollars per barrel. This anomaly is assumed to be due to the fact that Cushing had reached capacity. This information was translated in a fall in North American oil market, which is focused on the WTI price. And, the additional fact that contributed to the important spread between both blends is that Brent price was increasing due to the turmoil in Egypt and in the Middle East in general.

These anomalies also show that arbitrage does not always succeed in making oil prices move together all the time. Indeed, in some situations, mainly due to exogenous factors, arbitrage fails to bring together both prices because it is not easy to transport Cushing stockpiles to the Gulf Coast for export.

2.2.2. Contracts

The futures contract of crude oil is used as a primary international pricing benchmark because of its extremely high liquidity and price transparency. One futures contract represents 1000 barrels of oil. The first futures contracts on crude oil were traded in 1983 with the New York Mercantile Exchange (NYMEX) and the Chicago Board of Trade (CBOT). CBOT's initial contracts had delivery complications, so customers abandoned it for NYMEX.

Crude oil became the most actively traded commodity worldwide, and the NYMEX Division light sweet crude oil futures contract are the world's most liquid form for crude oil trading, as well as the world's largest-volume futures contract trading on a physical commodity. Supplementary risk management (hedging instruments) and trading opportunities are offered through options on the futures contract.

Investors can access the oil market through different options. They can invest in energy-related stocks (Shell, Total…) or get more direct exposure to the price of oil by purchasing shares in Exchange Traded Funds (ETFs) that track oil or Exchange Traded Notes (ETNs). These ETFs generally invest in oil futures contracts instead of energy stocks, because ETFs follow the price of oil much more closely than stocks of petroleum companies do. It is worth noting that ETFs can be: single-commodity ETFs (they track a unique and specific commodity, crude oil for example) or multi-commodity ETFs that will invest in diverse energy commodities (oil, gasoline, natural gas and heating oil).

2.2.3. Factors Influencing the Price of Crude Oil/Forces Driving the Market

Various factors influence the global crude oil prices including production, consumption, storage of crude oil (one major indicator is the US crude oil inventory data), political issues etc. Below are some of the important factors that influence crude oil prices globally.

2.2.3.1. Supply

Countries supplying oil are divided into OPEC and non-OPEC producers. OPEC (Organization of Petroleum Exporting Countries) produces a large share of world’s crude oil. The OPEC group is responsible for forty percent of world’s oil production. And, oil exported by OPEC represents sixty percent of all the oil traded on international markets. Because of the substantial size of OPEC's crude oil supply market share any decision, action or even statement immediately impacts the price of oil in the global commodity market. For example, OPEC production cuts will lead to crude price increase. This is the method OPEC producers follow in order to attempt to manipulate prices.

The non-OPEC suppliers account for sixty percent of world's oil supply. Even though, as a group, non-OPEC suppliers are fifty percent larger than OPEC, non-OPEC nations have almost no spare capacity: they produce at or near full capacity. Hence, they are referred to a "Price Takers". Explicitly, they respond to market prices rather than attempting to manipulate them, as OPEC does.

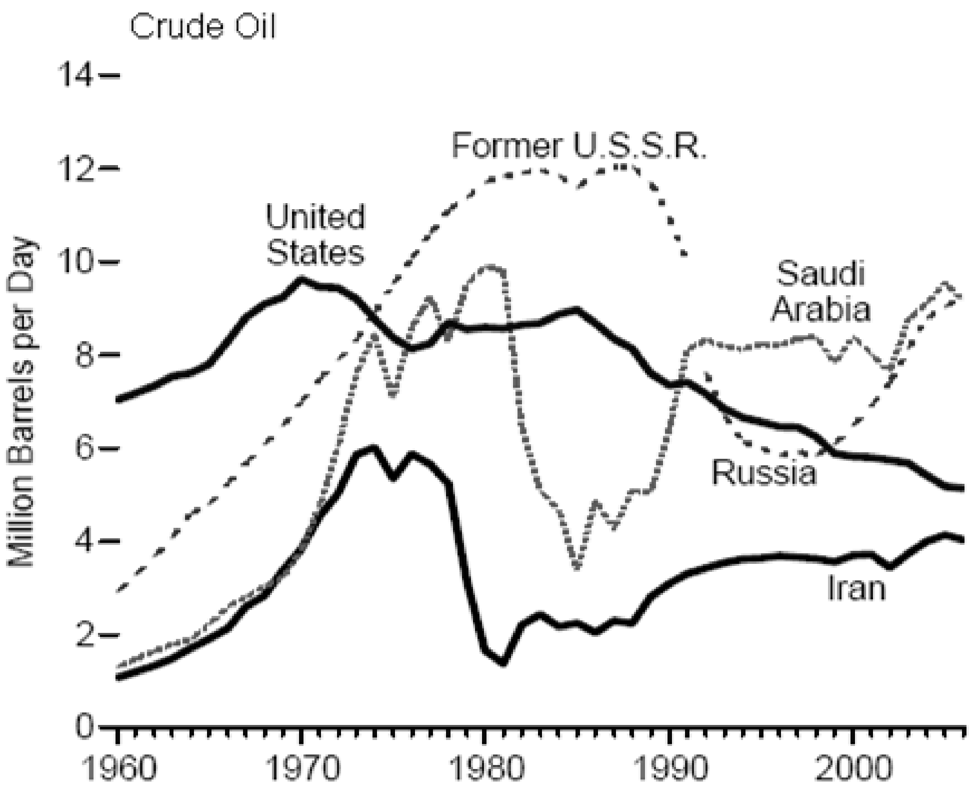

Fig. 4. Top producing Countries, 1960-2006
Source: U.S. Department of Energy, Energy Information Administration

Table 1. Net exports by country – Source: US Energy Information Administration

Exporting Nation	1000bbl/d (2009)	1000m3/d (2009)	1000bbl/d (2006)	1000m3/d (2006)
Saudi Arabia (OPEC)	7,322.00	1,164.00	8651	1376
Russia	7,194.00	1,144.00	6565	1044
Iran (OPEC)	2,486.00	395	2519	401
United Arab Emirates(OPEC)	2,303.00	366	2515	400
Norway	2,132.00	339	2542	404
Kuwait (OPEC)	2,124.00	338	2150	342
Nigeria (OPEC)	1,939.00	308	2146	341
Angola (OPEC)	1,878.00	299	1363	217
Algeria (OPEC)	1,767.00	281	1847	297
Iraq (OPEC)	1,764.00	280	1438	229
Venezuela (OPEC)	1,748.00	278	2203	350
Libya (OPEC)	1,525.00	242	1525	242
Kazakhstan	1,299.00	207	1114	177
Canada	1,168.00	187	1071	170
Qatar (OPEC)	1,066.00	169	–	–
Mexico	1,039.00	165	1676	266

2.2.3.2. Demand

In order to analyze the demand of oil as a factor influencing the price of oil, a distinction will be made between OECD demand and non-OECD demand, because the economic structure of these economies and their economic growth may affect differently the price of oil.

- *OECD Demand*

The Organization of Economic Cooperation and Development (OECD) comprises the United States, most of Europe, Japan and other advanced countries. The OECD countries account for fifty three percent of world’s demand for oil. Although these large economies consume more oil than non-OECD countries, the growth rate of oil consumption is lower. Indeed, during the 2000-2010 decade, OECD oil consumption declined, while non-OECD consumption increased by forty percent for the same period.

It is worth noting that structural economic conditions of each country influence the relationships among oil prices, economic growth and oil consumption. As a matter of fact, the transportation sector in the OECD countries uses a larger portion of total oil consumption than in non-OECD countries because developed countries have higher vehicle ownership per capita. Moreover, measures undertaken by OECD countries to improve the fuel economy (fuel taxes…) tend to slow the growth in oil consumption even in periods of strong economic growth. Oil consumption in OECD countries is more mature and growing slower. Also, OECD countries have a larger service sector (low oil consuming sector) compared to manufacturing (high oil consuming sector). As a result, strong economic growth in developed countries may not have the same impact on oil consumption as it would in non-OECD countries.

- *Non-OECD Demand*

In recent years, oil consumption in countries that are not member of the Organization of Economic Cooperation and Development (OECD), i.e. developing countries, has exploded. Whereas oil consumption in the OECD countries dropped between 2000 and 2010, non-OECD oil consumption augmented by more than forty percent. During this period, Saudi Arabia, India and China recorded the highest growth among the non-OECD countries.

Growing oil consumption reveals rapid economic growth in these nations. Current and expected levels of economic growth seriously affect global oil demand and oil prices. Personal and commercial transportation activities, manufacturing processes require large quantity of oil. Due to these uses, oil prices are likely to increase when economic activity and the related oil demand grow strongly. Another factor supporting strong oil consumption growth in the non-OECD countries is the fast population growth that is present in these countries.

As stated before, the economic structure of a country affects the relationship between oil prices and economic growth. Developing countries' economies rely to a greater extent on manufacturing industries, which are more oil consuming and energy intensive than service industries. Even though oil consumption for transportation generally represents a less important part of total oil consumption in non-OECD countries, this use is rising quickly in these expanding economies (because of the increasing need to transport people and goods and because of higher individual incomes which translates into rising vehicle ownership per capita). These are the reasons why non-OECD current and expected growth rates are important factors influencing oil prices. As an example, recently, China became the largest energy consumer and the second largest oil consumer in the world because of its strong economic growth. This resulted in additional growth in world's oil consumption, which pushed the price of oil upwards.

The Energy Information Administration[1] expects that almost all the net increase in oil consumption in the next 25 years will come from non-OECD countries. Indeed, the demand of crude oil is increasing sharply due to high growth and demand from the emerging economies. On the supply side, the major sources of supplies are still the same as they were in the last ten years. This is a factor that is influencing the upward move of crude oil prices.

[1] The U.S. Energy Information Administration (EIA) collects, analyzes, and publishes independent and unbiased energy information. www.eia.gov

Table 2. Amount of petroleum consumed in 2008 – Source: US Energy Information Administration

Consuming Nation 2008	(1000 bbl/day)	(1000 m3/day)	population in millions	bbl/year per capita	m3/year per capita
United States	19,497.95	3,099.90	314	22.6	3.59
China	7,831.00	1,245.00	1345	2.1	0.33
Japan	4,784.85	760.7	127	13.7	2.18
India	2,962.00	470.9	1198	0.9	0.14
Russia	2,916.00	463.6	140	7.6	1.21
Germany	2,569.28	408.5	82	11.4	1.81
Brazil	2,485.00	395.1	193	4.7	0.75
Saudi Arabia (OPEC)	2,376.00	377.8	25	33.7	5.36
Canada	2,261.36	359.5	33	24.6	3.91
South Korea	2,174.91	345.8	48	16.4	2.61
Mexico	2,128.46	338.4	109	7.1	1.13
France	1,986.26	315.8	62	11.6	1.84
Iran (OPEC)	1,741.00	276.8	74	8.6	1.37
United Kingdom	1,709.66	271.8	61	10.1	1.61
Italy	1,639.01	260.6	60	10	1.6

2.2.3.3. <u>Global Oil Inventories</u>

One of the most used indicators by oil traders is the crude oil inventories (stock levels), which is the quantity of oil currently stored for future use. The value and the changes of this indicator give traders a signal of the trends in production and consumption of oil for a specific period of time, and thus an indication of the price direction. The global oil inventories measure comprises the U.S. crude oil and lease condensate (A mixture consisting primarily of pentanes and heavier hydrocarbons which is recovered as a liquid from natural gas in lease separation facilities) currently held at refineries, within pipelines and at pipeline terminals. This information is released in weekly estimates by the Energy Information Administration every week on Wednesdays.

Global oil inventories balance supply and demand. When production exceeds demand, excess supply is stored, which increases inventories and which should lead to lower energy prices. The opposite is true when inventories are declining.

When institutional investors, especially market makers, notice an increase in oil inventories, spot oil prices tend to decline because of the gap between supply and demand. However, if oil futures prices increase relatively to the spot price (because of higher expected demand), the incentive to store oil will increase, resulting in larger inventories. Any change in these inventory levels generates volatility in crude oil's prices which in turn causes ripples in the stock markets.

It is worth noting that crude oil inventories have shown a cyclical pattern in the past. Ordinarily, crude oil inventories increase in the summer and decline in winter. This is because in winter, the need for heating and thus for energy use is higher. In this time of the year, demand for fuel goes above supply and outcomes in a need to tap inventories. Similarly, during summer times, supply usually exceeds demand, oil inventories build up, and thus the crude oil prices decline.

2.2.3.4. <u>Other Drivers of Crude Oil Prices</u>

- *Natural causes and Geopolitical events*

The price of both crude and the finished products are affected by events that have the ability to disturb the flow of both crude and finished products. These events include hurricanes, geopolitical events, terrorist acts, etc. Since both supply and demand of oil are relatively inelastic, therefore, any of the above events, or the perceived risk of them, can lead to higher price volatility, especially in the futures market.

- *Technology*

Global warming issue that arises because of the use of petroleum-based products has led to a violent move towards the development of green energy sources such as electric cars, biodiesel, ethanol, liquid natural gas and others, in the hope that they can possibly reduce the world's dependence on crude oil. All of these alternatives, with the technological progress, may have the opportunity to upset crude oil prices.

- *Speculation*

As observed, another force driving oil prices has been speculators that are bidding on oil futures contracts. Numerous important institutional investors now involved in the oil markets, such as pension funds, hold commodity-linked investments as part of a long-term asset-allocation strategy. Others, like speculators, trade oil futures for very short periods of time to try to make quick profits. Some observers assign wide short-term fluctuations in oil prices to these speculators, while others believe their influence is minimal.

CHAPTER 3

LITERATURE REVIEW

3.1. Importance of Commodity Markets

Since the times of barter economies, before money was even invented, commodity markets have always been the leading and most essential of their kinds. This is mainly due to the important feature that they have: simplicity. Nowadays these markets have matured to highly developed institutions that play a crucial role in the modern economy. Indeed, commodities are now traded on international and extremely well organized exchanges. These commodities are mainly traded through futures instruments. Futures contract is derivative instrument: it is a standardized contract between two parties who agree to exchange a specified asset of standardized quantity and quality for a price agreed today (the futures price or the strike price) with delivery occurring at a specified future date, the delivery date. These contracts are traded on a futures exchange: the NYMEX (New York Mercantile Exchange), the COMEX (Commodity Exchange), or other well organized and regulated exchanges. In addition to facilitating the exchange of goods all over the world, these exchanges make room for massive speculation activities. Indeed, the high standardization of futures contracts make them highly fungible, liquid and thus open the possibility for speculations.

Commodities are raw materials used in numerous stages of production and of the economic activity, they represent a reliable measure of value to which analyst often refer especially in periods of economic downturn and during crises.

Since commodities became major inputs of intermediate consumption in all kind of products, related products are more and more correlated, making of diversification a difficult task (Sieczka 2009). This has a direct impact on market players that are having troubles at diversifying their portfolios efficiently, consequently facing them to increasing risk.

Correlation among commodities is an important subject to study. Indeed, correlations among different assets are essential in order to construct a solid investment portfolio. As known, the main rule for investors is to diversify their portfolio in order to optimize the risk versus return pair. And, this diversification cannot be completed without extracting the correlations among assets. Correlations can be studied for different classes of assets, or among assets of the same class. This means that for example, one can study the correlation between a stock and a commodity, or can explore the correlation between one type of commodity (oil for example) and another commodity (gold for example). If two assets are highly correlated, it makes no sense to use both of them in a portfolio, for a diversification purpose. Indeed, high correlation means that a movement in price of one asset will be practically the same for the other asset. So, if one includes both of these assets in the financial portfolio, it would be as if one includes only one asset because of the very close price movements of the highly correlated assets.

3.2. Relationship between Gold and Oil Prices

In order to be able to forecast market dynamics in the future and to manage the commodity market risk, the study of a lead-and-lag price mechanism between gold prices and oil prices is important (Zhang and Yue-Jun 2010). For this aim, a cointegration test is examined first, and then both linear and nonlinear Granger causality tests are run on the data. The cointegration test reveals whether there is a long term equilibrium relationship between two time series or not, when these series are nonstationary. In their paper, Zhang and Yue-Jun use daily data from January 4, 2000 to March 31, 2008. The data consists of gold (spot price in US dollars per ounce) and crude oil (Brent spot in US dollars per barrel) returns. First, data shows that there is a correlation of 0.9295 in the sampling period, which suggests that the gold and oil markets have very similar price trends and contain some common effective price information. Second, there is a significant cointegration relationship between the crude oil price and the gold price, which implies that there exists long-term equilibrium relationship between the two markets. Third, there is a linear Granger causality of the form: the change in the oil price linearly Granger causes the volatility of the gold price, but not the other way around. As for the nonlinear Granger causality, the two markets prices do not nonlinearly Granger cause each other. This indicates that for the sampling period, oil and gold prices have a fairly direct interactive mechanism.

Baffes (2007) finds that the crude oil price strongly influences the prices of precious metals. The study examines the effect of crude oil prices on the price of 35 internationally traded commodities using annual data from 1960 to 2005. Prices of commodities showed a positive response to increase in the price of oil. Particularly, the prices of precious metals exhibited a strong response to the crude oil price. This has the following explanations. First, rising crude oil prices, increase the disposable income of oil exporting countries, and therefore increases the demand for some commodities. The example of high consumption level of gold in the Middle Eastern oil exporting countries is given. Second, crude oil price peaks are regularly associated with inflationary pressure, and the demand (and thus the price) of precious metals (especially gold) is expected to increase since these metals are believed to be a more secure way for storing wealth. Gold exhibited a high elasticity of 0.34 to the oil price changes, which implies that crude oil prices are indeed associated with inflationary pressures by investors and households.

Le and Chang (2011) study the relationship between gold and oil, the two most strategic commodities, using monthly data from January 1986 to April 2011. They study the indirect impact of the oil price on the gold price. This indirect impact is studied through the inflation channel and the interaction with the US dollar index. The objective of the paper was first to discern whether there is a causal and directional relationship between oil prices and gold prices, and to see whether relationship between both commodity price returns are weak or strong, symmetric or asymmetric, linear or nonlinear.

First, their results show that there is cointegration (long run relationship) between the oil price and inflation, inflation and the gold price, and thus between oil price and gold price. This means that the relationships between the cited pairs are not restricted only to the short run. Moreover, this oil price/gold price relationship through the inflation channel was also supported by the Granger causality test. This result can be interpreted in the following way: higher oil prices engender higher inflation rates which reinforce the demand for gold and thus drive the gold price up. However, inflation is not the only mechanism that explains the connection between oil and gold prices.

Second, the results display that the cointegration effect (long run relationship) is also present among the price of oil, the price of gold and the US dollar index. Gold price responds instantly to new movements in oil price. The response is positive and extinguishes quickly in approximately two or three months after the oil price shock. As for the reaction of the gold price to the US dollar index, gold price responds immediately and negatively to fluctuations in the US dollar index. And, similarly to the reaction to oil price shocks, the response extinguishes quickly in two or three months after the currency shock.

According Le and Chang (2011), the oil price contributes significantly in explaining fluctuations in the gold price. However, it is worth noting that the variation in gold prices is better explained by variation of the US dollar index than the one of the oil prices. Indeed, oil price change accounts for approximately 4.04% of the variation in the gold price, whereas the US dollar index seems to account for about 15.84% of the variation f the gold price. So, clearly the US dollar index appears to play a more significant role in explaining volatilities in the price of gold.

3.3. Relationship of Oil and Gold Prices with Stock Indices and the US Dollar Exchange Rate

The co-movements of several economic variables were studied (Samanta 2012). These variables include: crude oil price traded on the NYMEX in the form of futures contracts, gold price, US stock price (by taking into consideration the Dow Jones Industrial Index) and the real exchange rate of the US dollar measured by the US Dollar index (USDX). These variables are considered in their daily values for a period of twenty years (from January 1989 through September 2009). They are used after a logarithmic transformation to check for the common trends, existence of cointegration and Granger causality. The Johansen cointegration test reveals that there is a cointegration relationship among these variables. The Stock-Watson's common trend test suggests that there is a common trend among these variables. So, there is clear evidence of the existence of cointegration. As for the Granger causality test, it examines the nature of the relationship among the studied variables. The test indicates the existence of causality from gold price and stock price to other variables (oil price and exchange rates) while they are not influenced by them: gold price and stock price are expected to move on their own while oil price and exchange rates likely to be influenced by other variables.

Bhar (2011) used daily data of 1327 observations from January 2004 through April 2009 to identify the explanatory variables of the oil price. The methodology used for this study is the Markov switching methodology instead of the conventional regression analysis. The interest in studying the explanatory variables is that during the sample period considered, there were periods of low to very high price volatility, so the author expects different explanatory variables to be significant during these different regimes.

During the low volatility regime, the stability in oil prices was also reflected by the stability in oil supply and demand fundamentals. When oil prices started climbing, during 2004-2006, driven by the global economic prosperity, an increase in the S&P 500 Index prices was also observed, along with Euro prices and gold prices. The stable and intermediate volatility regimes were followed by very high volatility when oil prices collapsed and this third regime is described by a fall in oil prices due to the financial crisis with a declining Euro and correcting gold prices. Therefore, different factors are believed to explain the behavior of oil prices across different regimes.

During a low oil price volatility regime, oil price is mainly driven by fundamental factors: the global supply and demand for oil. These fundamental elements contribute to small variations in the oil price. As an example, the rising demand from China and India contributed to the small increases in oil price. However, during high variations in the oil price, additional factors are required to explain such important changes.

According to Bhar (2011) hypothesis, oil prices are impacted by the value of the US dollar and by movements in the stock market. Indeed, he proposes that the depreciation of the US dollar, measured both by the appreciation of the gold prices and the Euro, affects oil prices as oil suppliers will demand compensation for the declining value of the US dollar. And the important movements in the stock market, represented by the S&P500 Index, have an effect on oil prices. This hypothesis is valid before the financial crisis of 2008, but its validity does not hold after the financial crisis. Indeed, after the crisis, oil prices and the S&P500 index declined together, the dollar was considered as a safe haven and the price of gold corrected slightly. This evidence was brought by using a Markov switching regime methodology.

The study of Sari *et al*. (2010) examines the co-movements and the transmission of information among four precious metals spot prices, oil price and US dollar/euro exchange rate. There is evidence of a weak long run relationship among these variables, which is asymmetric. Gold return does not appear to explain much of the oil price return, partly because gold is the least volatile precious metal commodities, whereas oil is a very volatile commodity. But, it is worth noting that the reverse relationship is to some extent stronger. Indeed, gold price returns do not seem to explain much of the oil price returns, whereas oil price returns explain 1.7% of gold price returns.

Gold and oil have diverse functions: gold is used as a safe haven, a reserve currency and for jewelry (where it is the first choice of metal in jewelry). Furthermore, Gold and oil have different hedging strategies. An interesting finding is that when oil prices change, it might move because of inflation, crises and changes in currency rate. These factors will affect the movement in price of gold, which acts as a safe haven and a hedge against inflationary pressures. But when gold prices change because of the change in demand for jewelry, reserve currency or investment asset, the relationship with gold is fragile.

There is also evidence of a strong linkage among the variables in the short run.

The spot of the precious metals market reacts significantly but temporarily to a shock in the currency rate. Concerning the relationship between precious metals and oil, shocks in the precious metals and oil markets have common but small positive impact on each other.

Bhar and Hammoudeh (2011) examine the interrelationships among commodities and financial variables in a changing regime environment. The analysis is based on the dynamic interdependence among four internationally traded commodities, oil, gold, copper and silver and three commodity relevant financial variables, short term interest rate, exchange rate and the world equity index. In order to study the simultaneous dynamic influence among the stated variables, weekly data from January 1990 through May 2006 was used in a Vector Autoregression (VAR) model subject to regime changes.

The different regimes are characterized by their different level of uncertainty. The regimes are defined in the following way: the first regime is characterized by a high volatility environment and the second regime is defined by a low volatility environment. It should be noted that the expected duration of the low volatility state is much longer than the duration of the high volatility state.

The methodology used by Bhar and Hammoudeh (2011) in their paper, is first to show that the normal linear VAR model is unable to take into consideration the instability factor over the period taken as a sample. Second, to detect whether the dynamic relationships among each of the commodities considered and the financial variables are regime dependent. Third, to discern, through the modeling approach, which commodity has the most significant relationship with the financial variables.

The relationships between the financial variables and commodity prices may vary depending on whether the existing environment is typified by brief, highly volatile shocks or by more lasting, more stable fundamentals.

Thus, the interrelationship between the commodity prices and the financial variables taken into consideration for the study is regime-dependent. Indeed, if the economy is in the high variance situation, oil prices affect negatively the stock markets. The reason behind it is that the high variance environment, characterized by high uncertainty and stressful state, influences consumer confidence and their spending, corporate profits and substitution of investments from stocks to oil. Therefore, higher oil prices, which add to uncertainty, are disadvantageous to stock markets in a high variance state.

However, if the economy is in the normal low variance state, higher oil prices affect positively the stock market. Indeed, in this condition, a rise in the oil prices is a sign of strong economic fundamentals and should be reflected in higher corporate profits and thus higher stock prices. So, in the low variance state, what is beneficial in for the oil market is also beneficial for the stock market.

The US dollar exchange rate and the oil price relationship is instinctive because of the believed flight to safety between dollar-priced assets. It is worth noting that this relationship between oil prices and exchange rate is more striking in the high variance, uncertain state than in the low variance state. This is due to the accelerated asset reallocation effect during a high uncertainty period. According to Bhar and Hammoudeh (2011), there is a negative relationship from the dollar to the oil price, meaning that a weakening dollar leads to higher prices in the futures oil market during a high variance environment, known as the flight to safety. However, in the long, low uncertainty state, this relationship is much weaker.

Concerning gold, Bhar and Hammoudeh (2011) found out that the precious metal does not appear to have an effect on the financial variables. This is mainly because of the use of gold as a safe haven in times of crises. This conclusion was expected because given the principal functions of gold as jewelry and safe haven asset, there is a limited association to the real economy and thus with other variables in the system.

Baur and Dirk (2010) examine the role of gold in the financial system. Their paper focuses on the following two issues: first, to what degree gold does protect wealth during severe negative market conditions. In other terms, it studies whether gold is a week or strong safe haven. Second, it shows which role the US dollar exchange rate movements do play in strengthening or at the contrary, weakening the safe haven property of gold.

To be able to tackle these issues, daily, weekly and monthly data from 1979 to 2009 was used.

It is important to distinguish between a strong hedge and a weak hedge and a strong safe haven and a weak safe haven. A strong hedge is defined as an asset that is negatively correlated with another asset, whereas a weak hedge is an asset that is uncorrelated with another asset. A strong safe haven is defined as an asset that is negatively correlated with another asset in certain periods of time only, whereas a weak safe haven is an asset that is uncorrelated with another asset during the specified period of time (for example during a fall in the stock markets). The difference between the two type of assets discussed above is the length of the effect: the key characteristic of the hedge is that it holds on average, while the important characteristic of the safe haven is that it only should hold in a definite periods, a crisis for example.

The empirical study reveals that the safe haven effect is present in most developed country stock markets. It is worth mentioning that this finding is strongest for daily data, particularly during extreme shocks. This result indicates that investors seek gold as a safe haven when they react to brief and extreme negative shocks: this reflects the aspect of gold as a “panic buy”. The reaction of investors to shocks appears different between investors of developed and those of emerging markets. In emerging markets, gold plays a relatively insignificant role as a safe haven asset. In fact, gold is, at the most, a weak safe haven for some of the emerging markets. This could be explained by the following: investors enduring losses in emerging markets are more likely to adjust their portfolio by entering to the developed markets stocks and retreating from the emerging markets, instead of moving towards the precious metal.

By taking into consideration specific crisis periods: the peak of the 2008-2010 financial crisis, gold appears to be a strong safe haven in the majority of the developed markets. This is also true for the North American stock market crash. However, none of the markets tested showed that there was a safe haven effect of gold during the Asian crisis.

The safe haven particularity of gold was not tested only during negative shocks in the stock markets, but also during periods of uncertainty. The uncertainty was spotted by using the conditional volatility of a world stock market index as a proxy. The results suggest that gold acts as a safe haven for increased levels of global uncertainty. Nevertheless, gold does not appear to act as a safe haven during extreme levels of global uncertainty. Indeed, an increasing uncertainty environment causes investors to go towards gold for a safe haven, but during periods of severe uncertainty, gold co-moves with stock markets, so it is not considered as a safe haven.

As explained above, the paper of (Baur and Dirk 2010) makes a difference between a weak and a strong safe haven effect. A weak safe haven will protect the investors because it will not move in line with other assets during a stock market crash. The strong haven not only will protect the investor but also will reduce the total losses for investors during a negative market shock, because the strong haven asset will move against the overall market. According to their study, gold is a strong safe haven for most of the major developed world stock markets including the Unites States of America, the larger Eurozone markets (France, Italy and Germany), the United Kingdom and Switzerland. Therefore, in these markets, gold has the ability to act as a stabilizer for the global financial system by reducing losses in periods of distress.

CHAPTER 4

EMPIRICAL STUDY

This section contains the empirical analysis comprising an introduction to the data set, a descriptive and econometric analysis and a summary of the main findings.

4.1. Data

Data used for this project is weekly time series from April 1983 (when WTI futures contract was first traded) through March 2012. Four variables are taken into consideration for the empirical study of this project: Gold price, Oil price, U.S. dollar versus British Pound exchange rate (USD/GBP) and the MSCI World Index. The MSCI Index values were extracted from Bloomberg, whereas the remaining variables were extracted from Thomson Reuters.

4.1.1. Data Definition

The gold price considered is the spot price of gold in U.S. dollars per ounce.

The oil price is proxied by the West Texas Intermediate light sweet crude oil futures contract price. Crude oil is the world's most actively traded commodity, and the light, sweet crude oil futures contract, traded on the NYMEX (member of the Chicago Mercantile Exchange) is the world's most liquid forum for crude oil trading, as well as the world's largest-volume futures contract trading on a physical commodity. Because of its very high liquidity and price transparency, WTI crude oil contract is used as a primary international pricing benchmark. This is the reason why I chose the WTI futures contracts to be the proxy for oil prices. As said in previous sections, the contract trades in units of 1,000 barrels, and the delivery point is Cushing, Oklahoma.

The MSCI World Index is the proxy used in this project to determine the movement of world equity markets. This index is a free float-adjusted market capitalization weighted index that is designed to measure the equity market performance of developed markets. It was developed with a base value of 100 as of December 31, 1969. The MSCI World Index includes developed world markets, and does not include emerging markets. The index consists of the following 24 developed market country indices: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom, and the United States. The MSCI World Index was chosen as a proxy of equity markets performance because it takes into consideration several equity markets of developed countries, i.e. liquid and relatively efficient markets. It does not only reflect the financial markets state of just one country. This World Index is more interesting to study than the S&P500 or any local index, especially that the study comprises internationally traded commodities.

The U.S. dollar exchange rate will be represented in this study by the USD/GBP[2] spot rate. The pound sterling (GBP) is the fourth most traded on currency exchange market, after the US dollar, the euro and the Japanese yen. It appears as a centerpiece of the forex market due to play a prominent role in the London foreign exchange transactions. It is also used as a reserve currency around the world and, according the IMF[3], the British pound is currently ranked third in value held as reserves. The U.S. dollar versus British Pound versus is taken as a proxy to reflect the dollar price

[2] USD/GBP exchange rate is taken as the inverse of the regularly quoted GBP/USD

[3] IMF: Currency Composition of Official Foreign Exchange Reserves

(i.e. to track when is the US dollar depreciating or contrariwise, appreciating) because it is an important currency rate tracked by investors and because data is present prior to the year 2000 (unlike the USD/EUR rate).

4.1.2. Descriptive Statistics

The descriptive statistics of all data is reported in Table 3 below:

Table 3. Descriptive Statistics

Sample: 4/03/1983 3/11/2012				
	GOLD	**OIL**	**MSCI**	**EXCH_GBP**
Mean	500.4379	36.42379	823.6078	0.621142
Median	383.1500	26.21000	814.9000	0.622045
Maximum	1883.800	145.2900	1675.290	0.939850
Minimum	253.5000	10.79000	166.1400	0.479065
Std. Dev.	318.2192	26.11497	393.7248	0.068961
Skewness	2.300037	1.558455	0.074263	0.658464
Kurtosis	7.767691	4.642925	1.905968	4.836961
Jarque-Bera	2763.339	781.5855	76.74414	321.6367
Probability	0.000000	0.000000	0.000000	0.000000
Sum	756161.7	55036.34	1244471.	938.5452
Sum Sq. Dev.	1.53E+08	1029808.	2.34E+08	7.181005
Observations	1511	1511	1511	1511

The standard deviation (indicator of variance) indicates that the gold price series has the highest volatility among others, followed by the MSCI World equity index, the oil price and finally the exchange rate. Further, the statistics of skewness, kurtuosis and Jacques-Bera of all the variables reveal that these variables series are non-normal. Indeed, the small probability values related to the Jarque-Bera statistics make us reject the null hypothesis of normal distribution.

4.1.3. Multicollinearity

Table 4 reports correlations among the considered variables. It shows clearly that weekly prices of oil are highly correlated to gold prices. Indeed, the correlation factor of these commodities is 82.6%. The table also indicates that there is no multicollinearity among variables as there is no correlation factor that is close to 99%.

Table 4. Correlation matrix

	OIL	**GOLD**	**EXCH_GBP**	**MSCI**
OIL	1.000000	0.826441	-0.316282	0.633281
GOLD	0.826441	1.000000	-0.150997	0.419931
EXCH_GBP	-0.316282	-0.150997	1.000000	-0.449669
MSCI	0.633281	0.419931	-0.449669	1.000000

4.2. Gold and Oil Prices Interrelationship

4.2.1. Methodology

The purpose of this part of the empirical study is to search for a cointegration relationship between the oil and gold prices series. Before testing for cointegration, a few steps should be undertaken.

First, it is necessary to identify whether the considered time series are stationary[4] or nonstationary, by using Unit Root testing. Indeed, ignoring this step will prevent us, if a cointegration relationship exists, from being sure that this cointegration is valid. The cointegration relationship makes sense only if variables considered are integrated of the same order. Testing for the order of integration of the series will be

[4] A time series is stationary if its mean and autocovariances do not depend on time. Therefore, this series reverts back to its constant mean, and its fluctuations are contained within a certain range. Any series that is not stationary is said to be nonstationary.

done through two Unit Root tests. The first test is informal: it consists of plotting variables against time and seeing whether the series tend to return to their mean value and have a finite variance or not. If yes, the series is said to be stationary. The second test, which is formal, is the Augmented Dickey-Fuller test. In this test, if a series should be differenced z times, it is assumed to be integrated of order z (I(z)). The order of integration of a series is the number of times the series needs to be differenced in order to become stationary; it is the number of unit roots.

Second, we estimate the Vector Autoregressive (VAR) and choose the lag length according to the minimal Akaike Information Criterion (AIC). This determines the number of lags to be considered in the cointegration.

Next, Johansen cointegration test suggests whether a long term relationship exists among variables. All variables considered for the cointegration must be integrated of the same order. The test joins the two variables, in our case, and attempts to find a combination of them that eliminates the unit root. If such a combination exists, then the two variables are said to be cointegrated. Therefore, there is a cointegration vector $\{\theta_1, \theta_2\}$ that gives a linear combination of the cointegration set {Y,X}. It is given by:

$$\theta_1 Y_t + \theta_2 X_t = u_t \sim I(0)$$

Note that in this case, a maximum of one cointegration vector can be present given that the existence of a long term relationship is tested between two variables[5].

If series are found to be cointegrated, series converge overtime to long term equilibrium.

Finally, the Granger causality test checks for the existence of short term relationship. It is very different from correlation among variables. Indeed, correlation

[5] r is the number of cointegrating vectors. A maximum of r = n-1 vectors can be found, where n is the number of variables considered.

dos not imply causation: a lot of correlations are meaningless and spurious. The Granger causality test though, helps indicates whether a variable x helps predicting another variable y, using past values or not. If yes, x is said to Granger cause y.

4.2.2. Empirical Results and Interpretations

4.2.2.1. Stationarity Tests

Before testing for the presence of cointegration, the properties of the time series should be determined. Series should be tested for stationarity. First, an informal test will be done to test for unit roots, then the Augmented Dickey-Fuller test, which is the most commonly used method to test for unit roots, will be also done as a formal test. It is worth noting that the cointegration results between nonstationary variables are meaningful only if these variables are integrated of the same order.

According to the informal unit root test shown in Fig. **5**. and Fig. **6**. , both variables (oil prices and gold prices) seem to have a unit root because they do not revert back to a constant mean, which means that both variables seem to be non-stationary.

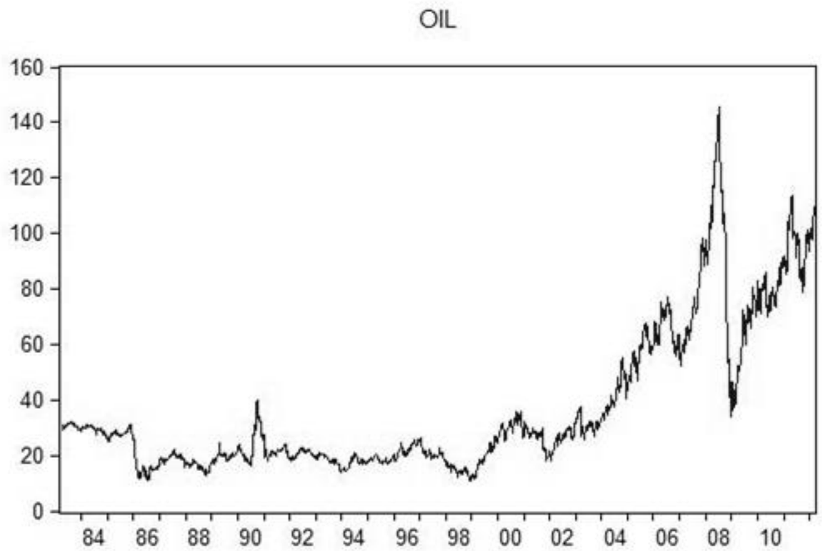

Fig. 5. Plot of oil prices overtime from 1983 to 2012

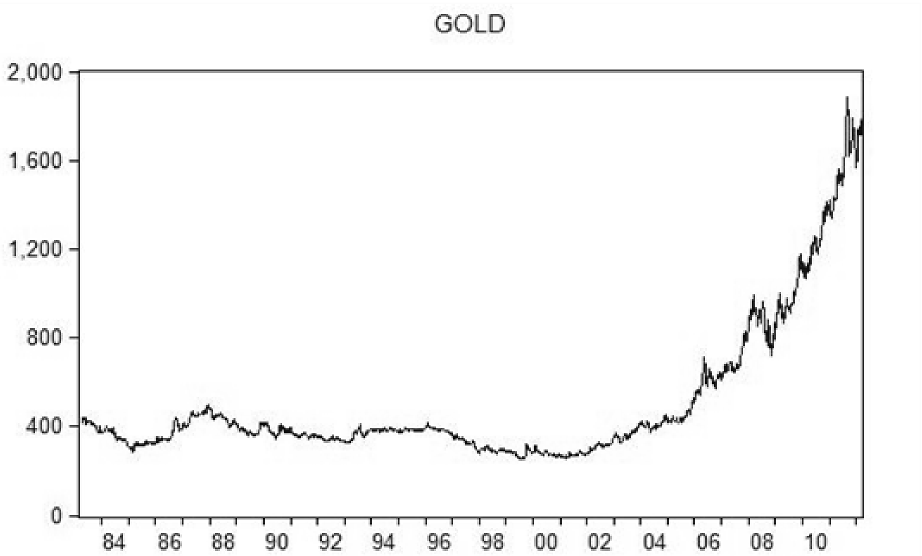

Fig. 6. Plot of gold prices overtime from 1983 to 2012

The results of the second test: the Augmented Dickey-Fuller formal test, are reported below (Table 5 and

Table **6**). These tables show that oil and gold prices, taken as levels, have a unit root. Also, Tables in the Appendix (Table A1 and Table A2) show that the first differences do not have a unit root. Therefore, the test shows that both variables are integrated of order one: they are I(1). Rejection of the null hypothesis of non-stationary is done at the 5% level of significance.

Table 5. ADF unit root test results of oil price (level)

Null Hypothesis: OIL has a unit root Exogenous: Constant, Linear Trend Lag Length: 8 (Automatic based on SIC, MAXLAG=23)			
		t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic		-3.114672	0.1031
Test critical values:	1% level	-3.964166	
	5% level	-3.412805	
	10% level	-3.128384	

*MacKinnon (1996) one-sided p-values.
Augmented Dickey-Fuller Test Equation Dependent Variable: D(OIL)

"Table 5 – *Continued*"

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OIL(-1)	-0.009949	0.003194	-3.114672	0.0019
D(OIL(-1))	-0.002832	0.025458	-0.111260	0.9114
D(OIL(-2))	-0.007241	0.025477	-0.284213	0.7763
D(OIL(-3))	0.036092	0.025539	1.413243	0.1578
D(OIL(-4))	0.059674	0.025584	2.332480	0.0198
D(OIL(-5))	0.020802	0.025601	0.812568	0.4166
D(OIL(-6))	0.031273	0.025605	1.221354	0.2221
D(OIL(-7))	0.003136	0.025615	0.122416	0.9026
D(OIL(-8))	0.182377	0.025614	7.120252	0.0000
C	-0.029583	0.112438	-0.263109	0.7925
@TREND(4/03/1983)	0.000564	0.000189	2.976323	0.0030

R-squared	0.044674	Mean dependent var	0.051405
Adjusted R-squared	0.038266	S.D. dependent var	2.192425
S.E. of regression	2.150068	Akaike info criterion	4.376172
Sum squared resid	6892.583	Schwarz criterion	4.415094
Log likelihood	-3275.506	F-statistic	6.972341
Durbin-Watson stat	2.010503	Prob(F-statistic)	0.000000

Table 6. ADF unit root test of gold price (level)

Null Hypothesis: GOLD has a unit root Exogenous: Constant, Linear Trend Lag Length: 14 (Automatic based on SIC, MAXLAG=23)			
		t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic		2.321724	1.0000
Test critical values:	1% level	-3.964190	
	5% level	-3.412817	
	10% level	-3.128391	
*MacKinnon (1996) one-sided p-values.			
Augmented Dickey-Fuller Test Equation Dependent Variable: D(GOLD) Method: Least Squares Date: 05/17/12 Time: 21:12 Sample (adjusted): 7/17/1983 3/11/2012 Included observations: 1496 after adjustments			

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GOLD(-1)	0.003892	0.001676	2.321724	0.0204
D(GOLD(-1))	-0.023600	0.026051	-0.905902	0.3651

D(GOLD(-2))	-0.000405	0.026158	-0.015482	0.9876
D(GOLD(-3))	-0.021051	0.026090	-0.806831	0.4199
D(GOLD(-4))	-0.029195	0.026056	-1.120487	0.2627

"Table 6 – *Continued*"

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(GOLD(-5))	-0.127787	0.026032	-4.908899	0.0000
D(GOLD(-6))	-0.126891	0.026213	-4.840719	0.0000
D(GOLD(-7))	-0.047029	0.026505	-1.774361	0.0762
D(GOLD(-8))	0.003171	0.026496	0.119679	0.9048
D(GOLD(-9))	-0.035985	0.026322	-1.367075	0.1718
D(GOLD(-10))	-0.071832	0.026215	-2.740076	0.0062
D(GOLD(-11))	-0.030603	0.026390	-1.159614	0.2464
D(GOLD(-12))	0.118847	0.026398	4.502187	0.0000
D(GOLD(-13))	0.090571	0.027073	3.345379	0.0008
D(GOLD(-14))	-0.088260	0.027202	-3.244660	0.0012
C	-2.616135	0.863451	-3.029860	0.0025
@TREND(4/03/1983)	0.002445	0.001152	2.122295	0.0340
R-squared	0.079691	Mean dependent var		0.856972
Adjusted R-squared	0.069735	S.D. dependent var		15.51561
S.E. of regression	14.96484	Akaike info criterion		8.260583
Sum squared resid	331217.0	Schwarz criterion		8.320930
Log likelihood	-6161.916	F-statistic		8.004356
Durbin-Watson stat	2.006569	Prob(F-statistic)		0.000000

4.2.2.2. Vector Autoregressive and Lag Length

In order to determine the number of lags to be used in the cointegration, the Vector Autoregressive (VAR) should be estimated first, and then the lag length would be selected based on the minimal Akaike Information Criterion (AIC).

First, the Vector Autoregressive estimates are revealed in

Table A**3**. in the Appendix. Then, the optimal lag length can be selected looking at Table 7, which represents the VAR lag length selection criterion. Considering the AIC[6], 11 lags should be selected.

[6] The optimal lag length is the one that has minimal AIC value, which is indicated by a star (*)

Table 7. VAR lag length selection criteria

VAR Lag Order Selection Criteria Endogenous variables: OIL GOLD						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-16932.33	NA	22262406	22.59416	22.60125	22.59680
1	-9429.455	14975.71	1005.505	12.58900	12.61026*	12.59692
2	-9420.965	16.92366	999.4992	12.58301	12.61845	12.59621
3	-9419.566	2.784279	1002.974	12.58648	12.63610	12.60496
4	-9411.906	15.22743	998.0890	12.58160	12.64539	12.60536
5	-9406.405	10.92201	996.0919	12.57959	12.65756	12.60864
6	-9391.000	30.54251	981.0498	12.56438	12.65652	12.59871
7	-9367.355	46.81764	955.6697	12.53817	12.64449	12.57778
8	-9358.743	17.02888	949.8075	12.53201	12.65251	12.57690
9	-9332.601	51.62132	922.1591	12.50247	12.63714	12.55264
10	-9316.747	31.26270	907.6906	12.48665	12.63550	12.54211
11	-9308.203	16.82670*	902.2047*	12.48059*	12.64362	12.54133*
12	-9304.508	7.265375	902.5740	12.48100	12.65820	12.54702
* indicates lag order selected by the criterion LR: sequential modified LR test statistic (each test at 5%evel) FPE: Final prediction error AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion						

4.2.2.3. Johansen Cointegration Test

The Johansen cointegration test results are reported in Table 8. According to Trace statistic and Max-eigenvalue statistic, there are 2 cointegration equations at 5% level of significance. Although, given that there could be only n-1 cointegration equations (where n is the number of variables), we conclude that there is 1 cointegration equation. Therefore, there is a cointegration relationship between gold prices and crude oil prices: they tend to converge to long term equilibrium.

Table 8. Johansen cointegration test

Trend assumption: Linear deterministic trend (restricted)
Series: OIL GOLD
Lags interval (in first differences): 1 to 11

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.020947	56.13941	25.87211	0.0000
At most 1 *	0.016150	24.40693	12.51798	0.0003

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.020947	31.73248	19.38704	0.0005
At most 1 *	0.016150	24.40693	12.51798	0.0003

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

OIL	GOLD	@TREND(4/10/83)
0.036059	-0.003761	-0.001926
-0.074858	0.002790	0.001160

Unrestricted Adjustment Coefficients (alpha):

D(OIL)	-0.221503	0.187566
D(GOLD)	-1.974678	-0.776011

1 Cointegrating Equation(s): Log likelihood -9310.441

Normalized cointegrating coefficients (standard error in parentheses)

OIL	GOLD	@TREND(4/10/83)
1.000000	-0.104300	-0.053405
	(0.02099)	(0.01464)

Adjustment coefficients (standard error in parentheses)

D(OIL)	-0.007987
	(0.00199)
D(GOLD)	-0.071205
	(0.01391)

4.2.2.4. Granger Causality

To check for a short term relationship between both time series (oil and gold), the Granger causality test is applied. Granger (1969) causality test consists of testing whether a variable x causes another variable y, using past values (or lags) of both variables. While running a regression, and applying Granger test, the null hypothesis of the first regression (in this case) is that gold does not Granger cause oil, and the null hypothesis in the second regression is that oil does not Granger cause gold.

As can be seen in Table 9, both probabilities are inferior to 5% (for a 5% significance level), so we reject the null hypothesis in both regressions, so gold does Granger cause oil and oil does Granger cause gold. There is a two-way short run causation between oil and gold.

Table 9. Granger Causality Test

Pairwise Granger Causality Tests Lags: 11			
Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
GOLD does not Granger Cause OIL	1500	3.94186	1.E-05
OIL does not Granger Cause GOLD		5.15587	5.E-08

4.3. Gold and Oil Prices Relationship with Crisis

4.3.1. Methodology

In this part of the empirical study, only Ordinary Least Squares (OLS) regressions will be run. Indeed, the objective of this part is to study how oil first, and then gold react to crisis. Crisis is considered to be the movement in the equity index: the MSCI World Index, and/or the movement in the value of the U.S. dollar: the USD/GBP exchange rate.

The general form of a OLS regression is the following:

$$Y = \beta X + \mu$$

Where: Y is the dependent vector

β is the OLS coefficients estimates vector

X is the matrix of explanatory variables

μ is the error terms vector

The first step is to run the following OLS regressions:

$$Oil = \beta_0 + \beta_1 \text{ MSCI} \quad (1)$$

$$Oil = \beta_0 + \beta_1 \text{ Exch\_GBP} \quad (2)$$

$$Oil = \beta_0 + \beta_1 \text{ MSCI} + \beta_2 \text{ Exch\_GBP} \quad (3)$$

Where oil is the dependent variable and MSCI and/or USD/GBP exchange rate are the explanatory variables considered.

$$Gold = \beta_0 + \beta_1 \text{ MSCI} \quad (4)$$

$$Gold = \beta_0 + \beta_1 \text{ Exch\_GBP} \quad (5)$$

$$Gold = \beta_0 + \beta_1 \text{ MSCI} + \beta_2 \text{ Exch\_GBP} \quad (6)$$

Where gold is the dependent variable and MSCI and/or USD/GBP exchange rate are the explanatory variables considered.

Note that values of variables were not transformed in any way. They are taken as level values.

The second step is to test their residuals for heteroskedasticity using the White heteroskedasticity test. Testing for heteroskedasticity consists in testing whether the variance of the residuals is constant or not, with the null hypothesis being:

$$H_0 = E(\mu^2) = \sigma^2$$

where σ^2 is a constant

Finally, in case of heteroskedasticity, these regressions are corrected by White method in case.

4.3.2. Empirical Results

4.3.2.1. OLS Oil Price Determination

The OLS regression results are presented as follows[7]:

(1) Oil = 1.829 + 0.042*MSCI

(2) Oil = 110.820 – 119.773*Exch_GBP

(3) Oil = 12.091 – 14.959*Exch_GBP + 0.041*MSCI

Testing for heteroskedasticity, using White heteroskedasticity test we obtain the following results:

The p-value of the F statistic is below 5% for the three regressions[8]. Therefore, we reject the null hypothesis of homoskedasticity; we conclude that the residuals derived from above regressions are heteroskedastic.

Given that the previous three regressions had heteroskedastic residuals, we re-run these regressions, correcting them for heteroskedasticity by White method. Results are shown in Table 10, Table 11 and

Table **12** for regressions (1), (2) and (3) respectively. Note that while correcting for heteroskedasticity, estimators of coefficient remain the same as the

[7] Results of the three regressions are presented in Tables A4, A6, and A8 in Appendix 1.

[8] White heteroskedasticity tests for regressions (1), (2) and (3) are respectively reported in Tables A5, A7, and A9 in Appendix 1.

original (non-corrected) regression, but t-statistics change.

For:

(1) Oil = 1.829 + 0.042*MSCI

As reported in Table 10, constant coefficient is not significant (with a t-statistic of 1.80, lower than 1.96 for a 5% significance level). Coefficient for MSCI is highly significant (with a t-statistic of 27.45). The MSCI affects positively oil prices. An increase in the MSCI of 1 unit increases the oil price by 0.04 U.S. dollars. The R^2 of the regression is 40%, which is higher than the regression that is not corrected for heteroskedasticity, but still small.

Table 10. Regression – MSCI on oil - corrected for heteroskedasticity

Dependent Variable: OIL Method: Least Squares White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.828780	1.014573	1.802512	0.0717
MSCI	0.042004	0.001530	27.45067	0.0000
R-squared	0.401044	Mean dependent var		36.42379
Adjusted R-squared	0.400647	S.D. dependent var		26.11497
S.E. of regression	20.21765	Akaike info criterion		8.852312
Sum squared resid	616809.1	Schwarz criterion		8.859355
Log likelihood	-6685.922	Hannan-Quinn criter.		8.854935
F-statistic	1010.385	Durbin-Watson stat		0.011175
Prob(F-statistic)	0.000000			

(2) Oil = 110.820 – 119.773*Exch_GBP

As reported in Table 11, the constant is significant (t-statistic of 18.05), and the coefficient for exchange rate that affects negatively the oil is highly significant (t-statistic of 12.67). The R2 of 10% is very small.

(3) Oil = 12.091 – 14.959*Exch_GBP + 0.041*MSCI

As shown in

Table **12**, constant coefficient is significant (t-statistic of 2.27), the coefficient for exchange rate is nearly significant (t-statistic of 1.87), and coefficient of MSCI is highly significant (t-statistic of 25.45). The R^2 of 40.2% is higher than in precedent regressions but is still weak.

Table 11. Regression – USD/GBP exchange rate on oil - corrected for heteroskedasticity

Dependent Variable: OIL				
Method: Least Squares				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	110.8200	6.138830	18.05230	0.0000
EXCH_GBP	-119.7733	9.448293	-12.67671	0.0000
R-squared	0.100034	Mean dependent var		36.42379
Adjusted R-squared	0.099438	S.D. dependent var		26.11497
S.E. of regression	24.78257	Akaike info criterion		9.259481
Sum squared resid	926791.4	Schwarz criterion		9.266524
Log likelihood	-6993.538	Hannan-Quinn criter.		9.262104
F-statistic	167.7307	Durbin-Watson stat		0.008759
Prob(F-statistic)	0.000000			

Table 12. Regression – USD/GBP exchange rate and MSCI on oil – corrected for heteroskedasticity

Dependent Variable: OIL				
Method: Least Squares				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	12.09105	5.319646	2.272904	0.0232
EXCH_GBP	-14.95938	7.980259	-1.874548	0.0610
MSCI	0.040826	0.001604	25.45258	0.0000
R-squared	0.402289	Mean dependent var		36.42379
Adjusted R-squared	0.401497	S.D. dependent var		26.11497
S.E. of regression	20.20333	Akaike info criterion		8.851555
Sum squared resid	615527.0	Schwarz criterion		8.862119
Log likelihood	-6684.350	Hannan-Quinn criter.		8.855489
F-statistic	507.4797	Durbin-Watson stat		0.011129

Prob(F-statistic)	0.000000

4.3.2.2. Gold Price Determination

The OLS regression results are presented as follows[9]:

(4) Gold = 220.905 + 0.339*MSCI

(5) Gold = 933.232 – 696.771*Exch_GBP

(6) Gold = 70.787 + 218.829*Exch_GBP + 0.356*MSCI

Testing for heteroskedasticity, using White heteroskedasticity test we obtain the following results:

The p-value of the F statistic is below 5% for the three regressions[10]. Therefore, we reject the null hypothesis of homoskedasticity; we conclude that the residuals derived from above regressions are heteroskedastic.

Given that the previous three regressions had heteroskedastic residuals, we re-run these regressions, correcting them for heteroskedasticity by White method. Results are shown in Table 13, Table 14 and Table 15 for regressions (4), (5) and (6) respectively. Note that while correcting for heteroskedasticity, estimators of coefficient remain the same as the original (non-corrected) regression, but t-statistics change.

For:

(7) Gold = 220.905 + 0.339*MSCI

As reported in Table 13, constant coefficient is highly significant (with a t-statistic of 23.37). Coefficient for MSCI is highly significant (with a t-statistic of 18.16). The MSCI affects positively oil prices. An increase in the MSCI of 1 unit increases the

[9] Results of the three regressions are presented in Tables A10, A12, and A14 in Appendix 1.

[10] White heteroskedasticity tests for regressions (4), (5) and (6) are respectively reported in Tables 11, 13 and 15 in Appendix 1.

oil price by 0.34 U.S. dollars. The R^2 of the regression is 17%, which is small

(8) Gold = 933.232 – 696.771*Exch_GBP

As reported in Table 14, the constant is significant (t-statistic of 23.71), and the coefficient for exchange rate that affects negatively the oil price is highly significant (t-statistic of 10.96). The R^2 of 2% is extremely small.

Table 13. Regression – MSCI on gold – corrected for heteroskedasticity

Dependent Variable: GOLD				
Method: Least Squares				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	220.9053	9.449573	23.37728	0.0000
MSCI	0.339400	0.018684	18.16525	0.0000
R-squared	0.176342	Mean dependent var		500.4379
Adjusted R-squared	0.175797	S.D. dependent var		318.2192
S.E. of regression	288.8974	Akaike info criterion		14.17134
Sum squared resid	1.26E+08	Schwarz criterion		14.17839
Log likelihood	-10704.45	Hannan-Quinn criter.		14.17397
F-statistic	323.0718	Durbin-Watson stat		0.003120
Prob(F-statistic)	0.000000			

Table 14. Regression – USD/GBP exchange rate on gold – corrected for heteroskedasticity

Dependent Variable: GOLD				
Method: Least Squares				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	933.2316	39.36091	23.70960	0.0000
EXCH_GBP	-696.7711	63.52827	-10.96789	0.0000
R-squared	0.022800	Mean dependent var		500.4379
Adjusted R-squared	0.022152	S.D. dependent var		318.2192
S.E. of regression	314.6748	Akaike info criterion		14.34228
Sum squared resid	1.49E+08	Schwarz criterion		14.34932
Log likelihood	-10833.59	Hannan-Quinn criter.		14.34490
F-statistic	35.20802	Durbin-Watson stat		0.002416
Prob(F-statistic)	0.000000			

(9) Gold = 70.787 + 218.829*Exch_GBP + 0.356*MSCI

As shown in Table 15, constant coefficient is not significant (t-statistic of 0.94), the coefficient for exchange rate is significant (t-statistic of 2.16), and coefficient of MSCI is highly significant (t-statistic of 14.28). The R^2 of 17% is higher than in precedent regressions but is still weak.

Table 15. Regression – USD/GBP exchange rate and MSCI on gold – corrected for heteroskedasticity

Dependent Variable: GOLD				
Method: Least Squares				
White heteroskedasticity-consistent standard errors & covariance				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	70.78660	75.06094	0.943055	0.3458
EXCH_GBP	218.8291	100.9247	2.168241	0.0303
MSCI	0.356635	0.024973	14.28063	0.0000
R-squared	0.178136	Mean dependent var		500.4379
Adjusted R-squared	0.177046	S.D. dependent var		318.2192
S.E. of regression	288.6783	Akaike info criterion		14.17049
Sum squared resid	1.26E+08	Schwarz criterion		14.18105
Log likelihood	-10702.80	Hannan-Quinn criter.		14.17442
F-statistic	163.4273	Durbin-Watson stat		0.003309
Prob(F-statistic)	0.000000			

4.3.3. Interpretation of Results

By taking the highest adjusted R^2 in both sets of regressions: equation (3) for the first set and equation (6) for the second set, we conclude the following.

Concerning oil, the equity markets have a positive and highly significant effect on the price of oil, and the USD/GBP exchange rate has a negative and close to significant effect on oil. Therefore, a crash in the stock market will affect oil prices in the bad way, and the USD/GBP effect appears to be neutral (because of non-significant estimator).

Concerning gold, both the equity market and the USD/GBP exchange rate have a significant positive effect on the price of gold. That is, a fall in the equity markets and in the value of U.S. dollar versus GBP will result in a decline of gold prices.

CHAPTER 5

CONCLUSION

First, this project investigates the relationship between spot gold prices and the futures contract of crude oil. One of the reasons we expect to find a link between both considered commodities is that they are both priced in the U.S dollar.

Second, the reaction of gold and oil prices to crisis is also studied. Crisis is illustrated by the movements in the equity index, the MSCI World Index, and the currency exchange rate, the USD/GBP spot value. Indeed, a fall in the equity index will indicate a depressed equity markets, and the decline in the USD/GBP exchange rate will indicate a depreciating U.S. dollar. The MSCI was chosen as a proxy for equity markets performance because it considers equity indices from 24 developed countries, which gives us an idea of the performance of world stock market. As well, the USD/GBP exchange rate is chosen to reflect the value of the U.S. dollar because it is an important rate for traders, central banks and because this rate exists prior to year 2000.

Results from time series analysis confirm that there is a long term relationship between gold and oil: both commodities will tend to converge to a long term equilibrium. Indeed, after checking that both series are integrated of order one, we find evidence of existence of one cointegrating vector using the Johansen maximum likelihood test. Granger causality tests for short term dynamics reveals the existence of bidirectional causation between oil and gold.

To study the reaction to crisis of both commodities, Ordinary Least Squares approach was used. Results from OLS regressions suggest the following. For oil: the equity markets have a positive and highly significant effect on the price of oil, and the

USD/GBP exchange rate has a negative and close to significant effect on oil. Therefore, a crash in the stock market will affect oil prices in the bad way, and the USD/GBP effect appears to be neutral (because of non-significant estimator). For gold: both the equity market and the USD/GBP exchange rate have a significant positive effect on the price of gold. That is, a fall in the equity markets and in the value of U.S. dollar versus GBP will result in a decline of gold prices. This last conclusion is not in line with the hedge feature of gold, but can be explained by the following: gold as a commodity is used as an input in various industries like electronics and jewelry. So, when the economy is doing well, the demand of gold as an input for production increases, this in turn increases the price of gold. The same is true for a stock market downturn: the falling stock market will reflect a weak economic situation, in which the demand for inputs is lower, thus the price of gold as an input will be affected negatively.

As for the future work, with regards to the relationship between the gold and the crude oil markets and their reaction to crisis, no less than two things have to be conducted further.

First, this project focuses on the relationship of prices in both oil and crude oil prices, while other tools can also be considered in the future, such as the volume traded, in order to build a more complete understanding of the gold and crude oil markets or even the entire commodity market.

Second, the reaction of gold and oil prices to crisis is studied by taking the entire period from 1983 to 2012 in this project. However, in order to be more precise, only periods of crisis should be considered.

APPENDIX 1

TABLES

Table A1. ADF unit root results of oil price (first difference)

Null Hypothesis: D(OIL) has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 7 (Automatic based on SIC, MAXLAG=23)				
			t-Statistic	**Prob.***
Augmented Dickey-Fuller test statistic			-10.55708	0.0000
Test critical values:	1% level		-3.964166	
	5% level		-3.412805	
	10% level		-3.128384	
*MacKinnon (1996) one-sided p-values.				

Augmented Dickey-Fuller Test Equation				
Dependent Variable: D(OIL,2)				
Method: Least Squares				
Date: 05/17/12 Time: 21:11				
Sample (adjusted): 6/05/1983 3/11/2012				
Included observations: 1502 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(OIL(-1))	-0.718331	0.068043	-10.55708	0.0000
D(OIL(-1),2)	-0.289196	0.064390	-4.491287	0.0000
D(OIL(-2),2)	-0.301229	0.060606	-4.970311	0.0000
D(OIL(-3),2)	-0.269710	0.056277	-4.792576	0.0000
D(OIL(-4),2)	-0.214699	0.051260	-4.188406	0.0000
D(OIL(-5),2)	-0.199248	0.044732	-4.454243	0.0000
D(OIL(-6),2)	-0.173760	0.036397	-4.774083	0.0000
D(OIL(-7),2)	-0.176490	0.025618	-6.889195	0.0000
C	-0.060231	0.112333	-0.536185	0.5919
@TREND(4/03/1983)	0.000130	0.000129	1.009139	0.3131
R-squared	0.520725	Mean dependent var		0.000539
Adjusted R-squared	0.517834	S.D. dependent var		3.105394
S.E. of regression	2.156328	Akaike info criterion		4.381326
Sum squared resid	6937.429	Schwarz criterion		4.416710
Log likelihood	-3280.376	F-statistic		180.1153
Durbin-Watson stat	2.007683	Prob(F-statistic)		0.000000

Table A2. ADF unit root test of gold price (first difference)

Null Hypothesis: D(GOLD) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 13 (Automatic based on SIC, MAXLAG=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.95264	0.0000
Test critical values:	1% level	-3.964190	
	5% level	-3.412817	
	10% level	-3.128391	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(GOLD,2)
Method: Least Squares
Date: 05/17/12 Time: 21:13
Sample (adjusted): 7/17/1983 3/11/2012
Included observations: 1496 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GOLD(-1))	-1.283476	0.117184	-10.95264	0.0000
D(GOLD(-1),2)	0.266663	0.113180	2.356100	0.0186
D(GOLD(-2),2)	0.274461	0.108202	2.536563	0.0113
D(GOLD(-3),2)	0.261897	0.101943	2.569045	0.0103
D(GOLD(-4),2)	0.240945	0.095649	2.519044	0.0119
D(GOLD(-5),2)	0.121254	0.089301	1.357817	0.1747
D(GOLD(-6),2)	0.002786	0.082671	0.033701	0.9731
D(GOLD(-7),2)	-0.035847	0.075246	-0.476398	0.6339
D(GOLD(-8),2)	-0.024394	0.067537	-0.361188	0.7180
D(GOLD(-9),2)	-0.053056	0.060326	-0.879490	0.3793
D(GOLD(-10),2)	-0.118773	0.053962	-2.201058	0.0279
D(GOLD(-11),2)	-0.142589	0.046720	-3.051963	0.0023
D(GOLD(-12),2)	-0.017058	0.038393	-0.444318	0.6569
D(GOLD(-13),2)	0.080938	0.027058	2.991263	0.0028
C	-1.880128	0.804342	-2.337473	0.0195
@TREND(4/03/1983)	0.003916	0.000964	4.064084	0.0001

R-squared	0.529382	Mean dependent var	-0.009051
Adjusted R-squared	0.524613	S.D. dependent var	21.73660
S.E. of regression	14.98702	Akaike info criterion	8.262884
Sum squared resid	332424.1	Schwarz criterion	8.319682
Log likelihood	-6164.637	F-statistic	110.9869
Durbin-Watson stat	2.004552	Prob(F-statistic)	0.000000

Table A3. Vector Auto Regression (VAR) estimates of oil and gold prices

Vector Autoregression Estimates
Sample (adjusted): 6/26/1983 3/11/2012
Included observations: 1499 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	OIL	**GOLD**
OIL(-1)	1.010339	0.036026
	(0.02805)	(0.19663)
	[36.0150]	[0.18322]
OIL(-2)	-0.025721	-0.208335
	(0.03983)	(0.27921)
	[-0.64568]	[-0.74617]
OIL(-3)	0.061605	0.234206
	(0.03978)	(0.27884)
	[1.54853]	[0.83992]
OIL(-4)	0.025929	-0.005540
	(0.03972)	(0.27838)
	[0.65284]	[-0.01990]
OIL(-5)	-0.066099	-0.210318
	(0.03936)	(0.27591)
	[-1.67920]	[-0.76228]
OIL(-6)	-0.009031	0.036245
	(0.03929)	(0.27537)
	[-0.22988]	[0.13162]
OIL(-7)	-0.011867	0.747941
	(0.03929)	(0.27542)
	[-0.30199]	[2.71561]
OIL(-8)	0.178658	0.031456
	(0.03929)	(0.27541)
	[4.54680]	[0.11421]
OIL(-9)	-0.146999	-1.558270
	(0.03960)	(0.27757)
	[-3.71204]	[-5.61406]
OIL(-10)	-0.076502	0.319698
	(0.04004)	(0.28066)
	[-1.91054]	[1.13910]
OIL(-11)	0.076600	0.316307
	(0.04010)	(0.28108)
	[1.91013]	[1.12533]
OIL(-12)	-0.030916	0.283624
	(0.02823)	(0.19788)
	[-1.09511]	[1.43333]
GOLD(-1)	-0.013922	0.973243
	(0.00400)	(0.02805)
	[-3.47908]	[34.6993]
GOLD(-2)	0.013311	0.038630
	(0.00571)	(0.04005)
	[2.32932]	[0.96445]
GOLD(-3)	-0.010347	-0.028188
	(0.00576)	(0.04034)
	[-1.79792]	[-0.69878]

“Table A3 – *Continued*”

	OIL	**GOLD**
GOLD(-4)	0.002342	-0.011194
	(0.00573)	(0.04013)
	[0.40899]	[-0.27894]
GOLD(-5)	0.010313	-0.089957
	(0.00572)	(0.04007)
	[1.80411]	[-2.24519]
GOLD(-6)	0.004438	-0.014759
	(0.00570)	(0.03996)
	[0.77837]	[-0.36934]
GOLD(-7)	-0.007349	0.044350
	(0.00573)	(0.04019)
	[-1.28175]	[1.10360]
GOLD(-8)	0.001957	0.066345
	(0.00574)	(0.04022)
	[0.34099]	[1.64944]
GOLD(-9)	-0.003758	0.047850
	(0.00574)	(0.04026)
	[-0.65417]	[1.18842]
GOLD(-10)	3.71E-05	-0.064198
	(0.00575)	(0.04030)
	[0.00645]	[-1.59314]
GOLD(-11)	-0.002266	0.028527
	(0.00578)	(0.04055)
	[-0.39178]	[0.70358]
GOLD(-12)	0.006574	0.014490
	(0.00407)	(0.02851)
	[1.61654]	[0.50833]
C	-0.078362	-2.080270
	(0.10712)	(0.75078)
	[-0.73157]	[-2.77080]
R-squared	0.993489	0.997846
Adj. R-squared	0.993383	0.997811
Sum sq. resids	6701.724	329240.0
S.E. equation	2.132281	14.94540
F-statistic	9371.968	28449.71
Log likelihood	-3249.415	-6168.284
Akaike AIC	4.368799	8.263221
Schwarz SC	4.457401	8.351823
Mean dependent	36.47224	501.0251
S.D. dependent	26.21368	319.4217
Determinant resid covariance (dof adj.)		873.2048
Determinant resid covariance		844.3215
Log likelihood		-9304.508
Akaike information criterion		12.48100
Schwarz criterion		12.65820

"Table A3 – *Continued*"

Vector Error Correction Estimates Sample (adjusted): 6/26/1983 3/11/2012 Included observations: 1499 after adjustments Standard errors in ( ) & t-statistics in [ ]		
Cointegrating Eq:	**CointEq1**	
OIL(-1)	1.000000	
GOLD(-1)	0.033478 (0.02194) [1.52601]	
C	-53.16598	
Error Correction:	**D(OIL)**	**D(GOLD)**
CointEq1	0.000263 (0.00170) [0.15435]	0.057696 (0.01189) [4.85177]
D(OIL(-1))	0.020723 (0.02805) [0.73887]	0.004193 (0.19563) [0.02143]
D(OIL(-2))	-0.005088 (0.02804) [-0.18148]	-0.204362 (0.19557) [-1.04497]
D(OIL(-3))	0.055367 (0.02800) [1.97725]	0.027052 (0.19532) [0.13850]
D(OIL(-4))	0.079273 (0.02777) [2.85424]	0.016596 (0.19372) [0.08567]
D(OIL(-5))	0.012676 (0.02784) [0.45532]	-0.194929 (0.19418) [-1.00384]
D(OIL(-6))	0.004032 (0.02772) [0.14544]	-0.157744 (0.19338) [-0.81571]
D(OIL(-7))	-0.007241 (0.02772) [-0.26117]	0.591639 (0.19338) [3.05945]
D(OIL(-8))	0.170657 (0.02776) [6.14767]	0.621247 (0.19362) [3.20851]
D(OIL(-9))	0.020790 (0.02801) [0.74226]	-0.943989 (0.19536) [-4.83201]
D(OIL(-10))	-0.056498 (0.02828) [-1.99791]	-0.626201 (0.19725) [-3.17474]
D(OIL(-11))	0.019869 (0.02825) [0.70344]	-0.310459 (0.19702) [-1.57580]
D(GOLD(-1))	-0.013919 (0.00403) [-3.45367]	-0.028661 (0.02811) [-1.01954]

"Table A3 – *Continued*"

Error Correction:	**D(OIL)**	**D(GOLD)**
D(GOLD(-2))	-0.000323	0.010663
	(0.00405)	(0.02825)
	[-0.07964]	[0.37743]
D(GOLD(-3))	-0.010536	-0.017198
	(0.00401)	(0.02800)
	[-2.62441]	[-0.61420]
D(GOLD(-4))	-0.008116	-0.028203
	(0.00402)	(0.02806)
	[-2.01762]	[-1.00519]
D(GOLD(-5))	0.002098	-0.118401
	(0.00401)	(0.02794)
	[0.52378]	[-4.23834]
D(GOLD(-6))	0.006402	-0.133484
	(0.00398)	(0.02773)
	[1.61013]	[-4.81328]
D(GOLD(-7))	-0.001212	-0.089779
	(0.00403)	(0.02810)
	[-0.30092]	[-3.19450]
D(GOLD(-8))	0.000783	-0.023341
	(0.00404)	(0.02820)
	[0.19361]	[-0.82768]
D(GOLD(-9))	-0.002976	0.024506
	(0.00405)	(0.02822)
	[-0.73574]	[0.86848]
D(GOLD(-10))	-0.002948	-0.039712
	(0.00405)	(0.02828)
	[-0.72705]	[-1.40436]
D(GOLD(-11))	-0.005046	-0.010778
	(0.00407)	(0.02839)
	[-1.23972]	[-0.37962]
C	0.066017	1.303932
	(0.05676)	(0.39591)
	[1.16308]	[3.29353]
R-squared	0.060718	0.084463
Adj. R-squared	0.046072	0.070187
Sum sq. resids	6776.376	329680.6
S.E. equation	2.143398	14.95033
F-statistic	4.145580	5.916357
Log likelihood	-3257.718	-6169.287
Akaike AIC	4.378543	8.263224
Schwarz SC	4.463600	8.348282
Mean dependent	0.050700	0.862262
S.D. dependent	2.194547	15.50432
Determinant resid covariance (dof adj.)		881.7437
Determinant resid covariance		853.7351
Log likelihood		-9312.819
Akaike information criterion		12.49209
Schwarz criterion		12.66929

Table A4. Regression - MSCI on oil

Dependent Variable: OIL				
Method: Least Squares				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.828780	1.206247	1.516091	0.1297
MSCI	0.042004	0.001321	31.78655	0.0000
R-squared	0.401044	Mean dependent var		36.42379
Adjusted R-squared	0.400647	S.D. dependent var		26.11497
S.E. of regression	20.21765	Akaike info criterion		8.852312
Sum squared resid	616809.1	Schwarz criterion		8.859355
Log likelihood	-6685.922	Hannan-Quinn criter.		8.854935
F-statistic	1010.385	Durbin-Watson stat		0.011175
Prob(F-statistic)	0.000000			

Table A5. White heteroskedasticity test for the regression of MSCI on oil

White Heteroskedasticity Test:				
F-statistic	213.3725	Probability		0.000000
Obs*R-squared	333.2799	Probability		0.000000
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 05/16/12 Time: 19:01				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	241.3450	68.69632	3.513216	0.0005
MSCI	-0.645449	0.182940	-3.528205	0.0004
MSCI^2	0.000838	0.000107	7.869933	0.0000
R-squared	0.220569	Mean dependent var		408.2125
Adjusted R-squared	0.219535	S.D. dependent var		688.9434
S.E. of regression	608.6395	Akaike info criterion		15.66231
Sum squared resid	5.59E+08	Schwarz criterion		15.67288
Log likelihood	-11829.88	F-statistic		213.3725
Durbin-Watson stat	0.057257	Prob(F-statistic)		0.000000

Table A6. Regression – USD/GBP exchange rate on oil

Dependent Variable: OIL				
Method: Least Squares				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	110.8200	5.779669	19.17411	0.0000
EXCH_GBP	-119.7733	9.248127	-12.95109	0.0000
R-squared	0.100034	Mean dependent var		36.42379
Adjusted R-squared	0.099438	S.D. dependent var		26.11497
S.E. of regression	24.78257	Akaike info criterion		9.259481
Sum squared resid	926791.4	Schwarz criterion		9.266524
Log likelihood	-6993.538	Hannan-Quinn criter.		9.262104
F-statistic	167.7307	Durbin-Watson stat		0.008759
Prob(F-statistic)	0.000000			

Table A7. White heteroskedasticity test for the regression of USD/GBP exchange rate on oil

White Heteroskedasticity Test:				
F-statistic	44.76304	Probability		0.000000
Obs*R-squared	84.67712	Probability		0.000000
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 05/16/12 Time: 19:03				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	7390.601	1294.004	5.711419	0.0000
EXCH_GBP	-18035.11	4016.165	-4.490630	0.0000
EXCH_GBP^2	11329.93	3103.821	3.650315	0.0003
R-squared	0.056040	Mean dependent var		613.3629
Adjusted R-squared	0.054789	S.D. dependent var		1088.030
S.E. of regression	1057.804	Akaike info criterion		16.76776
Sum squared resid	1.69E+09	Schwarz criterion		16.77833
Log likelihood	-12665.04	F-statistic		44.76304
Durbin-Watson stat	0.030422	Prob(F-statistic)		0.000000

Table A8. Regression - USD/GBP exchange rate and MSCI on oil

Dependent Variable: OIL				
Method: Least Squares				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	12.09105	5.914601	2.044271	0.0411
EXCH_GBP	-14.95938	8.440807	-1.772269	0.0766
MSCI	0.040826	0.001478	27.61479	0.0000
R-squared	0.402289	Mean dependent var		36.42379
Adjusted R-squared	0.401497	S.D. dependent var		26.11497
S.E. of regression	20.20333	Akaike info criterion		8.851555
Sum squared resid	615527.0	Schwarz criterion		8.862119
Log likelihood	-6684.350	Hannan-Quinn criter.		8.855489
F-statistic	507.4797	Durbin-Watson stat		0.011129
Prob(F-statistic)	0.000000			

Table A9. White heteroskedasticity test for the regression of USD/GBP exchange rate and MSCI on oil

White Heteroskedasticity Test:				
F-statistic	94.76822	Probability		0.000000
Obs*R-squared	361.8147	Probability		0.000000
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 05/16/12 Time: 19:00				
Sample: 4/03/1983 3/11/2012				
Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-947.5101	1304.419	-0.726385	0.4677
EXCH_GBP	3687.225	3632.646	1.015024	0.3103
EXCH_GBP^2	-2524.619	2537.905	-0.994765	0.3200
EXCH_GBP*MSCI	1.698189	0.801270	2.119372	0.0342
MSCI	-2.164055	0.669321	-3.233208	0.0013
MSCI^2	0.001182	0.000149	7.915771	0.0000
R-squared	0.239454	Mean dependent var		407.3640
Adjusted R-squared	0.236927	S.D. dependent var		679.9951
S.E. of regression	594.0032	Akaike info criterion		15.61561
Sum squared resid	5.31E+08	Schwarz criterion		15.63674
Log likelihood	-11791.59	F-statistic		94.76822
Durbin-Watson stat	0.060685	Prob(F-statistic)		0.000000

Table A10. Regression – MSCI on gold

Dependent Variable: GOLD Method: Least Squares Sample: 4/03/1983 3/11/2012 Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	220.9053	17.23650	12.81614	0.0000
MSCI	0.339400	0.018883	17.97420	0.0000
R-squared	0.176342	Mean dependent var		500.4379
Adjusted R-squared	0.175797	S.D. dependent var		318.2192
S.E. of regression	288.8974	Akaike info criterion		14.17134
Sum squared resid	1.26E+08	Schwarz criterion		14.17839
Log likelihood	-10704.45	Hannan-Quinn criter.		14.17397
F-statistic	323.0718	Durbin-Watson stat		0.003120
Prob(F-statistic)	0.000000			

Table A11. White heteroskedasticity test for the regression of MSCI on gold

White Heteroskedasticity Test:				
F-statistic	114.0175	Probability		0.000000
Obs*R-squared	198.4757	Probability		0.000000
Test Equation: Dependent Variable: RESID^2 Method: Least Squares Date: 05/16/12 Time: 19:01 Sample: 4/03/1983 3/11/2012 Included observations: 1511				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-97769.39	21352.33	-4.578862	0.0000
MSCI	271.9333	56.86168	4.782365	0.0000
MSCI^2	-0.051420	0.033106	-1.553185	0.1206
R-squared	0.131354	Mean dependent var		83351.24
Adjusted R-squared	0.130202	S.D. dependent var		202844.3
S.E. of regression	189178.6	Akaike info criterion		27.14075
Sum squared resid	5.40E+13	Schwarz criterion		27.15132
Log likelihood	-20501.84	F-statistic		114.0175
Durbin-Watson stat	0.012183	Prob(F-statistic)		0.000000

Table A12. Regression - USD/GBP exchange rate on gold

Dependent Variable: GOLD
Method: Least Squares
Sample: 4/03/1983 3/11/2012
Included observations: 1511

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	933.2316	73.38691	12.71659	0.0000
EXCH_GBP	-696.7711	117.4274	-5.933634	0.0000

R-squared	0.022800	Mean dependent var	500.4379
Adjusted R-squared	0.022152	S.D. dependent var	318.2192
S.E. of regression	314.6748	Akaike info criterion	14.34228
Sum squared resid	1.49E+08	Schwarz criterion	14.34932
Log likelihood	-10833.59	Hannan-Quinn criter.	14.34490
F-statistic	35.20802	Durbin-Watson stat	0.002416
Prob(F-statistic)	0.000000		

Table A13. White heteroskedasticity test for the regression of USD/GBP exchange rate on gold

White Heteroskedasticity Test:

F-statistic	17.83387	Probability	0.000000
Obs*R-squared	34.91293	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/16/12 Time: 18:59
Sample: 4/03/1983 3/11/2012
Included observations: 1511

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1828615.	323057.0	-5.660348	0.0000
EXCH_GBP	5979579.	1002663.	5.963698	0.0000
EXCH_GBP^2	-4574504.	774890.1	-5.903423	0.0000

R-squared	0.023106	Mean dependent var	98889.18
Adjusted R-squared	0.021810	S.D. dependent var	267015.9
S.E. of regression	264088.1	Akaike info criterion	27.80794
Sum squared resid	1.05E+14	Schwarz criterion	27.81850
Log likelihood	-21005.90	F-statistic	17.83387
Durbin-Watson stat	0.009119	Prob(F-statistic)	0.000000

Table A14. Regression - USD/GBP exchange rate and MSCI on gold

Dependent Variable: GOLD
Method: Least Squares
Sample: 4/03/1983 3/11/2012
Included observations: 1511

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	70.78660	84.51166	0.837596	0.4024
EXCH_GBP	218.8291	120.6077	1.814387	0.0698
MSCI	0.356635	0.021125	16.88253	0.0000

R-squared	0.178136	Mean dependent var	500.4379
Adjusted R-squared	0.177046	S.D. dependent var	318.2192
S.E. of regression	288.6783	Akaike info criterion	14.17049
Sum squared resid	1.26E+08	Schwarz criterion	14.18105
Log likelihood	-10702.80	Hannan-Quinn criter.	14.17442
F-statistic	163.4273	Durbin-Watson stat	0.003309
Prob(F-statistic)	0.000000		

Table A15. White heteroskedasticity test for the regression of USD/GBP exchange rate and MSCI on gold

White Heteroskedasticity Test:

F-statistic	124.3592	Probability	0.000000
Obs*R-squared	441.7601	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/16/12 Time: 19:00
Sample: 4/03/1983 3/11/2012
Included observations: 1511

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	432315.1	369198.5	1.170956	0.2418
EXCH_GBP	-306443.1	1028172.	-0.298047	0.7657
EXCH_GBP^2	-417786.1	718320.1	-0.581615	0.5609
EXCH_GBP*MSCI	2418.812	226.7888	10.66548	0.0000
MSCI	-1817.898	189.4425	-9.596042	0.0000
MSCI^2	0.352492	0.042265	8.340088	0.0000

R-squared	0.292363	Mean dependent var	83169.68
Adjusted R-squared	0.290012	S.D. dependent var	199529.0
S.E. of regression	168124.7	Akaike info criterion	26.90676
Sum squared resid	4.25E+13	Schwarz criterion	26.92789
Log likelihood	-20322.06	F-statistic	124.3592
Durbin-Watson stat	0.021929	Prob(F-statistic)	0.000000

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