



**UNIVERSITY OF GOTHENBURG**  
**SCHOOL OF BUSINESS, ECONOMICS AND LAW**

# *Examining exchange rate return factors before and after the Lehman bankruptcy*

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*Master Thesis 15 ECTS*

*Spring 2013*

Keywords: Arbitrage pricing theory, factor pricing of exchange rate, safe haven assets, flight to safety, Lehman Brothers and Financial Crisis effect on foreign exchange rate return.

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# *Examining exchange rate return factors before and after the Lehman bankruptcy*

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## **Abstract**

This thesis examines exchange rate return factors of holding USD before and after Lehman Brothers Bankruptcy on September 15<sup>th</sup> 2008, by analysing the relationship with multiple regressions and correlation to trace any significant influence by applying the framework provided by the Arbitrage Pricing Theory, spearheaded by Chen, Roll and Ross, 1986. Thus, regressions on the exchange rate return were computed on the historical macroeconomic data. Factors were compared 2004 – 2012 and pre/post the financial crisis, delimited by Lehman. Notably, only regressions combining several factors yielded significant results in explaining the return's factors. Individual factor significances were found to vary notably before and after the financial crisis – displaying that the market had changed post Lehman. Remarkably, the Dow Jones Industrial Average index transitioned from a negative factor before Lehman, to an influential positive factor, notably stronger than inflation, which was the only positive factor before Lehman. Thereto, the relationship between oil, gold and the return was evaluated thru correlation, indexation and cross-rates modelling, which yielded findings of flight to safety into Gold in the market post Lehman, consistent with the sayings of Baele, Bekaert, Inghelbrecht and Wie, 2012.

## **Acknowledgments**

- Dr. Charles Nadeau for his valuable insights, commentary and highly appreciated support throughout this assignment.
- Prof. Martin Holmén for his review and feedback that provided us with treasured contributions to the thesis.



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## Introduction

This thesis examines exchange rate return factors of holding USD before and after Lehman Brothers Bankruptcy on September 15<sup>th</sup> 2008, by analysing the relationship with multiple regressions and correlation to trace any significant influence by applying the framework built in the Arbitrage Pricing Theory. Factors that are evaluated include the commonly referred 'safe haven' assets of gold and oil, as well as other macroeconomic data such as interest rates, GDP and money stock etc.

Seeking a deeper understanding of which drivers are behind foreign exchange rate returns we desired to analyse the factor sensitivities, to see if there is one identifiable factor or is it a combined influence of the market? What effect or difference is observable around Lehman Brothers' bankruptcy, which could possibly show that the market is not fully informed, as the bankruptcy event might not have been priced in? Also, thru the exchange rate return factors, can we trace any evidence of flight to safety, as the market goes bust?

We wish to contribute to the understanding of contemporary understanding of currency factor pricing, relationships and to trace if the financial crisis had a notable effect on the exchange rate return's historical factor sensitivity.

## Literature Review

The arbitrage pricing theory (APT) put together by Ross, 1976, offers a option to the well-known capital asset pricing model (CAPM) formulated by Sharpe, 1964, Lintner, 1965, Treynor, 1961 and Mossin, 1966. There are two major differences between the APT and the original Sharpe et al. model, the single factor-generating model, the CAPM. First of all, the APT allows for more than one generating factor. Second, the APT demonstrates that given that market equilibrium must be consistent with no arbitrage profits, all equilibrium will be regarded as a linear relationship between each asset's expected return and its return's weight, on the common factors as formulated by Roll & Ross, 1980. Therefore, this structure makes the APT model quite practical and convincingly appealing to test explanatory abilities. Nevertheless, the CAPM is still the most commonly used model today. There have been tests of extending the APT model of Ross, 1976, to an international setting such as done by Solnik, 1982 and Cho, Eun & Senbet, 1986. Solnik concludes that compared to the international CAPM the problem with currency translation does not occur when using the APT model because the factors used are constrained to being portfolios of the original asset. This fact, invites to



test the ability of the APT model to explain other relationships within the financial market, such as foreign exchange relationships. Also concluded by Chen, Roll & Ross, 1986 - "Asset prices should depend on their exposures to the state variable that describe the company".

There to, research papers published regarding the clarification of the common factors within linear relationships between countries and financial markets reveals that conclusively there are about three or four worldwide common factors and the number of common factors between two countries ranges from one to five depending on the degree of their economic integration, as stated by Cho, Eun and Senbet, 1986.

As described by Akram, Rime b, Sarno, 2008, the theoretical condition of no-arbitrage opportunities within the foreign exchange market is well-known and partly defined as covered interest rate parity (CIRP). CIRP states that net returns on an investment that lends at home and borrows abroad (or v. v.) in similar interest generating assets will equal zero, when exchange rate risk is hedged. The conditions of CIRP are the cornerstone riskless no-arbitrage condition in the FX market. This suggests that interest rates comparison is an interesting factor to test in a linear regression model with FX.

Closely related, is the fact that when comparing common factors between different countries there can be more than economic integration and ratios to analyse. Such as financial power and the information held by the countries compared. (Strange, 1990).

Financial markets are known to be partly driven by news and information. As concluded by Chen, Roll and Ross there are factors that stock returns are exposed to as economic news, which are priced in accordance to their exposure to certain factors.

An interesting aspect is to see if and what factors implement a change in exchange rates between currencies. Numerous authors, such as Lustig, Roussanov and Verdelhan, 2011, have derived studies on this subject, which further suggests that APT is a capable framework that can be a useful tool to explain e.g. carry-trade returns.

There are good reasons to say that there are many factors which, when aggregated gives a higher explanatory variable to the comparable. Another aspect when completing analyses would be to look at a specific time period, markets change and different factor's explanatory power move likewise.

To analyse the change in explanatory power of different factors during a specific time period, including a significant market event such as a financial crisis would with a modest assumption show a significant change in the factor relationship.



In uncertain times, it lays in people's nature to move to safety. This is reflected in their investment decisions and investor than tries to re allocate their portfolios into more "safe" asset classes, this phenomenon is also commonly referred to as "Flight to safety" (FTS).

"Both money market instruments and corporate bonds face abnormal negative returns in FTS episodes. Most commodity prices decrease sharply during FTS episodes, whereas the gold price measured in dollars increases slightly. Both economic growth and inflation decline right after and up to a year following a FTS spell." (Baele, Bekaert, Inghelbrecht and Wie, 2012)

In recent times, many have questioned the true value of currencies and gold as well as gold's possibility to act as a safe haven, protecting against inflation and market volatility. In such times the relationship between oil, gold and USD becomes very important, as oil is one of the fundamental global energy sources in limited supply, while gold holds inherent value derived from its scarcity and historical position of base of money – in contrary of the modern USD which is backed by only a promise that the currency holds value, a so called fiat currency as discussed by Kim & Dilts, 2011.

## Theory

The arbitrage pricing theory was developed and described mainly by Stephen Ross in 1976 and consists of a single period model, where an arbitrary investor trust in the stochastic, i.e. random, returns on capital assets is driven by factor structures. (Ross, 1976)

### Arbitrage pricing theory in theory

According to APT expected return can be described as a linear function of various macro-economic factors and/or market indices, where the beta in each factor represents the sensitivity. Differences between the assumptions of the well-known CAPM model compared to the APT model are three main key points that are the corner stones of APT. (Ross, 1976)

$$r_j = a_j + b_{j1}F_1 + b_{j2}F_2 + \dots + b_{jn}F_n + \epsilon_j$$

- Assumed factor model that describes the securities return.
- Assumed that an adequate number of securities exist to form well diversified portfolios.
- Well-functioning efficient security markets do not allow persistent arbitrage opportunities.

The above assumptions are in accordance to the law of one price and efficient markets.



## Arbitrage pricing theory in practice

Ross continued to use the APT framework and together with Chen and Roll found macro-economic factors to be significant in explaining returns for securities. Thereafter the APT has been used to analyse factor pricing of returns in many cases, one being the paper “An empirical examination of the Arbitrage Pricing Theory: Using Japanese data” by Yasushi Hamao and others being e.g. Lustig, Cho and Solnik as previously mentioned above.

## Regression model

Analysing relationships between a dependent variable and one or more independent variables, e.g. the effect of an increase in demand upon the price level, is frequently performed by regression analysis. Multi regression model allows more factors to be added to the analyses individually so the effect of every factor can be investigated. The modified model can be expressed as below:

$$Y = \beta_0 + \beta_1 X_1 + \dots + \beta_m X_m + \varepsilon.$$

It is assumed that the last term ( $\varepsilon$ ) is a random variable that is normally distributed; as such it describes the small deviations between observed Y values and Y values that one expects.

Significance level ( $\alpha$ ), i.e. the limit for robustness in the model, describes the probability of seeing the same result in a randomised dataset in which the variable has no effect. (Anderson, et al., 2005)

The method to analyse factor sensitivity is construed as the standard F-test and T-test applied to test the factor sensitivities significance as well as the overall significance of the model. Techniques to measure the explanatory power of a regression model:

- Review model fit “Anova – significance” if it explains deviations in the dependent variable.
- Adjusted R-square measures the proportion of the variance in the dependent variable, which is explained by variations in the independent variable, adjusted for model size.
- Std error of estimate shows dispersion of the dependent variables estimate around its mean.

## Regression coefficients

- Specifies the individual variables (Estimated Coefficients = beta) on the dependent variable



- Standardised Coefficients is adjusted for difference in unit size, i.e. compare millions vs. fractions by calculating Beta per unit of standard deviation.

### *Correlation*

Correlation describes a statistical measure of how two variables move in relation to each other. This measure is often used within portfolio management. Normally when speaking about a calculated correlation reference is given to the correlation coefficient or "Pearson's correlation", a measure ranging from -1 to +1. Perfect positive correlation (+1) indicates that when one of the securities moves, both down or up, the other security will move the same. (Anderson, et al., 2005)

$$\rho_{X,Y} = \text{corr}(X, Y) = \frac{\text{cov}(X, Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_X)(Y - \mu_Y)]}{\sigma_X \sigma_Y},$$

### *Covered Interest Rate Parity*

This condition states that the relationship between interest rates and the spot and forward (future) currency values of two countries are in equilibrium. As a result there are no arbitrage opportunities between the two currencies.

In other words, this condition states the size of the forward discount or premium on a foreign currency should be equal to the interest rate differences between the countries in comparison. (Akram, Rime, Sarno, 2008)

$$(1 + i_{\$}) = \frac{F_t}{S_t}(1 + i_c)$$





## Hypotheses

- Hypothesis 1: Oil, Gold and the Dollar's flying to safety.

***Do oil and gold prices, the rate return of holding USD and the corresponding correlation change thru flight to safety events due to financial crisis, such as Lehman Brother's bankruptcy?***

- Hypothesis 2: Significant exchange rate's return factors.

***Are there a set of factors such as stock indices or interest rates that with their huge capital flows significantly influences the exchange rate return or is it influenced by the combined dataset of available factors?***

- Hypothesis 3: A financial crisis's impact on return factors.

***Does a financial crisis, such as Lehman Brother's bankruptcy, cause different pricing on the exchange rate return's factors?***

## Data & Methodology

The analysed dataset for this study is collected from various renowned sources, such as the Federal Reserve Economic Data, DataStream (Reuters) and Eurostat; all being reliable, public and known sources to provide independent information.

The selected data consists of daily observation stretching from 30-09-2004 to 30-09-2012. Starting in 2004 is rationalised to observe a major financial crisis – triggered by the insolvency of Lehman Brothers – and ending 2012 to balance the cyclicity of the. Also, the amount of observations and data will lower the random errors that might distort the dataset from a statistical point of view.



Any differences in availability of data in regards of date and or the seasonality of publishing this is resolved by following one major timeline (USD return) on which changes are noted and if no value or change is made that date holds most recent published value for the applicable series.

The data framework used and applied in this thesis consist of the studied exchange rate return by holding United States Dollars, commodity prices and other macro-economic indicators from the American and European markets. Main focus on macroeconomic indicators is American since the majority of all trading occurs in dollars as well as it is the current world reserve currency.

## Studied foreign exchange rate return

Foreign exchange rate between the United States Dollar and the European Monetary Union Euro analysed as reference for daily returns and in further, the return of holding USD versus the Euro conforms to the basis of the factor analysis, again due to reserve status.

(EUR/USD | Federal Reserve Bank of St. Louis, 2012)

## Interest rates

The daily overnight (T/N – tomorrow/next) interest rate for different currencies covered by the British Bankers Association (BBA) is published as ‘LIBOR’ – London Interbank Offered Rates.

Considered fundamental amongst financial benchmarks it serve as the interest base rate in contract and derivatives worldwide. Thomson Reuters calculates it as trimmed average based on data provided by major London banks. Basically, the LIBOR rate is an average interest rate between banks if they lend money to other banks and is viewed as a well-known reference rate. (BBA, 2012)

**EUR LIBOR T/N** acts as the benchmark for European Interest rates on commercial basis.

(EUR LIBOR | Federal Reserve Bank of St. Louis, 2012)

**USD LIBOR T/N** acts as the benchmark for European Interest rates on commercial basis.

(USD LIBOR | Federal Reserve Bank of St. Louis, 2012)

The interest rates are studied to analyse if there is any trace of exchange rate return fluctuations due to interest rate levels, which would be logically visible given interest rate parity.

## Commodities

Gold with its consistent and measurable mass infers that an ounce of gold today is the same as an ounce of gold was yesterday and exists in a limited scarce supply. Thus, given the historical demand for gold, it can be considered storage of purchasing power over time, especially interesting in the case of so called ‘safe havens’ during flight to safety events. (Hwan Kim & A. Dilts, 2011)



**Gold price fixing** - Gold is included since it may possibly be storage of value over time. It is also a major precious metal and fiercely traded in USD. (Gold | Federal Reserve Bank of St. Louis, 2012)

**Oil** is analysed to see if the price levels of the two main sources of world energy will have any effect on the return rate. The price level for **West Texas Intermediate Oil** acts as the benchmark for petroleum and its derivatives in the US. Characteristically, WTI, also known as Texas light sweet, is used as a grade of crude oil. (WTI | Federal Reserve Bank of St. Louis, 2012) Typically, Brent has a higher price than WTI crude oil, even though a difference in quality as less sulphur makes WTI easier to refine crude into gasoline. Brent is both heavier and contains more sulphur. Both are benchmarks used within oil pricing around the globe, but Brent is considered to be the global reference as WTI is more locally applied throughout the US. (Energy and Capital, 2012)

The price level for **Brent Oil**, acts as the benchmark for petroleum and its derivatives in the EMU. Brent crude is retrieved from the North Sea and is also classified as a sweet light crude oil. (Brent | Federal Reserve Bank of St. Louis, 2012)

## Stock indices

**EURO STOXX 50®** provides an industrial benchmark for the EMU, famous for being the leading blue-chip index for the Eurozone. The index covers fifty stocks from twelve Euro countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain. (EURO STOXX 50®, 2012)

**Dow Jones Industrial Average (DJIA)** is a well renowned market index for United States industry sector. Beginning as a twelve stock industrial average it has grown to a thirty stock average. Primarily, it is compiled by industrial manufacturers and consumer goods but in more modern time also including corporations in the entertainment business, financial sector as well as information technology. The DJIA is calculated as a price-weighted average. (DJIA | Federal Reserve Bank of St. Louis, 2012)

These two stock indexes are extensive and measure the average price development on both the European and the United States stock market. Therefore, it is an appropriate benchmark to use when measuring different movements in price performances between our respective markets, which may have effects on the exchange rate return due to the large capital flows in the stock market.



## Economic indicators

Economists who want to compare the living standards of one country to another or the wealth of one country over time often use gross domestic product (GDP). Designed to measure the value of a country's production of goods and services, the metric has for decades provided a critical framework to guide policy decisions that affect people's living standards. (Council on Foreign Relations, 2010)

**United States of America Gross Domestic Production**, measures the U.S. output and is the market value of goods and services produced within the United States. Measured on a quarterly basis this is published by the St. Louis FED. GDP is included as a proxy for the economic activity in the US market. (US GDP | Federal Reserve Bank of St. Louis, 2012)

**United States of America Consumer Price**, measures the U.S. changes in price levels and is a common gauge for inflation including all items. Data is published by the St. Louis FED on a monthly basis. This measure could be considered a proxy for the loss of purchasing power in USD over time. (CPI | Federal Reserve Bank of St. Louis, 2013)

**United States of America Trade weighted U.S. Dollar**, weighted average by trading partners, of foreign exchange rates versus the Dollar, include global currencies such as Euro, Canadian Dollar, Japanese Yen, UK Pound Sterling, Swiss Francs, Australian Dollar and Swedish Crowns. Measured on a weekly basis and published by St. Louis FED. Provides a gauge of trading activity and benchmarks the global capital exchange rate flows. (USD Index | Federal Reserve Bank of St. Louis, 2013)

**United States of America Non-Farm Payroll** measures employees currently hired in the U.S. and is a common market factor for analysing job creation and economic activity. Measured on a weekly basis this is published by the St. Louis FED. This provides an interesting gauge of the productivity and the employment level in the US market. (All Emp. | Federal Reserve Bank of St. Louis, 2013)

**United States of America Money Stock (M2)** measures the monetary stock on an aggregated level in the U.S. Measured on a weekly basis this is published by the St. Louis FED. This is included since it will grant a measurement of the supply of USD, which logically could affect returns. (Money Stock | Federal Reserve Bank of St. Louis, 2013)



**European Monetary Union (EMU) Gross Domestic Production** measures the EMU output and is the market value of goods and services produced within the EMU. Measured on a quarterly basis this is published by the European Union's official Statistics centre – Eurostat. GDP is included as a proxy for the economic activity in the European market. (Eurostat, 2012)

## Methodology

By applying quantitative analysis on the historical dataset; ranging from foreign exchange rates, returns on stock indices economic activity measurement - the objective is to analyse and possibly identify factor pricing that significantly influence (or not) the foreign exchange rate return between the Euro and the United States Dollar. Thus, by the scope of the financial theory incorporated within the aforementioned Arbitrage Pricing Theory it will be possible to evaluate time series using multiple regressions and capture any traces of factor pricing on the USD holding return.

The exchange rate was converted to yield of holding dollars daily return that is the basis for the factor pricing analysis. In order to illuminate the respective factor pricing, the dataset is analysed and possible combinations within the dynamics of the dataset, to identify relationships, especially on commodities to capture changes in allocation pattern due to investors' possible flight to safety.

Thereafter, following multiple regression and correlation analysis, the statistical factor significances are evaluated as well as the constructed regression model's ability to explain the factor returns.

## Limitations and demarcations of study

Given analysis of time series there are naturally possible sources of error; most significant being autocorrelation and multicollinearity. Remaining stringent with the relationships between variables and analysing the data in separate time series as well as one total, may mitigate such risk. In addition we have opted to use variables with over 2000 observations – eight years data - to create opportunity to compare boom versus bust periods, i.e. pre/post Lehman Brothers with enough data to grant diversification on seasonality over the midpoint in Lehman.



## Results and Analysis

- Hypothesis 1: Oil, Gold and the Dollar’s flying to safety.

**“Do oil and gold prices, the rate return of holding USD and the corresponding correlation change thru flight to safety events due to financial crisis, such as Lehman Brother’s bankruptcy?”**

Results showed that gold and oil were both negatively correlated versus the dollar, with the relationship suggesting that if there is a positive return on USD there should be a slight loss on gold/oil (and v.v.). Thus it is plausible that these assets are valued and priced in Dollars and not as a cross-trade between energy now and value over time.

2004-10-01 to 2008-09-15	USD	WTI	BRENT	GOLD
USD	1,00			
WTI	-0,17	1,00		
BRENT	-0,20	0,54	1,00	
GOLD	-0,26	0,09	0,19	1,00

Table 1: Correlation matrix USD vs. WTI/BRENT/GOLD returns 2004-2008 – Pre Lehman

2008-09-15 to 2012-10-30	USD	WTI	BRENT	GOLD
USD	1,00			
WTI	-0,35	1,00		
BRENT	-0,41	0,58	1,00	
GOLD	-0,26	0,13	0,18	1,00

Table 2: Correlation matrix USD vs. WTI/BRENT/GOLD returns 2008-2012 – Post Lehman

However, it was noted that these relationships differ significantly pre/post Lehman, supporting our hypothesis and the flight to safety schematics as mentioned by Baele, Bekaert, Inghelbrecht and Wie, 2012. Consequently, a cross-rate ratio was calculated between oil and gold – barrels of oil per an ounce of gold – to illustrate any impact of the financial crisis on these assets inherent relationship.

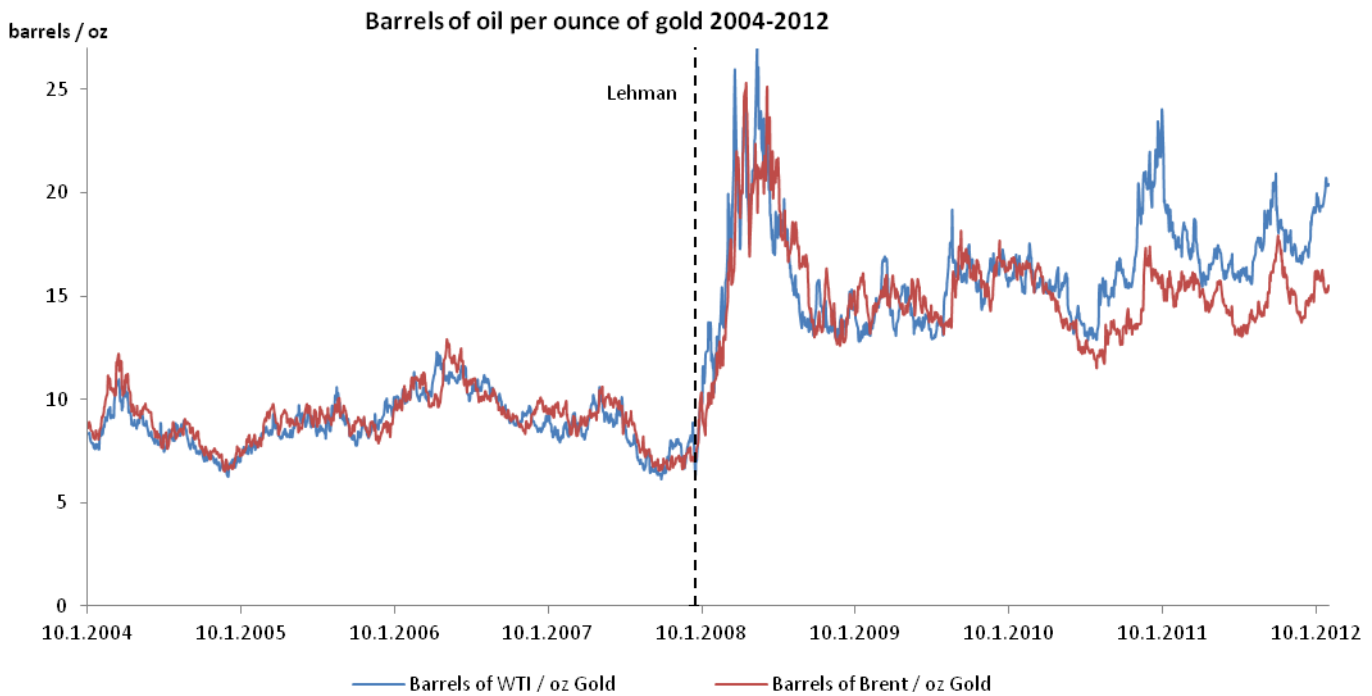


Figure 1: Cross rate ratio barrel of Oil (WTI/Brent) per ounce of Gold - per price fixing USD.

Fascinatingly, it is shown in figure 1 that volatility in this relationship exploded after Lehman and that oil has depreciated significantly in terms of gold also supporting the flight to safety schematics as mentioned by Baele, Bekaert, Inghelbrecht and Wie, 2012.

At the end of the year 2008 one ounce of gold equalled 25 barrels of oil, compared to an average of 10 between 2004 & 2008. Thereafter, levels have withdrawn but remain at 1,5 - 2 times the pre-Lehman level.

Also, it is interesting that this illustrates the correlation between Brent and WTI as observed in the correlation matrixes above. The relationship between oil and gold does however also indicate that Brent is worth more than WTI since fewer barrels of Brent is required to obtain one ounce of gold, even though Brent is often referred to having lower quality – since WTI is more of a local index for the US, one could infer that oil demand vs. supply has risen in the world, except in the US, as displayed by the higher spread.

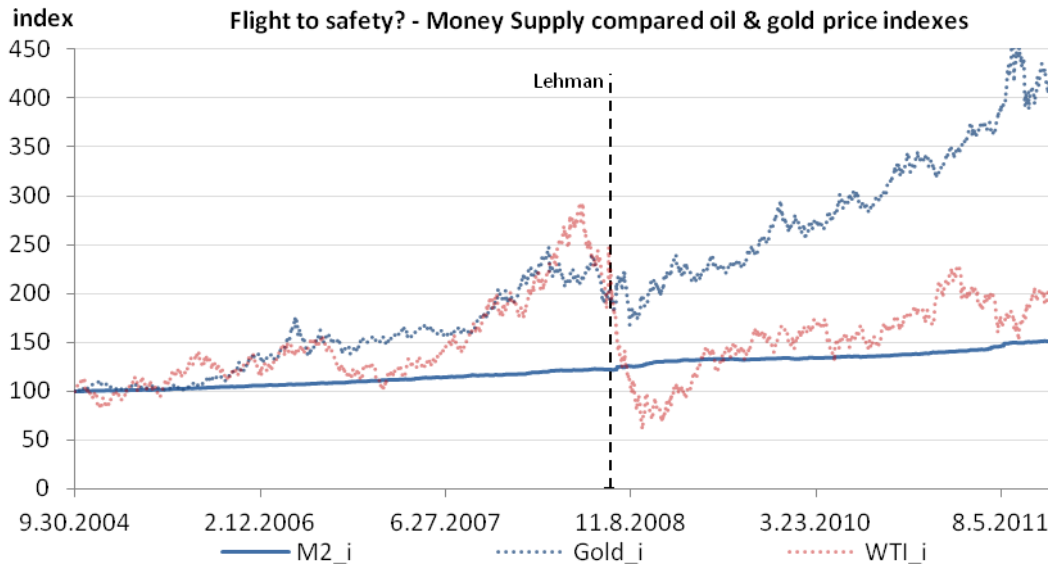


Figure 2: Indexed change of M2 (Money Stock), Gold spot prices and WTI prices indexed from 2004-09-30.

Comparing the growth patterns indicate that the money stock of USD is steadily increasing with oil following the same trend, however with additional volatility. Gold on the other hand has grown at a significantly higher rate, which is depicted in the sharper rise of the dotted blue line (Gold index: Gold\_i in figure 2). Money supply and WTI has increased by almost 40 per cent since Lehman while Gold has risen from 200 to almost 430 – an increase by more than twofold.

By observing the graph above (figure 2) it seems evident that gold has appreciated significantly versus both oil and the USD, also supporting that the financial crisis surrounding Lehman Brothers' bankruptcy could have inspired investors to fly to safety. Noteworthy, the results are similar as the ones reached by Baele, Bekaert, Inghelbrecht and Wie, 2012 and Kim & Dilts, 2011; with the exception that oil does not seem to have been considered a safe have asset during the studied period herein, in contrary to Hwan Kim & A. Dilts findings.

- Hypothesis 2: Significant exchange rates return factors.





Regression Model '04-'12	R <sup>2</sup>	Adjusted R <sup>2</sup>	Significance level	Conclusion ( $\alpha = 0,05$ )
Interest rate factors LIBOR USD & EUR	0,001	0,000	0,447	<i>Not statistically significant</i>
Wealth Factors US & EU GDP, Stock indices	0,002	0,000	0,466	<i>Not statistically significant</i>
<b>Combined factor model, complete variable set</b>	<b>0,038</b>	<b>0,032</b>	<b>0,000</b>	<b><i>Statistically significant</i></b>

Interestingly, while comparing significance of regression models including an interest rate model, a wealth & GDP model as well as a combined model with all factors, it became evident that the interest rate and wealth models did not yield any significant results at all. Thus, only the combined model display significance and yielded any applicable factor pricing – although with a low overall explanatory power, as adjusted “R-square” is just over three per cent.

Possibly, the insignificance of the interest rate model is due to that the overnight LIBOR rate is not a really a significant rate in the daily return of the dollar. Also, behind the lack of results could be due to autocorrelation, multicollinearity or timing as LIBOR could influence changes on FX in future days. Also, Insiders might be hedging their position early in the futures market to benefit from possible trade flows. Another possibility is that reported rates might not be actual traded rates in these currencies, as LIBOR is an average of reported rates and there have recently been lots of media discussions on possible LIBOR manipulation, where traders posted rates that benefited them. LIBOR rates are also available in many terms and there are other interest rates in the market.

Gross Domestic Product is a difficult factor to measure, often lagging with publication with numerous analysts worldwide constantly updating and adjusting their numbers, models and trades. Given this continuous adaptation, this could be a force inducing traders to change positions on the FX-market daily, possibly in futures as well, which could explain why the return of the daily USD is not influenced by the quarterly changes in published GDP data. In regards of the stock indices, they could become insignificant if these indexes hold too many global companies. Thus, these multinational corporations may possibly be superseding currency risks and influence as their business is global in all currencies.



Standardized

Combined Factor Model 2004-2012	Factor Sensitivity	Std. Error	Coefficients	T-test	Significance
<b>Constant Slope</b>	<b>-0,092</b>	<b>0,039</b>		<b>- 2,353</b>	<b>0,019</b>
<b>WTI Oil price</b>	0,000	0,000	0,099	- 4,024	0,000
Employment data US	0,000	0,000	0,229	0,919	0,358
<b>DJIA stock index</b>	0,000	0,000	- 1,858	3,109	0,002
<b>US Money Stock (M2)</b>	0,000	0,000	1,373	- 5,259	0,000
<b>Core price inflation US</b>	<b>0,001</b>	0,000	- 0,391	4,443	0,000
<b>USD FX Trade index</b>	<b>-0,001</b>	0,000	- 0,063	- 5,506	0,000
EU GDP	0,000	0,000	0,521	- 0,881	0,379
<b>US GDP</b>	0,000	0,000	- 0,701	2,007	0,045
<b>Eurostoxx stock index</b>	0,000	0,000	- 0,393	-6,594	0,000
<b>Interest Rate Libor EUR</b>	<b>-0,002</b>	0,001	0,253	-3,309	0,001
<b>Interest Rate Libor USD</b>	<b>0,001</b>	0,000	- 0,527	2,391	0,017
<b>Gold price</b>	0,000	0,000	0,151	-3,115	0,002
Brent Oil price	0,000	0,000	- 0,524	0,944	0,345

*Dependent Variable: USD return, red marks not significant factor in combined model*

Despite the model being significant in its whole one can observe that three factors are insignificant; Non-farm employees in the US (USEMP), Gross domestic production in the EU (EUGDP) as well as Brent oil prices (BRENT). Gross domestic production for the United States is almost not significant with a p-value of 0,045. GDP and Non-farm employee’s factors are most likely not significant due the timing and lag effect of the corresponding data. However, the Brent could be reviewed as the European side of the WTI, with significant correlation them between, as captured in hypothesis 1, and may not be that influential on US exchange rate return as the US have a local trade index - WTI.

Greatest standardised factor sensitivity, i.e. a change of one standard deviation of the factor, is found with the negative Money stock factor, closely followed by positive Consumer price index (1,373, USCPI). Hence, these results suggest that the currency market was sensitive to shocks in the Money Stock and inflation data, in line with inflationary and interest rate parity in the global market. Also, there is evidence of a significant constant negative slope, thus meaning that, ceteris paribus, the USD return rate is negative over the time-period.



➤ Hypothesis 3: A financial crisis's impact on return factors.

Regression Models Pre/Post L	R <sup>2</sup>	Adjusted R <sup>2</sup>	Significance level	Conclusion ( $\alpha = 0,05$ )
CFM, complete variable set <b>Pre</b> Lehman	0,050	0,040	0,000	<b><i>Statistically significant</i></b>
CFM, complete variable set <b>Post</b> Lehman	0,060	0,040	0,000	<b><i>Statistically significant</i></b>

Moving forward, by dividing the model into a pre- and a post-Lehman time series, the power of each model improved. Thus supporting that there is a possible cycle effect inside of the dataset, as it was able to achieve higher power to predict the return even though it is a smaller sample. Given that there were noteworthy differences between the pre/post periods, the factor sensitivities were further analysed and it was concluded that the statistical significant factors were different when comparing 2004-2012, 2004-2008 and 2008-2012.



Combined Factor Model 2004-2008	Factor	Standardized			
	Sensitivity	Std. Error	Coefficients	T-test	Significance
<b>Constant Slope</b>	-0,060	0,110		-0,560	0,570
<b>WTI Oil price</b>	0,000	0,000	<b>-0,980</b>	-2,700	0,010
Employment data US	0,000	0,000	0,030	0,080	0,940
<b>DJIA stock index</b>	0,000	0,000	-0,420	-1,950	0,050
US Money Stock (M2)	0,000	0,000	-0,170	-0,280	0,780
<b>Core price inflation US</b>	0,000	0,000	<b>0,700</b>	1,960	0,050
<b>USD FX Trade index</b>	0,000	0,000	-0,550	-4,090	0,000
EU GDP	0,000	0,000	-0,090	-0,800	0,420
US GDP	0,000	0,000	0,810	1,790	0,070
Eurostoxx stock index	0,000	0,000	0,060	0,270	0,790
Interest Rate Libor EUR	0,000	0,000	-0,310	-1,650	0,100
Interest Rate Libor USD	0,000	0,000	-0,110	-0,760	0,450
<b>Gold price</b>	0,000	0,000	-0,650	-3,630	0,000
Brent Oil price	0,000	0,000	0,380	1,090	0,280

*Dependent Variable: USD return, red marks non-significant factor in combined model*

During the period 2004-2008, WTI and core price inflation data were the main drivers of the return rate with significant influence; WTI was highly negative and had a depreciating effect while inflation had a slightly weaker but positive influence. Thus displaying that the market was closely linked to the current prices changes in oil but also in the future expectation of price increases thru inflation. Gold, USD foreign trade index and Dow Jones were also significant and negative factors, possibly also linked to the only positive effect of inflation that would gauge short-term historic price changes.



Combined Factor Model 2008-2012	Factor	Standardized			
	Sensitivity	Std. Error	Coefficients	T-test	Significance
<b>Constant Slope</b>	-0,050	0,080		-0,560	0,580
WTI Oil price	0,000	0,000	-0,220	-1,400	0,160
Employment data US	0,000	0,000	0,200	1,590	0,110
DJIA stock index	0,000	0,000	<b>0,700</b>	2,880	0,000
US Money Stock (M2)	0,000	0,000	<b>-1,380</b>	-4,230	0,000
Core price inflation US	0,000	0,000	0,590	1,970	0,050
USD FX Trade index	0,000	0,000	-0,500	-5,210	0,000
EU GDP	0,000	0,000	-0,010	-0,290	0,770
US GDP	0,000	0,000	0,090	0,340	0,730
Eurostoxx stock index	0,000	0,000	<b>-0,610</b>	-5,240	0,000
Interest Rate Libor EUR	0,000	0,000	-0,360	-2,810	0,010
Interest Rate Libor USD	0,000	0,000	0,060	1,240	0,220
Gold price	0,000	0,000	-0,280	-1,690	0,090
Brent Oil price	0,000	0,000	-0,180	-0,820	0,410

*Dependent Variable: USD return, red marks not significant factor in combined model*

On the other hand, throughout the period 2008 to 2012, the most significant factor is the US money stock with a very high influence in the model, followed by other significant factors such as interest rate (LIBOR) in EUR and shared factors with 2004-2012 as inflation, USD trade weighted FX as well as the Dow Jones I.A. index. All of the shared factors displayed similar but lower model sensitivity, except Dow Jones I.A. Index that actually increased from -0,420 to 0,700. Thus, the US stock indices have actually transitioned to a positive influence on the exchange rate. Yet again, these findings suggest that the market is supply sided and looking for any traces of USD being hold and the overall quantity, and the Dow Jones supposedly influences the exchange rate return more than the inflation data – which in itself shows a major shift in the market.

## Conclusions

Accordingly, we are able to gather that the USD's return – delimited by Lehman – contains a change in the mind-set in Dollar investors, as different factors apparently are valued differently before and after the crisis. Prior to the crisis, oil inflation and gold were key drivers – in line with an expanding inflationary economy where the currency would depreciate as the purchasing value diminishes, thus being a demand side driven market. Following the crisis, the sensitivity is highly skewed towards money stock and stock indices, proposing that the market is more supply-focused where return is further governed by the amount of Dollars visible in the capital market.



Further expanding the research of Solnik, 1982, Ross, 1976, Cho, Eun & Senbet, 1986, as well as Lustig, Roussanov and Verdelhan, 2011 et al, we can clearly observe that the Arbitrage Pricing Theory and multiple regression provided a sound framework that allowed different models – interest rates, wealth factors and the combined model (including all variables in the dataset) – of which only the combined model was found significant and that displayed findings that suggest that the bankruptcy on September 15<sup>th</sup> 2008, may have shocked the market. Thus, this leads us to question if the market is as informed and efficient as theory predicts, as this would have been priced in, in a completely informed and efficient market?

Logically, the findings in this thesis points out that the relationships and significant factors are changing over time, which could be in fact be linked to different parts of a business cycle and/or external shocks to the market. However, since the market's factor sensitivities are different between the periods analysed, and that e.g. Dow Jones Industrial Index went from a negative influence on the return to become the highest positive factor – stronger than inflation.

Given that the currency model overall has a low explainability it is difficult to infer on the individual factors in detail but our results clearly display that the foreign exchange market has changed. Possibly linked to the gold price growth disconnect from the USD, maybe due to a flight to safety as investors are cautious about holding Dollars, as discussed by Baele, Bekaert, Inghelbrecht and Wie, 2012; any such change in psychological and/or behaviour mechanism for the appraisal of assets' return and risk would have an immense impact in the pricing mechanism and given the American markets size and financial power could be influenced and shocked by its own financial weight and power, and as Strange, 1990 established, the sheer size of the US financial power might have caused markets to react in fear of an implosion of the market itself, possibly setting of various flight to safety movements and re-evaluations of risk everywhere. Also, it is evident that the market has been more sensitive to changes in money stock during 2008-2012 that may be linked to the bailouts and government interventions.

Overall, the results are in line with what was expected since the dollar is a crucial part of the world's economy and thus the world influences the USD and vice versa, all in line with Strange's weighting of the financial powers in the world. The key conclusion that the market factor pricing is different before and after the Financial Crisis adds to the understanding of contemporary currency evaluation and the impact of a crisis.



## Suggestions for further studies

- Further study the intricate relationship between oil and gold and extending the study to include other interesting money market measures. Close link to money stock could suggest a significant link to the credit system, wherein the shadow banking and expanded money stock might be an interesting growth factor to compare.
- Broaden view on different interest rates – different setups using a larger term structure than daily. Also expand and analyse the effect of key interest levels set by central banks, such as the Federal Reserve Banks reserve rate.
- Factoring differences and re-pricing on the futures and/or derivatives market.
- Expanding the models by adding more factors to the analysis, possibly more currencies, additional economic measures and try to improve the models performance.

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