The relationship between carry trade currencies and equity markets, during the 2003-2012 time period

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Summary

One of the most popular investment and trading strategies over the last decade, has been the currency carry trade, which allows traders and investors to buy high-yielding currencies in the Foreign Exchange spot market by borrowing, low or zero interest rate currencies in the form of pairs, such as the Australian Dollar/Japanese Yen (AUD/JPY), with the purpose of investing the proceeds afterwards into fixed-income securities.

To be able to determine the causality between the returns of equity markets and the foreign exchange market, we choose to observe the sensitivity and influence of two equity indexes on several pairs involved in carry trading. The reason for studying these relationships is to further explain the causes of the uncovered interest parity puzzle, thus adding our contribution to the academic field through this thesis.

To accomplish our goals, data was gathered for daily quotes of 16 different currency pairs, grouped by interest differentials, and two equity indexes, the S&P 500 and FTSE All-World, along with data for the VIX volatility index, for the 2003-2012 period. The data was collected from Thomson Reuters Datastream and the selected ten year span was divided into three different periods. This was done in order to discover the differences on how equity indexes relate to typical carry trade currency pairs, depending on market developments before, during and after the world financial crisis.

The tests conducted on the collected data measured the correlations, influences and sensitivity for the 16 different currency pairs with the S&P 500 Index, the FTSE All-World index, and the volatility index between the years of 2003-2012. For influences and sensitivity, we performed Maximum Likelihood (ML) regressions with Generalized Autoregressive Conditional Heteroscedasticity (GARCH) [1,1], in Eviews software.

After analyzing the results, we found that, during our chosen time period, the majority of currency pair daily returns are positively correlated with the equity indexes and that the FX pairs show greater correlation with the FTSE All-World, than with the S&P 500. Factors such as the interest rate of a currency and the choice of funding currency played an important role in the foreign exchange markets, during the ten year time span, for every yield group of FX pairs.

Regarding the influence and sensitivity between currency pairs and the S&P 500 with its VIX index, we found that our models explanatory power seems to be stronger when the interest rate differential between the currency pairs is smaller. Our regression analysis also uncovered that the characteristics of an individual currency can show noticeable effects for the relationship between its pair and the two indexes.

Keywords: carry trade, correlation, currency, equity indexes, financial crisis, foreign exchange, risk premia, uncovered interest parity, volatility, S&P 500, FTSE All-World, VIX.
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Chapter 1: Introduction

The purpose of this first chapter is to introduce a well described theoretical background of the research problem to the reader, as well as providing a clear and delimited outline of the focus, thus transitioning towards stating the research questions and purpose of study (U.S.B.E., 2013).

1.1 Problem Background

The currency carry trade has been one of the most popular investment and trading strategies over the last decade, especially the Japanese Yen (JPY) carry trade, because it allows traders and investors to buy high-yield currencies in the Foreign Exchange (FX) spot market, such as the Australian Dollar (AUD) and the New Zealand Dollar (NZD) with borrowed Japanese Yens for a very low or zero interest rate and investing the proceeds afterwards into fixed-income securities, according to Liu M. et al. (2012, p. 48).

For over a decade, the JPY had the lowest interest rate in the world, which made it one of the most popular funding currencies, in contrast to AUD, GBP and NZD that provided high yields, making them desirable investment currencies.

Together with the rise in popularity of easily accessible internet based margin trading platforms from brokers such as fxcm.com or forex.com, retail traders are gaining access to currency trading and benefits like small bid/ask spread and high leverage, which are not reserved anymore just for institutional traders and investors such as banks or hedge-funds. The nature of carry trading implies the use of leverage, as it allow the trader to provide a very small collateral for the ability to control large positions, however, high leverage can be a double-sided factor, increasing gains as well as losses. Adverse movements can lead to margin calls which might force the closure of trades if not topped up, thus realizing the paper losses. Being an essential feature of the carry trade, leverage creates volatility in the currency markets, according to Liu M. et al. (2012, p. 49).

When talking about carry trading, one of main factors involved is the interest rate, which allows for it to exist in the first place. The higher the interest differential between two currencies is, the more appealing that pair becomes for investors of all kinds to involve themselves in carry trading. In 2003, the pair to invest in was NZD/JPY, generating 5.75% interest for bulls in the market. However, the recent global financial crisis had an unprecedented impact on the financial markets, causing previous gains accumulated in four years of uptrends to vanish in almost half the time during 2007-2009, forcing investors with open positions in high interest generating pairs to unwind their carry trades as well. After the crisis made its mark, uptrends started once again and the carry trade became profitable once more. Although interest rates had fallen, the most appealing pair due to its interest differential being AUD/JPY, which generated only 2.9% in interest.

In the following chapters, an in depth explanation of the theories behind carry trading, will show that in reality, the markets don’t always respect logic and put forward puzzles, on which investors can capitalize by exposing themselves to certain risks.
1.2 Problematization and Research Questions

In theory, it should not be possible to generate profits through carry trading, as an investment strategy. This is due to the uncovered interest parity theory (UIP) which states that in a rational and risk-neutral world, all of the possible arbitrage opportunities in exchange rates should vanish when the exchange rates of currencies adjust, according to Menkhoff, et al. (2011, p.1). However, there is scientific proof that in reality UIP does not hold and this anomaly is regularly exploited by participants, thus making the puzzle a persistent fact in the foreign exchange markets.

Due to this well documented puzzle, we try to provide new information on the relationships between returns of currency pairs involved in carry trading and returns of equity indexes and volatility for the periods before, during and after the recent world financial crisis. By reviewing formerly conducted research and relevant data relating to our topic, we will form research questions which will support our research and work as a backbone through the whole thesis. Our research questions are:

1. What is the relationship between daily returns of carry trading currencies, equity indexes and volatility before, during and after the recent world financial crisis?

2. Are daily returns of some currency pairs more sensitive or greater influenced than others, by equity returns and volatility?

As these research questions are very specific, they will act as hypotheses throughout the thesis. We think that after studying relevant scientific material and previous research papers we will answer the two research questions from our perspective and through this, bring our contribution to some of the researched material.

1.3 Purpose of Research

As stated in the previous section, we want to study the relationship between carry trade currencies and equity markets, during the 2003-2012 time period. We recognize that the UIP puzzle exists in the foreign exchange markets, and for that reason the market participants can exploit the situation. We choose to study the relationships, influences, and sensitivities of carry trade returns to equity indexes returns, as well as volatility. During the past ten years, between 2003 and 2012, the financial markets have experienced large amounts of fluctuation, thus giving us a reason to choose this certain period to gather our data from. In some parts of our thesis, we divide the data in three different sections so that we could measure the differences between the periods.

The reason why we choose to observe the sensitivity and influence of indexes on carry trading returns is that, this way, we can show the causality between the returns of equity markets and the foreign exchange market. We consider that, by studying these relationships, we can further explain the implications of the UIP puzzle and add our contribution to the academic field.
1.4 Limitations

While conducting our research, we became aware of certain limitations, in regards to our collected data and some of the regression results, and would like to explain them for readers of this paper, in order to bring clarity.

The collection and use of data, in the form of daily price quotes for financial instruments, in favor of weekly ones, brings some advantages, as well as disadvantages. The reasoning behind our choice of daily data instead of weekly is that the former allows for a more exact calculation of the required results, while the latter, lower frequency data does not capture short term demand shifts caused by market fluctuations. A minus, however, is that daily quotes may include noise, when considering a long period, such as ten years of price data.

Another limitation is found in our regression results, which display negative adjusted R$^2$ values for some of the currency pairs. This might suggest that for those certain scenarios, our model does not fit perfectly and the use of some other model may be appropriate.
Chapter 2: Methodology

This chapter describes the methodological assumptions used within the adopted research strategy and design, the data collection methods employed, as well as the quality criteria that we took into consideration and ethical principles that guide this thesis.

2.1 Methodological Assumptions

An essential requirement before going further with the literature review, empirical findings and analysis chapters is that of determining the method used to conduct research for this thesis and to establish our epistemological orientation and ontological perspective of reality.

Because we will be dealing with the comparison and analysis of numerical data comprised of historical quotes, the appropriate method to be employed is a quantitative one. Since our thesis uses the quantitative method, our principal orientation for the role of theory and research is deductive. This means that we will be testing a theory in our research, unlike in a situation of inductive orientation where the theory is the outcome of the research, according to Bryman & Bell (2011, p. 27).

Referring to the same two authors, in regards to our epistemological orientation, this thesis is on the side of positivism, advocating the use of methods of the natural sciences while studying social reality. Our ontological orientation is objectivism, implying that social phenomena and its meanings exist independently from social actors, according to Bryman & Bell (2011, p. 21). This means that in our research methodology the data and empirical findings are assumed to have an existence independent of us.

When talking about the subject of epistemology and ontology, one has to take into account Burrel & Morgan’s (1985) theory of the four research paradigms. The concept of paradigm is attributed to Kuhn (1970) who considers that a paradigm is a cluster of beliefs and dictates, which influences, for scientists of a certain discipline, the object of the study, the way in which research should be conducted and how results should be interpreted. Due to their contrasting assumptions and methods, the paradigms are inconsistent with one another, or incommensurable.

To construct the four research paradigms, Burrel & Morgan (1985) classify research into two dimensions. The first one is a subjective-objective dimension, while the second one deals with the purpose of research, which can be approached from a Regulation or Radical change point of view. The former suggests research should refrain judgment when describing phenomena, while the latter considers judgment, on the state of things, the actual purpose of research. Due to the approach of this thesis towards epistemology and ontology, we find ourselves on the Objective side of the first dimension, with a Regulatory view of the second dimension.
Table 1. The four paradigms of research

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<thead>
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<th>Subjective</th>
<th>Objective</th>
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<tr>
<td>Radical Humanist</td>
<td>Radical structuralist</td>
</tr>
<tr>
<td>Interpretative</td>
<td>Functionalist</td>
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</table>

REGULATION

With the previously given information and the table above, we can clearly say that the approach of this thesis towards the desired study is a Functionalist one, which is also the traditional research method used in finance.

2.2 Research Design

According to Bryman & Bell (2011, p. 40), the research design constitutes a framework for the collection and analysis of data, as well as establishing why research should be conducted in regards to the chosen topic. The five prominent research design are named experimental design, cross-sectional design, social survey, longitudinal design, comparative design and case study.

For a better understanding of our choice of research design, a short explanation of each will follow. The experimental design eliminates alternative explanations of results deriving from it by administering a random assignment to a control group and to an experimental group exposed to a treatment. The cross-sectional design aims to collect quantitative data, at a single point in time, on more than one case, in order to examine two or more variables. The survey research is a type of cross-sectional design with similar characteristics, except for the collection of data which is done through structured interview or self-completion questionnaire. When using the longitudinal design, a researcher collects data of a sample on at least two different points of time for further analysis. The comparative design uncovers contrasting results by comparing two or more cases with the purpose of generating theoretical insights. The case study design analyses a single case in a detailed and intensive manner and for comparative purposes can be extended to include two or three cases, according to Bryman & Bell (2011, p. 712-719)

In our thesis we study and analyze the daily data for currency pairs used in carry trading, as well as two equity indexes and one volatility index between the years of 2003-2012. This advocates that the most suitable research design for our thesis is a longitudinal one. In our sample, we have 2604 active trading days on which we have collected data for further analysis. We also divided the data into three different periods described as before, during and after the global financial crisis, so it is efficient to have a design type which enables us to have a credible way for comparison of results. The basic idea of the longitudinal design is described visually, in the table below.
According to Bryman & Bell (2011, p. 58), the longitudinal design can be refined with two different subcategories: the panel study and the cohort study. The difference between these two lies in sampling. For the panel study, the researcher chooses a sample, which often is a random one and studies it on at least two occasions. The cohort study also studies the sample during two different occasions but the sample generally shares certain characteristics similar to one another. Our longitudinal design lies more on the side of panel study, since we have fixed samples for the whole period of ten years and we investigate how the samples correlate and act with each other during different periods of time, as well as during the whole period.

Due to the panel study’s concern with improving the understanding of causal influences over time, our choice of a longitudinal design is clearly supported by the advantage it has over cross-sectional design, in regards to better managing the ambiguity over the direction of causal influence.

2.3 Research Strategy

The general orientation one has while conducting business research is called a research strategy. According to Bryman & Bell (2011, p. 26), there are two directions in which research can be carried, although the distinction between them is ambiguous.

The quantitative research emphasizes quantification in the process of collecting and analyzing data by approaching the relationship between theory and research from a deductive standpoint, following the natural scientific model and incorporating positivism, as well as viewing social reality from an external, objective perspective. In opposition, the qualitative research strategy places emphasis on words instead of quantification, in the process of collecting and analyzing the data. The relationship between theory and research is approached from a theory generating, inductive standpoint. Instead of embracing the natural scientific model, qualitative research emphasizes the individual's interpretation of the world, asserting that social phenomena and their meaning are being accomplished by social actors in a continuous way.

As stated in methodological assumptions, our thesis uses the quantitative approach. The use of a this approach implies that our research strategy is a deductive one, meaning that we proceed from general to more specific, while the theory leads to findings and observations, according to Bryman & Bell (2011, p. 13). The process of deduction described by the same two authors, starts from the chosen theory, followed by the research questions derived from theory. Afterwards, one should proceed with data

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<td>Obs$_n$</td>
<td>Obs$_n$</td>
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</table>

*Table 2. Structure of longitudinal design*

*Source: Adaptation from Bryman & Bell (2011, p. 58)*
collection and receive findings through that. In the last phase of the process of deduction the research questions should be answered and through that, the theory should be revised, if needed.

For this thesis, the process of deduction follows the above mentioned steps by choosing and describing relevant theories and concepts, such as the uncovered interest rate parity theory, the forward premium puzzle, the time varying risk premia and the carry trade strategy, from which it deduces research questions presented in Chapter 1. After the empirical findings are analyzed and discussed, the proposed research questions will be answered in the conclusions chapter.

2.4 Data Collection Methods

The data collection methods employed for this thesis rely strongly on numerical data gathered from Thomson Reuters Datastream, from which we collected quotes for 16 different currency pairs, two different equity indexes, and one volatility index. For the period between 6th of January 2003 and 31st of December 2012, the data is entirely available in Datastream and can be viewed to be robust for our analysis of the relationships between them, during the ten year period. The data collection method employed in this thesis is quantitative content analysis.

Quantitative content analysis, as described by Bryman & Bell (2011, p. 291) refers to the analysis of documents and texts in a systematic and replicable manner that seeks to quantify content in terms of predetermined categories. We find this type of data collection method to be highly relevant for this type of thesis since it is extremely transparent and it easily follows our choice of longitudinal research design. In the thesis, we will take into consideration the certain limitations of content analysis, using criteria recommended by John Scott (1990). First off, we will only use authentic information, meaning that the data and documents are what they are supposed to be. Secondly, the issue of credibility is highly regarded, in order to have valid and unbiased data. Finally, the representativeness is taken into account to avoid the use of unavailable information or information that does not exist anymore.

Datastream can be viewed to be a credible source for data collection, as it is a widely used databank for historical financial content owned by Thomson Reuters Corporation, which is one of the largest companies in the field of media and information industry (Thomson Reuters, 2013). We consider that, by using Datastream as a source for our data for quantitative content analysis, we can satisfy all of the Scott’s (1990) three criteria recommendations in a credible academic way.

2.5 Quality Criteria

The quality of our findings while conducting quantitative research is guided by three main criteria, as depicted from Bryman & Bell (2011, p. 157). These are reliability, replicability and validity, each with different contributing factors.

Reliability entails the consistency of concept measuring and one has to take into consideration three contributing factors towards this criteria. Stability of measures over time gives confidence in the study results, while internal reliability answers the question of whether the indicators are consistent and the degree of dependability of results to
one-another, on different indicators. Finally, inter-observer consistency plays a less important role in this thesis because of the lack of subjective judgment involved in the process of collecting and categorizing data. Replicability is linked to internal reliability and is concerned with the degree of to which the study results can be reproduced.

When we include the three contributing factors to our quality criteria we can say that reliability is treated with the highest possible appreciation. According to Bryman & Bell (2011, p. 158), most of the research findings do not carry out the test of stability and for that reason the longitudinal research method is often used so that social changes and correlations could be identified. This helps us, in our research, to achieve a higher level of stability as our choice of the longitudinal research design, lets us identify the changes and correlations between carry trade currency pairs and the chosen indexes, over the observed ten year period.

Our data consists of daily returns for the observed variables, instead of weekly or annual returns, in order to achieve the highest possible level of truthfulness about the correlations between the chosen currency pairs and indexes. In this thesis, we secure internal reliability by applying correlation and regression methods for our data. We calculate the correlation and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) for the currency pairs and chosen indexes. The methods chosen for analysis are presented in a more detailed manner in section 4.1. The replicability of our results is, in our opinion, well enabled for further research. We clearly present the time period, the research objects, the analysis methods, and the sources where we gathered the data from.

An important part of the quality criteria is the validity of the results. According to Bryman & Bell (2011) the main types of validity are measurement validity, internal validity, external validity, and ecological validity. In this paper, we study the relationships between the carry trade currencies, two equity indexes, and one volatility index in a quantitative way, thus the most significant type of validity for us is measurement validity.

The measurement validity criteria are established in several ways and show whether an indicator measures the concept for which it was developed. The main types of measurement validity according to Bryman & Bell (2011, p. 160) are face validity, concurrent validity, convergent validity, and construct validity. The measure devised by a researcher should reflect the content of the concept for which it was created, thus achieving face validity. Concurrent validity is tested by employing a contemporary criterion on cases that differ, while the use of a future criterion tests predictive validity for a certain measure. Estimating convergent validity is done by comparing the measure of a concept to measures of the same one, but devised through other methods. Finally, the concept of construct validity plays an important role in this thesis, as relevant theory is used to deduce the hypothesis about the chosen topic.

Other main types of validity are also thought in the thesis. As internal validity concerns if causal relationships between variables hold water, we have used logical and transparent methods which are clearly presented through the paper. We measure the relationships, sensitivities, and influences between the 16 currency pairs, dependent variables, and the chosen indexes, which are independent variables. The external validity deals with whether the research results can be generalized over the research
context. According to Bryman & Bell (2011, p. 165), external validity is quite strong with our chosen longitudinal research design, thus we feel that our findings can be used beyond this thesis, for further research. The ecological validity concerns with the question if the findings can be applied to people's normal life. Our findings show poor relation to everyday social settings since the knowledge about currency pairs daily returns relation to daily returns of equity indexes do not make any person’s everyday chores any easier.

As a conclusion, we feel that we obey the quality criteria explained in this subchapter and show respect to academic standards by applying reliability, replicability, and validity measures in our thesis.

2.6 Ethical Considerations

Diener & Crandall (1978) state four main ethical principles that should be followed with respect to participants involved in a research study. These standards are equally important and stated as: do no harm to participants, whether it is physical harm, stress or harm to self-esteem and career development, as well as inducing reprehensible actions on their part, avoid lack of informed consent by fully briefing all participants about the research process they will take part in, respect the respondents values regardless of the study objective by not invading their privacy and aim to avoid or minimize deception in order to gather more information by not misrepresenting the research as something else.

We are confident in saying that the principles mentioned above have been given the proper attention and respected in detail, due to the publicly available nature of the data used throughout the research conducted for this thesis, as well as the fact that actual people are not involved in our study because we only deal with numerical data.
Chapter 3: Literature Review

In this chapter, we review previously conducted scientific research and literature from the field of Foreign Exchange markets and, namely carry trading, in order to adapt a thorough understanding of our topic and research questions. Our source of scientific articles is the ScienceDirect electronic database, from which we selected relevant academic articles. Due to the fact that we investigate the relationship between daily returns of currencies involved in carry trading and global equity indexes and the regression of currencies in relation to equity returns and volatility, it is highly relevant to present the main theories related to carry trade regimes.

First, we present the uncovered interest rate parity theory (UIP) and the forward premium puzzle in order to give the general idea about the main theory used in this thesis and follow with presenting the main findings of previous research relating to different solutions for UIP puzzle. Among the literature of UIP and forward premium puzzle, we reviewed the past literature of carry trade strategies, liquidity and volatility in the foreign exchange markets, time-varying risk premia, and finally conclude the chapter by reviewing the literature on the subject of correlations between the foreign exchange markets and equity markets.

We will present the most relevant theories and characteristics, so that we have a strong upholding backbone for our empirical findings, data, and conclusions in later chapters. The review of previous literature aids us in our own scientific research about carry trade schemes between the years of 2003-2012, since it lets us compare previous findings of others to our findings, ensuring the robustness of the results presented.

3.1 Uncovered Interest Parity and Forward Premium Puzzle

Carry trades are considered risky because of their high leverage nature in which a trader invests in high interest rate currency pairs denominated in low interest rate borrowed currency. To earn profit through these interest arbitrage trades the UIP must fail, so that the high yielding currency does not depreciate to the point where yield differentials are surpassed. Documented evidence shows that this anomaly is regularly the case in the markets and relatively large profits can be obtained by exploiting this so called forward premium puzzle.

The uncovered interest parity theory states that in a rational and risk-neutral world, all of the possible arbitrage opportunities in exchange rates should vanish when the exchange rates of currencies change. According to our understanding, UIP can be stated as:

\[ (i_1 - i_2) = E(e) \]  (1)

Where \( i_1 \) is the interest rate of the first country, \( i_2 \) is the interest rate of the second country, and \( E(e) \) is expected rate of change in the exchange rates. The situation is however different in the real world markets, where it has been shown that the currencies with higher interest rates tend to appreciate more, while currencies with lower interest rates keep depreciating.

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In a situation where UIP holds perfectly it would be impossible to gain any profits from carry trading but as long as this failure in UIP exists, investors are able to generate profits by shorting low interest rate currencies and taking long positions in high interest rate currencies. Hansen & Hodrick (1980) investigated the hypothesis that the expected rate of return of speculation in the forward foreign exchange rate is zero and Fama (1984) conducted a research where he investigated the forward and spot exchange rates. Empirical findings on both of the papers lead to problems in the accuracy of the UIP, thus the situation called forward premium puzzle occurs.

There have been several explanations and conclusions while trying to solve the forward premium puzzle caused by the violation in UIP, but even today the researchers in the field have not unanimously decided why the forward premium puzzle exists. The possible solutions for the forward premium puzzle in the carry trade emphasize the changes in volatility, changes in the liquidity of the markets, and time-varying risk premia. Empirical findings from these fields of research have suggested partial solutions to the UIP problem, as presented in the following sub-chapters.

### 3.2 The Currency Carry Trade Strategies

One of the popular strategies used in foreign exchange markets is called the carry trade strategy, which refers to a way of trading where an investor borrows, or sells short, currencies with low interest rates and buys, or takes long positions, in currencies with high interest rates, according to Menkhoff, et al. (2011, p.1). The profit obtained from this endeavor is only possible due to the violation of the UIP theory.

Currencies can be divided into different groups by measuring the pairs’ interest rate differential. The currency groups normally are low interest rate group, middle interest rate group, and high interest rate group. The group of popular low interest rate currencies include such currencies as Japanese Yen (JPY), Swiss Franc (CHF) and United States Dollar (USD). The latter can also be classified in the group of mid interest currencies among Euro (EUR) and Pound Sterling (GBP) depending on the period during the past ten years. The high interest group normally consists of the Australian Dollar (AUD) and New Zealand Dollar (NZD) currencies, according to Katechos (2011, p. 553).

The normal strategy for carry trading is to pair currencies with high interest rate and low interest rate and earn the interest different between the two currencies every day, along with the possible profit from the appreciation of the high interest currency. The returns from such high-low pairing is normally left-skewed and fat-tailed according to findings of Brunnermeier et al. (2009, p. 341-324) and Christiansen et al. (2011, p. 1112). Naturally, in order to lower the risk of holding just one pair at the time, an investor can lower the risk of the investment by conducting a portfolio of different currency pairs.

Burnside, et al. (2006), studied different currency speculation strategies exploiting the forward premium puzzle. Their findings suggested that although the strategies yield on the high side of Sharpe ratios, these ratios are not a compensation for risk since, in practice, bid-ask spreads and price pressure reduce the profitability of currency speculation. They also found that although the average Sharpe ratio can be positive, the marginal Sharpe ratio associated with speculation can be zero. However some recent
findings promote the use of carry trade components in the conventional asset portfolios. Das, et al. (2012), state that portfolio performance increases, measured by both Sharpe ratio and modified Sharpe ratio, when an investor adds carry trade components in the asset portfolio. They find that the portfolio performance also increases despite turbulent times, such as experienced during the financial crisis.

The currency carry trade has been a profitable way to generate profits for investors and many of them, like hedge funds, pension funds, investment banks, and others are known to use high amounts of leverage in their carry trade strategies, at least before the late 2000s economic crisis. The problem with the carry trade is that it should not generate any profits due to the fact that UIP states that if all investors in the market are risk-neutral and rational then the changes in exchange rates should eliminate all of the profits generated by the interest rate differential.

Relating to the controversy around UIP, there has been extensive amounts of scientific investigation conducted in the field of foreign exchange and carry trading, which have largely found that UIP does not hold. As it has been shown that the UIP puzzle exists in the foreign exchange markets, it should not be taken as a bulletproof insurance to generate profits through carry trade, as discussed by Jorda, et al. (2012) when they state that naive carry trade strategies do not account the loss functions, skewness of the results, and Sharpe ratio, that matter to investors.

### 3.3 Liquidity in Foreign Exchange Markets

According to Fong W. (2009), one factor that may lead to the creation of currency bubbles is funding liquidity. When banks become highly risk-averse due to unfavorable conditions in the market, carry trade speculators which use leverage to fund their positions in the market become subject to the risk of a liquidity squeeze. The cyclical nature of the bank lending process can result in prolonged currency appreciation followed by rapid crashes, a phenomenon graphically described by the phrase “going up by the stairs and down by the elevator”, which suggests the asymmetrical nature of exchange rate movements.

The research results of Hattori & Shin (2009) indicate that the VIX index, of implied volatility on the S&P 500 index options, influences carry trade activities, predicted by two simultaneous conditions inversely correlated with the VIX, such as the large borrowing of JPY by the U.S. Banks and the movement of these liabilities to central offices on Wall Street. An abundance of funding liquidity can be assessed by changes in proxies such as low short term interest rates, tight interbank rate spreads and corporate default risk premiums, all of which explain the majority of changes in the VIX.

Increases in global risk and the two funding illiquidity indicators, the VIX index and the TED spread are positively correlated with currency crash risk resulting in decreased amounts of capital available to speculators who trade with high leverage, which close open positions and become reluctant to new ones. Controlling the investors’ risk aids to a certain degree in solving the forward premium puzzle found in empirical tests of the uncovered interest parity hypothesis, according to Brunnermeier, et al. (2009).

As mentioned in Menkhoff, et al. (2011), on the subject of currency crashes, liquidity plays a key part because as it dries up, currencies take a turn for the worst. Liquidity
proxies offer valuable information regarding currency crash risk, however a more powerful risk factor includes all this information and that is foreign exchange volatility, concept which will be covered in the next subchapter.

3.4 Volatility in Foreign Exchange Markets

During the past ten years the FX markets and carry trade strategy have experienced particularly interesting situations in terms of changes in volatility, liquidity, and returns. Volatility in foreign exchange markets culminated during the global financial crisis when many of the carry trade positions were unwound. According to Melvin, et al. (2009, p. 1318), the crisis in FX markets started in August of 2007, when major unwinding in carry trade positions happened. For example, average 1-day price change of AUD/JPY is normally 0.7%, but in August 16 it was -7.7%. They also state that during stressed market conditions it is common that market participants unwind their positions causing large fluctuations for market volatility. Melvin, et al. (2009) findings support our decision of choosing the time period of 2003-2012, since during these years the carry trade has experienced both turbulent and stable times in terms of volatility and returns, as can be observed in the chart below.

![Chart 1. CBOE SPX Volatility VIX, during 2003-2012](chart1.png)

Source: Thomson Reuters Datastream
Brunnermeier, et al. (2009, p. 314) findings show that S&P 500 implied volatility index VIX has an effect to foreign exchange market volatility, because as the VIX increases the carry trade positions tend to be unwound. Also, if the VIX is high then it can be predicted that investment currencies produce higher returns while funding currencies do the opposite. Controlling of VIX can as well help resolve the UIP violation through reducing the predictive coefficient for interest rate differentials.

Ranaldo, et al. (2007) also suggest that safe-haven currencies, such as CHF and JPY, experience appreciation when VIX increases which shows that FX market volatility and VIX have correlation with each other. Safe-haven currencies can however be used as a protection against the volatility, as shown by Habib, et al. (2011), who find that less financially open economies provide a hedge against financial shocks. Also, by observing the history of some particular currencies, it is possible to determine which currencies provide the best hedge during turbulent times.

Clarida, et al. (2009) showed that strategies which use forward contracts have similar payoff and risk characteristics as the currency options strategies, selling out of the money puts of high interest rate currencies. Their findings suggest that volatility rises when these positions are unwound quickly in crisis environments. Macroeconomic news can also have an impact to volatility in foreign exchange market. Hutchison, et al. (2013) found that surprising macroeconomic news can cause more than one third of the total adjustments in carry trade positions. Adjustments of this size will cause fluctuations in volatility which happened during the financial crisis, when large positions were unwound due to several surprising news from the financial markets.

Changes in volatility can also be related to violation of UIP, as shown by Christiansen, et al. (2011, p. 1107-1108), when they suggest that volatility exposure affects the stock market’s risk and suggest that on volatile markets the time varying systematic risk increases. They also found that between 1998-2008, high market volatility affects the carry trade performance in a way that a third of the returns is driven by exposure to risk factors, such as bond and equity returns and two thirds is caused by exposure to volatility itself, according to Christiansen, et al. (2011, p. 1124). The times of high volatility in the FX market provide a good base for speculative traders but devastating results may appear for highly leveraged trades who start unwinding their positions as soon as the volatility rises too high.

Menkhoff, et al. (2011) studied carry trading and global foreign exchange volatility by applying asset pricing methods of stock markets to FX markets finding volatility risk to be one of the main drivers of risk premia. Empirical findings of Menkhoff, et al. (2011, p.33) show that high interest carry trade currencies, such as AUD, have negative co-movement with FX volatility innovations where the carry trade funding currencies, such as JPY, work as a hedge in case of unexpected volatility changes. Nirei & Sushko (2010) find that currencies, such as JPY, have asymmetry between appreciation and depreciation. However, these asymmetries are more evident when interest rate differential is higher among two countries, or if volatility is high in the markets.

The general view of previous research shows that the carry trade does not perform well during unstable financial times, such as the late 2000s financial crisis, and that the high returns generated are pretty much only compensation for the time-varying risk premia.
This concept has been widely studied, during the past 20 to 30 years, as it is one of the more convincing solutions for the UIP violation.

3.5 Time-Varying Risk Premia

The time-varying risk premia has been suggested to be a convincing solution for the UIP violation and the forward premium puzzle, although some empirical findings still are dubious against it. The time-varying risk premia states that when investment currencies, like AUD and NZD, which have high interest rates, provide low returns during the crisis period, then the profits from carry trade are sort of a compensation for the investors higher risk exposure.

Engel (1984) and Fama (1984) referred to time-varying risk premia as a partial solution for the UIP violation and the forward premium puzzle. Lately, Christiansen, et al. (2011, p. 1124) suggested while studying carry trade returns of ten different currencies, during 1995-2008, that carry trade returns are regime dependent. Their empirical findings say that investment currencies have positive exposure to equity markets but the exposure during the unstable times is greater. They state that once the carry trade would look less tempting if the models would be correctly priced by regime-dependent models. This further evidence of regime dependability and co-movements during crisis periods, with large effects on volatility and liquidity have straight effects on asset returns. These findings suggest a partial solution to the UIP violation.

3.6 Correlations between FX Market and Equity Markets

Approaching our topic of research, the aim of this subchapter is to explore the relationships between exchange rates and equity returns, by taking into account the integrated nature of financial markets and the role of global variables. These relationships can be perceived from two different angles, one in which exchange rates are linked to relative equity market performance in two countries and the other approach, which considers that global equity returns affect exchange rates, the sign of the correlation being determined by the relative interest rate level of a currency.

The two main approaches on the relationship between exchange rates and stock prices are the goods market approach by Dornbusch & Fischer (1980) and the Portfolio Balance Model (PBM) derived approach. In the first one, causation runs from exchange rates to stock prices with a negative relation between them when assuming indirect quotations. The less favorable terms of trade created by appreciating domestic currency value reflects on local stock prices which start to decline and vice versa.

In the second approach, which also assumes indirect quotations, the causation runs the other way around, from stock prices to exchange rates, thus determining a positive relation between them. The explanation is that growing wealth and more demand for money by investors is due to increasing local stock prices. Foreign capital is attracted by higher domestic interest rates, resulting in an increasing demand for local currency and its value, according to Katechos (2011, p. 551).

The approaches taken by other researchers attempt to answer the issue and are mentioned next, in chronological order. According to Zapatero (1995), exchange rates are explained in completely integrated markets by the stock market volatilities of the
two countries in question. Ajayi & Mougoue (1996) show that in the long term, currency values are positively correlated to stock market returns, while the opposite is true on a short term basis. In the case of US and G-7 countries, Chow et al. (1997) consider that real exchange rate changes influences stock returns only in the long run, while Bahmani & Sohrabian (1992) and Nieh & Lee (2001) find no long term relationship. For the U.S., U.K. and Japan, the research of Kanas’ (2002) indicates that the volatility of exchange rate changes is determined in a significant way by the volatility of stock returns, findings which support the asset approach models to exchange rates.

Using VAR and the Granger causality test, Mishra (2004) suggests that a correlation between stocks and currency returns exists, but cannot determine a consistent relationship between them. Cheung, et al. (2012) studied how carry trading affects stock market activities in countries whose currency is used in this type of activity. Their findings suggested that carry trading tends to move stock prices when buildup in positions appear, as well as when positions are unwound. These things tend to cause disruptive effects to global financial systems.

Hau and Rey (2004) approached the relationship between stock prices and exchange rates from an integrated Microstructure framework point of view that brings evidence towards exchange rates being affected by customer initiated order flows. They consider that there are dynamic links between equity, bond and foreign exchange markets, which form a channel for portfolio rebalancing. The explanation shows that capital flows created by repatriated foreign equity wealth by international investors can cause appreciations in the investor’s home currency and vice versa.

A new approach on the relationship between stock markets and exchange rates, similar to the UIP, can be attributed to Cappiello & De Santis (2005). If expected equity returns of one country are higher than those of another, the former country’s currency would depreciate to maintain equilibrium between expected equity returns in different currency denominated stocks and vice versa.

Although there are a multitude of approaches which try to identify a connection between stock market returns and exchange rates, none actually provide a concrete description of the nature of this relationship. “There is theoretical consensus neither on the existence of relationship between stock prices and exchange rates nor on the direction of the relationship” according to Stavárek (2005, p. 141).

The link between exchange rates and equity returns is often suggested even in market commentary and the financial press, with the assumption that the investor’s risk appetite is reduced when stock prices start to decline and vice versa. This, in turn, influences the degree to which investors involve themselves in carry trading activity. Taking this into account, our suggestion is that the value of low interest rate currencies is negatively correlated with global equity market returns, while a positive correlation is the case for high interest rate currencies and global equity markets.

To better explain the mechanism behind this relationship, we describe how carry trades are unwinded, as presented in Katechos (2011). The moment investors experience negative returns, they become less likely to hold risky positions in the market, such as carry trades. The order flow induced by unwinding interest arbitrage trades creates
selling pressure for high interest currencies and the opposite for low interest ones, thus producing an appreciation of the low interest currency and the reverse for the high interest one. In contrast to other research, we consider that exchange rates are affected by one global variable, which is equity returns and that the sign of this variable’s relationship to exchange rates is influenced by the currency’s relative interest rate level.
Chapter 4: Analysis methods and data grouping

The aim of this chapter is to explain the analysis methods employed and the data grouping, in a systematic way, by determining the 16 most commonly used currency pairs through review of relevant recent literature, from the field of research studying carry trade regimes, and organizing them in three yield groups, according to criteria described by Katechos (2011) in his recent study about exchange rates.

When choosing the equity indexes, our criteria are that they should be recognized throughout the world and that they represent a significant portion of information on the stock markets. For this reason, we choose to employ Standard & Poor’s 500 (S&P 500) stock market index, as one of the equity indexes, since it measures the development of 500 U.S based large-cap publicly traded companies’ stocks. We also chose to have FTSE All-World, as a second equity index, so that we could measure how returns, generated all over the world, relate to carry trade returns. The FTSE All-World is an ideal equity index for this purpose, as it is a large and mid-cap aggregate of 2800 stocks, covering over 90% of investable market capitalization (FTSE, 2013). In order to measure the relationships of carry trade returns and volatility, we choose to use Chicago Board Options Exchange Market Volatility Index (VIX), as a volatility index measure. VIX measures the implied volatility of S&P 500 index so we think that it is a truthful measure of volatility for our purpose.

We decided to gather data for daily returns of 16 different currency pairs and the two equity indexes along with the volatility index, between the years of 2003-2012. The data was collected from Thomson Reuters Datastream and the selected ten year span was divided into three different periods. This was done in order to discover the differences on how typical carry trade currency pairs and equity indexes relate to each other, depending on market developments before, during and after the world financial crisis. The absence of the Euro currency before 2002 and the lack of quotes for some of the analyzed pairs pushed us towards this ten year period.

For a better understanding of the tests performed on the data, the chapter is divided into two different parts. First off, we present the analysis methods by explaining the most important formulas used in this thesis, after which we present the way of grouping the research data.

4.1 Analysis Methods

This chapter presents the analysis methods we used to analyze our data. We show the most important formulas and explain them briefly. This way, when we display our results, later in chapter 5, it is easier to understand what we have done. Presenting the most important formulas also helps replicability for further research.

We have measured the correlations between the 16 different currency pairs with S&P 500 Index, FTSE All-World Index, and VIX volatility index, between the years of 2003-2012. Following the correlations we performed Maximum Likelihood (ML) regressions with Generalized Autoregressive Conditional Heteroscedasticity (GARCH) [1,1] errors, using the currency pairs as dependent variables. Our ML-GARCH [1,1] method is similar to the one used by Katechos (2011) in his paper, but we use it for different data.
In the equations for our models, the dependent variables are represented by each currency pair, while the independent variables are the indexes. To clarify, the dependent variables represent the output or the effect caused by the independent variables.

As to compare the carry trade returns to equity indexes returns and VIX volatility index changes, we measured the correlation between the different variables. The correlation between the assets simply tells us how the returns of currency pairs move in relation to those of equity indices. The measure of correlations among different assets is a standard procedure in modern portfolio management and the formula for correlation is:

\[
Corr \left( R_D, R_E \right) = \frac{Cov \left( R_D, R_E \right)}{\sigma_D \sigma_E} \tag{2}
\]

Where \( R_D \) is the return of a chosen currency pair and \( R_E \) is the return of the chosen equity index. \( \sigma_D \) and \( \sigma_E \) are the standard deviations of the two variables, according to Bodie, et al. (2011, p. 271). The correlation of two assets varies between +1 and -1, meaning that if there is a perfect positive correlation between the assets, then the asset prices move perfectly synchronized. If the correlation is negative, then the asset prices move in opposite direction of one another.

The GARCH model we use is a model proposed by Bollerslev (1986). According to Hull (2012, p. 205), the GARCH [1,1] model has distinctive features such as recognizing that volatility will not be constant during all periods. This is one of the reasons why it is widely used in modeling and forecasting time-dependent variance of stock price returns. The formula for ML - regressions with GARCH [1,1] is:

\[
\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{n-1}^2 \tag{3}
\]

Where \( \omega \), \( \alpha \), and \( \beta \) are constants, \( \varepsilon_{t-1}^2 \) is the lag of the squared residual from the mean equation - the ARCH-term, and \( \sigma_{n-1}^2 \) is the last period’s variance forecast - the GARCH-term.

We think that our methods for data analysis provide good and broad information about the relationships between the currency pairs and chosen indexes. The chosen analysis methods enable us to investigate a variety of different variables and to compare them to one another, so that sensitivity and influence between daily carry trade returns, S&P 500 returns and VIX can be observed.

4.2 Data Grouping

This section will focus on explaining the way in which the research data is grouped, the time period for which it was collected and how is it divided, as well as the reasoning behind this and the relevance towards the purpose of this thesis.
Following the approach to data structuring observed in the research of Katechos (2011), currencies have been classified into three categories based on their yield, in terms of interest rate, which is set by their respective central bank and their values can be observed in Chart 1, below. An average yield of 5.13% and 5.04%, over the 2003-2012 period, puts NZD and AUD into the high yielding category (H), while the low yielding (L) currencies are CHF and JPY, providing only 1.32% and 0.14% average interest. The middle category (M) is occupied by GBP, USD and EUR, yielding on average 2.96%, 2.15% and 1.87% respectively, over the mentioned time period.

The following overlaid line chart provides a view of the interest rate changes that occurred for the six currencies between January 2003 and December 2012. The seven chosen currencies account for over 90% of the foreign exchange market turnover, according to statistics from the Bank for International Settlements for the year of 2010.

![Chart 2. Interest rate development, during 2003-2012](image)

For the purpose of obtaining results that are relevant and easy to compare and interpret, we have generated three groups of currency pairs which will be analyzed separately. These are H/L for exchange rates quoted as one unit of high yielding currency denominated in units of low yielding currency, H/M for exchange rates quoted as one unit of high yielding currency denominated in units of mid yielding currency and M/L for exchange rates quoted as one unit of mid yielding currency denominated in units of low yielding currency.
To capture equity returns, we use the daily time series of the FTSE All-World index for a global equity view and the S&P 500 index for a view of the U.S. equity market return, sourced from Thomson Reuters Datastream. Our choice was for these two indexes because the FTSE All-World consists of 2800 large and mid-capitalization stocks, covering more than 90% of investable market capitalization, while the S&P 500 index covers 500 leading large cap companies publicly traded in the U.S. stock markets and it is considered the best gauge of U.S. equity markets.

The ten year span for the analyzed data has also been separated into three time periods by taking into account the world economic crisis that has influenced and shaped the world’s financial markets. Our choice of time period is also confirmed by the research of Melvin, et al. (2009), who acknowledges that, between 2003 and 2012, the carry trade has gone through both turbulent and stable times in terms of volatility and returns. Our first time period consists of 1040 trading days, starts on the 6th of January 2003 and ends on the 29th of December 2006. The second period contains 651 trading days, starts on the 1st of January 2007 and ends on the 30th of June 2009. The third and final period has 913 trading days starting from the 1st of July 2009 and ending on the 31st of December 2012. The whole ten year period has 2604 active trading days.

Chart 3. FTSE All-World and S&P 500 development, during 2003-2012
By observing the above chart, the period between 2003 and the beginning of 2007 can be considered as bullish, with financial markets trending upwards. Between 2007 and 2009, the world economic crisis is clearly visible, as the all the gains are lost in a steep downtrend. After 2009 towards 2012, the markets entered a recovery period which shows positive changes by restoring prices to similar levels, as the ones seen in 2007. Due to the financial market’s behavior between 2003 and 2012, we see fit to divide our analysis into the three time periods mentioned, for an even more in depth view on how the foreign exchange market correlates to equity markets.

For our analysis, daily exchange rate quotes were sourced for currency pairs obtained by combining the seven currencies mentioned earlier in the chapter. The H/L yield group is comprised of AUD/JPY, NZD/JPY, AUD/CHF and NZD/CHF. Part of the M/L yield group are EUR/JPY, GBP/JPY, USD/JPY, EUR/CHF, GBP/CHF and USD/CHF. The H/M yield group is comprised of AUD/EUR, AUD/GBP, AUD/USD, NZD/USD, NZD/EUR and NZD/GBP. The reasoning behind our choice of daily data instead of weekly is that the later, lower frequency data, does not capture short term demand shifts caused by market fluctuations, while the former also allows for a more exact calculation of the required results.
Chapter 5: Empirical Findings

The purpose of this chapter is to present and explain our empirical findings on the correlation and regression tests, in order to ensure that we are capable to answer our research question with respect to the theory of the UIP puzzle, which persists in the FX markets and more specifically in the carry trade.

5.1 Empirical Findings for Correlations

The aim of this subchapter is to present and interpret, in an easy to understand manner, the results obtained after analyzing the correlations between daily currency pair returns and the selected indexes’ daily returns, by making relevant observation statements. The findings are grouped in two tables, with the first one including all currency pairs, divided by yield group, for the 2003-2012 period, while the second table takes an in depth look at correlations for the H/L yield group of currencies, for each period, that stand out in terms of market behavior, determined by the world financial crisis.

The reason for choosing the H/L yield group of exchange rates is that, after analyzing the data, we found that this the one deserving the most attention due to its highest interest rate differential of all the groups and the fact that it contains some of the most used currencies for carry trading by investors.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pair</th>
<th>S&amp;P 500</th>
<th>FTSE ALL</th>
<th>VIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/L</td>
<td>AUD/JPY</td>
<td>0.0722</td>
<td>0.3391</td>
<td>-0.0600</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>-0.0781</td>
<td>0.1387</td>
<td>0.0486</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>-0.0154</td>
<td>-0.0424</td>
<td>0.0192</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>-0.0446</td>
<td>-0.0419</td>
<td>0.0361</td>
</tr>
<tr>
<td>M/L</td>
<td>EUR/JPY</td>
<td>0.2957</td>
<td>0.4969</td>
<td>-0.2530</td>
</tr>
<tr>
<td></td>
<td>GBP/JPY</td>
<td>0.2790</td>
<td>0.4558</td>
<td>-0.2222</td>
</tr>
<tr>
<td></td>
<td>USD/JPY</td>
<td>0.2018</td>
<td>0.1922</td>
<td>-0.1774</td>
</tr>
<tr>
<td></td>
<td>EUR/CHF</td>
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<td>0.3362</td>
<td>-0.2062</td>
</tr>
<tr>
<td></td>
<td>GBP/CHF</td>
<td>-0.0459</td>
<td>-0.0446</td>
<td>0.0276</td>
</tr>
<tr>
<td></td>
<td>USD/CHF</td>
<td>0.0122</td>
<td>-0.1701</td>
<td>-0.0066</td>
</tr>
<tr>
<td>H/M</td>
<td>AUD/EUR</td>
<td>-0.0093</td>
<td>-0.0413</td>
<td>0.0142</td>
</tr>
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<td>-0.0040</td>
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<tr>
<td></td>
<td>NZD/EUR</td>
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<td>0.3248</td>
<td>-0.1347</td>
</tr>
<tr>
<td></td>
<td>NZD/GBP</td>
<td>0.1756</td>
<td>0.3160</td>
<td>-0.1359</td>
</tr>
</tbody>
</table>

Table 3. Correlations results, during 2003-2012

The structure of the following interpretation, for the empirical findings on correlations displayed in Table 3, is divided for each yield group of currency pairs and further explanation of values is provided in relation to each funding currency or investment currency.
For the H/L yield group, we can make empirical observations for the four currency pairs according to the funding currency used in each pair. There are two pairs which use JPY as the funding currency and two pairs using CHF. During the observed period of 2003-2012, the two CHF pairs have negative correlation with both of the observed equity indexes. The negative correlation is relatively weak, although we are dealing with daily data which makes the values look relatively small. The daily returns’ correlations, of the CHF pairs, with the daily returns of FTSE All-World are on the same range with each other, unlike with the S&P 500, where the NZD/CHF is larger.

The two JPY pairs, observed in Chart 4 above, have slightly more inconsistency in the correlation with the S&P 500, compared to the NZD pairs’ results. NZD/JPY shows the largest negative correlation out of the whole H/L yield group, while AUD/JPY shows the largest positive correlation in relation to S&P 500. The situation is similar when the JPY pairs are compared with FTSE All-World, as the AUD/JPY pair has much larger positive correlation than the NZD/JPY.

Chart 4. AUD/JPY and NZD/JPY development, during 2003-2012
The H/L yield groups’ correlation with the volatility index VIX has been positive for three of the group’s currency pairs. Only daily returns of AUD/JPY have negative correlation with the VIX. The other three currency pairs from the H/L yield group have weak positive correlation with a small range of changes between each other.

As with the H/L yield group, the M/L yield group also uses JPY and CHF as funding currencies. The correlation results for the M/L yield group show mostly positive correlation with the two equity indexes, S&P 500 and FTSE All-World, and negative correlation with the VIX volatility index. When JPY is used as the funding currency, the correlation with equity indexes is positive for all three pairs observed in Chart 4 and generally the correlation is stronger with FTSE All-World compared to correlation with S&P 500. Two notable pairs, using JPY as the funding currency, in the M/L yield group are EUR/JPY and GBP/JPY, which have positive daily returns correlation of 0.4969 and 0.4558 with FTSE All-World. Although they have the strongest positive correlation from the whole M/L yielding group, it can be said that the correlation was only average, since normally a strong correlation between two variables is 0.8 or higher. Our findings
also show that the range of correlation in JPY pairs tends to be smaller when measured with S&P 500 compared to measurements with FTSE All-World.

When CHF is used as the funding currency, the situation is a bit more mixed in the M/L yield group. Unlike with JPY pairs, it can be seen that negative correlations appear to some of the currency pairs. GBP/CHF has negative correlation with both equity indexes, while USD/CHF has negative correlation only with FTSE All-World. However none of the three pairs, using CHF as a funding currency, tend to have notably high positive or negative correlation in daily returns with each of the equity indexes.

The M/L yield group’s daily returns mainly have a negative correlation with VIX. The only exception here is the GBP/CHF pair, with a positive correlation, as the two other CHF currency pairs have a weak negative correlation with the VIX. All three pairs using JPY as the funding currency have a weak negative correlation with the VIX, without any significant changes in the range of the correlations.

Finally, we present the correlations for the H/M yield group with six different currency pairs. The difference in H/M yield group to H/L and H/M yield groups is however the funding currency. In the H/M yield group, the funding currency varies between USD, EUR, and GBP so it is more efficient to observe the investment currencies in this case. There are two investment currencies, AUD and NZD, observed in the chart below, which form the six currency pairs with the three different funding currencies.

Chart 6. AUD/USD and NZD/USD development, during 2003-2012
Similar to the two previously presented yield groups, the daily returns of the currency pairs in the H/M yield group also correlate more with the returns of the FTSE All-World, than with the S&P 500. All of the three NZD pairs have positive correlation in daily returns with the two equity indexes. The situation differs for the AUD pairs since they experienced negative correlation, except AUD/USD, in relation to equity indexes during the ten year period. Major observations can be made about AUD/USD and NZD/USD since they have the highest correlations with the daily returns of the FTSE All-World compared to any of the other currency pairs during the ten year span. These two currency pairs also show the strongest correlation to S&P 500, out of the whole H/M yield group.

The H/M yield group’s correlation with VIX was negative for all of the currency pairs, except AUD/EUR, during 2003-2012. As AUD/USD and NZD/USD experienced the strongest positive correlation with the two equity indexes, they also experienced the strongest negative correlation with the VIX in the H/M yield group. The other two NZD pairs had similar negative correlation with VIX but not a single one of the currency pairs reached the 0.8 level, so it can be concluded that the correlation was quite weak for the H/M yield group.

In conclusion, the results for the period of 2003-2012, presented in Table 3, are statistically significant and show mostly positive correlation between the daily returns of the 16 currency pairs and the daily returns of the two equity indexes. During the ten year period, the currency pairs have, in general, larger positive correlation with the FTSE All-World over S&P 500. In most of the cases, the volatility index VIX is negatively correlated with the daily returns of the 16 currency pairs with values over the yield group limits. An exception to VIX correlation is the H/L yield group where most of the currency pairs are positively correlated with it.

After we have presented the results for correlations between the 16 currency pairs, two equity indexes and one volatility index, we will follow with more detailed results for the H/L yield group and the most important empirical observations for each of the three periods before, during and after the financial crisis, in Table 4.

<table>
<thead>
<tr>
<th>Period</th>
<th>Pair</th>
<th>S&amp;P 500</th>
<th>FTSE ALL</th>
<th>VIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>03-07</td>
<td>AUD/JPY</td>
<td>0.0269</td>
<td>0.0732</td>
<td>0.0238</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>-0.0148</td>
<td>0.0048</td>
<td>0.0296</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>-0.0649</td>
<td>-0.0567</td>
<td>0.0374</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>-0.0149</td>
<td>-0.0268</td>
<td>0.0166</td>
</tr>
<tr>
<td>07-09</td>
<td>AUD/JPY</td>
<td>0.0537</td>
<td>0.3876</td>
<td>-0.0429</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>-0.1103</td>
<td>0.1695</td>
<td>0.0969</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>0.0000</td>
<td>-0.0572</td>
<td>-0.0054</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>-0.0450</td>
<td>-0.0302</td>
<td>0.0203</td>
</tr>
<tr>
<td>09-12</td>
<td>AUD/JPY</td>
<td>0.1302</td>
<td>0.3568</td>
<td>-0.1237</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>-0.0317</td>
<td>0.1386</td>
<td>-0.0163</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>-0.0201</td>
<td>-0.0157</td>
<td>0.0384</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>-0.0607</td>
<td>-0.0385</td>
<td>0.0656</td>
</tr>
</tbody>
</table>

Table 4. H/L yield group’s correlation results, divided by periods
For a more in depth look on how correlations changed because of the world financial crisis, we observe the H/L yield group’s correlation coefficients during 2003-2007, in Table 4. The 2003-2007 period, before the world financial crisis, determined the pairs with JPY as the funding currency to experience a positive correlation to equity indexes, with the exception of NZD/JPY, while the pairs with CHF as the funding currency display a negative relationship. All four currency pairs show an average degree of positive correlation with VIX volatility index during the five years before the world financial crisis. The largest positive and negative correlation can be observed when AUD is used as an investment currency. During the bullish market before the crisis, all the pairs display rather small correlation coefficients which suggest that all pairs present a weak degree of correlation to equity indexes and VIX.

The world financial crisis period of 2007-June 2009, saw markets crashing and some profits evaporating. The two pairs which use JPY as the funding currency experienced positive correlations with equity indexes during the crisis period, except for NZD/JPY in relation to S&P 500. On the other hand, when CHF was used as the funding currency for AUD and NZD, the values show a negative relationship to equity indexes, except for AUD/CHF which was neutral to S&P 500. Worth mentioning is the 0.38757 value exhibited by AUD/JPY in relation to the FTSE All-World, suggesting an average degree of correlation compared to other pairs’ weak coefficients.

The correlations to VIX, during the crash period of 2007-June 2009, depend on the choice of investment currency for the carry trade. Traders who invested in AUD would have experienced a negative correlation to VIX, while the other choice of NZD has shown the opposite. Nevertheless the correlation with VIX is still quite weak on both positive and negative sides. Menkhoff, et al. (2011) findings show similar effects about the negative co-movements of high interest rate currencies against the situations when volatility fluctuates.

Finally, the four year period of recovery saw markets regaining lost profits and reaching similar price peaks, as those seen in 2007. The structure of correlation results is almost identical to the previous period, in regards to equity indexes, with AUD/JPY maintaining an average degree of correlation to FTSE All-World, above all others. The currency pairs which use CHF as funding currency have negative correlation to equity indexes, unlike those funded with JPY.

The relationship to VIX, as displayed in the last column, shows again that the differences in a currency pairs correlation depends on the chosen funding currency. In this case of JPY, we can observe a negative correlation with VIX, while the other choice of CHF, as the funding currency, shows a positive relationship. AUD/JPY stands out with the highest coefficient of 0.3568, as values for other pairs only start from the hundredth decimal point.

In conclusion, the detailed results displayed in Table 4 for each period, determined by the world financial crisis timeline, are statistically significant and show mostly negative correlations between the daily returns of the H/L yield group of currency pairs and the daily returns of the two equity indexes. During each of the three periods, the correlations exhibit somewhat larger coefficients, both on the positive and negative side, with the FTSE All-World over S&P 500. In regards to the volatility index VIX, it is clear that the four year period before the crisis shows a positive correlation between
currency returns and equity indexes’ returns, while the crash and recovery periods present mixed results, depending on the choice of investment currency or funding currency respectively. These results are in agreement with previously stated theories from our literature review part and will be discussed further in Chapter 6.

5.2 Empirical Findings for Regressions

While the previous subchapter focused on the empirical findings for correlations between currency pair returns, equity indexes returns and volatility, this second subchapter will present the results obtained after testing the relationship between the all the currency pairs’ returns and S&P 500 returns, as well as for VIX, by using the ML-GARCH (1,1) test in EViews software.

The first two tables below display the variance equation results for all 16 pairs versus S&P 500 and VIX respectively, while the last three tables feature regression results for the three yield groups of currency pairs versus S&P 500 and VIX. All the tables of results, presented in this subchapter, are derived from daily returns for the ten years period of 2003-2012.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>(\omega)</th>
<th>Std.</th>
<th>(\alpha)</th>
<th>Std. Error</th>
<th>(\beta)</th>
<th>Std. Error</th>
<th>(\alpha+\beta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD/JPY</td>
<td>1.09E-06</td>
<td>1.59E-07</td>
<td>0.1019</td>
<td>0.0073</td>
<td>0.8897</td>
<td>0.0074</td>
<td>0.9916</td>
</tr>
<tr>
<td>NZD/JPY</td>
<td>1.69E-06</td>
<td>2.70E-07</td>
<td>0.1238</td>
<td>0.0092</td>
<td>0.8891</td>
<td>0.0086</td>
<td>0.9929</td>
</tr>
<tr>
<td>AUD/CHF</td>
<td>6.72E-07</td>
<td>1.04E-07</td>
<td>0.078</td>
<td>0.0066</td>
<td>0.9128</td>
<td>0.0065</td>
<td>0.9908</td>
</tr>
<tr>
<td>NZD/CHF</td>
<td>8.25E-07</td>
<td>1.86E-07</td>
<td>0.0654</td>
<td>0.0057</td>
<td>0.9244</td>
<td>0.0067</td>
<td>0.9896</td>
</tr>
<tr>
<td>EUR/JPY</td>
<td>3.85E-07</td>
<td>1.14E-07</td>
<td>0.0496</td>
<td>0.0045</td>
<td>0.9443</td>
<td>0.0052</td>
<td>0.9939</td>
</tr>
<tr>
<td>GBP/JPY</td>
<td>5.22E-07</td>
<td>1.37E-07</td>
<td>0.0599</td>
<td>0.0058</td>
<td>0.9342</td>
<td>0.0065</td>
<td>0.9941</td>
</tr>
<tr>
<td>USD/JPY</td>
<td>5.46E-07</td>
<td>1.08E-07</td>
<td>0.0305</td>
<td>0.0038</td>
<td>0.9561</td>
<td>0.0055</td>
<td>0.9866</td>
</tr>
<tr>
<td>EUR/CHF</td>
<td>1.97E-08</td>
<td>2.60E-09</td>
<td>0.0865</td>
<td>0.004</td>
<td>0.9193</td>
<td>0.0026</td>
<td>1.0028</td>
</tr>
<tr>
<td>GBP/CHF</td>
<td>1.45E-07</td>
<td>4.16E-08</td>
<td>0.0533</td>
<td>0.0052</td>
<td>0.9397</td>
<td>0.0051</td>
<td>0.9981</td>
</tr>
<tr>
<td>USD/CHF</td>
<td>2.48E-07</td>
<td>1.05E-07</td>
<td>0.0444</td>
<td>0.0042</td>
<td>0.9519</td>
<td>0.0055</td>
<td>0.9966</td>
</tr>
</tbody>
</table>

Table 5. Variance equation results for all FX pairs and S&P 500, during 2003-2012

The time series models’ results for the variance equation, as shown in Table 5 above, display significant \(\alpha\) - ARCH parameters and \(\beta\) - GARCH parameters, with the sum of the two very close to one, for all the analyzed currency pairs. Due to very high and close to unity estimates of the \(\beta\) parameter, we can state that volatility shocks are persistent, thus our results for estimating the relationship between currency pair returns and S&P 500 returns are in accordance with the findings of Katechos (2011) regarding FTSE All-World.
To further improve our contribution to Katechos (2011) research, we conducted the same analysis to determine the relationship between the 16 chosen currency pairs and the VIX volatility index. The results of the variance equation for this case can be observed in the table below, along with explanations following it.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Variance Coefficients</th>
<th>Std. Error</th>
<th>α</th>
<th>Std. Error</th>
<th>β</th>
<th>Std. Error</th>
<th>α+β</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD/JPY</td>
<td>0.0036</td>
<td>0.0027</td>
<td>0.0074</td>
<td>0.0007</td>
<td>0.0093</td>
<td>0.0027</td>
<td>0.0036</td>
</tr>
<tr>
<td>NZD/JPY</td>
<td>0.0038</td>
<td>0.0026</td>
<td>0.0072</td>
<td>0.0006</td>
<td>0.0092</td>
<td>0.0026</td>
<td>0.0038</td>
</tr>
<tr>
<td>AUD/CHF</td>
<td>0.0037</td>
<td>0.0025</td>
<td>0.0070</td>
<td>0.0006</td>
<td>0.0091</td>
<td>0.0025</td>
<td>0.0037</td>
</tr>
<tr>
<td>NZD/CHF</td>
<td>0.0039</td>
<td>0.0024</td>
<td>0.0068</td>
<td>0.0006</td>
<td>0.0090</td>
<td>0.0024</td>
<td>0.0039</td>
</tr>
<tr>
<td>EUR/JPY</td>
<td>0.0033</td>
<td>0.0023</td>
<td>0.0069</td>
<td>0.0006</td>
<td>0.0090</td>
<td>0.0023</td>
<td>0.0033</td>
</tr>
<tr>
<td>GBP/JPY</td>
<td>0.0035</td>
<td>0.0022</td>
<td>0.0068</td>
<td>0.0006</td>
<td>0.0090</td>
<td>0.0022</td>
<td>0.0035</td>
</tr>
<tr>
<td>USD/JPY</td>
<td>0.0036</td>
<td>0.0023</td>
<td>0.0068</td>
<td>0.0006</td>
<td>0.0090</td>
<td>0.0023</td>
<td>0.0036</td>
</tr>
<tr>
<td>EUR/CHF</td>
<td>0.0039</td>
<td>0.0022</td>
<td>0.0067</td>
<td>0.0006</td>
<td>0.0089</td>
<td>0.0022</td>
<td>0.0039</td>
</tr>
<tr>
<td>GBP/CHF</td>
<td>0.0037</td>
<td>0.0021</td>
<td>0.0066</td>
<td>0.0006</td>
<td>0.0088</td>
<td>0.0021</td>
<td>0.0037</td>
</tr>
<tr>
<td>USD/CHF</td>
<td>0.0040</td>
<td>0.0021</td>
<td>0.0065</td>
<td>0.0006</td>
<td>0.0087</td>
<td>0.0021</td>
<td>0.0040</td>
</tr>
</tbody>
</table>

Table 6. Variance equation results for all FX pairs and VIX, during 2003-2012

The time series models’ results for the variance equation, as shown in Table 6, display significant α - ARCH parameters and β - GARCH parameters, with the sum of the two very close to one for all the analyzed exchange rates. Because the β parameter estimates are very high and close to unity, we can state that volatility shocks are persistent, thus our results for determining the relationship between currency pair returns and VIX are in accordance with the theory stated in Chapter 3.

<table>
<thead>
<tr>
<th>Index</th>
<th>H/L Group</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>Adj. R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500</td>
<td>AUD/JPY</td>
<td>0.0028</td>
<td>0.0019</td>
<td>-0.0004</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>-0.0027</td>
<td>0.0014</td>
<td>-0.0001</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>0.0019</td>
<td>0.0016</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>0.0037</td>
<td>0.0019</td>
<td>0.0020</td>
</tr>
<tr>
<td>VIX</td>
<td>AUD/JPY</td>
<td>0.0016</td>
<td>0.0018</td>
<td>-0.0006</td>
</tr>
<tr>
<td></td>
<td>NZD/JPY</td>
<td>0.0044</td>
<td>0.0020</td>
<td>-0.0018</td>
</tr>
<tr>
<td></td>
<td>AUD/CHF</td>
<td>0.0013</td>
<td>0.0016</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>NZD/CHF</td>
<td>0.0037</td>
<td>0.0019</td>
<td>0.0020</td>
</tr>
</tbody>
</table>

Table 7. H/L group’s regression results for S&P 500 and VIX, during 2003-2012
In Table 7 above, we present the high yield/low yield group’s regression results for the 2003-2012 period, in relation to S&P 500 and VIX. More specifically, we can observe to what degree the daily changes in S&P 500 and VIX affect the daily returns of a certain currency pair, as measured by the regression coefficient and adjusted R².

In the H/L yield group, the coefficients are negative for all currency pairs, except for AUD/JPY, when S&P 500 is used as an independent variable. The three pairs with the negative coefficients also show negative correlation to S&P 500 in Table 3, which indicates why they are negative here as well. Out of the four currency pairs, NZD/CHF has the largest adj. R² value of 0.0301. This means that, out of the H/L yield group, the daily returns of NZD/CHF are the most sensitive to daily returns of S&P 500.

When we measured the four currency pairs, i.e. dependent variables to the VIX, we see that the coefficients are positive for all currency pairs, except for AUD/JPY. The coefficients show that the VIX has largest influence to NZD/JPY pair and negative influence to AUD/JPY pair, during the 2003-2012 time period. The influence of VIX on the two pairs using CHF as the funding currency is the same for both of the pairs. The sensitivity measure adj.R² shows mixed results for the H/L yield pairs relating to VIX. Out of the four pairs, NZD/CHF has the highest sensitivity of 0.0020. The three remaining pairs received negative adj. R² values because of very low R² values. We have considered the negative adj. R² values in Limitations chapter.

<table>
<thead>
<tr>
<th>Index</th>
<th>M/L Group</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>Adj. R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500</td>
<td>EUR/JPY</td>
<td>0.1375</td>
<td>0.0111</td>
<td>0.0828</td>
</tr>
<tr>
<td></td>
<td>GBP/JPY</td>
<td>0.1054</td>
<td>0.012</td>
<td>0.0618</td>
</tr>
<tr>
<td></td>
<td>USD/JPY</td>
<td>0.0836</td>
<td>0.0097</td>
<td>0.0411</td>
</tr>
<tr>
<td></td>
<td>EUR/CHF</td>
<td>0.0295</td>
<td>0.0036</td>
<td>0.0364</td>
</tr>
<tr>
<td></td>
<td>GBP/CHF</td>
<td>-0.0101</td>
<td>0.0085</td>
<td>-0.0018</td>
</tr>
<tr>
<td></td>
<td>USD/CHF</td>
<td>-0.0008</td>
<td>0.009</td>
<td>-0.0014</td>
</tr>
</tbody>
</table>

| VIX    | EUR/JPY  | -0.0174     | 0.0018     | 0.0514  |
|        | GBP/JPY  | -0.0121     | 0.0019     | 0.0307  |
|        | USD/JPY  | -0.0126     | 0.0015     | 0.03    |
|        | EUR/CHF  | -0.0035     | 0.0005     | 0.0191  |
|        | GBP/CHF  | 0.0012      | 0.0014     | -0.0028 |
|        | USD/CHF  | -0.0022     | 0.0017     | -0.0015 |

Table 8. M/L group’s regression results for S&P 500 and VIX, during 2003-2012

The regression results for the M/L yield group of exchange rates and S&P 500, during the ten year span, show positive coefficients for pairs with JPY as the funding currency, while the opposite is true when carry trades are funded with CHF, except for the EUR/CHF pair. It is notable that the equity index accounts the most for EUR/JPY’s daily returns, with a coefficient of 0.1375. This fact is also supported by the pair’s sensitivity to S&P 500 which is indicated by the highest adjusted R squared from the entire group, with a value of 0.0828.

In regards to VIX, although all the pairs show a negative coefficient, EUR/JPY stands out again with the highest sensitivity to the volatility index, denoted by the highest adjusted R squared value of 0.0514. It would seem that our model does not fit well for
the GBP/CHF and USD/CHF pairs, as they display negative values in the Adj. $R^2$ column for both S&P 500 and VIX. The larger values of the M/L yield group coefficients denote a higher explanatory power of our model than the results for the H/L group.

<table>
<thead>
<tr>
<th>Index</th>
<th>H/M Group</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>Adj. $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;P 500</td>
<td>AUD/EUR</td>
<td>-0.0121</td>
<td>0.0086</td>
<td>0.0025</td>
</tr>
<tr>
<td></td>
<td>AUD/GBP</td>
<td>-0.0092</td>
<td>0.0096</td>
<td>-0.0018</td>
</tr>
<tr>
<td></td>
<td>AUD/USD</td>
<td>0.1859</td>
<td>0.0116</td>
<td>0.0837</td>
</tr>
<tr>
<td></td>
<td>NZD/USD</td>
<td>0.1905</td>
<td>0.0132</td>
<td>0.0726</td>
</tr>
<tr>
<td></td>
<td>NZD/EUR</td>
<td>0.0986</td>
<td>0.0111</td>
<td>0.0371</td>
</tr>
<tr>
<td></td>
<td>NZD/GBP</td>
<td>0.1048</td>
<td>0.0106</td>
<td>0.0208</td>
</tr>
<tr>
<td>VIX</td>
<td>AUD/EUR</td>
<td>0.0023</td>
<td>0.0014</td>
<td>0.0028</td>
</tr>
<tr>
<td></td>
<td>AUD/GBP</td>
<td>0.0003</td>
<td>0.0015</td>
<td>-0.0009</td>
</tr>
<tr>
<td></td>
<td>AUD/USD</td>
<td>-0.0160</td>
<td>0.0017</td>
<td>0.0353</td>
</tr>
<tr>
<td></td>
<td>NZD/USD</td>
<td>-0.0189</td>
<td>0.0022</td>
<td>0.0344</td>
</tr>
<tr>
<td></td>
<td>NZD/EUR</td>
<td>-0.0092</td>
<td>0.0017</td>
<td>0.0159</td>
</tr>
<tr>
<td></td>
<td>NZD/GBP</td>
<td>-0.0107</td>
<td>0.0017</td>
<td>0.0163</td>
</tr>
</tbody>
</table>

Table 9. H/M group’s regression results for S&P 500 and VIX, during 2003-2012

In Table 9, we have the regression results for the last group of currency pairs. The H/M group’s coefficients with S&P 500 are positive with four currency pairs except for AUD/EUR and AUD/GBP which have negative values. The daily returns of the S&P 500 have the largest influence on the daily returns of AUD/USD and NZD/USD, as the coefficient values are 0.1859 and 0.1905 respectively. In general, it can be seen that the currency pairs which use NZD as an investment currency tend to be positively influenced by the changes in S&P 500 daily returns. The results for adj. $R^2$ show that the same currency pairs with highest coefficient values also have the largest adj. $R^2$ values for the 2003-2012 period. Again, the NZD currency pairs suppress the AUD currency pairs with larger adj. $R^2$ values, indicating that NZD currency pairs are more sensitive than AUD currency pairs to the fluctuations in S&P 500 returns.

The regressions results with VIX are somewhat different compared to S&P 500 results. The coefficients values are negative for all of the currency pairs which had positive coefficient values with S&P 500. The AUD/EUR and AUD/GBP currency pairs are the only ones with the positive coefficient values out of H/M yield group relating to VIX. The currency pairs with USD as the funding currency have the largest negative coefficient values from the whole group, as well as the largest adj. $R^2$ values of 0.0355 and 0.0344. Similarly to the adj. $R^2$ values with S&P 500, the NZD currency pairs overpower the AUD currency pairs with greater adj. $R^2$ values.
Chapter 6: Analysis

In this chapter, we combine and discuss our empirical findings in a systematic manner, by following the structure of results employed in Chapter 5. Correlations between currency pair returns, equity returns and volatility play an important role in answering our first research question, so those are going to be discussed first, by taking a look at how yield groups correlate to each other, how the three different time periods influenced by the world financial crisis relate to one another and which index influenced currency returns the most. The subject of regressions for currency pairs comes next, for it will generate answers to our second research question, with a look at currency sensitivity to equity returns and which index accounted the most for returns obtained from carry trading.

To make sure our analysis is relevant and avoids just restating results from the previous chapter, we will use the theories and findings of previous researchers mentioned in literature review, to support our statements and clearly show the reasoning behind them, in an attempt to evaluate the similarities and differences between them, in regards to our own findings.

6.1 Correlation Analysis

The correlations between all three yield groups and two equity indexes, during the period of 2003-2012, show that there is consistency in the results of M/L and H/M yield group and mixed findings in the H/L yield group. Generally, in all yield groups the correlation of daily returns for currency pairs is stronger with FTSE All-World than with S&P 500. This difference in correlation, might depend on the size of the equity indexes, as the FTSE All-World is an index consisting of 2800 different stocks from all over the world, while S&P 500 covers just the market capitalizations of the largest 500 publicly traded companies from the U.S stock markets.

When we analyze the differences between the three yield groups, in relation to S&P 500, our findings show that in the H/L yield group the currency pair’s coefficients are mostly negative, unlike with the two other yield groups, where there are only a couple of negative coefficient values. The difference in correlations among the yield groups also show that, in general, the M/L yield group and H/M yield group have stronger correlations with the two equity indexes than the H/L yield group. Despite the negative correlations in the H/M yield group, the majority of all currency pair’s daily returns are positively correlated with the equity indexes’ returns. This finding is similar to those of Ajayi & Mougoue (1996), who found that in the long run, the currency values are positively correlated to stock market returns.

The correlations between the currency pairs and equity indexes are also dependable on the currency used to fund the trade. We found that in the H/L and M/L yield group, the use of CHF as the funding currency tends to produce negative correlations with both equity indexes. The situation is however different when JPY is used as the funding currency, because then the pairs show mostly positive correlations with the equity indexes. The relationship between the JPY pairs and equity indexes respects the Portfolio Balance Model stating that the causations runs from stock prices to exchange rates, determining a positive relation between them.
Despite the fact that the funding currencies are the same in the H/L and M/L yield groups, the correlations between currency pairs and equity indexes tend to be stronger in the M/L yield group. This is natural, since the investment currencies of M/L yield group have higher correlation with the FTSE All-World and S&P 500 equity indexes, than AUD and NZD. Therefore, similar to Katechos (2011) findings, we can state that the correlation is dependent on the interest rate of the currency. One relatively interesting observation, confirming Katechos (2011) findings, is that the majority of USD currency pairs have positive correlation with the equity indexes. When the USD is used as the funding currency in H/M yield group, the correlation is stronger with the FTSE All-World than with S&P 500. The situation is different in the M/L yield group, where the USD is used as an investment currency.

Our results on the correlation of currency pairs, in relation to volatility index VIX, are mostly consistent during the period of 2003-2012, as M/L and H/M yield groups had partly negative correlation with the index. We found that the exception is the H/L yield group, which has mostly positive correlation with VIX. As it measures the volatility of S&P 500, our results of the correlation between the VIX and the currency pairs have similar coefficients, just with different signs as the correlations between the currency pairs and the S&P 500. The correlation was a little bit weaker with the VIX, than with the S&P 500, but otherwise the range is pretty similar.

Our in depth results also show how correlations changed because of the world financial crisis, during those three defining periods of gains, crash and recovery for the H/L yield group of currency pairs. We found that the period of 2003-2007, before the crisis, determined carry trades funded through JPY to respect Ajayi & Mougoue (1996) findings on the positive correlation of currency returns to stock market returns, although this did not hold true for carry trades funded by borrowing CHF. The partly congruent results are due to market development over time, which might have changed the FX market behavior, since 1996 when Ajayi & Mougoue conducted the study, although some of its relevancy still holds. All four currency pairs show an average degree of positive correlation with the volatility index during the five years before the world financial crisis, thus supporting carry trades returns during the uptrend.

The market crash period of 2007-June 2009 saw currency pairs take a turn for the worst, with liquidity playing an important part. Our results share similarities with those of Menkhoff, et al. (2011) on this matter and suggest that during this time, traders who held on to carry trades funded through JPY currency, would have experienced great losses due to the positive correlation with equity indexes, also affected by the world financial crisis. On the other hand, the CHF funding currency’s relation to equity indexes performed much like the previous four years period, maintaining a slightly negative correlation, thus allowing traders who made this choice to suffer less from losses. The correlations with volatility fluctuations depend on the choice of investment currency, with traders who bought AUD experiencing negative co-movements to VIX, a finding similar to that of Menkhoff, et al. (2011) on this matter.

In the recovery period of June 2009-2012, traders could once again engage in carry trading with an uptrend allowing profits to be made, although some currency pairs fared better than others, due to their different correlations to equity indexes. Our results for these years show comparable coefficients to the crash period, with a negative correlation to indexes for carry trades using CHF as the borrowed currency, unlike those
funded with JPY. Our findings are in agreement with the research of Dornbusch and Fischer (1980) on the negative relation to stock returns, of pairs using CHF for funding. On the subject of correlations to VIX, our results are supported by the research of Ranaldo, et al. (2007) for the other funding choice of JPY, as the borrowed currency for carry trading, which displays a negative relationship.

To conclude this subchapter, our analysis of the empirical findings for correlations between the 16 chosen currency pairs, two equity indexes and the volatility index determined mostly a positive relationship between them for the whole ten year span, while period detailed analysis for the H/L yield group of currencies displayed positive co-movements before the crisis and mostly a negative relationship during the crisis and afterwards. Our conclusion is similar, in a sense, to that of Mishra (2004) due to the fact that throughout the whole ten year period, correlations with equity indexes and VIX have been proven to exist, and are consistent through time or when comparing results for funding currencies with similar characteristics, despite the financial crisis, which left its mark worldwide in the markets.

6.2 Regression Analysis

While the previous subchapter dealt with correlations, the current one will analyze and discuss the relationships between currency returns, equity indexes return and volatility from a more statistical approach, with reference to empirical findings presented in Chapter 5.2. The analysis structure is divided in regards to the index for which the comparison, between the three yield groups of currency pairs, is conducted. We start by discussing about the influence of S&P 500 returns on currency pair returns and their sensitivity to it, followed by the same line of argument for VIX.

Before getting into the regression analysis, it is worth mentioning that both of our time series models, Table 5 and Table 6, have substantial α-ARCH parameters and β- GARCH parameters with a sum of close to one for all currency pairs. Since the β- parameter is very high, we can say that volatility shocks might be persistent.

The regression analysis presenting the influence and sensitivity results of S&P 500 daily returns to daily returns of 16 different currency pairs shows a similar outcome as we got from correlation analysis. When the three yield groups are compared together, the coefficient values are mostly positive in M/L and H/M yield groups, indicating that S&P 500 has a positive influence for currency pairs in these groups. The H/L yield group’s daily returns, on the other hand, experience mostly negative influence from the daily returns of S&P 500. Our models explanatory power seems to be stronger when the interest rate differential between the currency pairs is smaller, as can be seen with the larger coefficient values in M/L and H/M yield groups. The influence of S&P 500 on currency pair returns, using CHF as the funding currency, is mainly negative while the currency pairs using JPY as a funding currency are almost in opposition, with positive coefficient values. The JPY pairs’ positive coefficient values, when compared to CHF pairs, are mostly higher due to the larger interest rate differential.

During the period of 2003-2012, the Bank of Japan kept zero interest policy for JPY compared to Swiss target rate, which varied between 3% and 0.25%. The USD currency pairs are generally showing the strongest positive coefficients in H/M yield group, when the USD is used as the funding currency. One major reason for this is that between the
years 2007-2008 the US Federal Target Rate was lowered radically from 5.25% to 0.25%, making the USD desirable funding currency for carry trade. As the period of 2003-2012 experienced both stable and turbulent times with growing bullish situations and sudden crashes during the financial crisis, we can say, similar to Katechos (2011) findings, that the interest rate characteristic of an individual currency can have notable effects in the relationship between the currency pairs and equity indexes. Our sensitivity measure’s adj. R² results show similar tendencies as the coefficient values of the H/L yielding group’s daily returns, which display lower sensitivity to S&P 500, than M/L and H/M yield group’s daily returns. The two pairs using USD as the funding currency within the H/M yield group show the strongest sensitivity for S&P 500 returns, while in M/L yield group, the sensitivity is less significant when USD is the investment currency.

Moving on to regression results, for the case when the VIX volatility index is considered as an independent variable and each currency as the dependent one, we can make certain remarks on the resulting relationships. The regression coefficients for all the three yield groups have the correct sign, as seen in the correlations table. When we compare them, we observe that the volatility index has partly a negative influence on the M/L and H/M yield groups, while the H/L yield group is positively influenced. By also analyzing the coefficient values, we are lead to believe that the explanatory power of our model is greater for yield groups with lower interest differential such as M/L and H/M, which is different from the research findings of Katechos (2011).

Chart 7. EUR/JPY, EUR/CHF and VIX development, during 2003-2012
Taking a look at funding currencies, our results suggest that pairs denominated in JPY, as well as CHF, from the M/L yield group have a higher sensitivity to VIX and volatility accounts for a greater part of their return than for pairs from the H/L yield group, as can be observed for the highest coefficient values of EUR/JPY, in Chart 7. In regards to investment currencies, larger values of coefficients and adj. R² demand that NZD shows higher sensitivity to volatility than AUD, as well as its return being influenced by volatility in a greater manner.

These results confirm the findings of Kanas’ (2002) and suggest that the volatility of equity returns, namely the volatility index of S&P 500, does determine the volatility of exchange rates. Thus, we are able to state that the asset approach model can be applied to foreign exchange markets, supporting Menkhoff, et al. (2011) research and the fact that volatility risk is one of the main drivers of risk premia in these markets.
Chapter 7: Conclusions

The aim of this concluding chapter is to revisit and answer our two research questions, in order to finalize the deductive process started in the first chapter. By doing so, we can evaluate whether the objectives of this thesis have been achieved and also summarize our contribution to new knowledge on the chosen topic of research.

Our main research questions were derived from theories of foreign exchange and equity markets after careful systematic investigation of other researchers’ scientific work. We found that the following two issues stirred our interest and decided to try and answer them through research.

The first question of interest “What is the relationship between daily returns of carry trading currencies, equity indexes and volatility before, during and after the recent world financial crisis?” found its answer in the correlation analysis conducted in Chapter 6.1. To summarize, we consider that the foreign exchange markets are connected and influenced by equity markets and volatility, statement supported by our results which show that correlations and sensitivity between them exists, and are consistent on the long term, despite the influence of the world financial crisis on market development.

The second research question naturally occurs from the first, as it tries to address a more specific issue, which is “Are daily returns of some currency pairs more sensitive, or greater influenced than others, by equity returns and volatility?”. By conducting statistical tests and interpreting the results, we uncovered the answer to this specific issue and can argue that the S&P 500 equity index, as well as the VIX, which measures its volatility, exert a certain amount of influence on daily returns of currency pairs involved in carry trading.

Having answered the issues which challenged us throughout our research, we consider to have achieved the purpose set in the beginning, that of showing what kind of a relationship do carry trade returns have with equity indexes and with volatility index VIX. We also think that by observing the influence of S&P 500 and VIX to carry trade returns, one can note some explanatory power confirming the existence of UIP puzzle in the field of foreign exchange markets.

While conducting our research in the field of carry trading, we found several interesting characteristics on the relationships between the currency pairs and the FTSE All-World index, the S&P 500 index, and the VIX volatility index. The results of correlation, influence, and sensitivity between the currency pairs and the indexes confirm that the UIP puzzle exists in the foreign exchange markets.

We find that, during the period of 2003-2012, majority of the daily returns in our chosen currency pairs are positively correlated with the equity indexes and that the currency pair’s show greater correlation with the FTSE All-World than with the S&P 500. Factors such as the interest rate of a currency and the choice of funding currency played an important role in the foreign exchange markets, during the ten year time span, in every yield group. Our findings on correlations, during the three different periods, are in a line with the findings for the ten year period, as the same characteristics play an important role in the relationships between currency pairs and indexes. Slight difference
worth mentioning is that during the crisis years 2007-2009, the choice of an investment currency can have an effect to correlations, since the volatility fluctuations cause position unwinding among the traders.

When we analyzed the influence and sensitivity issues between the currency pairs, S&P 500, and VIX we find that our models explanatory power seems to be stronger when the interest rate differential between the currency pairs is smaller. Also the characteristics of an individual currency can show notable effects in the relationship between the currency pairs and two indexes, measured in our regression analysis.

The influence of the chosen funding currency and the effect of interest rate differential, show that the UIP puzzle exists in the field of carry trading. The UIP states that in a rational and risk-neutral world, all of the possible arbitrage opportunities in exchange rates should vanish when exchange rates of currencies adjust. We can state that this does not happen, since if UIP would hold there should not be any difference between the chosen funding currency and its interest rate differential. We find that as long as the UIP puzzle exists in the financial markets, the traders can take advantage of it and realize profits, with the downside of being exposed to crash risk generated by volatility fluctuations.

7.1 Contribution to knowledge

For this is a thesis conducted at the Master’s level, it is important to underline the contribution to knowledge we bring through our research, towards existing scientific literature. Having certain research articles which guided us to reach our goal, we would like to bring forth an author mentioned several times in this paper, Katechos (2011). Sharing similar interests about issues discussed in his research, which focuses on the relationship between currency pairs involved in carry trading and the FTSE All-World, we decided to add our contribution by further investigation on the connection of carry trading currency pairs to the S&P 500 index and its measure of volatility, the VIX. To add another layer of causality, the world financial crisis was included in the analysis, as a timeline divider. Since our research topic is one that gains momentum in popularity, we consider that our results are relevant for reference and comparison in other future scientific works.
Chapter 8: Further research

As there are always new things to discover in any area of research, we would like to list some aspects of our topic of research that could benefit from further investigation.

To deeper investigate the effects of the world financial crisis on the relationships between different yield groups of currency pairs and equity indexes, one might also conduct our period divided analysis for the H/M and M/L yield groups, to uncover further details and causality.

Finally, another interesting idea would be to calculate the risk an investor might have to bear, by holding a portfolio of currency pairs, for each of the three periods determined by the world financial crisis.
Reference List


