Relationship between Currency Carry Trades and Gold Returns

A quantitative study of G-10 currencies: correlation and spillover effects for the last two decades.

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Sincerely

Johannes Hornbrinck

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Abstract

Currency carry trade is an investment strategy that recently started gaining a lot of interest not only among investors and financial institutions but also academically. One of the underlying theoretical assumptions regarding the mechanisms of the foreign exchange market, the Uncovered Interest Parity has frequently been disproved in practice which has led to the conclusion that carry trade is profitable in practice. The function of a carry trade strategy is that a short position is taken in a low interest rate currency to finance a long position in another currency offering higher yields. This thesis is adding to the existing literature that is explaining the characteristics of currency carry trade but is adopting a different approach than most other recent researches that has focused on identifying especially risk factors. Gold as a financial asset has also received much attention largely due to its, contrarily to other asset classes, low dependence on macroeconomic factors. This makes gold desirable to diversify portfolios and decreasing overall risks. By investigating how the returns of currency carry trades and gold relates to each other an increased understanding in how carry trades can be beneficially included in managing portfolios are developed. Looking at a currency carry trade index, Deutsche Bank’s G10 Currency Future Harvest index, and the development of the gold price at the London bullion market for the 20 year period of 1993-2013 this research is exploring correlation, mean and volatility spillover effects. Spearman’s correlation, Vector Autoregression and a diagonal BEKK GARCH model are employed to test these effects. It also investigates if gold possesses hedge, diversifier and safe haven characteristics when combined with carry trades as it has been found to do with stock markets. This is determined by a regression analysis and supplemented by a portfolio simulation.

This thesis found that there is a low positive correlation between the returns of gold and currency carry trades and that there is spillover effects as well between the two in both returns and volatility. This in addition to the regression analysis and portfolio analysis determined that there are diversification benefits by adding gold to a portfolio consisting of currency carry trade in the form of higher risk adjusted returns. However special caution has to be taken to the spillover effects as these complicate the relationship between the returns of the two variables and especially the volatility spillover effects slightly decreases the potential diversification benefit. The regression analysis concluded that gold work as a diversifier for carry trade but could not determine if it also exhibited hedge or safe haven characteristics. These findings pushes the existing understanding of carry trades forward and adds to focus of matching carry trades within a portfolio which could have implications to more efficiently match risks and returns by combining several asset classes in portfolio management.
Glossary

G-10
The term G-10 is a group of the ten most actively traded currencies which are also therefore considered the most liquid and in extension, safe currencies to trade in.

Spillover
Spillover refers to the effect of where a situation unintentionally affects another. It is thus a secondary effect that arises from and is to some extent caused by a primary effect. Although these effects are separated by time and space.

Correlation
Correlation corresponds and measures to what extent two random variables vary in the same directions. Variables that are considered highly correlated tend to often move increase or decrease in value at the same time while uncorrelated move independently of each other.

Variance
Variance in finance concerns how much the value of a certain asset fluctuates over a time period. This is largely considered in regard to risk as assets associated with higher fluctuations are more unpredictable and more risky.

Safe haven
Safe haven is regarded as something or someplace relatively safe to turn to when all else seems risky and turbulent, thus as the climate becomes more unpredictable and unsafe the safe havens are still being considered calm and are therefore associated with lower risk (Baur & McDermott, 2010, p. 1893).
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1. Introduction

This chapter introduces the research and research topic. It begins with providing the background to the problem at hand which summarizes the current knowledge regarding the subject and what is not yet known. Sequentially the research question is presented and the core method for how the research is going to be conducted. Contributions and limitations of this research are stated and the chapter is concluded with a disposition of the thesis.

1.1 Problem Background

Currency carry trades and the failure of the uncovered interest rate parity have puzzled researchers over the world. The focus have then started to shift towards finding the driving risk factors related to this in order to try to understand if the excess returns can be justified.

Currency carry trades or just carry trade is an investment strategy where you are borrowing in low-yielding currencies and lend (invest) in high yielding currencies. The theoretical basis is the uncovered interest rate parity which suggests that it should not be possible to attain positive returns with this kind of trading (Rosenberg, 2013, p. 13). Since the difference in the interest rates will be canceled out by a depreciation/appreciation in the exchange rate. This works according to the principle of no arbitrage, however there are a considerable amount of empirical evidence that have found that this is not necessarily the case (Clarida et al., 2009).

This discrepancy have led researchers into considering that the failure of the uncovered interest rate parity could be attributable to a risk premium that might have to be incorporated due to accommodate for the different risk associated with different countries. Researchers have extensively been trying to shed light on how to evaluate the risk associated to these investments. There have been a lot of research trying to solve this issue but these have yet been unsuccessful able to find a good pricing model that incorporates the correct risk associated to it (Bhansali, 2007; Clarida et al., 2009; Brunnermeier et al., 2008; Cenedese et al., 2014).

Banks have introduced carry trade indices in light of the growing interest in currency carry trades and the area getting ever increasingly coverage as well as an ever larger increase in the legitimacy as a solid investment strategy (Arnold et al., 2006). Despite its popularity there is a lack of consensus on the actual attributes of the strategy and how it relates to other investments strategies, academic literature have especially had trouble identifying the risk drivers associated to the carry trade strategy (Burnside, 2011a, p. 853). Thus obstructing the possibility of effectively managing such an investment by introducing it to portfolios consisting of other assets and the benefits carry trades could bring to a portfolio.

Currency carry trades have been found to behave differently depending on the state of exchange rate volatility (Bhansali, 2007; Clarida et al., 2009). Empirical research has found that it systematically generates positive returns in states of low volatility and considerably large negative returns in high volatility states (Clarida et al., 2009, p. 20). This have been linked to a lot of investors unwinding their carry trade positions in
turbulent times, resulting in a steep appreciation of the low-yielding funding currencies and the large losses for investors (Brunnermeier et al., 2008, p. 29; Clarida et al., 2009).

For a carry trade portfolio it has been proven that there is a diversification benefit of including different currencies (Clarida et al., 2009, p. 8; Lustig & Verdelhan, 2007, p. 113). However due to the behavior in different volatility regimes it have not been much research regarding how to handle and potentially hedge a carry trade portfolio in these high volatility states.

Since there is no general consensus on how to determine and appropriately appraise the risks, it does not exist a definite way in how to eliminate some downside risk by sacrificing some return. As a common measure for measuring the risk/return for the carry trades have been the Sharpe ratio. This is a way to analyze and more specifically compare the investments performance with respect to its respective risk.

Previous researches on carry trades have revolved a lot around currency carry trades as an individual asset class. However as Das et al. (2012, p. 256) states it should receive more attention for the purpose of portfolio management. Since it possesses several favorable characteristics as it displays low standard deviation and also shows modest correlation to equity-based assets (Das et al., 2012, p. 256).

As for the relationship between various currencies and the equity market it has also shown different characteristics depending on the features of the currency. High yielding currencies has proven to be positively related to the returns of the stock market, while low yielding on the other hand has demonstrated negative relationships (Katecheos, 2011, p. 558). This further defies the uncovered interest rate parity as currencies generally has shown to move in the opposite direction of what this condition suggest, increasing potential returns from currency carry trades even more. The relationship is also dependent on the interest rate differentials between the different currencies where larger differentials suggest a stronger relationship and vice versa when the differentials are lower (Katecheos, 2011, p. 558).

Gold is an asset class that historically has been regarded as a safe-haven due to its property of being largely uncorrelated to stocks and bonds on average. Safe-haven is distinguished from hedge or diversifier, since it has the property of retaining or increasing in value even in times of market turmoil (Baur & McDermott, 2010, p. 1893). The purpose and benefits of safe haven assets is then to be invested in order to limit the losses that might be incurred in these situations. Baur & Lucey (2010, p. 228) discovered empirical evidence that gold act as a safe haven for stocks.

Considering that there is a recently increased academic interest in currency carry trades with many articles dating back just a few years it is interesting to investigate the currency carry trades characteristics in regard to portfolio management (Bhansali, 2007; Clarida et al., 2009; Brunnermeier et al., 2008). Currencies have shown modest correlation with the stock market, given that carry trades share the characteristics of yielding very negative returns in states when the exchange rate market are experiencing high volatility. This effect might to some extent be able to be mitigated by gold investment due to its safe-haven characteristics. This is an issue that as far as we have found lacks empirical evidence and is therefore an area of interest and in need of further investigation.
1.2 Research Questions

Building on the problem background and previous research we find that there is a lot of researches with emphasis on the risk drivers for currency carry trades. A less researched area regarding currency carry trades are the relation to other financial assets. We found it interesting to further explore potential portfolio diversification of carry trades. We intend to explore this in relation how carry trades returns and gold returns relate to each other. In order to enable us to achieve this we have develop the following research questions:

Is there a co-movement between currency carry trade returns and gold price returns?

Are there any spillover effects between currency carry trade returns and gold price returns?

1.3 Research Purpose

The purpose of the research is to investigate the relationship in the movements of currency carry trade returns and gold returns. Firstly, this will be done by establishing the correlation between carry trade returns and gold returns. Secondly, we are going to extend the analysis of this relationship by testing the mean and volatility spillover effects. Thirdly, we are going to investigate the potential safe-haven, hedge and diversifier properties of gold in relation to a currency carry trade portfolio by employing a regression model. Furthermore the regression analysis will also help us to investigate the relationship between these assets in different volatility states.

1.4 Research Gap

Most of earlier research for currency carry trades have been centered round identifying the specific risk factors that are associated to this investment vehicle. In order to understand what drives the excess returns and if these excess returns associated with the currency carry trade is fair given the risks undertaken (Clarida et al., 2009; Bhansali, 2007; Brunnermeier et al., 2008). These researches have focused on currency carry trades as an individual asset type and little attention has been given to carry trades as an asset class among others in a portfolio.

Lustig & Verdelhan (2007, p. 94-95) looked a bit more into the portfolio aspects of currency carry trades when they investigated the diversification benefits of including additional currencies into a currency portfolio. Their findings that a well-designed currency portfolio can eliminate some of this hypersensitive risk that individual currencies experience some that there are potential benefits of diversifying your currency carry trade portfolio.

This research intends to contribute to the academic field by fulfilling the research gap of currency carry trades portfolios aspects by providing empirical evidence of how
currency carry trade returns relate to the returns characteristics of other asset classes, in this case gold price returns.

1.5 Research Contributions

As stated previously this study, on the contrary to previous studies, will focus more on carry trades as an asset class for portfolio management. This is something that have been lacking since most of the earlier studies have focused on identifying the risk with the carry trades as an individual asset rather than how it relates to other assets.

Building from Clarida et al. (2009) findings of the negative returns associated with carry trade returns in high volatility states, our research will investigate how gold relates to the currency carry trades. To during the chosen time period generate an understanding whether gold can be used to help offset some of these downside risks. Lustig & Verdelhan (2007, p. 94-95) findings established that there are some diversification benefits by a well-designed currency portfolio where we want to investigate if this can be extended further to other assets, which in this case is gold due to its’ desirable safe haven characteristics with the equity markets.

The results can help narrow down or pinpoint more factors that can relate to the movements of the currency carry trades returns. Additionally explaining how currency carry trade returns relates to other assets help will not only shed further light on the behavior of carry trades and allow for more appropriate allocation in portfolios, but also provides another aspect in explaining the uncovered interest rate parity puzzle. The academically derived parity condition regarding economics and the mechanisms of the foreign rate market that surprisingly and frequently been disproved empirically.

It will also extend on the research of Das et al. (2013) which found that currency carry trades can be matched with other asset classes in a portfolio for better risk-adjusted returns. By investigating how carry trade relates to gold implications regarding how to match them to effectively manage risks can be made.

This can be of help for currency fund managers since it can help them better understand how to manage their portfolios during different risk scenarios of the market. This could further explain the behavior of currency carry trades and help determine how the associated downside risks in more turbulent market environments better can be handled.

Empirically we will contribute to how currency carry trades relate towards the gold price returns. A relationship that has not as far as we could establish receive any significant academic attention beforehand. It can then also be seen if the inclusion of other assets, other than including more currencies which has been researched be Lustig & Verdelhan (2007), within the carry trade portfolios can help better handle the downside risk and generate a portfolio with a better trade-off between the risk and return.
1.6 Delimitations

This study is limited to testing carry trade strategies for currencies included in the G-10 currency group. These currencies are those mostly included when conducting carry trades as they are considered the most liquid, making them appropriate to investigate in the research. It utilizes data from the limited twenty year time period of 1993-2013. This will be enough to provide statistical strength to the employed tests while still not compromising accessibility or comparability of the by employing data from different sources, which might have been collected or been measured differently.

Also the conclusion and assumptions made regarding portfolios comprised of currency carry trade strategies and other assets does not reflect actual portfolios or trading positions but is rather concerned with theoretical and academic implications. This thesis also focuses on the entire time period in its entirety and does thus not delve deeper into certain periods within the time sample. This as general conclusions aimed to be made rather than what could be more accurate but only so for a short period in time.

1.7 Dispositions

Chapter 1. Introduction
In this chapter the research topic is introduced as well as background information regarding the subject and what gap in existing theory the thesis is looking to answer. A research question is defined as is also the contributions of the study and the chapter ends with covering the delimitations the research is subject to.

Chapter 2. Research Methodology
The chosen methodology is presented in the second chapter starting off with the authors preconceptions and why the specific subject was chosen. It will also cover the philosophical standpoints underlying the research and what research method and approach were chosen. The implemented design follows and the chapter concludes with discussing how information was gathered and the quality criterion concerning the thesis.

Chapter 3. Theoretical Framework
The theories underlying the research and necessary background information is presented to the reasoning and practical methodology following in the study. This is to ensure that the reader has the proper knowledge and understanding to assess the conclusion and implications presented in later chapter. The chapter includes financial theories as well as common expressions and concepts used throughout the thesis.

Chapter 4. Practical Methodology
The actual methodology employed to conduct the research is presented in this chapter. The data collection and the treatment of the data are presented as well as the logic and reasoning behind it. Also the statistical tests and measures that are used in the research are introduced with assumptions they pose and the basic of how they are functioning. Following this the reader will be able to understand how the research was done and will allow for a more thorough understanding of the findings presented in later chapters. Finally the hypotheses constructed and used to answer the research question are posted.
Chapter 5. Empirical Findings
This chapter presents some descriptive statistics regarding the employed variables and the underlying data, to provide the reader some familiarity with the data and provide background information of the nature of the data. This is followed by the results of the various statistical tests which were conducted in this research and a brief interpretation of the findings. The chapter concludes with a follow-up on the posed hypotheses in light of the results.

Chapter 6. Discussion
After the results and hypotheses has been answered concluding the previous chapters these findings are further elaborated and discussed in the following sections. Starting off is a brief section summarizing the empirical findings, followed by the discussion where existing theories and previous academic literature is connected with the results of the empirical findings. The connection between the findings of the different tests as well as the nature of the relationship between gold returns and currency carry trade returns are assessed. Some speculations and inferences are made regarding this relationship as well.

Chapter 7. Conclusion & Recommendations
In the final chapter of this thesis the research is summarized covering the major various parts. The research question is restated as well as answered and all different measures used are connected again including the purpose of why they were conducted. Further the quality criteria that have continuously been worked with and constantly demonstrated all throughout the study. Following is the ethical concerns we were facing in connection to this research and how they were handled and the thesis is ended in a section suggested extensions for further research.
2. Research Methodology

This chapter will assess the philosophical standpoints adopted in this research as well as the structural and methodological choices made. It starts off by introducing the authors, their preconceptions, background and their relation to the topic at hand. Further, the philosophy of the research as well as the approach, method and design will be presented and discussed. The chapter will conclude with explaining the different data sources used in the research and a brief overview of the quality concerns regarding the validity and reliability of the study. It will end with a summary of the research methodology.

2.1 Preconceptions & Choice of Subject

The authors are both studying their second master-year in finance at Umeå School of Business and Economics and have since long had an interest, both academically and personal, within the field of finance. They have both completed master and bachelor level courses in finance in Umeå and internationally. Through this the authors have been able to develop a theoretical understanding of the theories and concepts employed in this research and have improved their ability to better assess appropriate tests in conducting the research as well as more accurately interpret the findings.

Within the field of finance we both have a preference of international finance which is the first direction of topic this thesis took. When we were subsequently browsing through academic literature and encountered the UIP puzzle surrounding currency carry trades an interest and curiosity was formed. Delving deeper into the subject it became apparent that most research concerning the concept had taken a similar approach by investigating it in separation to determine its’ characteristics and attributes. We figured that researching how currency carry trade functions in relation to other assets or investment would provide valuable insights regarding carry trades and how to approach it.

2.2 Research Philosophy

When conducting a research it is of great importance to consider what research philosophy to adopt. The research philosophical stances are the foundation for the choice of the research strategy and then the research methods you choose as components of this strategy (Saunders et al., 2009, p. 107-108). The different research paradigms that underpin the research philosophy are mainly the ontological and epistemological considerations. These paradigms provide the authors representation of beliefs, assumptions and the nature of what they regard can be defined as reality and truth (Flowers, 2009, p. 1).

Since the assumptions regarding the research philosophies echoes throughout the whole research we find it of utmost importance to give clarity upon it before continuing with the actual research. This is also crucial to present in order to enable the reader to understand from what point of view the research is conducted.
2.2.1 Ontology

The original definition for ontology is “the science or study of being” (Flowers, 2009, p. 1) which then develops into “claims about what exists, what it looks like, what units make it up and how these units interact with each other” (Flowers, 2009, p. 1). The central point of the concern with the ontological consideration is the question if social entities should be considered objective entities that have a reality external to the social actors which are interacting with it, or if they should be considered social construction built up from the perceptions and actions from the social actors (Bryman & Bell, 2011, p. 20). These two positions are called objectivism and constructionism and both of these are going to be discussed further below.

Objectivism is the position that expresses social phenomena opposes us as external facts that are out of our reach or influence (Bryman & Bell, 2009, p. 21). An organization is looked at as a tangible object with rules, regulations and adopts a standardized procedure to get things done (Bryman & Bell, 2009, p. 21). This means that we recognize that organizations have a reality that is external to the individuals who inhabit it (Bryman & Bell, 2009, p. 21). This basically means that for even if all people of which an organization consists of are replaced or removed from the organization, the organization would still be functioning similarly as before. It also implies that generalizations are possible to some extent between similar organizations (Saunders et al., 2009, p. 110).

Constructionism, also referred to as subjectivism, is the opposite position to the objectivism. This implies that the social actors may place many different interpretations on the situation in which they find themselves. In turn then these different interpretations will likely affect their actions and the nature of their social interactions with others, implicating that the social structure of the organization cease to exist when social actors are removed from it (Saunders et al., 2009, p. 111).

2.2.2 Epistemology

Epistemology is concerned with the asking about the nature the world, how knowledge is defined and the limits of knowledge (Flowers, 2009, p. 2). In essence the epistemological considerations are concern with answering the questions of what constitutes as acceptable knowledge in a field of study (Saunders et al., 2009, p. 112). The central point that needs to be given a careful thought is if the social world can and should be studied according to the same principles, procedures and ethos as the natural sciences. Just as in ontology epistemology is comprised of two main opposite views positivism and interpretivism, although a research in social sciences is likely to exhibit some characteristics of both (Bryman & Bell, 2009, p. 15-16).

Positivism reflects a stance where you adopt the philosophical standpoint of the natural scientist. This means that the researcher is considering himself to be working in an observable social reality and through such research will be able to end up with a result where the results are generalizable (Saunders et al., 2009, p. 113). This view assume that the social world exists objectively and externally, valid knowledge is thus only if it is based on observations of this reality and there is an existence of universal general
laws or the possibility to develop theoretical models that are generalizable (Flowers, 2009, p. 3). In the positivistic view the purpose of the theory is to generate hypothesis that will be tested, this enables the research to be conducted in a manner that is objective (Bryman & Bell, 2011, p. 15). Furthermore it could be used to explain the cause and effect of a relationship and then using these findings to help predicting outcomes (Flowers, 2009, p. 3).

Interpretivism on the contrary to positivism is grounded in that there is a distinct difference between the matters of natural sciences and social sciences (Flowers, 2009, p. 3). This stance argues for that in the social world, the individuals and groups makes sense of situations based upon their individual experiences, memories and expectations (Flowers, 2009, p. 3). Meaning is therefore constantly changing with new experiences which will result in different interpretations. Knowledge then becomes relative to the observer and the situation observed, interpretivists tend to work together with others with the aim to make sense of, draw meaning from and to create realities to understand their point of view (Flowers, 2009, p. 3). The challenge for the researcher adopting an interpretivist stance is to adopt an empathetic stance and to enter the social world of the research subjects and understand their world from their point of view often leading to a low degree of generalizability of this kind of researches (Saunders et al., 2009, p. 116).

For this research the ontological position adopted is the objectivism. Since we are going the investigate the relationship between the variable of gold prices returns and the carry trade portfolio returns to see if there is tendencies of a dependent relationship. We can treat the data objectively since we are going to use statistical and numerical methods in the analysis of it. The data is out of our reach to reasonably influence it, since it is based on historical observations. Given this ontological position the epistemological position in the research is of the positivistic nature. Since the essence of the research will be given to the number and their interpretation there is little room for a subjective opinion. We are using existing theories to develop the hypothesis we will be testing. As Remeyi (1996, p. 10) states the emphasis within positivism lies in quantifiable observations which can be done through statistical analysis. Given this, these are the research philosophical stances adopted in this research.

2.3 Research Approach

The research approach mainly concerns what approach is choosing and suitable for the thesis where the two exclusive possible approaches are deduction and induction. Which of these is appropriate depends on the relationship between the research and existing theory, where deduction tests and develops existing theory while induction usually is associated with developing new theories based on current observations (Saunders et al., 2009, p. 124-126). How studies are conducted based on the two approaches is presented in figure 1 below.
As is shown in the figure the deductive approach is conducted through using existing theory from which one or several hypotheses are derived (Bryman & Bell, 2011, p. 11). These hypotheses aim at testing some aspect of the theory to improve the understanding of a certain phenomenon and test the applicability of the current theory (Bryman & Bell, 2011, p. 11). Then after conducting the research and interpreting its findings the new knowledge is added to the existing understanding and the theory is adjusted accordingly (Bryman & Bell, 2011, p. 11). An inductive approach on the other hand is employed when the researcher sets out to study a certain phenomenon and based on the observations derive hypotheses which are later translated into new theories or additions to existing ones (Saunders et al., 2009, p. 61).

Considering the philosophical standpoints adopted in this thesis and that the aim of the research is to complement existing theory by testing it from a new perspective it is aligned with an approach associated with deduction. As the hypotheses are based on existing knowledge and they are examined through this research it is following a deductive approach.

2.4 Research Method

Choosing the appropriate research method depends on the nature of the data and how the analysis will be carried out. There are two main research methods, qualitative and quantitative research. They differ in terms of how the research is conducted significantly in some areas including but not limited to the role and possible impact of the researcher and how rigid the structure of the methods are, i.e. if it changes along the course of the research or not (Bryman & Bell, 2011, p. 410). A qualitative research is highly related to the inductive approach discussed in the previous section as it most commonly seeks to make some kind of generalization based on an observation. Quantitative on the other hand is more closely linked to a deductive approach as it usually tests if certain generalizations, theories, apply to specific instances. This is a generalization that is not always true and expressed in a simplified manner as inductive.
researches can exhibit characteristics of a quantitative approach and vice versa (Lee, 1992, p. 88). This as both inductive and deductive research to a varying extent use processes from both methods (Hyde, 2000, p. 82). Nonetheless a deductive approach is largely associated with the quantitative method, an association that is valid for this study as the applied processes all inhibit quantitative characteristics. This data for this research is numerical data analyzed through statistical means which is the essence of a quantitative which perfectly aligns with the quantitative approach where theory is tested in practice under certain conditions.

2.5 Research Design

The research design is concerned with how data will be analyzed and collected. This will then be concerned with the overall plan the researcher have for answering the research question and the research objectives (Saunders et al., 2009, p. 141). There are several different strategies that can be implemented in order to do this. As with other choices of research structures, the choice of strategy will depend upon the nature of the research in question (Saunders et al., 2009, p. 141).

For this research we are going to employ a longitudinal design. Since the main focus of the study is to investigate the relationship between currency carry trades returns and gold price returns over a time horizon of 20 years (1993-2013). The research is longitudinal since we have data that is collect over several points in time.

2.6 Literature & Data Sources

This study employs a mixture of different data sources, each with their own advantages and drawbacks as will be presented in this section. Saunders et al. (2009, p. 69) distinguishes between three different types of data sources: primary, secondary and tertiary. Primary literature sources mainly refers to the original source of data, be it data collected for the first time by the researcher or published documents. Although going back to the original source or gathering data yourself could be desirable to ensure reliability and suitability of the data for the specific research being conducted, it is often very time consuming. This study does not make use any primary literature data source as the nature of the data needed to answer the research question is inherently secondary.

The main advantages of using secondary data is that it is associated with lower cost and is considerably less time consuming than the alternative of it being collected by the researcher. This allows for the use of higher quality data and a more comprehensive analysis since the secondary data is not subject to the same limitations as the researcher might face. Some of the drawbacks of these kinds of data are that the researcher can do little to influence or improve the quality of the data nor do they necessarily possess the same level understanding and familiarity of the data as if it were collected specifically by the researcher (Bryman & Bell, 2011, p. 313-321). As suggested by Fisher (2007, p. 82-83) most of the secondary data is collected through the university library’s online catalogue, both to find relevant books and academic articles, which has the benefit of being more time-efficient and increases the likelihood of us locating the necessary information. Bryman & Bell (2011, p. 312) separates secondary data into two different categories both of which are employed in this research. The first category is data
collected by previous researchers which we access through academic journals and various textbooks. The second category is data collected by organizations for various reasons. Most of the raw data we use, such as currency carry trade returns and gold returns, are either collected through Thomson Reuters DataStream or directly from Deutsche Bank which would fit into the second category of secondary data.

Tertiary literature sources are used to locate and identify primary and secondary literature relevant to the researched topic (Saunders et al., 2009, p. 81). It has the advantage of allowing the researcher to navigate through an abundance of academic and non-academic sources and pick out the necessary information in an easy and time-efficient manner (Saunders et al., 2009, p. 81). As these various databases and indices which are classified as tertiary literature sources link the researcher to other sources and literature there is not many drawbacks associated with them rather than access might be limited and costly (Saunders et al., 2009, p. 81). This research has gained access to and located articles from several such online databases including but not limited to EBSCO, Springer and Business Source Premier, from which access was gained through the university library of Umeå University. Key Terms that were used when discovering articles and literature were among others: currency carry trade, gold returns, uncovered interest rate, forward premium puzzle, exchange rate risks, behavioral finance & portfolio theory.

2.7 Quality Criterion

In order to assess the quality of a research paper the concepts of reliability and validity must be addressed. Ensuring that these criteria are sufficiently fulfilled is thus crucial as whether or not the result of a study can be trusted, i.e. the degree of credibility of the thesis depends on it (Bryman & Bell, 2011, p. 700). Addressing the concerns of these aspects and how they have been dealt with is thus necessary to allow the reader to assess if the findings of the study are reliable (Bryman & Bell, 2011, p. 700). Reflexivity concerns also needs to be assessed in order to make clear the role of the researcher and what effect the researcher has on the findings (Bryman & Bell, 2011, p. 700).

Reliability concerns the consistency of the utilized methods, i.e. if another research using the same research methods and approach on the same data would produce the same or at least similar findings. In quantitative research this relates to inter and intra-observer consistency (Bryman & Bell, 2011, p. 279). The degree of inter-observer consistency provides to what extent another researcher would come to the same conclusion and intra-observer consistency whether the same researcher would reach the same result and interprets it similarly if they were to conduct the research at another point in time (Bryman & Bell, 2011, p. 279). By clearly stating how the data were collected and treated, what tests were conducted and summarize as well as provide the output of the tests in addition to showing the research philosophies adopted we aim to achieve not only a high degree of transparency but also fulfill the reliability criterion to a satisfactory extent. Tranfield et al. (2003) stressed the importance of giving account for the strategy in how sources were discovered. This implicates that through specifying and declaring all aspects of the research replicability will be ensured.

Validity on the other hand concerns whether the implemented tests are appropriate and valid measures for its intended purposes. Extending from this Greener (2008, p. 37)
divides validity into three different categories; face validity, construct validity and internal validity. Simply put face validity is whether or not the chosen approach seem reasonable or not at “face value” to someone not well-informed within the subject. Thus at first glance if the way a research is conducted actually seems to test what it is supposed to, that it could be argued that doing a research with the adopted measures would yield the correct results (Greener, 2008, p. 37). To account for this we have been sure to employ statistical tests and data used in previous research so that a consensus regarding the appropriateness of the variables and tests has already been established. The description of how the research was conducted have also been provided clearly and discussed in a manner to make sure that the reasoning why certain tests and variables were included is unambiguous.

Construct validity, also known as measurement validity, regards the issue of the researched variables not appropriately represents the research topic, i.e. that used methods and data might not correctly reflect the underlying phenomena which undisputedly might distort the results (Bryman & Bell, 2011, p. 42). The data collected in this thesis is analyzed in its own respect and the tests used have been conducted by previous researchers in testing similar conditions in other relationships which is why we found them applicable and appropriate. Special caution has also been used when deciding upon what variables to choose to best represent the underlying factors.

Finally internal validity emphasizes the issue of causality, if causality can be determined from a research or whether only a relationship has been proved (Greener, 2008, p. 37). As this study will not conclude causality as the statistical tests used are not able to determine it, rather the relationship is discovered will be covered extensively and discussions will be added regarding potential directions of said relationship. Reflexivity relates to the role of the researcher and is important to assess to inform the reader on what possible impact the specific researcher conducted the study could have on the result and interpretation. It is discussed as a warning of potential biases of the researcher (Riach, 2009, p. 357). By presenting the background of the authors and relevant preconceptions earlier in this chapter we thoroughly examine our own understanding of the subject as well as sharing this evaluation to the reader to critically assess. This will facilitate for the reader to follow the reasoning and the part we as researcher play in conducting this study.

Ethical considerations have been present all through the process of the study and what specific ethical concerns this thesis was facing is featured and further discussed after the findings.
2.8 Summary of Research Methodology

The methodical standpoints and choices made in this research and presented throughout this chapter are summarized in the figure below.

**Research Methodology**

- Objectivistism
- Positivistic stance
- Deductive process
- Quantitative method
- Longitudinal design
- Secondary data sources

Figure 2: Research Methodology
Source: The authors
3. Theoretical Framework

This chapter will introduce the theories and concepts underlying this research. It starts off with both Uncovered and Covered Interest Rate Parity which is the very foundation of how carry trades function. This is followed by an explanation of the mechanics of a Currency Carry Trade strategy and what is known about its’ characteristics. Subsequently relevant finance theory is presented as well as the characteristics of gold as a financial asset and the chapter is concluded with a brief explanation regarding the terms G-10 and various characteristics of assets in portfolios.

3.1 Uncovered Interest Rate Parity

The uncovered interest rate parity condition ensures there is no arbitrage possibility between the interest rates of two different countries. The basic condition states that any risk adjusted interest rate differential between the two countries will be offset by changes in the exchange rate leading to an indifferent preference between the alternatives for a risk-neutral investor.

The parity is functioning in accordance to the following equation:

\[ i - i^* = E(s_{t+1}) - s_t \] (1)

The uncovered interest rate parity is thus indicating that the interest rate differential between the home and foreign interest rates, \( i - i^* \), will be offset by the difference between current and future spot exchange rate, \( E(s_{t+1}) - s_t \) (McCallum, 1994, p. 108). Thus in theory the gains made from trying to exploit the differences in interest rates should systematically be cancelled by the loss from unwinding the position due to an appreciation of the funding currency. As exchange rates are influenced by several factors and interest rates is simply one of them, this will not always be the case but should according to theory generally be true on an aggregate level (McCallum, 1994, p. 109).

This relationship described by McCallum (1994) has consistently failed to be proven on an empirical basis, something which has surprised researchers and is commonly referred to as the uncovered interest rate parity puzzle, or the forward premium puzzle (Brunnermeier et al., 2008, p. 314). The failure in the uncovered interest rate parity is the foundation of existence and popularity of currency carry trades.

3.2 Covered Interest Rate Parity

The covered interest rate parity is based on the following formula and the theory concludes that this equation holds and there are thus no arbitrage profits to be made.

\[ \frac{F - S}{S} = \frac{i - i^*}{1 + i^*} \] (2)

In this equation \( F \) and \( S \) are the forward and spot rate of an exchange rate, \( i \) is the home interest rate and \( i^* \) is the foreign interest rate (Frenkel & Levich, 1981, p. 267). The
intuition behind this is that it is not possible to gain a positive return by exploiting the interest differential and securing the exchange rate transactions using forward and spot exchange rates. This is similar to how the currency carry trades strategies are conducted but with the exception that the exchange rate risk is eliminated by the inclusions of forward contracts.

Deviations from this equation which on several occasions have been discovered in empirical research would indicate that there exists a profitable zero-risk investment strategy which violates this parity condition. Although true in theory these profits have been found to be non-existing when including transaction costs, as well as political risk and capital market imperfections to a lesser extent, so that exploiting these mismatching and exerting a profit would not possible in practice (Frenkel & Levich, 1975, p. 326-327). Frenkel & Levich (1975) concluded that this applies to all deviations they did identify in their data and that the covered interest rate parity with the inclusion of transaction cost, political stability and imperfect market conditions, holds.

What is concluded using the covered interest rate parity is that forward exchange rate is efficiently and appropriately priced, something that is automatically enforced on the foreign exchange market. Similarly this ensures the efficiency of forward contracts on foreign exchange rates as there are no possible arbitrage profits. It differs from uncovered interest rate parity in that by immediately securing the future exchange rate by entering a forward contract it is considered covered and therefore not associated with exchange rate risk. Since this condition holds in practice forwards to secure future exchange rates cannot be included in a currency carry trade portfolio without effectively eliminating all return obtainable from it.

3.3 Currency Carry Trade

A currency carry trade is when an investor borrows funds in a low interest rate currency and lends those funds in a high interest rate currency (Burnside, 2011a, p. 853). For example with the domestic currency being Swedish krona (SEK) and the Swedish interest rate on riskless Swedish securities. The interest rate for the foreign denominated securities as $i^*$. The payoff for borrowing one SEK in order to lend the foreign currency is then:

$$ (1 + i^*_t) \frac{S_{t+1}}{S_t} - (1 + i_t) $$

(3)

$S_t$ denotes the spot exchange rate expressed as SEK per foreign currency unit, note also that this equation disregards transaction cost which is not the case in practice. The payoff from the carry trade strategy then becomes:

$$ Z_{t+1} = sign(i^*_t - i_t) \left[ (1 + i^*_t) \frac{S_{t+1}}{S_t} - (1 + i_t) \right] $$

(4)

(Burnside et al., 2011b, p. 513).
3.4 Carry Trades and Volatility

Rosenberg (2013) summary of the research on currency carry trades established one of the major issues with the currency carry trades. There is not one single risk factor that can explain the risk encumbered in the currency carry trades. Currency carry trades are exposed to several different risk factors, however it has not been established yet which are the most economically important and statistically significant ones (Rosenberg, 2013, p. 47). Much of the currency carry trades crashes have been linked the sudden unwinding in the carry trades when the investor’s confidence in the market has dropped (Brunnermeier, 2008, p. 342).

Vineer Bhansali (2007) researched currency carry trade returns relationship to volatility levels. He found that both theoretical and empirical evidence supported the positive relationship between these factors. He further went on that there was a possibility to implement option-based carry strategies that would give higher information ratio and favorable distribution of returns. Clarida et al. (2009) extended this research and found that currency carry trades that are done with forward contracts have payoff and risk characteristics that are similar to those of currency option strategies where you sell out of the money puts on high interest currencies. Since both these strategies are focused on collecting premiums/carry to generate constant excess returns that falls and result in losses if actual and implied volatility changes (Clarida et al., 2009, p. 2).

Clarida et al. (2009) investigated the factors that account for the returns on currency carry trade strategies. In their paper they found evidence of previous research on currency carry trades with a clear link between carry trade excess returns and exchange rate volatility, where carry trades are related to enhanced positive returns in low volatility states and large negative returns in high volatility states (Clarida et al., 2009, p. 20). Furthermore they found links between the potential currency risk premium for carry trades and risk premium in yield curve factors that drive bond yields in the countries which currencies are included in the carry trade portfolio (Clarida et al., 2009, p. 27).

Brunnermeier et al. (2008) found a relationship between currency carry trades the stock market volatility VIX, which is used to represent the implied volatility of the stock market, and the TED indices spread. He argues that these indices can be employed to derive the relationship between currency carry and currency crash risk. They also find a positive link between currency crashes and the VIX index. This can be due to the illiquidity that arises when implied volatility increases because of a shortage of speculator capital. Moreover he finds that carry trades generate higher returns for the future when VIX is high. Lastly, empirical evidence shows that there is a co-movement between currencies with similar interest rates (Brunnermeier et al., 2008, p. 342). Results that are consistent with the idea that UIP partly is corrected by the currency carry trade, however it does not completely offset the deviations. The crash risk of the carry trades are increased with the size of the carry, interest rate differential, speculators carry futures positions and decrease with the price of insurance (Brunnermeier et al., 2008, p. 342).

Cenedese et al. (2014) study of foreign exchange risks and their predictability upon currency carry trade returns, following Clarida et al. (2009), also found that higher
market variance is related to a large future loss in the currency carry trade. This is consistent with Clarida et al’s (2009) conclusion, that the large losses incurred is due to the unwinding of carry trades during this turbulent times which severely affect the exchange rates (Cenedese et al., 2014, p. 20-21).

Lustig & Verdelhan (2007, p. 94) investigated the carry trade characteristics found by Brunnermeier et al. (2008) and discovered that negatively skewed returns between high interest rate and low interest rate currencies also exists within individual currencies crosses in currency portfolios. However a well-designed currency portfolio, including several currency pairs, is able to eliminate some of this hypersensitive risk in individual currencies while still collecting the carry trade premium (Lustig & Verdelhan, 2007, p. 94-95). Furthermore Lustig & Verdelhan (2007) describes the interest rates to currencies as what the book-to-market ratios are for stocks, namely it functions as a measure of the currencies risk characteristics for foreign investors. That is the interest rates work as a measure of the risk characteristics in the different economies associated with the respective currencies. Relatively lower interest rates currencies would then offer an insurance against the higher risk in high interest rate currencies according to the principle of diversification (Lustig & Verdelhan, 2007, p. 113). Brunnermeier et al. (2008) provided empirical evidence for this relationship when they found that long positions in high interest rate currencies and short positions in low interest rate currencies expose investors to substantial crash risk.

Das et al. (2013) study on the contrary to the above mentioned focused on carry trade as a viable asset class to be used in a portfolio. According to their study they find that carry trades have several beneficial characteristics, over their time period of 22 years they compare the carry trade to conventional and alternative asset classes. The carry trade is one of the few assets that display such low standard deviation and only modest correlation with equity based assets (Das et al., 2013, p. 256). Furthermore they find that carry trades considerable boost the risk adjusted performance of the portfolio compared to if the portfolio would consist of other alternative asset classes, for example emerging market stocks, commodities and real estate (Das et al., 2013, p. 256). Characteristics that is persistent throughout the recent financial crisis, leading Das et al. (2013) to believe that investors can increase the risk adjusted performance of a portfolio by investments in the carry-trade exchange-traded fund (Das et al, 2013, p. 257).

These studies provide good insight into the current understanding of how currency carry trade volatility can be explained. However it is also evident that it is a complex issue which still needs to be discovered further.

3.5 Currency Carry Trades and Stock Markets

Katechos (2011) researched the relationship between exchange rates and equity returns. He introduced a new approach where he investigates how high/low interest rate currencies relates with stock markets globally. His findings are that the relative level of the interest rates will determine the direction of the relationship. The value of high interest rate currencies has a positive relation to the stock market and the value of low interest rate currencies show a negative relationship. This provides empirical evidence of the strong link between the equity market and the exchange rates (Katechos, 2011, p. 558).
Currency carry trades are closely linked to the stock markets given the global capital flows (Fung et al., 2013, p. 215). Tse & Zhao (2012) investigated the relationship between the carry-trade market and the US stock market from 1995 to 2005. Before this research a relationship between the two was treated as given. The study found empirical evidence that there indeed exist spillover effects from the stock market returns to currency carry trade returns, however carry trades returns does not have any spillover effect on the stock market. So this relationship was only found for one direction. These results from Tse & Zhao (2012) gave some further understanding to the carry trades for example that they likely reflect information slower than the stock market. Furthermore it is also consistent with the view that the stock market and carry trades are driven by the same volatility factors (Tse & Zhao, 2012, p. 268-269).

An extension of Tse & Zhao (2012) was made by Lee & Chang (2013) as they investigated the relationship between carry trades, the US market returns and the different market segments. Their empirical findings first reaffirm the results of the Tse & Zhao’s (2012) research. Moreover they also found that the spillover effects from the market returns on the carry trade returns are stronger when the trade markets are in a bear regime (Lee & Chang, 2013, p. 215). The finding suggests that high stock prices that are followed by a sharp decline will have relatively high spillover on currency carry trades (Lee & Chang, 2013, p. 215). Information that can be important to consider for investors when managing a currency carry trade portfolio.

Fung et al. (2013) further examined the relationship with the Japanese, Australian, Indian and Korean stock markets. Here they found the presence of cross-market spillover effects in both directions. The causality between the carry trade returns and the stock market are not visible until the crisis period in 2008. This adds to the pile of empirical evidence that the UIP condition does not hold systematically. The spillover effects from carry trades to the Asian stock market are most evident during crisis and the post crisis-period.

The relationship between the currency carry trades and the stock market has evidently been found in several empirical studies. Cheung et al. (2012) found further that it often is a relationship between the carry trade returns and the stock market in the target currency countries. However it can be unclear to whether or not this is disruptive effects of carry trades on the financial system or the general notion of global liquidity affecting asset prices (Cheung et al., 2012, p. 181).

3.6 Characteristics of Gold

Gold serves a very special purpose in finance and numerous researches have been conducted regarding its financial characteristics and how it can effectively be included and matched with other assets in portfolio management. Following is a brief summary of the main findings regarding gold and the usefulness of it as an asset class.

Gold has been found to be an effective asset for diversifying a portfolio as research conducted on the subject established that the correlation between returns on gold and that of other assets is low, including equities and other commodities (McCown & Zimmerman, 2006, p. 11). Lawrence (2003, p. 23) also discovered that gold is less dependent on macroeconomic factors than other commodities, further reinforcing the
argument that gold can effectively be used to as a diversifier during sour market conditions. Baur & McDermott (2008, p. 1897) rather argues whether the correct definition of gold as a financial asset should more appropriately would be “safe haven” as they observed that investors, especially in developed countries, seems to turn to gold in times of financial turmoil and distress. Baur & Lucey (2010) extended this reasoning by the adding that gold regularly also functions as a hedge against stocks but still is used as a safe haven during extreme market conditions. Regardless of definition there has been definitely been established in academic literature that including exposure to gold in a portfolio can help in managing the aggregated risk.

Gold is generally considered as a highly liquid asset, there are even arguments that there is a high price to pay for this liquidity in terms of lower returns (Jaffe, 1989, p. 53). This is due to the high liquidity of gold compared to other assets, especially in times of economic hardships, makes it less risky in regard to the ease at which gold can be bought and sold even when positions in other assets might be difficult to liquidate forcing investors to sell at discount price levels (Jaffe, 1989, p. 57). Gold also exhibit the positive traits of high trade volumes and small bid-ask spreads which further affirms its position as a highly useful asset to complement and diversify a portfolio (Bhatia et al., 2011, p. 8).

Given the evident relationship between the stock market and the currency carry trade returns that has been extensively researched, we found it important to extend this understanding for currency carry trades and gold returns since gold have been found as hedge and safe-haven for investments in the stock market. So this empirical evidence leads us to believe gold as an asset could be used in a similar fashion for a currency carry trade portfolio.

3.7 Portfolio Theory

3.7.1 Risk

Risk in this context is financial risk. The most central aspect concerning financial risk is the risk premium, which comes from the idea that investors will have to be compensated in terms of expected return for bearing the risk of an asset (Bodie & Merton, 2000, p. 348). This expected return can also be referred to as excess return which is the difference between the expected holding period return on an assets and the risk free rate (Bodie et al., 2011, p. 157). Risk is commonly measured by standard deviation, denoted as $\sigma$. The standard deviation is a quantification and measure of the volatility of an assets probability distribution of returns.

$$\sigma = \sqrt{\sum_{i=1}^{n} p_i (r_i - E(r))^2}$$  \hspace{1cm} (5)

(Bodie & Merton, 2000, p. 275)
A larger standard deviation means a greater volatility of the asset. A riskless investment will have a standard deviation of 0 (Bodie & Merton, 2000, p. 275-276).
3.7.2 Modern Portfolio Theory

For this paper in order to enables us to be able to evaluate our results and to draw conclusions regarding character of gold for currency carry trade portfolio diversification from it we will be dependent on the Modern Portfolio Theory (MPT). The modern portfolio theory was created by Harry Markowitz (1959) and describes the relationship between the expected returns and risk of the assets (Markowitz, 1959). The MPT is the quantitative analysis for optimal risk management. Irrespective of what unit of analysis the theory is concerned with the trade-off between the benefits and costs of reducing risk with the aim to establish the optimal course of action. Risk preferences of the investing party is in the center of this. However the theory does not consist of answering what these preferences are rather it focuses upon how to choose among financial alternatives as to maximize these given risk preferences. Normally these choices are evaluating the trade-off between a higher expected return and taking a greater risk (Bodie & Merton, 2000, p. 272).

In Markowitz monograph 1959 he was one of the first to introduce and draw attention to the diversification concept. He showed that combining uncorrelated securities was an extremely powerful approach in order to devise a portfolio that yields a higher return but through the properties of correlations yields more downside protection (Markowitz, 1959, p. 102). As the expected return of a portfolio is the same irrespective of the assets are correlated or not (Markowitz, 1959, p. 70). Diversification then is today more or less defined as to the ability for the investor to reduce their risk exposure without having to sacrifice the expected return (Bodie & Merton, 2000, p. 298). For the stock market there have been evidence found that you cannot diversify away all risk. Therefore risk have been divided up into non-diversifiable and diversifiable risk. Non-diversifiable risk in the context of stocks is for example an event that affects many firms such as an economic downturn (Bodie & Merton, 2000, p. 302). The diversifiable risk is the risk associated to asset in question which can be removed by diversification (Bodie & Merton, 2000, p. 302).

For a portfolio the expected return is calculated as presented by Markowitz (1959, p. 172).

(Notations: \( w_i \) = weight of asset I, \( E(r_i) \) = expected return on asset I, \( \sigma_{ij} \) = covariance between asset i and j)

\[
E(r_p) = \sum_{i=1}^{n} w_i E(r_i)
\]  

(Markowitz, 1959, p. 172)

This is discussed above the expected return is simply a weighted average of the returns from the individual assets. If we then look at equation 7 how to calculate the standard deviation of the portfolio we can see this diversification effect of combining several uncorrelated assets in the portfolio.
\[ \sigma_p = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij}} \]  

(Markowitz, 1959, p. 172)

We can see here then by this formula that the level of diversifiable risk in the portfolio depends on the covariance of the returns of the assets. In which the covariance turn is function of the importance of the systematic factors in the economy (Bodie et al., 2011, p. 246).

### 3.7.3 Sharpe Ratio

To measure the risk-adjusted performance of particular investments or a portfolio of investments the Sharpe ratio is often used. It is calculated by dividing the risk premium, how much the return exceeds that of a risk-free investment, by the standard deviation of the return as illustrated in equation 8 (Brealey et al., 2011, p. 219). A higher Sharpe ratio is naturally more desirable as it indicates a greater payoff in form of a higher expected return for the risk undertaken.

\[ \text{Sharpe ratio} = \frac{\text{Risk premium}}{\text{Standard deviation}} = \frac{r - r_f}{\sigma} \]  

(Brealey et al., 2011, p. 219)

Although a rather blunt instrument as standard deviation account for historic volatility but does not include other risk factors nor indicate future risks it is still useful to assess how effectively certain assets performed (Burnside et al., 2011a, p. 883).

As Markowitz (1959, p. 125) states the combination of expected return and variance that creates the portfolio with the greatest return in the long run is not always the best to meet the investors need. The investor might want to have a portfolio that does not solely have a high long-run return, they might rather prefer to sacrifice some return for a greater short-run stability. That is why in order to enable us in this research to draw conclusion and make a discussion from the results, theories regarding behavior finance will be considered, especially when inferring conclusions and recommendations concerning investors.

### 3.7.4 Behavioral finance

As we discussed above the MPT is dependent on the investors’ perception and tolerance for risk. Markowitz (1959) was one of the first in proposing a model which would help deal with the issue of the inconsistency in human behavior. This was based on the famous economist puzzle that is contradictory to the idea of rational expectations, why would people buy lottery tickets when the expected value is less than the actual cost? (Brown et al., 2014, p. 501). Markowitz idea was centered on the value of the investment, if the investment was of large amounts compared to the “customary wealth”
the investments was treated more conservatively. With these models he paved the way into an alternative course of action in how to study investor’s decision making. The traditional view of risk aversion which was based largely on the rational attitude towards uncertainty was receiving less light. Researchers started to explore decision making models which incorporate more of the investors’ psychology, mood, mental “shortcuts” or heuristics which have been found playing a big role behind the decision (Brown et al., 2014, p. 502). Understanding the different psychological aspects behind the investors’ choice is important in order to be able to analyze and understand different movements in the gold prices and to understand the currency carry trade portfolio design.

Behavioral finance is concerned with how investors make decisions and the core of it is based on investor psychology and behavior and the important role this can play on their decision making and finally leading up to how this can influence asset prices (Brown et al, 2014, p. 499). Behavioral finance goes beyond the traditional framework that agents act rationally and try to understand financial phenomena when agents do not act fully rational (Barberis & Thaler, 2002, p. 1). The traditional framework where actors on financial markets are to be considered rational is rooted from the famous efficient market hypothesis developed by Eugene Fama (1970). This has its roots from Friedman’s work in 1953 which states that even in the presence of irrational actors involved in financial exchanges, these are few and any dislocation in pricing caused by their action will be undone and corrected by rational traders which should outnumber their less rational counterparts (Barberis & Thaler, 2002, p. 3-4).

As concluded by Barberis & Thaler (2002) that these behavior phenomenon can bias the financial markets in from the investors’ decision making process by two factors beliefs and preferences. An important feature underlying this factor is the phenomenon called heuristics. Some examples of this is; Representativeness is the tendency to stereotype a situation through a conceptual analogy. Empirical findings have found that people tend to jump to conclusions about probabilities without rationally consider issues such as sample size and to extrapolate beliefs from an isolated experience (Brown et al., 2014, p. 502). Anchoring and adjustment is when you apply your understanding of a situation on a familiar one and just make some modest adjustments for the perceived differences. Availability is when investors can tend to only look at the most recent market trends and ignore the whole data set. Overconfidence is when you overestimate your own personal ability to estimate the range of outcomes of a gamble. (Brown et al, 2014., p. 502). Another interesting heuristics that can affect the way an investor chooses to for example invest their pension money is that if they are offered three government bond funds they will invest more of their money in government bonds compared to if they only are offered one government bond fund. This is often called diversification heuristics (Brown et al, 2014., p. 505). Cognitive dissonance is the tendency of people to after for example making a purchase after a difficult decision to focus on positive and reinforcing information behind the decision they made and to filter out the negative contradictory information (Brown et al, 2014., p. 502). Mental accounting is a psychological feature that affects the formulation of the portfolio. This phenomenon means that the investors conceptually (and sometimes actually) place assets in a separate “account” and treat them differently. Basically this is the case when a person is more likely to be less risk averse with the money they gained one evening gambling compared to the money they won to cover their initial stake (Brown et al,
2014., p. 502). Ambiguity aversion is when investors are excessively fearful when they have little information and on the contrary have excessive preferences on the one they feel they have good information (Arnold, 2008, p. 600).

Built upon these inconsistencies in decision making the prospect theory was developed by Kahneman & Tversky (1979) in order to understand investors’ decision making process regarding its preferences towards risk and loss aversion. According to the prospect theory then when weighting between two risky options this is divided in two themes. The first theme is called editing and is concerned with determination of how prospects are perceived. The second theme is revolved around the judgmental principles that govern the evaluation of gains and losses and the weighting of uncertain outcomes (Kahneman & Tversky, 1979, p. 289). This theory states that investors normally underweight outcomes that are merely probable in comparison with certain outcomes (Kahneman & Tversky, 1979, p. 263). Another effect identified within this theory is the isolation effect this is when people discard components that are shared by all prospects under consideration. Something that leads into inconsistent preferences when the same choice is presented in different forms (Kahneman & Tversky, 1979, p. 263).

Barberis & Thaler (2002) furthermore presents how this affects investors’ decision making when it comes to portfolio diversification. The first issue is with insufficient diversification which arises from investors’ ability to demonstrate home bias (Barberis & Thaler, 2002, p. 48-49). Where investors are more inclined to hold domestic assets for example stocks, located close geographically, with reports in the domestic language and have executives that share the same cultural background (Barberis & Thaler, 2002, p. 48-49). Naive diversification is the when people do diversify but have a tendency to do so in a naïve fashion. For example they might allocate 1/n of their savings in each of the available investments (Barberis & Thaler, 2002, p. 48-49).

3.8 G-10 Currencies

G-10 stands for group of ten which is a list of what are considered the most liquid currencies. Originating from 1962 as the GAB, General Agreement to Borrow, between ten countries that agreed to if necessary provide currency from their respective central banks to IMF, the International Monetary Fund (IMF, 2014). When discussing currencies the group that is being referred as G-10 although based in the group of ten has developed to include the countries presented in table 1. These are generally considered the most liquid currencies and are therefore often used in various financial transactions as they are subject to lower liquidity risk (IMF, 2014). As such they are the currencies mostly involved in currency carry trade and carry trade indices are based on the use of only these ten currencies.
## G-10 Currencies

<table>
<thead>
<tr>
<th>Currency</th>
<th>Denotation</th>
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<tbody>
<tr>
<td>Australian Dollar, AUD</td>
<td>A$</td>
</tr>
<tr>
<td>Canadian Dollar, CAD</td>
<td>C$</td>
</tr>
<tr>
<td>Euro, EUR</td>
<td>€</td>
</tr>
<tr>
<td>Japanese Yen, JPY</td>
<td>¥</td>
</tr>
<tr>
<td>Norwegian Krone, NOK</td>
<td>NOK</td>
</tr>
<tr>
<td>New Zealand Dollar, NZD</td>
<td>NZ$</td>
</tr>
<tr>
<td>Swedish Krona, SEK</td>
<td>SEK</td>
</tr>
<tr>
<td>Swiss Franc, CHF</td>
<td>CHF</td>
</tr>
<tr>
<td>United Kingdom Pound Sterling, GBP</td>
<td>£</td>
</tr>
<tr>
<td>United States Dollar, USD</td>
<td>$</td>
</tr>
</tbody>
</table>

### Table 1: G-10 Currencies

3.9 Asset Characteristics for portfolio diversification

In order to be able to analyze the properties and the relationship between gold and carry trades, the definitions and properties behind the terms hedge, diversifier and safe haven has to be covered and determined.

Based on Baur & Lucey (2010, p. 219) which investigated gold and stocks for these three characteristics, the following definitions have been adopted in this research:

**Hedge:** "A hedge is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio on average" (Baur & Lucey, 2010, p. 219). An asset with the hedge properties does not necessarily reduce losses in times of market turmoil or stress. The assets can have positive correlation during these extreme market states and during normal times experience negative correlation. The key point is that they have a negative correlation on average (Baur & Lucey, 2010, p. 219).

**Diversifier:** "A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average” (Baur & Lucey, 2010, p. 219). Just as for hedging assets an asset with diversifier characteristics will not necessarily ensure loss reduction in extreme market states since the correlation property only is required to hold on average (Baur & Lucey, 2010, p. 219).

**Safe haven:** "A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil” (Baur & Lucey, 2010, p.219). Safe haven assets on the contrary to what have been mentioned above for diversifier assets have the properties of having a non-positive correlation with a portfolio in extreme market states (Baur & Lucey, 2010, p. 219). This implicate that the asset exhibiting safe haven characteristics generally is not associated with constant correlation relationships with other assets. If the asset has negative correlation in extreme conditions it will compensate for losses since its price then tend to rise when other assets the portfolio falls in value (Baur & Lucey, 2010, p. 219).
4. Practical Methodology

This chapter presents how the research has been conducted, starting off with what data was gathered and what criteria’s were imposed in determining the data sample, including what time period was chosen. The data treatment process is later discussed including how the tested variables were constructed to fit the purpose of the research and what tests it is being put through. It also provides background information to how the tests function and why they were chosen.

4.1 Data sample

As this research investigates the relationship between the returns of currency carry trades and of gold the relevant data of our variables have been collected and employed. The data was partially gathered using Thomson Reuters Datastream and partially collected from Deutsche Bank. The time series of gold price was available on a daily basis from Datastream and has been collected from there for the entire time period of this research. As the variable representing currency carry trade is based on an index created by Deutsche Bank daily data for the development of this time series have been accessed through Deutsche Bank. This index is more thoroughly presented later in section 4.5. The collected data was price series of both gold and of the carry trade index, these had to be transformed into returns following the method that is presented in later sections, as the research is investigating returns of time series rather than price development.

The collected gold prices are those listed on the London Bullion Market made available through Thomson Reuters Datastream.

4.2 Time horizon

It is crucial to choose an appropriate time horizon when conducting a research as a short time period produces a small data sample which makes it more difficult to generate significant findings and ensure that the findings are generalizable and consistent over time. A long time period on the other hand is more time and resource consuming which could come at the cost of other parts of the research receiving less attention than preferable (Greener, 2008, p. 36). This is attributable to longer time necessary to gather the data, depending on its accessibility, and also time and effort put into processing and evaluating the larger data set. It might also fail to identify and explain short-time patterns that affect the investigated subject.

A time period of 20 years has been employed in this research, 1993-2013. This will provide a sufficiently large data set which would show significant relationships where such are to be found. We argue that this time period is suitable and properly balance the aforementioned advantages and disadvantages. The chosen time period is also suitable considering the availability of the data, although the carry index that is considered in this thesis was only created by Deutsche Bank in 2006 it is indexed back to the beginning of our time period, 1993. Thus the data of the index is only accessible from that point in time and onward (Arnold et al., 2006).

Using daily data from 20 years has yielded a data sample of 5029 observation for each of the two variables. As the investigated relationship is between the returns of the
variables and the data collected reflects the price development this has resulted in one less data point, meaning that the actual number of values for the variables are 5028.

4.3 Return Calculations

This research employs log returns as it possesses certain desirable characteristics, which are useful when conducting our statistical tests well (Ruppert, 2004, p. 77). Especially when investigating time series log returns are useful as it exhibits time additivity, i.e. it is consistent over time all periods and sub periods included in the sample. Also if the log variables are considered normally distributed then normality can be assumed for the original results as well (Ruppert, 2004, p. 77). The logged returns are calculated as shown in the following formula.

\[
R_t = \ln(P_t) - \ln(P_{t-1}) = \ln\left(\frac{P_t}{P_{t-1}}\right)
\]  

(9)

Where \( R_t \) is the return of either the carry trade index or gold in time period \( t \). It is calculated from the natural logarithm of the price in period \( t, P_t \), divided by the price in the previous period, \( P_{t-1} \).

The employed carry trade index is the Deutsche Bank’s G10 Currency Future Harvest index which is composed of a 3*3 portfolio consisting entirely of G10 currencies. It is divided into three long currencies, the currencies that are currently offering the highest interest rates and therefore are held to “carry”. These positions are funded by short positions in the three currencies that yield the lowest interest rate and six currencies have an almost equal weight in the index (Arnold et al., 2006). The index allocation is recalculated quarterly and which positions of which low and high yielding currencies are used is based on the three month Libor rate for all individual currencies (Arnold et al., 2006).

The currencies currently employed in the Deutsche Bank G10 Currency Future Harvest index are listed in table 2 below. They are the currencies that are included as of May 9, 2014 and the included currencies have switched multiple times during the time sample and are likely to change again in the periods following this research (Arnold et al., 2006).

<table>
<thead>
<tr>
<th>Carry Currency</th>
<th>Australian Dollar</th>
<th>New Zealand Dollar</th>
<th>Norwegian Krone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding Currency</td>
<td>Swiss Franc</td>
<td>Japanese</td>
<td>United States Dollar</td>
</tr>
</tbody>
</table>

Table 2: Deutsche Bank Carry Index

4.4 Correlation

In order to assess the relationship between currency carry trade returns and gold returns the correlation is going to be tested. The correlation measures the strength of a relationship between two variables and a correlation coefficient can assume values
within the range of 1 to -1 (Moore et al., 2008, p. 113). A correlation coefficient of 0 indicates no relationship and the closer the coefficient is to 1 or -1 the stronger the correlation relationship (Moore et al., 2008, p. 113). It should be noted that correlation does not measure nor test causality among the included variables but rather provides an indication of whether the variables tend to vary similarly or not (Moore et al., 2008, p. 143). The findings of correlation statistics must therefore be considered with this in mind and conclusions derived from these kinds of tests needs to be modest and consistent with the results.

In this research the returns of our carry trade portfolio are going to be put through the Pearson product-moment correlation test if the data is found to be consistent with the assumption behind the test, if not another test needs to be employed with better fit the data distribution such as the Spearman’s rank correlation coefficient. The Pearson test requires the data to be measured on an interval or ratio basis and also assumes normality among the data, something that needs to be tested for (Lund & Lund, 2013). It is also necessary to have homoscedasticity in the data distribution a (Studenmund, 2006, p. 347). As it tests for a linear relationship between the variables it is also crucial that the underlying relationship is in fact a linear one as Pearson might not be able to detect a nonlinear correlation (Lund & Lund, 2013).

If the data distribution does not fulfill the required imposed by the Pearson test another test will be conducted as earlier mentioned, this as the Spearman test does not have quite as strict requirements. It does for instance not require a normal distribution nor does the relationship need to be linear (Hauke & Kossowsku, 2011, p. 92).

4.5 Spillover Effects

In this research we test for the presence of any spillover effects between the carry trade returns and gold returns, both in terms of the actual returns and the volatility of returns. This is done with two different statistical tests which are presented in the following sections as well as the assumptions underlying the tests and the requirements on the distribution of the data that is imposed by the employed tests.

As the relationship that is being researched tests for effects between returns and volatility of previous periods on the return and volatility of the current period an appropriate lag length has to be chosen. Lag length regards to how many previous variables are included to explain the current outcome (Liew, Khim-Sen 2004, p. 1). An inappropriate lag length could either lead to missing serial correlation detectable at larger lag lengths or an excessively large lag length is chosen might produce low power and unreliable results in statistical tests (Harvey, 1981, cited in Li & Giles, 2013, p. 16). Several criteria has been developed to find an appropriate lag length which will be investigated in this research, where a special focus will be put on Akaike’s information criterion (AIC) as suggested by Liew Khim-Sen (2004, p. 6-7) and Karolyi (1995, p. 17). This will need to be done individually for both the VAR and BEKK GARCH test and the chosen lag structure that produces the lowest AIC score is the lag length that minimizes information loss (Karolyi, 1995, p. 15).

In order to employ the appropriate statistical tests a unit root test has been conducted, as the possibility to make accurate conclusions based on the findings are deeply impaired by the presence of a unit root. To test for unit root and stationarity among the variables
the Augmented Dickey-Fuller test was used. The Dickey-Fuller and Augmented Dickey-Fuller tests examines whether the means or variance of time series shifts over time, as it does if the data has a unit root problem. It does so by testing the null hypothesis of a unit root presence (Elliott et al., 1996, p. 813).

If the properties of the data distribution of a time series shift over time it causes problems for certain models as the statistical tests used to derive them does not account for non-stationarity. In such cases more advanced tests are necessary which can include the developing trends of such data. This does not necessarily implicate that the data distribution is constant, non-static but rather that shifts in it are not a function of time (Elliot et al., 1996, p. 817). The stationarity of the included variables must thus be assessed before conducting the tests that assumes it.

4.5.1 Return Spillover

In order to study a dynamic relationship between several time series the Vector Autoregression, VAR, has been proposed by multiple researchers due to some different desirable attributes (Sims, 1980, p. 33; Hansen, 1999, p. 306). It allows the tested variable in the relationship that is being investigated to depend on both themselves in previous terms, i.e. lagged, and of other variables in earlier periods, also lagged. Employing this test does thus show whether, and how much the return in one of our variables is dependent not only on previous returns of the same variable but also previous returns of another return, thus the spillover effect between returns of several variables (Li & Giles, 2013, p. 11).

In order to employ the Vector Autoregression test all included time series need to be stationary, in this theses this implies that stationarity is required among the gold returns and carry trade returns. If the data series are found to be non-stationary VAR can still be used to test the interdependence among the variables but further measures has to be employed to ensure the reliability of the results (Stock & Watson, 2001, p.101-102).

A bivariate VAR model, which is being tested in this thesis, with two lags has the following equational form:

\[
\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} \pi_{11}^2 & \pi_{12}^2 \\ \pi_{21}^2 & \pi_{22}^2 \end{pmatrix} \begin{pmatrix} y_{1t-2} \\ y_{2t-2} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \tag{10}
\]

(Stock & Watson, 2001, p. 110)

A VAR(2) model like this implicate that the current value of variable 1 and 2, \(y_{1t}\) and \(y_{2t}\), depends on a constant, \(c_1\) and \(c_2\), the value of both variable 1 and 2 for the last two previous periods with different associated coefficients as well as an error term. \(\pi\) is the coefficients associated with the lag periods and the different previous values of the two variables. The error terms is a white noise vector, implicating it is statistically uncorrelated with the covariance, and has a zero mean (Fessler, 1998, p. 4).

Equation 10 above can also be described individually for the two variables and the effects between them and does then follow the equations presented below.
The VAR model has the advantage of being able to detect co-movements over other univariate and bivariate models as it investigates current and lagged variables. This allows for a more thorough investigation for the relationship between two variables (Stock & Watson, 2001, p. 110). This benefit is crucial for this research and the reason VAR has been employed in this thesis.

4.5.2 Volatility Spillover

In order to test for a relationship for any spillover effects in the relationship between gold and carry trades returns a GARCH, General Autoregressive Conditional Heteroscedasticity, model will be used. This is an extension proposed by Bollerslev (1986) of the original ARCH model made by Engle in 1982 (Bollerslev, 1986, p. 307). It is improved by allowing the model to include less strictly defined lags and provides a better fit than its predecessor (Bollerslev, 1986, p. 308).

However some further extensions are required for the model to properly suit the data and research conducted in this thesis. As the relationship between the two variables is investigated for an effect of conditional variance the test that is to be conducted is bivariate, this require certain additions when modelling the relationship (Bollerslev, 1986, p. 318). The extension from univariate GARCH analysis to a multivariate one poses additional problems as the model has difficulties estimating covariances due to the nonlinearity and nonconvexity in the relationship (Altay-Salih et al., 2003, p. 486). These problems are addressed in development of the model into the VECH GARCH which was developed by Bollerslev (1988, p. 318). The VECH GARCH model assumed constant covariance which is not perfectly accurate but help ensuring that the multivariate model actually could be solved (Altay-Salih et al., 2003, p. 486). Altay-Salih et al. (2003, p. 486) described this approach as a tradeoff between the practical ability and theoretical accuracy of the model.

The development and additions to these models has culminated in the BEKK GARCH model which in contrast to the VECH GARCH model significantly reduces the number of included parameters to a much more manageable amount, this is accurate both for diagonal and scalar BEKK GARCH models (Li & Giles, 2013, p. 13). The BEKK GARCH approach was introduced by Engle & Kroner (1995) and was extended to detect specification errors later in 1998 (Kroner & Ng, 1998, p. 817). The basic of the BEKK GARCH model is presented in the equation below (Kroner & Ng, 1998, p. 820).

\[
y_{1t} = c_1 + \pi_{11} y_{1t-1} + \pi_{12} y_{1t-2} + \pi_{13} y_{t-3} + \pi_{21} y_{2t-1} + \pi_{22} y_{2t-2} + \pi_{23} y_{2t-3} + \epsilon_{1t}
\]

\[
y_{2t} = c_2 + \pi_{21} y_{2t-1} + \pi_{22} y_{2t-2} + \pi_{23} y_{t-3} + \pi_{11} y_{1t-1} + \pi_{12} y_{1t-2} + \pi_{13} y_{1t-3} + \epsilon_{2t}
\]

(Stock & Watson, 2001, p. 110)
Equation 13 represents the structure that is underlying the BEKK GARCH model. $H_t$ in the equation above is a matrix of the conditional variance between the, in the bivariate case, two investigated variables at time period $t$ and $C$ represent a matrix of constants (Engle & Kroner, 1995, p. 128). The last, lower, part of the equation is the GARCH term, associated with $g$, and the $a$ matrix captures the ARCH term. As $H$ represent the conditional variance the $g$ matrix and GARCH term shows how present conditional variance between the included variance depends on the conditional variance in the previous term. Similarly the ARCH term and $a$ matrix show the dependence of conditional variance in time period $t$ on the observed error term for the variables of the period before $t$ (Engle & Kroner, 1995, p. 128-130).

Reconstructed to equational form the diagonal BEKK GARCH model takes the following expressions shown in equation 14-16 assuming ARCH and GARCH terms of only the first order (Kroner & Ng, 1998, 817).

\[ H_{11,t} = C_{11} + a_{11}^2 \epsilon_{1,t-1}^2 + b_{11}^2 H_{11,t-1} \]  
\[ H_{22,t} = C_{22} + a_{22}^2 \epsilon_{2,t-1}^2 + b_{22}^2 H_{22,t-1} \]  
\[ H_{12,t} = C_{12} + a_{11}a_{22} \epsilon_{1,t-1} \epsilon_{2,t-1} + b_{11}b_{22} H_{12,t-1} \]  

(Kroner & Ng, 1998, 817)

In contrast to other statistical tests used in this thesis the BEKK GARCH statistics will not be conducted using the statistical software Stata 12 but rather Eviews 7. This is due to the fact that Stata is not able to run this specific extension of the GARCH model while Eviews is. The choice of which statistical software is appropriate to utilize has been based on the article by Brooks et al. (2003, p. 8).

4.6 OLS Regression

The regression analysis is a statistical method that is explaining a dependent variable as a function of movements in the independent variable(s). The output of the regression will generate a single equation that will model this relationship between the variables (Studenmund, 2006, p. 6). It is considered a suitable investigation tool when trying to look at potential cause and effect relationship (Studenmund, 2006, p. 7). Equation 17 illustrates an example of a multivariate linear regression equation for a time series:

\[ Y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_K X_{Ki} + \epsilon_i \]  

(17)
In this equation $Y$ represents the dependent variables and $X$ is the independent variables. Where $i = \text{means the ith observation of the respective independent variable}$. $\beta_o$ is the intercept or constant which represents the value of $Y$ if the independent variables are zero. The other $\beta_{1,2,...,K}$ represents the coefficient for the respective independent variable. The last term in the equation $\varepsilon_i$ is a stochastic error term, this variable represents variation that is caused in the dependent variable that cannot be explained by any of the independent variables. This error term is then made of variation that can be caused from omitted variables, measurement error, incorrect functional form or purely random unpredictable occurrences (Studenmund, 2006, 8-13).

The model regression model in this paper is the ordinary least square (OLS) regression analysis. In order for OLS to be the most appropriate regression equation to use there is some classical assumptions that must hold for the specific equation for it to be the best estimator available for regression models (Studenmund, 2006, p. 88).

These assumptions are:

I. The regression model is linear, is correctly specified, and has an additive error term.
II. The error term has zero population mean.
III. All explanatory variables are uncorrelated with the error term.
IV. Observations of the error term are uncorrelated with each other (serial correlation).
V. The error term has constant variance (no heteroscedasticity).
VI. No independent variable is a perfect linear function of any other explanatory variable(s) (no perfect multicollinearity).
VII. The error term is normally distributed (optional assumption).

(Studenmund, 2006, p. 89)

So in order for us in this research to make sure that our estimated regression model is appropriate we will have to test this model for these assumptions.

For assumption four the test we are going to use is the Durbin-Watson d statistic which test for if we have positive, negative or no serial correlation (Studenmund, 2006, p. 393). For assumption five the test we are going to use Stata hettest and imtest which will check the variance of the error term. For assumption three and six we can make use of a simple Pearson correlation test to check make sure this assumption is not violated (Studenmund, 2006, p. 393). If we would have any issue with our model we will have to use alternative regression methods that will help correct for this potential violation.

$R^2$ is the output value in the regression analysis that describes the overall fit of the estimated model (Studenmund, 2006, p. 50). For hypothesis testing there are two different tests, the T-test which is for individual coefficients in the regression model.
(Studenmund, 2006, p. 121) and the F-test is for the overall significance of the model (Studenmund, 2006, p. 154).

The model we are going to use in order to analyze if gold’s relationship to currency carry trade have any safe-haven or hedge properties are based on the model from Baur & Lucey (2010). In the article they investigate these properties in relation to stocks and bonds applying this model for currency carry trades would then become:

\[
r_{gold,t} = \alpha + \beta_1 r_{carry,t} + D_1 \beta_2 r_{carry,t(q10)} + D_2 \beta_3 r_{carry,t(q5)} + D_3 \beta_4 r_{carry,t(q1)} + \epsilon_t
\]  

(18)

The model is then constructed in the way that we test if the gold returns dependency on the carry trade returns. In order to account for differences in the relationship in turbulent and extreme market conditions we have constructed dummy variables for different quantile thresholds. \( D_x \) represents the dummy variables for different quantile levels of the carry trade returns. We choose the quantile levels to be 1%, 5% and 10% as we believe these are appropriate to capture these different market states. As Baur & Lucey states ”the choice of the quantiles is arbitrary to some degree” (Baur & Lucey, 2010, p. 220). If the carry trade returns are larger than the q% the value of the dummy variable will be zero and one if not.

We will also test this relationship for lagged periods were we test the current periods gold returns against previous period(s) carry trades return to make sure of the nature of the relationship. Since we have not found any earlier paper that have investigated the relationship between gold and carry trades.

This regression will help us extend on Clarida et al. (2009, p. 20) findings and investigate if gold can help to offset the high negative returns for carry trades during high volatility states.

We explained the properties of safe-haven, hedge and diversifier in the theoretical framework which together with the results from the regression will be our basis to analyze this.

4.7 Hypotheses

Seeking to answer the research question stated in chapter one, we constructed the following hypotheses. The hypotheses are divided into subgroups below regarding the different tests they correspond to. Following up on and concluding the answers to the various hypotheses will be done in chapter 6 after the empirical findings have been presented. The adopted confidence level for all hypotheses testing in this thesis is 95% which indicate that if the findings regarding of a found relationship has shown to, using our data, have a lower chance than five percent to be discovered by chance it will be deemed to be correct and the relationship in question will be concluded as valid. More specifically if the significance level found during the testing exceed the critical value of 95% the null hypothesis that no relationship can be concluded will be rejected in favor of an alternative one of an existing relationship.
4.7.1 Correlation Testing

Hypothesis 1: During the correlation testing between gold returns and carry trade index returns the hypothesis that will be tested is whether there is any correlation relationship between the two variables shown in the following expressions:

\[ H_0: \text{There is no correlation between the daily returns of gold and the daily currency carry trade index returns over the time period of 1993 – 2013.} \]

4.7.2 Spillover Effects

Hypothesis 2 & 3: This hypothesis concerns the testing of mean spillover effects using the VAR model and will thus conclude whether the current returns of either are influenced by the past returns of the other variable. This is presented in two hypotheses to differentiate between the two variables.

\[ H_0: \text{There is no mean spillover effects on the daily returns of gold from the daily currency carry trade index returns over the time period of 1993 – 2013.} \]

\[ H_0: \text{There is no mean spillover effects on the daily returns of currency carry trade index from the gold returns over the time period of 1993 – 2013.} \]

Hypothesis 4: As the diagonal BEKK GARCH test will not be able to deduct neither direction nor causality of the included variables this hypothesis will only concern if there is any volatility spillover effect between the variables at all.

\[ H_0: \text{There is no volatility spillover effects between the daily returns of gold and the currency carry trade index returns over the time period of 1993 – 2013.} \]

4.7.3 Regression Testing

Hypothesis 5: The regression is testing whether the relationship between gold returns are, in relation to carry trade returns, exhibiting hedge or safe haven characteristics and is tested as such. The hypothesis is thus constructed in order to test for these characteristics.

\[ H_0: \text{There are no hedge or safe haven characteristics for gold returns on the returns for the currency carry trade index over the time period of 1993 – 2013.} \]
5. Empirical Findings

This chapter displays what has been found using the data and methods presented in the previous chapter. Firstly, it provides background information regarding the data to provide some understanding and familiarity to the data employed. Sequentially, the output of the different statistical tests and measures are presented which in following chapters will be analyzed and discussed.

5.1 Descriptive Statistics

The data employed in this research is explored and presented in the following section as well as some overall traits and characteristics. The development of the time series and the statistical properties associated with it are as well included to provide an overview on the data from which inferences in later sections are made.

5.1.1 Development

The following graph in figure 3 shows the development of the investigated variables in the chosen time period. It is based on the raw data collected from Thomson Reuter Datastream and Deutsche bank. As can be told from the graph, investors holding either gold or following the currency carry trades index has over these 20 years experienced substantial positive returns. The gold price has been indexed to 100 at the start of the time horizon to facilitate comparison.

![Graph showing development 1993-2013](image)

**Figure 3: Gold & Carry Trade Development**
Source: The authors

Interestingly what can also be told from the graph is that the development of the two different variables does not seem to follow any similar pattern. Carry trades have experienced systematically large increases evenly distributed over the time horizon with the exception of a large dip in around the end of 2008 to the beginning of 2009.
Whereas the gold price development in was almost stagnant for the first half which was followed by an exponential increase in the latter.

The development over time is also summarized in the following table which shows the total development in the entire sample as well as the average annual. The returns presented in table 3 below are however simple returns and not the log returns that have been put to use in the statistical tests. This should be kept in and the returns presented below rather provide some basic info surrounding the development over time and conclusion will not be drawn from these returns.

<table>
<thead>
<tr>
<th></th>
<th>Total Return</th>
<th>Avg. annual return</th>
</tr>
</thead>
<tbody>
<tr>
<td>G10 Currency Future Harvest Index</td>
<td>449.08%</td>
<td>8.89%</td>
</tr>
<tr>
<td>Gold Price</td>
<td>385.90%</td>
<td>6.99%</td>
</tr>
</tbody>
</table>

Table 3: Total Returns

5.1.2 Return Distributions

As can be derived from table 4 the two investigated variables do not differ only in actual returns but also significantly in the return distribution.

<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>St. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold returns</td>
<td>5028</td>
<td>0.00031</td>
<td>-0.0628</td>
<td>0.07382</td>
<td>0.0103</td>
</tr>
<tr>
<td>Carry trade returns</td>
<td>5028</td>
<td>0.00034</td>
<td>-0.0801</td>
<td>0.06072</td>
<td>0.0065</td>
</tr>
</tbody>
</table>

Table 4: Descriptive Statistics

Table 4 contains the information of the return distribution of daily returns regarding the entire time horizon.

![Gold Returns](image)

Figure 4: Gold Return Volatility
Source: The authors

Figure 4 and 5 depicts the volatility of the gold and carry trade returns over the time period of 1993 to 2013. What can be said generally is that over the entire time horizon
that the volatility is generally higher for the gold returns than the carry trade return. This is also reaffirmed from table 4 above as the standard deviation of the gold returns are higher than those of the currency carry trade index, 0.0102829 compared to 0.0064897 respectively.

It seems that the returns of carry trade has experienced a more stable growth over time rather than the gold which for the larger part of the sample has not shown a significant positive return but only in later years shown substantial increase in value, as can be seen in figure 3 as well. This kind of development is more unpredictable and, to the extent that risk is measured by volatility more risky.

Figure 5: Carry Returns Volatility
Source: The authors

The currency carry trade returns volatility on the other hand as is depicted in figure 5 shows a much smaller distribution in how the returns are distributed. It does though also show a much larger downside risk as individual observations of losses are much larger than were found among the gold returns.

What also can be said by looking at figure 5 is that the carry trade returns experienced a long period of tranquility between late 90s and mid 2000s. This was followed by an unsettled period which also is depicted in figure 5 before. During and after the financial crisis period the returns of the carry trade index have been highly volatile with comparatively high positive gains followed by even larger losses following days.

Still, the volatility of gold returns is also greater during this period and although the carry trades have some more extreme losses in their observation the gold returns volatility still substantially exceed that of the carry trade index over the entire time sample.
5.2 Correlation

In order to figure out which correlation test to conduct the normality of the data has to be assessed as described in chapter 4. This is done graphically, looking at the histogram and q-q and p-p plots of the return variables, and statistically by conducting the Shapiro-Francia. The histograms and plots are presented in appendix 1. The Shapiro-Francia test was used as the number of observations exceed 2000 making Shapiro-Wilks test for normality inappropriate. The result of the Shapiro-Francia test is shown in table 5 below.

| Variable          | Obs | W'   | V'   | z    | Prob>|z| |
|------------------|-----|------|------|------|------|
| Gold Returns     | 5028 | 0,9209 | 232,362 | 13,805 | 0,00001 |
| Carry Return     | 5028 | 0,8734 | 371,869 | 14,997 | 0,00001 |

Table 5: Normality Test

As the Shapiro-Francia test for normal data tests for the null hypothesis that the data is normally distributed it can be rejected at the chosen 95% confidence interval and from this test the inference can be drawn that the data in not normally distributed.

Looking at the graphics provided in appendix 1 the findings regarding normality is reaffirmed and for both return variables included in the research it can be concluded that neither exhibits a normal distribution. As for the correlation testing this implicates that the Pearson product-moment correlation is inappropriate as it requires normal distribution among the investigated variables. It is thus appropriate to conduct the Spearman correlation test instead of Pearson as the latter also only detects linear relationship and deriving whether the underlying relationship is actually linear or not would require further investigation.

Due to the reasoning previously presented the Spearman rank correlation coefficient test was conducted and the result is presented in table 6 below.

| Spearman’s ρ | Prob > |z| |
|--------------|--------|
| 0,0949       | 0,000  |

Table 6: Spearman's Correlation

The probability variable of 0,000 means that the null hypothesis that the returns of gold and the carry trade index returns are independent of each other can be rejected and the correlation coefficient of this test is statistically significant. The Spearman’s rho, ρ, represents the correlation coefficient of the test and although significant assumes the low value of 0,0949.

This correlation test is conducted over the entire period of 20 years, including all 5028 observations. Since the correlation coefficient is significant and assumes a positive value this indicates a positive relationship between the returns of gold and carry trade, i.e. generally if the gold returns are positive it is associated with positive returns of the carry trade index. Although this relationship is only to a certain limited extent as the value of the correlation coefficient is relatively low.
5.3 Spillover Effect

Before conducting the various spillover test the presence of a unit root problem among the data sample has to be assessed as described in chapter 4. The augmented Dickey-Fuller was conducted to test for stationarity and the output is presented below in table 7. The augmented Dickey-Fuller test checks the null hypothesis that there is a unit root among the data, i.e. that the data distribution is non-stationary.

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>1% Crit. Value</th>
<th>5% Crit. Value</th>
<th>10% Crit. Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Z(t)</td>
<td>-70.820</td>
<td>-3.430</td>
<td>-2.860</td>
<td>0.000</td>
</tr>
<tr>
<td>Carry Z(t)</td>
<td>-72.578</td>
<td>-3.430</td>
<td>-2.860</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Table 7: Unit Root Test

Investigated at the 1%, 5% and 10% critical values both for the gold returns variable and the currency carry index return variable, both are found to have a Z(t) value well above that required for even the 1% critical value. Thus, the null hypothesis can be rejected for both variables and we can conclude that the data is stationary. Without the presence of a unit root and the problems that would entail the previous suggested tests can be employed without further extensions or additions.

5.3.1 Mean Spillover

With stationarity assured the appropriate lag length has to be derived which was done using the Akaike information criterion. The optimal number lag structure is the one producing the lowest AIC score and the scores for various lag lengths are presented in appendix 2. As is shown from the table in appendix 2 the VAR model was tested for up to 15 lags and the amount of lags that produced the best model following the AIC was employing 12 lags. Thus 12 lags are used to derive the mean spillover effects between the two variables.

The values denoted with a * are the lowest AIC values produced in each individual test. Derived from the appendix 2 above can be said that the appropriate lag structure that will ensure the lowest information loss. Thus when conducting the VAR test a lag length of 12 lags will be adopted. Adapting equation 10 from chapter 4 to include twelve lags it will take the following look:

\[
\begin{align*}
(y_{1t} & ) = (c_1) + (\pi_{11}^1 \pi_{12}^1) (y_{1t-1}^1) + \cdots + (\pi_{11}^3 \pi_{12}^3) (y_{1t-3}^3) + (\epsilon_{1t}) \\
(y_{2t} & ) = (c_2) + (\pi_{21}^1 \pi_{22}^1) (y_{2t-1}^1) + \cdots + (\pi_{21}^3 \pi_{22}^3) (y_{2t-3}^3) + (\epsilon_{2t})
\end{align*}
\]

(19)

In table 8 and 9 below the output from the Vector Autoregression is displayed.
Table 8: VAR Gold Returns

Coefficient values denoted with a * are statistically significant at a 95% confidence interval. Expressed individually for the Gold return variable the VAR-model take the following form before plugging in the values from table 8.

\[ y_{1t} = c_1 + \pi_1^1 y_{1t-1} + \cdots + \pi_3^3 y_{1t-12} + \pi_1^1 y_{2t-1} + \cdots + \pi_3^3 y_{2t-12} + \varepsilon_{1t} \]  \hspace{1cm} (20)

\( y_{1t} \) is the return of gold in time period \( t \).

Inserting the values from table 8, although keeping in mind that only the constant proved statistically significant at the chosen 95% confidence interval, produces the following expression for the mean spillover from carry trade returns on gold returns:

\[ y_{1t} = 0.0003 + 0.0003 y_{1t-1} + \cdots - 0.0257 y_{t-12} + 0.0756 y_{2t-1} + \cdots + 0.0486 y_{2t-12} + \varepsilon_{1t} \]  \hspace{1cm} (21)
| Carry Ret. | Coef. | z  | P>|z| | Coef. | z  | P>|z| |
|-----------|-------|----|-----|-------|----|-----|
| Gold Ret. |       |    |     | Carry Ret. |       |    |     |
| L1        | 0,0198* | 2,22 | 0,027 | -0,0300* | -2,12 | 0,034 |
| L2        | 0,0139  | 1,56 | 0,118 | -0,0109  | -0,77 | 0,443 |
| L3        | -0,0052 | -0,58 | 0,562 | -0,0267 | -1,88 | 0,060 |
| L4        | -0,0168 | -1,88 | 0,060 | 0,0119  | 0,84  | 0,401 |
| L5        | 0,0037  | 0,41 | 0,681 | -0,0611* | -4,31 | 0,000 |
| L6        | 0,0279  | 3,13 | 0,002 | -0,0146 | -1,03 | 0,303 |
| L7        | -0,0134 | -1,5 | 0,134 | 0,0041  | 0,29  | 0,773 |
| L8        | -0,0278* | -3,12 | 0,002 | -0,0194 | -1,37 | 0,171 |
| L9        | -0,0124 | -1,39 | 0,166 | 0,0220  | 1,55  | 0,121 |
| L10       | -0,0224* | -2,51 | 0,012 | 0,0107  | 0,76  | 0,448 |
| L11       | -0,0088 | -0,99 | 0,322 | 0,0232  | 1,64  | 0,101 |
| L12       | -0,0206* | -2,31 | 0,021 | 0,0399* | 2,82  | 0,005 |

Table 9: VAR Carry Returns

Again all coefficient that have been found to be statistically significant have been marked with a *.

\[ y_{2t} = c_2 + \pi_{22}^1 y_{2t-1} + \cdots + \pi_{22}^3 y_{t-12} + \pi_{21}^1 y_{1t-1} + \cdots + \pi_{21}^3 y_{1t-3} + \varepsilon_{2t} \]  

(22)

\[ y_{2t} = 0,0004 - 0,0300y_{2t-1} + \cdots + 0,0399y_{2t-12} + 0,0198y_{1t-1} + \cdots - 0,0206y_{1t-12} + \varepsilon_{2t} \]  

(23)

5.3.2 Volatility Spillover

Before conducting the BEKK GARCH test the order of the ARCH and GARCH term has to be determined which is done similarly to the lag structure in the VAR model. Minimizing the Akaike information criterion is desirable as lower AIC scores are associated with less information loss. The following matrix in table 10 shows the AIC score for different ARCH and GARCH orders.
As can be told from table 10 the lowest AIC-score is produced by the diagonal BEKK GARCH model with two ARCH and three GARCH terms. This model can also be expressed BEKK GARCH(2,3). With a ARCH order of two and GARCH order of three the model deemed appropriate for our data includes two autoregressive lags and three moving average lags.

Since the two terms measure the impact of different factors on current conditional variance there is no issue in adopted different lag structures for them. It could be, as in this case, appropriate to use a certain lag length of autoregressive lags and another for moving average lags to better model the relationship of conditional variance between the two variables.

The result from running a diagonal BEKK GARCH(2,3) is presented in the following table and the different parameters will be noted again as the model showing the tested relationship are matched with the values produced by the test.

<table>
<thead>
<tr>
<th>BEKK GARCH</th>
<th>Coefficient</th>
<th>Denotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M11</td>
<td>5.79E-07**</td>
<td>$\gamma_{11}$</td>
</tr>
<tr>
<td>M22</td>
<td>6.70E-07**</td>
<td>$\gamma_{22}$</td>
</tr>
<tr>
<td>M12</td>
<td>0.0005**</td>
<td>$\gamma_{12}$</td>
</tr>
<tr>
<td>A1, 11</td>
<td>0.2717**</td>
<td>$\alpha_{11,t-1}$</td>
</tr>
<tr>
<td>A1, 22</td>
<td>0.2746**</td>
<td>$\alpha_{22,t-1}$</td>
</tr>
<tr>
<td>A2, 11</td>
<td>-0.0248</td>
<td>$\alpha_{11,t-2}$</td>
</tr>
<tr>
<td>A2, 22</td>
<td>0.2614**</td>
<td>$\alpha_{22,t-2}$</td>
</tr>
<tr>
<td>B1, 11</td>
<td>0.6023**</td>
<td>$\beta_{11,t-1}$</td>
</tr>
<tr>
<td>B1, 22</td>
<td>0.5927**</td>
<td>$\beta_{22,t-1}$</td>
</tr>
<tr>
<td>B2, 11</td>
<td>0.5822**</td>
<td>$\beta_{11,t-2}$</td>
</tr>
<tr>
<td>B2, 22</td>
<td>0.5428*</td>
<td>$\beta_{22,t-2}$</td>
</tr>
<tr>
<td>B3, 11</td>
<td>0.4700**</td>
<td>$\beta_{11,t-3}$</td>
</tr>
<tr>
<td>B3, 22</td>
<td>0.4423**</td>
<td>$\beta_{22,t-3}$</td>
</tr>
</tbody>
</table>

Table 11: BEKK GARCH Test

The statistically significant parameters from the diagonal BEKK GARCH test have been denoted with a *. Whether one or two * is used represents whether the finding is significant on a 95% and 99% confidence interval respectively.

Applying these coefficients into the equational form of the model earlier presented in equations 14-16, chapter 4 and suppressing the error term gives us the following:
What can be derived from table 11 is that most effects from autoregressive and moving average lags have a relationship on the conditional variance at time period t, with the exception of A2,11 which on the other hand is the only coefficient not found to be statistically significant.

As it is difficult to make any inferences about parameters that are not statistically significant the parameter A2,11 will be kept in special regard. With a coefficient of 0.024761 and a standard error of 0.026989 not much can be concluded regarding the relationship, barely even the direction of it as it centers on 0.

We also note that the effect of the various B-parameters are without exception greater than those coefficient values of A-parameters indicating that for the model produced by the BEKK GARCH test, the GARCH effect is substantially greater than the ARCH effect. The implication of which is that previous conditional variance has a greater magnitude in determining the conditional variance of the current period than the squared residuals do.

The general finding from this test is that conditional variance and in extension volatility is positively related to lagged residuals and of conditional volatility in previous periods. This is valid for almost all parameters and the included 2 autoregressive lags and 3 moving average lags.

This result is illustrated in the figure 6 below which maps the respective variance of the two investigated variables over the entire time sample as well as their covariance. The covariance between the two fluctuate around zero for most of the time sample and is only shifting substantially from that in periods where one or both of the variables experience a high level of distress.
This graph also demonstrates how gold over most period in the time sample have experienced higher levels of volatility. Interestingly a volatility spike in one of the variables is usually not accompanied by especially large increases, if any at all, in the variance of the other variable. Even when this is not the case as in 2008-2009 and around 2012 where the volatility for both gold return and carry trade returns experiences a surge at the same time the drops in the covariance indicate that the variables do not move in the same direction, rather the opposite.

5.4 Regression

| Gold returns | Coefficient | Standard Error | p>|T| |
|--------------|-------------|----------------|--------|
| Carry trade returns | 0.1835 | 0.0518 | 0.000 |
| Carry trade returns (10%) | 0.0003 | 0.0033 | 0.075 |
| Carry trade returns (5%) | -0.0007 | 0.0012 | 0.579 |
| Carry trade returns (1%) | 0.0059 | 0.0009 | 0.709 |

Table 12: Regression Analysis

\[
    r_{gold,t} = \alpha + \beta_1 r_{carry,t} + D_1 \beta_2 r_{carry,t}^{(q\_10)} + D_2 \beta_3 r_{carry,t}^{(q\_5)} \\
    + D_3 \beta_4 r_{carry,t}^{(q\_1)} + \epsilon_t
\]  

(27)

Table 12 shows the results from our regression analysis of the safe-haven, hedge and diversifier characteristics of gold for carry trades.

The regression model have been tested for the assumptions discussed in chapter 4. The vif test for multicollinearity showed a value of 2.01 which is within the acceptable
range. If the vif value is over 5 one can start to consider multicollinearity as an issue (Studenmund, 2006, p. 259).

Due to the nature over our data with the long time series covering both normal and turbulent market environment, it is likely that the model will experience heteroscedasticity with a non-constant volatility. After conducting the White-test in Stata we found that this was the case. Since that is an issue of the nature of the data the heteroscedasticity is likely of the pure form which will not cause bias in the coefficient estimates. It will create some bias for the T-values which would generate unreliable hypothesis testing (Studenmund, 2006, p. 352-354). In order to fix for this we run the regression with heteroscedasticity corrected standard errors which will correct the standard errors of the models and generate t-values that is without inference from the heteroscedasticity enabling the model to be used for hypothesis testing (Studenmund, 2006, p. 365-366).

Table 12 shows the final results from the regression model with heteroscedasticity corrected standard errors. The lagged variables have been excluded from the table 12 since all of them was statistically insignificant. The only statistically significant relationship that was found was between Carry trade returns and gold returns within the same time period. The coefficient of 0.1834639 indicates that relationship some a low level of average correlation. This means that for a 1% change in the carry trade returns would yield an increase of 0.1834639% in the gold returns. This then demonstrate a positive co-movement between the assets.

Since the quantiles of 1%, 5% and 10% showed insignificant we cannot determine the relationship between gold returns and carry trade returns in different volatility states.

5.5 Portfolio Simulation

![Portfolio Simulation](image)

**Figure 7: Portfolio Simulation**

Source: The authors
The table and graph above illustrates a portfolio simulation over our sample period of March 151993 to March 12 in 2013. The comparison includes one portfolio which consists of 80% Carry trade and 20% gold and the other is a full carry trade portfolio. This simulation shows that including gold in the carry trade portfolio reduces the standard deviation and gives an increase in the risk/return trade-off given by the Sharpe ratio. We can see from the graph that the full carry trade portfolio outperforms the one with gold up until around the financial crisis were the drop is substantially larger for the full carry trade portfolio. The full carry trade portfolio outperforms the gold portfolio over the time period, however this comes at a cost of a high risk. Looking at the Sharpe ratio over the whole time period including gold in the portfolio will give you a higher payoff given the risk undertaken.

5.6 Hypotheses Testing

In light of the empirical findings presented in this chapter the hypotheses which concluded the previous chapter will be revisited. By looking at the results we will be able to conclude what relationships have been found between gold returns and carry trade returns. The various hypotheses and the rejection and acceptance of which will be assessed in further depth in the following chapter as this part only looks at what can be immediately derived from the empirical findings.

Hypothesis 1: Correlation

\textit{H}_0\textbf{: There is no correlation between the daily returns of gold and the daily currency carry trade index returns over the time period of 1993 – 2013.}

Looking at table 6 in which the result from the Spearman correlation test is shown it can be said that there is in fact some correlation present between these two variables. Although a correlation coefficient of only 0.0949 it is statistically significant not only on the chosen 95% confidence interval but even on a 99% confidence interval as well. Thus is can be concluded that there is a small positive correlation between the returns of gold and of the carry trade, i.e. hypothesis 1 of no correlation can be rejected.
Hypotheses 2 & 3: Mean Spillover

$H_0$: There is no mean spillover effects on the daily returns of gold from the daily currency carry trade index returns over the time period of 1993 – 2013.

Section 5.3.1 in this chapter regarding the mean spillover effects did not produce many significant variables, see table 8 and 9. Although one lagged significant variable it would be enough to reject either of the hypotheses 3 and 4 if it would be for for the return equation of the other variable. Derived from table 8 where the returns of gold is being testing, statistically significant coefficients were discovered for the lagged trade return of carry trade for lag 1, 2, 10, 11 and 12. This implicate that gold returns has a relationship with the lags of carry trade and hypothesis 2 of no mean spillover from carry trade to gold returns can be rejected.

$H_0$: There is no mean spillover effects on the daily returns of currency carry trade index from the gold returns over the time period of 1993 – 2013.

Similarly for carry trades returns, some lags of gold returns were found to be significant. As seen on table 9 these were lags 1, 6, 8, 10, 12. As the returns of the currency carry trade index exhibit a relationship with the lagged return on gold hypothesis 3 can also be rejected on a 95% confidence interval.

Hypotheses 2 and 3 are both rejected as the empirical findings show that there is mean spillover effects between gold returns and that of carry trade.

Hypothesis 4: Volatility Spillover

$H_0$: There is no volatility spillover effects between the daily returns of gold and the currency carry trade index returns over the time period of 1993 – 2013.

The BEKK GARCH Model derived from the values in table 11 and expressed in equations 24-26 including significant ARCH and GARCH terms implicate that to it some extent manage to explain the conditional variance in the present period. As this model cannot show the direction of volatility spillover but rather just conclude the presence of any such effect. As earlier mentioned the model showed significance for almost all included parameters so we can deduct that there is a spillover effect in variance between gold and carry trade returns. Hypothesis 4 is rejected.

Hypothesis 5: Hedge and Safe Haven Characteristics

$H_0$: There are no hedge or safe haven characteristics for gold returns on the returns for the currency carry trade index over the time period of 1993 – 2013.
Since the results that most of the variables in the regression analysis showed to be insignificant we cannot reject the null hypothesis. Meaning that we did not find statistically significant evidence from the regression if gold have safe-haven characteristics or not. Regarding hedge we can see that the average correlation between the carry returns and gold are positive but far from 1, which indicates that it experiences diversifier characteristics rather than hedge characteristics, where average correlation should be non-positive or negative.
6. Discussion

This chapter connects the empirical findings and the hypothesis testing in the previous chapter with theories and previous research. It makes conclusion regarding the findings and the implications that are derived from it. Further what the empirical findings indicate in practice as well as theoretically is discussed and concluded and a general overview of the results finishes the chapter.

6.1 Summary Results

What was actually discovered in the last chapter is briefly reintroduced here as to remind from where the discussion takes off and provide a distinction between the empirical findings and discussion.

Firstly, a significant correlation between gold returns and carry trade returns was discovered and it indicated a positive relationship which means that the two variables tend to vary in the same direction. But the correlation coefficient exhibits a small value and the closer it is to zero the weaker this relationship. Thus with the relatively low correlation the returns do not vary much in the same direction.

Secondly, significant findings were also found regarding the existence of mean spillover effects on returns between the two variables. This was found for both variables individually, meaning that carry trade returns has mean spillover effect on gold returns and vice versa. The dispersion between the effects these variables had on each other differed slightly and not much can be said regarding the direction of the relationship. The twelve included lags in the model were dispersed relatively arbitrarily for the carry trade return mean spillover effects on gold return. Regarding the gold return spillover effects on carry trade returns there is an indication that later lags, 7-12, tend to have a negative relationship whereas earlier lags differ between each different lag.

Thirdly, there were significant findings regarding the volatility spillover effects as well indicating that there are in fact volatility spillover effects between gold returns and carry trade returns. Due to the limitations of the employed diagonal BEKK GARCH test not much can be derived regarding the nature of the relationship, rather it implicates that there is one. This means that the volatility of at least one of the return variables have spillover effects on the volatility of the other, this could due a one-way or two-way relationship which is impossible to conclude from this result. However the finding show that this effect has to be taken into special consideration when contemplating undertaking positions in both the underlying assets.

Fourthly, the regression testing the hedge and safe haven characteristics did not manage to found neither hedge or safe haven characteristics for gold on carry trade returns. Non-surprisingly however it found that for the chosen confidence interval there are diversification benefits of combining gold and a carry trade strategy in a portfolio. But for the extreme observations in the 1, 5 and 10% quantiles the observed relationship was not found statistically significant so we cannot conclude whether gold works as a safe haven or hedge for carry trade or not.
6.2 Carry-trade and Gold Correlation

Carry trades have mostly been researched in isolation to uncover its’ various characteristics but investors has seldom taken only a position in currency carry trades but rather holds an entire portfolio of numerous different assets and asset classes. As this is the case some recent literature has focused on carry trade as a specific asset class to include in a portfolio of others which is where this research draws ground as well (Das et al., 2013). Extending the understanding of how the returns of carry trades and gold leads to a more effective matching of the two different assets when building a portfolio and following findings regarding this relationship is described as discovered by this research.

The positive relationship between gold returns and those of the currency carry trade index that is derived from the positive correlation coefficient produced by the correlation test means that the two variables vary in the same direction to some extent. Though since the coefficient value is not higher than 0,0949 the correlation dependence between the different returns can be questioned. In the case of this research as both investigated variables have experienced substantial growth over the time period and the small positive correlation could thus been due to both variables exhibiting positive returns in the majority of observations. As is the case with correlation tests the actual dependence and causality of this relationship cannot be concluded.

That gold and carry trade returns only demonstrate a weak correlation, small correlation coefficient, extend on the conclusion derived by Das et al. (2012, p. 256) who argued that carry trade strategies only show moderate correlation to equity markets as well. It also reaffirm the findings of McCown & Zimmer (2006, p. 11) that gold only exhibit low correlation with other asset classes and extend those asset classes to include currency carry trade.

As carry trade returns and gold returns possesses a very small positive correlation coefficient there is definitely diversification benefits attached to including the two in a portfolio. This finding is also reaffirmed in the regression analysis which found a positive but low relation between gold and carry trade returns. Combined with attractive growth over the investigated time period indicates that the two assets are viable investment strategies and could beneficially be pooled in a portfolio. This is also illustrated in the portfolio simulation where the portfolio combining gold and the carry trade strategy offer a higher risk adjusted return, measured by the Sharpe ratio, than the one consisting of only currency carry trade, 0,6 and 0,56 respectively.

But the relationship between gold returns and returns of carry trade is not quite as simple as indicated by the correlation testing. Just as Burnside et al. (2011a; 2011b) argues that the risk profile of carry trades is not appropriately covered by usual risk factors, special properties of the relationship between gold returns and carry trades also needs to be considered. This is where the spillover effects between the two become relevant.
6.3 Spillover Effects

With the relationship of the same time period established by testing for the correlation which discovered low correlation and as both assets over the time period produced attractive returns an investment strategy combining them would seem like a good idea. However the effect on the respective variables attributable to the behavior of the other past behavior of the other variable could be rather drastic effect and substantially affect the performance of a portfolio including consisting of these two assets.

The result regarding the mean spillover effects are although conclusive enough to establish that for both gold returns and carry trade returns mean spillover between the two variables exists. However the findings that the different significant lags produced different coefficient signs make generalization beyond the point of rejecting the hypothesis of no spillover effect difficult. This also causes complications when trying to match the two assets as there is no clear cut relationship. The different signs associated with the cross-lag dependence between the variables are nonetheless unintuitive as the VAR test also shows that the relationship between the returns on their own lagged returns also shifts between positive and negative relationships.

It should be kept in mind that although significant many of the coefficients produced when testing for mean spillover have small coefficient values, indicating that the relationship between returns in the current period and of previous returns is relatively small. These results should thus not be interpreted as explaining nor forecasting actual returns in a period but rather adding to relationship between gold and carry trades return.

As the relationship between currency carry trade and the equity markets has been established (McCown & Zimmerman, 2006, p. 11) and also so the relationship between equity markets and gold (Katechos, 2011, p. 558) finding spillover effects, albeit small, in extension between gold and carry trade is not surprising. Thus special caution need to be considered when combining the assets in a portfolio, but with small spillover effects on return and most parameters tested, lags, insignificant other factors might be more crucial in determining the portfolio behavior. That too much emphasize should not be put on implementing and managing return spillover effects between the two is reinforced by the portfolio simulation presented in the last chapter as portfolios consisting of the two assets rather than just one of them has demonstrated higher risk-adjusted returns all through the implemented time period.

The volatility spillover effects that we were able to conclude in the previous chapter are a bit more difficult to interpret as the employed diagonal BEKK GARCH model does not imply direction or causality of the spillover effects. The implication of this which can also be shown from figure 6 is that periods of high volatility in one of the return variables is associated with the increased volatility in the other variable as well. To the extent that volatility is considered as risk the overall risk decreasing benefits of matching gold and carry trade strategies in a portfolio are somewhat diminishing due to this effect. It should be told that figure 6 also shows that in the periods of high volatility,
when spillover effects should be observable, the covariance between the two variables has assumed negative values. If this is the case the benefits of combining the two assets are greater than what is achieved simply from diversification. What can be read into this is that in moments of high volatility the returns of gold and carry trades generally moves in opposite directions, this would indicate safe haven characteristics for gold. However the regression analysis failed to reproduce this finding making inferences about whether gold can be considered a safe haven for carry trade investments mere speculations.

6.4 Diversification Benefits of Gold

For one of the objectives of our empirical findings was to see to see if gold could be included in the currency carry trade portfolio in order to help control the downside risk for high volatility states when currency carry trade experience very negative returns.

The main tool used for this investigation was the regression analysis which showed that there was no statistical significant relationship between gold returns and carry trade returns for the more extreme quantiles 1%, 5% and 10%.

From the regression we found that there was a statistical significant relationship between the gold returns and the currency carry trade returns within the same time period. From Baur & Lucey’s (2010, p. 219) definition of the different asset characteristics hedge, diversifier and safe haven introduced in chapter 3, based on our findings of the relationship between carry trades and gold, gold can be characterized as a diversifier for the carry trade portfolio. The regression analysis shows that they exhibit a positive but not perfect correlation. As for a diversifier there is no guarantee that this correlation property will hold during extreme markets states.

The graph illustration, figure 7, the performance of a carry trade portfolio with 20% gold versus the normal currency carry trade portfolio further support this. The results of this shows that including the gold in the portfolio increase the average annual Sharpe ratio from 0.54 to 0.6 over the time period of 15 of mars 1993 to 12 of mars 2013. The portfolio including gold also have a lower standard deviation showing that there indeed might exist benefits in diversifying a carry trade portfolio with gold.

Following Markowitz (1959) famous modern portfolio theory introduced in chapter 3. There is certainly the main concern when it comes to portfolio design to design the portfolio with respect to the risk/return trade-off. According to this view the addition of gold in a carry trade portfolio exhibits certain benefits yielding a higher return for the risk incurred. Gold within the portfolio will give the investor a high risk premium for holding the portfolio. Our findings have shown that there exists the possibility to reduce the volatility of the carry trade portfolio with inclusion of gold.

The lowered volatility will be tied to certainly a lower possible payoff, so the central theoretical issue also in the discussion will be the investors’ preferences and the behavioral finance aspects. The findings of this study can only show the benefits how gold can help mitigate some losses and help stabilize the portfolio over time. However the inclusion of the gold will also lower the potential payoff shown in the portfolio simulation graph in chapter 5. The full carry trade portfolio outperforms the gold up until that point when the financial crisis hit. It is then evident that the losses incurred are
far greater without gold in the portfolio. Both portfolios do drop substantially in value during this time. The illustration of the performance differences for the gold price versus the carry trade portfolio show that during the time of the crisis both the gold and the currency carry trade portfolio drops. The gold price drops substantially less compared to the carry index. The graph however is intuitively following the findings of our empirical research where the gold and carry trades seem to follow a weak positive correlation. This graph might suggest that this relationship holds even through more turbulent times, since our statistical test on this proved insignificant we cannot prove this is the case during 1993-2013.

Lustig & Verdelhan’s (2007) findings of the diversification benefits of the inclusion of different currencies in the currency portfolio can be extend to our findings. Showing that there is certainly increased diversification benefits of including more assets in the portfolio, i.e. gold.

Extending on the current issue of the risk drivers of carry trades there could be so that the carry trades and gold can share some of these drivers, given the properties of the co-movements.
7. Conclusion & Recommendations

In the final chapter of this thesis the research question will be answered, drawing upon the results presented in the earlier chapters. Then concluding remarks regarding the entire research and how it was conducted leads to an assessment of the validity and reliability of the study which were introduced in chapter 3 and various ethical concerns are also addressed. The thesis is settled with a section of suggestions for further research.

7.1 Conclusion

The purpose of this research was to investigate the relationship in the movements between currency carry trade returns and gold returns and also to examine the potential safe-haven, hedge or diversifier characteristics of gold in relation to currency carry trades. The sample period was between the 12th of March 1993 to the 12th of March 2013. The currency carry trade was represented by Deutsche Bank’s G10 Currency Future Harvest index, and the gold prices were downloaded from the Thomson Reuters database. Empirically this was investigated through the means of correlation, mean and volatility spillover and a regression analysis.

The correlation and volatility spillover effects were to determine the relationship and partly co-movements of the assets. The regression analysis enabled us to look closer to how this relationship alters in different market states.

Complemented by a portfolio simulation, this test gave evidence for the co-movements between carry trade returns and the gold returns and clearly established that there is diversification benefits to attain by matching gold and currency carry trade investments in a portfolio. This gives answer to the research questions stated in chapter 1:

*Is there a co-movement between currency carry trade returns and gold price returns?*

According to the empirical test in our study, mainly the correlation test and the regression analysis. We found that there is a weak correlation between currency carry trade returns and gold price returns.

*Are there any spillover effects between currency carry trade returns and gold price return?*

Our empirical test found that it exists mean spillover effects between currency carry trade returns and gold price returns. However our significant returns exhibited different coefficient signs so we cannot draw conclusions beyond the point of the existence of the mean spillover effects. As for volatility spillovers our results showed their existence. Due to the nature of the BEKK GARCH test we cannot conclude the direction of the relationship merely establish its existence.

As sub purpose we wanted to briefly look into the characteristics of gold in a carry trade portfolio. Given the insignificant results from the regression analysis for the dummy variables covering the lower quantile returns. We cannot conclude that gold would have any hedge nor safe-haven properties. However due to the weak correlation found in the correlation test and in the regression model during our time period gold showed to
exhibit diversifying characteristics to a currency carry trade portfolio. Due to the insignificant results in we cannot conclude anything regarding the relationship during the higher volatility states.

7.2 Contributions

When we began conducting this research we found that there was a lack of research investigating the portfolio aspects of currency carry trades. Our findings help giving empirical evidence for the benefits of diversification in a currency carry trade portfolio by including gold. Our conclusions considered together with Lustig & Verdelhan’s (2007) findings of the diversification benefits of including different currencies can help pave the way to further explore the portfolio aspects and benefits of currency carry trades. The results of this research also extends on the empirical evidence discovered by Das et al. (2013) on if and how carry trades can be effectively implemented in portfolios consisting of other assets.

From Clarida et al (2009) we cannot see empirically that there is a benefit to invest in gold in order to mitigate the losses in currency carry trades associated to turbulent market states.

For practical contributions the evidence in this research show that investors that frequently trade with currency carry trades can find some more stability (i.e. lower volatility) in their portfolio with the inclusion of gold. With gold in the portfolio they can potentially gain a better payoff for the risk incurred.

As for the handling of the carry trade portfolio in more turbulent market environments, we found no statistically significant relationship with gold returns in our regression analysis. This is therefore one of the areas where we suggest that additional research in since it is especially during times of distress when the dangers of carry trades arises.

7.3 Reliability & Validity

The main quality assessment criterion when conducting research is the validity and reliability of the findings. Fulfilling these not only makes the findings more reliable but do also provide strength to the arguments and indicate to what extent the conclusions drawn can be trusted. These quality criterions must thus be achieved all throughout a research to ensure the credibility and that the thesis is up to par.

The question of reliability, and also replicability, of a research is regarding the consistency of the results, i.e. if similar researches would yield similar findings (Saunders et al., 2009, p. 156). Also referred to as inter- and intra-observer consistency this concerns whether other researchers would produce the same findings employing the same data and if the same researcher would find the same results if investigating another time period or sample. Together with the transparency that would allow other researchers to follow and replicate the study are the different aspects of reliability (Bryman & Bell, 2011, p. 279; Saunders et al., 2009, p. 156).
By using numerical data covering the time period and employing clear statistical tests whose interpretation are clear-cut, not much subjectivity is allowed into this research which otherwise would be a potential source of problem to the inter-observer consistency. By also clearly differentiate and make clear when speculations are made rather than pure research we also aim at informing readers which sections might be subject to a lower extent of inter-observer consistency, in this thesis such sections are only existing in the discussion chapter. The intra-observer consistency is much harder to ensure for a research like this as the findings can only be concluded for the investigated time period and might not be relevant for another time. The results are for the employed time period and should be regarded as such, it does not make inferences about time outside the used time horizon making the intra-observer consistency to some extent inapplicable. The discussion regarding transparency will return for the validity criteria and in the ethical considerations as well and is of importance all throughout this study. We realize this and have therefore made sure to document all choices and steps taken in this thesis so that the reader can follow how the results were reached and what assumptions are being made.

Validity which concerns itself with if the measures used in the research actually measures what it is supposed to. This goes for both the concepts and what is of special concern with quantitative research is the measurement validity (Bryman & Bell, 2011, p. 42). The measurement validity can be fulfilled to a satisfactory extent if the employed measures such as the carry trade index in this thesis is a good proxy for how carry trade behaves. By anchoring the practical methodological choices in previous academic literature we aim to achieve this criterion as some guidelines are considered standard in research. The employed measure were not only chosen based on academic custom but also with common reasoning by us if it makes sense to use the employed measures or not.

Internal and external validity also needs to assessed which refers to respectively whether the relationship between two variables are what they look to be and to what extent the results can be generalized (Bryman & Bell, 2011, p. 42-43; Saunders et al., 2009, p. 158). The internal validity further relate to the presence of causality in a relationship which can be difficult to depict, however in this research various statistical measures are conducted but none assume a causal link in the result. Thus although there might be causality between the gold and carry trade returns this is not found through these tests and other than for discussion purposes the issue of causality is not addressed in the thesis. As for the generalizability, or external validity, it is tricky to assess as the investigated time horizon and sample might not be representative for the phenomena at large (Saunders et al., 2009, p. 158). The observed effects are valid for the chosen time period but the relationship between the two variables might change over time rendering inferences made from these findings irrelevant for future time periods. However employing a large time sample of 20 years, 5028 observations, has helped improving generalizability of the results and increasing the chances of finding any real relationship between the two variables.
7.4 Ethical Concerns

At the very fundamental level ethical concerns not just when conducting research but also generally is how the choices and actions undertaken by someone affects the environment around him, what the impact of those actions are. When it comes to research addressing and following ethic guidelines is crucial as it helps the researcher to achieve their goals in research while still ensuring that scientific work is compatible with the values and goals considered as most important (Diener & Crandall, 1978, p. 1, 14).

Ethical concerns in social research are largely concerned the direct and indirect treatment of participants and the uses of the knowledge produced by the research (Diener & Crandall, 1978, p. 215). Greener (2008, p. 43) extended the latter category to include objectivity in through the handling of data, analysis and reporting results as well as clearly providing all steps of the research so readers for themselves can follow-up on the research. By conducting a quantitative study employing numerical financial data the number of participants is nonexistent except for the people involved in conducting the research, these are however not included in the ethical concerns as it mainly regards how others are affected. Thus the second part of what Diener & Crandall (1978) and Greener (2008, p. 43) discussed as ethical concerns in social research has been giving a large focus in this thesis.

Further related to this research and thesis what has been especially large attention regards the concerns of objectivity and uses of research knowledge, these are guidelines suggested by Diener & Crandall (1978, p. 217) and more narrowly defined concerns but taken from those presented above. Throughout the research and reporting the result we aim to be as objective as possible and never deliberately employ faulty methodology. This in order to report accurate results rather than trying to find and reaffirm an idea already determined beforehand. Correspondingly we will consequently work to avoid what is being described by Fisher (2007) when discussing ethics in business research “It is more probable they may be tempted by the lesser ethical offense of being economical with the truth” (Fisher, 2007, p. 299).

In order to ensure that the data is fairly reported and not in a subjectively manner, to both enforce the objectivity and that the use of the findings are appropriate, we make sure to account and present for all different aspects of the research. As such, the data collection process, treatment and analyzing stages are presented in a transparent manner as well as how the data sets were collected from, as suggested by Greener (2008, p. 43). Not only will this allow the reader themselves to assess the quality of the results by evaluating how it was reached but allow follow the procedure and replicate the results for themselves.

As the result of the research can be used by others what effect the result will have also has to be considered, this is done by establishing what the applications of the results are and what impact the research will have on those (Diener & Crandall, 1978, p. 217).
Assessing the effects of the results and taking responsibility for the work is one of the most important ethical concerns for a researcher (American Sociological Association, 1999). Although tricky to predict looking at the result of this thesis it could be done to better understand how currency carry trade and gold functions. This knowledge can be used in further research as well as by investors but is unlikely to be regarded in isolation; as such it is crucial that the reported results are accurate which they can only be by being presented objectively. Thus the ethical concern of utmost importance in this study is objectivity which we have strived to strongly maintain all throughout the research.

7.5 Suggestions for further research

Following the research conducted in this thesis and the limitations of which there are some natural additions and extensions that can be made by further researchers. Due to the dynamic nature of financial markets it would be interesting to see how the findings of this research would compare to researches which employ another carry trade strategy, for instance one that also included currencies from emerging markets. It would also be interested to test carry trades with other asset classes to further develop the understanding of how to efficiently handle currency carry trades in portfolio management.

Also as this research due to various constraints are only investigating the time period over the entire time period in not how it differs over smaller sub-periods when markets experience certain characteristics. Thus investigating the relationship between gold returns and carry trade returns and how it differs over during times of market turbulence and calmer periods would provide valuable insights.

Further more advanced portfolio simulations which included more different asset classes could be of great interest to research to further expand the understanding of how currency carry trade and gold can efficiently be combined into another currency.

As the risk characteristics of currency carry trade strategies are not fully explored this also has to be done. This to ensure that the risk and return tradeoffs are acceptable and to advance the knowledge of the effects of introducing carries trade to a portfolio.

As the regression conducted in this research did not manage to prove the safe haven characteristics of gold on carry trades suggested by figure 6. This could be further developed which could be done by running other statistical test and checking for other definitions of the safe haven which also are sensible to test.
Reference List


Appendix 1 – Normality tests

Histogram Gold returns

Histogram Carry returns

Quantile plot gold returns

Quantile plot carry returns
Appendix 2 – AIC Lag test

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Selection-order criteria
Sample: 16 - 5028  Number of obs  =  5013

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