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- Master Thesis Report -

"Risk Management of Carry Trade with Options"

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Program:
Master of Science in Business and Economics

Examination code and name:
GRA 19003 Master Thesis

Delivery date:
03.09.2012

Place of study:
BI Oslo

Abstract

This paper examines currency carry trades as well as an extension to the strategy by embracing options for risk management. Due to severe losses by Norwegian investors due to exchange rate movements during the financial crisis' of 2007-2012, a Norwegian carry trade perspective is also studied. Our results show that including options for risk management increases Sharpe ratios significantly on all levels as well as substantially reducing volatility. Especially in times of extreme financial incidents, the use of options emerges as an essential tool of risk reduction and loss-minimization. Our results conclude that by excluding the use of options in a simple carry trade strategy, an investor will in many cases undertake an excessive amount of risk.

TABLE OF CONTENTS

1. Introduction

With the bankruptcy of Lehman Brothers September 15 2008, the financial crisis of 2007-2009, also called "the great recession", was a reality. The money market essentially froze and the whole financial market almost collapsed. Panic hit the market and a flight to safety ensued, which lead to soaring bond prices and stock market tanking. Uncertainty was at an all-time high and the real economy took a nose dive (Bekaert and Hodrick 2012, 7-9). In this paper we will use options in carry trade strategies as tools of risk reduction and management. Our paper will show that implementation of options can, in several cases, be essential to avoid substantial losses as well as circumventing unbearable volatility.

During the increasing uncertainty in the financial markets before the fall of Lehman Brothers, and the panic after, there were abnormal appreciations of the American dollar (USD), Swiss franc (CHF) and Japanese yen (JPY) against Norwegian kroner (NOK). As a result many Norwegian investors speculating in currency loans experienced severe losses on their investment capital since they could not post the margin calls that came from the financial institutions they had borrowed from. An example is Alexander Vik`s company, Sebastian Holding, who according to E24 lost one billion dollars in money market funds and 750 million dollars in currency trades the month following the bankruptcy of the Lehman Brothers. When the Deutsche Bank asked him to increase his security margins on his accounts in the bank, he withdrew 300 million dollars instead. The response from Deutsche Bank was to close all his accounts which resulted to a lawsuit from Sebastian Holding for 3.2 billion dollars including lost gain. This is just one of currently many lawsuits against Deutsche Bank. We will argue that this could have been avoided to some extent by implementing risk management tools as an option collar or a protective put.

In just a 5 month period from 22.05.2008-23.10.2008 the USD appreciated with 43%, from 4.99 NOK/USD to 7.15 NOK/USD. Effectively this appreciation would have initiated several margin calls to any investor trading on margin accounts. Only the most solid investor would have the ability to maintain the margin with this appreciation. Hence, many investors would lose a lot of the invested capital, when forced to close their positions. In the period 23.10.2008-09.03.2009 the USD varied mostly around 7.00 NOK/USD, before further

depreciation. From 18.03.2009 to 19.03.2009 the NOK/USD dropped 5.75% in just one day. Slowly, but steady NOK appreciated, until 29.04.2011 when it reached 5.24 NOK/USD, which is the lowest since the financial crisis of 2007-2009. Since then it has depreciated as the current European debt crisis proceeds.

Another extreme example is the Japanese yen which appreciated by 7.7% against the Australian dollar on 16 August 2008 according to Bank of International Settlement Triennial Central Bank Survey (BIS) 2010.

In carry trade literature, such extreme fluctuations are explained as a sudden unwinding of carry trade positions (Brunnermeier, Nagel and Pedersen 2008). Unwinding of the positions will lead to an appreciation of the funding currency, and since carry trades often are heavily levered, this appreciation will produce margin calls to the speculators. The fear of losing profit or the failing ability to cover the margin call amounts may lead investors to close their currency positions.

In this paper we are contributing to the carry trade literature by examining risk management of a zero-investment carry trade strategy, using zero-premium option collars and protective puts, in a retrospective portfolio analysis of the simple carry trade strategy done by Bø and Klokkerhaug (2010). By employing a zero-premium collar and protective put strategy, we wish to mitigate risk, and reduce losses, especially in times of crisis. Two cases will be considered: i) a global case where there are no restrictions on borrowing/investment country, and ii) a Norwegian case where funds borrowed are restricted to be invested in Norway. Our analysis is extended to contain a Norwegian case, due to the substantial losses that many Norwegian investors and companies experienced because of the sudden appreciations of the funding currency while executing a carry trade strategy. Mosvold & Co is an example; they lost 15 million NOK, betting that CHF would depreciate in 2011 (Dagens Næringsliv, 13th of July 2012).

Bekaert and Hodrick (2012, 229) wrote about householders in Eastern-Europe having, likely unwittingly, turned their mortgages into carry trades. By adding a Norwegian point of view, we contribute to the carry trade literature by examining carry trade from the householder's point of view.

Jylhä and Suominen (2010) found in their paper that failure of the uncovered interest rate parity (UIRP) is due to compensation for risks. According to theory, full risk reduction in carry trade with the use of forwards or futures in covered interest rate parity effectively eliminate any abnormal returns or else the traders could make an extraordinary profit via covered interest rate arbitrage (Bekaert and Hodrick 2012, 173-176). A zero cost option collar is somewhere in between an unhedged and hedged position with forwards/futures. By implementing a hedging strategy we may get results that will not to the same extent support the violation of uncovered interest rate parity. By retracing the analysis of Bø and Klokkerhaug (2010) we are testing for violation of the UIRP over a 20 year period (1992-2011) in a global and Norwegian perspective. This will contribute to the carry trade literature with a more nuanced representation of carry trade returns both with and without risk management through the financial crisis of 2007-2009 and the European debt crisis that started late 2009.

Initially in this thesis we will describe some background information of the foreign exchange market and foreign exchange options. Further we explain what carry trade is, which popular funding and target currencies are used in carry trade, and market changes in the period 1992-2011. We will then move on to address the growing importance of retail as an investor class, carry trade in crises and finally householders as carry traders.

In the third section we will review some of the previous research done on subjects surrounding our master thesis. In this part the research article of Burnside et al. (2011) and the master thesis of Bø and Klokkerhaug (2010) will be especially important. This is due to the fact that our thesis in many ways builds on the work done by Bø and Klokkerhaug (2010) on the simple carry trade strategy, and extends this research by adding options for risk management.

We will in the fourth section explain the data material we have used in the research. The choices of currencies and corresponding interest rates used in the research will then be justified. Further we will explain how to calculate options prices, choices of forecasting volatility technique, as well as addressing the subject of transaction costs.

In the fifth section we will go through the methodology used in the research, explain the carry trade model and strategies used, both with and without options. Further we will go into details of the option pricing model of Garman and Kohlhagen (1983), the GARCH (1,1) model we use to forecast volatility and how we employed all these elements in a carry trade model.

The results and analysis of the research will be presented in the sixth section. By performing a robustness test, we deemed the forecasted volatilities appropriate for currency option valuations. Results of the three carry trade strategies showed that the collar strategy is superior to the other strategies in all measurements of performance, both in the global and the two Norwegian cases. The summary of the returns in the strategies shows the benefits of option hedging in time of crisis. It is remarkable that the protective put strategy never is able to come close to the collar strategy even though the upside is preserved. Obviously, the protective put strategy is too expensive to implement. In the Norwegian case one, where funds are borrowed in the single lowest-yielding currency, the unhedged strategy does not prove violation of the UIRP. However, by implementing options, the violation is upheld. When using of a basket of the three lowest-yielding currencies for the Norwegian case, we are able to prove violation of the UIRP, both when unhedged and hedged with options. This indicates potential benefits of diversification by borrowing funds in a basket of three currencies rather than just one.

We sum up the results and can conclude in the seventh section that using the collar strategy in carry trade substantially reduce the risk for losses in times of crises without necessarily having to sacrifice return. In fact, in many cases, the collar strategy actually generates higher return as well as lower standard deviation. Needless to say, the Sharpe ratio is significantly increased by using a collar.

In section eight we introduce some ideas for further research in the subject of using and extending the use of options in carry trade strategies.

2. Background information

2.1 The foreign currency exchange market.

2.1.1 The size of the foreign currency exchange market.

The foreign exchange market is the largest and most liquid financial market in the world and is open 24 hours a day, five days a week. London, New York, and Tokyo are today, as in 1992, the centers of the foreign exchange market. Traders in this market include large banks, central banks, institutional investors, currency speculators, corporations, governments, other financial institutions, and retail investors. The market has grown from 1 trillion USD in April 1992 to 4 trillion USD in April 2010. In this period it has only been one decline in trading volume. This happened from 1998 to 2001 with a decrease of 19% from 1,490 trillion USD to 1.2 trillion USD. The decline in this period can be explained by the introduction of the Euro and change in risk tolerance that followed the financial market turbulence in the autumn of 1998 (BIS Triennial Central Bank Survey, 2010, 2001 and 1992). CLS Bank is the operator of the largest currency-trading settlement system and BIS use data from them in their reports. CLS handled an average of $4.5 trillion per day in 2011, compared with $2 trillion in early 2005 (Bloomberg 2012).

2.1.2 What is carry trade?

In essence, when performing a simple carry trade, we are implicitly testing the Uncovered Interest Rate Parity (UIRP). The UIRP states that funding an investment in one country, investing the proceeds in another country, and converting back at a later point in time should not yield more return than both borrowing and investing the proceeds domestically (Mishkin 2012).

Carry trading, or uncovered interest arbitrage, is when an investor borrows money in a low-yielding currency and investing the proceeds in a high-yielding currency without hedging the position (Investopedia 2012). This will start a buildup in the targeted currencies and lead to a strengthening of this currency, while it will also start a weakening of the funding currency (Galati, Heath and McGuire 2007). This is typically described as self-reinforcing arbitrage opportunity that will exhibit the classic price pattern of "going up by the stairs and coming down in the elevator" by Plantin and Shin (2008). Unwinding of these positions will have the opposite

effect, which goes against the uncovered interest parity theorem (Galati, Heath and McGuire 2007).

A carry trade consists of two elements:

i) The interest rate element

- The investor profit on the difference between the two interests, since he borrows at a low rate, and invests at a high rate.

ii) The Foreign Exchange rate element

- This is the risky element, since the foreign exchange rate fluctuates, and may more than remove the return from the interest rate element.

2.1.3 The most traded currencies and top ten currency traders

Table 1

Most traded currencies by value

Currency distribution of global foreign exchange market turnover[3]

Rank	Currency	ISO 4217 code (Symbol)	% daily share (April 2010)
1	United States dollar	USD ($)	84.9%
2	Euro	EUR (€)	39.1%
3	Japanese yen	JPY (¥)	19.0%
4	Pound sterling	GBP (£)	12.9%
5	Australian dollar	AUD ($)	7.6%
6	Swiss franc	CHF (Fr)	6.4%
7	Canadian dollar	CAD ($)	5.3%
8	Hong Kong dollar	HKD ($)	2.4%
9	Swedish krona	SEK (kr)	2.2%
10	New Zealand dollar	NZD ($)	1.6%
11	South Korean won	KRW (₩)	1.5%
12	Singapore dollar	SGD ($)	1.4%
13	Norwegian krone	NOK (kr)	1.3%
14	Mexican peso	MXN ($)	1.3%
15	Indian rupee	INR (₹)	0.9%
	Other		12.2%
	Total[67]		200%

Top 10 currency traders

% of overall volume, May 2012

Rank	Name	Market share
1	Deutsche Bank	14.57%
2	Citi	12.26%
3	Barclays Capital	10.95%
4	UBS AG	10.48%
5	HSBC	6.72%
6	JPMorgan	6.6%
7	Royal Bank of Scotland	5.86%
8	Credit Suisse	4.68%
9	Morgan Stanley	3.52%
10	Goldman Sachs	3.12%

This table shows the most traded currencies by value as well as the top 10 currency traders. Since there are two currencies of each currency rate, the total amount of traded currencies in percent will always be 200% (Euromoney 2012).

Top 10 dealers account for 78.76% of overall volume in May 2012. Our carry trade sample consists of 10 of the 13 most traded currencies and counts for 180.3% of daily turnover in traded currencies. The top seven currencies are often considered as major currencies. However, some view the Canadian and Australian dollar as minor currencies (Forextraders 2011), but they will be implemented as major currencies in our paper. The major currency pairs are USD/EUR, USD/JPY,

USD/GBP, USD/CHF, USD/AUD and USD/CAD. EUR/JPY, EUR/GDP, EUR/CHF and GDP/JPY are called major cross pairs. These have dedicated interbank market makers and brokers. The rest of the cross pairs of the majors are called minor cross pairs and fall into the minor currency class. The minor cross pairs are less active and generally do not have dedicated interbank market makers or brokers. The number of minor currencies fluctuates and variably includes the SEK, DKK, NZD and NOK against the majors. However they are viewed as exotic currencies by many traders (IBtimesFX. 2011 and Forextraders 2011). The term "exotic currencies" refers to currencies which are illiquid and traded in very low volumes and offered for trading by a selective group of Forex brokers. NOK/USD is viewed as a commodity currency pair due to the Norwegian oil export (Netplaces 2012).

2.1.4 The market size of foreign exchange options

Foreign exchange options (or currency options) gives the owner the right, but not the obligation to exchange one currency into another currency at a pre-agreed exchange rate on a specified date. The foreign exchange options are the most liquid options of any kind according to BIS 2010, and are usually traded over the counter (OTC) (Bekaert and Hodrick 2012, 683).

The first measure of global turnover in OTC derivative instruments was done by BIS in 1995. Currency options then had a turnover of 41 billion USD on average per day. In 2010 it has grown to 135 billion USD on average per day.

2.1.5 Popular funding and target currencies

The most popular funding currencies in the period 2001-2004 was USD, CHF and JPY according to the review of BIS 2004 triennial survey by Galati and Melvin (2004). In our sample we find that this is also consistent with our data. Further analysis of the data indicates that JPY (1992-2011), CHF (October 1992-march 1993 and April 1994-2011) and USD (1992-94, 2001-04 and 2008-11) are the most popular funding currencies. USD is also the targeted currency in 1996-97 and 2006-07. The most popular target currencies are currencies from France, Italy and UK before the introduction of the Euro, and New Zealand, Australia, Norway and UK post-Euro.

2.2 Market changes since 1992

2.2.1 Electronic brokering and multi-bank trading systems

In the foreign exchange market of the 1990s, barriers for entry were high, competition was limited and customers typically paid large spreads on their trades. In 1992 the inter-dealer foreign exchange market introduced electronic brokering, while their customers continued trading by telephone with direct contact to dealers (BIS 2010).

With the introduction of electronic brokering and multi-bank trading systems the market changed dramatically with increased transparency, reduced transaction costs and new customer classes. The first multi-bank trading system "Currenex" was launched in 1999. New and increasing competition made top foreign exchange dealers to launch proprietary single-bank trading systems for their clients. Barclay lunched BARX in 2001, Deutsche Bank lunched Autobahn in 2002 and Citigroup lunched Velocity in 2006. Through prime brokerage accounts, hedge funds and other major traders gained access to inter-dealer markets in 2005. This is the deepest and most liquid part of the foreign exchange market (BIS 2010).

Tight bid-ask spreads and guaranteed market liquidity is making it unprofitable for smaller players to compete for customers in the major currency pairs. The smaller banks are instead becoming clients of the top dealers for these currencies, while continuing to make markets for customers in local currencies. While USD/EUR is the most popular currency pair traded, the long-term trend towards greater concentration of foreign exchange activity in a few global banks can help explain the trend of traded currency pairs becoming more diversified.

The upside with lower costs, improved trade processing and settlement systems is that new customers as retail investors with smaller trade sizes can be accommodated. These new customers are entering the global foreign exchange markets and the speculative activities have increased since trading strategies in the foreign exchange market has become profitable for them as well (BIS 2010).

In the foreign exchange spot market most trades are done electronically, due to low credit and settlement risk. Limitations of what can be traded electronically

come with instruments that embody high counterparty credit and settlement risk, such as foreign exchange swaps and options. Individual transactions tend to be large and negotiated on a bilateral basis. Given the greater risk with foreign exchange swaps, than in trades done in the foreign exchange spot market, they are usually transacted via inter-dealer and voice brokers directly (BIS 2010).

2.2.2 Growing importance of retail as an investor class

The introduction of electronic trading opened up the foreign exchange market to the customer segment retail investors. Now, also households and small non-bank institutions can trade through the retail aggregator, a new type of financial institution which acts as foreign exchange intermediary by aggregating bid-offer quotes steamed live quotes from the banks on an online platform and facilitates trades done by retail investors back to the banks (BIS 2010).

The long trading hours, market liquidity, low transaction costs and the ability to generate leverage through margin accounts attract retail investors to the foreign exchange spot market. The retail market has grown colossally and is in 2010 estimated to account for 8-10% ($125–150 billion per day) of the turnover in the foreign exchange spot market. In other words, retail investor as an investor class is growing (BIS 2010).

Margin accounts are used to generate leverage, although the cap used to be 100:1, increased regulations have reduced the cap on retail leverage to 50:1 for major currencies and 20:1 for other currencies in 2010 in the US and Japan. In Europe there are no restrictions (BIS 2010).

2.3 Carry Trade in Crisis

2.3.1 Safe haven currency

According to Reuters is a safe haven currency "a major traded currency, such as the U.S. dollar or Swiss franc, used by investors and fund managers seeking a safe haven for their funds in times of market turmoil". CHF is considered as a safe haven currency that is resilient to crisis (Daniel Kothler 2007), as well as USD and JPY. The Guardian (2011) wrote about the Swiss central bank that even went out and said they would not tolerate the further appreciation of the CHF against the Euro and did an intervention August 3rd 2011 to lower the value of CHF. Such

interventions are evaluated as a factor of exchange rate movements by Cai et al. (2001).

2.3.2 Generally about financial crises

In time of financial crisis, foreign exchange volatility will rise and the increased risk aversions of investors lead to a rapid unwinding of currency carry trade positions. Investors seeking a safe haven for their funds will cause the funding currencies to appreciate sharply and carry trade speculators might experience huge losses if they do not get out in time (Galati, Heath and McGuire 2007).

A financial crisis may start with a currency crisis where foreign investors have targeted a currency with intense speculative attacks, as in the European currency crisis in 1992-1993 or in the Asian Financial crisis in 1997-1998 (Mishkin 2012). The Global Financial Crisis in 2007-2009, also called "the Great Recession", started with a real estate bubble where mortgages were defaulted on in the US-market. This turmoil later rapidly spread around the world. The European debt crisis in 2009-2012 was caused by European countries being unable to serve their debt obligations.

2.3.2.1 European currency crisis 1992-1993

In 1992, investors borrowed extensively and speculated that the governments would not be able to keep the GBP pegged to DEM. The British government was forced to intervene after significant pressure to the pegged value, which on September 16, 1992 (Black Monday) led to the devaluation of the pound. One investor, George Soros made a staggering US $ 1 billion and becoming famous as the man who "broke the Bank of England". The British government was forced to pull it from the European Exchange Rate Mechanism (ERM). (Mishkin 2012, 514-515).

2.3.2.2 The Thai Financial Crisis of 1997-98

On July 2nd 1997, Thailand decided to switch to a flexible exchange rate regime, after experiencing vast attacks by speculators. A real-estate driven financial overextension forced the Thailand government to deplete their foreign currency reserves after exhaustive efforts to support the currency. The Thai Baht therefore experienced an immense 50% depreciation by the end of the year. As Thailand effectively became bankrupt, the predicament also spread to Japan and other

countries in south-east of Asia. Many Asian countries therefore experienced sinking asset prices and currencies (Hunter, Kaufman and Krueger 1999).

2.3.2.3 The Great Recession of 2007-2009

After the bankruptcy of Lehman Brothers on the 15 September 2008, high risk aversion became a steady state of the economy and investors were unwinding their carry trade positions and reallocating to USD, CHF and JPY according to BIS of 2010. Such actions lead to appreciation of these currencies.

Another reason for the appreciation was the freeze up in the money market and a shortage of dollar liquidity in the market. Several banks found it hard to obtain dollar funding via the usual channels. Foreign exchange market provided the solution; banks borrowed in another currency and exchanged it to dollars, while it bought this currency with dollars in the forward market. This action actually created a deviation from covered interest rate parity since USD as a safe haven currency appreciated in the spot market; while the action of the bank, selling forward prevented it from appreciating in the forward market. Because the deviations were persistent during the crisis, any arbitrage activity seemed fairly limited. When there is a shortage in dollars, no one can borrow to exploit these deviations. At the same time there was a massive flight to safety, i.e. investors wanted dollars. Nobody would then go against the flow and sell USD (Bekaert and Hodrick 2012, 188-190).

Countries all over the world had to use fiscal stimulus packages to keep financial markets from collapsing and to stimulate the economy. The governments and the respective central banks had to infuse the banks with money, engaging in massive bailouts and guaranteeing for deposits. The most extreme cases in 2008 were in Ireland and Iceland where banks were nationalized. Everything possible was done to reassure the market that they would do anything to prevent a collapse of the financial markets in order to restore trust to the market. The degree of international coordination was unprecedented (Mishkin 2012, 239-242). Another particular thing about this crisis was that banks around the world needed dollars, not euros or pounds. The Federal Reserve essentially provided global dollar liquidity by lending to other central banks in Europe, Latin-America and Asia (Bekaert and Hodrick 2012, 189).

2.3.2.4 European debt crisis 2009-

Five of Europe's countries – Portugal, Italy, Ireland, Greece, and Spain have not been able to service the debt the respective countries have built up through the last decades. The reason for this is simply that the economic growth has not been sufficient for the countries to be able to pay back their bondholders. The crisis has affected the Global system, and many other European countries have provided financial aid, as the future of the Euro-currency has been in jeopardy (About.com 2012).

2.4 Householders as carry traders?

Bekaert and Hodrick (2012, 229) wrote about householders in Eastern-Europe having, likely unwittingly, turned their mortgages into carry trades. Because of the high interest rates in these countries, the financial institutions started offering mortgages and other loans expressed in foreign currency, mostly in CHF. In Hungary the central bank data reveal that over 50% of the mortgages were in CHF. Bekaert and Hodrick (2012) also expressed their doubt that the average household fully understood the risks involved, which painfully was realized in Hungary when the forint depreciated 15% against CHF at the same time as housing prices fell. The financial institutions in Hungary should rather have managed these mortgages on behalf of their customers in a basket, as we will address in the Norwegian case in this paper to diversify risk. By managing these mortgages for their customers, they may also reduce own risk of default on the mortgages.

3. Literature Review

3.1. Literature about carry trade strategies that give excess return:

In the article "Carry Trades and Speculative Dynamics", Guillaume Plantin and Hyun Song Shin (2008) found that markets that combine significant costs of carry and low resiliency, such as the foreign exchange market, have the preconditions for large and persistent deviations of price from fundamentals, followed by abrupt reversals. High interest rates will exhibit the classic price pattern of "going up by the stairs and coming down in the elevator" and therefore describes carry trades as self-reinforcing arbitrage.

Craig Burnside, Martin Eichenbaum, Isacc Kleshchelski and Sergio Rebelo (2011) claim in "Do peso problems explain the returns to the carry trade?" that even the disastrous returns of 2008 do not suffice to make the peso problem become true. They claim that investors can hedge their downside risk using options and still have some excess returns. Carry trade returns can be explained if they assume agents become risk averse when an unwinding of carry trade happens.

The study "Returns to Currency Carry Trades and Hedge Funds" conducted by Bø and Klokkerhaug (2010) explored a simple carry trade strategy. The strategy consists of borrowing funds from an equally-weighted basket of the three lowest interest-yielding currencies and investing the proceeds in the three highest interest-yielding currencies.

Bø and Klokkerhaug's (2010) study was built on an earlier paper by two Finish researchers, Jylhä and Suominen (2010), who explored a so-called "risk-adjusted carry trade". The risk-adjusted carry trade strategy and simple carry trade have many similarities. The main difference in these strategies is that funding currencies is from countries with low Sharpe ratio, instead of low interest rate, and invest in countries with high Sharpe ratio, instead of high interest rate.

Both studies use the same sub-periods (1979-1992, 1993-1998 and 1999-2008) and conclude that uncovered interest parity does not hold in the long run. Hence carry trade has been profitable in the sample period of 30 years. Even though the returns are decreasing in the sample period, the two studies differ on the

conclusion that increased speculative capital produces lower carry trade returns as a consistent statement. This is because Bø and Klokkerhaug (2010) included AUD and NZD in their currency sample due to the earlier study by Galati and Melvin (2004) who stated that in the period 2001-2004 there were three main funding currencies: USD, JPY and the CHF. The main recipients of the borrowed funds were British pound (GBP), the Australian dollar (AUD), New Zealand dollars (NZD), as well as a number of emerging market currencies. The article also addressed an increased turnover in the AUD and NZD: by 98% and 152% in this period which is consistent with new currencies being targeted in carry trades.

Bø and Klokkerhaug (2010) also added NOK due to the article "Evidence of carry trade activity" by Galati, Heath and McGuire in 2007. This article examined the turnover and carry-to-risk ratio. They found that the correlation is adequately high enough to suggest that a carry trade strategy is related to the turnover. In this study NOK had the highest correlation and was therefore added. The SEK was included in April 1997 since Bø and Klokkerhaug (2010) believed that it was used in carry trade before the introduction of the Euro.

Table 2 Monthly return simple carry trade:

	1979-1992	1993-1998	1999-2008	1979-2008
Bø and Klokkerhaug	0,70 %	0,40%	0,39%	0,54%
Jylhä and Suominen	0,69%	0,38%	0,17%	0,47%

This table displays the monthly average returns for the simple carry trade strategy utilized in two different papers: i) Bø and Klokkerhaug and ii) Jylhä and Suominen. The total sample of 1979-2008 is divided into four sub-periods.

Jylhä and Suominen (2008) had corresponding standard deviation of 2.06 % on their strategies and returns, while Bø and Klokkerhaug (2010) had a corresponding standard deviation of 5.92 %. This indicates that the strategy of Jylhä and Suominen (2008) is superior when considering the Sharpe ratio. The studies obtain almost identical returns in the 2 first sub-periods. Bø and Klokkerhaug (2010) argue that the high return in third sub-period is because of the four new added currencies (AUD, NZD, SWE and NOK) and is the reason for the different conclusions of the papers. This may imply that the Bø and Klokkerhaug (2010) study is an improvement of Jylhä and Suominen (2008) study, when it comes to sample currencies. Both articles also argue that the majority of hedge funds engage in some sort of currency speculation.

3.2 Carry trade in time of crisis:

"The revenge of Purchasing Power Parity on Carry Trades during Crises" by Marie Brière and Bastien Drut (2009) examined the performance of carry trade and fundamental models over the last 20 years. They compared Purchasing Power Parity (PPP) against carry trade strategy instead of Uncovered Interest Rate Parity (UIRP). They concluded that when carry trade perform well, the fundamental models does not and vice versa. Additionally they found that in time of crisis, carry trades underperform and works like a catalyst for carry trade unwinding and the better the carry trade strategies had performed before a crisis, the more violent return to equilibrium. This unwinding leads to huge losses, that ultimately may wipe out much of the earlier gains.

"Carry trades and currency crashes*"* by Markus K. Brunnermeier, Stefan Nagel and Lasse H. Pedersen (2008) found that sudden exchange rate movements that are not related to news, can be a result of unwinding of carry trade positions. This crash risk may discourage speculators from taking on large enough positions to enforce UIRP. Compensation for crash risk may help explain the empirically well documented violation of the UIRP. The authors established a strong link between currency carry and crash risk, meaning that simple carry trade strategies delivers negatively skewed returns. They also argued that the occasional currency crashes happen due to liquidity crises in the market and can be a result of the unwinding of these carry trades positions. The reallocation of capital helps resolve the UIRP violation. Another noteworthy finding in the article is that the price of protecting against a crash in a currency after a crash increase, despite the fact that a subsequent crash is less likely. Hence currency crashes are positively correlated with increases in implied stock market volatility as the VIX and the TED spread

In "Evidence of carry trade activity" by Gabrielle Galati, Alexandra Heath and Patrick McGuire (2007) argued that carry trades are an important driver of exchange rate developments. They stated that the build-up in the targeted currencies will lead to strengthening of these and weakening of funding currencies. When unwinding these positions, the opposite will happen. This goes against UIRP theorem.

There are also other articles about carry trade and crisis, but most say that in time of economic crisis there will be an unwinding of carry trade. This unwinding will lead to appreciation of the funding currencies and depreciation of the target currencies. Hence carry trades will have considerable correlation risk with the global stock market and economic conditions of the world as Daniel Kothler (2007) found in his study "Carry Trades: Betting Against Safe Haven". He argues that investors that are not aware of conditional correlation dynamics between the markets will face an unexpected diversification meltdown in times of crises, when diversification is most desirable. The CHF seems to be a safe haven currency and offer protection against diversification meltdown in turbulent times.

"Why has FX trading surged? Explaining the 2004 triennial survey" by Gabrielle Galati and Michael Melvin (2004) describes the declining foreign exchange market activity between 1998 and 2001. The reason is the introduction of the euro, the consolidation in the banking industry, the growth of electronic broking, mergers in the corporate sector, and the events of 1998, which lead to a period that was characterized by higher risk aversion and a global withdrawal of liquidity. In the conclusion, they argue for the importance of short-term factors in the foreign exchange market, in specific the trading strategies hedge funds engage in. An increase in assets under management in hedge funds will make an impact on the market, in general on prices and interest rates.

3.3 carry trade and the effect of order flow.

"Order flow and exchange rate dynamics" by Evans, Martin D. D. and Richard K. Lyons (2002) introduces a new kind of model for exchange rate determination. Instead of relying exclusively on macroeconomic determinants, the model includes a determinant from the field of microstructure order flow. The order flow variable within the microstructure is both theoretically and empirically the driver of price. This is a radical departure from traditional approaches to exchange rate determination. The model is strikingly successful in accounting for realized rates as it accounts for more than 60% of daily changes in the DM/USD rate, and more than 40% of daily changes in the JPY/USD rate. For log exchange rates the model produces R^2 statistics above 50%. $1 billion of net dollar purchases increase the DM price of a dollar by 0.54%.

”Once-in-a-Generation” Yen Volatility in 1998: Fundamentals, Intervention and Order Flow” by Jun Cai, Yan-Leung Cheung, Raymond Lee and Michael Melvin (2001) examined the impact of three factors on the yen-dollar volatility in 1998: i) announcements related to macroeconomic fundamentals, ii) interventions by Bank of Japan, US treasury and Federal Reserve, and iii) portfolio switches by large institutions (order flows). The authors introduced a model capturing the typical intraday volatility pattern over a 24-hour trading day. By comparing the alternative sources of volatility, they concluded that order flow, hedge fund activity or unwinding of carry trade positions played an important role in the yen-dollar volatility in 1998 as determinants of exchange rates.

“Evidence of carry trade activity” by Gabrielle Galati, Alexandra Heath and Patrick McGuire (2007) stated that the buildup of carry trade in the targeted currencies will lead to strengthening of these and weakening of funding currencies. Unwinding of these positions will have the opposite effect and goes against the uncovered interest parity theorem. The authors therefore claimed that carry trades are important drivers of exchange rate developments.

3.4 Carry trade and options

“Do peso problems explain the returns to the carry trade?” by Craig Burnside, Martin Eichenbaum, Isacc Kleshchelski and Sergio Rebelo (2011) uses options to reduce the downside in a carry trade strategy. The results indicate that with an at-the-money protective put, the investors can hedge their downside risk using options without sacrificing all their returns. They used plain vanilla options in their research when analyzing returns. The authors claim that the even the disastrous returns in 2008 do not suffice to make the peso problem become true. If it were true, it would have been avoidable by implementing a protective put. They can also explain the carry trade returns if they assume agents become very risk averse when an unwinding of carry trade happens.

“Theory of Rational Option Pricing” by Robert Merton (1973) presents a formula which is a generalization of the Black-Scholes (1973) formula in order to price European options on stocks or indices paying a known dividend yield. This formula only applies to European options and over-the-counter (OTC) in general.

"Foreign Currency Option Values" by Mark B, Garman and Steven Kohlhagen (1983) generalizes the formula of Merton further and make it applicable for foreign exchange options. The risk-free rate from Merton's formula is here the domestic interest rate, while the known dividend yield is the foreign interest rate. Like the Merton formula, the Garman and Kohlhagen formula applies only to European options, generally over the counter currency options, as we are using in this paper.

3.5 Volatility forcasting

"Forecasting Volatility in Financial Markets: A Review" by Poon, Ser-Huang Poon and Clive W. J. Granger (2003) reviews different techniques for forecasting volatility in financial markets. The authors conclude that historical volatility and GARCH performs roughly equally when it comes to accuracy in volatility forecasting.

According to Chris Brooks (2008, 379-428) the simplest model of forecasting volatility is the historical volatility estimation and was used traditionally in options pricing models. A growing body of articles indicate that volatility forecasted with more sophisticated time series models, as the GARCH (1,1), will lead to better option valuation. Brooks referred to articles by Chu and Freund (1996) and Akgiray (1989) and claims that the reason is because the non-linear dependence in financial time series data is best characterized by a GARCH-type process. Brooks declares that "historical volatility is still useful as a benchmark for comparing the forecasting ability of more complex time models" (Brooks 2008, 384).

4. DATA

We downloaded daily historical time series data of exchange rates from "Norges Bank" and daily one month interest rates from Datastream for all sample currencies. We will use this data to calculate the monthly return on the 1st each month. If there is no data for the 1st in each month, we use the last traded day before. We will also use the exchange rate data to forecast volatility between the currency pairs using a GARCH (1,1) technique. The forecasted volatility will then be used in a Black and Scholes options pricing model extended by Garman and Kohlhagen (1983). We will estimate prices of call and put options for these currencies pairs in order to utilize a zero-premium collar and protective put strategy to manage risk in a simple carry trade strategy.

4.1. Sample Currencies:

Bø and Klokkerhaug (2010) researched in their master thesis "Returns to Currency Carry Trades and Hedge Funds" to find the most commonly traded currencies during the period 1979-2008 to best reflect the real life carry trade. We will use the same currencies as Bø and Klokkerhaug (2010) did in their research with a little modifications. Bø and Klokkerhaug (2010) post restrictions on when to use currencies in different sub-periods. We will not post this restriction, since most literature does not; one example is Burnside et al. (2011). Hence we will use the currencies from Canada, Japan, Norway Switzerland, the UK and the US for the whole period and add Sweden, New Zealand and Australia from 1st of April 1997, since Datastream only provides one month Euro interest rates for these countries from then. Belgium, Germany, Netherland, Italy and France will be applied from 1992 and replaced with Euro January 1st, 1999. The other modification is to change the period from 1979-2008 to 1992-2011, i.e. removing most of the first sub-period of Bø and Klokkerhaug (2010), where they had an average monthly return of 0.70%. There are several reasons for this choice; first we acknowledge there was a change in the foreign exchange market with the 1992 European currency crisis, where the European countries went from pegged to floating currencies. Second, at the same time as this crisis, the electronic brokering system was introduced in the inter-dealer foreign exchange market, which was the start of increased transparency and reduced transaction costs, which again attracted new customers. Third, the average returns of 0.70 % per month is almost twice as high as the returns in the other two periods, thus may not

be representative for carry trade returns as of today, and hence may give an upward bias towards explaining the violation of UIRP today.

The currencies we are left with from 1999 are only ten of the top 13 currencies traded in 2010 (BIS 2010). Hong Kong dollar (HKD), Singapore dollar (SGD) and the South Korean Won (KRW) are excluded due to political risk. The reason stems from Burnside et al (2011) that claim the high Sharpe ratio associated with HKD carry trade in their study is reflected by political risk. Hence there can be a possible peso problem in the future. We fear that an unsuspected and high devaluation of HKD would have the same impact on the region as the devaluation of the Thai Bath had in 1997 in Asia. However, we notice in the BIS 2010 survey the list of currency pairs has been expanded from the 2007 survey to capture transactions involving currencies typically used in carry trade strategies, among them USD/HKD and USD/KRW. Generally we will in this master thesis avoid any currencies from emerging markets that is used in carry trade as the Brazilian real, Chinese renminbi and Indian rupee (BIS 2010), since the main point is to risk manage carry trade and we generally perceive currencies in emerging markets as too risky to be implemented in a carry trade strategy.

The last modification we have done is to change home currency from British Pounds to Norwegian kroner because of the Norwegian case we will examine.

4.2. Interest rates of the sample currencies:

The one month euro interest rates are quoted annually when downloaded from Thomson Datastream for the period 1992-2011. It is therefore divided by 12 to obtain monthly interest rates. The use of euro rates makes the analysis more precise and gives international comparable rates when analyzing the interest rates differentials in the countries concerned. The three currencies with the highest interest rates the 1st each month will be target currencies and the three currencies with the lowest interest rate are used as funding currencies. Any closure and opening of positions are done simultaneously the 1st of each month. If there are no trading day this day, the prior trading day are used to close and open positions. These interest rates will also be used when calculating the call and put option prices to each currency pair.

Bø and Klokkerhaug (2010) addressed the issue of negative interest rates, which are observed in longer periods of time in Japan between 30.09.2002-10.02.2006. The use of negative interest rates in Japan has presumably been to reduce their exposure in times of very low confidence in the Japanese economy.

4.3 Options data

All options are assumed to be European options and are bought in the OTC-market. Option prices on call and put will be calculated using the extension of Black and Scholes option pricing model by Garman and Kohlhagen (1983). This model takes into account interest rate differences between different currencies when calculating the prices of the European options. To create a zero-premium collar, we will buy a one month put option on the target currency with a strike price 3% below spot price the 1st of each month. The option premium will be financed by selling a Call option at the strike price that neutralizes the put option. A strike price for the call option will be found by iteration using the Microsoft Excel Solver tool. As a function of the option pricing model input variables and the put option premium, a corresponding call option strike price will be calculated. We assume that a counterparty at these prices will always be found in the OTC-market.

4.4 Volatility data to currencies pairs obtained by forecasting volatility

Neither Datastream nor Bloomberg terminal had all the implied volatility data we needed to the 37 currencies pairs we are using in this master thesis. The only obtainable implied volatility-data were data from 2005 and until 2011 of every NOK currencies pairs we have in our sample. This data will be used to analyze how accurate the forecasted volatilities of the GARCH (1,1) model are.

The volatility input needed to calculate option prices will be forecasted one month ahead using daily exchange rates one year prior to the forecasting period. To find the right forecasting model we have read different articles along with Chris Brooks "Introductory Econometrics for Finance" on the subject. Poon and Granger (2003) wrote a review article on forecasting volatility in financial markets. A lot of weight in their article was put in reviewing a GARCH versus historical volatility as volatility forecasting techniques. It is concluded that GARCH and historical volatility perform roughly equal. However according to

Brooks (2008, 383-384) "there is a growing body of evidence suggesting that the use of volatility predicted from more sophisticated time series models will lead to more accurate option valuations". Since our goal is to value options, a GARCH (1,1) model is deemed the most adequate. A GARCH (1,1) "is a very parsimonious model, which allows an infinite number of past squared errors to influence the current conditional variance" (Brooks 2008, 394). In other words, a GARCH (1,1) is superior to any ARCH model.

We will use GARCH(1,1) forecasting technique, as it is evaluated as superior to historical volatility as a forecasting technique by Brooks (2008, 379-428). These one-month forecasts will then be used as input parameters in our option pricing model to determine both call and put option prices.

4.5 Transaction costs

Some researchers emphasize the importance of the inclusion of transaction costs. Burnside et al. 2006 compared simple carry trade and an alternative strategy that involved buying and selling the pound forward according to when it is at a forward premium or discount. They found that simple carry trade was not as profitable due to higher transaction costs. Other studies on the same matter exclude the transaction cost completely. Bø and Klokkerhaug (2010) concluded that previous literature disagree on the importance of transaction cost, and decided to exclude the subject in their analysis. Since carry trades were performed at a rather low frequency (monthly), as well as transaction costs are perceived to be small in the foreign exchange market, they evaluate the impact to be insignificant to their results. Prices are 2 pips on EUR/USD as an offering to retailers on both Saxo Bank`s and Deutsche Banks`s websites. We will follow this assumption on our simple carry trade analysis, but the transaction cost of the implemented options is another matter we will now consider.

Since we are both selling and buying currency options to equal prices to get a zero cost collar the cost will be the bid-ask spread to the bank. A sample of offered bid-ask spreads to retailers in different currencies pairs was downloaded from Saxo Bank`s website and are listed in Table 3.

Table 3

FX VANILLA OPTIONS - RATES & CONDITIONS

BID/ASK SPREADS AND AUTOEXECUTION

Saxo Bank is a global leader in Forex Vanilla Options trading. We are able to provide streaming prices for most of the popular currency pairs with larger strike ranges and longer maturities than others. This means you have direct access to trade Forex Vanilla Options on live prices without dealer intervention. Except on low-value trades, there are no commissions on trading Forex Vanilla Options, only the difference in the spread. Since Saxo Bank always quotes both the bid and ask price, the current spread is always visible to you.

ACCOUNT:	CLASSIC	PREMIUM	PLATINUM	ACCOUNT:	CLASSIC	PREMIUM	PLATINUM
EURUSD	0.0006	0.0005	0.0004	EURNZD	0.0017	0.0016	0.0015
USDJPY	0.05	0.05	0.04	EURPLN	0.0051	0.0045	0.0043
GBPUSD	0.0009	0.0008	0.0008	EURSEK	0.0120	0.0110	0.0105
AUDUSD	0.0007	0.0007	0.0006	EURTRY	0.0029	0.0027	0.0026
USDCAD	0.0007	0.0007	0.0006	GBPAUD	0.0019	0.0018	0.0017
USDCHF	0.0007	0.0007	0.0006	GBPCAD	0.0023	0.0022	0.0021
EURJPY	0.09	0.08	0.07	GBPCHF	0.0016	0.0014	0.0014
EURGBP	0.0005	0.0005	0.0004	GBPJPY	0.15	0.14	0.14
EURCHF	0.0012	0.0011	0.0011	NOKSEK	0.0016	0.0015	0.0014
GOLD	3.00	2.85	2.80	NZDJPY	0.09	0.09	0.08
AUDJPY	0.09	0.09	0.08	NZDUSD	0.0007	0.0007	0.0006
AUDNZD	0.0010	0.0009	0.0009	USDHUF	0.64	0.63	0.62
AUDSGD	0.0016	0.0014	0.0014	USDILS	0.0065	0.0061	0.0059
CADJPY	0.09	0.09	0.08	USDMXN	0.0220	0.0215	0.0210
CHFJPY	0.09	0.09	0.08	USDNOK	0.0090	0.0085	0.0082
EURAUD	0.0010	0.0009	0.0009	USDPLN	0.0051	0.0049	0.0048
EURCAD	0.0014	0.0013	0.0013	USDSEK	0.0086	0.0081	0.0077
EURCZK	0.041	0.038	0.037	USDSGD	0.0011	0.0009	0.0009
EURHUF	0.45	0.42	0.41	USDTRY	0.0020	0.0018	0.0017
EURNOK	0.0093	0.0088	0.0083	USDZAR	0.0114	0.0109	0.0105

Sampled 2012-08-16 08:45 GMT

Table 3 displays rates and conditions for currency plain vanilla options. Bid-ask spread for different currencies and settings for different accounts are likewise presented.

As we can see is the bid-ask spread quite tight even for classic customer accounts. An option collar is believed to be beneficial to the financial intermediary`s interest, because of the risk reduction to huge losses for their customers. In other words this reduces their risk to take losses from customers that are unable to repay a loan. In addition, less force closures of margin accounts may occur. We therefore presume that the transaction costs on options of a simple carry trade strategy are insignificant to our results.

5. Methodology

5.1 Simple Carry trade

As mentioned in section two about background information, the UIRP states that carry trade would lead to a return that is equal to the return of borrowing and investing domestically. Simple carry trades on a monthly basis throughout the 20-year period of 1992-2011 will be employed in order to test this condition. Since our test-portfolio will be a zero-investment portfolio, the expected return according to UIRP should be zero. Statistical tests will therefore be employed to analyze whether obtained returns are significantly greater than zero. Throughout the analysis, a significance level of 5% will be used. In our paper, we will consequentially quote exchange rates as the amount of low-yielding currency units per one high-yielding currency unit.

5.1.1 The Norwegian perspective

Before 2000 and up to 2005 it was popular to borrow money for mortgages in Norway. In 2007, some Norwegian currency brokers again recommended to borrow money in foreign currencies. Popular funding currencies in Norway have been CHF and JPY (Rogalandsavis 2007). With this as a background, we wanted to research carry trading in a Norwegian perspective, i.e. a case where funds are borrowed in foreign currencies, and invested in Norway. The carry trade analysis will be performed with two separate borrowing policies: i) borrowing funds in the lowest-yielding currency and ii) borrowing funds in an equally-weighted basket of the three lowest-yielding currencies. We will do this in order to explore potential diversification benefits Norwegian investors may have had if borrowing funds in a basket of three currencies rather than only in CHF or JPY.

Since, as mentioned above, many Norwegian investors borrowed money for mortgages in CHF or JPY, we will execute a carry trade analysis where proceeds are borrowed in the lowest-yielding currencies, and invested in Norway, unless the interest rate differential is less than 1 %. In such case, funds are both borrowed and invested in Norway. The investor is assumed to be Norwegian. The analysis is employed on monthly data from January 1992 until December 2011, i.e. 240 months, and the only criterion of where to borrow is the ranking of interest rates. Returns will also be computed monthly, based on the interest rate and foreign exchange rate elements.

Another carry trade analysis will be utilized in a similar manner as the one above. In this case, however, a basket of the three lowest-yielding currencies will be used as funding currencies, unless the interest rate differential is less than 1 %. In such case, funds are both borrowed and invested in Norway. The proceeds will be invested in Norway, and the investor is assumed to be Norwegian. In this way, we are able to research whether Norwegian investors could have diversification benefits of borrowing in a basket of three currencies instead of only in one. The analysis is employed on monthly data from January 1992 until December 2011, i.e. 240 months, and the only criterion of where to borrow is the ranking of interest rates. Returns will also be computed monthly, based on the interest rate and foreign exchange rate elements.

5.1.2 The Global perspective

It is also interesting to research the UIRP without restrictions of investment country. This will be a pure carry trade analysis where a basket of the three lowest-yielding currencies will be used as funding currencies, and the proceeds will be invested in a basket of the three highest-yielding currencies. The analysis is employed on monthly data from January 1992 until December 2011, i.e. 240 months, and the only criterion of where to borrow and invest is the ranking of interest rates. Returns will also be computed monthly, based on the interest rate and foreign exchange rate elements.

5.2 Carry trade risk managed with options

A Norwegian investor looking for borrowing money in a low-yielding currency is facing currency risk. As mentioned before, the investor will profit from the interest rate differences between the two countries, and the risk lies in currency rate fluctuations. For risk-averse investors it is desirable to mitigate this risk. Our carry trade analyses will therefore be extended to implement options for risk management. Two strategies will be examined throughout this paper:

i) Protective Put

- Burnside et al. (2011) hedged currency risk by using a protective put. This approach will also be used in our paper. By using a put-option, we have created a floor for future losses, i.e. a so-called Protective Put-strategy. In such case we have to pay the option premium.

ii) Zero-premium Collar

- In our paper, we have also chosen to extend the analysis of Burnside et al. (2011) by implementing a short call position. A collar is established by buying a protective put-option on the high-yielding currency to effectively creating a floor, as addressed above. However, a put-option itself may be costly. Selling a call is therefore implemented to create a cap and reducing the net-premium. This is the so-called Collar spread. The strike prices of the call and the put will be selected such that the net premium is zero, which implies a zero-premium Collar (Hull 2005). Applying a zero-premium collar will have the practical implications that we do not have to consider the option premiums, as they will net each other out. In addition, as many investors would use options for risk minimizing, a collar is useful for mitigating volatility.

For the Norwegian perspective, we will continue to consider two separate cases:

i) Borrowing funds in the lowest-yielding currency and investing the proceeds in Norway, and

ii) Borrowing funds in a basket of the three lowest-yielding currencies and investing the proceeds in Norway.

The carry trade analyses will then be utilized using both a zero-premium Collar and a protective put for Risk Management.

For the Global Perspective, we will consider the same case as earlier, namely where funds are borrowed in a basket of the three lowest-yielding currencies, and the proceeds are invested in the three highest-yielding currencies. The analyses are now extended to implementing a zero-premium Collar and protective Put for Risk Management.

5.3 The model

5.3.1 Simple Carry trade

For the Simple Carry Trade, our model approach is somewhat similar to the one used by Bø and Klokkerhaug (2010). UIRP states that, if a market is efficient, borrowing in low-yielding currency and investing in high-yielding currency would yield the same return as borrowing and investing in the same country. We assume that an investor is able to borrow and invest at the risk-free monthly rate and is able to convert between currencies without significant transaction costs.

Let $E(R^*_{t+1})$ be the expected return of holding an investment in a high-yielding currency, and $E(R_{t+1})$ the expected return of holding an investment in a low-yielding currency. According to UIRP:

(1) $$E(R^*_{t+1}) - E(R_{t+1}) = 0$$

Let S_t denote the exchange rate as low-yielding currency per high-yielding currency at time t. Borrowing one unit of the low-yielding currency at the risk-free rate r_t and investing the proceeds in the high-yielding currency at rate r^*_t, will yield at time t+1:

(2) $$R^{CT}_{t+1} = \log\left(\frac{S_{t+1}}{S_t}\right) + r^*_t - r_t,$$

where R^{CT}_{t+1} is the Carry Trade return for the period. According to UIRP, this return should equal zero. We will therefore perform statistical t-tests on whether or not the Carry Trade return is significantly greater than zero. We use a significance level of 5 %. In addition, Sharpe ratios will be calculated.

For the Norwegian perspective, the investment country will always be Norway, while funding currencies may vary from month to month. For the Global perspective, both funding and investment country may differ from month to month, as the only criterion of where to borrow and invest is the ranking of the interest rates.

5.3.2 Carry Trade Risk Managed with Options

In this section we will introduce the Carry Trade analyses extended with the use of options as Risk Management. As addressed earlier, we will be using the Garman and Kohlhagen's option pricing formula for Call (C) and Put (P) options:

(3) $$C = Se^{-r^*T}N(d_1) - Ke^{-rT}N(d_2)$$

(4) $$P = Ke^{-rT}N(d_2) - Se^{-r^*T}N(d_1)$$

Where:

(5) $$d_1 = \frac{log\left(\frac{S}{K}\right)+(r-r^*+0{,}5\sigma^2)T}{\sigma\sqrt{T}}$$

(6) $$d_2 = d_1 - \sigma\sqrt{T}$$

S is the current spot rate,

K is the strike price,

N is the cumulative normal distribution function,

r is the domestic, and in our paper, the low-yielding currency risk free interest rate,

r^* is the foreign, and in our paper, the high-yielding currency risk free interest rate,

T is the time to maturity, and

σ is the volatility of the foreign exchange rate.

The volatility of the foreign exchange rate, σ, will separately be forecasted using a GARCH (1,1) approach.

5.4 Forecasting volatility

To calculate option prices, we need techniques for volatility forecasting. When a volatility measure has been forecasted, it will be used as input in the option pricing formula.

5.4.1 GARCH (1,1)

With a GARCH (1,1) model, we can forecast volatility by taking into account the change from the day before, as well as all previous lags of changes in the history

of the time series. By doing so, we will be able to forecast next period's *conditional variance*, σ_t^2.

(7) $$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta \sigma_{t-1}^2$$

Where u_{t-1}^2 is the change in the time series is in the last period while σ_{t-1}^2 is the calculated conditional variance last period.

A GARCH (1,1) is not of a usual linear form, which implies that an Ordinary Least Squares (OLS) estimation is inadequate. Instead, we will employ a maximum likelihood (ML) parameter estimation technique. In order to do so, the following steps will be utilized (Brooks 2008):

i) Specify the log-likelihood function

(8) $$L = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log(\sigma_t^2) - \frac{1}{2}\sum_{t=1}^{T}(y_t - \mu - \Phi y_{t-1})^2 / \sigma_t^2$$

ii) Maximizing the log-likelihood by changing the three parameters (α_0, α_1, and β). The maximization will be performed by using the Microsoft Excel Solver tool.

iii) When the log-likelihood function is maximized, we can retrieve a forecast of next period's conditional variance. This is the volatility measure that will be used in our option pricing model.

In order to use this log-likelihood function to forecast next period's we need a *convergence criterion*. For a GARCH (1,1), this convergence criterion is the long term unconditional variance, and the conditional variance will therefore, in the long term, stick to this unconditional variance (Brooks 2008).

5.5 Zero-Premium Collar

As addresses earlier, a zero-premium Collar is an option strategy employing the Collar spread, with strike prices of the put and call selected such that the net-premium equals zero. We have chosen a pre-specified lower limit of our strategy, i.e. a floor for each month arbitrarily 3 % below spot exchange rate. The lower strike price will therefore always be:

(9) $$K_{L,t} = 0{,}97 S_t$$

which will be the strike price of the put option. By iteration, we will find the upper strike price for the call that will net out the option premiums. We will use the Microsoft Excel Solver tool to iterate the $K_{U,t}$. With this we have limited our downside of exchange rate fluctuations to 3 % every month. The upside will vary from month to month, as the upper strike price is iterated as a function of the option pricing formula inputs and the put option premium. As we now are implementing a zero-premium Collar, we have effectively reduced the range of possible outcomes that may occur in simple Carry Trade. Let S_t denote the exchange rate as low-yielding currency per high-yielding currency at time t. Borrowing one unit of the low-yielding currency at the risk-free rate r_t and investing the proceeds in the high-yielding currency at rate r_t^*, will yield at time t+1:

$$(10) \quad R_{t+1}^{CT} = \log\left(\frac{S_{t+1}|K_{L,t} \leq S_{t+1} \leq K_{U,t}}{S_t}\right) + r_t^* - r_t$$

If $S_{t+1} < K_L$, the put option will be exercised:

$$(11) \quad R_{t+1}^{CT} = \log\left(\frac{K_{L,t}}{S_t}\right) + r_t^* - r_t$$

If $S_{t+1} > K_U$, the call option will be exercised:

$$(12) \quad R_{t+1}^{CT} = \log\left(\frac{K_{U,t}}{S_t}\right) + r_t^* - r_t$$

We will perform t-tests on whether or not the returns we get from Carry Trade risk managed with zero-premium Collar are significantly greater than zero. We use a significance level of 5 %. In addition, from a risk-return point of view, Sharpe ratios will be calculated as an indicator of which strategies perform better.

5.6 Protective Put

For the protective put strategy, we will use the same put option as earlier, i.e. where the "floor" is set 3 % below spot exchange rate. The floor will therefore be the same as for the zero-premium Collar. For the protective put strategy, we are not selling a call at K_U, meaning that we are not giving away any upside potential, but that we now have to consider the put option premium.

Let S_t denote the exchange rate as low-yielding currency per high-yielding currency at time t. Borrowing one unit of the low-yielding currency at the risk-free rate r_t and investing the proceeds in the high-yielding currency at rate r_t^*, will yield at time t+1:

$$(13) \quad R_{t+1}^{CT} = \log\left(\frac{S_{t+1}|K_{L,t} \leq S_{t+1}}{S_t}\right) + r_t^* - r_t - \frac{FV(P)}{S_t}$$

Where $FV(P)$ is the future value of the put option premium.

If $S_{t+1} < K_L$ the put option will be exercised:

$$(14) \quad R_{t+1}^{CT} = \log\left(\frac{K_{L,t}}{S_t}\right) + r_t^* - r_t - \frac{FV(P)}{S_t}$$

We will perform t-tests on whether or not the returns we get from Carry Trade risk managed with protective puts are significantly greater than zero. We use a significance level of 5 %. In addition, from a risk-return point of view, Sharpe ratios will be calculated as an indicator of which strategies perform better.

5.7 Supplementary calculations

Supplementary calculations and analyses based on our results will also be performed in section six to support and confirm the findings.

6. Results and Analysis

This section presents the results from our study. Discussions and conclusions will be addressed in the last section of this paper. For each strategy, a Sharpe ratio will be calculated. However, it is worth mentioning that the use of Sharpe ratios assumes normal distribution of returns. We acknowledge that this may not be the case when implementing options for risk management purposes. Nevertheless, we rely on previous work by esteemed academics as Burnside et al. (2011) which use Sharpe ratios as performance measures when using protective put. We will therefore utilize the Sharpe ratio as an indicator of which strategy performs better.

6.1 Robustness test of GARCH (1,1) forecasts

We performed a two-sided t-test on the difference between the real implied volatility obtained from Bloomberg and the forecasted volatility to test whether the difference is significantly different from zero. The results are displayed in table 4.

Table 4

	Implied volatility	Calculated volatility	Difference	T-stats
Pair 1	16.5910 %	15.6476 %	0.9434 %	0.3176
Pair 2	13.8714 %	13.2711 %	0.6003 %	0.2911
Pair 3	11.1055 %	10.7724 %	0.3332 %	0.1033

Average of implied volatility data obtained from Bloomberg Terminal, and average forecasted volatilities with a GARCH (1,1). The difference between averages is calculated in order to compute t-statistics on the difference between the implied and forecasted volatility.

The t-statistics are small and insignificant; hence we can assume that our forecasts are robust compared to the real implied volatility and. We therefore deem our forecasted volatilities as appropriate for currency option valuations.

However, if it was the case that our forecasted volatilities were systematically underestimated, it would only add difficulties of obtaining significant positive results with a collar strategy. According to Vega of an option, as volatility increases, so does the cap of the collar strategy. This is due to the fact that Vega is higher the closer to the money an option gets. As addressed earlier, the cap will always be less out-of-the money than the put due to interest rate differentials. This implies that if volatility increases, the cap also increases. The downside is the same as before, while the upside is greater (Kolb and Overdahl 2007, 487). In

other words, if our estimated volatilities were higher, the cap will also be higher and thus average returns will increase.

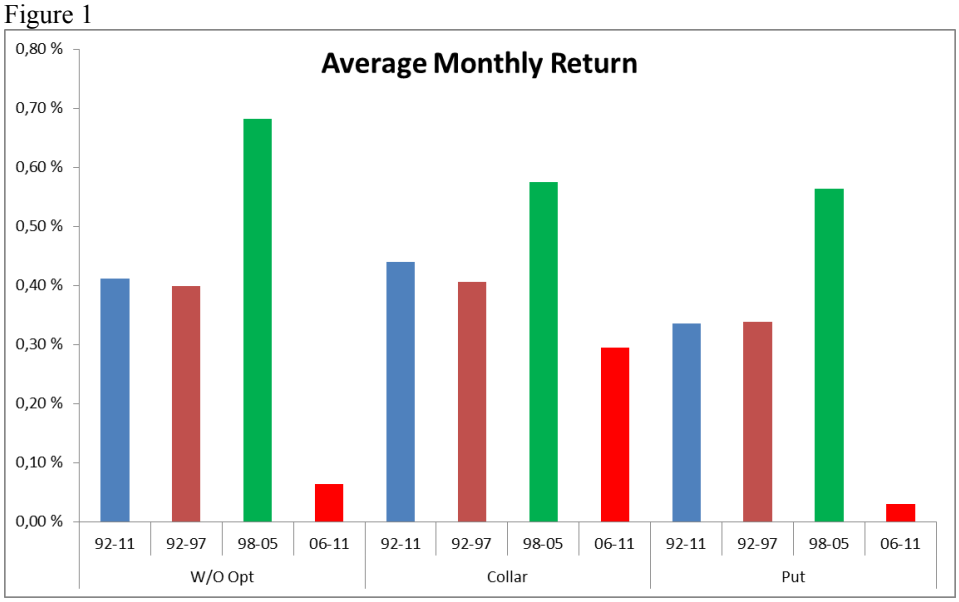
6.2 Average results

The first results we introduce are the average results of the carry trade strategies. The question we will address and discuss later is whether or not the strategies are able to give excess returns, i.e. if the UIRP is violated. We will initially focus on the Global perspective, and then the Norwegian perspective.

6.2.1 The Global perspective

Figure 1 shows average monthly return throughout the 20-year period for our carry trade analyses.

Figure 1

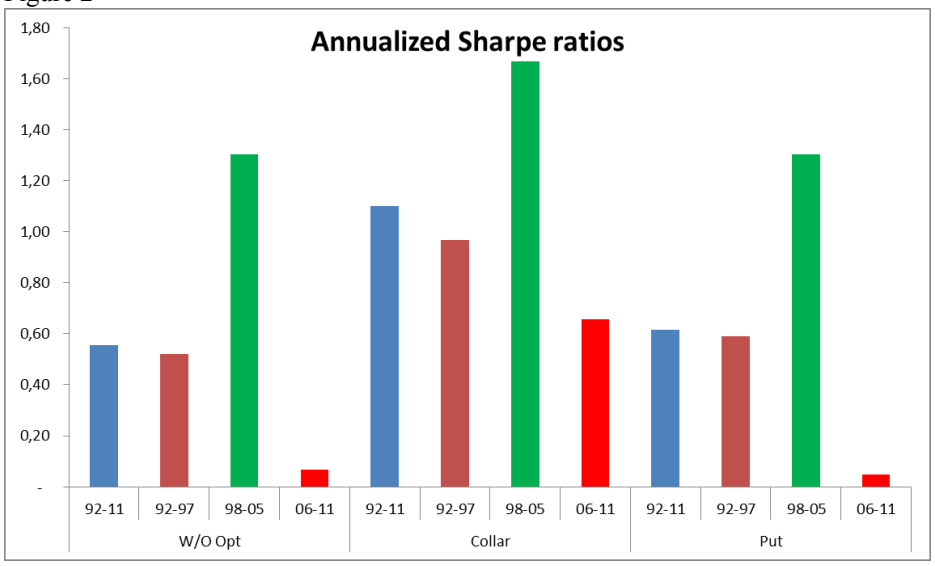


This figure provides a visual representation on how each of the three strategies performs in the global perspective. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively.

The average monthly return for the whole period for the strategy without options is 0.41%, while 0.44% for the Collar strategy, and 0.34% for the protective put strategy. For the first of our sub-periods, 1992-1997, the three strategies yielded 0.38%, 0.40% and 0.34% average monthly return respectively. In the second sub-period, 1998-2005, the strategies yielded 0.68%, 0.58% and 0.58% average monthly return respectively. In the third and final sub-period, 2006-2011, the strategies yielded 0.06%, 0.29% and 0.03% average monthly return respectively.

Figure 2 shows the calculated annualized Sharpe Ratios for the three carry trade strategies.

Figure 2



This figure provides a visual representation for the annual Sharpe ratios for the three carry trade strategies in the global perspective. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively.

For the whole period, the annualized Sharpe ratios are 0.55 for the strategy without options, 1.09 for the Collar strategy, and 0.61 for the protective put strategy. For the first of our sub-periods, 1992-1997, the annualized Sharpe ratios were 0.50, 0.95 and 0.58 respectively for the three strategies. In the second sub-period, 1998-2005, the annualized Sharpe ratios were 1.30, 1.67 and 1.30 respectively for the three strategies. In the third and final sub-period, 2006-2011, the annualized Sharpe ratios were 0.07, 0.66 and 0.05 respectively for the three strategies.

Table 5 below displays some calculated descriptive statistics for our sample.

Table 5

	Whole Period			92-97			98-05			06-11		
	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put
Mean	0,41 %	0,44 %	0,34 %	0,38 %	0,40 %	0,34 %	0,68 %	0,58 %	0,58 %	0,06 %	0,29 %	0,03 %
Std	2,58 %	1,39 %	1,93 %	2,68 %	1,46 %	2,05 %	1,81 %	1,19 %	1,50 %	3,25 %	1,55 %	2,26 %
Sharpe*	0,55	1,09	0,62	0,50	0,95	0,57	1,30	1,67	1,35	0,07	0,66	0,05
T	2,45	4,89	2,77	1,22	2,34	1,39	3,69	4,72	3,81	0,17	1,61	0,13
P-value	0,75 %	0,00 %	0,30 %	11,39 %	1,12 %	8,48 %	0,02 %	0,00 %	0,01 %	43,42 %	5,60 %	44,92 %

*Annualized

The table presents numerical calculations of our sample currency carry trade strategies. Results are presented for the whole period 1992-2011, as well as for the three sub-periods 1992-1997, 1998-2005 and 2006-2011. Mean monthly return, standard deviation of the returns, annualized Sharpe ratios t-statistics and p-values are computed for each of the three strategies.

As we can see, the sample currencies we have used support what other researchers have confirmed, namely that UIRP does not hold. Hence, simple carry trade

produces excess return in the long run. For all strategies in the 20 year period, we observed returns with a p-value less than 5%, and are therefore concluded as significantly greater than zero. For all strategies the sub-period 2006-2011 is insignificant, although the collar strategy is almost significant with a p-value of 5.60%

An interesting aspect of the last sub-period is the two immense crises that have affected the whole world economy the last years. These crises have surly affected the returns of a carry trade strategy as the unhedged strategy shows. By comparing the zero-premium collar option strategy against the protective put strategy, we see how the cost of options affects hedging. Volatility increases in time of crises, and thus also option prices. Returns therefore decline. We can see from the results that the cost of the protective put wipes out any benefits of the hedge in the last sub-period. Executing a collar strategy, however, is clearly superior to the other strategies, and much of the excess mean return is preserved.

From the calculated Sharpe ratios, the collar strategy obviously is superior. For every sub-period, the collar strategy outperforms. The protective put strategy and the unhedged strategy yield roughly equal Sharpe ratios. For the whole period, the Sharpe ratio of the protective put strategy is 0.61, which is a bit higher than for the unhedged strategy, where the Sharpe ratio is 0.55.

Interestingly, in the sub-period 1998-2005 the unhedged strategy yielded as much as 0.68% on average per month. This shows the benefit of being unhedged in a relatively good sub-period. When it comes to Sharpe ratio, it was however surpassed by the collar strategy and equally good as the protective put.

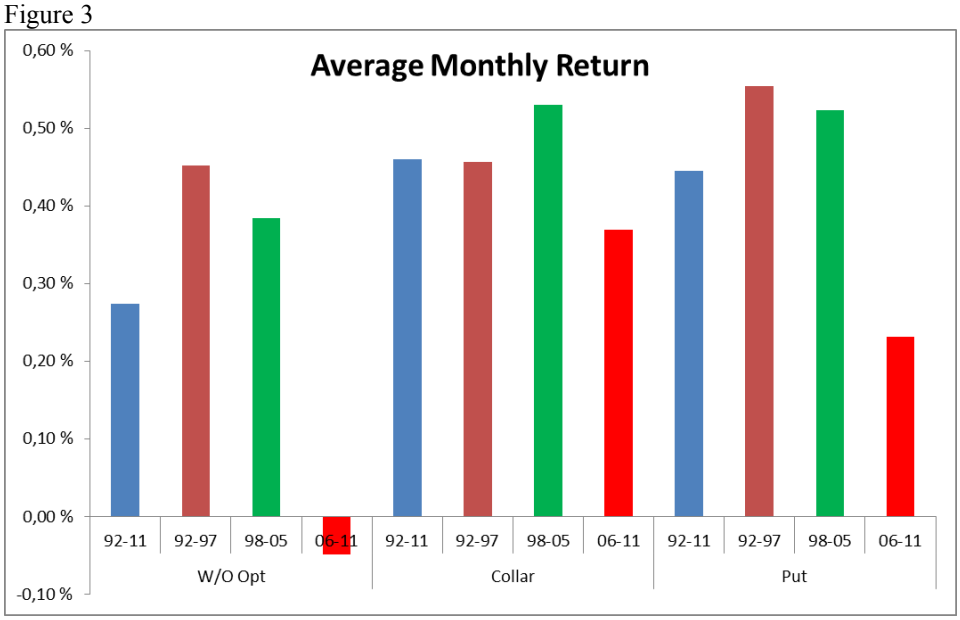
6.2.2 The Norwegian perspective

For the Norwegian perspective, we have considered two separate cases: i) Carry trade where funds are borrowed in the single lowest-yielding currency and invested in NOK, and ii) Carry trade where funds are borrowed in a basket of the three lowest-yielding currency and invested in NOK. As addressed, this is due to the extensive borrowing in only one currency utilized by Norwegian investors. We will also further exam any potential diversification benefits of borrowing funds in a basket of currencies contrary to only one currency.

6.2.2.1 Carry trade where funds are borrowed in the lowest-yielding currency

Figure 3 shows average monthly return throughout the 20-year period.

Figure 3

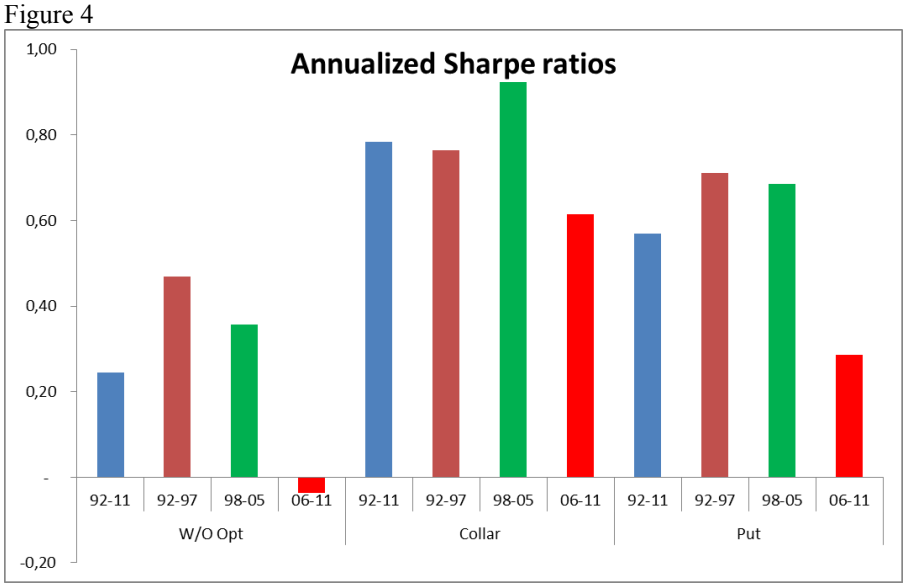


This figure provides a visual representation on how each of the three strategies performs in the Norwegian perspective, where funds are borrowed in the single lowest-yielding currency. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively.

The average monthly return for the whole period for the strategy without options is 0.27%, while 0.46% for the Collar strategy, and 0.44% for the protective put strategy. For the first of our sub-periods, 1992-1997, the three strategies yielded 0.45%, 0.46% and 0.55% average monthly return respectively. In the second sub-period, 1998-2005, the strategies yielded 0.38%, 0.53% and 0.52% average monthly return respectively. In the third and final sub-period, 2006-2011, the strategies yielded -0.05%, 0.37% and 0.23% average monthly return respectively.

Figure 4 shows the calculated annualized Sharpe Ratios.

Figure 4



This figure provides a visual representation for the annual Sharpe ratios for the three carry trade strategies in the Norwegian perspective where funds are borrowed in the single lowest-yielding currency. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively.

For the whole period, the annualized Sharpe ratios are 0.24 for the strategy without options, 0.78 for the Collar strategy, and 0.57 for the protective put strategy. For the first of our sub-periods, 1992-1997, the annualized Sharpe ratios were 0.47, 0.76 and 0.71 respectively for the three strategies. In the second sub-period, 1998-2005, the annualized Sharpe ratios were 0.36, 0.92 and 0.69 respectively for the three strategies. In the third and final sub-period, 2006-2011, the annualized Sharpe ratios were -0.04, 0.61 and 0.29 respectively for the three strategies.

Table 6 below presents some calculated descriptive statistics for our observed results.

Table 6

	Whole Period			92-97			98-05			06-11		
	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put
Mean	0,27 %	0,46 %	0,44 %	0,45 %	0,46 %	0,55 %	0,38 %	0,53 %	0,52 %	-0,05 %	0,37 %	0,23 %
Std	3,90 %	2,03 %	2,70 %	3,34 %	2,07 %	2,70 %	3,73 %	1,99 %	2,64 %	4,62 %	2,08 %	2,81 %
Sharpe*	0,24	0,78	0,57	0,47	0,76	0,71	0,36	0,92	0,69	-0,04	0,61	0,29
T	1,09	3,50	2,55	1,15	1,87	1,74	1,01	2,61	1,94	-0,09	1,51	0,70
P-value	13,82 %	0,03 %	0,57 %	12,75 %	3,27 %	4,30 %	15,74 %	0,52 %	2,78 %	53,57 %	6,84 %	24,34 %

*Annualized

The table presents numerical calculations of our sample currency carry trade strategies. Results are presented for the whole period 1992-2011, as well as for the three sub-periods 1992-1997, 1998-2005 and 2006-2011. Mean monthly return, standard deviation of the returns, annualized Sharpe ratios t-statistics and p-values are computed for each of the three strategies.

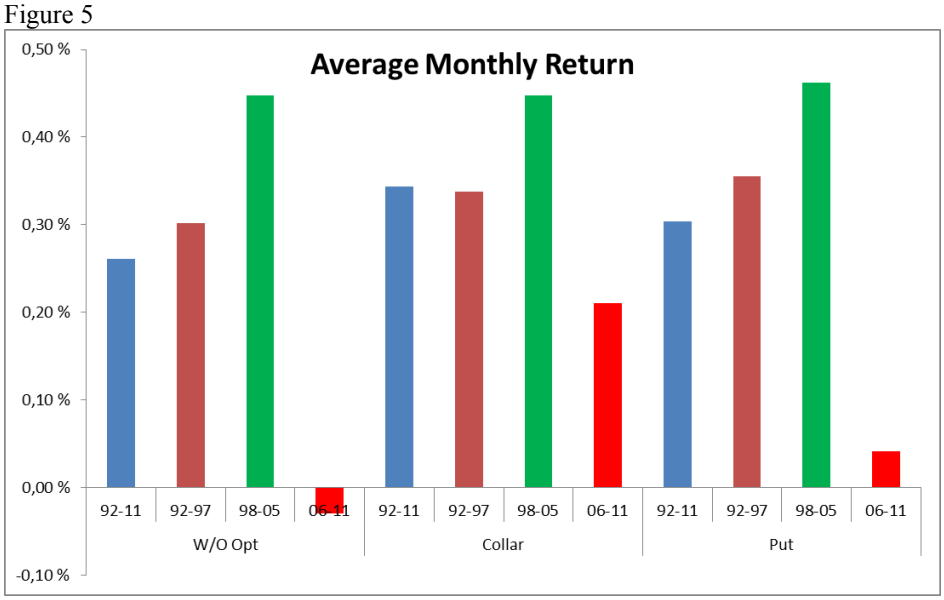
As we observe from our results, the collar strategy is superior to the protective put and unhedged strategy and produces significant average monthly returns for the whole periods and for the first two sub-periods. The protective put strategy also performs rather well as the only insignificant period is 2006-2011 where the p-value is 24.34%. The unhedged strategy is insignificant for the whole period as well as for each sub-period. Without the use of options we would not have any significant proof of violation of the UIRP, even at a 10 % significance level in the Norwegian case. The absence of proof of violation of the UIRP in the unhedged strategy may be because of the narrower interest rate gap when the investment country is fixed to Norway. In addition, funding in just one currency increases the risk, so we may need higher average monthly returns to prove deviations from UIRP. The last speculation we will test in the next analysis when we use a basket of currencies to fund from. The use of options reduces the risk and hence the volatility in returns and are one of the reasons we can prove that UIRP does not hold with options in this analysis. The estimated average return when executing a collar hedge yielded 0.19%-points more than the unhedged strategy, which goes against most risk management theories.

From a risk-return interpretation, our calculated numbers support the statement that the Collar strategy is superior to the two other strategies when it comes to returns, standard deviation and Sharpe ratio. Again the last sub-period especially shows the superiority of the collar strategy in time of crisis, as mentioned in section 6.2.

6.2.2.2 Carry trade where funds are borrowed in a basket of currencies

Figure 5 shows average monthly return throughout the 20-year period.

Figure 5

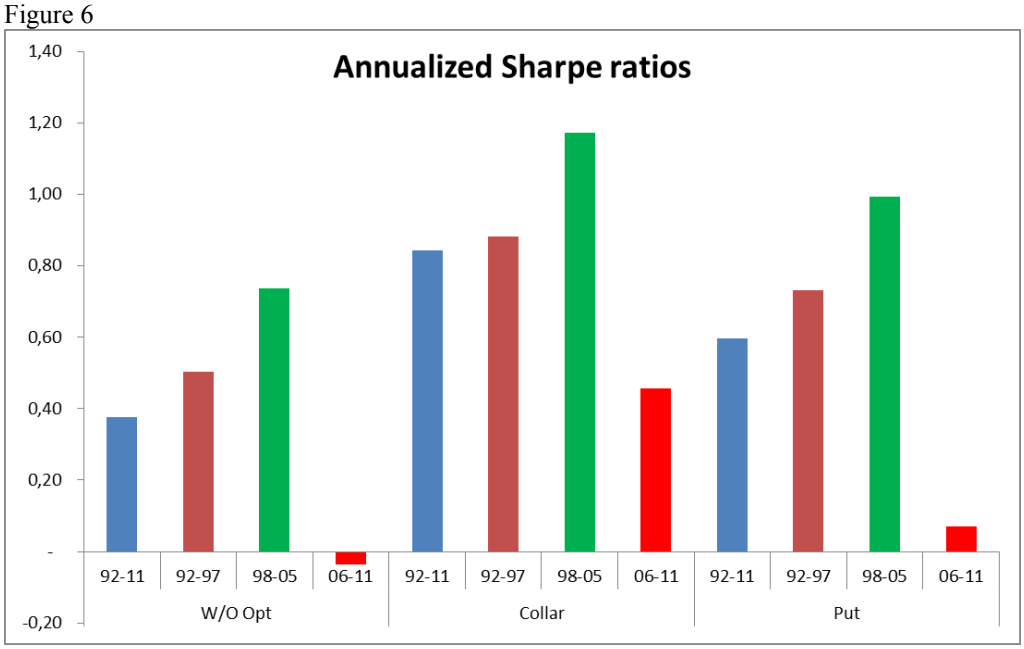


This figure provides a visual representation on how each of the three strategies performs in the Norwegian perspective, where funds are borrowed in a basket of the three lowest-yielding currencies. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively.

The average monthly return for the whole period for the unhedged strategy is 0.26%, while 0.34% for the Collar strategy, and 0.30% for the protective put strategy. For the first of our sub-periods, 1992-1997, the three strategies yielded 0.30%, 0.34% and 0.36% average monthly return respectively. In the second sub-period, 1998-2005, the strategies yielded 0.45%, 0.45% and 0.46% average monthly return respectively. In the third and final sub-period, 2006-2011, the strategies yielded -0.03%, 0.21% and 0.04% average monthly return respectively.

Figure 6 shows the calculated annualized Sharpe Ratios.

Figure 6



This figure displays a visual representation for the annual Sharpe ratios for the three carry trade strategies in the Norwegian perspective where funds are borrowed in a basket of the three lowest-yielding currencies. First section is the unhedged strategy, where results are shown for the whole period 1992-2011, as well as for three sub-periods: 1992-1997, 1998-2005 and 2006-2011. The same representation also applies for the collar and put strategies respectively

For the whole period, the annualized Sharpe ratios are 0.38 for the unhedged strategy, 0.84 for the Collar strategy, and 0.60 for the protective put strategy. For the first of our sub-periods, 1992-1997, the annualized Sharpe ratios were 0.50, 0.88 and 0.73 respectively for the three strategies. In the second sub-period, 1998-2005, the annualized Sharpe ratios were 0.74, 1.17 and 0.99 respectively for the three strategies. In the third and final sub-period, 2006-2011, the annualized Sharpe ratios were -0.03, 0.46 and 0.07 respectively for the three strategies.

Table 7 below shows some calculated descriptive statistics along with t-statistics and p-values for our observed results.

Table 7

	Whole Period			92-97			98-05			06-11		
	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put	W/O Opt	Collar	Put
Mean	0,26 %	0,34 %	0,30 %	0,30 %	0,34 %	0,36 %	0,45 %	0,45 %	0,46 %	-0,03 %	0,21 %	0,04 %
Std	2,39 %	1,41 %	1,76 %	2,07 %	1,33 %	1,68 %	2,10 %	1,32 %	1,61 %	2,99 %	1,60 %	2,01 %
Sharpe*	0,38	0,84	0,60	0,50	0,88	0,73	0,74	1,17	0,99	-0,03	0,46	0,07
T	1,69	3,78	2,67	1,23	2,16	1,79	2,09	3,31	2,81	-0,09	1,12	0,17
P-value	4,65 %	0,01 %	0,40 %	11,06 %	1,70 %	3,87 %	1,98 %	0,07 %	0,30 %	53,39 %	13,36 %	43,14 %

*Annualized

The table presents numerical calculations of our sample currency carry trade strategies. Results are presented for the whole period 1992-2011, as well as for the three sub-periods 1992-1997, 1998-2005 and 2006-2011. Mean monthly return, standard deviation of the returns, annualized Sharpe ratios t-statistics and p-values are computed for each of the three strategies.

All three strategies are significant different from zero and we can claim violation of UIRP. It is however worth noticing that the unhedged strategy is barely significant at a 5% level, but the diversification benefits of funding from a basket versus just one currency is nevertheless obvious. The collar strategy is also superior here, when it comes to return, standard deviation and Sharpe ratio. The collar strategy yields significant results for the whole period, as well as for the two first sub-periods, and the Sharpe ratios for each period dominates the Sharpe ratio for the two other strategies. Again, in the sub-period 2006-2011 all strategies are insignificant. Still, the last sub period show the superiority of the collar strategy in time of crisis as mentioned in section 6.2.

6.2.2.3 Borrowing funds in one currency versus three currencies

From our sample results, the results indicate that there exist diversification benefits of borrowing funds in three currencies rather than only one currency. For the whole period, the Sharpe ratios of borrowing funds in three currencies are superior for all three strategies and funding from a basket of currencies enables us to prove that UIRP does not hold in the unhedged strategy. For the sub-periods 1992-1997 and 1998-2005, borrowing funds in three currencies yield clearly better results for all strategies. However, in the final sub-period 2006-2011, borrowing funds in one currency seems to outperform the strategy of borrowing funds in a basket of three currencies.

Figure 7 a, b and c show cumulative returns for the two borrowing policies given each carry trade strategy:

Figure 7a.

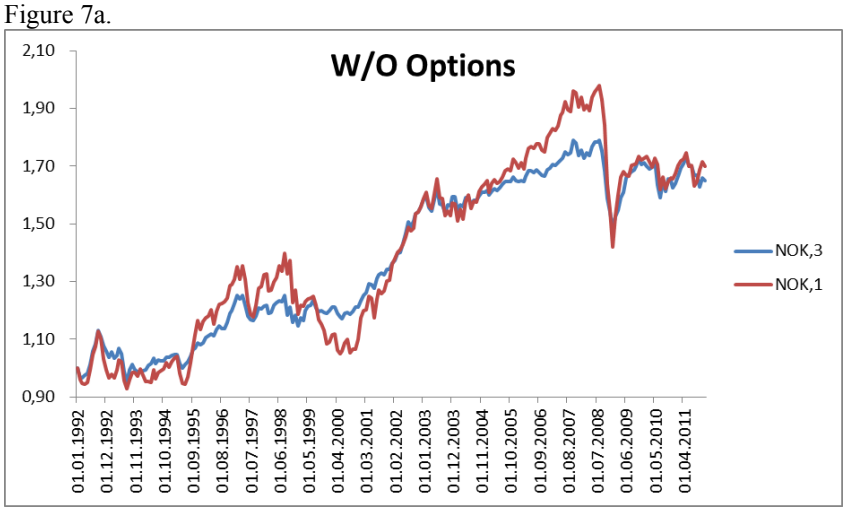


Figure 7b.

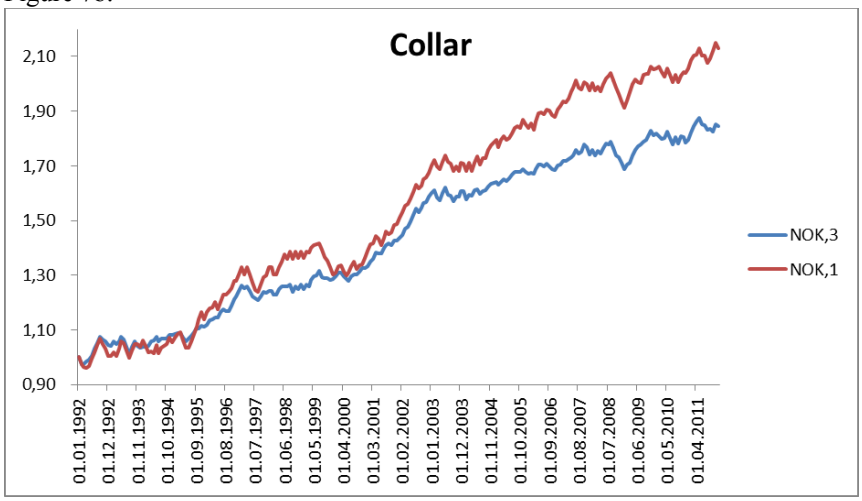
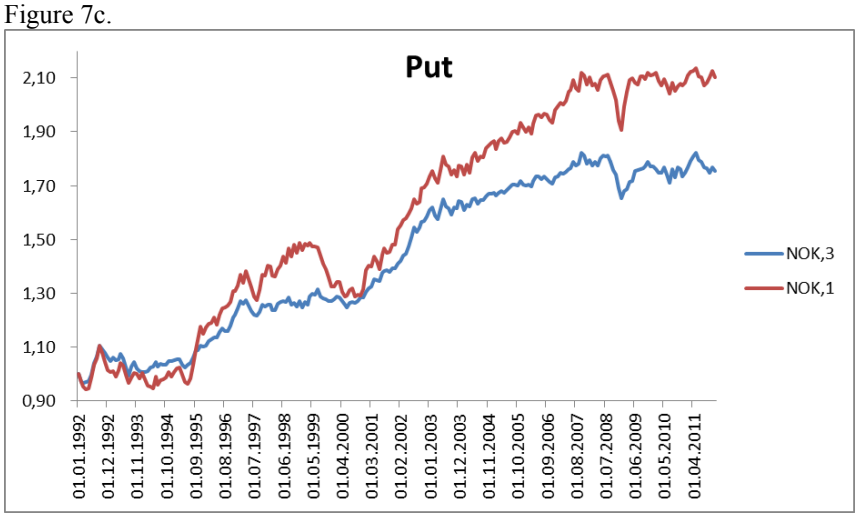


Figure 7c.



The three figures above display cumulative returns throughout the 240 months for each of the defined borrowing policies in the Norwegian perspective. NOK,1 indicates the policy of borrowing funds in the single lowest-yielding currency, while NOK,3 indicates the policy of borrowing funds in a basket of the three lowest-yielding currencies.

These graphs show that over time, borrowing funds in only one currency yields higher cumulative returns than borrowing in three currencies. However, there seem to be more volatility in the NOK,1 policy, which is also supported by previously calculated standard deviations and Sharpe ratios. Especially around 2008, during the great recession, the volatility seems to be vast. This is an indication of diversification benefits in using a basket of currencies for funding in carry trades.

The global case is always able to exploit a greater interest rate differential than the Norwegian case and our results show that the Sharpe ratios produced are higher than in any of the Norwegian cases. This indicates the limitations that restrictions of investment country places on a carry trade strategy.

6.3 Option performance as risk management

In this section we will evaluate the performance of the options strategy versus the no-hedging strategy merely as a tool to reduce volatility and variation. Mitigating risk will always be an important aspect of a strategy; either the investor is speculating or holding a mortgage. By analyzing standard deviations, range and quartile range, we can elucidate the effects of implementing options as risk management.

6.3.1 The Global perspective

Table 8 indicates how the three strategies i) Unhedged, ii) Collar hedge, and iii) Protective put hedge perform in a risk management setting for the global perspective.

Table 8

	W/O Opt	Collar	Put
Std.	2,58 %	1,39 %	1,89 %
Max Return	8,15 %	2,96 %	6,38 %
Min Return	-11,86 %	-2,80 %	-6,02 %
Upper Quartile	1,98 %	1,53 %	1,62 %
Lower Quartile	-0,76 %	-0,53 %	-1,00 %

This table presents numerical calculations performed on the return series generated from our three defined carry trade strategies for the global perspective. Three different types of volatility measures are utilized: i) Standard deviation, ii) max and min return, whereas the difference between the two is known as the "range", and iii) Upper and lower quartile, whereas the difference between the two is known as the "quartile range".

The table shows that the collar strategy performs best in every aspect. The collar strategy produces the lowest standard deviation, and has a considerably narrower range and quartile range than the two other strategies. For the unhedged strategy, the volatility seems to be significantly greater than for the option-hedging strategies. The quartile range for the unhedged and protective put strategies are virtually the same, but the range and standard deviation are substantially greater when unhedged.

6.3.2 The Norwegian perspective

This section will analyze the performance of options as tools for volatility-reduction in the Norwegian case.

6.3.2.1 Carry trade where funds are borrowed in the lowest-yielding currency

Table 9 indicate how the three strategies i) Unhedged, ii) Collar hedge, and iii) Protective put hedge perform in a risk management setting for the Norwegian perspective, where funds are borrowed in the single lowest-yielding currency.

Table 9

	W/O Opt	Collar	Put
Std.	3,90 %	2,03 %	2,70 %
Max Return	10,80 %	2,98 %	8,83 %
Min Return	-20,54 %	-2,88 %	-7,55 %
Upper Quartile	2,68 %	2,48 %	2,25 %
Lower Quartile	-1,53 %	-1,43 %	-1,87 %

This table presents numerical calculations performed on the return series generated from our three defined carry trade strategies for the Norwegian perspective, where funds are borrowed in the single lowest-yielding currency. Three different types of volatility measures are utilized: i) Standard deviation, ii) max and min return, whereas the difference between the two is known as the "range", and iii) Upper and lower quartile, whereas the difference between the two is known as the "quartile range".

Also here, the calculations imply that the collar strategy is superior when it comes to minimizing volatility and ranges. Furthermore, the table indicates that the protective put and unhedged strategies perform roughly equal when considering the quartile range. However, the standard deviation and range are rather lower for the protective put strategy.

6.3.2.2 Carry trade where funds are borrowed in a basket of currencies

Table 10 indicate how the three strategies i) Unhedged, ii) Collar hedge, and iii) Protective put hedge perform in a risk management setting for the Norwegian perspective, where funds are borrowed in a basket of the three lowest-yielding currencies.

Table 10

	W/O Opt	Collar	Put
Std.	2,39 %	1,41 %	1,76 %
Max Return	5,60 %	2,92 %	4,98 %
Min Return	-9,46 %	-2,87 %	-4,98 %
Upper Quartile	1,89 %	1,48 %	1,57 %
Lower Quartile	-0,80 %	-0,61 %	-0,91 %

This table presents numerical calculations performed on the return series generated from our three defined carry trade strategies for the Norwegian perspective, where funds are borrowed in a basket of the three lowest-yielding currencies. Three different types of volatility measures are utilized: i) Standard deviation, ii) max and min return, whereas the difference between the two is known as the "range", and iii) Upper and lower quartile, whereas the difference between the two is known as the "quartile range".

These results also correspond to earlier results, namely that the collar strategy is superior as a risk-minimizing tool. The standard deviation and ranges are significantly lower than the two other strategies. The quartile range for the protective put and unhedged strategies are similarly as earlier roughly equal, but considering standard deviation and range, the protective put strategy performs

better. In addition, as our previously presented results have indicated, borrowing funds in a basket of the three lowest-yielding currencies seem to be associated with less volatility than borrowing in the single lowest-yielding currency.

6.4 Annual returns

Table 11 presents the annual results of the three carry trade strategies throughout the 20-year period of 1992-2011.

Table 11

	Annual Returns NOK,1			Annual Returns NOK,3			Annual Returns Global		
	Unhedged	Collar	Put	Unhedged	Collar	Put	Unhedged	Collar	Put
1992	-3,29 %	0,53 %	0,53 %	3,64 %	1,73 %	2,23 %	0,94 %	5,44 %	5,22 %
1993	2,96 %	5,65 %	-0,32 %	-4,73 %	-0,64 %	-5,23 %	-3,87 %	0,99 %	-2,92 %
1994	2,49 %	1,01 %	0,60 %	5,49 %	4,95 %	5,67 %	6,20 %	5,71 %	2,93 %
1995	14,11 %	9,24 %	16,61 %	4,36 %	3,57 %	5,24 %	1,69 %	0,92 %	0,65 %
1996	14,66 %	13,71 %	15,45 %	13,55 %	13,13 %	13,75 %	21,75 %	14,92 %	18,49 %
1997	1,61 %	2,69 %	7,03 %	-0,60 %	0,38 %	1,13 %	0,97 %	0,99 %	-0,24 %
1998	-13,83 %	3,39 %	5,97 %	-7,03 %	0,30 %	-2,60 %	-6,58 %	-0,75 %	-4,73 %
1999	-9,56 %	-5,28 %	-13,52 %	5,20 %	5,20 %	3,40 %	7,09 %	7,72 %	3,93 %
2000	8,37 %	7,92 %	6,06 %	5,56 %	4,64 %	3,07 %	5,44 %	3,62 %	5,18 %
2001	18,60 %	12,28 %	15,39 %	12,79 %	11,64 %	11,59 %	10,57 %	9,19 %	7,06 %
2002	22,59 %	18,83 %	19,54 %	22,10 %	18,34 %	20,92 %	14,95 %	11,10 %	13,60 %
2003	-1,67 %	0,98 %	3,83 %	0,87 %	0,69 %	2,54 %	15,55 %	9,68 %	13,83 %
2004	7,92 %	8,62 %	9,49 %	2,19 %	3,20 %	3,00 %	6,77 %	6,05 %	6,41 %
2005	4,50 %	4,16 %	3,43 %	3,26 %	3,22 %	2,83 %	11,67 %	8,60 %	10,76 %
2006	11,87 %	8,26 %	9,23 %	2,63 %	1,87 %	1,77 %	2,22 %	2,13 %	2,68 %
2007	12,43 %	8,15 %	11,06 %	6,37 %	5,42 %	6,14 %	4,20 %	3,91 %	2,72 %
2008	-51,74 %	-9,07 %	-19,72 %	-27,17 %	-8,84 %	-15,32 %	-27,06 %	-7,26 %	-19,21 %
2009	30,79 %	14,69 %	20,61 %	22,65 %	13,20 %	12,13 %	23,41 %	15,99 %	14,77 %
2010	-5,46 %	0,01 %	-3,15 %	-7,10 %	-2,39 %	-2,75 %	1,00 %	2,91 %	2,99 %
2011	-1,42 %	4,57 %	-1,35 %	-1,47 %	2,71 %	-1,64 %	0,80 %	3,49 %	-1,50 %
Mean	3,30 %	5,52 %	5,34 %	3,13 %	4,12 %	3,39 %	4,89 %	5,27 %	4,13 %

The table displays annual returns of the three strategies from 1992-2011. The table is divided into three sections: i) The NOK,1 case, where funds are borrowed in the single lowest-yielding currency, ii) The NOK,3 case where funds are borrowed in an equally-weighted basket of the lowest-yielding currencies, and iii) The general global case.

As the results have indicated earlier, the collar is superior to the other strategies. The effects of the collar strategy are particularly remarkable during the financial crisis of 2008. Unquestionably, an implemented collar strategy would spare an investor of excruciating losses. The most extreme case is in 2008 of the NOK,1 case, where a collar strategy would reduce the loss with 42,67 %-points. Considering other periods of great losses, it is obvious that the collar strategy is very efficient. It is also worth mentioning that the collar strategy does not perform as well as an unhedged strategy in good periods. However, the loss of profit is more than outweighed by the extreme negative returns of the recurring crisis of 1992-2011.

6.4 Carry trade analysis in times of special events

As addressed earlier, carry trading may be extremely volatile and risky in times of crisis, due to the sudden unwinding of carry trade positions. Bø and Klokkerhaug (2010) put a lot of weight in analyzing carry trade in times of special events. Three separate cases were examined: i) the convergence from ERM to EMU, 1992, ii) the Russian crisis, 1998 and iii) the financial turmoil of 2008. The conclusions drawn from their results were, as confirmed by earlier research, that carry trade offers poor return in times of financial turmoil. Credit crunches, as one explicitly experienced in the financial crisis of 2008, led to severe losses for a carry trade strategy. As Bø and Klokkerhaug (2010, 34) describe it: "shortage of liquidity creates heavy appreciation in low-yielding currencies because the speculators need to unwind their funding positions". We want to extend the analysis by including the recent European debt crisis.

6.4.1 The European debt crisis

To examine how the European sovereign-debt crisis has affected carry trade returns, we will consider 2010 and 2011. Table 12 shows the results with average monthly return for these two years, as well as calculated standard deviation and Sharpe ratios. The cases where carry trades are risk managed with options will not be considered, as this is merely an extension of Bø and Klokkerhaug's analysis (2010).

Table 12

	Simple Carry Trade		
	Avg. Return	Std	Sharpe*
2010	0,08 %	3,85 %	0,0747
2011	0,07 %	2,45 %	0,0948

*Annualized

The table presents calculated average monthly returns, standard deviations and annualized Sharpe ratios for a simple carry trade strategy carried through 2010 and 2011.

As we can see, carry trade offered fairly low average monthly returns both in 2010 and 2011 compared to the monthly average throughout the whole period, which was 0.41% as calculated earlier. The standard deviation for the whole period was 2.58%. Year 2010 was therefore more volatile than average, while 2011 was slightly less volatile. The results imply Sharpe ratios that are considerably lower than the average for the whole period, which is 0.55.

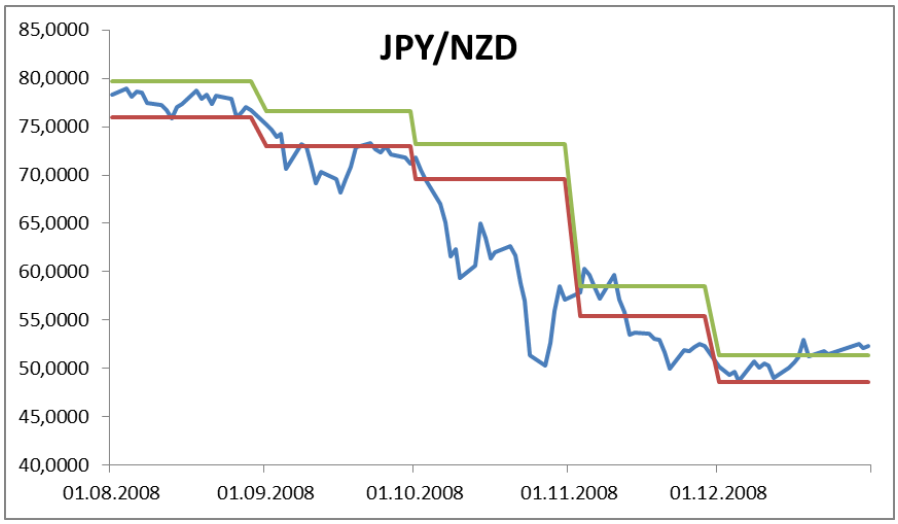
Our sample does not yield negative average monthly returns in 2010 and 2011. However, the returns are significantly lower returns than average, which then again provide relatively low Sharpe ratios. This underpins previous research that during times of crisis, sudden unwinding of carry trade positions takes place leaving carry trade strategies with low returns.

6.4.2 Zero-premium collar performance in time of special events

In crisis, earlier research argue that unwinding of carry trades take place leaving carry trade investors to poor and even negative returns. We therefore examined how the collar strategy performed in times of crisis with huge volatility where the funding currencies typically appreciate and target currencies typically depreciate. Only the collar strategy is implemented here, as earlier results unquestionably deem its superiority.

Figure 8 shows the development of the JPY/NZD from August 2008 until the end of December 2008, which is well known for being a turbulent period in financial history. As usual, JPY/NZD is quoted as the number of units funding currency per one unit target currency.

Figure 8



The graph shows how the JPY/NZD exchange rate fluctuates compared to the locked in bounds created by the executed zero-premium collar.

As earlier research states; in times of crisis, funding currencies, which in this case is JPY, depreciate severely compared to target currencies, which here is NZD. The exchange rate JPY/NZD therefore experiences a severe price drop. The two bands in the figure indicate the floor and cap created monthly by the zero-premium

collar spread. Unquestionably, the collar strategy protects a carry trade investor for excruciating losses of which he would experience if unhedged.

6.4.3 The Global perspective

Table 13 give numerical results of how the collar strategy protects a carry trade investor for the three crises defined by Bø and Klokkerhaug (2010), and extended with the latest Euro debt crisis for the global perspective.

Table 13

Panel A

	Unhedged	Collar
sept-92	-5,00 %	-0,53 %
oct-92	-1,85 %	0,00 %
nov-92	-3,12 %	-1,32 %
dec-92	-1,69 %	-0,53 %
jan-93	1,14 %	0,83 %
feb-93	-3,70 %	-0,88 %

Panel B

	Unhedged	Collar
jul-98	-0,61 %	-0,62 %
aug-98	-2,31 %	-1,21 %
sept-98	-0,52 %	-0,35 %
oct-98	-6,48 %	-1,53 %
nov-98	2,93 %	2,06 %
dec-98	-2,77 %	-1,46 %

Panel C

	Unhedged	Collar
aug-08	-4,34 %	-2,59 %
sept-08	-5,10 %	-2,60 %
oct-08	-11,86 %	-0,92 %
nov-08	-5,11 %	-1,05 %
dec-08	-0,93 %	-0,54 %
jan-09	-3,64 %	0,03 %

Panel D

	Unhedged	Collar
jul-11	-0,51 %	0,09 %
aug-11	-1,47 %	-1,36 %
sept-11	-5,28 %	-0,96 %
oct-11	4,56 %	2,84 %
nov-11	-0,74 %	-0,74 %
dec-11	-0,43 %	-0,26 %

Panel A show how the unhedged and collar-hedged carry trade strategies perform during the turbulent times of September 1992 until February 1993 for the global perspective. The same applies for panel B, C and D, only for the other three defined volatile financial periods.

Undoubtedly, the collar strategy would be invaluable for a carry trade investor in such tempestuous times. The downside is significantly cut, which in times of financial turmoil must be said to be essential considering the crucially volatile times the currency markets have experienced.

6.4.4 The Norwegian perspective

Table 14 give numerical results of how the collar strategy protects a carry trade investor in the same four crises as above, where the policy of borrowing funds in an equally weighted basket of the three lowest-yielding currencies, and investing in Norway is used.

Table 14

Panel A

	Unhedged	Collar
sept-92	-2,13 %	-1,08 %
oct-92	-2,97 %	-0,47 %
nov-92	-1,88 %	-1,49 %
dec-92	-2,32 %	-0,12 %
jan-93	1,98 %	1,54 %
feb-93	-2,23 %	-0,88 %

Panel B

	Unhedged	Collar
jul-98	1,98 %	0,87 %
aug-98	-6,59 %	-2,75 %
sept-98	2,60 %	1,80 %
oct-98	-5,05 %	-0,90 %
nov-98	2,51 %	1,82 %
dec-98	-3,84 %	-1,82 %

Panel C

	Unhedged	Collar
aug-08	-3,87 %	-2,07 %
sept-08	-6,83 %	-2,68 %
oct-08	-9,46 %	-0,89 %
nov-08	-4,71 %	-1,79 %
dec-08	-5,75 %	-2,35 %
jan-09	4,22 %	1,59 %

Panel D

	Unhedged	Collar
jul-11	-3,32 %	-1,57 %
aug-11	0,23 %	0,23 %
sept-11	-4,10 %	-0,91 %
oct-11	3,06 %	2,54 %
nov-11	-0,76 %	-0,76 %
dec-11	-2,59 %	-1,97 %

Panel A show how the unhedged and collar-hedged carry trade strategies perform during the turbulent times of September 1992 until February 1993 for the Norwegian perspective. The same applies for panel B, C and D, only for the other three defined volatile financial periods.

Also here, there is no doubt that the collar strategy significantly reduces the downside in all four cases of extreme financial environments. The importance of hedging a simple carry trade strategy becomes obvious when evaluating the critical negative returns experiences in times of special events. A collar strategy clearly stands out as a good risk management tool.

Obviously, the policy of borrowing in the single lowest-yielding currency and investing the proceeds in Norway is implemented in the analysis above, hence will not be considered separately.

6.5 Exercising options in a collar spread

A question that arises when implementing a zero-premium collar as we have done throughout this paper is how often the options are exercised. Since the 3 % level of the floor is chosen arbitrarily, it will be important to evaluate how effective and robust the long puts and short calls are.

With an equally-weighted basket of three currencies during a 20-year period with 240 months, there will be 720 potential option exercises - three each month. For our sample, a total of 286 exercises were observed, i.e. 39.72%. 173 exercises (60.49%) were with the short call, i.e. a so-called "cap exercise". 113 exercises (39.51%) were with the long put, i.e. a so-called "floor exercise".

For the Norwegian case, when borrowing funds in the single lowest-yielding currency, a maximum of 240 exercises may occur, of which 105 (43.75%) did. 60 (57.14%) were cap exercises, whereas 55 (42.86%) were floor exercises.

For the Norwegian case, when borrowing funds is in an equally-weighted basket of the three lowest-yielding currencies, a maximum of 720 potential exercises may occur, of which 207 (28.75%) did. 114 (55.07%) were cap exercises, whereas 93 (44.93%) were floor exercises.

As the results show, there are always more cap- than floor exercises. If returns are remotely normal distributed, which is assumed when using the option pricing formula, there should obviously be more cap- than floor exercises. This is based on mathematics of the Garman and Kohlhagen's (1983) formula. Since the interest rate of the funding currency always will be lower than the interest rate of the target currency, the cap will always be "closer" to the spot than the floor. A floor of 3% below spot, as in our paper, will imply, by mathematics that the cap will be less than 3% above spot.

6.6 Zero-premium collar with other floors

In our paper, all collar strategies have been applied with a floor 3% below spot. However, 3% is chosen somewhat arbitrary as a reasonable level of monthly fluctuations. An interesting addition to our analyses is therefore to examine the effects of using other levels of the floor in a zero-premium collar strategy. Otherwise, the analysis is similar as earlier, i.e. that the short call is chosen such that the net-premium is equal to zero. Table 15 displays the descriptive statistics.

Table 15

	Collar Floors		
	2 %	3 %	4 %
Avg. Return	0,33 %	0,44 %	0,51 %
Std. dev.	0,94 %	1,39 %	1,73 %
Sharpe*	1,19	1,09	1,01
N	240	240	240
T-stat.	5,34	4,89	4,53
P-value	0,00 %	0,00 %	0,00 %
Max return	1,90 %	2,96 %	4,04 %
Min Return	-1,78 %	-2,80 %	-3,71 %
Upper Quartile	1,09 %	1,53 %	1,79 %
Lower Quartile	-0,36 %	-0,53 %	-0,58 %

*Annualized

The table presents descriptive statistics of a zero-premium collar employed with three distinct levels of the floor; i) 2%, ii) 3% and iii) 4%. Calculated descriptive statistics from the sample are average monthly return, standard deviation, annualized Sharpe ratio, number of observations, t-statistic and p-value. Additionally max and min returns, whereas the difference between the two is known as the "range", and upper and lower quartile, whereas the difference between the two is known as the "quartile range"

The results indicate that the tighter the collar spread, the higher the Sharpe ratio. The average monthly returns increase as the collar spread increases, but so does also the standard deviation, leaving a maximized Sharpe ratio for the collar strategy where the floor is 2%. The results also indicate that the tighter the collar spread, the tighter the range and quartile range.

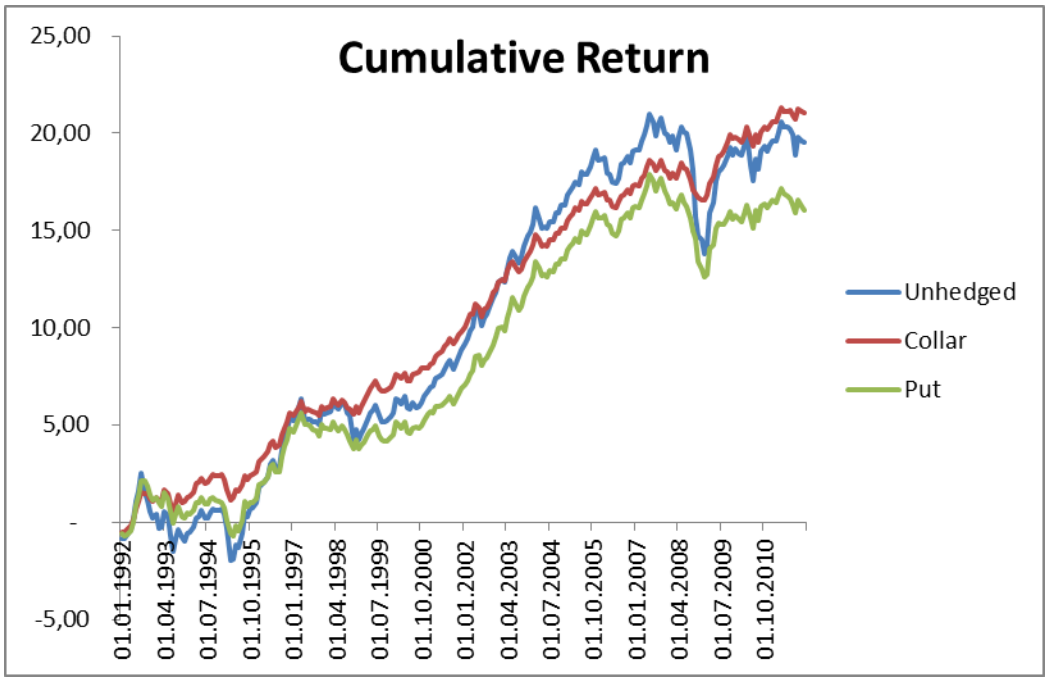
6.7 Reality check: retail carry trade investors

In this section we will present results aimed at a real-life approach for a retail investor or a regular household, on how carry trading can take place and work in practice. We will therefore consider a hypothetical hedge fund executing our defined carry trade strategies on behalf of retailers and households. We thus assume a margin account of which a retail investor places his money. Further on we will assume a 5% margin requirement and a 40% maintenance margin. In

other words, investing \$1 imply that the hedge fund can perform carry trades of a size of \$20, and a margin call occurs if there is less than \$0.40 left in the margin account. In such case, the funds must be transferred from the investor to the margin account such that the amount is back to the initial margin requirement, namely \$1. Margin calls and account rebalances will happen on a monthly basis. However, even though the total amount of funds in the margin account exceeds \$1, we assume that the hedge fund never will trade with a larger contract size than the initial margin, namely 1\$. Moreover we also assume that at the end of each year, the amount on the margin account shall sum up to \$1, i.e. that the investor either takes out superfluous funds, or provides extra funds if necessary. Otherwise, the hedge fund is free to utilize our three carry trade strategies: i) unhedged, ii) protective put hedge, or iii) zero-premium collar hedge.

The cases we consider are as earlier the carry trade strategies where funds are borrowed in an equally-weighted basket of the three lowest-yielding currencies, and invested in an equally-weighted basket of the three highest-yielding currencies. Figure 9 below shows the cumulative return for the margin account during January 1992 until December 2011 for the three strategies.

Figure 9



Cumulative returns for the three defined carry trade strategies: i) Unhedged, ii) Collar hedge and iii) protective put hedge. The graph shows how the value of \$1 develops through the 240 months of January 1992 until December 2011.

The figure indicates what our aforementioned results point out, namely that the collar strategy performs best, both when it comes to total cumulative return and volatility. One dollar invested in the hedge fund that executed the collar strategy, would have grown to $22.07 during the 240 months. This implies an average monthly return of 8.78%. The high return is of course due to the highly levered positions we are assuming in this case. This does also imply that the risk is amplified. The unhedged strategy got 14 margin calls, the protective put strategy got 11 margin calls while the collar strategy only got four margin calls during the 20-year period. For an unhedged investor, his total initial equity would have been completely wiped out five times. By employing a zero-premium collar strategy, an investor will never face the threat of losing more than 60 % of the invested equity in one month because of the option floor given the margin requirements. If the unhedged strategy has one or several calls in a month, we only register one because we use monthly returns in this analysis.

7. Summary and conclusions

In this paper, our base case has essentially been a test of the uncovered interest rate parity (UIRP), by performing monthly rebalanced carry trades over a 20-year period from 1992-2011. In the long run, our sample results show, as earlier research on this topic, that UIRP does not hold. Our carry trade strategy was able to generate average monthly returns that produce p-values less than 5 %, i.e. that they are significantly greater than zero. This would not be the case for a zero-investment portfolio if UIRP held.

Our carry trade analyses were further extended to embrace options for risk management. Unquestionably, inclusion of risk managing options reduces the standard deviation of returns. For the zero-premium collar, average return increased as well as standard deviation was reduced, yielding considerably higher Sharpe ratios than the other strategies. The collar strategy was by far superior, and offered significant average monthly returns for the whole period, as well as for the two first sub-periods. The protective put strategy achieved higher Sharpe ratio than the unhedged strategy for the whole period as one, but the two strategies performed roughly equal when considering the two last sub-periods 1998-2005 and 2006-2011. It becomes obvious in the last sub-period, how much the cost of the protective put affects average returns. Annual results also underpin the superiority of the collar strategy.

A great weight in our paper was put on a "Norwegian perspective", where borrowed funds exclusively were to be invested in Norway. With this we wanted to examine how a carry trade strategy of borrowing funds in low-yielding currencies and investing the proceeds in Norway would perform. This is due to the fact that many Norwegian house owners borrowed funds in currencies as CHF and JPY. Our study therefore included two Norwegian carry trade perspectives: i) funds borrowed in the single lowest-yielding currency and ii) funds borrowed in a basket of the three lowest-yielding currencies to see if Norwegian investors could obtain diversification benefits of borrowing funds in three currencies instead of one. The results indicated diversification benefits of funding the investment in a basket of currencies contrary to one currency.

Also for the Norwegian perspective, when options were added for risk management, the Sharpe ratios increase significantly. The collar strategy was, as for the global perspective, superior to the two other strategies, whereas the protective put performed better than the unhedged strategy.

Our results show that an inclusion of a zero-premium collar is substantially increasing Sharpe ratios on all levels. In almost all cases, average monthly return increases as well as standard deviation is reduced. Even though a zero-premium collar is a fairly simple option strategy without any premium up front, it is able to offer a great risk-adjusted return compared to an unhedged carry trade strategy. The annual returns particularly showed this in 2008 in all three cases.

Bø and Klokkerhaug (2010) examined carry trade returns in cases of special events. We extended their analysis by adding the latest European debt crisis. Our results underpin earlier research, namely that during the crisis, carry trade returns have been substantially lower, conceivably due to unwinding of carry trade positions. Furthermore, we extended the work by Bø and Klokkerhaug (2010) by evaluating the implementation of a collar for the three crises from their paper, as well as the latest Euro debt crisis. Our results showed that a collar strategy was extremely effective during time of crisis by effectively removing a significant fraction of the downside that typically happens when funding currencies appreciate.

The 3% floor in the zero-premium collar strategy was, as mentioned earlier, chosen somewhat arbitrarily. We therefore performed an analysis to examine the effects of utilizing other levels of the floor in the principally same strategy. As theory would indicate, return increased as the level of the floor increased to 4%, but so did also the standard deviation. A zero-premium collar strategy where the floor is 2% below spot appeared to maximize the Sharpe ratio. Considering other volatility measures, the 2% floor strategy also seemed superior when it comes to volatility measures.

We evaluated the effectiveness and robustness of the collar strategy by examining how frequently the different options were exercised. Of a potential 720 option exercises, 286 (39.72%) exercises actually took place in the global case. These

results imply that, on average, there was at least one exercise every month throughout the 20 year period in the global case. In other words, the collar spread was invaluable as a tool of risk management, which is also underpinned by the significant cut of losses during times of crises, if a collar was implemented. Similarly for the Norwegian case, the options of a collar strategy were exercised rather frequently implying a substantial reduction of possible extreme outcomes.

Finally we performed a reality check on how a regular retail investor or households can participate and earn the benefits of the different carry trade strategies. The investors can be everything from individuals wanting to invest their savings, saving for retirement, or hobby speculators. We wanted to review how entities can consequently use our defined carry trade strategies, and for "everyone" to be able to participate. As results mentioned above, the collar strategy is superior, both when it comes to return and volatility. A hedge fund managing one dollar invested in January 1992 would have been able to grow that dollar to $22.07 by the end of December 2011 with a gearing of 1:20, merely by using the collar strategy in the global case.

The idea of standardized currency loaning products managed by financial institutions may not be that farfetched. Today there exist stock market funds that invest in the stock market with the savings of the customers without knowledge about the stock market. The customers invest in different funds after different preferences and preset rules. Why not try to extend this to the currency market and give more people access to the currency market. If this is implemented right, this would even give the financial institutions higher earnings as compensation for managing the currency loans, shorter mortgage loan time for the customers and a more efficient currency market.

Throughout this paper, the collar strategy has clearly stood out as a necessary risk management tool. This applies both for increasing the Sharpe ratio, and as a utensil for mitigating risk, narrowing down the possible outcome ranges and protecting an investor in cases of extreme financial events.

8. Further Research

Our research outlines some areas of further research. As the main weight in our paper has been risk managing carry trade strategies with options, similar studies can be utilized. For our zero-premium collar, the floor of 3% has been selected arbitrarily as a base case for our analysis. Other floor levels were also tested, but this condition may be subject to further testing in order to increase Sharpe ratios. In other words, an iterative study could be executed in order to find the optimal level of a floor, i.e. the floor level that maximizes the Sharpe ratio. This also applies for the protective put – the floor need not necessarily be 3% below spot.

Further on, other option strategies like a straddle, strangle, butterfly spread, etc. should also be implemented in later studies. European basket options are the most popular rainbow options, and can also be employed as risk managing techniques. The essential difference between rainbow options and the plain vanilla options used in this paper is that the rainbow options take into account correlation between assets, i.e. currencies.

Finally implementing the collar on the strategy used by Burnside et al, could be an nice extension of the research.

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ID-number : **0878655**
0876277

BI Norwegian Business School

- Preliminary Master Thesis Report.

"The Creation of Standardized Currency Loaning Products."

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Examination code and name:
GRA 19002 Preliminary Thesis

Delivery date:
15.01.2012

Place of study:
BI Oslo

TABLE OF CONTENTS

1. Introduction

1.1. Background for this idea:

With the bankruptcy of Lehman Brothers September 15 2008, the financial crisis officially started. During the increasing uncertainty in the financial markets before the fall of Lehman Brothers, and the panic after, there were abnormal appreciations of the American dollar (USD) against Norwegian kroner (NOK).

- 16.04.2008 exchange rate was 4,9589 NOK/USD, the lowest the dollar has been since at least 1981.
- 22.05.2008 exchange rate was 4,9854 NOK/USD, from this day we see a steady climb in the USD vs. NOK.
- 15.09.2008 exchange rate was 5,78260 NOK/USD, Lehman Brothers filed for Chapter 11 bankruptcy protection.
- 14.10.2008 exchange rate was 6,1355 NOK/USD
- 23.10.2008 exchange rate was 7,1468 NOK/USD, note the rapid appreciation of USD with over 1 NOK per dollar over a period of 9 days.
- 15.01.2009 exchange rate was 7,2048 NOK/USD, highest exchange rate since 07.11.2003
- 09.03.2009 exchange rate was 7,1421 NOK/USD last time USD was above seven.

In just a 5 month period from 22.05.2008-23.10.2008 the USD appreciated with 2,1614 NOK per USD. In the period after and until 09.03.2009 the USD have varied some but mostly around 7.00 NOK/USD.

- From 18.03.2009 to 19.03.2009 there were a drop from 6,7091 to 6,3236 NOK/USD.
- At 07.09.2009 the exchange rate was for the first time since the financial crisis below 6,000 NOK/USD.
- 29.04.2011 it reached 5,2369 NOK/USD which is the lowest since the financial crisis of 2008. Since then it has appreciated due to the new crisis growing in Europe and is today, 12.01.2012 at 6,0278 NOK/USD. As this debt crisis proceeds, the USD could appreciate even more. At such high levels of NOK/USD, converting the mortgage into USD could be highly profitable if "normal" level of the exchange rate is expected to reoccur. After summer when this master thesis is due to deliver, we will see if this prediction has come true.

USD is considered as a "safe haven currency", but also Swiss franc (CHF) is considered as a safe haven currency that are resilient to crisis (Daniel Kothler , 2007). In this study, we will, amongst other things, show that CHF and JPY show the same pattern of appreciation in time of crises as the USD, but USD and Japanese yen (JPY) appreciated more in the financial crisis of 2008 than CHF and CHF appreciated more than USD and JPY in the current debt crisis, during summer of 2011.

The Guardian wrote about the Swiss central bank even went out and said they would not tolerate the further appreciation of the CHF and did an intervention august 3 2011 to lower the value of CHF. Such interventions are particularly interesting to evaluate as a factor of exchange rate movements.

In carry trade literature, this appreciation is explained as a sudden unwinding of carry trade positions. Unwinding of the positions will lead to an appreciation of the funding currency, and since carry trade are heavily levered, this appreciation will produce margin calls to the speculators. The fear of losing their profits or the ability not to produce the margin calls amount made investors close their currency positions. The most popular funding currencies after 2000 have been USD, CHF and JPY, but USD was also the targeted currency in 2005-2007. Following the carry trade literature, we will expect USD to depreciate over this time period. Compared to the period before and after, exchange rate data show this pattern, as expected, with a low on16 of April 2008.

Since for example USD is considered to be a "safe" currency, many investors might reallocate in USD during difficult times. Foreign currency will therefore depreciate relative to the USD. During the financial crisis of 2008, US government used cash injections to keep financial markets from collapsing. These so-called unsterilized governmental interventions would therefore lead to a depreciation of USD. However, due to the bad global economic state, investors were reallocating to USD, which instead lead to an appreciation. The USD had probably appreciated even more if the government had not done this.

During the financial crisis of 2008 it would have been very attractive for a Norwegian house-owner to convert his mortgage to USD. A mortgage in NOK of

for example $100,000 would have been at a point about 720,000 NOK and later as little as 524,000 NOK, a reduction of more than NOK 192,000. However, converting a mortgage from NOK to USD or any other currency is not easy in many cases. There is no doubt that the possibility of a mortgage-conversion could be beneficial to house-owners. Of course, there is a lot of currency risk to consider when converting a mortgage, the timing of the conversion is essential. Therefore, banks must use their competence in helping house-owners with the timing of conversion. A type of carry-trade with mortgages could therefore be a loaning product the banks could implement. This is the essence of what we want to research in this thesis. Can banks establish profitable carry-trade strategies using house-owners mortgages, which is mutual beneficial for a house-owner? A strategy the bank also would profit from.

The idea of standardized currency loaning products managed by financial institutions may not be that farfetched. Today there exist stock market funds that invest in the stock market with the savings of the customers without knowledge about the stock market. The customers invest in different funds after different preferences and preset rules. Why not try to extend this to the currency market and give more people access to the currency market. If this is implemented right, this would even give the financial institutions higher earnings as compensation for managing the currency loans, shorter mortgage loan time for the customers and a more efficient currency market.

We will create four strategies that can be viewed as new loaning products a financial institution can offer their customers.

- Strategy 1 will be simple carry trade with restriction on investment country.
- Strategy 2 will exploit sudden and high appreciation in currencies in case of special events.
- Strategy 3 will try to exploit interest differentials and mean reversion of exchange rates.
- Strategy 4 will be simple carry trade with no restriction to investment place, but risk managed with options.

1.2. Increased risk related to the new products:

These new mortgage products can be perceived as very risky speculation with the mortgage. While these products introduce more risk related to the mortgage than a normal mortgage in home currency, they also introduce possibility of lower mortgage time (instead of profit).

To reduce the risk to these new products we will standardize them and take away the risk related to individual behavior, this because we mean that a normal mortgage holders do not have the financial knowledge and means to know when to go in and out of the exchange market. If they have this knowledge and want the flexibility to go between currencies as they choose to, they can use normal currency loans that are in the market today. We will also use options to reduce the risk in one strategy.

The new products will be a combination between normal mortgage loan and currency loan, but without the flexibility to choose which currency to loan in and when to move in and out of these currencies. The financial institutions that offer this product will manage the currency movement by some predetermined factors.

Some of the factors we will examine are:

- Interest rate to the sample currencies and the interest differential between NOK and the foreign sample currencies.
- Economic state in each country and in the world (market as a whole).
- Target exchange rates of a country.
- Mean exchange rate between currencies and compare with the exchange rate today.
- Abnormal movements in time of crises (special events).

Most literature we found are using arbitrage strategies to get excess returns from carry trade in different forms and are more theoretically interesting than practical interesting for a normal mortgage customer, since this market are practically unavailable for most customers. These new products will hopefully make this market more available for house-owners with mortgages and this study is therefore a more practical approach and an implementation of the carry trade literature.

1.3.Contribution to the carry trade literature.

Contribute to the carry trade literature is by examining trading strategies using mortgage instead of the zero investment strategies that hedge funds and other currency investors use. The zero investment strategy is presumed to be superior to the mortgage approach, since using mortgage will put limits on investment placements, and therefor limitations on when carry trade will be profitable. Investment placement will be in NOK in strategy one, two and three, since the mortgage holders in this study are presumed to have mortgage on houses in Norway. Strategy four will explore risk reduction with options and no restriction to investment placement.

This study is a more practical approach of the carry trade literature and these strategies can be new implemented as loaning products in the financial market.
If such strategies as explored in this study should be implemented in financial markets, exchange rate carry-trades will have become more available to the public and especially mortgage-holders than before. This practical approach is therefore of huge importance for this thesis.

Standardizing currency loans and let the financial institutions manage them as they manage stock market funds, will open new profitable possibilities for an industry with heavy competition. Since financial institutions already have a foreign exchange department with foreign exchange traders to manage their currency inventory, costs of implementing and managing these new foreign exchange products will be minimal. This risk reduction because of greater control will make it possible to make currency loan more available to house owners with good security.

2. Literature review

2.1. Highlights of literature that is important to this thesis:

”Once-in-a-Generation” Yen Volatility in 1998: Fundamentals, Intervention and Order Flow” by Jun Cai, Yan-Leung Cheung, Raymond Lee and Michael Melvin (2001):

- Examined the impact of three factors on the yen-dollar volatility in 1998.
    1. Announcements related to macroeconomic fundamentals.
    2. Intervention by Bank of Japan, US treasury and Federal Reserve.
    3. Portfolio switches by large institutions. (Order flows)
- Introduced a model capturing the typical intraday volatility pattern over a 24-hour trading day
- By comparing the alternative sources of volatility, they found that order flow is most important.
- The conclusion was that order flow or hedge fund activity played an important role in the yen-dollar volatility in 1998 as determinant of exchange rates.

“Why has FX trading surged? Explaining the 2004 triennial survey” by Gabrielle Galati and Michael Melvin (2004):

Between 1998 and 2001, foreign exchange market activity declined markedly, arguably because of the introduction of the euro, the consolidation in the banking industry, the growth of electronic broking, mergers in the corporate sector, and the events of 1998, characterized by higher risk aversion and a global withdrawal of liquidity.

- The activity in the traditional foreign exchange market has increased in the period 2001- 2004.
- Turnover in the interbank market increased, but it share of the exchange market fell from 59 % in 2001 to 53 % in 2004.
- Three main funding currencies: USD, JPY and the CHF. The main recipients of the borrowed funds: British pound (GBP) and the Australian (AUD) and New Zealand dollars (NZD), as well as a number of emerging market currencies.
- Strong increase in turnover in the AUD and NZD: by 98% and 152%, consistent with new currency being used in carry trade.

- Underlined the importance of short-term factors in the foreign exchange market and their trading strategies, that may be overwhelming long-term structural factors.
- They concluded that hedge funds engaged in currency speculation in the form of carry trades.
- They found significant proof that an increase in assets under management in hedge funds will make an impact on the market, in general on prices and interest rates.

"Evidence of carry trade activity" by Gabrielle Galati, Alexandra Heath and Patrick McGuire (2007):

- Stated that the buildup in the targeted currencies will lead to strengthening of these and weakening of funding currencies. When unwinding of these positions will have the opposite effect. This goes against the uncovered interest parity theorem.
- Carry trade are an important driver of exchange rate developments.
- This insinuate that it is difficult to draw concrete conclusions based on the data in the study alone, taken together they do shed light on specific market segments where carry trade activity is likely to be evident.

"Carry trades and currency crashes" by Markus K. Brunnermeier, Stefan Nagel and Lasse H. Pedersen (2008):

- Price of protecting against a crash in a currency after a crash increase, despite the fact that a subsequent crash is less likely.
- Currency crashes are positively correlated with increases in implied stock market volatility VIX and the TED spread.
- The crash risk may discourage speculators from taking on large enough positions to enforce uncovered interest rate parity. Crash risk may thus help explain the empirically well documented violation of the uncovered interest rate parity.
- Reallocation of capital help resolve the uncovered interest rate parity violation. Thus the occasional currency crashes happens due to liquidity crises in the market.

- Currencies with similar interest rate co-move with each other and suggest that carry trades affects exchange rate movements.
- They established strong link between currency carry and currency crash risk. Simple carry trade strategies delivers negatively skewed returns. Currency crashes can be a result of the unwinding of these carry trades positions

"Speculative capital and currency carry trades" by Petri Jylhä, and Matti J. Suominen (2009):

- Simple carry trade strategy gave 5,63 % in annually return. Monthly return of 0,47 % and a standard deviation of 2,06 %.
- The results for the risk-adjusted carry trade strategy are similar, with somewhat lower mean return and standard deviation.
- The results show that hedge funds do engage in the type of currency speculation that their model predicts and that this engagement affect effects exchange and interest rates.
- Their model explains more than 16% of the overall hedge fund index returns and more than 33% of the fixed income arbitrage sub-index returns.
- Returns were decreasing in the sample period. Concluded that increased speculative capital creates lower carry trade returns.
- Hedge funds play a positive economic role, transferring money from a country with little domestic inflation risk to a country with higher inflation risk, leading to better international risk sharing and an increase in the utilities of all agents.
- Failure of the uncovered interest rate parity is due to compensation for risks.
- Their evidence suggests that the historically observed large returns to strategies exploiting the forward premium puzzle, such as carry trades, were due to segmented markets and the gradual integration of fixed income securities markets during the past few decades.

"Returns to Currency Carry Trades and Hedge Funds" by Bø and Klokkerhaug (2010):

- Improved the study by Jylhä and Suominen (2009)
    1. Added new currency in sub period two and three.
    2. Control for volatility.
    3. How the introduction of the Euro (EUR) had an effect on the outcome of the study.
- Uncovered interest rate parity does not hold in the long run.
- Simple carry trade strategy gave 6,48 % in annually return and corresponding standard deviation of 5,92 %.
- Returns were decreasing in the sample period. But could not conclude that increased speculative capital creates lower carry trade returns as a consistent statement.
- The majority of hedge funds engage in some way of currency speculation.

"The revenge of Purchasing Power Parity on Carry Trades during Crises" by Marie Brière and Bastien Drut (2009):

- Their findings where that when carry trade perform well the fundamental models does not and vice versa.
- In time of crisis carry trades underperform and works like a catalyst for carry trade unwinding.
- The stronger the carry trades' performance and the greater the divergence from fundamental value, the more violent the subsequent return to equilibrium. This leads to huge losses that ultimately wipe out much of the earlier gains.

"Carry Trades: Betting Against Safe Haven" by Daniel Kothler (2007):

- Found that carry trade positions are exposed to considerable correlation risk with global stock markets.
- Investors not aware of conditional correlation dynamics might face an unexpected diversification meltdown in times of crises when diversification is most desirable.
- The CHF seems to offer protection against diversification meltdown in turbulent times, and living up to its expectation as a safe haven currency.

"Order flow and exchange rate dynamics." Evans, Martin D. D. and Richard K. Lyons (2002):

- Introduce a new kind of model for exchange rate determination. Instead of relying exclusively on macroeconomic determinants, the model includes a determinant from the field of microstructure order flow. The order flow variable within the microstructure is both theoretically and empirically the driver of price. This is a radical departure from traditional approaches to exchange rate determination.
- The model is also strikingly successful in accounting for realized rates. It accounts for more than 60% of daily changes in the DM/USD rate, and more than 40% of daily changes in the JPY/USD rate.
- In log exchange rates the model produces R^2 statistics above 50%.
- $1 billion of net dollar purchases increases the DM price of a dollar by 0.54%.

"Carry Trades and Speculative Dynamics" by Guillaume Plantin and Hyun Song Shin. 2008.

- Their results suggest that markets that combine significant costs of carry and low resiliency (such as the foreign exchange market) have the preconditions for large and persistent deviations of price from fundamentals, followed by abrupt reversals.
- High interest rate will exhibit the classic price pattern of "going up by the stairs and coming down in the elevator".
- Describe carry trades as self-reinforcing arbitrage.

"*Option Pricing: A Simplified Approach." by* Cox, Ross and Rubinstein (1979) is a simplified approach to option pricing of the Black and Scholes formula (1973) and are used to calculate currency options. This formula will be used to calculate all options in this study.

2.2. Literature about carry trade strategies that give excess return:

The recent study "Returns to Currency Carry Trades and Hedge Funds" conducted by Bø and Klokkerhaug (2010) explored a simple carry trade strategy defined as borrowing from the country with the lowest interest rate and invest the proceeds in the country with the highest interest rate. They choose to use a basket to invest

in, meaning that they invested, equally weighted, in the three countries with highest interest rate funded by leverage, equally weighted, in the three lowest interest rate countries.

This study was built on an earlier paper by two finish researchers Jylhä and Suominen from 2009, but they explored what they called the "risk-adjusted carry trade". This strategy and simple carry trade have many similarities, but differ with that the investors invest in a leveraged hedge fund that borrows from countries with low Sharpe ratio, instead of low interest rate, and invest in countries with high Sharpe ratio, instead of high interest rate.

Both studies have the same sub-periods (1979-1992, 1993-1998 and 1999-2008) and concluded that uncovered interest parity does not hold in the long run and carry trade have been profitable in the sample period of 30 years. Even though the returns are decreasing in the sample period, the studies differ on the conclusion that increased speculative capital creates lower carry trades returns as a consistent statement.

The difference in conclusions is because Bø and Klokkerhaug (2010) included the Swedish krona (SEK) from April 1997 and AUD, NZD and NOK in the last sub-period, which created significantly higher returns for their study.

Bø and Klokkerhaug (2010) included the AUD and NZD since an earlier study by Galati and Melvin (2004) stated that these currencies have in the recent past been the most common targeted currencies. Galati and Melvin (2004) found that in the period 2001-2004 the increased turnover in these currencies had been 98% and 152%.

The article "Evidence of carry trade activity" by Galati, Heath and McGuire in 2007 examined the turnover and carry-to-risk ratio. They found that the correlation is adequately high enough to suggest that carry trade strategy is related to the turnover. In this study NOK had the highest correlation and were therefore added.

The SEK where included in April 1997 (they would have preferred 1992, but Datastream had only data from April 1997), since Bø and Klokkerhaug (2010) believed that it was used in carry trade before the introduction of the Euro.

Monthly return simple carry trade:

	1979-1992	1993-1998	1999-2008	1979-2008
Bø and Klokkerhaug	0,70 %	0,40%	0,39%	0,54%
Jylhä and Suominen	0,69%	0,38%	0,17%	0,47%

They got almost the same return in the 2 first sub-periods, compared to the study to Jylhä and Suominen. This can imply that Bø and Klokkerhaug (2010) study is an improvement of Jylhä and Suominen study, and that the low return in third sub-period is because new currencies that was not in the currency sample were targeted, which their study do not take into account.

2.3. Literature on hedge funds and their impact on the market:

There are many studies that conclude that hedge funds use carry trade when engaging in currency speculation and that this engagement has an impact on the market.

"Order flow and exchange rate dynamics." by Martin D. D. Evans and Richard K. Lyons (2002) and "Once-in-a-Generation` Yen Volatility in 1998: Fundamentals, Intervention and Order Flow" by Jun Cai, Yan-Leung Cheung, Raymond Lee and Michael Melvin (2001) both came at almost the same time and had a radical departure from traditional approaches. Instead of relying exclusively on macroeconomic determinants, these studies include a determinant from the field of microstructure- order flow. The conclusion was that order flow or hedge fund activity played an important role as determinant of exchange rates. Following these papers, there have been done a lot of new research on order flow as a determinant.

"Why has FX trading surged? Explaining the 2004 triennial survey" by Gabrielle Galati and Michael Melvin (2004) concluded that hedge funds engaged in currency speculation in the form of carry trades. Galati and Melvin found

significant proof that an increase in assets under management in hedge funds will make an impact on the market, in general on prices and interest rates.
Other notable conclusions in this paper are that the activity in the traditional foreign exchange market has increased in the period 2001-2004, after a decline in the period 1998-2001(see highlights for further explanation on the decline), that new currencies was targeted in carry trade and this study underlined the importance of short-term factors in the foreign exchange market and trading strategies accordingly.

"Carry trades and currency crashes" by Markus K. Brunnermeier, Stefan Nagel and Lasse H. Pedersen(2008) found that sudden exchange rate movements that are not related to news can be a result of unwinding of carry trade positions.

In "Evidence of carry trade activity" argued Gabrielle Galati, Alexandra Heath and Patrick McGuire (2007) that carry trade are an important driver of exchange rate developments. They stated that the buildup in the targeted currencies will lead to strengthening of these and weakening of funding currencies. When unwinding of these positions will have the opposite effect. This goes against the uncovered interest rate parity theorem.

2.4 Carry trade in time of crisis:

"The revenge of Purchasing Power Parity on Carry Trades during Crises" by Marie Brière and Bastien Drut (2009) examined the performance of carry trade and fundamental models over the last 20 years. Their findings where that when carry trade perform well, the fundamental models does not and vice versa. They also found that it is in time of crisis carry trades underperform and works like a catalyst for carry trade unwinding. This unwinding would lead to more violent return to equilibrium the better the carry trade strategies had performed.

There are also some other articles about carry trade and crisis but all say essentially the same that in time of economic crisis there will be an unwinding of carry trade and this unwinding will make the funding currency appreciate and the targeted currency depreciate. Hence carry trade will have considerable correlation risk with the global stock market and economic conditions in the world as Daniel Kothler (2007) found in his study.

3. DATA

Historical time series data of exchange rates and interest rates from sample currencies will be the most important data we will use in this study.

We will also collect data on the central banks targeted exchange rates against each other.

3.1. Sample Currencies:

The sample currencies that will be used are from large developed economies and the most liquid currencies that are traded in the market. Which are American dollar (80,1%), Euro (61,6%), British pound (14,5%), Japanese yen (11,4%), Swiss franc (8,5%), Australian dollar (4,0%), Canadian dollar (2,3%) Swedish krona (2,9%), Norwegian kroner (1,1%), Danish kroner (0,9%) and New Zealand (0,7%) dollars. (BIS, 2010)

Table 3 Currency distribution of reported euro area foreign exchange market turnover

(daily averages in April 2004, April 2007 and April 2010; USD billions and percentages) [1]

Currency	2004		2007 [2]		2010	
	Average daily turnover	Share	Average daily turnover	Share	Average daily turnover	Share
USD	257	83.2	329	82.0	344	80.1
EUR	187	60.4	245	61.0	265	61.6
JPY	43	13.8	48	11.9	49	11.4
GBP	47	15.1	50	12.6	62	14.5
CHF	29	9.3	37	9.2	36	8.5
AUD	7	2.2	12	3.0	17	4.0
CAD	5	1.7	10	2.5	10	2.3
SEK	7	2.2	7	1.9	12	2.9
HKD	1	0.5	6	1.5	3	0.7
NOK	4	1.4	7	1.6	5	1.1
DKK	3	1.1	6	1.6	4	0.9
SGD	1	0.3	3	0.7	2	0.5
ZAR	1	0.4	2	0.6	2	0.5
MXN	1	0.3	1	0.4	3	0.8
KRW	0	0.0	0	0.1	0	0.1
NZD	1	0.3	4	0.9	3	0.7
PLN	4	1.2	5	1.1	5	1.3
BRL	0	0.1	1	0.3	2	0.5
RUB	0	0.1	2	0.4	1	0.3
TWD	0	0.1	0	0.1	0	0.0
CZK	2	0.5	3	0.7	4	0.9
INR	0	0.0	0	0.0	0	0.0
THB	0	0.0	0	0.0	0	0.0
HUF	2	0.7	3	0.7	2	0.6
Other currencies	16	5.2	20	5.1	26	6.0
Total [3]	309	200	402	200	430	200

Source: BIS.
1) Adjusted for local inter-dealer double-counting, i.e. on a "net-gross basis".
2) Data for 2007 have been revised.
3) Because two currencies are involved in each transaction, the sum of the percentage shares of individual currencies totals 200%, rather than 100%.

From the exchange rate data the mean exchange rate for each currency to NOK will be calculated and the development of the historical currency movements against NOK will be graphed. This graphical representation will be used to determine if the exchange rate are over, under or at mean.

3.2. Interest rates of the sample currencies:

Three month interest rates for the sample currencies will be collected and used to find interest differentials against the NOK. The interest differential will be used differently depending on the strategy.

3.3. The targeted exchange rate to the Central Banks for the sample currencies:

We will compare mean exchange rate and targeted exchange rate of the Norwegian Central Bank and the corresponding currencies Central Bank. We will examine if the Central Banks have the same targeted exchange rate and if the mean exchange rate are close to targeted exchange rate.

3.4 Options data

Option prices on call and put will be calculated using the methods of Cox, Ross and Rubinstein (1979). Time horizon, value and price must be adapted to the mortgages and have to be explored further as this study progresses.

4. METHODOLOGY

We will take some assumptions from earlier research in this study to develop different strategies a financial institution can use to create new currency mortgage products. All strategies will have the same financial rules and repayment plan.

4.1. Proposed rules are:

- The bank will follow the rules of each strategy, to determine when to initiate currency switches. They will have their professional exchange brokers to manage these products.
- Mortgage in home currency cannot be higher than 70 % of house value.
- When converted to foreign currency, 10 % of the home currency mortgage is added to the mortgage and this amount is placed into a margin account. This will then not exceed the 85 % limit of house value in mortgage the Norwegian government implemented in 2011 on houses.
- A margin call will come when there is only 5 % left in the margin account.
- Each month the mortgage holders have to pay in a fixed down payment and the accumulated Norwegian interest into the margin account in NOK.
- Every day the margin account will be marked to market.
- Each month the account will be deducted a fixed down payment and the accumulated interest in the foreign currency.
- If at years end, there is more than 10 % of the mortgage value, in the margin account, this will be used to reduce the mortgage and will not be paid out to the mortgage holder. This to reduce the risk related to margin call, if the foreign currency/currencies suddenly appreciate.
- To avoid cash payment when getting a margin call, the financial institution will always as long as the mortgage holder has this mortgage have 85% loaning capacity in the house and can just extend the loan up to 85% of the value of the house, when the mortgage was initiated.
- Mortgage holder must be able to handle a total debt of 85% of the house value.
- Revaluation of the house should be done now and then to estimate risk.
- If there is a sudden drop in the value, in the housing market, the financial institution should ask for a new valuation of the house.

- If a margin call occurs the bank must inform the customers immediately about this, and inform about the new amount added to their mortgage or the amount they have to pay into the margin account to avoid getting more debt.
- Failure to post the margin amount, the loan will be converted back to home currency and work as a regular mortgage.
- Each mortgage holder will have own mortgage accounts and can follow the development 24 hours a day.

4.2. Assumptions in this study:

We will use the literature on carry trade as background to assume:

1. Uncovered interest rate parity does not hold in the long run, and that carry trade can give excess return.
2. Carry trade are an important driver of exchange rate developments.
3. Currencies with similar interest rate co-move with each other.
4. In time of crisis carry trades underperform and this works like a catalyst for carry trade unwinding.
5. Currency crashes can be a result of the unwinding of these carry trades positions.
6. The crash risk may discourage speculators from taking on large enough positions to enforce uncovered interest rate parity. Crash risk may thus help explain the empirically well documented violation of the uncovered interest rate parity.
7. Carry traders use low interest rate currencies as funding and invest in high interest rate currencies to achieve arbitrage.
8. Carry trade are a self-fulfilling arbitrage opportunity.

These assumptions will be referred to as assumption 3.1, 3.2 and so on.

4.3 The different strategies.

We will concentrate on four different strategies.

4.3.1. Strategy 1:

Strategy one will borrow in another currency when the interest rate in Norway is substantial higher than in foreign currency. A foreign interest rate that is 3 % lower will for now be substantial. After assumption 3.3, this study will assume all currency that has a 3 % lower interest rate or more, will co-move.

For diversification purposes against sudden and large appreciation in one currency, all currencies fulfill this interests rate differential will be equally weighted when borrowing foreign currency. Hence if no currencies fulfill the interest differential the mortgage stays in NOK. Here there are a potential to make many different products with different interest rate differential.

This strategy is simple carry trade just with small modifications, and will contribute to make the currency market more inefficient after assumption 3.8.

4.3.2. Strategy 2:

Strategy two will be highly interesting, since this strategy will try to exploit the sudden appreciation of safe haven currencies in special events. In general this strategy will take the position that Brunnermeier et al (2008) though crash risk discouraged speculators from taking on large enough positions to enforce uncovered interest rate. This strategy will if the position is large enough, make the currency market more efficient and the appreciation of the safe haven currency will be less than it otherwise would have been. When this strategy start to position itself in the exchange market, the customers must expect further appreciation of the currency, since there are a situation of unwinding of carry trade positions. The key in this strategy will be finding at which exchange rate level the financial institutions are going to start positioning and when to start withdraw the customer's money.

4.3.3 Strategy 3:

Strategy three will check for a situation in the market where the exchange rate of the foreign currency are over the mean exchange rate and at the same time has lower interest rate compared to the Norwegian interest rate. This currency, if it exists in the sample, does not necessary has the lowest interest rate in the currency sample and hence avoided the attention of arbitrage strategies. This currency will also probably follow uncovered interest rate parity better and can possibly

appreciate further, but since currency might have a tendency to revert to mean, we believe this could be an interesting concept to examine. The strategy will then be as following: Convert the mortgage into this/these currencies to exploit lower interest rate and a latent reversal to mean. If the currency/currencies depreciate under mean, exchange back if there is not a strong indication for further depreciation.

4.3.4 Strategy 4:

Strategy four will take the simple carry trade strategy further, than strategy one. Now we use the arbitrage strategy Bø and Klokkerhaug (2010) used in their paper as a foundation and add options to reduce risk related to mortgage holders lose all in abnormal appreciation of currencies. The financial institution will here sell some of the upside to finance buying insurance against the downside, creating a roof and a floor for this strategy.

4.4 Hypothesis

Each strategy will have this hypothesis.

H_0: The strategy does not produce excess return.

H_A: The strategy produces excess return.

H_0 will be rejected if the strategy has significant positive return.

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