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Thesis

- The Foreign Exchange Market: Can Order Flow Improve a Currency Carry Trade? -

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Abstract

The objective of this master thesis is to examine if a currency carry trade can be improved by accounting for order flow. We construct a carry trade strategy by pairing the three highest interest rate currencies to the three lowest yielding currencies, rebalancing every month. We find that the carry trade outperforms the alternative of investing capital at the risk free rate; however the recent financial crisis inflicted great losses on the strategy. In the attempt to explain the carry trade return using order flow, we fail to find any proof of causality on a monthly basis.

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-PRELIMINARY THESIS AT THE END-

1. Introduction

The foreign exchange market is the largest and most liquid market in the world, and consequentially a considerable amount of research has been conducted on the dynamics of this market. The global foreign exchange market had in 2010 an average daily turnover of 4 trillion dollars according to Bank of International Settlements (BIS) (2010). The size of this market makes it interesting to investigate foreign exchange trading strategies.

Empirical research has rejected the Uncovered Interest Rate Parity (UIP) numerous times. This violation implies that one can profit from borrowing money in a low interest rate currency and investing in a higher yielding currency, known as carry trade. The strategy gives a profit if the high interest rate currency appreciates towards the low interest rate currency, or not depreciates more than the interest rate differential. It entails that the profitability of this strategy is driven by interest rate- and exchange rate movements.

Macroeconomic models that link exchange rates to macro fundamentals have gained little support. Evans and Lyons (2002) were the pioneers to introduce the microstructure approach for exchange rate determination, an area of economics which has received a lot of attention and motivated extensive research. They found that exchange rates and order flow are strongly positively correlated and that a model including order flow outperforms a naïve random walk, which according to Meese and Rogoff (1983), macro based exchange rate models fail to do.

The main objective of this thesis is to examine several currency pairs with the aim to investigate if a carry trade strategy can be improved by introducing order flow as an explanatory variable. To the best of our knowledge, this has not yet been done.

Our thesis is divided into two main parts. First we construct a carry trade strategy and test its profitability over the period January 1997 till December 2011. The carry trade positions are rebalanced every month, giving us a return profile. We find an average monthly return of 0.28%, constituting an annualized return of 3.36%. Splitting the time period into two sub-periods, we see that the financial

crisis has inflicted a great loss on the strategy. From July 2007 throughout December 2011 there is a negative monthly return of 0.08% while the first sub-period has a positive return of 0.43%. This is in line with previous findings of among others Brière and Drut (2009) who have documented that a carry trade performs poorly in times of crisis.

We proceed with creating order flow variables, and investigate if one can get additional information and improve a currency carry trade strategy by introducing order flow as an explanatory variable. We cannot confirm any effect of order flow on the carry trade return with a one month horizon. As previous research has found that order flow can explain exchange rate movements on a daily and weekly basis, we find it reasonable to assume that it is possible to find significant explanatory power of order flow on a carry trade return if the study is conducted on a shorter time horizon.

The remainder of our thesis is organized as follows. Section 2 provides background information on the foreign exchange market, and accounts for the concepts of carry trade and order flow. We further explain how the traditional carry trade was affected by the Russian crisis of 1998 and the recent financial crisis. Section 3 gives a brief literature review on the topics separately and combined. Section 4 describes our data sample and section 5 presents the methodology. In section 6 we provide and discuss our results, and finally in section 7 we summarize and make our concluding remarks.

2. Background Information

2.1 The Foreign Exchange Market

The foreign exchange market is the largest of all financial markets. It is primarily an over the counter market and is extremely active. According to BIS (2010) the average daily turnover of the global foreign exchange market was up 20% from April 2007 to April 2010. The report suggests that this increase was largely due to increased trading activity of hedge funds, pension funds, mutual funds, insurance companies, central banks and non-reporting banks. Although significant, 20% was a decline from the 72% rise between 2004 and 2007; however this must be seen in

the light of the financial crisis of 2007-2009, and is according to King and Rime (2010) a sign of the robustness of this market.

There is foreign exchange trading around the world 24 hours a day, except on weekends. The dominating market is The United Kingdom, accounting for 37% of global foreign exchange market turnover, followed by the United States (18%), Japan (6%), Singapore (5%), Switzerland (5%), Hong Kong (5%) and Australia (4%), as presented by BIS (2010). Further the five most traded currency pairs in 2010 were USD/EUR (28%), USD/JPY (14%), USD/GBP (9%), USD/AUD (6%) and USD/CHF (4%) (BIS 2010).

Also according to BIS (2010), the US dollar dominates the foreign exchange market with 84.9 % of average daily turnover in April 2010, followed by the euro (39.1%), Japanese yen (19%) and Pound Sterling (12.9%). This reflects the practice in the foreign exchange market of trading minor currencies through major currencies, concentrating liquidity to a smaller amount of currency pairs (King, Osler and Rime 2011).

2.2 Understanding Carry Trade

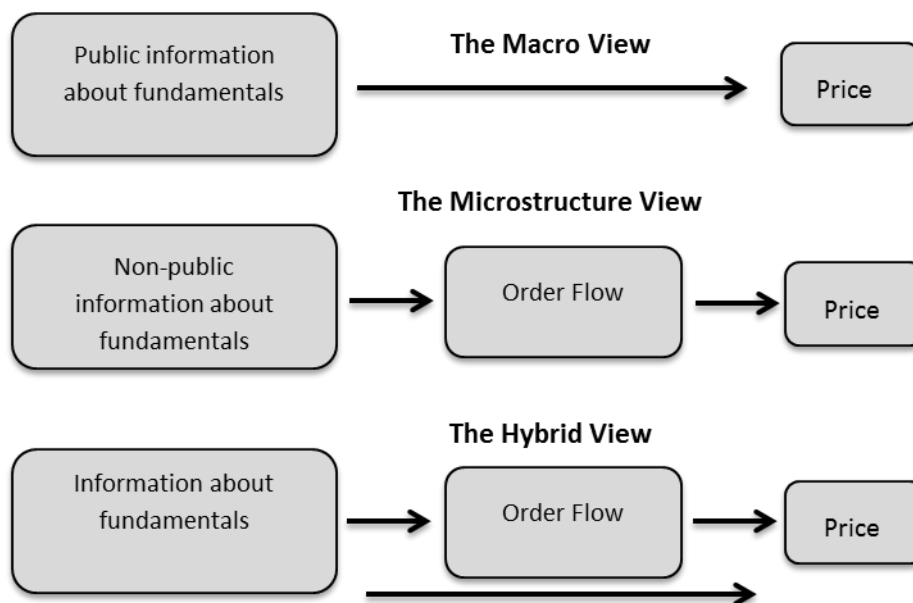
A carry trade consists of selling currencies forward that are at a significant forward premium - that is, selling a low interest rate currency to fund the purchase of a high interest rate currency (Plantin and Shin 2007). The profitability of a carry trade strategy is conditioned upon the violation of the UIP; namely that high interest rate currencies should depreciate against low interest rate currencies. Hence, there should be no difference in the return from domestic and foreign investments, because the interest rate differential is evaporated by the exchange rate. Empirical research has rejected the UIP and found that the high interest rate currency tends to appreciate. This is referred to as the “forward premium puzzle”. For the carry trade to be successful, the high interest rate currency must appreciate, or not depreciate more than the interest rate difference against the low interest rate currency. If the currency depreciation exceeds the interest rate differential, the strategy entails a loss.

Plantin and Shin (2007) show that the carry trade is a self-enforcing arbitrage strategy. Contrary to usual arbitrage opportunities, which become less and less profitable as more investors become aware of the miss-pricing, the carry trade generates more value the more speculators that enter. An increasing buy (sell) pressure on the high (low) yielding interest rate currency will cause a strengthening (weakening) of the exchange rate and hence the market inefficiency gap widens.

2.3 Understanding Order Flow

In the traditional macro approach it is assumed that price is driven by macro determinants exclusively. These determinants are public information variables. In all microstructure models, order flow is the proximate determinant of price. Microstructure models predict a positive relationship between variation in price and variation in order flow because the latter conveys non-public information, which when communicated to dealers, is reflected in the price (Evans and Lyons 2002). Actual markets include both public and non-public information which is the hybrid approach. We find Lyons' (2001) figure presented below helpful in understanding order flow.

Figure 1: Understanding Order Flow



According to Lyons (2001), understanding order flow is important for understanding how the microstructure approach differs from earlier approaches. He states that order flow differs from transaction volume, and that it is transaction volume which is signed. An example provided by Lyons (2001) is that if you sell 10 units to a dealer, then transaction volume is 10, but order flow is -10. The quoting dealer is on the passive side of the trade and you are on the sell side, so the order flow takes a negative sign. The trade is signed according to the initiating side. The order flow in a specific time interval can then be measured as the sum of signed buyer-initiated and seller-initiated orders in that period. A sum with a negative sign means net selling pressure, and a sum with a positive sign means net buying pressure over the period.

2.4 The Russian Financial Crisis of 1998

The Asian crisis began in Thailand in July 1997 with the financial collapse of the Thai baht. Despite great efforts to support its peg to the U.S dollar the government in Thailand had to float the baht because they lacked foreign currency to support it. The crisis spread to most of Southeast Asia and Japan. Here one experienced depreciating currencies and loss of value in stock markets. The Asian crisis also affected the Russian foreign exchange reserves severely, as it led to a decline in the price of crude oil and metals. This contributed heavily to the country's increased unemployment, decreased GDP per capita, and to global investors liquidating their Russian assets. It resulted in the Russian crisis which erupted on August 17th 1998 ending with the country's government devaluating the ruble and defaulting on its debt. The yen that had been weakening for months, now appreciated. As it began to appreciate the unwinding of yen carry trades increased the rise further. Those who had borrowed to a low interest rate in yen and invested in a high yielding currency were now looking to close out their debt as a yen that was appreciating resulted in losses to their strategy.

2.5 The Recent Financial Crisis

Melvin and Taylor provide a crisis timeline in their paper “The crisis in the foreign exchange market” from 2009. This paragraph is based on this timeline. The recent financial crisis has had considerable effect on the foreign exchange market. Fixed income markets were in the early summer of 2007 under serious stress, and in the midsummer the same year, equity markets experienced the same. A month later, on August 16, many currency investors suffered huge losses due to a considerable unwinding of the carry trade. Carry trade has a tendency of doing so in times of market stress. This was triggered by high volatility in other asset markets, and not surprisingly, did one see that the willingness to carry risk among investors was considerably reduced, affecting risky trades like the carry trade. Later in August it seemed as though things were on its way back to normal and volatility decreased over September and October. However, this came to an end on November 7. Again, one experienced a considerable unwinding of the carry trade. In the second quarter of 2008 and throughout the summer, risk appetite increased again and investors took positions indicating a belief that things were on its way back to normal in foreign exchange. Then came the failure of the Lehman Brothers in September 2008, causing volatility and transaction costs in the exchange rate market to rise to incredible levels and consequentially liquidity to disappear, as the cost of trading currencies increased enormously. One experienced unwinding of carry trades, and extreme appreciation of typical funding currencies caused severe losses to speculators.

3. Literature Review

3.1 Carry Trade

The failure of the UIP has been well documented, starting in the 1980s with Hansen and Hodrick (1980, referred in Mancini and Ranaldo, 2012). Since then there has been extensive research on this premium puzzle which allows for a positive carry trade return. Between 2001 and 2004 there was an increase in traditional foreign exchange trading (BIS, 2004, referred in Galati and Melvin,

2004). Galati and Melvin (2004) explain this increase by an extended period of exchange rate appreciation of high interest rate currencies which lead investors to speculate in carry trades. Also a period of low and flat bond yields may have been a reason for a growing trend of investing in the FX market. Low interest rate currencies like the US dollar, yen and the Swiss franc has typically been used as funding currencies, while the main target currencies includes the Australian and New Zealand dollar and sterling.

Galati, Heath and McGuire (2007) emphasize carry trades as a central driver of exchange rate movements. The main players are large institutional investors such as hedge funds and commodity trading advisors (Galati and Melvin 2004), hence the investment positions are large, leading to increased pressure on the currencies bought and sold. When investors take on a carry trade position it generally leads to a strengthening of the high interest rate currency and a weakening of the low interest rate currency. When large positions are suddenly closed out, the exchange rates experience sharp reversals. In the study “Carry Trades and Currency Crashes” (2008), Brunnermeier, Nagel and Pedersen also speculate on the unwinding of carry trades as being the reason for sudden exchange-rate movements that are not related to news announcements. Their findings confirm this idea. In times of high risk aversion and low liquidity, investors tend to pull out of carry trade positions, leading to currency crashes. Hence, carry traders expect to profit from such strategies, but the activity also increases the risk of a currency crash.

Brière and Drut (2009) found that carry trade strategies and fundamental strategies tend to perform in opposite directions. Especially during crisis, the fundamental strategies have shown to perform exceptionally well, while the carry trade strategy has performed poorly. We are therefore curious to see the results of our carry trade strategy during and after the financial crisis of 2007.

The liquidity of the foreign exchange market, increased capital flow between countries and currency speculation raises the question why carry trading has been profitable for so long. Menkhoff et al. (2011) argue that the high returns from carry trades are a compensation for time-varying risk. They find that high interest rate currencies give low returns in times of high volatility. On the contrary low

interest rate currencies yield positive returns in times of high volatility. Hence carry trades perform badly during times of crisis, rationalizing their high returns.

Later Mancini and Ranaldo (2012) studied the impact of liquidity risk on carry trades and found that low interest rate currencies generally have high liquidity and exhibit negative liquidity betas, which implies that they offer an insurance against liquidity risk. On the other hand high interest rate currencies tend to have positive betas and therefore present an exposure to liquidity risk. When liquidity in the FX market improves, the positive betas make the high interest rate currencies appreciate while low interest rate currencies depreciate due to negative betas. This increases the exchange rate difference and makes the carry trade profitable. They find strong co-movements between carry trade returns and unexpected changes in liquidity, suggesting that liquidity risk is priced in currency trade return. Menkhoff et al. (2011) also find that liquidity risk matters for carry trade returns, however to a smaller extent than time-varying risk.

3.2 Order Flow

There has been little success among financial economists to forecast future exchange rates correctly, and traditional macroeconomic exchange rate determination models have failed to empirically explain and forecast fluctuations in exchange rates. According to Meese and Rogoff (1983) who compared the accuracy of the out-of-sample forecasting of different macro based exchange rate models of the seventies, macro based models cannot predict future exchange rates better than a naïve random walk at a one to twelve months horizon.

Cheung, Chinn and Pascual (2005) later conducted a study examining the exchange rate models of the nineties. They were motivated by the fact that several new models had been forwarded, but not been subject to examination as rigorous as that of Meese and Rogoff (1983) on the models of the seventies. They found that it was difficult to find a macroeconomic model that could beat the random walk which was in accordance with existing literature. Their contribution was that they documented this also for models of the nineties.

With the switch to electronic trading and detailed records of order flow, a different approach for exchange rate determination - the microstructure approach - emerged. In their research, Martin D. D. Evans and Richard K. Lyons (2002) introduced a radically different approach to exchange rate determination because, instead of relying exclusively on macroeconomic determinants, order flow was included in the model. They found that exchange rates and order flow are strongly positively correlated, in other words that price increases with buying pressure. To address this they developed a model that included both macroeconomic determinants and order flow, and found that this model, out of sample, produced significantly better short-horizon forecasts than a random walk. Later this has been supported by, among others, Danielsson, Payne and Luo (2002) who investigated the dependence of major foreign exchange rates on order flow for 5 minutes to one week time horizons, and found strong dependence and explanatory power across the sampling frequencies. In another research by Evans and Lyons (2003) where they test whether order flow has first moment effects on the exchange rate, it is found that in regard to total variation in exchange rates, the order flow channel takes news' explanatory power up to 30 per cent.

In their paper on inventory information Cao, Evans and Lyons (2006) take a step further. They test the forecasting power of inventory information in foreign exchange and find that order flow effects on price persist. In fact they find the permanent effect from inventory information, of that from public information, to be between 15 % and 30%. This is supported by Rime, Sarno and Sojli (2010) who find the predictability of order flow on exchange rates to be powerful. However, on the contrary, Sager and Taylor (2008) find no evidence in their research that order flow can forecast exchange rates. Their results also shed doubt on the value of order flow to those operating in the foreign exchange market. Bjønnes, Osler and Rime (2012) further examine the sources of information advantage in the foreign exchange market and find that larger banks has a benefit over smaller banks. This advantage compiles from their more extensive network of customers that bring private information to the market, such as hedge funds, investment managers and pension funds. While previous literature has uniformly agreed that end users are the source to all private information in the currency marked, Bjønnes, Osler and Rime (2012) are the first to suggest that the currency banks also bring private information to the marked.

In the paper “Micro approaches to foreign exchange determination” from 2011, Evans and Rime provide an overview of micro based research on exchange rate determination. They emphasize that this research has made significant progress on providing exchange rate models, however that there is yet a lot to be done. Most theoretical research has examined the behaviour of major currency markets such as the USD/EUR and USD/JPY, and according to the authors existing models are not as suitable for examining the behaviour of exchange rates between currencies which are traded less often. Evans and Rime (2011) identify adapting the micro based models to these less liquid currencies as an important priority for future research.

3.3 Carry Trade and Order Flow

In the paper “A transaction data study of the forward bias puzzle” (2010), Breedon, Rime and Vitale look into order flow as an explanation for the forward bias puzzle. By using a simple micro-structure approach, they decompose the forward discount bias into a time-varying risk premium as a function of order flow and a forecasted error term. They investigate three currency pairs; EUR/USD, USD/JPY and GBP/USD. For the two first mentioned currency crosses they find evidence that order flow accounts for approximately 50 and 90 per cent respectively, of the expected risk premium. For the latter they do not find order flow to be of much importance for the forward bias. However, they argue that the Electronic Broker Service (EBS) platform, from which they have gathered their data, is not the main trading platform for this particular currency cross. Hence, the measure for order flow is less representative.

Based on these previous findings we find it reasonable to assume that the carry trade strategy can be improved by taking order flow into account.

4. Data

In the construction of the carry trade strategy we employ annual interest rates converted into monthly rates and monthly spot exchange rates obtained from Thomson's Reuters Datastream, a large provider of financial data. The data stretches from 1st of January 1997 to 31st of December 2011. The data set on order flow is obtained from ICAP, a world-leading interdealer broker and provider of post trade risk and information service. It spans from 31st of December 1996 to 31st of August 2007 and is provided by our thesis supervisor. It consists of high frequency data, which includes exchange rates, deal trades, quotes and inter-dealer order flow down to the second on different currencies traded on the EBS platform.

We investigate eight currencies, namely USD, GBP, CAD, AUD, SEK, JPY, CHF and EUR. The currencies are selected due to their common involvement in carry trades and the availability of transaction data. Typically low interest rate currencies are JPY and CHF, while AUD and GBP have generally had a high interest rate. In spite of the New Zealand dollar being one of the most popular carry trade targets, we do not include it in our analysis. The reason is that it has only been traded on EBS in 2007. Since our aim is to improve a carry trade strategy using order flow, we need a significant amount of trades over the whole sample period for each currency examined.

The Euro was introduced in January 1999, and enters into our analysis from 1st of February 1999. We have trading data up to 31st of August, but choose to expand our carry trade strategy till the end of 2011 in order to obtain a more robust test. It also allows us to look at what happened during and after the financial crisis of 2008.

In the interdealer market all currencies are traded against USD or EUR. We therefore look at our chosen currencies paired with USD and EUR which makes out the following crosses: AUD/USD, EUR/USD, GBP/USD, USD/JPY, USD/CHF, USD/CAD, EUR/CHF, EUR/GBP, EUR/JPY and EUR/SEK.

The data series used are not subject to non-stationarity. Hence we feel confident that our regressions are not spurious and that the results can be investigated.

5. Methodology

In this section we present the methodology used in this thesis. First we construct a carry trade strategy and test the UIP condition and the profitability of the carry trade strategy. Next we create order flow variables for the chosen currencies in seven different crosses. Finally we investigate if one can get additional information and improve a currency carry trade strategy by introducing order flow as an explanatory variable.

5.1 Carry Trade

Our approach is a simple carry trade strategy which involves pairing the three lowest interest rate currencies to the three highest interest rate currencies at all times. The pair constituting of the highest and lowest interest rate, we will call the first pair. By using such a “basket” of currencies, rather than placing the whole investment in one market, we to some extent achieve an effect of diversification. Every month the accounts are rebalanced giving us a return profile. The carry trade will be profitable if the high interest rate currency has appreciated against the low interest rate currency or if it has not depreciated more than the interest rate differential between the two countries. The profitability test implies comparing the returns of investing in a market with high interest rate towards the return of investing the equivalent amount in a lower interest rate market.

5.1.1 Testing the Uncovered Interest Rate Parity

According to the UIP, domestic and foreign investments must generate the same expected rate of return. Hence, any interest rate differential should be absorbed by the nominal exchange rate, expressed as:

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

Equation 1

Where $E(R_{t+1}^*)$ is the expected return from investing in the foreign currency quoted in dollars, and $E(R_{t+1})$ is the expected return from investing in the domestic risk free rate.

We begin to test the UIP hypothesis for the chosen currencies. The test is based on the Covered Interest Rate Parity condition (CIP) given by:

$$F_t = \frac{(1+r_t^*)S_t}{(1+r_t)}$$

Equation 2

Where F_t denotes the forward exchange rate at time t, S_t is the spot exchange rate at time t expressed as foreign currency per USD, while r_t and r_t^* is the domestic (US) and foreign interest rate respectively. The efficient market hypothesis states that the forward rate will equal the expected future spot rates assuming risk neutrality, rational expectations, no taxes and perfect capital mobility. Hence, $E(S_{t+1}) = F_t$. Taking log of CIP we obtain the estimate:

$$f_t - s_t = r_t^* - r_t$$

Equation 3

Where logs of the forward and spot rate at time t is denoted by lowercase letters. By taking a first order Taylor expansion of the log of S_{t+1} around its expected value we get that $E(S_{t+1}) = f_t$. We can now write the UIP condition as:

$$E(s_{t+1}) - s_t = r_t^* - r_t$$

Equation 4

Where the left hand side is the expected rate of depreciation of the currency, and the right hand side is the interest rate differential. With rational expectations we can convey the exchange rate dynamics as:

$$s_{t+1} = E(s_{t+1}) + \varepsilon_{t+1}$$

Equation 5

Where ε_{t+1} denotes a random error term. From equation 3 - 5 we then obtain a testable version of the UIP:

$$s_{t+1} - s_t = (f_t - s_t) + \varepsilon_{t+1}$$

Equation 6

Which conveys into the following regression:

$$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1}$$

Equation 7

Where Δs_{t+1} is the change in the log of the spot exchange rate from this period to the next period.

We run this regression for the seven currencies examined against the US dollar. From the resulting alpha and beta coefficients we can determine if UIP holds. A negative beta usually implies that UIP can be rejected. If the alpha coefficient also is negative, one can expect an appreciation of the high yielding currency. Hence, if we obtain negative beta and alpha coefficients for some or all of the currencies, we can assume that one can make an excess return on a carry trade strategy and move on to testing the profitability.

Table 1 Estimates of equation 7: $\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1}$. The p-values are shown in parenthesis in the row below the alpha and beta coefficients respectively.

	GBP/USD	CAD/USD	AUD/USD	SEK/USD	JPY/USD	CHF/USD	EUR/USD
α	-0,0002 (0,8456)	-0,0007 (0,4029)	0,0012 (0,4910)	0,0000 (0,9794)	-0,0029 (0,1534)	-0,0030 (0,1070)	-0,0007 (0,7184)
β	0,0149 (0,6359)	-0,0221 (0,4556)	-0,0333 (0,1519)	-0,0203 (0,4083)	-0,0205 (0,2676)	-0,0377 (0,1611)	-0,0078 (0,8503)

Running the regression in equation 7 we see that all currencies tested except from the pound have negative beta coefficients, and that all currencies except the Australian dollar have negative alpha coefficients. However the pound beta of 0.0149 and Australian dollar alpha of 0.0012 are clearly different from one. Based on this we reject UIP and take on the notion that carry trading is profitable.

5.1.2 Testing the Profitability of Carry Trade

We now assume the alternatives of either investing at the risk free rate in the country with the highest interest rate or investing the same amount at the risk free rate in the country with the lowest interest rate. Equivalently we pair the currencies with the second and third highest interest rate to the currencies with the second and third lowest interest rate. We follow the approach used in Olmo and Pilbeam's paper "The Profitability of Carry Trades" (2009). Our carry trade strategy is constructed from an US investor's point of view, meaning that returns are expressed in US dollar. Hence we compare the dollar return of investing in a high interest rate market to the dollar return of investing in a low interest rate market. The returns can be expressed separately as:

$$R_{t+1}^H = \frac{S_t^H}{S_{t+1}^H} (1 + r_t^H) - 1$$

Equation 8

$$R_{t+1}^L = \frac{S_t^L}{S_{t+1}^L} (1 + r_t^L) - 1$$

Equation 9

Where the spot exchange rate for the high and low interest rate currency is denoted by S_t^H and S_t^L respectively. The spot exchange rate for the end of the period is indicated by S_{t+1}^H and S_{t+1}^L and the interest rate for the high and low interest rate currencies are denoted by r_t^H and r_t^L . The total carry trade return is then given by:

$$R_{t+1}^{CT} = \frac{S_t^H}{S_{t+1}^H} (1 + r_t^H) - \frac{S_t^L}{S_{t+1}^L} (1 + r_t^L)$$

Equation 10

When the USD as our base currency is part of a currency pair, either as the high or low interest rate currency, the exchange rate for this part of the equation becomes one, reducing the expression to:

$$R_{t+1}^{CT} = (1 + r_t^H) - \frac{S_t^L}{S_{t+1}^L} (1 + r_t^L)$$

Equation 11

if the USD is currently the highest yielding interest rate and equivalently:

$$R_{t+1}^{CT} = \frac{S_t^H}{S_{t+1}^H} (1 + r_t^H) - (1 + r_t^L)$$

Equation 12

if the USD has the lowest interest rate for this period.

5.2 Order Flow

Order flow is the net of buyer-initiated and seller-initiated orders (Evans and Lyons, 2002). Thus, buy pressure is indicated by +1 and sell pressure is indicated by -1. One variable of cumulated order flow is constructed for every month.

5.2.1 Creating Order Flow Variables

Due to variation in trading, the major currencies experience a larger absolute size of order flow than the less liquid currencies. We therefore need to perform a standardization of the order flow variables to be able to make a comparison across currencies. We follow the approach by Menkhoff et al. (2012). To remove the difference in sizes, the order flows are divided by their standard deviation. The in-sample standardization which serves as a benchmark, divides daily order flows by their full sample standard deviation, as demonstrated in equation 13 below. $x_{(j,t)}$ denotes order flow of currency j on day t and $\sigma_{(Xj,1;T)}$ denotes the full sample standard deviation.

$$\hat{X}_{j,t} = \frac{x_{(j,t)}}{\sigma_{(Xj,1;T)}}$$

Equation 13

After standardizing order flows to make them more comparable we construct a series of one-period lagged values.

In order to examine order flow against the carry trade strategy we need the variables to be expressed under the same terms namely units of foreign currency per USD. When JPY is sold against USD, the order flow for JPY/USD takes on a positive sign while a JPY bought against USD gives the same variable a negative sign. Order flow variables expressed as USD/foreign currency can easily be turned around by changing the sign. We have four currencies that are traded against EUR; namely CHF, GBP, JPY and SEK. To convert the order flow (in equations denoted by OF) of these pairs into USD denominator variables we apply the following formula, here with CHF as an example:

$$OF^{CHF/USD} = OF^{CHF/EUR} - OF^{USD/EUR}$$

Equation 14

CHF, GBP and JPY are traded against both USD and EUR. The majority of trades in JPY are against the USD, while CHF and GBP are approximately equally frequently traded against USD and EUR. After normalizing to USD denominated variables the order flow is therefore summarized for these three currencies.

5.2.2 Can Order Flow Improve a Carry Trade Strategy?

If order flow can explain the carry trade return in the next period it is reasonable to assume that order flow can improve a carry trade strategy. When entering a carry trade one can look at order flow from the previous period to better predict the appreciation/depreciation of the high/low interest rate currencies over the investment horizon.

In the carry trade strategy we have paired the three highest yielding interest rate currencies with the three lowest yielding currencies for every month over the sample period. When testing if order flow can explain the carry trade return, we therefore construct order flow variables corresponding to the lowest/highest pair every month. For the first pair (highest/lowest interest rate over one month) the lowest interest rate is JPY throughout the entire period. The highest interest rate

alters between GBP, USD and AUD. We specify the order flow variables as low interest rate currency sold against high interest currency. Hence, the relevant variables for this pair are JPY/GBP, JPY/USD and JPY/AUD. The JPY/GBP variable is created using the formula:

$$OF^{JPY/GBP} = OF^{JPY/USD} - OF^{GBP/USD}$$

Equation 15

Equation 15 also applies for the construction of all other order flow variables.

From February 2002 and throughout our period of order flow data which ends in September 2007, the Australian interest rate has had the highest interest rate. However, the last trading event of AUD on EBS was in September 2006. This will therefore be the last observation in the testing of the first pair.

We attempt to investigate whether order flow from the previous period can explain the carry trade return. The corresponding regression has the carry trade return as the dependent variable and the one-period lagged order flow of the currency pairs with the lowest and highest interest rate for each month as the explanatory variable. We specify the model in the following way:

$$R_t^{CT} = \alpha + \beta OF_{t-1}^{low/high} + \varepsilon_t$$

Equation 16

6. Analysis

In this section we present and discuss the evidence resulting from the tests described in section 5. First we evaluate the profitability of our carry trade strategy, and finally we provide a discussion of whether it is likely that order flow can improve a carry trade strategy.

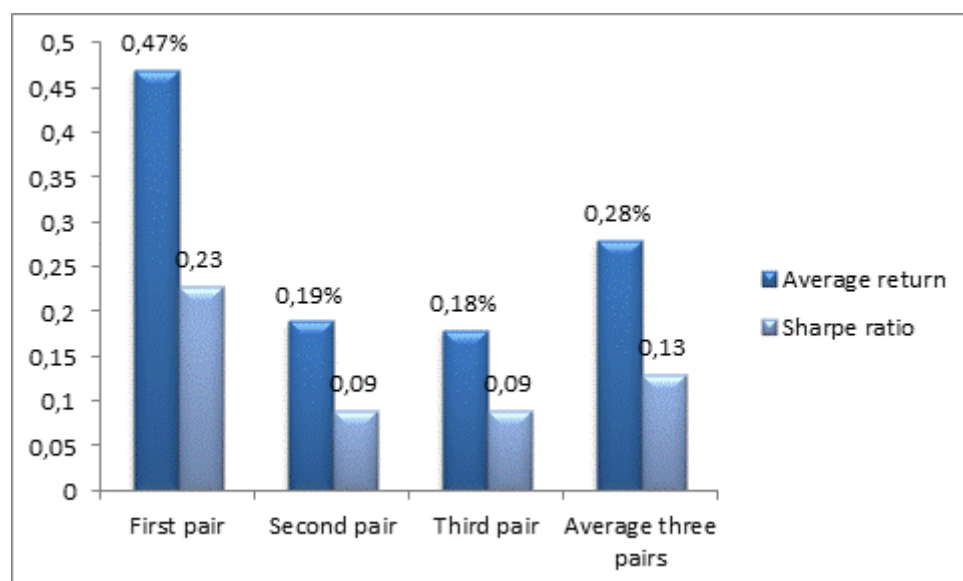
6.1 The Profitability of Carry Trade

First we look at the results from testing the carry trade strategy. In our test of the UIP, as mentioned earlier, it was rejected and carry trade found to be profitable in the long run. This is what we expected to find and also in line with previous research. The prediction is then that following our approach of pairing the three lowest interest rate currencies to the three highest interest rate currencies at all times, gives a positive return in the long run.

6.1.1 Average Return

Figure 2 below shows the average return of the three different pairs as well as the total average return on the carry trade, and the corresponding Sharpe ratios, all for the whole period.

Figure 2: This figure shows total average monthly return and Sharpe ratio for the whole period as well as average monthly return for the three pairs separately.



The average monthly return is 0.28%, constituting an annualized return of 3.36%. The average monthly standard deviation is 2.09% and consequently the Sharpe ratio is 0.13. The average monthly return generated from the first pair is 0.47% (annualized 5.64%), from the second pair 0.19% (annualized 2.28%), and from the third pair 0.18% (annualized 2.16%). As we expected, the first pair contributes the most to the total average return. This is because the interest rate differential is considerably larger here than for the second and third pair. Also we see a smaller exchange rate differential for the first pair than for the second and third pair.

6.1.2 The Impact of the Russian Financial Crisis of 1998

We look at the impact of the Russian crisis of 1998 and table 2 presents the returns to the strategy during this period. We see that the Japanese yen and the Swiss franc appreciated considerably, causing a loss to our strategy as the total monthly average return is negative 0.53%. The yen appreciated by more than 20% against the pound over the five months.

Table 2: This table presents the average monthly returns to the strategy from August 1998 to December 1998, for each pair and in total. It also shows funding and target currencies for each pair in that period as well as corresponding returns.

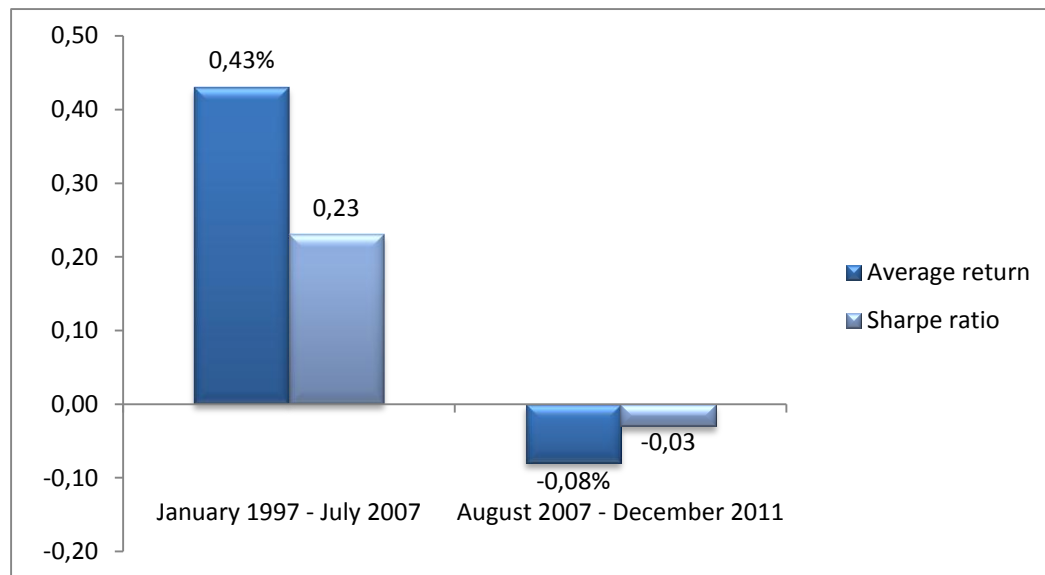
	First pair			Second pair			Third pair		
	Funding	Target	Return	Funding	Target	Return	Funding	Target	Return
Aug.98	JPY	GBP	-0,89 %	CHF	USD	-1,54 %	SEK	CAD	-1,27 %
Sep.98	JPY	GBP	0,92 %	CHF	CAD	-1,52 %	SEK	AUD	0,83 %
Oct.98	JPY	GBP	-7,62 %	CHF	CAD	-0,07 %	SEK	USD	-0,39 %
Nov.98	JPY	GBP	2,84 %	CHF	USD	1,31 %	SEK	CAD	1,98 %
Dec.98	JPY	GBP	-2,66 %	CHF	USD	0,20 %	SEK	CAD	-0,10 %
Average	-1,48 %			-0,33 %			0,21 %		
Total monthly average return				-0,53 %					

6.1.3 The Impact of the Recent Financial Crisis

To look at the impact of the recent financial crisis we first divide the period into two sub periods; January 1997 - July 2007 and August 2007 - December 2011. Figure 3 shows the average monthly return on the carry trade and the corresponding Sharpe ratio for the two periods. The average monthly return for the first period, before the financial crisis erupted, is 0.43% and the Sharpe ratio

0.23. The return in the second period, which includes the financial crisis, is negative 0.08% and the Sharpe ratio negative 0.03.

Figure 2: This figure shows average monthly return and Sharpe ratios for the two sub periods; January 1997 - July 2007 and August 2007 - December 2011.



Further table 3 presents the returns to the strategy during the most critical months of the crisis. Liquidity did almost not exist and one experienced extreme appreciation of typical funding currencies as speculators had to unwind their funding positions. Also here typical funding currencies such as the Japanese yen and Swiss franc appreciated considerably, resulting in a negative total monthly average return of 2.34%.

Table 3: This table presents the average monthly returns to the strategy from August 2008 to December 2008, for each pair and in total. It also shows funding and target currencies for each pair in that period as well as corresponding returns.

	First pair			Second pair			Third pair		
	Funding	Target	Return	Funding	Target	Return	Funding	Target	Return
Aug.08	JPY	AUD	-3,27 %	CHF	GBP	-0,01612	USD	SEK	-0,02566
Sep.08	JPY	AUD	-3,33 %	CHF	GBP	0,003354	USD	SEK	-0,02688
Oct.08	JPY	AUD	-9,04 %	CHF	GBP	-0,02681	USD	SEK	-0,04901
Nov.08	JPY	AUD	-4,46 %	CHF	GBP	-0,01359	CAD	EURO	0,018522
Dec.08	JPY	AUD	2,68 %	CHF	SEK	-0,02778	USD	GBP	-0,0127
Average			-3,48 %			-1,62 %			-1,91 %
Total monthly average return				-2,34 %					

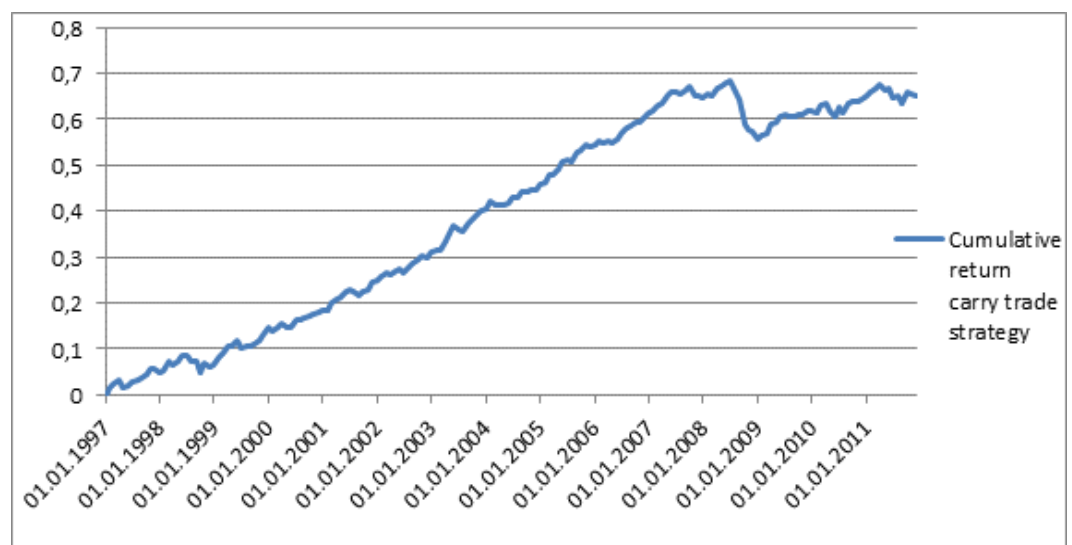
These results are all in line with Brunmeier, Nagel and Pedersen's (2008) who found that in times of high risk aversion and low liquidity, investors tend to pull out of carry trade positions, leading to currency crashes. Our results are also in

line with Brière and Drut (2009) who found that carry trade strategies and fundamental strategies tend to perform in opposite directions. Especially during times of crisis, when one would want return to be high, the carry trade strategy has shown to perform poorly and fundamental strategies exceptionally well.

6.1.2 Cumulative Return

Following the procedure of Burnside et al. (2006) we compute the cumulative returns to investing one U.S dollar in the beginning of the period in the carry trade, and then reinvesting the proceeds. An investor starts with one US dollar in a bank account and invests this dollar in the carry trade strategy. From that point the investor bets the balance on the bank account on the carry trade. The payoffs from the currency strategy are either deposited or withdrawn from the investor's account. As the strategy is a zero cost investment, the investor's net balances are kept in the bank, accumulating interest at the US Libor rate. Figure 3 below shows that the carry trade is more profitable than investing at the risk free rate. The one US dollar invested will rise to 2.28, reinvesting proceeds over the 15 years. This is 1.36 dollars in excess of placing the same amount in the bank to simply earn interest over the same period. The carry trade strategy however, involves great volatility.

Figure 3: This figure shows cumulative return from the carry trade strategy.



As can be seen in figure 4, the cumulative return never becomes negative in our sample, but there are times when returns have been negative, reducing the cumulative return. Especially visible is the drop in return in 2008, which is due to the recent financial crisis hitting with full force in the late summer that year.

6.2 Can Order Flow improve a Carry Trade Strategy?

Evans and Lyons (2002) states three timing possibilities of order flow/price relation, depending on whether order flow precedes, is concurrent with, or lags price adjustment. They refer to these three timing hypotheses as the Anticipation-, Pressure- and Feedback hypotheses. We look at the causality under the different hypotheses in relevance for the foreign exchange market. Under the Anticipation hypothesis a change in order flow causes the price to change, however the effects are delayed. Under the Pressure hypothesis, order flow and price are concurrent but causality still runs from order flow to price. Under the Feedback hypothesis, feedback trading is present and thus order flow lags price (Positive-feedback implies that a price increase (decrease) causes systematic buying (selling), negative feedback is the reverse).

In the attempt to see if one can improve a carry trade strategy by looking into order flow we apply the Anticipation hypothesis, meaning that we introduce lagged order flow. We run the following regression:

$$R_t^{CT} = \alpha + \beta OF_{t-1}^{low/high} + \varepsilon_t$$

Equation 16

We would expect that an increasing buy (sell) pressure on the high (low) yielding interest rate currency should have a positive effect on the carry trade return. Hence the resulting beta coefficient should take a positive value. On the contrary to our expectations, we find a negative beta coefficient of 0.0011 for the first pair which would imply that when the high (low) interest rate currency is more frequently bought (sold) the carry trade return is affected negatively. However, the finding is not significant and the explanatory power is close to zero, hence we

cannot confirm any effect on the carry trade return. For the second and third pair the beta is also negative and insignificant. The test statistics are summarized in table 4 below.

Table 4 Estimates of equation 16: $R_t^{CT} = \alpha + \beta^{low/high} / high_{t-1} + \varepsilon_t$. Period: 1st January

2001- 31st August 2007. The p-values are shown in parenthesis in the row below the order flow coefficients.

	First pair	Second pair	Third pair
Order flow	-0,0011 (0,1182)	-0,0004 (0,4396)	-0,0003 (0,5168)
R-square	0,0211	0,0047	0,0041

Since we cannot find significant results when using lagged order flow, we proceed with concurrent data, still aiming to find causality from order flow to carry trade return. Thus, the regression we run is:

$$R_t^{CT} = \alpha + \beta OF_t^{low/high} + \varepsilon_t$$

Equation 17

We would assume that simultaneous order flow can better explain the carry trade returns, so once again we expect to find a positive beta coefficient. The resulting beta is positive, however vanishingly small. The r-square is very close to zero and the adjusted r-square takes a negative value which would imply that the order flow variable is useless in predicting a carry trade return.

6.2.1 Can Order Flow Explain Exchange Rate Movements?

Since the carry trade return is affected by exchange rate- and interest rate movements, it should be a reasonable assumption that order flow can explain the carry trade return. We therefore move on to testing whether our order flow data can explain the movements in the exchange rates used in the carry trade strategy.

By running the regression below we look at the influence of order flow on exchange rates.

$$\Delta P_t = \alpha + \beta \Delta X_t + \varepsilon_t$$

Equation 18

In equation 18 $\Delta P_t = \log\left(\frac{P_t}{P_{t-1}}\right)$ is the log change in the exchange rate from the previous period and ΔX_t is the change in order flow from the previous period. All variables are expressed as foreign currency sold against USD. As noted by Evans and Lyons (2002); when net order flow is positive, meaning that dollar is bought more frequently, the price of USD in terms of foreign currency should increase. Hence, an increase in buyer initiated trades should lead to an appreciation of the USD, and equivalently an increase in seller initiated trades should lead to depreciation. We would therefore expect the beta coefficients to have positive values. We summarize the test results in table 5 below.

Table 5 Estimates of equation 18: $\Delta P_t = \alpha + \beta \Delta X_t + \varepsilon_t$. Period: 1st January 2001- 31st

August 2007. The p-values are shown in parenthesis in the row below the coefficients for change in order flow from the previous period.

	GBP/USD	CAD/USD	AUD/USD	SEK/USD	JPY/USD	CHF/USD	EUR/USD
ΔX_t	-0,0023 (0,0003)	0,0004 (0,6820)	-0,0005 (0,6935)	0,0019 (0,0349)	0,0022 (0,2971)	-0,0008 (0,3991)	0,0047 (0,0004)
R-square	0,1345	0,0019	0,002	0,0485	0,0079	0,0079	0,1319

We find small positive and significant betas for the SEK and EUR exchange rates. For the GBP/USD exchange rate we find a significant negative beta which would imply that increasing buy pressure on the USD leads to a depreciation of the USD towards the GBP. Due to these result it is not likely that order flow can accurately explain exchange rate movements on a monthly basis. Previous research has concluded that order flow in fact can forecast exchange rate movements on a shorter time horizon. For example Danielsson, Payne and Luo (2002) found evidence of the forecasting ability of order flow on major exchange rates such as EUR/USD and USD/JPY on daily and weekly frequencies. Taking the size and trading frequency of the foreign exchange market into consideration, it may not be so surprising that a one month period is too long of a time horizon to successfully predict movements.

Most of previous research has focused on major currency markets with high trading activity such as EUR/USD and USD/JPY, when trying to understand the behavior in FX markets. Evans and Rime (2010) concludes that existing models are not as well suited in explaining changes in exchange rates for less liquid

currencies. This is an interesting remark, as most currencies are categorized as low liquid-currencies.

We proceed with testing the causality of order flow on some chosen exchange rates used in our carry trade strategy, on shorter time horizons. EUR/USD is the most liquid pair, followed by GBP/USD. The AUD/USD and CAD/USD however experience much less liquidity in trading. The time frame now starts with 1st of June 2004 because daily trading was extremely sporadic for AUD and CAD up to this day. The test statistics are summarized in table 6 below.

Table 6 Estimates of equation 18: $\Delta P_t = \alpha + \beta \Delta X_t + \varepsilon_t$. Period: 1st June 2004 – 31st August 2007. The p-values are shown in parenthesis in the row below the coefficients for change in order flow from the previous period.

	AUD/USD		CAD/USD		GBP/USD		EUR/USD	
	ΔX_t	R-square	ΔX_t	R-square	ΔX_t	R-square	ΔX_t	R-square
Daily	0,0002 (0,0004)	0,0128	0,0003 (0,0000)	0,0304	0,0001 (0,0546)	0,0038	-0,0003 (0,0000)	0,0524
Weekly	-0,0004 (0,0275)	0,0291	0,0001 (0,4635)	0,0033	-0,0002 (0,3450)	0,0054	0,0009 (0,0914)	0,0171

On a daily basis we find significant coefficients for all currencies except GBP. The beta coefficients are however very small, and for the EUR it is negative. The r-square is also surprisingly low; in fact the explanatory power decreases from a monthly to daily horizon for EUR, which is the only currency with a significant coefficient on both monthly and daily basis. Weekly testing only provides significant results for the AUD; where the coefficient takes a negative value. Hence, once again we find that an increased buy pressure leads to depreciation, disagreeing with what one would expect. The r-square increases slightly from daily to weekly testing.

An important aspect to point out is that the data on exchange rates and order flow are gathered from different sources. The exchange rates we use are daily, weekly and monthly estimates. Hence, there is a possibility that the trades were quoted at different prices than the ones used in our analysis. In addition EBS is not the main trading platform for all currency pairs tested, making the order flow measure less representative. These potential data problems will off course affect the validity of the test, and could be the reason for our unanticipated results.

If order flow cannot forecast exchange rate movements over a one month period, it entails that it is also useless in explaining a carry trade return for the same time horizon. The common practice is to rebalance the carry trade every month; hence this is the approach we have followed. As already mentioned, previous research has found that order flow can explain and predict exchange rate movements on a daily and weekly basis. However the models show best results for major currencies with high liquidity. In light of this we would further suggest attempting to explain the carry trade return using fewer currencies and a shorter time horizon.

7. Summary and Conclusion

In this thesis we aim to improve a carry trade strategy by introducing order flow as an explanatory variable for the profitability of a carry trade. The carry trade strategy implies borrowing funds in a low interest rate currency to invest in a high interest rate currency. The strategy gives a profit if the high interest rate currency appreciates towards the low interest rate currency, or not depreciates more than the interest rate differential. It entails that the profitability of this strategy is contingent upon a violation of the UIP; namely that the interest rate differential between two currencies should evaporate in the exchange rate. This failure has been well documented in empirical literature.

A carry trade is a zero-investment strategy, which implies that returns different from zero is evidence of an existing arbitrage opportunity. Over a 15 year period we find an average monthly return of 0.28%. In the event of the recent financial crisis and its aftermath the carry trade suffers a loss. Looking at the two periods January 1997 - July 2007, and August 2007 - December 2011 separately, the average monthly return for the first period is 0.43% while the average return for the last period is negative 0.08%.

It is evident that the carry trade return is driven by exchange rate movements. In line with previous findings of order flow's forecasting ability on exchange rates, we attempt to find similar abilities for order flow on carry trade return. We fail to find any evidence of order flow influencing the carry trade return. In further

testing it turns out that order flow has no effect on exchange rate movements on a monthly basis. Also weekly and daily testing offers poor results. We point out that we may have a data problem and also that some of the currencies we use fall into the category of low liquidity currencies, for which existing models have been less successful at explaining. However, since previous research has documented forecasting ability for high liquid currencies on higher frequencies of a day or a week, we would suggest further testing using only major currencies and a shorter time horizon.

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BI Norwegian Business School

Preliminary Thesis Report

- Can Carry Trades be Improved by Including Order Flow -

Supervisor:
Geir Høidal Bjønnes

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1. Introduction

The foreign exchange market is the largest of all financial markets. It is primarily an over the counter market and extremely active. The global foreign exchange market had in 2010 an average daily turnover of 4 trillion dollars according to Bank of International Settlements (2010). The size of this market makes it interesting to investigate foreign exchange trading strategies.

Empirical research has rejected the UIP hypothesis numerous times. This violation implies that one can profit from borrowing money in a low interest rate currency and investing in a higher yielding currency, known as carry trade. In order to make a return on such an investment, large positions are required. Hence, it may seem that carry trade is a self-enforcing arbitrage.

Macroeconomic models that link exchange rates to macro fundamentals have gained little support. Evans and Lyons (2002) were the pioneers to introduce the micro-structure approach for exchange rate determination, an area of economics which has received a lot of attention and motivated extensive research. They found that exchange rates and order flow are strongly positively correlated and that a model including order flow outperforms a naïve random walk, which according to Meese and Rogoff (1983), macro based exchange rate models fail to do.

There is extensive research on carry trade and order flow; however few have combined the two topics. Breedon, Rime and Vitale (2010) have found evidence that the forward discount bias can to a large extent be accounted for by order flow. Though, the study is only conducted on three different currency crosses where one of them gave insignificant results. In our thesis we intend to examine several currency pairs with the aim to investigate if a carry trade strategy can be improved by introducing order flow as an explanatory variable.

Our approach will be a simple carry trade strategy which involves pairing the three lowest interest rate currencies to the three highest interest rate currencies at all times. If the no-arbitrage condition UIP can be rejected, carry trades can be a profitable matter. We compare the returns of investing in a low interest rate

currency to that of investing in a high interest rate one. The difference is the carry trade profit. Further we take order flow into consideration. The exact method for this is yet to be determined.

This preliminary report contains several sections. First we provide an explanation of carry trade and order flow which is followed by a literature review of previous research on the topic. The data that will be used is presented in the next section followed by methodology. Finally we introduce a preliminary plan for further progress.

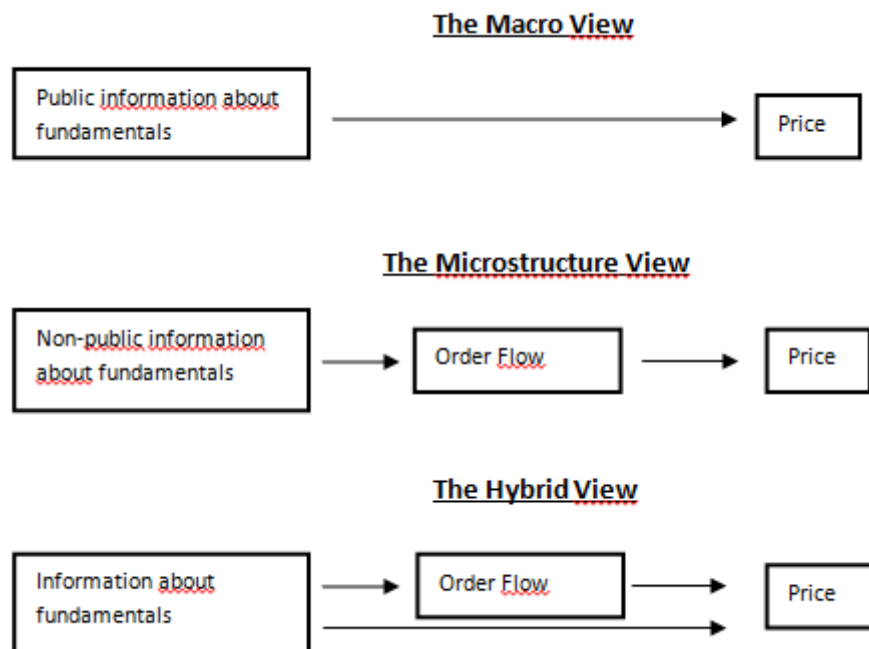
2. Understanding Carry Trade

A carry trade consists of selling currencies forward that are at a significant forward premium - that is, selling a low interest rate currency to fund the purchase of a high interest rate currency (Plantin and Shin 2007). The profitability of a carry trade strategy is conditioned upon the violation of UIP; namely that high interest rate currencies should depreciate against low interest rate currencies. Hence, there should be no difference in the return from domestic and foreign investments. Empirical research has rejected UIP and found that the high interest rate currency tends to appreciate. This is referred to as the “forward premium puzzle”. For the carry trade to be successful, the high interest rate currency must appreciate, or not depreciate more than the interest rate difference against the low interest rate currency. If the currency depreciation exceeds the interest rate differential, the strategy entails a loss.

Plantin and Shin (2007) show that the carry trade is a self-enforcing arbitrage strategy. Contrary to usual arbitrage opportunities, which become less and less profitable as more investors become aware of the miss-pricing, the carry trade generates more value the more speculators that enter. In order to make a return on carry trades, large investments are required. Hence, the exchange rate may be affected every time a carry trade is engaged.

3. Understanding Order Flow

In the traditional macro approach it is assumed that price is driven by macro determinants exclusively. These determinants are public information variables. In all micro-structure models, order flow is the proximate determinant of price. Micro-structure models predict a positive relationship between variation in price and variation in order flow because the latter conveys non-public information, which when communicated to dealers, is reflected in the price (Evans and Lyons, 2002). Actual markets include both public and non-public information which is the hybrid approach. We find Lyons' (2001) figure presented below a helpful tool to understand order flow.



According to Lyons (2001) understanding order flow is important for understanding how the micro-structure approach differ form earlier approaches. He states that order flow differs from transaction volume, and that it is transaction volume which is signed. An example provided by Lyons (2001) is that if you sell 10 units to a dealer, then transaction volume is 10, but order flow is -10. The quoting dealer is on the passive side of the trade and you are on the sell side, so the order flow takes a negative sign. The trade is signed according to the initiating side. The order flow in a specific time interval can then be measured as the sum of

signed buyer-initiated and seller-initiated orders in that period. A sum with a negative sign means net selling pressure, and a sum with a positive sign means net buying pressure over the period.

4. Literature Review

4.1 Carry Trade

The 2004 Triennial central Bank Survey of Foreign Exchange and Derivatives Market Activity showed a surge in traditional foreign exchange trading between 2001 and 2004. Galati and Melvin (2004) explains this increase by an extended period of exchange rate appreciation of high interest rate currencies which lead investors to speculate in carry trades. Low interest rate currencies like the US dollar, yen and the Swiss franc was typically used as funding currencies, while the main target currencies included the Australian and New Zealand dollar and sterling. The article “Evidence of carry trade activity” (2007) by Galati, Heath and McGuire cites the same popular target currencies, however points out that in 2004 the US dollar became a potential target currency after a policy rate normalization.

Galati et al. (2007) emphasizes carry trades as a central driver of exchange rate movements. When investors take on a carry trade position it generally leads to a strengthening of the high interest rate currency and a weakening of the low interest rate currency. When large positions are suddenly closed out, the exchange rates experience sharp reversals. In the study “Carry Trades and Currency Crashes” (2008), Brunnermeier, Nagel and Pedersen also speculate in the unwinding of carry trades as being the reason for sudden exchange-rate movements that are not related to news announcements. Their findings confirm this idea. In times of high risk aversion and low liquidity, investors tend to pull out of carry trade positions, leading to currency crashes. Hence, carry traders expect to profit from such strategies, but the activity also increases the risk of a currency crash.

Briere and Drut (2009) found that carry trade strategies and fundamental strategies tend to perform in opposite directions. Especially during crisis, the fundamental strategies have shown to perform exceptionally well, while the carry trade strategy

has performed poorly. We are curious to see the results of our carry trade strategy during and after the financial crisis of 2008.

4.2 Order Flow

There has been little success among financial economists to forecast future exchange rates correctly, and traditional macroeconomic exchange rate determination models have failed to empirically explain and forecast fluctuations in exchange rates. According to Meese and Rogoff (1983) who compared the accuracy of the out-of-sample forecasting of different macro based exchange rate models of the seventies, macro based models cannot predict future exchange rates better than a naïve random walk at a one to twelve months horizon.

Cheung, Chinn and Pascual (2005) later conducted a study examining the exchange rate models of the nineties. They were motivated by the fact that several new models had been forwarded, but not been subject to examination as rigorous as that of Meese and Rogoff (1983) on the models of the seventies. They found that it was difficult to find a macroeconomic model that can beat the random walk which was in accordance with existing literature. Their contribution was that they documented this also for models of the nineties.

With the switch to electronic trading and detailed records of order flow, a different approach for exchange rate determination- the micro-structure approach emerged. In their research, Martin D. D. Evans and Richard K. Lyons introduced a radically different approach to exchange rate determination because, instead of relying exclusively on macroeconomic determinants, order flow was included in the model (Evans and Lyons, 2002). In their research, Evans and Lyons (2002) found that exchange rates and order flow are strongly positively correlated, in other words that price increases with buying pressure. To address this they developed a model that included both macroeconomic determinants and order flow, and found that this model, out of sample, produced significantly better short-horizon forecasts than a random walk. Later this has been supported by, among others, Danielsson, Payne and Luo (2002) who investigated the dependence of major foreign exchange rates on order flow for 5 minutes to one week time horizons, and found strong dependence and explanatory power across

the sampling frequencies. In another research by Lyons and Evans (2003) where they test whether order flow has first moment effects on the exchange rate, it is found that in regard to total variation in exchange rates, the order flow channel takes news' explanatory power up to 30 percent.

The explanatory power of order flow on foreign exchange rates has been investigated in a series of articles during the past decade. In their paper on inventory information Cao, Evans and Lyons (2006) takes a step further. They test the forecasting power of inventory information in foreign exchange and find that order flow effects on price persist. In fact they find the permanent effect from inventory information, of that from public information, to be between 15 % and 30%. This is supported by Rime, Sarno and Sojli (2010) who find the predictability of order flow on exchange rates to be powerful. However, on the contrary, Sager and Taylor (2006) find no evidence in their research that order flow can forecast exchange rates. Their results also shed doubt on the value of order flow to those operating in the foreign exchange market. This implies the need for further research.

4.3 Carry Trade and Order Flow

In the paper "A transaction data study of the forward bias puzzle" (2010), Breedon, Rime and Vitale look into order flow as an explanation for the forward bias puzzle. By using a simple micro-structure approach, they decompose the forward discount bias into a time-varying risk premium as a function of order flow and a forecast error term. They investigate three currency pairs; EUR/USD, USD/JPY and GBP/USD. For the two first mentioned currency crosses they find evidence that order flow accounts for approximately 50 and 90 per cent respectively, of the expected risk premium. For the latter they do not find order flow to be of much importance for the forward bias. However, they argue that the EBS platform, from which they have gathered their data, is not the main trading platform for this particular currency cross. Hence, the measure for order flow is less representative. Breedon et al. further suggest an investigation of other currency pairs typically used in carry trades, such as USD/NZD and CHF/USD, to see if similar results can be found. In this thesis we will examine other currency crosses like the authors suggest. If order flow is found to explain most of the

forward discount bias, it is reasonable to assume that the carry trade strategy can be improved by taking order flow into account.

5. Data

The data set we will use in the carry trade strategy is obtained from Thomson's Reuters Datastream, a large provider of financial data. It consists of annual interest rates, which are converted into monthly rates for the relevant countries, and monthly observations for interbank spot exchange rates. We will choose a base currency and each exchange rate will be quoted as foreign currency units per base currency. The data stretches from 1st of January 1997 until 31st of December 2011.

The data set on order flow is obtained from ICAP, a world-leading interdealer broker and provider of post trade risk and information service. It spans from 1st of January 1997 to 31st of August 2007. These data will be provided by our thesis supervisor. It consists of high frequency data, which includes exchange rates, deal trades, quotes and inter-dealer order flow down to the second on different currencies.

In order to examine whether order flow information can improve a traditionally carry trade strategy we need to test both strategies for the same currency pairs. Which currencies to use will be decided based on the most traded currencies in the time interval of our order flow data set. The reason for using interest rate data past our availability of order flow data is to obtain a more robust test of the carry trade strategy. It also allows us to look at what happened during and after the financial crisis of 2008.

The interest rate data for the carry trade strategy will be prepared and analyzed using Excel and Eviews, while the order flow data needs to be prepared in a program which allows for high frequency data, such as SAS.

6. Methodology

Our approach will be a simple carry trade strategy which involves pairing the three lowest interest rate currencies to the three highest interest rate currencies at all times. By using such a “basket” of currencies, rather than placing the whole investment in one market, we to some extent achieve an effect of diversification. Every month the accounts are rebalanced giving us a return profile. The carry trade will be profitable if the high interest rate currency has appreciated against the low interest rate currency or if it has not depreciated more than the interest rate differential between the two countries. The profitability test implies comparing the returns of investing in a market with high interest rate towards the return of investing the equivalent amount in a lower interest rate market.

According to the uncovered interest rate parity (UIP) domestic and foreign investments must generate the same expected rate of return. Hence, any interest rate differential should be absorbed by the nominal exchange rate.

We begin to test the UIP hypothesis for the chosen currencies using a regression suggested by Olmo and Pilbeam (2009) in “The profitability of carry trades”:

$$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1}$$

From the resulting alpha and beta coefficients we can determine if UIP holds. A negative beta usually implies that UIP can be rejected. If the alpha is negative, one can expect an appreciation of the high yielding currency. Hence, if we obtain negative beta and alpha coefficients for some or all of the currency pairs tested, we can assume that one can make an excess return on a carry trade strategy and move on to testing the profitability.

We now assume the alternatives of either investing at the risk free rate in the country with the highest interest rate or investing the same amount at the risk free rate in the country with the lowest interest rate. Equivalently we pair the currencies with the second and third highest interest rate to the currencies with the second and third lowest interest rate. For notational purposes we will choose a

base currency for which all exchange rates are expressed as foreign currency units per base unit. The return of each investment can then be expressed as:

$$R_{t+1} = \frac{S_t}{S_{t+1}} (1 + r_t) - 1$$

Where the return of the investment is denoted by R, the currency spot rate by S and the interest rate for the investment by r. The efficient market hypothesis states that the two investments should offer the same expected return. If this hypothesis is violated, the carry trade offers a positive return assuming the right long/short position. The total return can be estimated as:

$$R_{t+1}^{CT} = \frac{S_t^H}{S_{t+1}^H} (1 + r_t^H) - \frac{S_t^L}{S_{t+1}^L} (1 + r_t^L)$$

Where H and L denotes the high and low interest rate respectively.

The next step in our research will be to see if one can get additional information by using order flow as an explanatory variable. The exact method for this is not yet decided, however the method used by Breedon, Rime and Vitale (2010) seems like a reasonable starting point.

7. Further Progress

The first step on our agenda is to collect data as described. After carefully examining the order flow data set we will choose which currencies to use in our research. The data further needs to be prepared for testing. As mentioned we will use the software program SAS when working with the order flow data set. This program is new to us and we expect the learning process to be time consuming. We plan to get familiar with the software and so prepare the data for testing in January - February. In March - April we hope to start testing, analyzing and interpreting the results. Finalizing the paper will be time consuming and we expect to be doing this by July.

This preliminary report will be presented in February 2012. Once we receive an evaluation of the work we have done so far, we can determine if we are on the right track or if adjustments need to be made. The methodology for the order flow test is not yet determined. We will have a closer look at the method used in the article “A Transaction Data Study of the Forward Bias Puzzle” by Breedon et al. (2010), to see if their approach can be used for our purpose.

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