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Home bias in currency carry trade

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Abstract

This thesis documents home bias in currency carry trade: i.e. carry trade activity from the main funding countries is biased towards investment countries that are located in the same region and thus more familiar to investors. My research provides new insight to the forward premium puzzle and arising currency carry trade excess returns stressing the importance of Switzerland, Japan and U.S. as the main funding countries in their own region during the sample period from January 1999 to January 2014. Utilizing spot and forward exchange rates of 28 currencies from EMEA, Asia Pacific and Americas, I form carry portfolios by sorting sample currencies based on their forward discount and examine the risk-return relationship between the main funding countries' funding liquidity measures and carry trade returns in these three regions. Furthermore, I test whether the tightening funding conditions in the main funding country are associated with currency crashes in the major investment countries located in the same region.

The results indicate that the main funding countries' key volatility measures and liquidity spreads have in general the highest explanatory power for carry trade returns in their own regions. While the liquidity spreads produce less significant values relating to carry trade returns, they prove to be more relevant measures when explaining the currency crashes in the major investment countries. I show that the contemporaneous change in the Swiss and U.S. volatility measures can alone explain around 20 percent of the regional currency carry trade returns and crashes in EMEA and Americas, respectively, leaving other main funding countries' volatility measures redundant. In Asia Pacific, the changes in the key volatility measure have also delayed effect to carry trade returns due to slow collective action of numerous Japanese retail investors. Japanese and U.S. funding liquidity measures explain together one third of the carry trade excess returns and over 40 percent of the currency crashes in major investment countries in Asia Pacific region.

Keywords Carry trade, home bias, regionality, forward premium puzzle, funding liquidity, implied volatility, risk aversion, TED spread, currency crash

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Tiivistelmä

Tutkin carry trade -toiminnan painottumista maihin, jotka sijaitsevat lähellä rahoitusmaata ja ovat näin ollen tutumpia sijoittajille. Tutkimukseni tähdentää Sveitsin, Japanin ja Yhdysvaltojen merkitystä päärahoitusmaina omilla alueillaan tutkimusjakson aikana tammikuusta 1999 tammikuuhun 2014. Otokseni koostuu 28 valuutasta EMEA:n, Aasian ja Tyynenmeren sekä Amerikan alueilta. Jaottelen valuutat termiini- ja avistakurssin erotuksen mukaan portfolioihin omilla alueillaan ja tutkin riskin ja tuoton suhdetta kolmen päärahoitusmaan rahoituslikviditeettimittareiden ja carry trade -tuottojen välillä. Lisäksi selvitän miten tiukentuvat rahoitusolosuhteet päärahoitusmaassa vaikuttavat valuuttaromahduksiin saman alueen merkittävimmissä investointimaissa.

Tulokset osoittavat, että päärahoitusmaiden volatiliteettimittarit sekä ero pankkien välisen koron ja valtion velkasitoumusten välillä selittävät yleisesti ottaen parhaiten carry trade -tuottojen kehitystä omilla alueillaan. Vaikkakin TED spreadit tuottavat tilastollisesti heikkoja arvoja liittyen carry trade -tuottoihin, niiden merkitys kasvaa huomattavasti selitettäessä valuuttaromahduksia tärkeimmissä investointimaissa. Yksinomaan muutokset Sveitsin ja Yhdysvaltojen volatiliteettimittareissa selittävät omilla alueillaan noin 20 prosenttia carry trade -tuotoista ja valuuttaromahduksista jättäen muiden rahoitusmaiden volatiliteettimittarit tarpeettomiksi. Aasian ja Tyynenmeren alueella keskeisen volatiliteettimittarin muutokset näkyvät osittain viiveellä carry trade -tuotoissa johtuen lukuisten japanilaisten yksityissijoittajien hitaasta kollektiivisesta toiminnasta. Japanin ja Yhdysvaltojen rahoituslikviditeettimittarit selittävät yhdessä kolmasosan carry trade -tuotoista ja yli 40 prosenttia valuuttaromahduksista merkittävissä investointimaissa Aasian ja Tyynenmeren alueella.

Avainsanat Carry trade, home bias, rahoitus likviditeetti, implisiittinen volatiliteetti, riskien välttäminen, TED spread, valuuttaromahdus

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1. Introduction

The currency carry trade is a popular trading strategy where one borrows in low interest rates "funding currencies" and invests in high interest rates "investment currencies". According to the uncovered interest parity (UIP), the carry gains arising from the differential between foreign and domestic interest rates are offset by the expected depreciation of the investment currency. However, investment currencies have been found to appreciate on average against funding currencies, moving completely opposite direction what the UIP would predict (see, e.g., Hansen and Hodrick, 1980; Fama, 1984). Thus, an investor participating in currency carry trade would earn the interest rate differential and also benefit from the investment currency appreciation during the holding period. This violation of the UIP makes the carry trade profitable on average and it is known as the "forward premium puzzle".

The positive currency excess returns have been widely documented for the past three decades. Although carry trade returns have decreased over time (see, e.g., Jylhä and Suominen, 2011), the forward premium puzzle still exist. Fama (1984) suggests that if investment currencies deliver low returns during bad times, then carry trade profits are nothing but compensation for higher risk-exposure. However, it has been difficult to identify risk factors behind carry trade returns. Recent studies find that the time-varying risk premium on investment currencies might reflect crash risk or rare disasters (see, e.g., Brunnermeier, Nagel, and Pedersen, 2009; Farhi, Fraiberger, Gabaix, Ranciere, and Verdelhan, 2013; Farhi and Garbaix, 2011; Jurek, 2014; Ferreira Filipe and Suominen, 2013) or the currencies might have different sensitivity to systematic risk factors (see, e.g., Lustig and Verdelhan, 2007; Lustig, Roussanov, and Verdelhan, 2011; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012; Verdelhan, 2010). While all these papers try to explain average excess returns on carry portfolios with global risk factors, my study aims to shed new light to the forward premium puzzle by examining the risk-return relationship between regional risk measures and carry trade returns.

1.1. Academic and practical motivation

In this thesis, I investigate home bias in carry trade. Although home bias is well documented phenomenon in equity markets, it has not been studied before in currency market to best of my knowledge. Grinblatt and Keloharju (2001) find that distance, language and culture are all factors influencing investors' investment decisions. People find familiar assets attractive and invest heavily in those, while they put little or no capital at all in ambiguous assets (Barberis and Thaler, 2003). In the carry trade setting, this means that investor would invest in high interest rate countries located usually in the nearby region with similar cultural backgrounds.

Carry trades can have significant effects on foreign exchange (FX) rates (Galati, Heath, and McGuire, 2007). In general, high interest rate currencies, which are targets for carry trades, strengthen and funding currencies weakens (Burnside, Eichenbaum and Rebelo, 2007). However, from time to time fundamental shocks in the market lead to a sudden unwinding of carry trades, causing investment currencies to crash and funding currencies to appreciate sharply (Brunnermeier and Pedersen, 2009). The average daily trading in the global FX market reached $5.3 trillion in April 2013 (Bank for International Settlements, 2014). A better understanding of what drives the carry trade returns and thus FX rates would be highly useful for the investors who trade in these huge markets.

My study is motivated by the novelty paper from Brunnermeier et al. (2009), where they show that funding liquidity measures predict exchange rate movements. I find the results relating to Chicago Board Options Exchange Market Volatility Index (VIX) and TED spread, which is the difference between the interest rates on 3-month interbank loans and on 3-month Treasury bill (T-Bill), especially interesting. They use VIX as a proxy of global risk aversion and TED spread as an indicator of tightening funding liquidity. When investors become more risk averse and liquidity in the interbank market dries out, funding constraints force speculators to unwind their carry trade positions. The investment currency depreciates as the speculative capital is withdrawn resulting in carry trade losses. This negative shock has spillover effects and is amplified as more speculators unwind their positions causing the investment currency to depreciate even further.

Moreover, Ferreira Filipe and Suominen (2013) stress that the funding risk in Japan, or in another major funding country Switzerland, is a better measure in explaining the carry trade returns than funding conditions and funding risk in the U.S. Their findings confirm the importance of Japanese yen (JPY) and Swiss franc (CHF) as major funding currencies besides the United States dollar (USD). Therefore, it is interesting to investigate more closely whether the funding liquidity measures of these three main funding countries have the highest explanatory power for carry trade returns when the investment country is located nearby and is more familiar to the investors.

1.2. Research problem and purpose

In order to test the home bias in currency carry trade I sort the sample currencies into three different groups according to their geographical location: EMEA (Europe, Middle East and Africa), Asia Pacific, and Americas. With this categorization, I try to capture both the distance and cultural aspects. I argue that CHF, JPY and USD are the main funding currencies in their own region. If investors prefer to invest in currencies that they are more familiar, then the funding liquidity measures of Switzerland, Japan and U.S. should have the highest explanatory power for carry trade returns in EMEA, Asia Pacific and Americas, respectively. Instead of trying to explain the currency carry trade excess returns with global funding liquidity measures, I focus on corresponding regional measures with the aim of getting more significant results.

To measure the funding liquidity in different regions, I select one key volatility measure and calculate TED spreads from each of the three main funding countries. My data set contains at most 28 different currencies and the sample period spans from January 1999 to January 2014. Following Lustig and Verdelhan (2007), I form portfolios from the sample currencies by sorting them based on their forward discount. My strategy is to borrow (invest in) the currency with the smallest (largest) forward discount within its own region. As a robustness check I also consider an alternative strategy where I go long (short) in the three currencies with the three largest (smallest) forward discounts. The portfolios are rebalanced at the end of every month. I expect the risk-return relationship between the main funding countries' liquidity measures and regional carry trade returns to be negative: when the key volatility measures and TED spreads increases the carry portfolios experience losses.

According to Brunnermeier and Pedersen's (2009) model of liquidity frictions, the tightening funding conditions in funding country are linked to large depreciations in investment currency. Hence, decreasing risk appetite and tightening funding liquidity in one of the main funding countries should also be associated with currency crashes in that regions' major investment countries. I test this by estimating a probit model where the dependent variable takes value 1 if crash happens and 0 otherwise. I define a crash when the monthly return of carry portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period.

1.3. Contribution to existing research

My empirical results provide evidence that carry trade activity is biased towards countries that are located in the same region than the main funding countries and thus more familiar to investors. I find the main funding countries' key volatility measures to be more significant variables than the liquidity spreads when explaining the regional carry trade returns. However, the liquidity spreads become also more meaningful when explaining currency crashes in the major investment countries. This is linked to the finding that the TED spreads are only relevant risk measures when there is turmoil in financial markets.

In EMEA, the contemporaneous change in the Volatility Index on the Swiss Market Index (VSMI), can alone explain around 20 percent of the regional currency carry trade returns, leaving other main funding countries' volatility measures redundant. Also in Americas, the CBOE Volatility Index, VIX, produces similar results and is the most dominant variable when explaining carry trade excess returns and currency crashes in that region. In Asia Pacific, however, the Volatility Index Japan (VXJ) and VIX are both relevant variables. While the change in VIX has larger contemporaneous effect to carry trade returns, interestingly part of the effect of increasing VXJ comes with delay as the collective action of numerous Japanese retail investors can be slow. When taking into consideration all the funding liquidity measures from Japan and U.S., they can together explain one third of the carry trade excess returns and over 40 percent of the currency crashes in Asia Pacific region.

My findings stress the importance of Switzerland, Japan and U.S. as the main funding countries in their own region. The results imply that investors participating in currency carry trade should pay attention to the Swiss volatility measures if the investment country is located in EMEA, and U.S. funding liquidity measures if the investment country is located in Americas. Moreover, when investing in Asia Pacific, also the U.S. funding liquidity measures are of interest in addition to the Japanese ones. Even though there are few papers that examine carry trade returns of some specific region or group of countries, my study is the first one to test how the geographical or cultural distance from the main funding country affects carry trade activity to best of my knowledge. This thesis contributes to the existing research by finding a home bias in currency carry trade and thus shedding new light to the forward premium puzzle.

1.4. Limitations of the study

My study has two main limitations. First, the currencies that have only non-deliverable forward (NDF) rates are excluded from the sample.[1] Doukas and Zhang (2013) compare the performance of NDF and deliverable forward carry trades and find that though they share common risk factors, the NDF carry trades are driven by deviations from covered interest parity (CIP) due to currency convertibility restrictions and capital controls.

The NDFs are offered by major financial institutions in the over-the-counter market and generally used to hedge exposure or speculate on a move in a currency where local market authorities limit such activity (see, e.g., Lipscomb, 2005; Doukas and Zhang, 2013). An NDF is alike a regular forward FX contract, except it does not require physical delivery of currencies at maturity and it is usually settled in U.S dollars as the other currency, typically an emerging market currency with capital controls, is “non-deliverable”. The currency convertibility restrictions and capital controls make onshore interest rate unavailable to international investors, which means that the offshore interest rates must be concluded from the NDF prices. This may lead to a situation where the onshore and offshore interest rates differs from each other as a result of a number of factors, such as market expectations and liquidity, perceived changes in foreign exchange policy, speculative positioning, accessibility to onshore money markets, and the relation between offshore and onshore currency forward markets (Ma, Ho, and McCauley, 2004; Lipscomb, 2005). While the CIP holds generally for deliverable forward currencies, Doukas and Zhang (2013) find that the gap between onshore and offshore interest rate for NDF currencies is economically large (-3.5% on annual basis), indicating deviations from CIP in offshore markets and superior performance of NDF carry trades.

Second, my estimates leave out of account bid-ask spreads on currency markets. An investor implementing carry trade using forward markets buys a forward contract at the ask price when he goes long on investment currency. After receiving the corresponding currency at the end of the contract, the investor converts the proceeds back into funding currency at the bid price. As a

[1] Argentine peso, Brazilian real, Chilean peso, Colombian peso and Peruvian nuevo sol were excluded from the sample. These five currencies from Americas region have only non-deliverable forward rates available starting from March 29, 2004.

result, the expected cost for doing this trade is half the bid-ask spread on both the forward and spot contract.

Taking into consideration the transaction costs would reduce the currency excess returns. Actually, Burnside et al. (2007) argue, that currency carry trades may be difficult to carry out due to the high transaction costs. Farhi et al. (2013) compute an average spread of 8 basis points for spot rates and 9 basis points for forwards in their sample of 32 countries during the period of 1996-2008. This would imply an annual cost around 100 basis points or 1 percent for a currency pair with 12 trades per year. However, such spreads might exaggerate transaction costs on currency markets, as investors may well roll over their positions each month instead of closing them just to reopen them again next day (Gilmore and Hayashi, 2008). This holds also for my currency portfolios. Even if the annual transaction costs would be around 100 basis points, all of the portfolios would still have large positive excess returns. All in all, the bid-ask spreads do not have a significant effect on my empirical findings regarding the explanatory power of different volatility measures and liquidity spreads for the carry trade returns and currency crashes.

1.5. Structure of the study

The rest of the paper is organized as follows. Section 2 presents the theoretical background and the previous empirical findings explaining the forward premium puzzle and carry trade excess returns. In Section 3, I discuss my hypotheses. Section 4 presents the data and methodology used in the study. In Section 5, I analyze the empirical results relating to the risk-return relationship between the main funding countries' liquidity measures and regional carry trade returns. Finally, Section 6 concludes and gives suggestion for further research.

1.6. Definitions

Table 1 below explains the key terms used in this thesis in order to ensure that the reader is aware of exact meanings and definitions of these frequently used terms and also to make the reading of the thesis easier.

Table 1: Definition of key terms

Carry trade	A trading strategy in which an investor borrows in a currency with a relatively low interest rate and invests the funds in a currency yielding a higher interest rate
Currency excess returns	Ex post deviations from the uncovered interest rate parity condition
Forward exchange rate	The rate at which trader agrees to exchange one currency for another at some specified future date
Forward discount (or premium)	A currency trades at a forward discount (premium) when its forward price is lower (higher) than its spot price
Funding currency	A currency with relatively low interest rate
Funding liquidity	The ease with which traders can obtain funding from the markets
Home bias	The tendency for investors make financial investments in their home markets rather than in foreign markets
Investment currency	A currency with relatively high interest rate
London Interbank Offered Rate (LIBOR)	An indication of the average rate at which some of the world's leading banks charge each other for unsecured short-term loans, in a given currency
Liquidity spreads	I use the following commonly used indicators of liquidity in interbank markets to capture the funding liquidity in different markets: • U.S. TED spread (TED) – the difference between 3-month USD LIBOR and 3-month U.S. Treasury bill • Swiss TED spread (S-TED) – the difference between the 3-month CHF LIBOR and Switzerland's 3-month federal money market debt register claims • Japanese TED spread (J-TED) – the difference between the 3-month JPY LIBOR and the Japanese Government 3-month Bill
Uncovered interest rate parity (UIP)	UIP states that the difference between two countries' interest rates is equal to the expected change in exchange rates between these countries' currencies
Unbiasedness hypothesis	This hypothesis states that assuming risk neutrality and rational expectations, the forward exchange rate is an unbiased predictor of the future spot exchange rate
Volatility measures	I use the following measures of implied volatility of stock index options to capture the risk aversion in different markets: • CBOE Volatility Index (VIX) – a measure of market expectations of volatility over the next 30 day period conveyed by S&P 500 stock index option prices • Volatility index on the SMI (VSMI) – a duration-independent index that applies implicit variances to all Eurex-traded SMI options • Volatility index Japan (VXJ) – a model-free index of market volatility implicit in the bid and asked prices of Nikkei225 options

2. Theoretical background

In this section I provide an overview on the existing literature. First, I discuss about the forward premium puzzle which refers to the well documented empirical finding that high interest rate currencies tend to appreciate on average relative to low interest rate currencies. The failure of unbiasedness hypothesis makes it possible for a speculator to pursue large excepted returns through currency carry trade. The question then turns out to be whether the findings of this bias are to be interpreted as a time-varying risk premium or as systematic expectation errors. I review arguments both in favor and against these views. Finally, I present the novelty empirical findings and theory behind the paper of Brunnermeier et al. (2009), where they show that funding liquidity measures predict exchange rate movements.

2.1. Forward premium puzzle and carry trade excess returns

The forward premium puzzle and the arising carry trade strategy have been widely documented for the past three decades. Large expected excess returns from currency carry trades challenge the benchmark models in international macroeconomics by bringing out the failure of uncovered interest parity and the fact that the forward rate does not provide an unbiased forecast of the future spot rate. Actually, in a regression of the future change in the spot rate against the forward discount, the exchange rate was found to move in exactly the opposite direction on average from what was forecasted. This unexpected finding has been replicated several times, on various sets of data, and with many refinements.[2]

To fix the concept and terms, I define the k-period interest rate of home and foreign country at time t as i_t^k and i_t^{k*}, respectively. S_t is the spot rate at time t and F_t^k is the forward rate at time t for a trade to take place at time k. The gross return for lending in the domestic money market is simply:

$$1 + i_t^k \tag{1}$$

Assuming there are no arbitrage opportunities, an investor should get same return than in (1) also by converting currency at the spot exchange rate in order to lend in foreign currency and hedging

[2] For surveys see Froot and Thaler (1990), Lewis (1995), Sarno (2005) or Engel (2013).

his exchange rate risk by buying home currency in the forward market. The return of this strategy is:

$$\left(1+i_t^{k*}\right)\frac{F_t^k}{S_t} \tag{2}$$

Since lending home currency and lending foreign currency combined with a forward hedge are both nominally riskless the investor should be indifferent whether to choose either (1) or (2), implying the covered interest parity condition:

$$\frac{\left(1+i_t^{k}\right)}{\left(1+i_t^{k*}\right)}=\frac{F_t^k}{S_t} \tag{3}$$

The uncovered interest parity states that the no-arbitrage condition is satisfied without the use of a forward hedge against exposure to exchange rate risk. Then the interest differential between home and foreign country should be an unbiased forecast of the future spot rate. Thus, one should expect:

$$S_{t+k}=F_t^k+u_{t+k} \tag{4}$$

where the forward rate equals the rational expectation of the spot rate at time t+k, given information available at time t, and the error term u_{t+k} is an expectational error.

The puzzle is that in a regression of the future change in the spot rate against the forward discount, not only do the regression estimates find the slope coefficient to differ from unity but it is even slightly negative on average, indicating a bias in the forward exchange rates (Chinn, 2007). In order to take a closer look for the different components of the forward premium puzzle, equation (4) can be rewritten by taking logarithms (indicated by lowercase letters) and subtracting the current log spot rate s_t from both sides:

$$\Delta s_{t+k}=\beta_0+\beta_1(f_t^k-s_t)+\tilde{u}_{t+k} \tag{5}$$

where the left hand side of the equation is ex post future depreciation, defined as, $s_{t+k}-s_t$, and the term in the parentheses is the forward discount. Equation (5) is a standard regression equation used to test the unbiasedness hypothesis, where under the null $\beta_0=0$ and $\beta_1=1$, and the error term, $\tilde{u}_{t+k}$, equals to the forward market forecast error. The null implies that there is no systematic time-varying component to the forecast errors: $E_t(\Delta s_{t+k}) - (f_t^k - s_t) = \beta_0$. To be more precise, the unbiasedness hypothesis is actually a joint hypothesis of rational expectations: $E_t(\Delta s_{t+k}) = \Delta s_t^e$, where $E_t(\Delta s_{t+k})$ is the mathematical expectation and Δs_t^e is the expectation held by investors, and the condition of no time-varying risk premium: $p_t \equiv E_t(\Delta s_{t+k}) - (f_t^k - s_t) - \beta_0 = 0$.

In a typical carry trade, an investor borrows funds in a low interest “funding currency” in order to lend in a high interest “investment currency”. If UIP held, the investor would expect to make zero profits on average, because the interest differential (or forward discount) would reflect the expected depreciation of the investment currency against the funding currency. But the null hypothesis of unbiasedness is almost always rejected statistically. In their paper, Meese and Rogoff (1983) find that exchange rates changes follow a near random walk, which gives investors an opportunity to gain from the interest differential without suffering from the depreciation of the investment currency. That is only a near random walk, as Fama (1984) shows that on average investment currencies tend to even appreciate against the funding currencies. For instance, Froot and Thaler (1990) find in their survey an average estimate of -0.88 for β_1.

The puzzling result that the coefficient estimates are typically negative suggests that the investor implementing a carry trade would also benefit from the investment currency appreciation during the holding period on top of the forward discount. However, Chinn and Meredith (2004) show that while β_1 is negative on average at short time periods (under one year), the bias tends to decrease at longer horizons. Furthermore, Frankel and Poonawala (2010) argue that the forward market in emerging currencies is less biased than in major currencies and find the coefficient for emerging market currencies to be on average slightly above zero. Also, recent studies report that carry trade returns have decreased over time, suggesting evidence that the bias has decreased in general over the last forty years (see, e.g., Jylhä and Suominen, 2011).

There are several reasons why the forward premium puzzle persists even when capital is perfectly mobile according to the covered interest parity. Almost all of the explanations fall into two categories focusing either on the risk premium or the invalidity of the rational expectations hypothesis. Vast majority of the authors contribute to the first category and interpret the systematic component of the forward market's forecast errors as a risk premium while at the same time upholding the rational expectations hypothesis. The second category of explanations question the validity of the rational expectations hypothesis and find that market participants have systematic expectation errors, at least within the sample.[3] I will next review arguments both in favor and against these different views.

2.1.1. Conventional risk-based explanations

Perhaps the most conventional explanation for the failure of UIP is that there exists a risk premium which account for differences between expected changes and actual changes in spot rates. However, it has been hard to come up with risk-based models that could fully explain the forward premium puzzle. In a simplistic model, risk premium can be measured by assuming that the exchange rate follows a random walk. This would suggest that the forward premium is the risk premium. The problem with this model, however, is that it is purely mechanical and does not provide us any information with economic source of risk (Burnside, 2008).

Engel (1996) provides a survey of the early attempts to model the risk premium, including tests of the consumption CAPM and the latent variable models as well as portfolio-balance and general equilibrium models. He concludes that while many things have been ruled out, we have not yet found a model of expected returns that fits the data. He stresses further, that in order to explain the puzzle, the models need to generate correlations between the risk premium and the forward premium.

Since then, many other risk-based explanations have been forwarded from presence of sticky prices in general equilibrium models to consumption based risk premiums and external habit preferences. Engel (1999) examines the properties of the risk premium in sticky-price general equilibrium models. He compares the two models of Obstfeld and Rogoff (1998) and Devereux and Engel (1998), where monetary shocks will cause changes in consumption because of sticky prices and risk premiums arise due to covariation of consumption and exchange rates. He finds that while Devereux and Engel (1998) model is capable of producing large enough risk premiums to match the data, it cannot generate correlation between the risk premium and the interest differential.

[3] The term, systematic expectation errors, is intended to cover the important areas of learning, peso problems, tests of rational expectations based on survey data and the models of irrational expectations and speculative bubbles.

More recently, Lustig and Verdelhan (2007) show by building currency portfolios according to their forward discount that UIP fails in the cross-section between the returns of high and low interest rate currencies. They conclude that large excess returns can be achieved by simply holding bonds from currencies with currently high interest rates, which have higher loading on US consumption growth risk. Burnside (2007) argues, however, that the stochastic discount factor corresponding to Lustig and Verdelhan's (2007) model is uncorrelated to carry trade portfolio returns and the forward premium puzzle remains a puzzle. Also Lustig et al. (2011) favor a risk-based explanation and use a two-factor interest rate model to explain the cross-sectional variation in average excess returns between high and low interest rate currencies. Their measure of volatility estimates the systematic risk of currency markets without using any exchange rate or interest rate data. They find that in the times of high global volatility, investment currencies tend to depreciate and funding currencies tend to appreciate, which means that investors load up on global risk by participating in currency carry trade. Moreover, Verdelhan (2010) shows how risk emerging from consumption habits affects the carry trade returns. He finds that during bad times at home country, the domestic interest rates are low, consumption is close to the habit level and investors are more risk averse. The changes in exchange rates follow domestic consumption shocks when the domestic investor is more risk averse than the foreign investor in high interest rate country, implying positive currency carry trade excess returns.

Despite the latest developments in risk-based models, they have not yet been able to fully explain the forward premium puzzle. Burnside, Eichenbaum, Kleshchelski and Rebelo (2011) construct stochastic discount factors from traditional risk measures such as consumption growth, stock returns, etc., and find that these risk factors are all statistically uncorrelated with carry trade excess return. The same is true for carry portfolios sorted on the basis of the forward premium. They make a straightforward argument – "without covariance a risk-based story can't work". If expected excess return from currency carry trade is non-zero, then the return must covary with the risk factor.

2.1.2. Systematic expectation errors and rare disasters

Systematic expectation errors include learning, peso problem and other sources of error patterns that appear statistically significant within the sample (Frankel and Poonawala, 2010). The definition itself does not necessarily mean that market participants are irrational. Among those who fall into the category of attributing the findings of the bias to systematic expectation errors are Froot and Frankel (1989). They demonstrate that the standard tests for UIP produce significantly different results when survey-based measures of exchange rate depreciation are used and find that vast majority of the variation of the forward discount seems to be related to expected depreciation rather than a time varying risk premium.

As mentioned, the rejection of the rational expectations hypothesis does not necessarily mean that market participants are irrational. It may be that market participants' forecasts are biased as they are constantly learning about the economic environment. Lewis (1989) is one of the early studies incorporating Bayesian learning. In her paper, she investigates how the increase in U.S. money demand in the early 1980s affected average dollar forecast errors as the market was learning about the new process of money. More recently, Bacchetta and van Wincoop (2010) argue that infrequent portfolio decisions can explain the forward premium puzzle. They show that little of foreign exchange exposure is actively managed as the welfare gains for doing so are generally below fees charged. Because of this infrequent decision making the impact of interest rate shocks on exchange rates is delayed and leads to substantial excess return predictability.

Another argument why the exchange rate puzzles might exist is a "peso problem". Originally, the peso problem referred to a situation where market participants anticipate rare switches in monetary policy that are infrequently observed.[4] Classical example of this is from the early 1970s, when the Mexican peso traded at a forward discount for several years even though being pegged to the United States dollar. Rogoff (1980) argues that the forward discount seemed to be a poor predictor of the change in the value of the peso as the market participants were anticipating a policy-driven devaluation of the peso, which did not occur until 1976. The proposal that the high measured excess returns are due to some infrequent event that has not materialized or is insufficiently represented in the sample would imply that carry trade returns that cannot be explained with observed skewness might still be explained with unobserved skewness.

More recent literature around infrequent events that lead to big negative payoffs tries to explain the forward premium puzzle with "rare disaster" models. In the model of Farhi and Gabaix (2011), countries differ in their exposures to rare global disasters according to a mean-reverting

[4] Early examples include Rogoff (1980) and Krasker (1980). For nice survey, see Lewis (1995).

process. Countries with high risk premium have depreciated exchange rate and high interest rate, but as their risk premium mean reverts their exchange rate appreciates, explaining why high interest rate currencies appreciate on average. However, Burnside et al. (2011) argue that the average payoff of the hedged carry trade is too close to the average payoff of the unhedged carry trade for peso problems or rare disasters to be plausible. They document that even after covering most of the downside risk with currency options carry trades still seem to be profitable. Farhi et al. (2013) decompose the currency risk premia into a Gaussian and a disaster risk premium. They form portfolios of hedged and unhedged carry trade excess returns and find that although disaster risk has a significant effect in explaining currency returns, it does not account for all carry trade returns. On average, the disaster risk premium explains over one third of carry trade returns in their recent sample period, 1996-2011, but an investor can still obtain significant excess returns while being hedged against large currency crashes due to the remaining Gaussian, non–disaster risk. Also Jurek (2014) finds the excess returns of crash-hedged currency carry trades to remain positive and statistically significant, indicating that the high returns to carry trades are not due to peso problems. Further, he compares the returns of hedged and unhedged currency carry trades and reports slightly smaller crash risk premium for the excess returns than Farhi et al. (2013).

2.2. Funding liquidity as a risk factor

The empirical failure of conventional risk models or peso problem explanations has led to a variety of alternative explanations of the returns to the carry trade or, equivalently, the forward premium puzzle. My research is inspired by the novelty paper from Brunnermeier et al. (2009), where they show that funding liquidity measures predict exchange rate movements. I find the results relating to VIX implied volatility and TED spread the most interesting. Both variables seem to be negatively contemporaneously correlated with currency excess returns, while the explanatory power of TED spread is also statistically significant for carry trade returns a week ahead.

Brunnermeier et al. (2009) empirical findings share several features of the liquidity spirals that arise in the theoretical model in Brunnermeier and Pedersen (2009). They show that speculators invest in securities with positive average return and negative skewness. The positive average return is compensation for providing liquidity to the market and the securities are negatively skewed because of the market participants’ asymmetric response to fundamental shocks. These shocks lead to speculator losses and are amplified when speculators unwind their positions as they hit funding constraints. This causes the value of the securities to depress even further leading to increased funding problems and higher volatility and margins in the market. On the contrary, positive shocks leading to speculator gains are not intensified.

What makes the model with liquidity frictions unique is that it offers an explanation to the forward premium puzzle which is dependent neither on a conventional risk mechanism, nor on peso problems. If we picture a standard exchange rate setting where UIP holds, then a country suddenly increasing its interest rate would attract new foreign capital which should lead to an immediate appreciation of the currency followed by an expected future depreciation of the exchange rate. In a model with liquidity frictions, however, the currency only appreciates gradually as investors respond to the interest rate increase slowly. In the meantime, holding on to the currency carry trade is profitable due to the deviations from UIP. The effect of slow moving capital is also documented in other markets (see, e.g., Mitchell, Pedersen, and Pulvino, 2007; Duffie, 2010).

Liquidity frictions have also a remarkable impact in currency crashes. Currency carry trades are usually highly leveraged and conducted by professional investors (Galati et al., 2007). Local equity is common collateral, so the market prices affect the available collateral of investors. Also banks in the main funding countries are large investors in the local equity market themselves, so when the volatility increases in the local stock market, they are less likely to lend more money or accept local equity as collateral (Ferreira Filipe and Suominen, 2013). The deviations from UIP are reduced when professional investors lever up their carry trades, but as a consequence also investors' risk of forced liquidation increases (Brunnermeier et al. 2009). Furthermore, it becomes more expensive for investor to hedge the carry trade portfolios when the perceived downside risk increases. These effects are having a negative impact in investors' willingness to speculate. Hence, in the face of shocks that lead to speculator losses, the liquidity in the market goes down and capital constraints are likely to force hedge funds and other speculators to unwind their carry trade positions from investment currencies, which then crash due to the sudden capital flight. Brunnermeier et al. (2009) find that carry trades experience often losses exactly at the times when speculators face funding problems.

As discussed above, funding constraints seem to be especially relevant during the times of financial stress and increased risk aversion. Brunnermeier et al. (2009) show that the volume of speculative trading and the carry trade returns decreases during the weeks when VIX index increase. The VIX, which measures the implied volatility of the S&P 500, is not mechanically linked to exchange rates since it is derived from equity options. It is often referred to as the “fear index” as during periods of financial stress and steep market declines, options tend to become more expensive. Thus, the greater the fear in the market, the higher the level of VIX. This explains why the changes in implied volatility measures are also interpreted as changes in investors’ risk aversion. When VIX increases, investors lose their general appetite for risk, which is seen as decreased speculation in the FX market. The unwinding of carry trade positions has spillover effects on other speculators leading to even larger losses.

As another proxy for funding liquidity, Brunnermeier et al. (2009) use the TED spread, which is the difference between the 3-month London Interbank Offered Rate (LIBOR), based on U.S. dollar, and the 3-month U.S. T-Bill rate. This spread indicates liquidity in the interbank markets, among other things. The LIBOR Eurodollar rate reflects uncollateralized lending in the interbank market, which is subject to default risk, while the T-Bill rate is riskless since it is guaranteed by the U.S. government. When banks face liquidity problems their willingness to provide funding in the interbank market weakens. This leads to increase in the TED spread and often decline in the T-Bill rate due to a flight-to-liquidity or fight-to-quality. Brunnermeier et al. (2009) show that increase in the TED spread has similar but less significant effects than a rise in VIX. Furthermore, the TED spread is also correlated with carry trade losses one week ahead. The negative correlation between the TED spread and carry trade returns provides evidence in support of the Brunnermeier and Pedersen (2009) theoretical model of liquidity spirals.

Relating to findings above, Ferreira Filipe and Suominen (2013) also stress the importance of funding constraints in currency speculation, but find that the funding risks in Japan and Switzerland are better measures in explaining the carry trade returns than funding conditions and funding risk in the U.S. (such as the VIX and the TED spread). They measure funding risk for carry trades using the equity options’ implied stock market volatility and crash risk in Japan and show that these measures can explain 42% of the monthly currency carry trade returns during their sample period, 2000-2011. In addition, Ranaldo and Söderlind (2010) argue that some currencies are viewed simply as safe havens and they tend to appreciate when stock market volatility increases. This result gives support to Brunnermeier et al. (2009) findings that unwinding of carry trades is correlated with VIX. Menkhoff et al. (2012) also confirm some relevance for illiquidity as a risk factor. However, they argue that the global volatility risk obtained from currency markets dominates liquidity risk and find that FX volatility can explain the cross-section of interest rate-sorted currency portfolios. Furthermore, Melvin and Taylor (2009) present financial stress index that have some predictive power for carry trade returns.

3. Hypotheses

Unlike the existing literature, which largely relies on different global measures of risk when trying to explain the positive excess returns of currency carry trade, my study provides an alternative explanation to the forward premium puzzle by finding home bias in the carry trades. In this section, I outline the hypotheses that are tested later on in the empirical section of the study. I also provide a brief theoretical background behind the stated hypotheses.

The theoretical background for my study comes from the paper of Brunnermeier et al. (2009). They show that decreasing risk appetite and tightening funding liquidity affect the carry trade returns. They use VIX as a proxy of global risk aversion and TED spread as an indicator of tightening funding liquidity. When VIX and TED spread increase, funding constraints lead to increased volatility and increased margins, forcing speculators to unwind their carry trade positions. The investment currency depreciates as the speculative capital is withdrawn resulting in carry trade losses. This negative shock has spillover effects and is amplified as more speculators unwind their positions causing the investment currency to depreciate even further.

My main argument is that instead of trying to explain the currency carry trade excess returns with global funding liquidity measures, one should use corresponding regional measures. Ferreira Filipe and Suominen (2013) stress that funding constraint and funding risk in Japan or in another funding country, Switzerland, are better measures in explaining the carry trade returns than funding conditions in the U.S. Their findings confirm the importance of Japanese yen and Swiss franc as major funding currencies besides the United States dollar. Nevertheless, one of these three currencies is usually more often used as a funding currency in carry trades than the others, depending on the investment currency. I argue that CHF, JPY and USD are the main funding currencies in their own region, and due to this regionality the funding liquidity measures of Switzerland, Japan and U.S. should have the highest explanatory power for carry trade returns in EMEA, Asia Pacific and Americas, respectively.

H1: *The main funding countries' key volatility measures and liquidity spreads have the highest explanatory power for carry trade returns in their own regions*

Carry trades are extremely difficult to track from the available data which makes it challenging to draw the lines for the principal regions of the main funding countries (Galati et al., 2007). One reason to assume that there is regionality in carry trades is that investors prefer securities they are familiar with. The familiarity is widely documented phenomenon in stock market.[5] People find familiar assets attractive and invest heavily in those, while they put little or no capital at all in ambiguous assets (Barberis and Thaler, 2003). In the carry trade setting, this means that investor would invest in high interest rate country located usually in the nearby region with similar cultural background.

According to the model of liquidity frictions, the tightening funding conditions in funding country are linked to large depreciations in investment currency. Hence, decreasing risk appetite and tightening funding liquidity in one of the main funding countries should be associated with currency crashes in that regions' major investment countries as the speculative capital is withdrawn.

H2: *Tightening funding conditions in the main funding country are associated with currency crashes in the major investment countries in that region*

To test the hypotheses I use spot and forward exchange rate data of 28 currencies commonly used in carry trades. The data and methodology is described in the following section.

[5] Coval and Moskowitz (1999) show that mutual fund managers in U.S. favor stocks whose company headquarters are located nearby their funds' home office. However, Coval and Moskowitz (2001) argue fund managers' preference for the familiar stocks can be explained with information-based story. They stress that fund managers focus on local firms as they are cheaper to research. Grinblatt and Keloharju (2001) argue against the information-based explanation and find that distance, language and culture are all factors influencing investors' investment decisions.

4. Data and methodology

This section describes the currency spot and forward rate data, formulation of carry trade excess returns and construction of the carry portfolios. Furthermore, I present the risk measures used in the empirical analysis and methodology applied in the study.

4.1. Data on spot and forward rates

My data set contains at most 28 different currencies, including Australian dollar (AUD), Canadian dollar (CAD), Chinese yuan (CNY), Czech koruna (CZK), Danish krone (DKK), Euro (EUR), Hong Kong dollar (HKD), Hungarian forint (HUF), Indian rupee (INR), Indonesian rupiah (IDR), Japanese yen (JPY), South Korean won (KRW), Malaysian ringgit (MYR), Mexican peso (MXN), New Taiwan dollar (TWD), New Zealand dollar (NZD), Norwegian krone (NOK), Philippine peso (PHP), Polish złoty (PLN), Pound sterling (GBP), Russian ruble (RUB), Singapore dollar (SGD), South African rand (ZAR), Swedish krona (SEK), Swiss franc (CHF), Thai baht (THB), Turkish lira (TRY), and United States dollar (USD).

The sample period spans from January 1999 to January 2014. The data for daily spot exchange rates and daily 1-month forward exchange rates to USD are obtained from Barclays Bank International and WM/Reuters via Datastream. The forward rates are available for CNY, KRW and PLN starting from February 11, 2002 and for RUB starting from March 29, 2004.

Following Lustig et al. (2011), I exclude the following observations from my sample due to large failures of covered interest parity in these countries: Malaysia from August 1998 to June 2005, Indonesia from December 2000 to May 2007, and Turkey from October 2000 to November 2001. In addition, Jones (2009) reports widespread deviations from covered interest rate parity during the latest financial crisis in the fall 2008. However, these deviations have only limited effect on the average excess returns during my whole sample period, but as a robustness check, I also present the results excluding the financial crisis period.[6]

[6] Jones (2009) show deviations from the CIP during the financial crisis would have made it possible for an arbitrageur to profit 126bp by borrowing in 12-month USD LIBOR and investing in 12-month EUR LIBOR. Returns of this magnitude in one of the 15 years of my sample can be considered as measurement error as they would only change the average return by around 8 basis points.

Spot and forward rates to the other currencies than USD are derived from the spot and forward rates to USD assuming there are no triangular arbitrage opportunities:

$$\frac{Foreign\ currency}{Home\ currency} = \frac{Foreign\ currency}{USD} \bigg/ \frac{Home\ currency}{USD} \tag{6}$$

Furthermore, I sort the sample currencies into three different groups according to their geographical location: EMEA (Europe, Middle East and Africa), Asia Pacific, and Americas. Table 2 shows this division between the regions. There are 12 currencies under EMEA, 13 under Asia Pacific and three under Americas. The reason why Americas has only three currencies is because most of the other candidates from that region, such as Argentine peso, Brazilian real, Chilean peso, Colombian peso and Peruvian nuevo sol, had only non-deliverable forward rates available and were therefore excluded from the sample.[7]

Table 2: Currencies by region

EMEA	**Asia Pacific**	**Americas**
Czech koruna (CZK)	Australian dollar (AUD)	Canadian dollar (CAD)
Danish krone (DKK)	Chinese yuan (CNY)	Mexican peso (MXN)
Euro (EUR)	Hong Kong dollar (HKD)	United States dollar (USD)
Hungarian forint (HUF)	Indian rupee (INR)	
Norwegian krone (NOK)	Indonesian rupiah (IDR)	
Polish złoty (PLN)	Japanese yen (JPY)	
Pound sterling (GBP)	South Korean won (KRW)	
Russian ruble (RUB)	Malaysian ringgit (MYR)	
South African rand (ZAR)	New Taiwan dollar (TWD)	
Swedish krona (SEK)	New Zealand dollar (NZD)	
Swiss franc (CHF)	Philippine peso (PHP)	
Turkish lira (TRY)	Singapore dollar (SGD)	
	Thai baht (THB)	

This table shows the sample currencies sorted to three geographical regions: EMEA (Europe, Middle East & Africa), Asia Pacific, and Americas. The sample period spans from January 1999 to January 2014. Due to data limitations in the forward market CNY, KRW and PLN are included in the sample starting from February 11, 2002 and RUB from March 29, 2004 onwards. Also the following observations are removed from the sample due to large failures of covered interest parity: MYR from August 1998 to June 2005; IDR from December 2000 to May 2007; TRY from October 2000 to November 2001.

[7] Doukas and Zhang (2013) show that NDF carry trades are driven by deviations from covered interest parity due to currency convertibility restrictions and capital controls.

4.2. Currency excess returns and carry portfolios

The carry trade strategy where one borrows in low interest rate currencies and invests in high interest rate currencies can also be implemented using only spot and forward exchange rate contracts (see, e.g., Galati et al., 2007). There are some practical benefits for using forward currency markets instead of Treasury bill markets. In forward currency markets the carry trade is easy to implement and the contracts are subject to minimal default and counter-party risk (Lustig et al., 2011). The downside of forward currency market is that it only exists for a limited set of currencies and shorter time periods.

The empirical analysis is carried out at monthly frequency using end-of-month values. Following Fama (1984), I use logarithms of spot and forward exchange rates for ease of exposition and notation. I denote the log of the spot exchange rate in units of investment currency per funding currency at time t by s_t, and the log of the forward exchange rate in units of investment currency per funding currency at time t by f_t. So, when *s* increases the funding currency appreciates. The monthly excess return z_{t+1} on buying an investment currency in the forward market and then selling it in the spot market after one month is:

$$z_{t+1} = f_t - s_{t+1} \tag{7}$$

The excess return can also be written as the log forward discount minus the rate of depreciation:

$$z_{t+1} = f_t - s_t - \Delta s_{t+1} \tag{8}$$

where $\Delta s_{t+1} = s_{t+1} - s_t$. Akram, Rime and Sarno (2008) show that covered interest rate parity holds closely at daily and lower frequencies, indicating that the forward discount is equivalent on interest rate differential: $f_t - s_t \approx i_t^* - i_t$. Accordingly, the log currency excess return equals approximately the interest rate differential less the rate of depreciation:

$$z_{t+1} \approx i_t^* - i_t - \Delta s_{t+1} \tag{9}$$

As discussed in Section 2.1., the failure of UIP makes the carry trade profitable on average. According to UIP, the expected excess return from the carry trade should be zero because the forward discount (or interest rate differential) reflects the expected depreciation of the investment currency against the funding currency. However, contrary to expectations, investment currencies tend to appreciate against funding currencies on average. Knowing this, a speculator could try to maximize his excess returns by finding a currency pair with largest forward discount, as he would earn that differential and also benefit from the investment currency appreciation during the holding period.

Following Lustig and Verdelhan (2007), I form portfolios by sorting the sample currencies based on their forward discount. My strategy is to borrow (invest in) the currency with the smallest (largest) forward discount within its own region. I denote this long-short strategy by HmL (High-minus-Low). For robustness purposes, I also consider an alternative HmL3 strategy for EMEA and Asia Pacific regions. In this strategy I go long (short) in the three currencies with the three largest (smallest) forward discounts. In Americas region, where there are only three sample currencies, HmL3 strategy is not possible to implement. The portfolios are rebalanced at the end of every month.

During my sample period, Swiss franc, Japanese yen and United States dollar were typically considered the standard funding currencies in their own regions. Turkish lira, South-African rand and Hungarian forint were some of the major investment currencies in EMEA. They were all included in the HmL3 portfolio over 85% of the time. Moreover, Turkish lira was investment currency approximately 80% of the time in HmL portfolio. In Asia Pacific, I went long mainly in Indian rupee, Indonesian rupiah, New Zealand dollar and Philippine peso. In Americas, Mexican peso was investment currency during the whole sample period. Table A.1 in Appendix A shows the breakdown of the carry portfolios' funding and investment currencies.

4.3. Risk measures

The risk measures used in this study are equivalent to the funding liquidity measures in Brunnermeier et al. (2009). They find that decrease in global risk appetite, measured by VIX implied volatility, coincides with reductions in speculator carry positions and carry trade losses. Furthermore, they show that an increase in the TED spread leads to tightening funding liquidity and has similar effects than increase in the VIX although with less statistical power. Where Brunnermeier et al. (2009) use only U.S. based funding liquidity measures in their study, I argue that the key volatility measures and liquidity spreads of the other two major funding countries, Switzerland and Japan, have higher explanatory power for the carry trade returns in their own regions. To examine this, I have selected one key volatility measure and liquidity spread from each main funding country.

4.3.1. Volatility measures

Changes in implied volatility measures for options can be interpreted as changes in investors' risk appetite. When the volatility measure gets higher values investors become more risk averse. In the model of Brunnermeier et al. (2009), fall in the general risk appetite would lead to decreased speculation in the currency market and carry trade losses as investors unwind their carry trade positions. To capture the changes in investors' risk aversion in different regions, I use the following three volatility measures: CBOE Market Volatility Index – VIX, Volatility Index on the Swiss Market Index (SMI) – VSMI, and Volatility Index Japan – VXJ.

VIX measures market expectation of near term volatility conveyed by S&P 500 index option prices. It is commonly used measure of risk aversion and market volatility in the U.S. While the VIX is clearly one of the most important volatility measures in Americas, it is also considered to be the premier barometer of investor sentiment in the whole world. The daily values for VIX are retrieved from CBOE website.[8]

VSMI model uses the implicit variances of all Eurex-traded SMI options of the same duration to measure the pure volatility in the market. It is a tool that enables investors to monitor anticipated fluctuations in the SMI index over the next month. As Switzerland is the main funding country in EMEA, the VSMI should also be the key measure of funding liquidity in that region. The daily data for the VSMI is available via the SIX Swiss Exchange website.[9]

VXJ is a model-free index of market volatility implicit in the bid and asked prices of Nikkei225 options traded at the Osaka Securities Exchange. It provides a measure of how volatile the Japanese stock market will be over the next month. As Japan is the main funding country in Asia Pacific, VXJ should also be the key measure of funding liquidity in that region. The data for VXJ is available from Osaka University's Center for the Study of Finance and Insurance website.[10]

[8] http://www.cboe.com/micro/vix/historical.aspx
[9] http://www.six-swiss-exchange.com/indices/data_centre/strategy_indices/vsmi_en.html
[10] http://www-csfi.sigmath.es.osaka-u.ac.jp/en/activity/vxj_download.php?

4.3.2. Liquidity spreads

The interest rate difference between 3-month LIBOR and 3-month Treasury bill, known as TED spread, is a commonly used indicator of liquidity in interbank markets. LIBOR rate indicates the uncollateralized lending in the interbank market, while the Treasury bill rate is considered to be riskless since it is guaranteed by the government. When banks face liquidity problems, the TED spread generally increases. Brunnermeier et al. (2009) show that a rise in the TED spread is correlated with carry trade losses also with one week delay. The negative correlation between liquidity spreads and carry trade returns would provide a strong link to the model of liquidity friction from Brunnermeier and Pedersen (2009).

To capture the tightening liquidity in the different regions, I compute the TED spreads for U.S., Switzerland and Japan. In order to separate these three liquidity spreads, I denote Swiss TED spread by S-TED and Japanese TED spread by J-TED. The spreads are calculated as

$$TED_t = i_t^{LIBOR} - i_t^{TBILL} \tag{10}$$

where i_t^{LIBOR} is the 3-month LIBOR rate and i_t^{TBILL} is the 3-month Treasury bill rate. In the United States, TED is the difference between 3-month USD LIBOR and 3-month U.S. Treasury bill. S-TED is the spread between the 3-month CHF LIBOR and Switzerland's 3-month federal money market debt register claims, and J-TED is the spread between the 3-month JPY LIBOR and the Japanese Government 3-month Bill. I obtain the interest rates for 3-month LIBOR and 3-month government debt for U.S., Switzerland and Japan from Datastream.

4.3.3. Correlation between the regional risk measures

Table 3 shows the correlation between the risk measures during the sample period. Forbes and Rigobon (2002) find that there is a high level of market co-movement in all states of the world, not only during the crises. As one could expect, also the volatility measures of the main funding countries are highly correlated. The end of the month values of VSMI and VXJ have correlation of 0.78, while the correlation between VIX and the other two volatility measures is over 0.80 during the sample period.

Table 3: Correlation matrix of key variables

This table shows the correlation between the key variables in my study. I use end of the month values and the sample period spans from 1/1999 to 1/2014. VSMI, VXJ and VIX are the key volatility measures in Switzerland, Japan and USA, respectively. They are all constructed from options on their main stock exchange indices and represent a measure of how volatile the stock market will be over the next month. S-TED, J-TED and TED are the differences between the interest rates on 3-month interbank loans and 3-month government debt in Switzerland, Japan and USA, respectively. These spreads indicate the liquidity in the interbank market.

	VSMI	VXJ	VIX	S-TED	J-TED	TED
VSMI	1.00					
VXJ	0.78	1.00				
VIX	0.88	0.81	1.00			
S-TED	0.45	0.53	0.46	1.00		
J-TED	0.31	0.41	0.49	0.42	1.00	
TED	0.37	0.46	0.43	0.76	0.35	1.00

Also the liquidity spreads from Switzerland and the United States seem to move together, with a coefficient of 0.76. On the other hand, J-TED is only weakly correlated with S-TED and TED. This is partly do the fact that the spread between the 3-month JPY LIBOR and the Japanese Government 3-month Bill has been rather flat during the sample period compared to noticeably more volatile TED spreads in Switzerland and in the United States. Moreover, the correlation between the key volatility measure and liquidity spread is between 0.41 and 0.45 in all regions. This would imply that shocks that lead to increased risk aversion or liquidity problems in the banking sector do not necessarily occur simultaneously. Therefore, it is good to examine the volatility measures' and liquidity spreads' explanatory power for carry trade returns both separately and also at the same time.

4.4. Methodology

First, to test whether the carry trade returns are related to volatility measures and liquidity spreads introduced above, I estimate the following univariate regression model for each portfolio *j*:

$$z_{jt+1} = \beta_{j0} + \beta_{j1} RM_{t+1} + \varepsilon_{jt+1} \tag{11}$$

Where I consider a given risk measure, $RM_t = \{VSMI_t, VXJ_t, VIX_t, S\text{–}TED_t, J\text{–}TED_t, TED_t\}$, separately for portfolio j at time t. ε_{jt} is the error term, and other variables are as defined previously. Besides the level of RM at the end of period t+1, I also test the explanatory power of the change in risk measure during the 1-month period defined as: $\Delta RM_{t+1} = RM_{t+1} - RM_t$. If the coefficient β_{j1} is significant, then there is a risk-return relationship between that particular risk measure and portfolio *j* carry trade returns.

My preliminary analysis indicates that the correlation between the key volatility measures is quite high. Therefore, I estimate a regression with one of the volatility measures as the dependent variable and the other two as the independent variables. I use the residuals of the regression as my orthogonal variable in the regression analysis to test the key volatility measure's explanatory power in its own region on top of the other two volatility measures. If the orthogonal variable is statistically significant it indicates that the underlying volatility measure is the most dominant risk factor in that region.

Next, I allow carry trade risk premium to stem from different risk measures at the same time. I use the following multivariable model to test which of the funding liquidity measures of the main funding country explain the currency excess returns in that region.

$$z_{jt+1} = \beta_{j0} + \beta_{j1}\Delta VM_{t+1}^{m} + \beta_{j2}VM_{t+1}^{m} + \beta_{j3}\Delta LS_{t+1}^{m} + \beta_{j4}LS_{t+1}^{m} + \varepsilon_{jt+1} \tag{12}$$

Where $VM_t^m = \{VSMI_t, VXJ_t, VIX_t\}$ is the key volatility measure in region *m* at time *t*, and $LS_t^m = \{S\text{–}TED_t, J\text{–}TED_t, TED_t\}$ is the liquidity spread in region *m* at time *t*. Furthermore, I investigate whether the risk measures have also non-contemporaneous relationship to currency excess returns. I do this by adding 1-period lagged explanatory variables to equation (12).

To test the hypothesis that tightening of funding conditions in the main funding country are associated with currency crashes in the investment countries in that region, I estimate a probit model where the dependent variable takes value 1 if crash happens, and 0 otherwise. I define a crash (denoted by *Y*), when the monthly return of carry portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period.

$$Y = \begin{cases} 1 & \text{if } z_{jt} < \bar{z}_j - 1SD(z_j) \\ 0 & \text{otherwize} \end{cases} \tag{13}$$

In the probit model the probability of a crisis is a non-linear function of the indicators:

$$\Pr(Y = 1|X) = \Phi(X'\beta) \tag{14}$$

Where Pr denotes probability, Φ is the standard normal cumulative distribution and X is the vector of the explanatory variables introduced above. Statistically significant positive coefficients would imply that increase in the funding liquidity risk indeed lead to a higher likelihood of currency crashes.

I use robust standard errors in all regression models and the reported R^2 values are adjusted R^2s. There are a total of 181 monthly returns per carry portfolio, but because of the data limitations discussed earlier, not all the currencies have 181 months of data. The empirical results are presented in the next chapter.

5. Analysis and results

This section presents the empirical results relating to the risk factors behind currency carry trade excess returns. First, I describe the summary statistics of the carry portfolios' excess returns. Next, I study the risk-return relationship between the main funding countries' liquidity measures and regional carry trade returns. This is done by first examining separately the characteristics of key volatility measures and liquidity spreads, and then combining them in a multivariable regression model. Furthermore, I show the link between currency crashes in major investment countries and the key risk variables in those regions.

5.1. Summary of currency carry trade returns

Panel A of Table 4 reports the summary statistics of carry portfolios' monthly excess returns for the entire sample period, 1/1999-1/2014. For each portfolio, the average change in spot exchange rate is lower than the average forward discount, implying a positive mean return from the carry trade strategy. Contrary to earlier studies that have used mainly major currencies from developed countries, I find that the average change in spot rate is positive for the carry portfolios. This gives some support to Frankel and Poonawala's (2010) argument that the forward market in emerging currencies is less biased than in major currencies, as most of the investment currencies in my portfolios are from emerging markets. Another thing possibly explaining the less biased forward rates is that I use relatively recent dataset. The studies that find the exchange rate to move in the opposite direction from what the forward rate predicts have usually a sample period starting from 70s or 80s. This result is consistent with the findings of Jylhä and Suominen (2011), who state that carry trade returns have decreased over time. Moreover, the financial crisis during 8/2007-3/2009 had a negative effect to the carry trade returns. Panel B shows that, when excluding the financial crisis period, the average change in spot rate is close to zero or even negative for Asia Pacific and Americas, but still significantly positive for EMEA.

The average monthly returns are positive for every portfolio and the HmL strategy in EMEA generates the largest mean profit; 1.08% per month or 12.97% per year. It has also the highest annualized Sharpe ratio of 0.78. The large excess returns stem from the long-short positions in TRY/CHF, which is the prevailing currency pair 80% of the time in the HmL portfolio in EMEA.

Table 4: Monthly carry trade returns

This table reports the summary statistics of the monthly returns for the carry trade portfolios, including mean, standard deviation (SD), skewness, kurtosis, annualized Sharpe ratio (SR) and median. The log currency excess returns are compute by subtracting the change in spot exchange rates from the forward discount: $z_{t+1} = (f_t - s_t) - \Delta s_{t+1}$. The currency portfolios are formed by first sorting the currencies in three different geographical regions. In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. Data are monthly, from Barclays and Reuters (Datastream). Panel A reports the data for full sample period from 1/1999 to 1/2014. Panel B excludes the financial crisis (8/2007 – 3/2009) from the sample. All moments are reported in percentage points.

Panel A: Full sample

Portfolios	**EMEA**		**Asia Pacific**		**Americas**
	HmL	HmL3	HmL	HmL3	HmL
Forward discount	1.819	0.992	0.838	0.526	0.552
SD	1.638	0.653	0.841	0.322	0.398
Spot change	0.738	0.563	0.212	0.108	0.284
SD	4.651	2.850	4.460	2.125	3.022
Mean	1.081	0.429	0.626	0.418	0.267
SD	4.776	2.918	4.591	2.160	3.078
Skewness	-0.503	-0.355	0.089	-1.243	-0.774
Kurtosis	5.905	4.573	5.329	7.480	5.820
Annualized SR	0.784	0.509	0.473	0.670	0.301
Median	1.528	0.717	0.821	0.710	0.327

Panel B: Full sample excl. financial crisis (8/2007-3/2009)

Portfolios	**EMEA**		**Asia Pacific**		**Americas**
	HmL	HmL3	HmL	HmL3	HmL
Forward discount	1.876	0.994	0.850	0.521	0.562
SD	1.722	0.670	0.876	0.335	0.411
Spot change	0.671	0.457	0.012	-0.092	0.095
SD	4.319	2.555	4.278	1.791	2.759
Mean	1.205	0.537	0.838	0.613	0.467
SD	4.449	2.655	4.405	1.835	2.826
Skewness	-0.307	-0.308	0.325	-0.380	-0.480
Kurtosis	6.692	5.181	5.892	3.766	4.752
Annualized SR	0.939	0.701	0.659	1.158	0.573
Median	1.481	0.717	0.826	0.770	0.407

The HmL portfolio in Americas has the lowest average return; 0.27% per month or 3.21% per year. One reason for the poor performance of Americas compared to other regions is that it has only three sample currencies of which Mexican peso is the investment currency during the whole sample period.

Burnside et al. (2008) report, the average excess return of close to five percent for a simple carry trade strategy based on up to 20 currencies and executed monthly over the period 1976-2007. I find similar average monthly returns for my HmL3 portfolios, while the returns of HmL portfolios are higher in EMEA and Asia Pacific, and lower in Americas. More surprisingly, Burnside et al. (2008) observe an annualized Sharpe ratio of 0.97 for the carry trade returns, which is more than double that of the value-weighted US stock market over the same period. I do not find as high level of annualized Sharpe ratio during my full sample period, but when the latest financial crisis is excluded, the average returns of the portfolios go up and standard deviation down, leading to higher Sharpe ratios in Panel B.

In addition, we can see that the HmL3 portfolios are less volatile than the HmL portfolios in the same region. Figure 3 in Appendix B shows the monthly currency excess returns for the carry portfolios. There are similarities in the monthly returns patterns of HmL and HmL3 portfolios' in the same region though HmL produces more extreme values. The correlation coefficient between HmL and HmL3 portfolios is 0.80 in EMEA and 0.78 in Asia Pacific. Moreover, there is no remarkable correlation between the monthly excess returns of carry portfolios' in EMEA, Asia Pacific and Americas. These findings would suggest that large movements in major investment currencies have been somewhat regional.

Although carry trade is profitable on average, the exchange rate speculation is often viewed as being especially risky in that the carry portfolios have crash risk (negative skeweness) and fat-tailed distributions (excess kurtosis). The skewness varies between the carry portfolios being most negative for HmL3 in Asia Pacific and even slightly positive for HmL in Asia Pacific. All the carry portfolios have fat tails. Brunnermeier et al. (2009) state that the negative skewness or excess kurtosis cannot be diversified away by adding more currencies to the carry trade portfolio. I also do not find any evidence that this could be done at least with the simple equal-weighted portfolio strategy I use in my study. The skewness of HmL3 portfolio in EMEA is only slightly less negative than the skewness of HmL portfolio, and the crash risk of HmL3 portfolio in Asia

Pacific is noticeably higher compared to HmL portfolio. The fact that skewness of the carry portfolios excess returns cannot be easily diversified away by adding more currencies suggests that currency crashes are correlated across different investment countries in the same region. The relationship between the regional liquidity risk factors and currency crashes is examined more detailed in Section 5.3.

5.2. Regional carry trade returns and funding liquidity measures

In this subsection, I test the hypothesis that the main funding countries' key volatility measures and liquidity spreads have the highest explanatory power for carry trade returns in their own regions. First, the key volatility measures' and liquidity spreads' relationship to currency excess returns are examined separately. Thereafter the risk behind carry trade returns is allowed to stem from multiple risk factors at the same time.

5.2.1. Risk aversion in the main funding countries

I find that all the volatility measures are negatively contemporaneously correlated with currency excess returns, indicating carry trade losses during the months when investors' risk aversion increase. Brunnermeier et al. (2009) reports similar results for VIX using weekly data from eight developed markets. In order to test the home bias in carry trades, I compare the explanatory power of VSMI, VXJ, and VIX for the carry portfolios' excess returns in EMEA, Asia Pacific, and Americas. Results stating that the main funding country's volatility measure is the most dominant in that region provide evidence for the regionality.

Table C.1 in Appendix C displays the results from the univariate regression between the main funding countries' volatility measures and the monthly excess returns of carry portfolios in different regions. In vast majority of the cases the change in the volatility measure during the one month period has a much larger explanatory power for the carry trade returns than the contemporaneous level. VXJ is somewhat an exemption, as it seems to be a more relevant risk factor than ΔVXJ when explaining the carry returns in Asia Pacific. However, this is mainly due to the latest financial crisis, as Panel B shows that the level of VXJ loses most of its explanatory power when the crisis period is excluded. This is not only case for VXJ as also the level of VSMI and VIX seem to lose their meaningfulness in Panel B. Figure 1, shows the end of the month values for the key volatility measures during the sample period. The level of volatility measures peaked remarkably high during the financial crisis, explaining the high correlation of the carry trade returns and the explanatory variable during that time. For instance, VXJ recorded a value as high as 96.7 in the end of October, 2008, compared to long time average of 26.2.

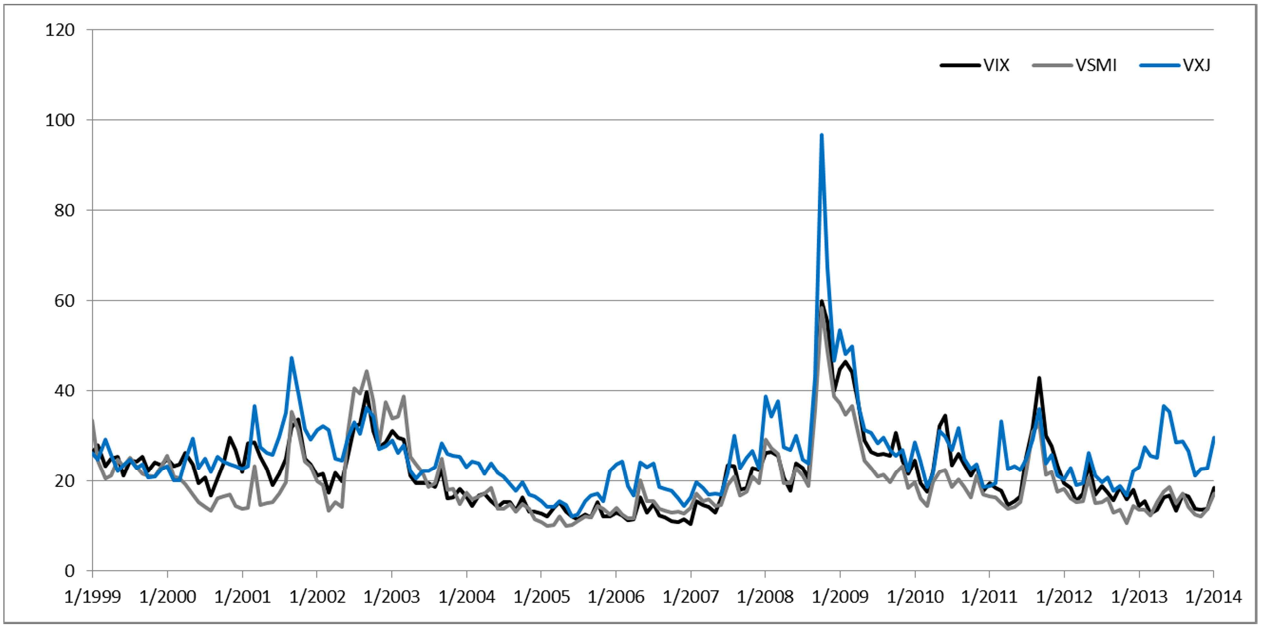

Figure 1: Level of key volatility measures. This figure shows end of the month values for the key volatility measures during the sample period of 1/1999-1/2014. VIX is the CBOE Volatility Index, VSMI is the volatility index on the SMI, and VXJ is the Volatility Index Japan. These measures represent market's expectations how volatile the stock market will be over the next month.

Unlike the level of the volatility measures, the change variables do not lose their explanatory power when the financial crisis period is excluded. In EMEA and Americas the values of ΔVSMI, ΔVXJ and ΔVIX stay almost the same in Panel B. In Asia Pacific, the variables have lower R^2 values but are still statistically significant. These finding would suggest the change in the volatility measure to be more relevant risk factor than the level, but in the times of large financial distress the level becomes also significant.

Table C.1 gives initial evidence to support the hypothesis that the key volatility measures of the main funding countries have the highest explanatory power for the carry trade returns in their own regions. In EMEA, the ΔVSMI has clearly highest adjusted R^2; 17.7% in HmL portfolio and 20.4% in HmL3 portfolio. Also in Americas, the ΔVIX explains 19.8% of the HmL strategy returns, dominating all the other variables. In the Asia Pacific region, the results of the univariate regression do not fully support my hypothesis, as the ΔVIX have larger adjusted R^2 values than

ΔVXJ in both HmL and HmL3 portfolios. However, the level of VXJ is almost as large as ΔVIX for HmL3 in Panel A, but as discussed earlier it loses its meaningfulness when the latest financial crisis period is excluded from the sample.

As the volatility measures are highly correlated, I also run a regression with one of the volatility measures as the dependent variable and the other two as the independent variables, and use the residuals of the regression as my orthogonal explanatory variable. Table 5 reports the orthogonalized values for ΔVSMI, ΔVXJ and ΔVIX. Even when taking into consideration the changes in VXJ and VIX, the oΔVSMI have adjusted R^2 values of 11.1% and 5.2% for HmL and HmL3 portfolios respectively. The oΔVXJ and oΔVIX do not have any explanatory power for the carry trade returns in EMEA, providing evidence that the ΔVSMI is the most dominant explanatory variable in the region. In Americas, oΔVIX is the only significant variable with adjusted R^2 value of 5.08%. The oΔVIX is also most dominant explanatory variable in Asia Pacific, confirming the relevance of ΔVIX in that region.

Table 5: Orthogonal volatility measure variables

This table documents the contemporaneous relationship between orthogonal volatility measure variables and carry portfolios' monthly excess returns in different regions. The orthogonal variables are constructed by regressing the volatility measure on the other two volatility measures of main funding countries and using the residuals from that regression. VIX is the CBOE Volatility Index, VSMI is the volatility index on the SMI, and VXJ is the Volatility Index Japan. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Data are monthly and the sample period is 1/1999 – 1/2014. Only significant values are shown in the table.

	EMEA				**Asia Pacific**				**Americas**	
	HmL		HmL3		HmL		HmL3		HmL	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
oΔVSMI	-0.6218***	-4.47	-0.2667***	-2.64	—		—		—	
oΔVXJ	—		—		—		—		—	
oΔVIX	—		—		-0.3817***	-2.97	-0.1776***	-2.68	-0.2692**	-2.47
const.	1.0809***	3.23	0.4289**	2.03	0.6263*	1.88	0.4180***	2.66	0.2672	1.20
Adj. R^2	11.07 %		5.17 %		4.53 %		4.42 %		5.08 %	

One reason why ΔVIX seems to be a better risk measure in Asia Pacific than ΔVXJ could be that the USD is actually more popular funding currency for the major investment countries in the region than JPY during my sample period. Long-short positions in INR/USD, PHP/USD, IDR/USD, and NZD/USD are not uncommon at all. This interpretation of the findings would fight against my hypothesis of regionality in carry trade. It might also be that the VXJ is not the most optimal funding liquidity measure in the region as Ferreira Filipe and Suominen (2013) show that their measure of funding risk in Japan leaves the U.S. measures redundant. However, their sample included only developed countries while the major investment countries in my sample are most of the time emerging countries.

In order to examine more closely the risk factors behind the carry trade excess returns in Asia Pacific, I also include one month lagged values of ΔVXJ and ΔVIX in the regressions due to the slow moving capital. Table 6 presents the empirical results of this regression for HmL and HmL3 portfolios in Asia Pacific. The 1-period lagged ΔVXJ is statistically significant in both portfolios together with the contemporaneous level and change in VXJ, while the VIX variables have only contemporaneous relationship with carry trade returns. The Japan based volatility measures can explain 11.1% of the currency excess returns in HmL portfolio and 29.0% in HmL3 portfolio. Similarly, the R^2 values for U.S. based volatility measures are 14.5% and 27.4% in HmL and HmL3 portfolios respectively.

The results would suggest that ΔVIX has larger contemporaneous effect while ΔVXJ is a better measure when predicting the carry trade returns one month ahead in Asia Pacific region. One possible explanation for this is that large amount of Japanese retail investors participate in currency carry trades. The professional investors in U.S., with highly leveraged large carry positions, have to react fast to tightening funding liquidity as they hit the funding constraints. In Japan, however, the collective action of numerous retail investors is slower explaining why part of the effect of increasing risk aversion to carry returns comes with delay. Ferreira Filipe and Suominen (2013) also argue that the popularity of carry trades amongst the Japanese retail investors is large enough to influence the global currency markets. Using stock market crash risk in Japan, they find the unexpected component of risk to be statistically significant when explaining the carry trade returns up to three months ahead. The predictive power of the key volatility measures one month ahead are not significant in EMEA and Americas, and are therefore not separately displayed in this thesis.

The fact that the lagged ΔVXJ is only statistically significant in Asia Pacific suggests that the Japanese retail investors participate in carry trades mainly in their own region. This gives support to the home bias in carry trade in Asia Pacific even though the U.S. based volatility measures have approximately the same explanatory power for the excess returns in both portfolios. In EMEA and Americas the main funding countries' key volatility measures provide more explicit evidence for the regionality hypothesis.

Table 6: Carry trade returns and volatility measures in Asia Pacific

This table shows the explanatory power of volatility measures in Japan and U.S. for the monthly carry trade returns in Asia Pacific region. The changes in the volatility measures are both contemporaneous and lagged. VIX is the CBOE Volatility Index and VXJ is the Volatility Index Japan. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Data are monthly and the sample period is 1/1999 – 1/2014.

	HmL		HmL		HmL3		HmL3	
	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat
VXJ								
L0.	-0.0818***	-2.65	——		-0.0691***	-3.75	——	
ΔVXJ								
L0.	-0.1521***	-3.46	——		-0.1022***	-4.14	——	
L1.	-0.0896**	-2.08	——		-0.0554**	-2.09	——	
VIX								
L0.	——		-0.0735**	-2.11	——		-0.0548**	-2.44
ΔVIX								
L0.	——		-0.3393***	-5.65	——		-0.1973***	-5.40
L1.	——		-0.0790	-1.06	——		-0.0645	-1.44
const.	2.7276***	3.08	2.1956***	2.87	2.1938***	4.62	1.5894***	3.43
Adj. R^2	11.06 %		14.45 %		28.98 %		27.37 %	

5.2.2. Liquidity in the interbank markets

Here I use the TED spreads in Switzerland, Japan and U.S. to test how the tightening liquidity in the interbank market affects the carry trade returns in EMEA, Asia Pacific and Americas. When significant, the negative coefficients of the TED spreads indicate that when banks face liquidity problems the carry portfolios experience losses. The results on the liquidity spreads are not as consistent as the findings related to the volatility measures discussed above. I find the liquidity spreads to be statistically less significant than the volatility measures and their explanatory power varies in different regions.

Table C.2 in Appendix C displays the contemporaneous relationship between the main funding countries' liquidity spreads and the monthly excess returns of carry portfolios in different regions. Overall, the results indicate that the level is more important factor than the change in the spread. Surprisingly, none of the variables are statistically significant in EMEA, implying that the liquidity spreads are not a risk factor at all in that region. Moreover, in Asia Pacific S-TED and TED are statistically significant while J-TED does not have any explanatory power for currency excess returns. The R^2 value of S-TED is 6.3% in HmL portfolio and 15.2% in HmL3 portfolio. TED has slightly lower R^2 values of 3.0% and 12.1% in HmL and HmL3 portfolios respectively. Also in Americas S-TED has higher explanatory power for the carry returns compared to TED (9.8% vs 5.4%), and J-TED remains insignificant.

Figure 2 shows the end of the month values of the liquidity spreads during my sample period. As we can see, J-TED has been staying quite flat compared to TED and S-TED, partly explaining its poor performance as a risk measure for highly volatile carry trade returns. TED and S-TED are correlated with each other and have higher variances than J-TED. They both also record some extreme values during the latest financial crises. In fact, if the crisis period is excluded from the sample, the TED spreads in every funding country lose their statistical significance.

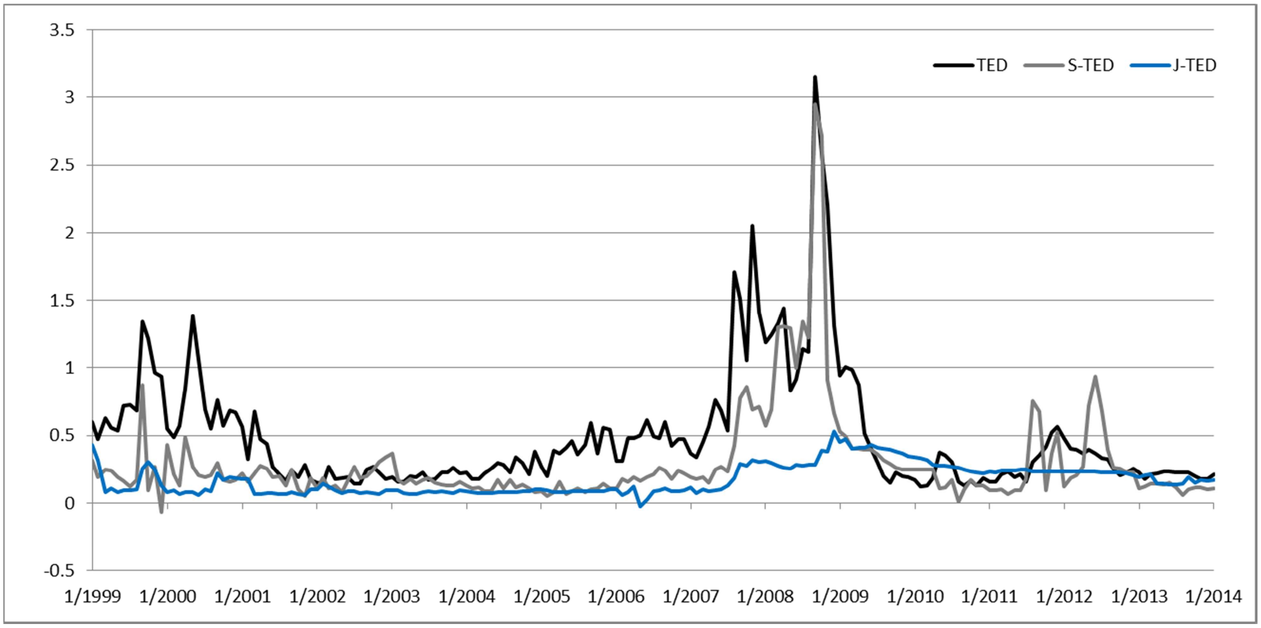

Figure 2: Level of liquidity spreads. This figure shows end of the month values for the liquidity spreads during the sample period of 1/1999-1/2014. TED is the spread between the 3-month USD LIBOR and the 3-month U.S. T-Bill rate. S-TED is the spread between the 3-month CHF LIBOR and Switzerland's 3-month federal money market debt register claims. J-TED is the spread between the 3-month JPY LIBOR and the Japanese Government 3-month Bill. These spreads are indicators of liquidity in interbank markets.

The results from the univaritate regression would suggest that the contemporaneous level of liquidity spreads is only a relevant risk measure during the times of large financial distress. However, Brunnermeier et al. (2009) report that the change in TED has a stronger predictive relationship to the carry trade return in one week ahead, and a smaller contemporaneous effect. In order to test if the changes in the liquidity spreads have delayed effect on currency excess returns, I also include one month lagged values of ΔTED, ΔS-TED and ΔJ-TED to the regression.

Table 7 presents the empirical results of this regression for HmL portfolio in Americas. I find the 1-period lagged ΔTED to have strong predictive power for the carry trade returns together with the contemporaneous level of TED. The adjusted R^2 value of the regression is 9.9%. From Switzerland based liquidity spread measures, only the current level of S-TED is statistically significant and explain 9.5% of the currency excess returns. Further, both the current and lagged values of ΔJ-TED are significant but with lower adjusted R^2 value of 4.9%.

Table 7: Carry trade returns and liquidity spreads in Americas

This table shows the explanatory power of the main funding countries' liquidity spreads for the monthly carry trade returns in Americas. The changes in the liquidity spreads are both contemporaneous and lagged. TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Data are monthly and the sample period is 1/1999 – 1/2014.

	HmL		HmL		HmL	
	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat
TED						
L0.	-1.2522**	-2.14	—		—	
ΔTED						
L0.	-0. 5158	-0.54	—		—	
L1.	-2.9456**	-2.42	—		—	
S-TED						
L0.	—		-2.4557***	-2.89	—	
ΔS-TED						
L0.	—		0.0442	0.04	—	
L1.	—		-1.1345	-0.75	—	
J-TED						
L0.	—		—		-0.7563	-0.33
ΔJ-TED						
L0.	—		—		-17.3406**	-2.40
L1.	—		—		-9.2794*	-1.93
const.	0. 8719**	2.57	1.0063***	3.49	0.3732	0.93
Adj. R^2	9.92 %		9.52 %		4.93 %	

As the end of the month values of TED and S-TED are highly correlated during the sample period, it is somewhat expected that also S-TED is a significant risk factor in Americas. The result that the coefficient of 1-period lagged ΔTED is negative and statistically significant supports Brunnermeier et al. (2009) finding that the changes in TED spread have delayed effect on carry trade returns. However, the results from Americas do not apply for the other regions. One month lagged changes in the liquidity spreads are not statistically significant in EMEA and

Asia Pacific. The reason for this might be that one month lag is too long time period in general, to capture the effect of tightening funding liquidity to carry trade returns. Nevertheless, Ferreira Filipe and Suominen (2013) argue that the TED spread is not the most optimal risk measure even for the weekly carry trade activity in AUD/JPY. This finding, together with the fact that the contemporaneous levels or changes in the liquidity spreads do not have any explanatory power over the carry trade returns in EMEA, suggest that the TED spreads are not a relevant risk factor in every region.

5.2.3. Regional funding liquidity risk

Next, I test the relationship between the main funding country's liquidity measures and the carry portfolios' excess returns in that region by allowing the funding liquidity risk behind the carry trade returns to stem from both the volatility measures and liquidity spreads simultaneously. The results provide more insight on which of the risk factors are the most dominant in EMEA, Asia Pacific and Americas. In general, I find strong evidence supporting the regional volatility measures while liquidity spreads seem to be more relevant risk factors during times of financial distress.

Table 8 reports the result of the regression between main funding countries' liquidity measures and carry portfolios' monthly excess returns in different regions. It is evident that ΔVSMI is the most dominant risk measure in EMEA. Inclusion of other measures of funding risk does not affect the results. In Asia Pacific, I have also included the contemporaneous U.S. based funding liquidity measures to the regression as they seem to be relevant risk factors in that region. For HmL3 portfolio, VXJ and ΔVIX are the only statistically significant variables explaining one third of the carry trade returns. For HmL portfolio, ΔTED is also statistically significant and together with VXJ and ΔVIX they explain 16.3% of the carry trade returns. In Americas, ΔVIX and TED are both statistically significant and have adjusted R^2 value of 22.2%.

In Panel B, I present the results for the sample excluding the financial crisis period. The results are roughly the same for EMEA and Americas but in Asia Pacific the adjusted R^2 drops considerably when the recent financial crisis period is excluded from the sample. Also VXJ and the TED spreads lose their significance confirming the result that the level of volatility measures and liquidity spreads are only relevant risk measures when there is turmoil in financial markets.

Table 8: Regional carry trade returns and funding liquidity

This table documents the contemporaneous relationship between the main funding countries' liquidity measures and carry portfolios' monthly excess returns in EMEA, Asia Pacific and Americas. VIX, VSMI and VXJ are the main volatility indexes and TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Panel A reports the monthly data for full sample period from 1/1999 to 1/2014. Panel B excludes the financial crisis (8/2007 – 3/2009).

Panel A: Full sample

	EMEA				**Asia Pacific**				**Americas**	
	HmL		HmL3		HmL		HmL3		HmL	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
VSMI	-0.0139	-0.25	-0.0177	-0.59	—		—		—	
ΔVSMI	-0.4579***	-4.14	-0.2932***	-4.82	—		—		—	
VXJ	—		—		-0.1346*	-1.65	-0.0935***	-2.67	—	
ΔVXJ	—		—		0.0481	0.64	-0.0029	-0.07	—	
VIX	—		—		0.0022	0.03	0.0301	0.87	-0.0205	-0.58
ΔVIX	—		—		-0.3087***	-2.69	-0.1642***	-3.07	-0.2968***	-4.75
S-TED	0.1284	0.11	0.1104	0.15	—		—		—	
ΔS-TED	0.9359	0.73	0.4139	0.55	—		—		—	
J-TED	—		—		3.0202	0.92	0.2708	0.19	—	
ΔJ-TED	—		—		-7.1484	-0.81	-1.3510	-0.37	—	
TED	—		—		0.1245	0.13	-0.6552	-1.62	-1.1577*	-1.93
ΔTED	—		—		-2.9970*	-1.93	-0.5431	-0.83	1.0985	1.19
const.	1.2850	1.27	0.7265	1.35	3.4193***	3.66	2.4357***	4.77	1.2737*	1.91
Adj. R^2	16.65 %		19.46 %		16.31 %		33.13 %		22.18 %	

Panel B: Full sample excl. financial crisis (8/2007-3/2009)										
	EMEA				**Asia Pacific**				**Americas**	
	HmL		HmL3		HmL		HmL3		HmL	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
VSMI	0.0469	0.96	0.0215	0.82	—		—		—	
ΔVSMI	-0.5055***	-4.71	-0.2862***	-4.33	—		—		—	
VXJ	—		—		-0.0741	-0.87	-0.0565	-1.47	—	
ΔVXJ	—		—		0.0817	0.74	-0.0043	-0.08	—	
VIX	—		—		-0.0289	-0.38	0.0136	0.38	0.0023	0.06
ΔVIX	—		—		-0.3160**	-2.54	-0.1488***	-2.65	-0.3176***	-5.11
S-TED	2.5148	1.05	1.0526	0.65	—		—		—	
ΔS-TED	-0.0924	-0.04	-0.5806	-0.37	—		—		—	
J-TED	—		—		2.4746	0.67	-0.4325	-0.29	—	
ΔJ-TED	—		—		-6.5759	-0.65	-2.6237	-0.71	—	
TED	—		—		0.9568	0.36	-0.4398	-0.52	0.6397	0.59
ΔTED	—		—		-3.9012	-1.07	-0.4462	-0.36	-2.5270	-1.28
const.	-0.2808	-0.30	-0.1343	-0.25	2.3864	1.38	1.8907***	2.84	0.1150	0.15
Adj. R^2	17.99 %		16.09 %		5.35 %		8.93 %		17.86 %	

Overall, I find the changes in the volatility measures to be the most relevant risk factors explaining the carry trade returns. Both ΔVSMI and ΔVIX explain around 20% of the carry trade returns in their own regions leaving other funding countries' volatility measures redundant. In Asia Pacific ΔVIX has larger contemporaneous effect than ΔVXJ, but when one month lagged variables are introduced, the Japanese and U.S. volatility measures have both approximately the same explanatory power for carry portfolios' excess returns. In Japan, carry trade is very popular among retail investors and their collective actions are slower than those of larger hedge funds, explaining why part of the effect of ΔVXJ to carry trade returns comes with delay. The liquidity spreads have very limited explanatory power for carry trade returns in the same regression with the key volatility measures. Even though the evidence that the main funding countries' liquidity spreads could explain the regional carry trade returns is quite weak, the TED spreads produce more significant results relating to currency crashes, presented in Section 5.3. This is linked to the finding that the TED spreads are better measures of funding risk when there is lots of turbulence in the market.

5.3. Currency crashes in the major investment countries

In this subsection, I test my second hypothesis that the tightening funding conditions in the main funding country are associated with currency crashes in the major investment countries in that region. When speculators face funding constraints, they are forced to unwind their carry trade positions causing the investment currencies to depreciate. This negative shock has spillover effects and is amplified as more speculative capital is being withdrawn from the investment countries. I define a crash when the monthly return of carry portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period. The results from the probit model indicate that in addition to the changes in the volatility measures, also the current level and the TED spreads have explanatory power over the currency crashes.

5.3.1. Americas

Table 9 shows the explanatory power of funding liquidity for currency crashes in Americas. Positive values on coefficients indicate that when the risk aversion or TED spreads increases, also the probability of crash in the investment currency increases. The results confirm that the U.S. based funding liquidity measures are the most significant when explaining currency crashes in Americas. The contemporaneous level and change in VIX together with the 1-month lagged ΔTED can explain 20.6% of the crashes. The fact that also the level of VIX is positive and statistically significant implies that the investment currency is more likely to crash when risk aversion in U.S. is high. Also, the results relating to one month lagged ΔTED are consistent with the earlier findings that the changes in TED spread have delayed effect on carry trade returns in Americas.

As expected, the Swiss and Japanese funding liquidity measures have less explanatory power for currency crashes in Americas than the U.S. ones. Switzerland based funding liquidity measures have pseudo R^2 value of 12.9%, S-TED being the most significant variable, and the Japan based measures have the lowest pseudo R^2 value of 11.9%, VXJ being the most significant variable.

Table 9: Currency crashes and funding liquidity in Americas

This table shows the explanatory power of funding liquidity for currency crashes in Americas region. I estimate a probit model, where the dependent variable takes value 1 if crash happens, and 0 otherwise. I define a crash when the monthly return of HmL portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period. VIX, VSMI and VXJ are the main volatility indexes and TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In Model (1), I show that contemporaneous level and change in VIX and also the 1-month lagged ΔTED explain currency crashes. Model (2) and (3) show the results for Swiss and Japan based funding liquidity measures separately. Model (4) considers all volatility measure variables and Model (5) all liquidity spread variables. The z-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The last row shows pseudo-R^2s. Returns are monthly and the sample period is 1/1999 – 1/2014.

	(1)		(2)		(3)		(4)		(5)	
	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat
VIX	0.0430**	2.15	—		—		-0.0006	-0.01	—	
ΔVIX	0.1285**	2.05	—		—		0.1285***	2.05	—	
L1.	0.0541	0.88	—		—		0.0541	0.88	—	
VSMI	—		0.0245	1.37	—		-0.0020	-0.05	—	
ΔVSMI	—		0.0426	1.56	—		-0.0059	-0.12	—	
L1.	—		0.0277	1.09	—		-0.0161	-0.34	—	
VXJ	—		—		0.0499***	2.94	0.0441	1.58	—	
ΔVXJ	—		—		0.0145	0.62	-0.0535	-1.57	—	
L1.	—		—		0.0071	0.38	-0.0239	-0.69	—	
TED	0.4477	1.60	—		—		—		-0.1110	-0.24
ΔTED	-0.5891	-1.23	—		—		—		0.5857	1.11
L1.	1.0601*	1.88	—		—		—		1.3155**	2.20
S-TED	—		0.5950**	2.03	—		—		1.0113*	1.67
ΔS-TED	—		-0.2488	-0.56	—		—		-0.8668	-1.36
L1.	—		-0.6597	-1.42	—		—		-1.1062*	-1.96
J-TED	—		—		-0.6392	-0.54	—		-0.0661	-0.05
ΔJ-TED	—		—		3.1336	0.88	—		-0.4925	-0.16
L1.	—		—		1.3635	0.51	—		-0.2758	-0.09
const.	-2.4441***	-5.15	-1.8818***	-5.01	-2.3822***	-5.21	-2.3513***	-5.35	-1.4403***	-5.22
Pseudo R^2	20.61 %		12.93 %		11.92 %		18.06 %		10.95 %	

All in all, the key volatility measures have higher explanatory power for currency crashes than the liquidity spreads. The ΔVIX is the most significant volatility measure and 1-period lagged ΔTED the most significant liquidity spread in Americas. The evidence that USD is the main funding currency in its own region is quite substantial, but in order to find out whether the USD carry trade activity is actually biased towards Americas or if the USD is just dominant funding currency globally, it is also necessary to examine more closely the currency crashes in Asia Pacific and EMEA.

5.3.2. Asia Pacific

Table 10 shows the explanatory power of funding liquidity for currency crashes in Asia Pacific region. As the Japanese funding liquidity measures have some predictive power for the carry trade returns one month ahead, I also include 1-period lagged variables to the probit model. First I examine separately the Japan and U.S. key volatility measures' explanatory power for currency crashes in the investment countries in HmL3 portfolio. I find that the contemporaneous levels and changes in VXJ and VIX are all statistically significant, though the Japanese volatility measures have slightly higher pseudo R^2 value of 19.4% compared to the U.S 17.9%. This result is consistent with the findings in Section 5.2.1, although the volatility measures have less explanatory power for currency crashes than carry trade returns in general. The Swiss funding liquidity measures are not shown in the table as the Japanese and U.S. variables leave them redundant.

I also test the explanatory Japanese and U.S TED spreads separately. The contemporaneous level and 1-period lagged change in J-TED are statistically significant and have pseudo R^2 value of 9.5%. Likewise the ΔTED in Americas, also ΔJ-TED have delayed effect on currency crashes in Asia Pacific, emphasizing the predictive power of TED spreads. However, the level and change in TED can explain 19.1% of the currency crashes in Asia Pacific, so it seems that TED have larger contemporaneous effect than J-TED.

Moreover, the Japanese and U.S. funding liquidity measures can together explain over 40% of the crashes in major investment currencies' in Asia Pacific. I conclude that the U.S. funding liquidity measures are also highly relevant in Asia Pacific in addition to the Japanese ones, and investors should use the key measures from both countries in order to best explain crashes in this region.

Table 10: Currency crashes and funding liquidity in Asia Pacific

This table shows the explanatory power of funding liquidity for currency crashes in Asia Pacific region. I estimate a probit model, where the dependent variable takes value 1 if crash happens, and 0 otherwise. I define a crash when the monthly return of HmL3 portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period. VIX, VSMI and VXJ are the main volatility indexes and TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In Model (1) and (2) I show that contemporaneous levels and changes in VXJ and VIX explain currency crashes. Model (3) shows that the level of J-TED and also 1-period lagged ΔVXJ are statistically significant. Model (4) shows that the contemporaneous level of TED is more significant than its change. Model (5) considers all variables. The z-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The last row shows pseudo-R^2s. Returns are monthly and the sample period is 1/1999 – 1/2014.

	(1)		(2)		(3)		(4)		(5)	
	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat
VXJ										
L0.	0.0571***	3.99	—		—		—		0.0648	1.38
ΔVXJ										
L0.	0.0534***	2.64	—		—		—		-0.0078	-0.18
L1.	0.0163	0.88	—		—		—		0.0333	0.76
VIX										
L0.	—		0.0503***	3.23	—		—		-0.0075	-0.17
ΔVIX										
L0.	—		0.0783***	2.92	—		—		0.1375**	1.97
L1.	—		-0.0144	-0.46	—		—		-0.1134	-1.59
J-TED										
L0.	—		—		2.2455**	2.07	—		0.7869	0.38
ΔJ-TED										
L0.	—		—		2.6452	0.78	—		-3.2883	-0.96
L1.	—		—		8.5991**	2.33	—		11.7725**	2.43
TED										
L0.	—		—		—		1.1620***	4.24	0.6952	1.45
ΔTED										
L0.	—		—		—		0.8854*	1.81	2.7711***	2.59
L1.	—		—		—		-0.2578	-0.62	0.3514	0.54
const.	-2.7798***	-6.60	-2.4210***	-6.32	-1.6451***	-6.70	-1.8489***	-8.21	-3.5704***	-4.76
Pseudo R^2	19.44 %		17.92 %		9.45 %		19.08 %		40.81 %	

5.3.3. EMEA

Table 11 shows the contemporaneous relationship between main funding countries' liquidity measures and currency crashes in EMEA. The results indicate that when investors become more risk averse also the probability of currency crashes in major investment countries increases. TED spreads have hardly any explanatory power for the crashes in this region. Even though in other regions the changes in the main funding country's TED spread have delayed effect on currency crashes, the lagged variables are not statistically significant in EMEA and are therefore not included to the probit model.

From Switzerland based liquidity measures ΔVSMI is the most significant and can explain around 19% of the currency crashes in the HmL3 portfolio. This result is similar to the findings when explaining carry trade returns in EMEA. However, the Japan and U.S. based liquidity measures produce very much alike probabilities for currency crashes in EMEA than the ΔVSMI. The level and change in VXJ have even slightly higher pseudo R^2 value of 21.4%; while ΔVIX and TED can explain 17.3% of the crashes. Interestingly, VXJ seems to be the most significant variable in a probit model where all the volatility measures from each main funding country are included to the regression.

If we compare these results to the ones reported in Section 5.2, the biggest change is that the Japanese and U.S funding liquidity measures become more significant when explaining currency crashes instead of carry trade returns. One reason for this might be that the large sudden depreciation of major investment currencies in EMEA has been driven mainly by global shocks which would explain why all the volatility measures produce fairly similar probabilities. As ΔVSMI is clearly the dominant variable when explaining carry trade returns in EMEA, it is reasonable to assume that the crashes are due to the withdraw of speculative CHF capital even though at the same time VXJ and VIX have increased.

Overall, the key volatility measures have much higher explanatory power for currency crashes in EMEA than the liquidity spreads. In fact, none of the TED spread variables are statistically significant in a probit model that includes the liquidity spreads from each funding country. This result is consistent with the earlier findings related to liquidity spreads and carry trade returns in EMEA.

Taking everything into account it is reasonable to argue that ΔVSMI is the key variable when explaining carry trade returns and currency crashes in EMEA. Also the fact, that Switzerland based funding liquidity measures are not the most significant ones in the two other regions, provides further evidence of home bias in carry trade in EMEA.

Table 11: Currency crashes and funding liquidity in EMEA

This table shows the contemporaneous relationship between the main funding countries' liquidity measures and currency crashes in EMEA. I estimate a probit model, where the dependent variable takes value 1 if crash happens, and 0 otherwise. I define a crash when the monthly return of HmL3 portfolio is lower than (minus) 1 standard deviation of its returns during the whole sample period. VIX, VSMI and VXJ are the main volatility indexes and TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In Model (1), (2) and (3), I show the results for Swiss, Japan and U.S. based funding liquidity measures separately. Model (4) considers all volatility measure variables and Model (5) all liquidity spread variables. The z-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The last row shows pseudo-R^2s. Returns are monthly and the sample period is 1/1999 – 1/2014.

	(1)		(2)		(3)		(4)		(5)	
	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat	Coef.	z-stat
VSMI	0.0289	1.59	―		―		0.0130	0.37	―	
ΔVSMI	0.0857**	2.39	―		―		0.0545	1.08	―	
VXJ	―		0.0587***	3.83	―		0.0883***	3.44	―	
ΔVXJ	―		0.0675***	3.34	―		-0.0075	-0.24	―	
VIX	―		―		0.0152	0.89	-0.0526	-1.16	―	
ΔVIX	―		―		0.1129***	2.75	0.0766	1.30	―	
S-TED	0.6696	1.62	―		―		―		0.5249	1.12
ΔS-TED	0.2686	0.54	―		―		―		0.6618	1.35
J-TED	―		0.1617	0.13	―		―		0.6485	0.53
ΔJ-TED	―		4.2093	1.15	―		―		0.5608	0.16
TED	―		―		0.5982*	1.95	―		0.2412	0.56
ΔTED	―		―		-0.5078	-1.03	―		-0.1314	-0.25
const.	-2.0381***	-5.21	-2.8272***	-6.25	-1.9057***	-4.79	-2.7363***	-5.81	-1.5841***	-5.69
Pseudo R^2	18.95 %		21.24 %		17.34 %		25.20 %		8.97 %	

6. Conclusions

The goal of my research is to provide new insight to the forward premium puzzle and arising currency carry trade excess returns. I expect the carry trade activity from the main funding countries to be biased towards investment countries that are located nearby and thus more familiar to investors. Utilizing spot and forward exchange rates of 28 currencies form EMEA, Asia Pacific and Americas, I examine the risk-return relationship between the main funding countries' funding liquidity measures and carry trade returns in these three regions. Furthermore, I test whether the tightening funding conditions in the main funding country are associated with currency crashes in the major investment countries in that region.

My empirical results provide support to the hypothesis that the main funding countries' funding liquidity measures have the highest explanatory power for carry trade returns in their own regions. I find strong evidence that the Swiss franc and the United States dollar are the main funding currencies in EMEA and Americas, respectively. The contemporaneous changes in VSMI and VIX can both alone explain around 20 percent of currency carry trade returns in their own regions, leaving other main funding countries' volatility measures redundant. In Asia Pacific, the changes in VXJ have also delayed effect to carry trade returns due to slow collective action of numerous Japanese retail investors. This provides an explanation why VIX has larger contemporaneous effect in this region. However, together the funding liquidity measures from Japan and U.S. can explain one third of the currency excess returns in Asia Pacific.

While the liquidity spreads (TED spreads) produce less significant values relating to carry trade returns, they prove to be more relevant measures when explaining the currency crashes in the major investment countries. This is related to the finding that the TED spreads are better measures of funding risk when there is lots of turbulence in the market. The U.S. and Japanese TED spreads have also predictive power for the currency crashes one month ahead in Americas and Asia Pacific, respectively. However, in EMEA the TED spreads have hardly any significance. All in all, the results from a probit model between the funding liquidity measures and currency crashes are fairly consistent with the findings relating to regional carry trade returns, although, the large sudden depreciation of major investment currencies in EMEA seems to happen in times when the risk aversion is high also globally and TED has highly significant explanatory power for crashes in Asia Pacific. The Swiss and U.S. funding liquidity measures can again explain around 20 percent of the currency crashes in EMEA and Americas, respectively. Moreover, 40 percent of the crashes in major investment currencies in Asia Pacific can be explained with the funding liquidity measures from Japan and U.S.

The results that the main funding countries' liquidity measures are the most dominant when explaining currency excess returns in their own region indicate a clear home bias in carry trades. Investor participating in currency carry trade should pay attention to the changes in Swiss volatility measures if the investment country is located in EMEA, and correspondingly, the changes in the U.S. volatility measure and the TED spread are most relevant variables if the investment country is located in Americas. Moreover, when investing in Asia Pacific, the Japanese funding liquidity measures should be accompanied by the U.S. ones.

My research primarily focuses on the funding liquidity measures of the three main funding countries: Switzerland, Japan and the United States. To get an even better understanding how the geographical and cultural distance between funding and investment countries affect investors' carry trade activity, the further research could also consider funding liquidity measures of other important funding countries, such as the United Kingdom and Euro area. Moreover, instead of sorting currencies to portfolios based on their forward discount, one should concentrate on specific currency pairs that have the desirable characteristic. It could be argued that in some cases the common cultural background can be more significant factor than the actual geographical distance between two countries.

Furthermore, it would be interesting to study more thoroughly how the different investor types affect the predictability of carry trade returns and currency crashes in major investment countries. My results suggest that the collective actions of numerous retail investors are slower than those of larger hedge funds. A better understanding on what type of investors are participating in a certain carry trade could help speculators to benefit more from the effect of slow moving capital.

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Appendix A.

Table A.1: Carry portfolios' funding and investment currencies

This table shows breakdown of the carry portfolios' funding and investment currencies in EMEA, Asia Pacific and Americas. In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The values in the table indicate how often the currency has been chosen to the portfolio, 1 being 100%. High refers to investment currencies and Low to funding currencies. The sample period spans from 1/1999 to 1/2014 and the portfolios are rebalanced at the end of each month.

EMEA	HmL		HmL3		Asia Pacific	HmL		HmL3		Americas	HmL	
	High	Low	High	Low		High	Low	High	Low		High	Low
CZK	-	-	-	0.425	AUD	-	-	0.243	-	CAD	-	0.326
DKK	-	-	-	0.232	CNY	0.006	-	0.166	0.094	MXN	1.000	-
EUR	-	-	-	0.685	HKD	-	0.088	-	0.580	USD	-	0.674
HUF	0.088	-	0.878	-	INR	0.298	-	0.818	-			
NOK	-	-	0.077	0.088	IDR	0.260	-	0.552	-			
PLN	-	-	0.028	-	JPY	-	0.884	-	1.000			
GBP	-	-	-	0.138	KRW	-	-	-	-			
RUB	0.099	-	0.243	-	MYR	-	-	-	-			
ZAR	0.011	-	0.851	-	TWD	-	-	-	0.282			
SEK	-	-	-	0.431	NZD	0.061	-	0.536	-			
CHF	-	1.000	-	1.000	PHP	0.376	-	0.685	-			
TRY	0.801	-	0.923	-	SGD	-	0.028	-	0.895			
					THB	-	-	-	0.149			

Appendix B.

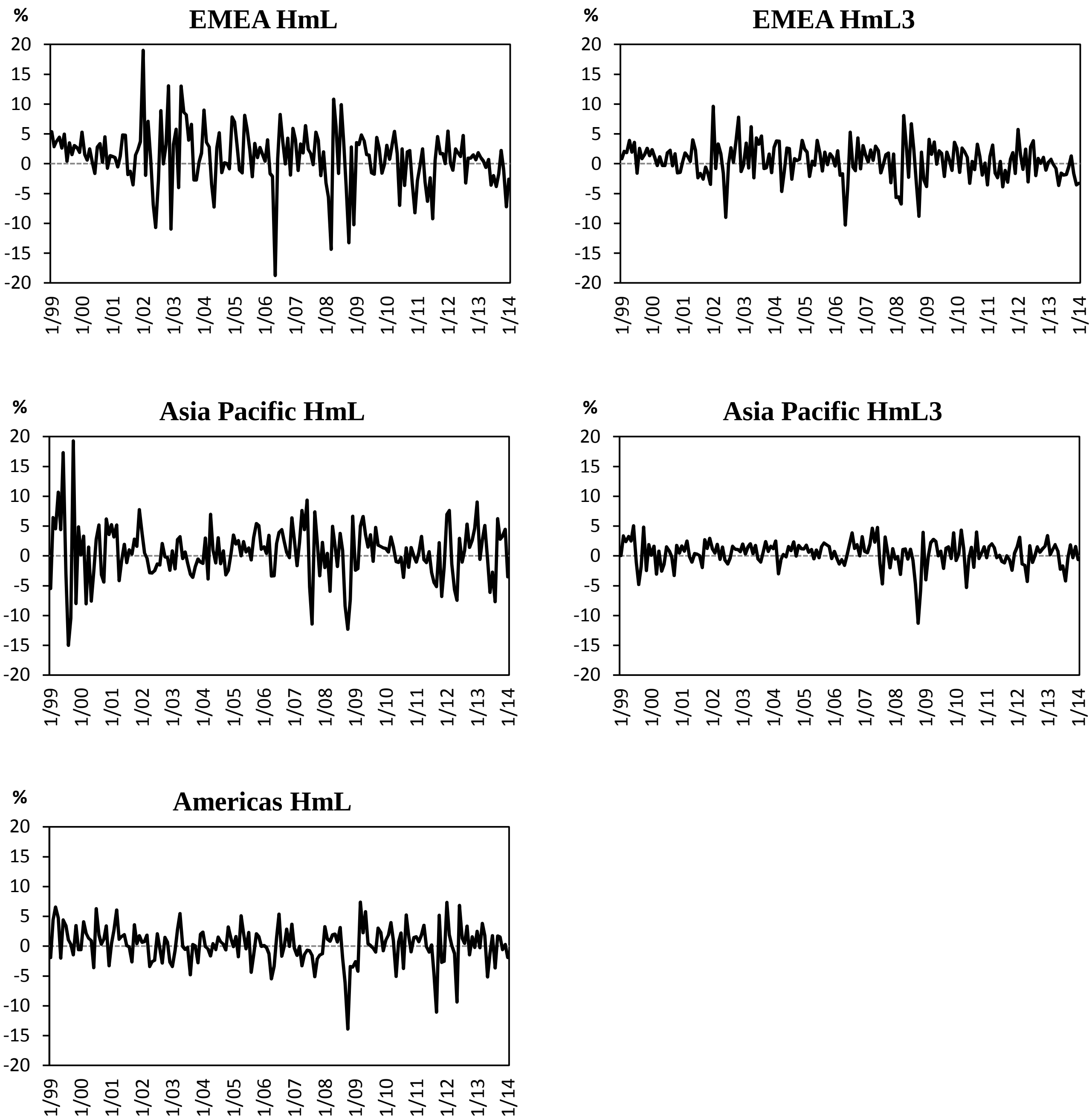

Figure 3: Carry portfolios' monthly currency excess returns. This figure shows the monthly currency excess returns for the carry portfolios in EMEA, Asia Pacific and Americas. The log currency excess returns are compute by subtracting the change in spot exchange rates from the forward discount: $z_{t+1} = (f_t - s_t) - \Delta s_{t+1}$. In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. Data are monthly, from Barclays and Reuters (Datastream). The sample period is from 1/1999 to 1/2014.

Appendix C.

Table C.1: Carry trade returns and key volatility measures

This table documents the contemporaneous relationship between the main funding countries' volatility measures and the carry portfolios' monthly excess return in EMEA, Asia Pacific and Americas. VIX, VSMI and VXJ are the main volatility indexes in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Panel A reports the monthly data for full sample period, 1/1999 – 1/2014. Panel B excludes the financial crisis (8/2007 – 3/2009).

Panel A: Full sample

	EMEA			Asia Pacific			Americas		
	HmL			HmL			HmL		
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2
ΔVSMI	-0.4476***	-5.14	17.73 %	-0.2704***	-3.78	6.67 %	-0.2521***	-3.57	13.41 %
ΔVXJ	-0.1879***	-3.09	6.35 %	-0.1838***	-2.93	6.60 %	-0.1537**	-2.53	10.57 %
ΔVIX	-0.2803**	-2.60	6.13 %	-0.3788***	-5.95	12.67 %	-0.3131***	-4.16	19.55 %
VSMI	-0.0872	-1.50	1.54 %	-0.1362***	-3.19	5.00 %	-0.1042**	-2.34	6.68 %
VXJ	-0.1210***	-2.78	5.00 %	-0.1392***	-4.59	7.42 %	-0.1047***	-2.74	9.47 %
VIX	-0.0651	-1.21	0.69 %	-0.1348***	-3.22	5.25 %	-0.0920**	-1.98	5.46 %
	HmL3			HmL3					
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2			
ΔVSMI	-0.2930***	-5.92	20.44 %	-0.1804***	-3.16	13.97 %			
ΔVXJ	-0.1545***	-4.88	11.96 %	-0.1311**	-2.54	15.88 %			
ΔVIX	-0.2420***	-4.33	12.81 %	-0.2270***	-4.40	20.90 %			
VSMI	-0.0636*	-1.88	2.44 %	-0.0837**	-2.34	8.92 %			
VXJ	-0.0873***	-3.38	7.19 %	-0.1067***	-4.35	20.61 %			
VIX	-0.0517	-1.56	1.56 %	-0.0934***	-2.81	12.01 %			

Panel B: Full sample excl. financial crisis (8/2007-3/2009)									
	EMEA			**Asia Pacific**			**Americas**		
	HmL			HmL			HmL		
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2
ΔVSMI	-0.4843***	-4.81	18.13 %	-0.1847***	-3.00	2.15 %	-0.2531***	-4.62	12.06 %
ΔVXJ	-0.1914**	-2.28	2.65 %	-0.1496**	-2.09	1.42 %	-0.2066***	-2.96	8.85 %
ΔVIX	-0.2743***	-2.81	4.82 %	-0.3054***	-3.93	6.26 %	-0.3227***	-4.81	18.06 %
VSMI	-0.0128	-0.21	-0.59 %	-0.0845**	-2.21	1.03 %	-0.0532	-1.48	0.97 %
VXJ	-0.0873*	-1.66	0.65 %	-0.1107**	-2.30	1.46 %	-0.0544	-1.21	0.60 %
VIX	0.0000	0.00	-0.63 %	-0.0923**	-2.12	1.24 %	-0.0359	-0.75	0.06 %
	HmL3			HmL3					
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2			
ΔVSMI	-0.2803***	-4.58	17.01 %	-0.1221***	-4.29	6.38 %			
ΔVXJ	-0.1445**	-2.55	4.62 %	-0.1048***	-2.66	5.15 %			
ΔVIX	-0.2174***	-3.85	8.98 %	-0.1587***	-3.98	10.09 %			
VSMI	-0.0164	-0.52	-0.47 %	-0.0217	-1.28	0.00 %			
VXJ	-0.0696**	-2.12	1.64 %	-0.0594**	-2.46	2.84 %			
VIX	-0.0124	-0.42	-0.54 %	-0.0414*	-1.93	1.54 %			

Table C.2: Carry trade returns and liquidity spreads

This table documents the contemporaneous relationship between the main funding countries' liquidity spreads and the carry portfolios' monthly excess return in EMEA, Asia Pacific and Americas. TED, S-TED and J-TED are the differences between 3-month LIBOR and 3-month Treasury bill in U.S., Switzerland and Japan, respectively. The change variables are denoted by delta (Δ). In HmL strategy, I borrow (invest in) the currency with the smallest (largest) forward discount. HmL3 follows the same principle, but instead of one currency I go long (short) in the three currencies with the three largest (smallest) forward discounts. The t-statistics are computed using robust standard errors and ***, **, and * indicates statistical significance at 1%, 5%, and 10% confidence level respectively. The reported R^2 values are adjusted R^2s. Data are monthly and the sample period is 1/1999 – 1/2014. The results excluding the recent financial crisis are not statistically significant, and are therefore not shown separately in this table.

	EMEA			**Asia Pacific**			**Americas**		
	HmL			HmL			HmL		
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2
ΔS-TED	-1.3558	-1.15	-0.07 %	-3.4643	-1.20	2.86 %	-1.1221	-0.78	0.24 %
ΔJ-TED	-5.1214	-0.37	-0.38 %	-9.5810	-0.85	0.13 %	-17.5871**	-2.34	4.57 %
ΔTED	-0.4264	-0.29	-0.51 %	-3.7173**	-2.61	3.75 %	-0.6878	-0.54	-0.23 %
S-TED	-1.3998	-0.95	0.63 %	-3.2306***	-3.75	6.32 %	-2.6527***	-2.84	9.76 %
J-TED	-4.5129	-1.16	0.53 %	-0.7777	-0.24	-0.52 %	-2.3064	-0.94	0.12 %
TED	-0.9173	-0.89	0.20 %	-1.8979*	-1.92	2.95 %	-1.6605**	-2.36	5.41 %
	HmL3			HmL3					
	Coef.	t-stat	Adj.R^2	Coef.	t-stat	Adj.R^2			
ΔS-TED	-1.0157	-1.50	0.17 %	-0.3716	-0.20	-0.38 %			
ΔJ-TED	-4.3672	-0.59	-0.21 %	-5.0028	-0.83	0.28 %			
ΔTED	-0.6431	-0.81	-0.24 %	-1.3332	-1.44	1.94 %			
S-TED	-0.9923	-1.07	1.05 %	-2.3020***	-3.32	15.22 %			
J-TED	-1.5971	-0.69	-0.19 %	-2.5789	-1.34	1.17 %			
TED	-0.7396	-1.15	0.76 %	-1.6938***	-2.94	12.05 %			