Risk and uncertainty in the foreign exchange market

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Abstract

We study the importance of risk in the foreign exchange market from the perspective of a carry trade investor, thereby considering 'known unknowns' (volatility) and 'unknown unknowns' (uncertainty) and their relative importance. First we present a theoretical framework to show how volatility and uncertainty affect risk and risk premia in the foreign exchange market. Based on this framework, we empirically examine the relation between risk, expected volatility and uncertainty of foreign exchange returns. We find that uncertainty is the most important factor driving risk, and therefore only focusing on volatility gives an incomplete representation of risk. Moreover, we find that volatility and uncertainty are also important for the expected risk premium. In times of high volatility and/or uncertainty, investors expect to receive a higher risk premium in the near future. We contribute to the foreign exchange asset market debate by showing that interest rate risk and uncertainty about fundamentals have a significant impact on exchange rate risk.

Keywords:
[foreign exchange market risk, disagreement, expectations, forward premium puzzle, uncertainty]

JEL classification codes: G12, G15

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1. Introduction

In this paper we study the relative importance of volatility and uncertainty as components of risk in the foreign exchange market. Giordani and Soderlind (2003) show that risk can be decomposed in two elements, one related to volatility, and a second related to disagreement. Other studies, such as Anderson et al. (2009), relate the former to risk (‘known unknowns’) and latter to uncertainty (‘unknown unknowns’). Anderson et al. decompose the equity risk premium into a compensation for those two elements and find that the uncertainty/return trade-off is stronger than the risk/return trade-off. We apply the same reasoning to the foreign exchange market and find, in line with the equity market results, that uncertainty is most important in explaining foreign exchange market dynamics.

By using disagreement as a proxy for uncertainty, we incorporate the effect of heterogeneity of beliefs on risk and risk premia. The heterogeneous nature of agents in economic and financial markets is becoming increasingly embedded in the finance literature. This is not only the case for the literature on behavioral finance, also traditional models based on rational expectations have been extended and adjusted to account for heterogeneity among agents. This is often done by modeling a representative agent, while taking into account the disagreement between different market participants (i.e. dispersion of beliefs). Support for such an approach comes from different sources. Fama and French (2007) conclude that disagreement matters for asset pricing if investors are risk averse. If informed traders would be risk neutral, they would offset the positions of the uninformed traders and CAPM prices would sustain. Anderson et al. (2005) find that heterogeneity of beliefs matters for asset pricing, and that disagreement about earnings is a risk factor affecting both equity returns and volatility.

Various studies have found that disagreement has an impact on the risk premium of assets. Buraschi and Whelan (2012) focus on bond markets and show that bond risk premia and volatility of the term structure are affected by disagreement about macroeconomic fundamentals and future bond prices. Giordani and Soderlind (2006) show that disagreement about the growth rate of consumption increases the equity premium in an Arrow-Debreu economy. Anderson et al. (2009) link a disagreement factor, based on the weighted cross-sectional volatility of equity return forecasts, to equity premia. They find that this measure of uncertainty is more important in explaining the equity premium than volatility. Several authors have linked disagreement or dispersion in believes to foreign exchange markets and puzzles. Fisher (2006) proposes a model where the foreign exchange forward premium depends on the diversity of prior beliefs about a country’s inflation process. Gourinchas and

Tornell (2004) propose a solution for both the forward premium puzzle and the delayed overshooting puzzle based on investor's distorted beliefs about interest rates. Beber et al. (2010) show that disagreement about future currency returns has a large impact on currency risk premiums.

Engel and West (2005) argue that fundamentals matter as an explanation for currency risk prima. Others have shown that carry trade, or the sign of the yield differential, is driving the premium (Brunnermeier et al., 2008; Sarno et al., 2012; Lustig et al., 2012). Menkhoff et al. (2012) confirm the link between carry trade and risk premia. They show that because returns on high yielding currencies are negatively related to market volatility, the return made on carry trades (i.e. holding long positions in high yielding currencies and short positions in low yielding currencies) is merely a compensation for holding that risk. This pro-cyclical behaviour of carry trade returns is also documented by Briere and Drut (2009). They document that whereas carry trade strategies perform superbly in stable economic times, fundamental models perform much better in times of crises and high global risk aversion. This suggests a link between carry trade and risk appetite also present in Brunnermeier et al. (2008), who show that carry trades generally unwind when risk appetite decreases.

In this paper, we combine these insights about risk, uncertainty, and carry trade returns to model and estimate the relation between risk on the one hand and volatility and uncertainty on the other hand. To proxy for uncertainty we use disagreement among investors from the Consensus Economics® survey. We relate these variables to the expected return risk premium - defined as the expected return in excess of the forward premium, and our aggregate risk measure – implied volatility. In this way we investigate both the risk premium itself and its main component risk. We find that both measures are positively related to volatility and uncertainty, and that uncertainty can be more important than volatility. After investigating the sources of this relation, we discover that risk in foreign exchange markets is correlated with volatility and uncertainty of future interest rates. This is suggestive of a strong link between interest rates and exchange rates, possibly driven by carry trades. Moreover, uncertainty about certain macro fundamentals such as the future current account balance and GDP are also very important in explaining risk in the foreign exchange market. This is supportive evidence for the literature trying to link exchange rate movements with fundamentals.

This paper contributes to the current literature in various ways. First of all, we adopt a framework from the literature on equity returns and inflation expectations and apply it to the foreign exchange market. Our results show that this asset market approach for the foreign exchange market is successful. We confirm results from the equity market that uncertainty is an important driver of risk and risk premium, and therefore should not be ignored in asset pricing models and models of investor behaviour. Our findings also suggest that investors are concerned about interest rate risk, possibly due to carry trade strategies. Moreover, we demonstrate that even though the FX market has certain features in common with other asset markets, trade-related fundamentals still matter for the foreign exchange risk premium. In addition we have a direct and straightforward way for measuring the expected return risk premium, using survey forecasts proxying for investors' expected return. This enables us to investigate the expected return risk premium without making strict assumptions about investors' rationality.

The remaining of the paper is set up as follows. Section 2 describes the model that links the foreign exchange risk premium to expected volatility and uncertainty. Section 3 discusses the method of estimation and our datasets. Section 4 covers the results from estimating the model from Section 2. Based on these findings, we estimate the model using volatility and uncertainty of interest rates and fundamentals and present the results in the remainder of Section 4. Section 5 summarizes the results and discusses implications for current and future research.

2. Model and Methodology

2.1 Expected return risk premium

Let us consider an investor borrowing in a country where interest rates are low and investing in a country where interest rates are high. This strategy is widely applied and generally referred to as 'carry trade'. The expected log returns of such an investor can be decomposed in returns from the interest differential and returns on the exchange rate movement[2] (Frankel, 1982):

$$E[r_{t+1}] = E[\Delta s_{t+1}] + \left(i^{high} - i^{low}\right) \tag{1}$$

[2] At the end of the period, the investor needs to pay his loan back in the low yielding currency and therefore benefits from an appreciation of the high yielding currency.

Where i^{high} is the interest rate of the high yielding currency and i^{low} is the interest rate of the low yielding currency. $E[\Delta s_{t+1}]$ is the expected change in exchange rate denoted as the low yielding currency over the high yielding currency.

According to the interest parity relations the interest differential between the countries should be offset by a change in the exchange rate in the opposite direction. Even though there is little evidence for uncovered interest parity (UIP) to hold, we can assume covered interest parity (CIP) to hold as this is an arbitrage relation.

$$f_t - s_t = i^{home} - i^{U.S.} \qquad (2)$$

Combining (1) and (2) gives us the following excess return relation:

$$E[r_{t+1}] = E[\Delta s_{t+1}] - fd_t \qquad (3)$$

where fd_t is the forward discount. If UIP holds $E[\Delta s_{t+1}] = fd_t$ and expected return to this strategy is zero. However, there is ample evidence in the literature that the latter relation does not hold, often referred to as the forward premium bias or the forward discount bias (a summary of the relevant literature can be found in Engel, 1996).

One of the explanations for this puzzle is that international investors demand a premium for the risk they bare that the exchange rate moves against them (Fama, 1984; Engel, 1984; Menkhoff et al., 2012). This is typically referred to as a (time-varying) risk-premium distorting the relation:

$$E[\Delta s_{t+1}] = i^{home} - i^{U.S.} + \rho_t \qquad (4)$$

where ρ is the risk premium. In a mean-variance framework, the magnitude of the risk premium depends on two factors: the risk and the risk aversion of the investor. Assuming the investor maximizes utility in a mean-variance optimizing way (Dornbusch, 1982; Frankel, 1982) we can impose the following relation:

$$\rho_t = risk_t \times \gamma_t \qquad (5)$$

Combining equations (3)-(5) tells us that the return r_{t+1} of the investor should equal the time-varying risk premium ρ_t. In other words, the return of the investor is a compensation for the risk of (unexpected) future exchange rate movements, scaled by her or his risk aversion:

$$E[r_{t+1}] = E[\Delta s_{t+1}] - fd_t = risk_t \times \gamma_t \qquad (6)$$

Note that in a rational world ($E[\Delta s_{t+1}] = \Delta s_{t+1}$) and for risk neutral investors ($\gamma_t = 0$), there would be no risk premium and uncovered interest parity would hold. Menkhoff et al. (2012) show that these excess returns are indeed a compensation for time-varying risk, as carry trades perform well in tranquil times, but perform very poorly in times of turmoil. They find that global FX volatility is important in explaining the cross-section of excess currency returns. In this paper we consider the time-variation of excess returns and risk in the foreign exchange market, and consider both volatility and uncertainty as explanatory variables.

$$\rho_t = risk_t \times \gamma_t = F\{\sigma_t, \psi_t\} \qquad (7)$$

2.2 Volatility and uncertainty

2.2.1 Risk

As risk is a crucial component in understanding the foreign exchange risk premium, we want to link risk in the foreign exchange market to its components - (expected) volatility and uncertainty - and investigate whether one of the components is dominating in explaining risk in this market. Decomposing risk in a component related to expected volatility and a component related to uncertainty is motivated by and based on earlier work from Lahiri et al. (1988), Giordani and Soderlind (2003) and Huisman et al. (2011). This approach of aggregate market risk is micro-based, and thus starts from an agents' subjective probability distribution.

In forecasting future foreign exchange returns$E[r_{t+1}]$, each agent is driven by its own subjective probability distribution function with mean μ_i and variance σ_i^2. Note that these (theoretically) correspond to an agent's point forecast for the future return and its expected volatility. The average expected volatility of the market then corresponds to $E(\sigma_i^2) = \frac{1}{N}\sum_{i=1}^{N}\sigma_i^2$. If agents are assumed to be homogeneous in their expectations the only risk they would face is the volatility of foreign exchange returns. However, the evidence for heterogeneous beliefs in financial markets is overwhelming (see, among others, Frankel and Froot, 1987; Jongen et al., 2012; Ter Ellen et al., 2012) and therefore we need to incorporate an uncertainty component to account for disagreement among agents. After all, if the distance between forecasts is very large (i.e. agents heavily disagree about their point forecasts) this will increase market risk about future exchange rate movements. Giordani and Soderlind (2003) and Huisman et al. (2011) show theoretically that aggregate risk in a market with heterogeneous expectations is equal to the sum of average expected volatility, $E(\sigma_i^2)$, and the cross-sectional variance, i.e., disagreement, of return expectations. This brings us to the following decomposition of risk:

$$risk_t = E(\sigma_i^2) + \sigma_{\mu_i}^2 \tag{8}$$

In words, the total risk of the market is a sum of the average expected volatility and the disagreement among investors about expected returns. This equation mainly differs from Giordani and Soderlind (2003) in the left-hand side component, where we have replaced the variance of the aggregate distribution with a more general term 'risk'. Giordani and Soderlind (2003) mention that interpreting the aggregate distribution is not straightforward for inflation forecasts. However, as Huisman et al. (2011) point out, in financial markets we can interpret the aggregate distribution as a measure of total risk in the market.

As pointed out by Anderson et al. (2009), because volatility is persistent, precise estimation is possible by sampling returns over relatively short time intervals. The drift component, however, requires a very long data interval rendering it difficult to obtain an efficient estimate due to structural breaks. Hence, asset returns are risky due to the deviations from the mean (i.e., volatility) but they are uncertain because the unconditional mean is unknown. Therefore, they argue, dispersion in the expected mean is a reasonable proxy for uncertainty. We follow their interpretation and argue that the dispersion in beliefs, $\sigma_{\mu_i}^2$, equals market uncertainty, given by ψ_t.

The foreign exchange risk premium, decomposed into risk and risk aversion, is a function of volatility σ_t and uncertainty ψ_t of future exchange rate returns. Former research has shown the importance of accounting for uncertainty in the context of risk premia. Beber et al. (2010) find that uncertainty has a large impact on currency risk premia. Anderson et al. (2009) focus on equity markets and show that uncertainty is more important in explaining the equity risk premium than volatility.

Many studies have measured risk or uncertainty[3] in a narrow way, taking only known unknowns into account, by using volatility models such as VAR, GARCH, squared returns or historical variance, which are all based on historical returns. However, such measures underestimate the real risk underlying the market for two reasons. First of all, it only measures one aspect of risk, thus leaving out a crucial component: Anderson et al. (2009) show that uncertainty is more important in explaining the equity risk premium than volatility. Second, it is biased by the perception of risk. It is a widely accepted idea that investors are on average risk averse, and therefore demand higher returns for bearing risk. Volatility based on historical returns will therefore be a biased measure of risk.

In this paper we want to define a measure of risk that captures both components, i.e. known and unknown risk, and controls for the perception of investors. Implied volatility is the volatility backed out from an option contracts on the price of the underlying, assuming that investors are risk-neutral and risk only consists of ‘known unknowns’. In other words, it is the volatility implied in option returns in case investors would be risk-neutral. Because extensive research has shown that most people appear to be risk averse, implied volatility differs from realized volatility. We therefore proxy risk with implied volatility and obtain:

$$\sigma_{IV}^2 = \sigma^2 + \psi_t \tag{9}$$

3. Data & Method

3.1 Expectations and uncertainty

For a long time, expected returns were proxied by ex-post realized returns based on the rational expectations framework, as actual expectations were not observable. This partly changed in and after the eighties when companies like Money Market Services International (MMSI) and Consensus Economics® started to gather investors’ expectations of future asset prices by means of surveys. Dominguez (1986) and many others after her found based on the

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[3] In finance and economics, different definitions of risk and uncertainty are used. In some cases, uncertainty is the ‘umbrella’ term, capturing both risk (known unknowns) and ambiguity (unknown unknowns). In some cases risk is defined as the aggregate of known and unknown unknowns, but proxied by measures of known unknowns. In other papers, risk is the ‘umbrella’ term and composed out of volatility (known unknowns) and uncertainty (unknown unknowns). We follow the latter approach.

survey results that investor expectations and realized outcomes are seriously misaligned, both on individual and aggregated level. When considering expected return risk premia, we therefore choose to work with survey forecasts as a close proxy for expectations instead of using realized returns in combination with a number of strict assumptions.

Furthermore, Giordani and Soderlind (2003) found that individuals underestimate total risk (i.e. have too narrow confidence intervals around their point forecasts), which is confirmed by Huisman et al. (2011), who find that investors only take their own perception of risk into account, while the total market risk is larger because of differences in point forecasts. Although Bomberger (1996) claims that disagreement is smaller than individual uncertainty rather than larger, he finds that the relation is linear and stable, and therefore concludes that disagreement is still a good proxy for uncertainty. When using disagreement as a measure of uncertainty, we assume that the forecasters only disagree on the point forecasts, and not on higher moments.

3.2 Data

For the first part of this paper, we use a dataset with monthly forecasts from financial analysts and investors gathered by Consensus Economics®. Consensus Economics is the world's leading international economic survey organization and their datasets are unique in terms of their long time span, large number of respondents, level of responding institutions, and the disaggregate level of forecasts. Forecasts are given every month for the future value of the dollar against the Euro and the Japanese yen 1, 3 and 12 months ahead. Our sample runs from January 1999 to December 2009. Besides the survey data we use implied volatilities, and spot and forward exchange rates from Thomson Reuters (obtained through Datastream).

3.3 Descriptive statistics

< Insert tables 1.1-1.4 about here >

Descriptive statistics for the variables of interest are shown in Tables 1.1-1.4. We can see that the longer the horizon, the larger the disagreement is on future values of the exchange rates. The same goes for annualized historical volatility. The expected (log) return risk premium is on average negative for the Euro and positive for the Japanese yen.

3.4 Volatility/uncertainty relation with risk premia

<Insert figure 1-2 about here>

To get an idea of how our measure of expected risk premia relates to our measures of volatility and uncertainty, we plotted the risk premium for different levels of those variables in Figure 1-2. Note that we work with currency pairs, so a positive risk premium for the JPY/USD means that investors require a risk premium for holding a long position in U.S. dollars and a short positive in Japanese yen. Since this is one of the most common carry strategies, we mainly look at the results for this currency pair at the moment. The plots show that investors demand a large positive premium when volatility and uncertainty is large and accept a negative premium for low levels of volatility and uncertainty. In other words, in times when carry strategies have proven to perform poorly, investors demand a high risk premium for holding a position in line with a carry strategy. From these plots we can already see the relative importance of uncertainty in this story. For medium to high levels of uncertainty, the demanded risk premium is of similar size as for medium to high levels of volatility, in some cases even bigger. This stresses the importance of uncertainty in a risk/return framework.

3.5 Estimation

In the remainder of the paper, we study the relations given by (7) and (8) empirically in order to determine the relative importance of volatility and uncertainty for different risk measures in the foreign exchange market. To be more specific, we estimate the following regressions. First the relation between implied volatility and total risk, given by (8) is studied:

$$\sigma_{IV}^2 = \alpha + \beta\sigma_t^2 + \gamma\psi_t + \varepsilon_t \quad (11a)$$

Second, we study the expected return risk premium, based on survey data of exchange rate expectations. That is,

$$E[\Delta s_{t+1}] - f_t = \alpha + \beta\sigma_t^2 + \gamma\psi_t + \varepsilon_t \quad (11b)$$

Where uncertainty (ψ_t) is measured as disagreement, i.e. the cross-sectional standard-deviation of forecasts $\sigma_t(\mu_i)$.

4. Results

4.1 FX Market

In this section we discuss the empirical analysis as a result of the theoretical implications from previous sections. Our empirical analysis consists of linear regressions (OLS) to estimate the relation between different features of foreign exchange risk premia on the one hand and volatility and uncertainty on the other hand.

Whereas implied volatility is a measure of risk and the return risk premium is a complete measure for the demanded risk compensation, as a combination of risk and risk aversion, the volatility risk premium reveals the level of risk aversion. Analyzing all three of them gives a complete representation of the relation between volatility and uncertainty and those three features of the foreign exchange market.

4.1.1 Implied volatility

The implied volatility of an asset is the risk-neutral volatility implied from an option pricing model such as the Black and Scholes (1973) model. Due to the fact that investors in real life are risk averse, realized volatility is generally smaller than implied volatility. Therefore, implied volatility can be seen as a purer and more direct measure of the true risk in the market. To see how this measure of risk relates to volatility and uncertainty, we regress implied volatility on historical volatility of the exchange rate and disagreement about future values of the exchange rate.

< Insert Table 2 about here >

Table 2 shows the results of this regression for the Euro against the US dollar and the Japanese yen against the US dollar. We can see that historical volatility is positively correlated with implied volatility, as expected. More interestingly, uncertainty, measured by disagreement, has a large and significant effect on implied volatility beyond the impact of historical volatility. Moreover, adjusted R-squares from this regression are all between 0.421

and 0.738, which means that the combination of volatility and uncertainty explains a large part of the variance of implied volatility.

4.1.2 Expected return risk premium

The difference between the expected exchange rate and the forward rate is the risk premium investors demand to be compensated for the volatility of currency returns and the uncertainty about the return process.

< Insert Table 3 about here >

Looking at the results in Table 3 we can see that it is mainly uncertainty that investors want to be compensated for. For both currencies and all horizons our disagreement variable has a statistically significant effect (on 1% or 5%) on the expected return risk premium. The impact of volatility on expected return risk premia is ambiguous. For the Euro it only has a significant impact for the 12 months horizon, and this effect is negative, implying that when Euro returns are more volatile, investors demand a smaller return risk premium. Volatility has a statistically significant positive effect on the expected risk premium for the Japanese yen for the 1 month and 12 month horizon, but this effect is very small. With the exception of the 1 month horizon for the Euro, adjusted R-squares are around 0.15 to 0.35.

These results confirm our expectations from figure 1. In times when carry strategies have proven to perform poorly (high volatility/uncertainty), investors demand a high future risk premium for holding a position in line with a carry strategy. This relation is stronger for uncertainty than for volatility.

4.2 Sources of risk and uncertainty: interest rates and fundamentals

Now we know that risk and risk premia are affected by volatility of and uncertainty about future currency returns, it is interesting to see what the source of this relation is. This adds to the debate about whether the foreign exchange market should be considered as an asset market, responding mainly to financial and monetary fundamentals such as interest rates, or as a market that is mainly influenced by trade flows and therefore responds to real and nominal fundamentals such as GDP, inflation and current account balance.

There is an ongoing discussion whether the foreign exchange market can be seen as an asset market. There are many papers successfully applying asset pricing theory on the foreign exchange market whereas many fundamental models appear to fail; see Meese and Rogoff (1982). Many puzzles in the foreign exchange literature are still largely unexplained. The forward discount puzzle, being one of the most important foreign exchange puzzles, describes the fact that the forward rate is a biased predictor of the future spot rate. This misalignment is often explained as a time-varying risk premium (see Engel 1996, for an overview of the related literature). Whether we can indeed regard this misalignment as a risk premium or should blame investors' irrational beliefs is ambiguous. Based on forecasts obtained from a survey, Froot and Frankel (1989) conclude that the bias is almost entirely explained by the biased beliefs of investors. However, Cavaglia et al. (1994) find, with a different dataset and methodology, that the forward discount puzzle is a result of both biased beliefs and the occurrence of time-varying risk premia.

We eliminate the discussion about biased beliefs by directly using the expected risk premium based on Consensus® survey forecasts. Following our model from section 2, we expect that the resulting expected risk premium is affected by interest rate risk, since the level of relative interest rates is the investors' motivation to hold a short or long position in a certain currency. However, from a macroeconomic rather than finance perspective, uncertainty about macro fundamentals should also affect the risk and risk premium of exchange rates if investors believe that they have an impact on exchange rate movements.

4.2.1 Fundamentals

Looking at the underlying sources of currency risk and returns, the risk investors in the foreign exchange market face (and want to be compensated for) can be decomposed in three parts:

1. The volatility of the underlying fundamentals
2. The uncertainty in the market about the movement of the underlying fundamentals
3. The uncertainty about the impact of the underlying fundamental model on the exchange rate

$$risk_t = \alpha + \lambda\sigma_t^f + \delta\psi_t^f + \varepsilon_t \tag{13}$$

The uncertainty about the impact of the underlying fundamental model on exchange rate movement is assumed to be time-invariant (α). Therefore, the time-variation in the currency risk comes from the time-varying volatility of the fundamental (σ_t) and the market uncertainty about future movements of the fundamental (ψ_t).

4.2.2 Data

For this second part of the paper we use a different (Consensus Economics®) dataset with survey forecasts for macro fundamentals. The forecasts we use to construct a measure for uncertainty are budget balance, current account, GDP, investments, industrial production, 3 month interest rates and 10 year government yields. The survey also contains consensus forecasts for the dollar against the Australian dollar, Japanese yen and New Zealand dollar. The exchange rate forecasts and interest rate forecasts are given monthly for horizons of 3 and 12 months. Forecasts on the other fundamentals are for realizations of those fundamentals for the current year. Therefore we cannot directly compare it to the analysis for the Euro and Japanese yen from the previous section. This also means that our uncertainty measure is only based on disagreement on future Australian, Japanese and New Zealand interest rates, and excludes disagreement on future U.S. interest rates.

4.2.3 Interest rates – carry trade

From the perspective of a carry trader, the relevant fundamental factor investors are concerned about is the interest rate differential ($i^{home} - i^{U.S.}$). Lustig et al. (2008) also stress the importance of interest rates for risk premia in the foreign exchange market. They show that currency risk premia are mainly determined by a global risk factor measured by interest rate differentials. We therefore consider the effect of interest rate volatility and uncertainty on risk and risk premia, to see whether we find similar effects as in the previous section.

Implied volatility

< Insert tables 4.1-4.3 about here >

The results of regressing implied volatility of exchange rates on uncertainty and volatility of the foreign (Australian, Japanese, or New Zealand) interest rates are presented in tables 4.1-4.3. Uncertainty and volatility of foreign interest rates have a significant impact on implied volatility. However, after controlling for U.S. interest rate volatility and the volatility of the exchange rate itself, most of these effects disappear. Therefore the results may be driven by correlation with these variables. This does not mean that interest rates are not important for returns and risk of exchange rates. In contrast, a high correlation between interest rate risk and exchange rate risk implies that interest rates should not be ignored. This strong relation is supportive for our carry trade perspective on risk premia.

Expected return risk premium

< Insert tables 5.1-5.3 about here >

As we can see from the results in tables 5.1-5.3 the expected return risk premium cannot be explained by volatility of and uncertainty on interest rates. This is in line with previous research, where a stable and linear relation between (excess) returns and interest rates seems to be absent (e.g. Meese and Rogoff, 1988; Bacchetta and Van Wincoop, 2009; Sarno and Valente, 2008). However, as mentioned above, it does not mean that the relation is absent.

4.2.4 Fundamentals

Many attempts have been made to connect exchange rate movements to (macro)fundamentals, the first and most famous example being Meese and Rogoff (1983), and many have failed. Exchange rate movements, especially for horizosn of a year or less, do not seem to be related to movements of (macro)fundamentals. In this section we will investigate whether this is different for aspects of risk. We therefore relate implied volatility, expected return risk premium, and volatility risk premium to uncertainty on a number of fundamentals, such as current account balance and GDP. Note that in this section we only use uncertainty about macro-fundamentals, and do not consider volatility. This is motivated by the fact that most of the fundamentals considered are only observed on an annual basis, and therefore monthly volatility is not relevant.

Implied volatility

< Insert table 6.1-6.3 about here >

Uncertainty about the current account balance is statistically significant and positively related to currency risk. Uncertainty about the real economy matters as well, GDP is an important measure for Australia and New Zealand, whereas industrial production matters for

Japan. The implied volatility of the NZ dollar is also affected by uncertainty about New Zealand's budget balance. Uncertainty about interest rates affects the riskiness of all three currencies. Uncertainty about investments is not related to exchange rate risk.

Expected return risk premium

< Insert table 7.1-7.3 about here >

In tables 7.1-7.3 we can see that uncertainty about trade and the real economy take over the significance from interest rate uncertainty. This indicated that for the expected risk premium, real factors seem to be more important than monetary or financial factors.

5. Conclusion

In this paper we have investigated the relation between foreign exchange market risk and volatility and uncertainty of exchange rates and fundamentals. Different features of foreign exchange market risk have been considered – return risk premium, risk and volatility risk premium (also a proxy for risk aversion). Return risk premium was measured as the difference between the expected return of the currency and the forward premium, risk was proxied by implied volatility and the volatility risk premium was calculated as the difference between implied and realized volatility. We have found that volatility and uncertainty are both related to foreign exchange risk, but that investors mainly want to be compensated for uncertainty. It is therefore crucial that future research does not merely focus on the volatility/return trade-off, but also incorporates a measure of market uncertainty.

Results of further investigating the sources of this relationship indicate that uncertainty on exchange-related fundamentals explain a large part in the variation of foreign exchange risk and risk premia. Volatility of and uncertainty on interest rates seem to have an effect on exchange rate risk, but this effect largely disappears after controlling for exchange rate volatility. This might be an effect of the strong interrelation between exchange rates and interest rates. It turns out that uncertainty on certain real factors, such as current account balance and GDP are more important. This is supportive evidence for the literature trying to link exchange rate movements with fundamentals.

This paper contributes to the current literature in various ways. First of all, we adopt a framework from the literature on equity returns and inflation expectations and apply it to the foreign exchange market. Our results show that this asset market approach for the foreign exchange market is successful. More importantly, we show that the uncertainty/return trade-off might be more important than the volatility/return trade-off. Moreover, we demonstrate that even though the FX market has certain features in common with other asset markets, trade-related fundamentals also matter for the foreign exchange risk premium. In addition we have a very direct and straightforward way for measuring the expected return risk premium, viz using survey forecasts proxying for investors' expected return. This enables us to investigate the expected return risk premium without making strict assumptions about investors' rationality.

Future research is necessary to further investigate the relation between risk and uncertainty of fundamentals and risk of foreign exchange movements, to isolate the fundamentals that are most important and identify which fundamentals drive what currency returns and why.

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Tables

Table 1.1-1.4 - Descriptives

Disagreement						
	Euro			Japan		
	1m	3m	12m	1m	3m	12m
Mean	0.028	0.040	0.068	2.842	4.238	7.243
Median	0.026	0.039	0.067	2.700	4.000	6.950
Maximum	0.170	0.076	0.103	7.400	10.300	13.600
Minimum	0.014	0.023	0.037	1.600	2.700	4.700
Std. Dev.	0.014	0.011	0.014	0.887	1.138	1.653

Table 1.1

Historical volatility						
	Euro			Japan		
	1m	3m	12m	1m	3m	12m
Mean	0.043	0.129	0.527	6.219	18.038	74.855
Median	0.037	0.114	0.493	5.734	15.640	74.049
Maximum	0.144	0.350	0.989	26.520	85.014	176.936
Minimum	0.009	0.038	0.145	1.839	6.520	29.674
Std. Dev.	0.023	0.067	0.209	3.295	9.902	32.625

Table 1.2

Implied Volatility						
	Euro			Japan		
	1m	3m	12m	1m	3m	12m
Mean	10.428	10.502	10.628	11.235	11.150	11.171
Median	9.963	10.213	10.400	10.300	10.113	10.600
Maximum	21.750	20.255	18.200	24.500	21.500	18.600
Minimum	5.050	5.250	5.630	6.275	6.600	6.650
Std. Dev.	2.917	2.682	2.369	3.493	3.066	2.749

Table 1.3

Expected return RP						
	Euro			Japan		
	1m	3m	12m	1m	3m	12m
Mean	-0.006	-0.010	-0.022	0.002	0.006	0.020
Median	-0.004	-0.010	-0.018	0.001	0.005	0.021
Maximum	0.031	0.036	0.074	0.086	0.114	0.171
Minimum	-0.064	-0.075	-0.158	-0.057	-0.068	-0.080
Std. Dev.	0.018	0.021	0.040	0.019	0.027	0.044
Skewness	-0.691	-0.313	-0.467	0.740	0.454	0.273

Table 1.4

Table 2 - FX Implied volatility

IV	Europe 1m		3m		12m		Japan 1m		3m		12m	
constant	5,576	***	2,314	***	3,485	***	2,670	***	2,624	***	2,985	***
	4,465		2,678		2,449		3,604		3,465		4,695	
FX unc	56,686		135,550	***	55,534	***	2,526	***	1,865	***	0,918	***
	1,044		7,894		2,924		9,229		10,252		7,713	
FX exp vol	70,572	***	20,407	***	6,092	***	0,223	***	0,035		0,020	**
	5,453		8,845		3,782		3,557		1,303		2,297	
adj R2	0,421		0,738		0,491		0,617		0,586		0,547	

The table above shows the results from regressing the implied volatility of the EUR/USD and JPY/USD exchange rates on the expected volatility of currency returns, proxied by historical volatility, and uncertainty about future exchange rate returns, proxied by disagreement. Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Table 3 – FX Expected return risk premium

Exp return RP	Europe 1m		3m		12m		Japan 1m		3m		12m	
constant	-0,012	***	-0,031	***	-0,040	*	-0,024	***	-0,054	***	-0,071	***
	-2,339		-4,678		-1,840		-4,459		-5,887		-3,992	
FX unc	0,155	**	0,787	***	0,894	***	0,005	***	0,014	***	0,008	***
	2,019		5,181		2,797		2,405		5,461		2,648	
FX exp vol	0,057		-0,080	***	-0,080	***	0,002	***	0,000		0,000	***
	0,695		-2,656		-3,009		3,134		0,419		3,036	
adjR2	0,010		0,148		0,199		0,237		0,351		0,328	

The table above shows the results from regressing the expected return risk premium of the EUR/USD and JPY/USD exchange rates on the expected volatility of currency returns, proxied by historical volatility, and uncertainty about future exchange rate returns, proxied by disagreement. Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Table 4.1-4.3 – Interest rates: Implied volatility

	Australia											
IV	3m						12m					
	I		II		III		I		II		III	
constant	8,839	***	8,530	***	4,508	***	11,924	***	11,367	***	4,559	***
	6,437		7,255		7,239		21,806		16,456		5,119	
unc for int rate	5,010		4,330		2,560		-9,427	***	-9,008	***	-0,624	
	0,654		0,661		0,938		-7,085		-6,223		-0,507	
exp vol for int rate	10,957	***	4,577		-3,298	*	6,944	***	5,929	***	-1,259	
	2,573		1,145		-1,657		6,502		4,769		-1,247	
exp vol U.S. int rate			9,572	***	-0,222				1,935	*	0,144	
			2,825		-0,151				1,791		0,265	
FX exp vol					56,915	***					58,893	***
					10,894						8,391	
adj R2	0,196		0,305		0,800		0,366		0,392		0,812	

Table 5.1

	Japan											
IV	3m						12m					
	I		II		III		I		II		III	
constant	9,204	***	8,637	***	3,592	***	10,141	***	10,006	***	5,163	***
	24,146		7,255		7,358		22,535		14,075		6,998	
unc for int rate	14,080	***	13,107		4,751		2,787		2,919		1,391	
	2,587		0,661		1,615		1,423		1,459		1,067	
exp vol for int rate	18,037	***	17,187		3,961		6,664	***	6,606	***	3,961	***
	3,660		1,145		1,219		4,187		4,168		2,632	
exp vol U.S. int rate			5,291	***	0,431				0,290		-0,273	
			2,825		0,501				0,303		-0,473	
FX exp vol					64,587	***					51,810	***
					13,316						8,568	
adj R2	0,243		0,317		0,734		0,132		0,129		0,581	

Table 5.2

	New Zealand											
IV	3m						12m					
	I		II		III		I		II		III	
constant	9,811	***	9,740	***	3,957	***	8,990	***	8,673	***	3,161	***
	11,585		11,955		7,297		10,328		10,864		3,360	
unc for int rate	9,263	*	7,487		3,702		4,575	*	3,701		-0,460	
	1,882		1,500		1,556		1,887		1,513		-0,382	
exp vol for int rate	11,022	***	8,175	***	-3,288	*	4,449	***	3,985	***	-1,314	**
	4,489		2,631		-1,682		7,069		5,685		-2,040	
exp vol U.S. int rate			5,169	**	0,708				1,806	**	0,153	
			2,250		0,577				2,132		0,392	
FX exp vol					67,475	***					79,370	***
					12,068						79,370	
adj R2	0,373		0,415		0,783		0,475		0,506		0,828	

Table 5.3

The tables above show the results from regressing the implied volatility of the AUD/USD, the JPY/USD and NZD/USD exchange rates on the expected volatility of interest rates, proxied by historical volatility, and uncertainty about future foreign interest rates, proxied by disagreement. Model III controls for the historical volatility of the exchange rate. Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Table 5.1-5.3 – Interest rates: Expected return risk premium

	Australia											
Exp return RP	3m						12m					
	I		II		III		I		II		III	
constant	-0,016	***	-0,017	***	-0,023	***	-0,040	***	-0,035	***	-0,041	*
	-2,989		-3,127		-3,133		-2,893		-2,440		-1,774	
unc for int rate	0,025		0,023		0,029		0,011		0,008		0,015	
	1,107		1,029		1,194		0,466		0,340		0,451	
exp vol for int rate	0,022		0,014		0,010		0,004		0,012		0,009	
	1,015		0,787		0,618		0,287		0,774		0,468	
exp vol U.S. int rate			0,015		0,005				-0,018		-0,019	
			0,916		0,255				-0,724		-0,764	
FX exp vol					0,061						0,047	
					1,131						0,484	
adj R2	0,024		0,026		0,036		-0,001		0,006		0,004	

Table 6.1

	Japan											
Exp return RP	3m						12m					
	I		II		III		I		II		III	
constant	0,004		0,003		-0,021	**	0,019	*	0,014		-0,049	***
	0,653		0,572		-2,300		1,772		0,966		-2,870	
unc for int rate	0,037		0,036		0,014		0,038		0,040		0,024	
	0,914		0,894		0,359		0,698		0,736		0,423	
exp vol for int rate	0,012		0,012		0,008		0,013		0,010		0,016	
	0,385		0,367		0,351		0,473		0,355		0,591	
exp vol U.S. int rate			0,003		-0,014				0,011		0,009	
			0,243		-1,069				0,739		0,627	
FX exp vol					0,277	***					0,618	***
					3,487						5,705	
adj R2	0,006		0,002		0,113		0,015		0,016		0,222	

Table 6.2

	New Zealand											
Exp return RP	3m						12m					
	I		II		III		I		II		III	
constant	-0,004		-0,003		-0,014		-0,035		-0,030		-0,072	***
	-0,612		-0,384		-1,414		-1,500		-1,261		-2,382	
unc for int rate	-0,042	**	-0,045	**	-0,034		0,012		0,011		0,045	
	-2,111		-2,016		-1,513		0,359		0,315		1,150	
exp vol for int rate	0,055	***	0,058	***	0,048		0,001		0,002		-0,012	
	3,555		3,144		2,561		0,058		0,134		-0,703	
exp vol U.S. int rate			-0,009		-0,023				-0,011		-0,031	
			-0,420		-0,860				-0,397		-1,072	
FX exp vol					0,099						0,360	**
					1,078						2,129	
adj R2	0,055		0,052		0,064		-0,009		-0,011		0,026	

Table 6.3

The tables above show the results from regressing the expected return risk premium of the AUD/USD, the JPY/USD and NZD/USD exchange rates on the expected volatility of interest rates, proxied by historical volatility, and uncertainty about future foreign interest rates, proxied by disagreement. Model III controls for the historical volatility of the exchange rate. Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Table 6.1-6.3 – Fundamentals: Implied volatility

	Australia							
IV	3m				12m			
	I		II		I		II	
constant	10,615	***	9,259	***	10,663	***	10,176	***
	9,779		8,019		11,572		10,973	
BB unc	-0,049		-0,025		0,028		0,037	
	-0,344		-0,183		0,184		0,247	
CA unc	0,791	***	0,723	***	0,737	***	0,754	***
	5,622		6,362		7,421		7,779	
GDP unc	-6,540	***	-6,590	***	-5,635	***	-5,260	***
	-2,369		-2,740		-3,024		-2,776	
Inv unc	0,078		0,011		-0,149		-0,182	
	0,231		0,034		-0,593		-0,787	
IP unc	-0,518		-0,230		-0,618		-0,697	
	-0,869		-0,478		-1,192		-1,371	
unc for int rate			11,822	*			-3,066	**
			1,751				-2,061	
unc for gtv yield			-3,153				4,126	
			-0,910				1,632	
adj R2	0,473		0,507		0,551		0,561	

Table 8.1

	Japan							
IV	3m				12m			
	I		II		I		II	
constant	9,352	***	6,186	***	9,168	***	7,043	***
	7,677		4,191		9,609		5,257	
BB unc	0,075		0,121		0,137		0,158	
	0,488		0,885		1,205		1,443	
CA unc	0,119		0,082		0,140	*	0,046	
	1,265		1,017		1,800		0,648	
GDP unc	1,922		-2,473		2,611		-0,790	
	0,824		-1,045		1,258		-0,350	
Inv unc	-0,513		-0,016		-0,695		-0,248	
	-0,963		-0,035		-1,452		-0,492	
IP unc	1,004	***	1,327	***	0,827	**	1,335	***
	2,685		3,590		2,098		3,619	
unc for int rate			15,879	***			5,301	**
			2,733				2,105	
unc for gtv yield			11,672	***			4,490	
			2,667				1,408	
adj R2	0,102		0,263		0,130		0,194	

Table 8.2

	New Zealand							
IV	3m				12m			
	I		II		I		II	
constant	8,866	***	6,389	***	8,560	***	6,767	***
	7,948		4,762		9,501		4,928	
BB unc	3,169	***	3,077	***	2,658	***	2,391	***
	4,274		4,626		4,933		5,032	
CA unc	0,569	**	0,500		0,954	***	0,985	***
	2,043		1,328		4,267		4,541	
GDP unc	2,260		0,579		0,638		-0,715	
	1,048		0,270		0,380		-0,397	
Inv unc	0,420		0,123		0,493		0,353	
	1,145		0,305		1,581		1,406	
IP unc	-0,758		-0,488		-0,311		-0,296	
	-1,353		-1,180		-0,631		-0,599	
unc for int rate			13,867	***			0,692	
			2,626				0,316	
unc for gtv yield			3,458				7,567	**
			1,121				2,120	
adj R2	0,368		0,481		0,484		0,532	

Table 8.3

The tables above show the results from regressing the implied volatility of the AUD/USD, the JPY/USD and NZD/USD exchange rates on the uncertainty about fundamentals, proxied by disagreement. Model I includes uncertainty about a number of real fundamentals (budget balance, current account, GDP, investments, industrial production), whereas model II also includes monetary fundamentals (3 months interest rates, 10 year government yields). Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Table 7.1-7.3 – Fundamentals: Expected return risk premium

	Australia							
Exp return RP	3m				12m			
	I		II		I		II	
constant	-0,023	***	-0,035	***	-0,058	***	-0,062	***
	-2,960		-3,620		-3,281		-2,622	
BB unc	0,001	***	0,002	***	0,005	***	0,006	***
	2,333		2,566		4,203		4,299	
CA unc	0,002	***	0,002	***	0,001		0,001	
	2,373		2,557		0,792		0,724	
GDP unc	-0,008		-0,010		0,031		0,021	
	-0,389		-0,449		0,770		0,526	
Inv unc	0,001		0,001		-0,004		-0,005	
	0,439		0,322		-0,697		-0,779	
IP unc	0,003		0,003		0,005		0,006	
	0,548		0,703		0,474		0,575	
unc for int rate			0,014				0,055	*
			0,570				1,809	
unc for gtv yield			0,036				-0,037	
			1,421				-0,818	
adj R2	0,132		0,137		0,141		0,158	

Table 9.1

	Japan							
Exp return RP	3m				12m			
	I		II		I		II	
constant	-0,001		-0,022	**	0,013		-0,017	
	-0,088		-2,168		0,955		-0,894	
BB unc	0,000		0,000		0,000		0,000	
	0,168		0,407		0,087		0,318	
CA unc	0,001	***	0,001	**	0,005	***	0,004	***
	2,465		2,231		3,057		2,497	
GDP unc	0,020		-0,012		-0,005		-0,043	
	1,266		-0,671		-0,141		-1,186	
Inv unc	-0,001		0,001		-0,003		0,001	
	-0,275		0,219		-0,371		0,143	
IP unc	-0,001		0,004		0,008		0,015	**
	-0,340		0,880		1,102		2,108	
unc for int rate			0,059				0,064	
			1,146				1,442	
unc for gtv yield			0,109	***			0,064	
			3,582				1,249	
adj R2	0,037		0,118		0,137		0,170	

Table 9.2

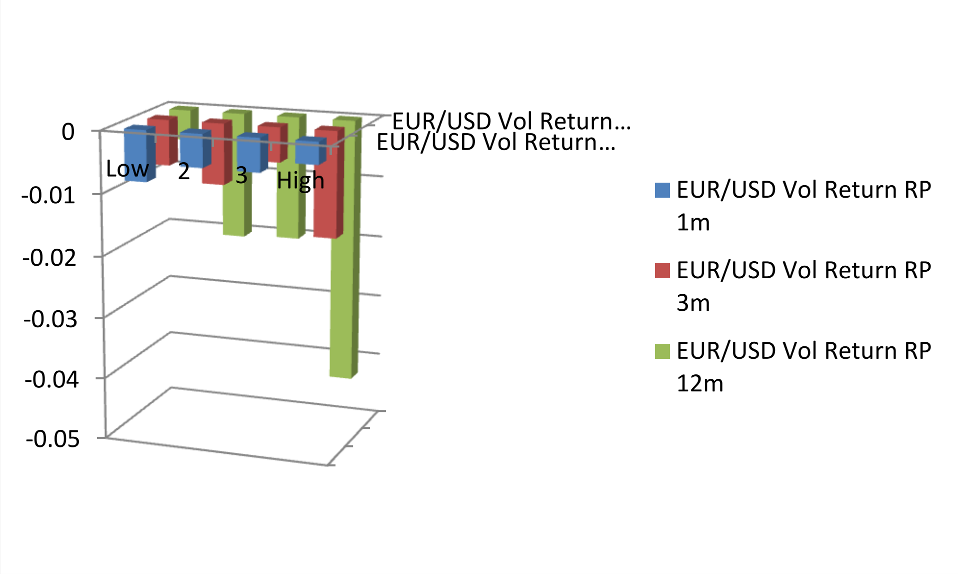
	New Zealand							
Exp return RP	3m				12m			
	I		II		I		II	
constant	-0,027	***	-0,036	***	-0,055	***	-0,075	***
	-3,015		-3,037		-2,704		-2,525	
BB unc	0,025	***	0,027	***	0,040	***	0,043	***
	4,295		4,730		3,685		3,921	
CA unc	0,001		0,001		0,014	**	0,016	**
	0,123		0,183		2,061		2,252	
GDP unc	0,006		-0,005		-0,026		-0,045	
	0,365		-0,243		-0,809		-1,349	
Inv unc	0,001		0,001		-0,004		-0,005	
	0,422		0,346		-0,584		-0,872	
IP unc	0,000		0,000		0,003		0,002	
	-0,076		-0,029		0,336		0,265	
unc for int rate			0,020				0,043	*
			0,823				1,683	
unc for gtv yield			0,019				0,017	
			0,864				0,409	
adj R2	0,194		0,205		0,214		0,229	

Table 9.3

The tables above show the results from regressing the expected return risk premium of the AUD/USD, the JPY/USD and NZD/USD exchange rates on the uncertainty about fundamentals, proxied by disagreement. Model I includes uncertainty about a number of real fundamentals, (budget balance, current account, GDP, investments, industrial production), whereas model II also includes monetary fundamentals (3 months interest rates, 10 year government yields). Significance of the coefficients is denoted by *, **, or *** for levels of 10%, 5%, or 1%. Shaded numbers are t-statistics.

Figure 1

Volatility – return risk premium



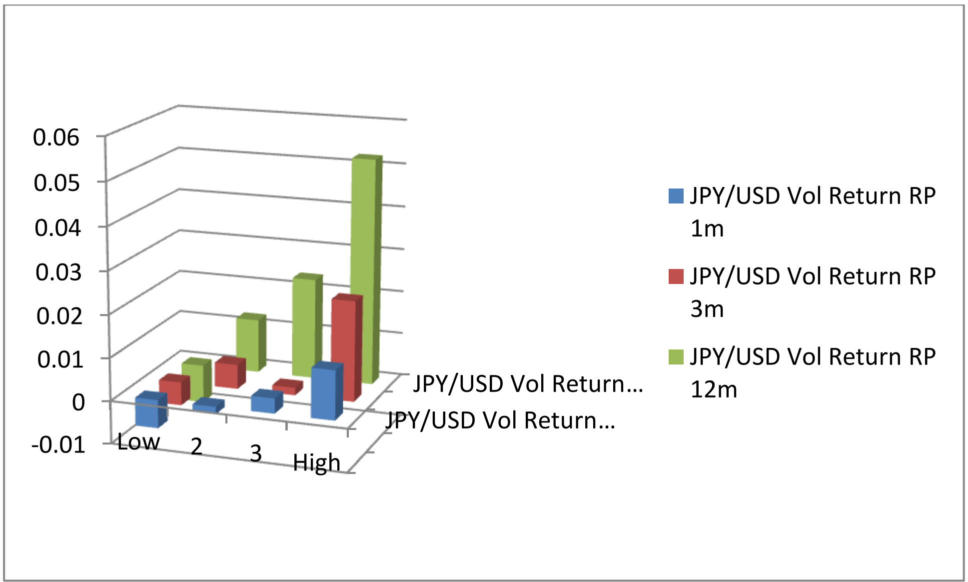


Figure 2

Uncertainty – return risk premium