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Downside risk and flight to quality in the currency market

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Currency downside risk and macroeconomic variables

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Abstract

Some currencies persistently move together with the stock market and crash in periods of market downturns or high volatility, while others serve as a 'safe haven'. In this paper, I study whether or not countries' macroeconomic characteristics are systematically related to the market risk of their currencies. I find that the market risk is not random, especially on the downside, and it can be predicted by macroeconomic variables. Moreover, the market risk has increased significantly since the 2000s, and its predictability also increased. The real interest rate has the highest explanatory power in accounting for the cross-section of currency market risk. Currencies of countries with high local real interest rates have high market betas, especially downside betas, while low real interest rate currencies are immune to stock market changes. Nominal interest rates also have some explanatory power, but only to the extent to which they correlate with the real interest rates. Other variables considered seem to be irrelevant.

JEL classification: G11, G15, F31

Keywords: currency risk, downside risk, downside beta, carry trades

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Introduction

If currencies serve as investment assets, the correlation of exchange rates with the stock market (or the market beta) is important for a diversifying investor. A growing volume of empirical evidence suggests that currency returns are not random; some currencies tend to move together with the stock market and depreciate in periods of high volatility or stock market crashes, while others seem to be immune to stock market changes and, thus, can serve as a hedging instrument. In this paper, I study whether or not there is a systematic relationship between a country's macroeconomic variables and the stock market risk of its currency. I try to answer the question as to which currencies tend to crash when the stock market goes down and which currencies serve as a 'safe haven'.

There are three main findings in the paper. Firstly, out of the three measures of the stock market risk - market beta, downside market beta and coskewness – the downside beta systematically varies more across currencies, and the explanatory power of macroeconomic variables for the downside beta is the highest. Hence, it is the downside risk which is the most important in the currency market, and it can be predicted by country macroeconomic variables.

Secondly, I find that the level of the real interest rate in an economy predicts its currency market risk much better than any other macroeconomic variable considered. Currencies of countries with high local real interest rates have high stock market betas, high downside betas and significantly negative coskewness with the stock market, while low real interest rate currencies have a low and insignificant stock market risk. Local nominal interest rates and inflation also have some explanatory power, but it vanishes once the real rates are taken into account.

Thirdly, the market risk of currencies has increased significantly since the 2000s, suggesting a greater interdependence of the stock and currency markets. Its predictability by macroeconomic variables also increased, especially for currencies of countries with emerging economies, the market risk of which was rather random in the 1990s. This can be a result of a remarkable growth of currency trades by institutional investors (e.g. carry trades), which was observed during the 2000s.

The relationship between stock market returns and exchange rate movements has already been explored in Campbell et al. (2010) and Ronaldo and Söderlind (2009) for the currencies of several developed countries. Campbell et al. (2010) find a consistent positive correlation of the Australian dollar and the Canadian dollar with the global equity markets and a negative correlation of the euro and the Swiss franc. The Japanese yen, the British pound and the US dollar fall in the middle of the two extremes. A high-frequency analysis in Ronaldo and Söderlind (2009) uncovers a similar pattern; the Swiss franc and the Japanese yen (and to a lesser extent the euro) appreciate when the US stock market goes down, while the opposite is observed for the British pound. The 'safe haven' properties of the Swiss franc and the Japanese yen are confirmed in periods of political, natural or financial disasters.

Rather than looking at few particular currencies, I take a sample of 50 major currencies of developed and developing countries. I also look at a longer period of time, compared to the above studies, and analyze trends over time, as well as the predictability of currency market risk in earlier years when carry trades were not common. I carry out the analysis for different sub-samples of single currencies, which were chosen by particular criteria (e.g. the exchange rate regime), as well as for portfolios of currencies sorted by country macroeconomic variables. My results are robust to different sub-samples of currencies, different sub-periods and different methods employed.

My findings suggest that there is a 'flight to quality' in the currency market. When the stock market goes down or its volatility increases, investors withdraw funds from currencies with a high default risk, as signaled by high local real interest rates, and transfer them to relatively safe currencies with low real interest rates or other assets. This leads to high stock market betas and negative coskewness of the former currencies and insignificant betas and coskewness of the latter currencies.

My findings also shed some light on why a carry trade is a very risky investment strategy. A carry trade – borrowing in low nominal interest rate currencies and investing in high nominal interest rate currencies – generates high excess returns which are negatively skewed (Brunnermeier et al., 2008) and have high stock market beta (Lustig and Verdelhan, 2010) and an even higher downside market beta (Dobrynskaya, 2010). Since nominal interest rates can be high due to high real interest rates, high inflation rates or both, I decompose nominal interest rates into inflation and real interest rates. I show that currencies with the same level of real interest rates but different inflation rates have the same stock market risk, while, controlling for inflation, currencies with higher real interest rates have a much higher market risk. Therefore, the high downside market risk of carry trades turns out to be a consequence of high real interest rates in the investment countries and low real interest rates in the funding countries, rather than the nominal interest rates. When nominal and real interest rates correlate significantly, high levels of these rates in an economy are both associated with the high market risk of its currency, but when the correlation between these rates is low (e.g. in the 90s for developing countries), only the real interest rate predicts the currency market risk, while the nominal interest rate is irrelevant.

The paper is organized as follows. I describe the data in section 1. In section 2, I show that there are indeed significant differences in the stock market risk of various currencies, especially in their downside risk. Section 3 is devoted to a cross-section regression analysis for individual currencies while section 4 lays out the main results for currency portfolios sorted by various macroeconomic variables. In section 5, I present regression results for bigger samples of currencies as a robustness test. Section 6 is devoted to an analysis of carry trades. Section 7 concludes the paper.

1. Data

The data covers the period from January 1990 until April 2009 on a monthly frequency. Earlier years are not considered because of the predominance of fixed exchange rate regimes around the world which makes the analysis very limited.

The sample of countries consists of 50 developed and emerging economies with the highest volume of currency turnover, and hence, the most liquid currencies, according to BIS (2007):

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Italy, Japan, Latvia, Lithuania, Malta, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, UK and the Euro Zone.

For each country, I collect the three-month Treasury bill rate (or the return of a comparable instrument), the CPI inflation rate and the exchange rate against the US dollar. An increase in the exchange rate means an appreciation of the respective currency against the US dollar. Exchange rate data is corrected for denominations and periods of de facto fixed to US dollar exchange rate (when the exchange rate does not change for more than 2 months) are excluded. The source of the macroeconomic data is the Global Financial Database.

Because some macroeconomic data is not available for some countries, especially for developing countries in early 90s, and because the periods of fixed exchange rate are dropped out, the actual number of cross-sectional observations varies from month to month between 26 and 49. I try to use the data most efficiently and not to restrict the analysis to countries with data available for the whole period. Therefore, the subsequent analysis is performed using alternative methods: cross-section regression analysis for different sub-samples of countries, chosen by particular criteria, and portfolio sorts for the whole sample of countries.

The exchange rate regime is an important factor of currency risk, and countries are sampled by the exchange rate regime, using the classification of Reinhart and Rogoff (RR, 2004) and Ilzetzki, Reinhart and Rogoff (2010) for later years. They classify exchange rate regimes in 227 countries into 15 categories by looking at the actual movements of exchange rates. Hence, they provide a de-facto classification which differs from the official classification in many cases. For example, a common case is when a country announces a flexible exchange rate regime, but in reality it keeps the exchange rate within a band by market interventions. More details on how countries are sampled are provided later in the text, and the RR fine classification is provided in appendix 1.

To study the stock market risk of currencies, I also collect data on the stock market returns. Since the main currency investors are institutional investors which invest in internationally, I take the global stock market index as a benchmark, and MSCI World index serves a proxy for it.

2. Variation of the stock market risk across currencies

In this section, I want to motivate the study of the stock market risk of currencies (i.e. correlation of exchange rate returns with the global stock market returns) by showing that the market risk is indeed an important type of a currency risk and how the market risk varies across currencies and over time.

I use the three measures of the market risk – a market beta, a downside market beta and a coskewness with the stock market. The market beta of each currency is estimated by regressing monthly percentage exchange rate changes on the global stock market index return. A high market beta means that a currency tends to significantly appreciate when the stock market goes up and depreciate when the stock market goes down. Currencies with the high betas are considered risky because investing in such currencies increases the risk of the overall portfolio of a globally diversifying investor.

The downside beta is conditional on a negative performance of the stock market; it shows how a currency's exchange rate changes when the global stock market goes down. The downside beta is, perhaps, a better measure of the market risk because it reflects an asset's performance in the worst states of the world when the overall market return is low and the marginal utility of wealth is high. Considering the downside beta as a measure of the market risk was motivated by Ang et al. (2006), who derive a two-beta CAPM with an upside beta and a downside beta and show that the downside betas explain the cross-section of stock returns better than the standard betas while the upside betas are completely irrelevant. Also, Ronaldo and Söderlind (2009) show that different currencies perform differently in periods of stock market crashes and disasters, and this should be reflected in different downside betas. The downside betas are estimated in the following regression:

$$\Delta er_{jt} = \alpha_j + \beta_j r_{mt} + \delta_j dummy_t * r_{mt}$$

where Δer_{jt} is the exchange rate return of asset j, r_{mt} is the stock market return, $dummy_t = \begin{cases} 0, r_{mt} < 0 \\ 1, r_{mt} > 0 \end{cases}$ and β_j is the estimate of downside beta. A positive value of β_j means that the currency usually depreciates when the stock market return is negative, and a higher value of β_j reflects a higher downside risk of a currency.

The coskewness of exchange rate returns with the stock market return shows how a currency's exchange rate changes in periods of high stock market volatility. The importance of the coskewness for asset pricing is shown in the three-moment CAPM, which goes back to Kraus and Litzenberger (1976), and is documented empirically in Harvey and Siddique (2000), for example. A high positive coskewness means that an asset's return is high when the stock market volatility is high. Intuitively, adding an asset with a high coskewness to the market portfolio increases the skewness of the portfolio, and, hence, such an asset is valuable and its expected return should be lower. The coskewness, as a risk measure, is not conditional on the downside, but since high volatility is usually observed when the stock market goes down, and not up, the coskewness, in fact, also measures the downside risk. I estimate the coskewness in the following regression:

$$\Delta er_{jt} = \alpha_j + \gamma_j r_{mt}^2$$

where γ_j is the estimate of the coskewness. A negative value of γ_j means that the currency usually depreciates when the volatility of the market return is high. A significantly negative coskewness means a high risk of a currency.

For each currency, I estimate the three measures of the market risk for the whole period of study[1]. If a country's exchange rate was pegged to another currency, e.g. the Douche mark, it still had some exchange rate risk relative to the US dollar and it is therefore included in the analysis, although the results may be a little bit biased. To control for such biases, the subsequent analysis is performed for different sub-samples of currencies and different sub-periods. Since the biggest change in the number of currencies occurred in January 1999, when the Euro replaced a number of currencies, the whole period of study is divided into two sub-periods around this date. Also, many countries moved to more flexible exchange rate regimes during 90s, and studying sub-period 1999-2009 gives a clearer picture.

Comparing the different risk measures across currencies, we see that the range of downside betas of individual currencies is much wider than the range of standard betas. During 1990-2009, the lowest downside beta of -0.1 is observed for Japanese yen, while the highest downside beta of 0.42 is observed for Turkish lira. During 1999-2009 the downside risk has increased for all currencies, but the same currencies are on the edges of the range with the downside betas of -0.04 and 0.71, respectively. Other countries with the highest downside risk of their currencies are Brazil, Australia, Iceland and New Zealand. The full list of currencies and their downside betas is presented in appendix 2.

Since individual currency betas and coskewness can be measured with errors, to get a more reliable picture of the stock market risk of currencies, I sort all currencies by their individual downside betas[2], form five equally-weighted portfolios and report the risk measures for these portfolios. Then measurement errors should be cancelled out if the portfolios are diversified enough. Table 1 presents the characteristics of the five portfolios (portfolio with a higher rank contains currencies with higher downside betas).

1 I only exclude the periods of de facto fixed to US dollar exchange rates and, thus, periods of zero betas and coskewness.

2 Sorting by other risk measures produces a similar picture, although sorting by the downside betas gives the biggest differences in the downside risk across portfolios.

[Table 1 somewhere here]

The range of the downside betas is wider than the range of the standard betas in the both samples, and this is not due to the sorting procedure. If I sort all currencies by their standard betas into portfolios and estimate the downside betas for these portfolios, I also obtain a wider range of the downside betas. Therefore, the downside risk is more pronounced in the currency market. Currencies in the top portfolios systematically depreciate when the stock market performs poorly, while currencies in the bottom portfolio generally do not react to the stock market dynamics and can serve as a hedging instrument.

The last decade is marked by a greater stock market risk of currencies. Betas, downside betas and coskewness are about twice as high as they were in 90s, the increase is more than 2 standard deviations and is statistically significant. This is a sign of a greater interdependence of the currency and the stock markets, but it also can be a result of more flexible exchange rate regimes and lower foreign exchange interventions in many countries. Furthermore, it can be a result of a higher carry trade activity, as evidenced in Galati et al. (2007), and unwinding of carry trade positions.

3. Cross-section analysis of individual currencies

This section is devoted to a cross-section analysis of the market risk of individual currencies. I study which country macroeconomic characteristics are systematically related to the market risk of its currency. Specifically, I look at nominal interest rates, inflation and real interest rates[3], and run 'horse races' between them. The choice of these variables is motivated by earlier findings that carry trade portfolios – long-short portfolios sorted by nominal interest rates – have high market risk, especially on the downside (Dobrynskaya, 2010).

To perform the cross-section analysis it is important to have a balanced panel of countries in order to measure market betas over the same period for all countries. Otherwise, the regression

[3] I have also looked at the GDP growth, the degree of openness, measured by the volume of exports to GDP, and country sovereign risk, measured by Fitch country rating. These variables proved to have no relation to the market risk of currencies. The results are available upon request.

results may be biased due to variation of betas over time. Since the biggest change in the composition of countries is due to the formation of the Euro Zone, the sample period is split into two sub-periods: January 1990 – December 1998 and January 1999 – April 2009 and the analysis is performed separately for them.

There are 17 countries in the sample in the first sub-period (the list of countries is given in table 2). These countries are selected by the following criteria: 1) they should be developed, because many developing countries were suffering hyperinflation in that period, some had fixed or free falling exchange rate regimes, negative real interest rates or capital controls, and their currencies were not very liquid; 2) all macroeconomic data for them should be available for at least five years. Out of these 17 developed countries, 8 had flexible exchange rate regime (had codes 9 or higher in the RR classification, see appendix 2) and 9 currencies were either pegged or had a band around the Douche mark (codes 4, 7 or 8 in RR classification). The later currencies are not excluded from the sample because although they had limited exchange rate risk against the Douche mark, they could have significant exchange rate risk against the US dollar, given the flexible exchange rate regime of the Douche mark.

In the second sub-period, the analysis is not restricted to developed countries for two reasons: first, very few developed countries remain in the sample after the formation of the Euro Zone; second, the developing countries in the sample stabilized their inflation and exchange rates, moved to flexible or managed floating exchange rate regimes and abandoned capital controls in 90s. So, there are 24 developed and emerging economies in the sample (table 2), which were chosen by the following criterion: they should have had flexible exchange rate regime for most of the period (codes 9 and above in RR classification, see appendix 2). Currencies which were pegged to US dollar or which had de facto crawling band that is narrower than or equal to +/-2% were excluded from the sample because their market risk was artificially low.

Table 2 presents the results of cross-section regressions of market beta, downside beta and coskewness, estimated for the respective sub-periods, on historical average nominal and real interest rates and inflation[4].

Although betas and coskewness of individual currencies may be estimated with errors, this does not affect the regression coefficients because they are the dependent variables in these specifications, and hence the common measurement error problem in asset pricing is not relevant here. What is relevant here is the time variation in betas and macroeconomic characteristics, what this analysis does not take into account. The next section accounts for these time variations.

[Table 2 somewhere here]

In the first sub-period, there is a striking difference between the explanatory power of the cross-section regressions for the market beta and the measures of downside risk: downside beta and coskewness. While there is no relationship between the market beta and the macroeconomic variables considered, as evidenced by low t-statistics and almost zero R^2, downside beta and coskewness are strongly related to nominal and real interest rates (R^2 is up to 38 percent).

Higher local interest rates are associated with higher currency downside risk (higher downside betas and lower coskewness, see specifications 1, 3 and 4). The explanatory power of real interest rates (measured by R^2) is almost twice as high as that of nominal interest rates. If two countries differ in their local real interest rates by ten percentage points, for instance, the downside beta of the country with the higher interest rate should be higher by 0.368 and its coskewness should be lower by 4.548. But inflation rate has no relation with the currency market risk, no matter whether it was considered alone (specification 2) or together with the real interest rate (specification 4). Since the nominal interest rate can be decomposed into inflation rate and real interest rate, the explanatory power of the nominal interest rate comes from the explanatory power of the real interest rate

[4] The average values are calculated for the respective sub-period or for the period of available data, if it is shorter. Countries should have macroeconomic data for at least five years to be included in each sample.

(although the cross-sectional correlation between nominal and real interest rates was only 0.43 in this sub-period), while inflation rate is irrelevant.

The results are very similar for the downside beta and coskewness because both of them measure the downside risk (the correlation between them was -0.9 in this sub-period). But the standard market beta had very low correlation with the downside beta and coskewness in that period (-0.05 and 0.45, respectively) and it was not related to any macroeconomic variable. These results suggest that it is easier to explain currency downside risk by macroeconomic variables than the average market risk, which was rather random in that period. This is perhaps the reason why many early studies of exchange rate dynamics concluded that currency returns are random and are not related to macroeconomic variables.

In the second sub-period, the correlation of the market beta with the downside beta and coskewness is much higher (0.95 and -0.85, respectively), and the cross-section regressions for all risk measures have much greater explanatory power (up to 53 percent, as measured by R^2), despite a bigger number of countries and inclusion of emerging economies in the sample.

Higher levels of nominal and real interest rates and inflation rates are all associated with higher betas and lower coskewness, and these relationships are all statistically significant (specifications 1-3). The real interest rate has the greatest explanatory power for all risk measures. For example, the real interest rate alone explains 52 percent of the cross-section variance of the downside beta. The nominal interest rate alone is not that powerful (R^2 is only 33 percent for the downside beta), and hence disentangling the nominal interest rate into the inflation rate and the real interest rate is important (R^2 rises to 53 percent). But when the inflation rate and the real interest rate are taken into account simultaneously, the inflation rate loses its explanatory power. Therefore, again, it is the real interest rate which explains the cross-section of the currency market risk, while the explanatory power of the nominal interest rate is only due to its high correlation with the real interest rate (0.78).

As in the first sub-period, the regression results are stronger for the downside beta than for the standard beta. Again, currency downside risk is better explained by macroeconomic variables than the average market risk, although the difference between them is not as significant as it was before.

Generally, all regression coefficients are higher in the second sub-period and all results are more pronounced. This is due to higher ranges of betas and coskewness (see table 1) and lower ranges of interest rates and inflation (see section 4 for details) in the second sub-period. Currency market risk is now better aligned with country macroeconomic variables in both developed and emerging economies, and the real interest rate is the main factor of the market risk, especially on the downside.

These results suggest that the high downside market risk of carry trades is not due to the big difference in the nominal interest rates of investment and funding currencies, but rather due to the big difference in their real interest rates, which the nominal interest rates capture.

4. Analysis of currency portfolios, sorted by macroeconomic variables

4.1. Alternative sorts by one macro variable

In this section, I study the market risk of currency portfolios instead of individual currencies. Every month, all currencies are sorted by a macroeconomic variable (nominal interest rate, real interest rate or inflation rate) and divided into five portfolios so that portfolio one contains 20 percent of currencies with the lowest value of the variable in the respective month and portfolio five contains 20 percent of currencies with the highest value of the variable. The portfolios are rebalanced monthly. Hence, portfolio one always contains currencies of countries with the lowest values of the macro variables and portfolio five always contains currencies with the highest values of these variables, although the country composition of each portfolio changes over time as the macroeconomic situation in countries changes. For example, in the real interest rate sort, Turkey started in portfolio 1 with a negative real interest rate in January 1990, moved across all portfolios over time, ended up in portfolio 5 in 1994 and remained in this portfolio until 2009. In general, currencies move across portfolios quite often.

This method extends the previous analysis in three ways. First, I include all countries with available data in the analysis rather than studying small sub-samples of countries. Only the periods with de factor fixed to US dollar exchange rate are excluded, all other exchange rate regimes are considered. Hence, this is the most general test which uses the widest spectrum of available data. Second, I take into account the time variation in the macroeconomic variables and currency market risk. If a country macroeconomic variable changes over time, this currency moves to another portfolio with the respective level of this macro variable. Third, I estimate the market risk measures for the currency portfolios instead of single currencies and hence minimize the measurement errors. Also, I can estimate portfolio betas and coskewness for almost 20 years.

If a macroeconomic variable is indeed systematically related to the currency market risk, sorting by this variable would produce the highest range of betas and coskewness because, for instance, portfolio five would always pick the currencies with the highest value of the variable in the respective period and, hence, the highest market risk. Since macroeconomic variables and the currency risk vary over time, periodic rebalancing should result in the most striking differences between the risks of portfolios. We should also find a monotonic relationship between the risk measures and portfolio rank if the sort variable is a relevant one.

The whole period 1990-2009

Table 3 shows the various risk measures of the five currency portfolios sorted by the nominal interest rate, the real interest rate and the inflation rate. The last column shows the characteristics of the portfolio which takes a long position in portfolio 5 and a short position in portfolio 1. The betas and the coskewness of this long-short portfolio are equal to the differences in the betas and the coskewness of portfolios 5 and 1, and their statistical significance means that the differences in the betas and the coskewness of the top and the bottom portfolios are statistically significant.

[Table 3 somewhere here]

The average values of the sort variables for each portfolio are presented in the first line of each panel. They are increasing with the portfolio rank because this is how the portfolios were sorted. The last line of each panel shows the average number of currencies in each portfolio, while the actual number of currencies varies from month to month due to unavailable data for some countries for some years. It is higher for the inflation rate sort because the data on inflation rates is available for a bigger number of countries in earlier years of the sample.

The second line of each panel shows the average monthly appr-/depreciation of each currency portfolio. The general tendency is that currencies with higher nominal and real interest rates and inflation tend to depreciate against the US dollar, on average, while currencies with low values of these variables tend to appreciate. Particular monotonicity is observed for the inflation rate sort, which is not surprising because a high inflation rate almost automatically leads to a depreciation of the currency in this country. But there is no such monotonicity in case of the real interest rate sort where portfolios one and five have the lowest levels of exchange rate changes. In other words, currencies with the highest and the lowest (negative) real interest rates tend to depreciate more than currencies with moderate real interest rates.

Turning to the riskiness of these portfolios, in all three panels the market risk of the portfolios is increasing with the portfolio rank, and hence all three sort variables are to some degree related to the riskiness of currencies. The differences between all risk measures of portfolios 5 and 1 are statistically significant, except for the inflation rate sort.

The ranges of the downside betas are always wider than the ranges of the standard betas, suggesting that currencies of countries with high nominal and real interest rates and inflation tend to depreciate more on the downside while currencies of countries with low values of these variables tend to depreciate less on the downside and hence are rather immune to the adverse stock market conditions. The downside betas and the coskewness of the first portfolios are close to zero and statistically insignificant which means that these currencies are rather stable in periods of market downturns or high stock market volatility. The coskewness of the top portfolios is, on the contrary, very low and statistically significant. Hence, currencies with high levels of interest rates and inflation tend to crash when the stock market has high volatility.

Comparing across the sort variables, we do not see significant differences. The ranges of the betas, the downside betas and the coskewness are very similar in the three panels. For instance, the riskiest portfolios in each panel (portfolios ranked 5) have the betas of 0.24, 0.31 and 0.19 and the downside betas of 0.30, 0.31 and 0.25. Sorting by the inflation rate produces the lowest range of the market risk of the extreme portfolios with the statistically insignificant difference, which suggests that the inflation rate is the least relevant variable for explaining the market risk. Sorting by the real interest rate, on the contrary, produces the highest range of the betas. Portfolio five in panel B has the highest beta and downside beta (0.31) than any other portfolio in table 3, and hence it contains the most risky currencies. Therefore, the real interest rate seems to have the greatest explanatory power for the differences in the market risk of currencies, as in the cross-section regressions.

The long-short portfolio sorted by the nominal interest rates (the carry trade portfolio) has the highest downside market risk, but my findings suggest that this is probably due to the high real interest rates in the investment countries, rather than the nominal ones.

Although the sorting by the three macroeconomic variables produces the similar results, this is not due to the same currency composition of the portfolios obtained by the alternative sorts. Portfolios with the same rank are rather different in the three panels of table 3. If we compare portfolios in panels A and B, only about one third of currencies are common in portfolios with the same rank. Comparing panels A and C, about 40 percent of currencies are common, while comparing panels B and C, only about 20 percent of currencies are common. Therefore, sorts by the nominal interest rate and the inflation rate produce the most similar portfolios in terms of their currency composition, while sorts by the real interest rate and the inflation rate produce the least similar portfolios. Hence, real interest rates and inflation are rather orthogonal to each other.

The recent period 1999-2009

To test the robustness of the results over time and to compare with the results of the regression analysis in section 3, I repeat the same exercise for the first decade of the 21 century separately. Table 4 presents the statistics of the portfolios in this recent sub-period. Inflation rates and, hence, nominal interest rates of the high-ranked portfolios have decreased significantly because many developing countries managed to stabilize their inflation in 90s. But the currency market risk has increased. For any sort variable and any portfolio, the betas and coskewness are almost twice as high as they were previously, and the differences in the risk measures of portfolios 5 and 1 are highly significant.

[Table 4 somewhere here]

For inflation rate sorting, portfolio five has much lower average inflation rate but a higher downside risk. This signals the irrelevance of inflation rate for the market risk again. Moreover, sorting by inflation leads to lower market risk of the top portfolios than sorting by the nominal and real interest rates.

The highest market risk is again observed for the portfolio of currencies with the highest real interest rates. The portfolio downside beta of 0.52 is the same as the downside beta of portfolio five in table 1. Hence, currencies with the highest real interest rates are the ones with the highest downside risk. But we cannot say the opposite about currencies with the lowest real interest rates. The downside beta of portfolio one in panel B of table 4 (0.2) is much higher than the downside beta of portfolio 1 in table 1 (0.03). It is also higher than the downside betas of the first portfolios in panels A and C. Therefore, low (negative) real interest rates do not ensure low market risk of currencies. Having low real interest rates is not a sufficient condition for a currency to be a 'safe heaven'.

4.2. Double sort by inflation and real interest rate

Since all three sort variables are closely related, in order to separate the effects of real interest rates and inflation, I use the following double sorting procedure. First, all currencies are sorted by inflation rate into three portfolios. Then, currencies of each portfolio are sorted by real interest rates and divided again into two portfolios. As previously, the portfolios are rebalanced every month. The descriptive statistics of the six portfolios is presented in table 5.

[Table 5 somewhere here]

If real interest rates and inflation rates were orthogonal to each other, portfolio pairs one and two, three and four, five and six would have similar average inflation rates but different average real interest rates. This is indeed true for portfolios one to four. But the average inflation rate of portfolio five is much higher than that of portfolio six. It means that countries with very low (negative) real interest rates tend to be the ones with the highest inflation rates. The average nominal interest rates of portfolios five and six are similar, and hence we can see the effect of the real interest rate on the market risk clearly.

Betas and especially downside betas of portfolios one, three and five are much lower than those of portfolios two, four and six, respectively. For instance, beta and downside beta of portfolio six (0.29 and 0.36 respectively) are three times as high as those of portfolio five (0.09 and 0.12 respectively). In all three portfolio pairs, portfolios with higher real interest rates have much higher market risk. The same conclusion can be drawn from looking at coskewness of portfolio pairs.

To determine whether inflation rate is related to the market risk of currencies, we should look across portfolio pairs. Higher inflation rate is somewhat related to higher market risk, but this relationship is not that strong. The average inflation rate of portfolio five (34.69 percent p.a.) is approximately nine times as high as the average inflation rate of portfolio three (3.96 percent p.a.), but the market risk of these portfolios, measured in whatever way, is the same. The market risk of portfolio six is three times as high as that of portfolio five, but its inflation rate is lower. Portfolio four also has a much lower average inflation rate than portfolio five but it has higher betas and lower coskewness. Hence, we hardly see any monotonic effect of inflation on the market risk of currencies.

Moreover, the market risk of portfolio six in table 5 is higher than that of any portfolio in table 3. Also, the downside risk of portfolio six is higher than the downside risk of portfolio five in table 1, which, by definition, contains currencies with the highest downside betas. But portfolios in table 1 are not rebalanced, while portfolios in table 5 are. If a currency's market risk is changing over time with the changing macroeconomic conditions, regular rebalancing would always pick currencies with the highest contemporary risk and, hence, the average downside beta would be higher. This is what we observe in table 5. By separating the effects of inflation and real interest rate, we have managed to identify the currencies with the highest level of downside risk. These are the currencies with the highest real interest rates. This confirms the results of the regression analysis, but for a bigger number of countries around the world.

The study of the last decade even reinforces this finding. In each portfolio pair, the average inflation rate of the portfolios is approximately the same, but the market risk increases significantly along with higher real interest rates.

But low real interest rates do not ensure 'safe heaven' properties. Portfolio with the lowest average real interest rate in the both periods is portfolio five. This portfolio has high average inflation rate and rather high market risk. The lowest market risk (especially the downside risk), though, is observed for portfolio one, which has both low real interest rate and low inflation rate. Consequently, this portfolio also has the lowest nominal interest rate. But it is not the low nominal interest rate per se which ensures low downside risk, because portfolios with rank one in panels A of tables 3 and 4 had higher downside risk. Low nominal interest rate can be a consequence of high inflation rate and a negative real interest rate in the economy, but such currencies have rather high market risk. Therefore, to be a 'safe heaven' currency, both low inflation rate and low real interest rate are required.

Since countries with high real interest rates on short-term government securities are supposed to have high default risk, and since the same currencies also have the highest downside market risk, we can suggest that there is 'flight to quality' in the currency market. When the general market conditions worsen, investors sell currencies of countries with high real interest rates because of their high default risk (which increases further in such states) and accumulate currencies of safe countries with low real interest rates and low inflation rates. This results in high downside risk of the former currencies and zero (insignificant) downside risk of the latter currencies.

5. Robustness test: regressions for bigger samples of countries

In this section, I repeat the cross-section regressions of section 3 for bigger sub-samples of currencies to test whether the results can generalize. As previously, the analysis is performed for two sub-periods: 1990-1998 and 1999-2009.

In the first sub-period, the sample of countries is extended to developing countries (see table 6). Now there are 24 countries in the sample: 17 developed and 7 developing countries, 13 countries have flexible exchange rate regime, 11 currencies are pegged to Douche mark. Countries with fixed to US dollar exchange rate and former socialist republics with free falling exchange rates are excluded. I also exclude countries, for which the macroeconomic data is available for less than half of the sub-period.

In the second sub-period, the sample is extended to countries with non-flexible exchange rate regimes. Now there are 35 developed and emerging countries: 24 countries with flexible exchange rates and 11 countries with narrow bands or pegs (RR codes of 8 and less, see appendix 1). Only countries with de facto fixed to US dollar exchange rates (when exchange rate does not change for two or more consecutive months) and countries with unavailable data are excluded. Hence, this is the biggest sample of countries which is possible.

Table 6 presents the results of cross-section regressions of the three measures of market risk on nominal and real interest rates and inflation.

[Table 6 somewhere here]

All regressions have lower R^2 than in section 3, especially for the first sub-period, because of bigger samples of countries and an addition of developing countries with rather noisy exchange rates. But all the main results remain robust.

First, in 1990-1998, again, only the measures of downside risk (downside beta and coskewness) can be explained by macroeconomic variables, while regressions for beta have very low explanatory power. Beta had very low correlation with the downside beta (0.33) and coskewness (0.02), while the downside beta and coskewness had high correlation (-0.91) in this period. Therefore, when downside risk is different from the average market risk, it is the downside risk which can be predicted by macroeconomic variables, while the average risk is rather random. Second, out of the three macroeconomic variables considered, only the real interest rate (specifications 3 and 4) is systematically positively related to the downside risk of currencies in the first sub-period. Neither the nominal interest rate nor the inflation rate has significant coefficients. Third, in 1999-2009, the explanatory power of all cross-section regressions is much higher, all three measures of the market risk are systematically related to country macroeconomic variables (the cross-correlations of all three risk measures are high) and all three rates are significantly related to currency market risk. Nevertheless, the real interest rate again has the highest explanatory power, as evidenced by R^2. The significant relationship between the nominal interest rate and the market risk is observed because of higher correlation of the nominal interest rate with the real interest rate in this period (0.62). The only difference compared to section 3 is the significance of the inflation rate, which does not disappear even after controlling for the real interest rate.

6. Macroeconomic variables and the market risk of carry trades

Although all tests show that the real interest rate has the highest explanatory power in explaining the cross-section of currency market risk, the nominal interest rate is also often significant: currencies of countries with higher nominal interest rates tend to have higher market risk, especially on the downside. Therefore, carry trade portfolios – portfolios long in currencies with high nominal interest rates and short in currencies with low nominal interest rates – are highly sensitive to the stock market and crash when the stock market goes down. The analysis in the paper shows that this is in fact due to the high real interest rates in the investment countries and low real interest rates in the funding countries, not the nominal interest rates.

Indeed, when we look at the sub-sample of countries and the time period when the nominal and the real interest rates were not related (as in the case described in section 5 in 1990-1998 when correlation between them was only 0.02), the nominal interest rate had no explanatory power at all. Hence, if we sorted these currencies in this period by the nominal interest rates and formed carry trade portfolios, they would not have had high market risk. But in the second sub-period, when carry trades actually gained popularity, the nominal and the real interest rates were highly related, and sorting by the nominal interest rates produced risky portfolios, as well as sorting by the real interest rates.

7. Conclusion

Several studies have shown that some particular currencies serve as a 'safe haven' (Campbell et al., 2010, Ronaldo and Söderlind, 2009). In this paper, I show that these currencies have two common features – low inflation and low real interest rates. Currencies which tend to crash with the stock market are, on the contrary, those with the highest real interest rates. This suggests that there is a 'flight to quality' in the currency market in periods of adverse stock market movements. Other macroeconomic variables do not seem to play a significant role in explaining the market risk of currencies.

These findings have important implications for portfolio choice when currencies are considered as investment assets. Although betas of currencies are generally lower than betas of stocks, currencies of countries with high real interest rates (but not necessarily with high nominal interest rates) are not attractive from the point of view of portfolio diversification. In order to reduce the overall market risk of a portfolio, investing into currencies of countries with both low real interest rates and low inflation rates is desirable, because such currencies tend to be stable or even appreciate when the stock market goes down and, hence, they can serve as a hedging instrument.

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Appendix 1. Reinhart and Rogoff (2004) and Ilzetzki, Reinhart and Rogoff (2010) classification of historical de facto exchange rate regimes

1990-1998				1999-2009			
Argentina	14, 2	Japan	13	Argentina	2, 15, 8	Poland	10, 12
Australia	13	Latvia	14, 10	Australia	13	Romania	14, 10
Austria	4	Lithuania	14, 2	Brazil	14, 12	Russia	14, 8, 10
Belgium	4	Malta	11	Bulgaria	2	Singapore	11
Brazil	14, 6	Mexico	5, 7, 4, 9, 14, 12	Canada	8, 10	Slovak Rep	8, 1
Bulgaria	14, 2	Netherlands	4	Chile	9, 12, 10	Slovenia	8, 4, 1
Canada	9	New Zealand	12	China	4, 11, 4	South Africa	13
Chile	9, 10	Norway	12	Cyprus	4, 1	South Korea	12
China	12, 8, 4	Philippines	7, 8, 10, 4, 14, 12	Czech Rep	12, 8	Sweden	11, 12
Cyprus	8, 4	Poland	2, 14, 15, 10	Denmark	4	Switzerland	11
Czech Rep	8, 10, 12	Portugal	8, 7, 4	Estonia	2	Taiwan	n/a
Denmark	7	Romania	14, 10	Euro Zone	n/a	Thailand	12, 11
Estonia	14, 2	Russia	14, 15, 14	Hong Kong	2	Turkey	10, 14, 13
Euro Zone	n/a	Singapore	11	Hungary	9	UK	12, 11, 12
Finland	8, 4	Slovak Rep	14, 8, 10	Iceland	8, 12		
France	4	Slovenia	14, 8	India	7, 8		
Germany	13	South Africa	15, 13	Indonesia	12		
Greece	4	South Korea	6, 7, 14, 12	Japan	13		
Hong Kong	2	Spain	8, 4	Latvia	10, 8, 11, 2		
Hungary	10, 8	Sweden	8, 12	Lithuania	2, 4, 8		
Iceland	8	Switzerland	8	Malta	4		
India	7, 4, 7	Taiwan	n/a	Mexico	12		
Indonesia	7, 14	Thailand	4, 14, 12	New Zealand	12		
Ireland	8, 4	Turkey	14, 10	Norway	12		
Italy	8, 7, 4	UK	12, 3, 12	Philippines	12, 8, 10		

The fine classification codes are:

1 No separate legal tender
2 Pre announced peg or currency board arrangement
3 Pre announced horizontal band that is narrower than or equal to +/-2%
4 De facto peg
5 Pre announced crawling peg
6 Pre announced crawling band that is narrower than or equal to +/-2%
7 De factor crawling peg
8 De facto crawling band that is narrower than or equal to +/-2%
9 Pre announced crawling band that is wider than or equal to +/-2%
10 De facto crawling band that is narrower than or equal to +/-5%
11 Moving band that is narrower than or equal to +/-2% (i.e. allows for both appreciation and depreciation over time)
12 Managed floating
13 Freely floating
14 Freely falling
15 Dual market in which parallel market data is missing.

The figures separated by commas represent classification codes for the exchange rate regimes in chronological order, which were observed during the respective periods.

Appendix 2. Downside betas of individual currencies (currencies listed in order of increasing downside betas)

1990-2009				1999-2009			
Japan	-0,10	Thailand	0,11	Japan	-0,04	Greece	0,35
Slovenia	-0,10	Romania	0,13	Malta	-0,02	South Korea	0,35
Ireland	-0,07	India	0,14	Hong Kong	-0,01	Canada	0,36
Cyprus	-0,06	Denmark	0,15	China	0,00	Mexico	0,38
Malta	-0,06	Estonia	0,16	Cyprus	0,03	Poland	0,39
France	-0,06	Lithuania	0,20	Switzerland	0,08	Sweden	0,40
Italy	-0,05	Russia	0,22	Argentina	0,09	Indonesia	0,40
Germany	-0,05	Norway	0,22	Slovenia	0,09	Hungary	0,42
Belgium	-0,05	Slovakia	0,24	Taiwan	0,10	South Africa	0,45
Finland	-0,05	Hungary	0,24	Philippines	0,10	Chile	0,46
Spain	-0,05	Czech Rep	0,25	Singapore	0,13	New Zealand	0,47
Portugal	-0,04	Sweden	0,25	Thailand	0,14	Iceland	0,47
Netherlands	-0,04	Euro Zone	0,26	UK	0,14	Australia	0,52
Austria	-0,03	Canada	0,28	Russia	0,18	Brazil	0,69
Bulgaria	-0,02	Mexico	0,29	India	0,18	Turkey	0,71
Switzerland	-0,01	South Korea	0,29	Czech Rep	0,23		
Hong Kong	0,00	Iceland	0,30	Estonia	0,25		
China	0,02	Latvia	0,30	Lithuania	0,25		
Indonesia	0,04	South Africa	0,33	Bulgaria	0,25		
Philippines	0,07	New Zealand	0,34	Denmark	0,25		
UK	0,08	Brazil	0,34	Euro Zone	0,26		
Taiwan	0,08	Chile	0,35	Latvia	0,26		
Greece	0,08	Poland	0,37	Slovakia	0,26		
Argentina	0,09	Australia	0,39	Norway	0,32		
Singapore	0,09	Turkey	0,42	Romania	0,34		

Downside betas are estimated in the following regression: $\Delta er_{jt} = \alpha_j + \beta_j r_{mt} + \delta_j dummy_t * r_{mt}$

where Δer_{jt} is the exchange rate return of asset j, r_{mt} is the stock market return, $dummy_t = \begin{cases} 0, r_{mt} < 0 \\ 1, r_{mt} > 0 \end{cases}$

and β_j is the estimate of downside beta.

Table 1. Risk characteristics of currency portfolios sorted by downside beta

	Pfl 1	2	3	4	Pfl 5
			1990-2009		
Average ER return (percent p.m.)	0,03	-0,29	-0,51	-0,58	-1,00
Beta	**0,01**	**0,06**	**0,11**	**0,15**	**0,28**
t-stat	[0,36]	[1,97]	[3,68]	[4,08]	[8,04]
Downside beta	**-0,10**	**0,04**	**0,12**	**0,23**	**0,34**
t-stat	[-1,66]	[0,78]	[2,33]	[3,60]	[5,83]
Coskewness	**1,28**	**-0,32**	**-0,67**	**-1,68**	**-1,91**
t-stat	[2,98]	[-0,85]	[-1,88]	[-3,78]	[-4,26]
Average number of currencies	6,49	7,80	9,50	9,25	9,94
			1999-2009		
Average ER return (percent p.m.)	0,01	-0,02	0,21	-0,11	-0,20
Beta	**0,04**	**0,14**	**0,20**	**0,34**	**0,43**
t-stat	[1,42]	[6,04]	[4,04]	[10,39]	[10,60]
Downside beta	**0,03**	**0,15**	**0,27**	**0,38**	**0,52**
t-stat	[0,64]	[3,85]	[3,36]	[6,98]	[7,84]
Coskewness	**-0,09**	**-0,94**	**-1,92**	**-2,19**	**-3,10**
t-stat	[-0,28]	[-3,34]	[-3,64]	[-4,88]	[-5,66]
Average number of currencies	7,52	8,00	7,96	7,19	8,00

t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

Table 2. Cross-section regressions for individual currencies

	Sub-period: 1990-1998				Sub-period: 1999-2009			
	Dependent variable: Market beta							
	1	2	3	4	1	2	3	4
Nominal interest rate	0,01				0,82			
	[0,02]				[2,61]			
Inflation rate		0,07		0,06		1,12		0,08
		[0,13]		[0,10]		[2,35]		[0,15]
Real interest rate			-0,39	-0,39			4,43	4,30
			[-0,37]	[-0,35]			[4,41]	[3,27]
Intercept	0,07	0,07	0,09	0,09	0,21	0,22	0,16	0,16
	[1,84]	[2,96]	[2,02]	[1,69]	[5,36]	[5,68]	[4,40]	[4,25]
R2	0,00	0,00	0,01	0,01	0,24	0,20	0,47	0,47
Adjusted R2	-0,07	-0,07	-0,06	-0,13	0,20	0,16	0,45	0,42
	Dependent variable: Downside market beta							
Nominal interest rate	1,42				1,20			
	[2,13]				[3,29]			
Inflation rate		0,69		0,82		1,65		0,39
		[0,82]		[1,17]		[2,94]		[0,66]
Real interest rate			3,68	3,78			5,79	5,16
			[2,68]	[2,79]			[4,93]	[3,37]
Intercept	-0,13	-0,05	-0,17	-0,20	0,22	0,24	0,17	0,16
	[-2,48]	[-1,38]	[-3,01]	[-3,25]	[4,80]	[5,12]	[3,83]	[3,68]
R2	0,23	0,04	0,32	0,38	0,33	0,28	0,52	0,53
Adjusted R2	0,18	-0,02	0,28	0,30	0,30	0,25	0,50	0,49
	Dependent variable: Coskewness							
Nominal interest rate	-14,47				-6,70			
	[-1,72]				[-2,58]			
Inflation rate		-5,46		-7,05		-9,31		-2,60
		[-0,53]		[-0,82]		[-2,37]		[-0,57]
Real interest rate			-45,48	-46,39			-31,83	-27,61
			[-2,76]	[-2,78]			[-3,49]	[-2,32]
Intercept	1,98	1,08	2,65	2,94	-1,31	-1,39	-1,01	-0,99
	[2,93]	[2,43]	[3,95]	[3,85]	[-3,98]	[-4,28]	[-3,02]	[-2,89]
R2	0,16	0,02	0,34	0,37	0,23	0,20	0,36	0,37
Adjusted R2	0,11	-0,05	0,29	0,28	0,20	0,17	0,33	0,31
Sample of countries (listed in order of increasing downside betas)	17 developed countries: Japan, Switzerland, France, Denmark, Italy, Germany, Belgium, Spain, Portugal, UK, Netherlands, Sweden, Norway, Greece, New Zealand, Australia, Canada				24 developed and emerging countries with flexible exchange rate regime: Japan, Malta, Cyprus, Switzerland, Singapore, Thailand, UK, Denmark, Euro Zone, Norway, Romania, Canada, Mexico, Poland, Sweden, Indonesia, Hungary, South Africa, Chile, New Zealand, Iceland, Australia, Brazil, Turkey			

This table shows coefficients of cross-section regressions of currency exchange rate market beta, downside beta and coskewness on local nominal and real interest rates and inflation for two different samples of countries for two sub-periods,

t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

Table 3. Risk characteristics of currency portfolios sorted by nominal and real interest rates and inflation 1990-2009

	Pfl 1	2	3	4	Pfl 5	5-1*
Panel A: Nominal interest rate sort						
Nom. int. rate (percent p.a.)	2,63	4,80	6,48	9,84	32,75	30,12
Average ER return (percent p.m.)	0,03	0,14	0,01	-0,23	-1,10	-1,13
Beta	**0,09**	**0,13**	**0,18**	**0,21**	**0,24**	**0,15**
t-stat	[3,72]	[4,49]	[5,61]	[6,59]	[6,43]	[4,10]
Downside beta	**0,05**	**0,14**	**0,18**	**0,23**	**0,30**	**0,25**
t-stat	[1,27]	[2,87]	[3,35]	[4,16]	[4,75]	[4,01]
Coskewness	**-0,05**	**-0,86**	**-1,06**	**-1,42**	**-1,85**	**-1,79**
t-stat	[-0,18]	[-2,52]	[-2,72]	[-3,51]	[-3,92]	[-4,07]
Av. No of currencies	7,39	7,25	7,21	6,64	6,44	
Panel B: Real interest rate sort						
Real int. rate (percent p.a.)	-3,75	1,04	2,65	4,36	9,60	13,35
Average ER return (percent p.m.)	-0,23	-0,01	-0,07	-0,18	-0,93	-0,70
Beta	**0,10**	**0,11**	**0,16**	**0,20**	**0,31**	**0,20**
t-stat	[3,85]	[3,88]	[5,90]	[6,60]	[6,98]	[5,27]
Downside beta	**0,09**	**0,08**	**0,15**	**0,31**	**0,31**	**0,22**
t-stat	[1,95]	[1,75]	[3,25]	[6,06]	[4,16]	[3,38]
Coskewness	**-0,43**	**-0,34**	**-0,85**	**-2,18**	**-1,79**	**-1,36**
t-stat	[-1,32]	[-0,99]	[-2,46]	[-5,85]	[-3,18]	[-2,85]
Av. No of currencies	7,44	7,40	7,21	6,47	5,03	
Panel C: Inflation rate sort						
Inflation rate (percent p.a.)	0,87	2,53	4,40	8,57	186,86	n.a.
Average ER return (percent p.m.)	0,05	0,00	-0,07	-0,26	-1,81	-1,86
Beta	**0,11**	**0,16**	**0,18**	**0,18**	**0,19**	**0,07**
t-stat	[4,02]	[4,99]	[6,60]	[7,01]	[3,65]	[1,42]
Downside beta	**0,06**	**0,16**	**0,18**	**0,23**	**0,25**	**0,19**
t-stat	[1,32]	[3,01]	[3,95]	[5,29]	[2,89]	[2,11]
Coskewness	**-0,18**	**-0,99**	**-1,07**	**-1,45**	**-1,33**	**-1,15**
t-stat	[-0,54]	[-2,58]	[-3,13]	[-4,56]	[-2,16]	[-1,84]
Av. No of currencies	8,22	8,29	8,72	8,25	7,85	

*portfolio which is long in portfolio 5 and short in portfolio 1
t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

Table 4. Risk characteristics of currency portfolios sorted by nominal and real interest rates and inflation 1999-2009

	Pfl 1	2	3	4	Pfl 5	5-1*
Panel A: Nominal interest rate sort						
Nom. int. rate (percent p.a.)	1,72	3,50	4,97	7,65	19,68	17,96
Average ER return (percent p.m.)	0,03	0,26	0,10	-0,18	-0,38	-0,41
Beta	**0,12**	**0,18**	**0,24**	**0,27**	**0,39**	**0,27**
t-stat	[4,45]	[5,01]	[6,46]	[6,81]	[9,16]	[6,00]
Downside beta	**0,11**	**0,20**	**0,28**	**0,33**	**0,51**	**0,40**
t-stat	[2,50]	[3,36]	[4,57]	[5,14]	[7,40]	[5,51]
Coskewness	**-0,49**	**-1,33**	**-1,72**	**-2,21**	**-2,96**	**-2,47**
t-stat	[-1,52]	[-3,23]	[-3,97]	[-4,82]	[-5,51]	[-4,93]
Av. No of currencies	7,65	7,43	7,27	6,05	6,00	
Panel B: Real interest rate sort						
Real int. rate (percent p.a.)	-2,10	0,69	1,92	3,60	8,49	10,59
Average ER return (percent p.m.)	0,12	0,19	0,03	-0,20	-0,44	-0,56
Beta	**0,17**	**0,17**	**0,21**	**0,27**	**0,45**	**0,28**
t-stat	[5,45]	[4,72]	[6,32]	[6,62]	[9,30]	[6,07]
Downside beta	**0,20**	**0,17**	**0,22**	**0,43**	**0,52**	**0,31**
t-stat	[4,05]	[2,99]	[3,84]	[6,54]	[6,54]	[4,10]
Coskewness	**-1,15**	**-0,93**	**-1,40**	**-2,94**	**-2,97**	**-1,82**
t-stat	[-3,21]	[-2,30]	[-3,45]	[-6,54]	[-4,74]	[-3,34]
Av. No of currencies	7,73	7,70	7,30	6,05	4,48	
Panel C: Inflation rate sort						
Inflation rate (percent p.a.)	0,30	2,08	3,36	5,56	16,06	n.a.
Average ER return (percent p.m.)	0,08	0,07	0,11	-0,17	-0,21	-0,30
Beta	**0,14**	**0,23**	**0,26**	**0,25**	**0,30**	**0,16**
t-stat	[4,31]	[5,82]	[7,57]	[7,25]	[8,05]	[4,41]
Downside beta	**0,11**	**0,26**	**0,30**	**0,29**	**0,42**	**0,30**
t-stat	[2,20]	[4,06]	[5,26]	[5,23]	[6,98]	[5,16]
Coskewness	**-0,65**	**-1,67**	**-1,81**	**-1,93**	**-2,42**	**-1,77**
t-stat	[-1,79]	[-3,68]	[-4,25]	[-4,78]	[-5,42]	[-4,44]
Av. No of currencies	7,25	7,87	8,00	7,85	7,06	

*portfolio which is long in portfolio 5 and short in portfolio 1
t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

Table 5. Risk characteristics of currency portfolios double sorted by inflation and real interest rates

	Pfl 1	2	3	4	5	Pfl 6
	Low infl Low r	Low infl High r	Med infl Low r	Med infl High r	High infl Low r	High infl High r
	1990-2009					
Inflation rate (percent p.a.)	1,46	1,27	3,96	3,99	34,69	18,74
Real int. rate (percent p.a.)	1,40	4,46	0,93	4,85	-4,30	6,42
Nom. int. rate (percent p.a.)	2,89	5,79	4,93	9,03	28,89	26,36
Average ER return (percent p.m.)	0,13	0,00	0,08	-0,24	-0,43	-0,95
Beta	**0,09**	**0,14**	**0,12**	**0,24**	**0,09**	**0,29**
t-stat	[3,23]	[4,40]	[4,29]	[6,92]	[3,16]	[7,98]
Downside beta	**0,03**	**0,12**	**0,12**	**0,26**	**0,12**	**0,36**
t-stat	[0,64]	[2,26]	[2,58]	[4,44]	[2,34]	[5,78]
Coskewness	**0,19**	**-0,76**	**-0,72**	**-1,69**	**-0,76**	**-2,15**
t-stat	[0,54]	[-1,92]	[-2,10]	[-3,88]	[-2,13]	[-4,53]
Av. No of currencies	5,68	5,57	5,66	5,59	5,57	5,37
	1999-2009					
Inflation rate (percent p.a.)	1,16	0,77	3,28	3,32	10,84	11,59
Real int. rate (percent p.a.)	0,68	3,59	0,25	3,73	-2,26	5,70
Nom. int. rate (percent p.a.)	1,85	4,39	3,54	7,17	8,34	17,95
Average ER return (percent p.m.)	0,18	0,04	0,18	-0,15	0,00	-0,33
Beta	**0,11**	**0,18**	**0,18**	**0,33**	**0,17**	**0,42**
t-stat	[3,17]	[5,08]	[5,30]	[7,83]	[4,81]	[10,18]
Downside beta	**0,08**	**0,19**	**0,21**	**0,40**	**0,23**	**0,54**
t-stat	[1,37]	[3,19]	[3,73]	[5,86]	[4,16]	[8,07]
Coskewness	**-0,25**	**-1,24**	**-1,28**	**-2,62**	**-1,42**	**-3,24**
t-stat	[-0,63]	[-3,04]	[-3,22]	[-5,22]	[-3,68]	[-6,03]
Av. No of currencies	5,74	5,48	5,65	5,48	5,61	5,11

First, all currencies are sorted by inflation into three portfolios, then currencies of each portfolio are sorted by the real interest rate into two portfolios, the portfolios are rebalanced monthly,
t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

Table 6. Cross-section regressions for individual currencies (bigger samples of countries)

	Sub-period: 1990-1998				Sub-period: 1999-2009			
	Dependent variable: Market beta							
	1	2	3	4	1	2	3	4
Nominal interest rate	-0,15				0,97			
	[-1,80]				[3,32]			
Inflation rate		-0,15		-0,15		0,88		0,67
		[-1,82]		[-1,77]		[2,13]		[1,93]
Real interest rate			0,10	-0,02			3,33	3,11
			[0,10]	[-0,02]			[4,19]	[4,01]
Intercept	0,09	0,09	0,07	0,09	0,16	0,19	0,17	0,14
	[5,73]	[5,98]	[1,98]	[2,45]	[5,13]	[5,52]	[6,38]	[4,53]
R2	0,13	0,13	0,00	0,13	0,25	0,12	0,35	0,42
Adjusted R2	0,09	0,09	-0,04	0,05	0,23	0,09	0,33	0,38
	Dependent variable: Downside market beta							
Nominal interest rate	0,07				1,34			
	[0,56]				[4,02]			
Inflation rate		0,04		0,06		1,31		1,06
		[0,36]		[0,54]		[2,71]		[2,64]
Real interest rate			2,47	2,52			4,02	3,67
			[2,13]	[2,13]			[4,19]	[4,10]
Intercept	-0,03	-0,02	-0,11	-0,11	0,17	0,20	0,20	0,15
	[-1,18]	[-1,10]	[-2,41]	[-2,43]	[4,80]	[5,13]	[6,06]	[4,11]
R2	0,01	0,01	0,17	0,18	0,33	0,18	0,35	0,46
Adjusted R2	-0,03	-0,04	0,13	0,10	0,31	0,16	0,33	0,43
	Dependent variable: Coskewness							
Nominal interest rate	-1,20				-7,32			
	[-0,94]				[-3,11]			
Inflation rate		-0,96		-1,16		-7,39		-6,10
		[-0,73]		[-0,96]		[-2,25]		[-2,02]
Real interest rate			-27,99	-28,89			-21,07	-19,01
			[-2,19]	[-2,25]			[-3,04]	[-2,83]
Intercept	0,92	0,86	1,76	1,88	-1,09	-1,23	-1,22	-0,93
	[3,70]	[3,78]	[3,64]	[3,76]	[-4,22]	[-4,58]	[-5,25]	[-3,52]
R2	0,04	0,02	0,18	0,21	0,23	0,13	0,22	0,31
Adjusted R2	-0,01	-0,02	0,14	0,14	0,20	0,11	0,19	0,26
Sample of countries (in order of increasing downside betas)	24 developed and developing countries : Japan, Switzerland, Cyprus, Malta, France, Denmark, Italy, Germany, Belgium, Turkey, Spain, Portugal, UK, Netherlands, Sweden, Iceland, Singapore, Norway, Greece, New Zealand, South Africa, Australia, Canada, Mexico				35 developed and emerging countries: Japan, Malta, Cyprus, Switzerland, Singapore, Thailand, UK, Denmark, Euro Zone, Norway, Romania, Canada, Mexico, Poland, Sweden, Indonesia, Hungary, South Africa, Chile, New Zealand, Iceland, Australia, Brazil, Turkey + Hong Kong, China, Slovenia, Phillipines, Russia, India, Czech Republic, Lithuania, Bulgaria, Latvia, Slovakia			

This table shows coefficients of cross-section regressions of currency exchange rate market beta, downside beta and coskewness on local nominal and real interest rates and inflation for two extended samples of countries for two sub-periods,
t-statistics are in brackets, t-statistics are calculated using Newey-West heteroskedasticity consistent standard errors.

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