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The Currency Carry Trade

A look at the currency carry trade and its implementation in a portfolio

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Abstract

In this paper we look at the currency carry trading strategy. We look at two different baskets of currencies; one for the G10, and one which include emerging markets currencies. We backtest our trading strategy and find that both baskets have positive returns, and better risk adjusted returns than the S&P 500. Furthermore, the returns are somewhat uncorrelated with the S&P 500 which makes the currency carry trade a nice addition to a portfolio in order to diversify and reduce the portfolio's risk. From the results of our data we present an optimal portfolio where the investor maximizes the expected returns for a given level of risk.

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1 Introduction

The paper will be looking at how an investor can implement the currency carry trading strategy in a portfolio. We will start by looking at theories regarding the trading strategy and present examples on why it should, but also should not work. Then we will be looking at portfolio theory as a basis for our analysis on how the institutional investor can implement the strategy in a diversified portfolio. Following this, we will provide empirical results, both from past research, and our backtest on the currency carry trading strategy. Lastly, we will analyse how the investor can implement the currency carry trading in a diversified portfolio, before we conclude whether the strategy fits a diversified portfolio.

2 Theory

2.1 The Currency Carry Trade

Currency carry trading is defined as the strategy where an investor borrows or shorts a low interest currency and lends or goes long in a high interest rate currency. Investors applying the strategy wants to take advantage of the interest rate difference between the two currencies (Laux & Zhang, 2014). The difference in interest rates can often be substantial, and by trading with leverage, the carry trade can often lead to large profits (Chen, Currency Carry Trade, 2018a).

Investors using the currency carry trading strategy needs to determine which currencies that has a high and low yield, i.e. find the target currency and the funding currency (Galati, Heath, & McGuire, 2007). The trading strategy can be implemented in many ways. Currency forwards, corporate bonds, bank deposits or government bond are the most common ways to carry out the strategy (Hwang, 2018).

Currency carry traders need to pay attention to the exchange rates between the chosen currencies. The investor makes money from the difference in interest rates but will lose money if the exchange rate moves against them. This is when the exchange rates move in the direction where the funding currency gets more expensive relative to the target currency. As the exchange rates change due to both micro- and macroeconomic events, the trader always has the risk of losing money in the currency carry trade. Investors using the currency carry trading strategy also stand to lose money on the trade, even if the exchange rates does not

change, if you calculate the true alternative cost; the opportunity cost. This is one of the reasons why the investors often use leverage. By using leverage, the investor can increase the profit to equity, but the potential losses increase equally. If the investor uses a leverage factor of 10:1, the investor will earn a profit ten times the difference between the interest rates (Chen, Currency Carry Trade, 2018a). If an investor earns 4,5% in the difference between the interest trades, and the leverage is 10:1, the investor will earn a profit of 45% on the invested capital.

As the trading strategy involves risk, the investor can choose to hedge his position in order to minimize the risk. The trading strategy is called covered carry trade if the investor hedges his position. If the investor does not hedge the position, the trading strategy is called an uncovered carry trade. When using the covered carry trading strategy, the investor purchases an exchange forward contract in order to hedge the foreign exchange risk involved in the trade (Laux & Zhang, 2014). However, purchasing the forward contract will decrease the profit opportunity the investor has in comparison to the uncovered trade because the investor will not get the currency (FX) impact on the investment. In this essay, we will focus on the uncovered carry trading strategy.

The currency carry trade is not a passive buy-and-hold investment. The investor needs to pay attention to which currencies has the greatest difference in interest rates in order to maximize their profit. This gives the currency carry trading strategy a trading perspective, as the investors must make several trades, depending on which currency pairs that can give the investor the greatest return. As a rule of thumb, investors can pick three currency pairs to invest in at the same time, where the investor picks the top three and bottom three currencies that has the highest and lowest interest rates (NBIM, 2014). However, if the interest rates stay the same, the investor does not trade, and holds the position until interest rates change.

2.2 Institutional Investors and the Currency Carry Trade

As the currency carry trade must involve some element of gearing because investors borrow money in one currency in order to catch the difference in interest rates, the trading strategy involves risk. However, the more gearing the investor uses the more the risk increases. For small investors, currency carry trade can be especially risky, and small investors implementing the currency carry trade strategy can sometimes be referred to as risk seekers. However, for an institutional investor, the currency carry trade can be implemented in their portfolio in order to lower risk exposure, even though the trade itself involves great amounts

of risk. This is the theory that we are going to discuss in chapter four. For institutional investors, low correlation between different investments is a key factor in order to diversify the risk and achieve good results on the investments (NBIM, 2018). Currency carry trading has a low correlation with both the stock and bond markets, which together with its high Sharpe ratio predicts that currency carry trading can positively contribute to a portfolio (NBIM, 2014).

2.3 Uncovered Interest Parity

Uncovered interest parity (UIP) is a condition in which there are no arbitrage opportunities. It assumes that the investors are rational and risk-neutral, meaning investors maximize returns without taking risk into account (NBIM, 2014). UIP postulates that the expected depreciation of the exchange rate between two currencies should be equal to the difference in interest rates. Therefore, if UIP holds the expected return on the investment is zero.

The formula for UIP is:

$$E\left\{S^{\frac{\$}{€}}_{t+1}\right\} = S^{\frac{\$}{€}}_{t} \times \frac{\left(1 + R^{\$}_{t,t+1}\right)}{\left(1 + R^{€}_{t,t+1}\right)} \quad (1)$$

where *S* is the spot exchange rate, E indicates expected value, *R* the interest rate from (t) to (t+1), $ and € indicate the two currencies used.

As one can see from the formula, the expected future spot exchange rate at time (t+1) is expected to develop according to the difference in interest rates. If the exchange rates do not develop accordingly it creates profit(loss) opportunities. The strategy for taking advantage of this involves borrowing in one currency, converting to another and placing the currency in a risk-free interest product. After a period, one exchanges back to the original currency and repays the loan. UIP is an unhedged strategy, which involves risk. Therefore, traders who try to make a profit with uncovered interest parity are pure speculators.

An example to illustrate:

An investor borrows $1000 at 1% annual interest, then exchanges the amount to euros at an exchange rate of 0,9 and receives an annual interest of 3%. If the exchange rate does not

change the investor will make a profit of the difference in the interest rates, which can be seen in Table 1.

	Start of year	End of year	In USD
USD	-$1000	(-$1000*1,01) = -$1010	-$1010
EUR	€900	(€900*1,03) = 927	€927*(1/0,9) = $1030
Profit			$20

Table 1: An example where UIP does not hold, and the investor makes a profit.

2.4 Forward-Rate Bias

The phenomenon where the UIP does not hold up is called Forward-Rate Bias (FRB). In other words, in order to profit from the currency carry trade, we need a market in an FRB condition. The FRB was discovered by Eugene Fama (1984) when he ran the Fama regression, as shown in (2). Where the UIP theory predicts a zero constant and a unit slope coefficient in a regression of future currency depreciation on the interest rate differential, Fama found that the slope in the regression is less than one and often negative (Berg & Mark, 2017).

$$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \epsilon_{t+1} \quad (2)$$

This implies that the larger interest rate differential, the smaller is the subsequent currency depreciation rate. The most recognized explanation is that this happens because the two currencies have different risks and the FRB comes from the risk premium across currencies (Berg & Mark, 2017).

2.5 Risk Aversion

It is normal to differentiate between three different types of investors; Risk seeking, risk neutral and risk averse. The difference between the three types are their approach to risk in an investment. There are different ways of measuring risk, but standard deviation is a much-used measure we will use for this discussion.

Risk seeking

A risk seeking investor considers risk in an investment something positive and derives utility from it (Kenton, 2018a). That is, for a risk seeker, an investment with more risk is considered

better than an investment with less risk. If given a choice between two investments with equal expected return, the risk seeker will choose the one with the highest standard deviation.

Risk neutral

A risk neutral investor is only interested in expected return on an investment and derives utility solely from expected returns (Kenton, 2018b). When presented with two investment options the risk neutral will always choose the one with the greatest expected return, regardless of the risk associated with that investment.

Risk averse

A risk averse investor considers risk something negative and will expect something in return for investing in a position involving risk (Chen, 2018b). A risk averse investor's utility is reduced with more risk. Presented with two investment options with equal expected return the risk averse investor will always choose the one with the least risk. There are different degrees of risk aversion, and therefore a more risk averse investor will expect a higher expected return for a certain level of risk, than a less risk averse investor.

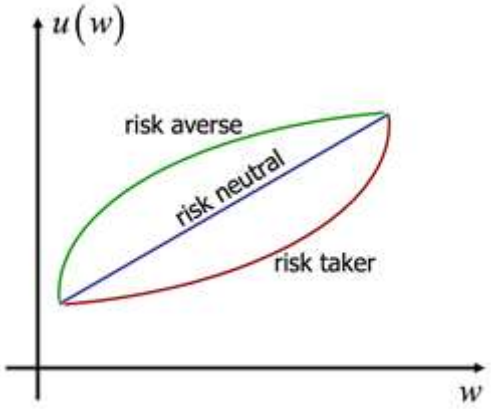


Figure 1: The utility (u(w)) the different investors derive as a function of expected returns (w)

2.6 Portfolio Theory

Modern portfolio theory says how risk-averse investors can construct portfolios to maximise expected return based on a given level of market risk. The theory was introduced by Harry Markowitz in The Journal of Finance in 1952. Markowitz (1952) argues that all investors should be risk averse. The theory uses diversification to lower the risk, measured by standard deviation. By investing in different assets in different sectors, which are uncorrelated or anticorrelated, the investor can earn a higher return, while also expose themselves to lower risk (Markowitz, 1952). The theory assumes that there are risk-free borrowing-lending opportunities in the market, so that all investors can borrow or lend as much as they like at a risk-free rate of interest (Fama, 1971). A portfolio consisting of a risk-free asset and risky assets can be expressed as:

$$\tilde{R}_p = xR_f + (1-x)\tilde{R}_a\,, \quad x \leq 1 \tag{3}$$

Where R_p is the portfolio, R_f the risk-free asset and R_a the portfolio of risky assets. The portfolio is borrowing when x<0, and lending when x>0. The return of the portfolio is then given:

$$\delta(\tilde{R}_p) = xR_f + (1-x)\delta(\tilde{R}_a) \tag{4}$$

And the standard deviation is:

$$\sigma(\tilde{R}_p) = (1-x)\sigma(\tilde{R}_a) \tag{5}$$

(the standard deviation is 0 for the risk-free asset).

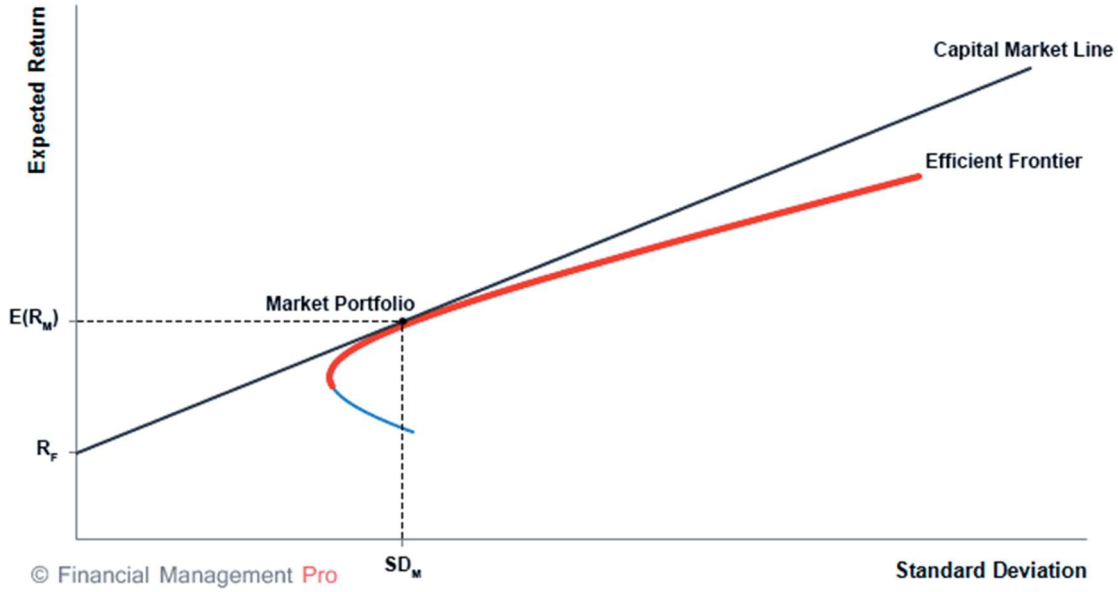


Figure 2: The capital market line

In figure 2 the capital market line is shown. The efficient frontier shows the portfolio (for example allocation between two stocks) that gives the highest return for each standard deviation. The capital market line goes from the risk-free return through its tangency with the efficient frontier, and can be written, as above:

$$\tilde{R}_p = xR_f + (1-x)\tilde{R}_m\,, \quad x \leq 1 \tag{6}$$

where R_m is the market portfolio. The portfolio theory says the tangency point, marked as "Market Portfolio" is the only efficient portfolio. If an investor wants lower risk, he should

place more in the risk-free asset, and therefore be between the market portfolio and R_f. If an investor wants higher return, he should borrow and therefore be above the market portfolio at the capital market line. Nobody will have an incentive to hold risky assets not included in the market portfolio (Fama, 1971).

2.7 Measurements

For calculations throughout the Empirical research and portfolio construction chapters we will have to use measurements. In the following, we will present measurements we will use for calculations throughout the essay.

2.7.1 Sharpe Ratio

The Sharpe ratio is a calculation of risk-adjusted return, where greater values indicates a more attractive risk-adjusted return. The calculation is shown below, where R_p is the portfolio return, R_f is the return from a risk-free investment and σ_p is the standard deviation of the portfolio's excess return.

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p} \tag{7}$$

2.7.2 Standard Deviation

The standard deviation is a common measure of an investment's risk. We have calculated the sample standard deviation from our data, and for this we have used the following formula:

$$\sigma_p = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{8}$$

Where σ is the standard deviation, x is the return, x-bar is the sample mean return, and n is the number of observations.

2.7.3 Correlation Coefficient

The correlation coefficient is a measure of how correlated two samples are. It spans from -1 to 1, where 1 is complete correlation and -1 is anticorrelated. If the correlation coefficient is zero there is no evidence the sample is correlated. We have used the following formula for calculating the correlation coefficient:

$$\rho_{XY} = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 (y - \bar{y})^2}} \quad (9)$$

Where X and Y are the two samples.

3 Empirical Research

3.1 Assumptions

In the following empirical analysis, we will have to make the following assumptions to simplify the model. We find it best to look at nominal interest rate differentials rather than real. Real interest rate differentials have been used more frequently in academic literature over the years, after Hazuka and Huberts (1994) found that including inflation leads to better performance. However, they could not prove statistical significance of improved return. Nevertheless, as the UIP displays the nominal interest rate differential, we find it best to use it rather than the real rate in our model. Moreover, the use of nominal interest rates would simplify our work as we now can refer to key policy rates and bond yields directly.

Secondly, we will not include transaction costs in our model to simplify it further. However, doing this will have limited impact on our result as the transaction costs in the liquid G10 currencies are small. Still, the results from emerging market currencies might be overstated as these currencies tend to have larger transaction costs. Furthermore, we have used 3-month bonds which reduce the cost of rolling forward contracts. It is worth noting that Menkhoff, Sarno, Schmeling and Schrimpf (2012) found that transaction costs for carry trading were approximately 79 basis points per annum. This is not substantial, but it can be worth keeping in mind when considering the strategy.

3.2 Strategy

Our strategy implies trading in currency baskets consisting of the G10 currencies and emerging market currencies separately. The G10 currencies are the most traded and liquid currencies in the world and it is therefore natural to have a look at those first. We will also

look at emerging market currencies, as they tend to have the highest interest rate differentials. The following strategy description applies for both baskets:

The currencies will be ranked by interest rate, where the currency with the highest interest rate will be ranked 1st, the second highest 2nd, and so forth. The bottom 3 (the currencies with lowest interest rate) will be used to fund long positions in the top 3 currencies. The ranking will be updated once a week, which ensures that the portfolio always reflects the best rate-differential opportunities. Furthermore, we will be investing in 3-month government bonds issued by countries with the higher-yielding currency.

3.3 Bloomberg Backtesting

To backtest our strategy, we have used the FX Strategy Workbench (FXSW) on the Bloomberg Terminal. This provides us with graphs and illustrations of the results from the trading strategy. It also produces data with daily returns, positions taken etc. that we can use for further analysis. To conduct this backtest, we have set the inputs as the strategy described above. This is shown in Figure 3, which is a screenshot from the input field in FXSW. In the inputs, we state that we will invest in 3-month government bonds in the G10 currency basket. Our base currency is the US Dollar and we use the S&P 500 as benchmark. As for the analysis with the emerging markets basket, we have only altered the investment universe in the input cells.



Figure 3: Inputs in the Bloomberg FX Strategy Workbench.

We have chosen to conduct our backtest in the timeframe between 1997 and 2018. This timeframe is long enough to show the long-term effect of the trade, as well as it includes two recessions[1]. Moreover, as our data package on the Bloomberg Terminal only went back to 1997, we felt it natural to use all the data available.

3.4 Results

The results from backtesting the G10 basket is shown in figure 4. The blue line is the return from the carry trading from 1997-2018, whilst the white line is the S&P 500 return. As the

[1] U.S. recessions, according to Federal Reserve Economic Data (2018)

backtest shows, the currency carry trade yielded more return in the time time frame 2002-2013. From 2013 and forward, the S&P 500 has had substansial greater returns than the currency carry trading strategy using the G10 currency basket. Figure 5 is the returns from the emerging markets basket from 2005 to 2018. The colours of the lines are the same as for the G10 basket.



Figure 4: Returns from the G10 basket from 1997 to 2018

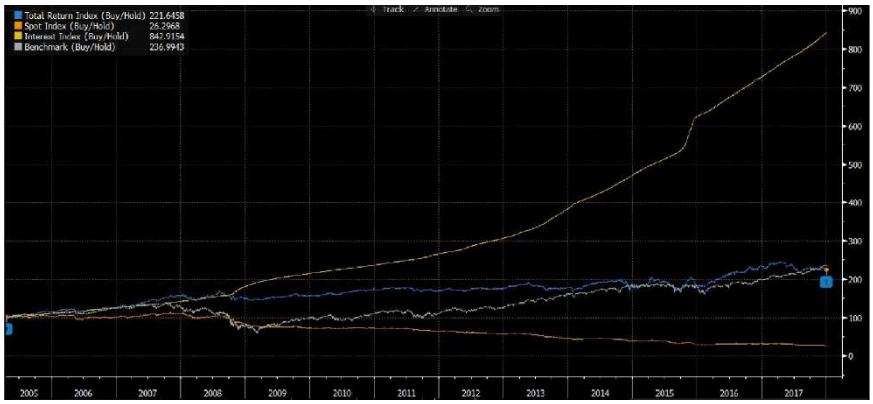


Figure 5: Returns from the emerging markets basket from 2005 to 2018

The return from the currency carry trade is the sum of the interest rate (yellow line) and the currency effect (orange line). If the blue line (return from currency trade) is above the interest rate line, the FX impact on return is positive, and vice versa if the blue line is under the yellow line. As the interest rate line is almost perfect linear, the volatility in the currency carry trade must come from the FX impact on return. The FX impact on the currency carry return peaked at almost 50% in mid-2007. From the all-time high, the trend on the currency effect is negative, and in 2018 the currency effect is slightly negative, and the interest rate yielded more return itself than the currency carry trade.

The currency effect was not volatile in comparison to the benchmark S&P 500 index. A clear example is the dot-com bubble where the S&P 500 fell ~40% while the currency carry G10 basket had an annual average return of ~8% This may indicate that the currency carry trade is more resistant to economic crisis than trades in the stock market. Looking back at the currency carry trade, the return on the trade from Lehman crisis until 2018 is close to 0%. This is due to the negative trend on the currency effect. In hindsight, one can see that trends also do apply for the currency market. Covered carry trading, where the investor hedges the position by buying forward exchange contracts, would have made sure the investor would

have had a bigger return than the uncovered carry trader. However, the return from 2001-2008 would have been approximately 50% less if the investor had used the covered currency trade. As an investor hedges his position, he minimizes risk, but also minimize the upside because the currency effect on the return would not apply for the investor. This statement is always easy to tell in hindsight.

In Table 2 we have extracted data from the FXSW to include five different backtests and have included the calculated Sharpe ratio (7) and standard deviation (8). In addition to analysing the G10 basket, we had a look at a basket consisting of 24 emerging market-currencies. The EM-basket shows improved returns compared to the G10, but the returns also comes at higher standard deviation. However, the Sharpe ratio was better for both EM baskets.

Basket	Time Period	Ann. Return	Standard Deviation	Sharpe[2)]
G10	1997-2018	3,85 %	9,39 %	0,1885
G10	1997-2010	5,85 %	9,52 %	0,2920
G10	2010-2018	0,67 %	9,17 %	0,0393
EM	2005-2018	4,33 %	9,82 %	0,3177
EM	2010-2018	6,44 %	9,76 %	0,3422
S&P 500	1997-2018	6,07%	19,16%	0,2037

Table 2: Our results from the backtest with different currency baskets. Data: Bloomberg

To compare, we have included a list of other publications in Table 3. Here, we can see that our results came in slightly below the average, especially if we look at the G10 basket. Our explanation is that the carry trade has been less profitable in the G10 currencies since 2010, where the FX impact on the trade has been either neutral or negative. That is why we have included isolated results with and without the 2010-2018 time period in Table 2. If we have not included the underperforming 2010-2018 period, our results are in line with other publications. This shows an interesting effect after 2010, that is not included in past research as the FX impact on the trade usually have not been negative for several years.

On the other hand, the EM basket performed well compared to previous research and alternative investments. With a Sharpe ratio of 0,32 they show great return compared to the risk the asset involves. In comparison, the S&P 500's Sharpe ratio was 0,20 from 1997-2018 when using the 3-month U.S. Treasury Yield as the risk-free rate.

[2] Calculated using a yearly arithmetic mean from the U.S. 3-month Treasury Yield as the risk-free rate

Authors	Period	Interest	Currencies	Ann. Return	Volatility	Sharpe[2)]
Barroso and Santa-Clara	1996-2011	1-month	27	21,40 %	24,30 %	0,7572
Brunnermeier, Nagel and Pedersen	1986-2006	3-month	9	6,40 %	10,20 %	0,1765
Burnside, Eichenbaum and Rebelo	1976-2007	-	23	5,40 %	6,50 %	-0,0862
Burnside, Eichenbaum, Kleshchelski and Rebelo	1976-2009	1-month	21	4,80 %	5,30 %	-0,1660
Darvas	1976-2008	1-month	11	4,10 %	4,60 %	-0,3804
Della Corte, Riddiough and Sarno	1983-2011	1-month	60	5,40 %	8,90 %	0,1056
Jurek	1990-2012	1-month	10	4,50 %	9,50 %	0,1179
Koijen, Moskowitz, Pedersen and Vrugt	1983-2011	1-month	20	5,30 %	7,80 %	0,1077
Lustig, Roussanov and Verdelhan	1983-2009	1-month	35	8,50 %	9,00 %	0,4122
Menkhoff, Sarno, Schmeling and Schrimpf	1983-2009	1-month	48	7,20 %	9,80 %	0,2459
NBIM	1983-2013	1-month	10	5,50 %	9,10 %	0,1143
Rafferty	1976-2011	1-month	37	7,00 %	8,30 %	0,1964
Average other publications			25,9	7,13 %	9,44 %	0,1334
Average other publications ex. Barroso			25,8	5,83 %	8,09 %	0,0767
Our results (G10)	**1997-2018**	**3-month**	**10**	**3,85 %**	**9,39 %**	**0,1885**
Our results (EM)	**2005-2018**	**3-month**	**24**	**6,44 %**	**9,76 %**	**0,5358**

Table 3: Overview of past empirical literature. Data: Bloomberg, NBIM and U.S. Department of the Treasury.

3.5 Statistical Tests

Before we started working with the data, we wanted to do a statistical test to make sure the differences we saw were statistically significant. We tested both the baskets of G10 and emerging markets. The Bloomberg backtest provided us with daily data on returns and standard deviation. Because we have daily observations of the returns over many years we can, according to the central limit theorem, assume the data is normally distributed regardless of the underlying distribution. This is illustrated in Figure 6. Therefore, we used variations of the following test statistic:

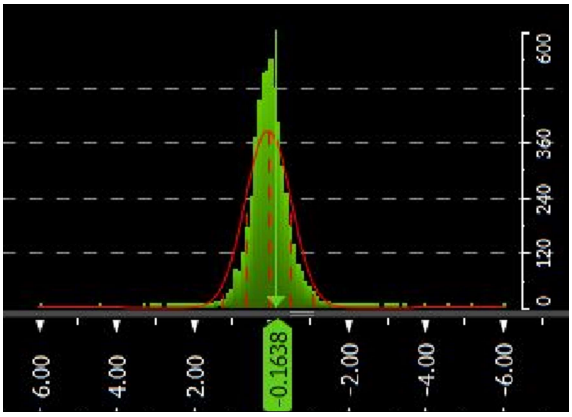


Figure 6: Distribution of daily returns from the G10 carry trade portfolio 97-18

$$Z = \frac{\bar{x}_{CCT} - \bar{x}_{S\&P}}{\sqrt{\frac{S^2_{CCT}}{N} + \frac{S^2_{S\&P}}{M}}} \qquad (10)$$

Where subscript CCT is currency carry trading, and S&P is the S&P500. *X*-bar is the sample mean, and *S* squared is the sample variance, *N* and *M* are the sample sizes. We tested the hypothesises at a significance level of 0,05.

The results were:

Instruments	Hypothesis	Test-statistic value	P-value	Significant at α=0,05
G10 and S&P: 97-18	$\begin{cases} H_0: \bar{x}_{S\&P} - \bar{x}_{CCT:G10} = 0 \\ H_1: \bar{x}_{S\&P} - \bar{x}_{CCT:G10} > 0 \end{cases}$	~1,845	~0,03	Yes
EM and S&P: 05-18	$\begin{cases} H_0: \bar{x}_{S\&P} - \bar{x}_{CCT:EM} = 0 \\ H_1: \bar{x}_{S\&P} - \bar{x}_{CCT:EM} > 0 \end{cases}$	~0,3	~0,43	No
EM and G10: 05-18	$\begin{cases} H_0: \bar{x}_{EM} - \bar{x}_{G10} = 0 \\ H_1: \bar{x}_{EM} - \bar{x}_{G10} > 0 \end{cases}$	~1,15	~0,125	No

Table 4: Our three different statistical tests.

As we can see from the test results in table 4 the difference in returns between the G10 currency basket and the S&P 500 in the period from 1997 to 2018 is statistically significant. On the other hand, the difference between the emerging markets basket and S&P 500 from 2005 to 2018 is clearly not significant. The main reason for this is that the returns for the emerging markets basket is greater than for the G10 basket. In addition, the difference in returns between the two baskets is not significant at α=0,05. However, we did not test for differences in Sharpe ratio. When reviewing the results from our strategy backtest, and when including other scientific publications, we can see that this trading strategy would yield a better risk-adjusted return than the S&P 500. This indicates that one can empirically conclude that the Forward-Rate Bias in fact does hold up in our selected markets. Knowing this, we can start to look at how to use these returns to impact a portfolio.

4 Implementing Currency Carry Trading in a Portfolio

4.1 Portfolio Allocation

4.1.1 G10

In the following discussion we have used data from the currency carry trade against the S&P 500 index. We want to look at how the low correlation between the instruments can be beneficial for a portfolio. In our backtest of the G10-bakset from 1997 to 2018, it gave an annual return of 3,85 % and we found a correlation between the G10 and S&P 500 of ~0,47.

By using Analytic Solver in excel, we have found optimal allocations between currency carry trading and S&P 500 to create an efficient frontier. We have programmed Analytic Solver to

minimize the standard deviation, for different given returns and allocations between the two assets. The results are shown in table 5.

Return	Standard deviation	% in CC trading	% in S&P 500
3,85 %	9,39 %	100,00 %	0,00 %
4,17 %	8,77 %	80,41 %	19,59 %
4,49 %	8,79 %	77,78 %	22,22 %
4,81 %	9,08 %	66,67 %	33,33 %
5,13 %	9,77 %	55,56 %	44,44 %
5,45 %	10,85 %	44,44 %	55,56 %
5,77 %	12,33 %	33,33 %	66,67 %
6,09 %	14,21 %	22,22 %	77,78 %
6,41 %	16,48 %	11,11 %	88,89 %
6,73 %	19,16 %	0,00 %	100,00 %

Table 5: Returns and standard deviation for different allocations.

The lowest standard deviation comes with approximately 80% in currency carry trading and 20% in S&P 500. The table shows that you can get a higher return and lower standard deviation with an 80/20 distribution, than with a 100/0 distribution. This is in line with the theory by Markowitz in combining assets with low correlation. We see that increasing the share of S&P 500 increases both the return and the risk. The highest return is given when S&P has a share of 100%. By investing all in S&P you miss the opportunity to lower the risk by diversification. It can here be said that the S&P 500 is an index containing 500 large companies and that it is relatively diversified. However, by including currency carry trade the portfolio can be even more diversified.

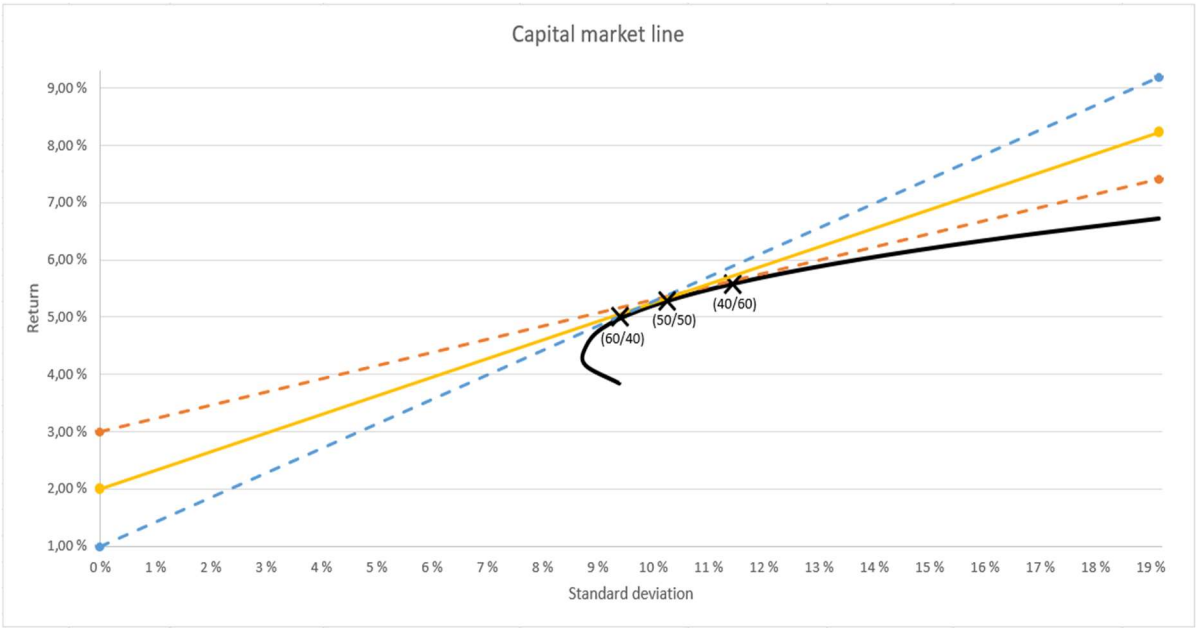


Figure 7: The efficient frontier of the G10 and S&P 500 allocation, with three different capital market lines.

Figure 7 shows the efficient front together with three capital market lines. The first capital market line is based on risk-free asset of 1% interest. This is the blue line in the diagram. The tangency point with the efficient front gives an allocation of approximately 60% in currency carry trade and 40% in S&P 500. This means that if the risk-free asset has a return of 1%, a risk-averse investor should have a distribution of 60/40. If the investor demands a higher annual return than 5%, he should borrow and place 60/40 in currency carry and S&P 500 respectively. If he on the other hand wants a lower risk, he should place some of his capital in the risk-free asset, and the rest 60/40 in currency carry trading and S&P 500.

The yellow line shows the capital market line with 2% interest for the risk-free asset. The optimal distribution is here 50/50 between currency carry trade and S&P 500. The orange/red line shows the capital market line when the risk-free interest is 3%. The optimal distribution is now 40/60. In the figure, one can see that the efficient front grows by less the higher the standard deviation gets. This means that the derivative of the function falls and gets closer to zero (but do not reach zero). It also means that an investor gets paid less for each extra unit of risk. By borrowing and investing in the portfolio distribution where the capital market line tangent the efficient front, the investor gets paid the same for each unit of risk. This can be seen by the linearity of the capital market line.

4.1.2 Emerging Markets

We did the exact same exercise with our results from the emerging markets baskets between 2005 and 2018, and the results are given in table 6. There were a couple of interesting facts to note about this. First, the correlation coefficient between the currency basket and the S&P 500 was ~0,25. This means that the EM-basket was less correlated with the S&P than the G10 basket. Secondly the returns from the EM-basket were greater than from the G10-basket. For a risk averse investor this means that a larger part of the portfolio can be invested in currency carry trading, while still earning higher returns. From Figure 8 we can see that the point of tangency between the efficient frontier and the three different capital market lines is approximately the same. The result is that the optimal portfolio for a risk averse investor combining S&P 500 and currency carry trading is investing 14% in the S&P and 86% in currency carry trading. This will result in an expected return of 6,50% with a standard deviation of 9,42%. This is almost half of the standard deviation of investing 100% in the S&P 500, but the expected return is only 0,50% lower.

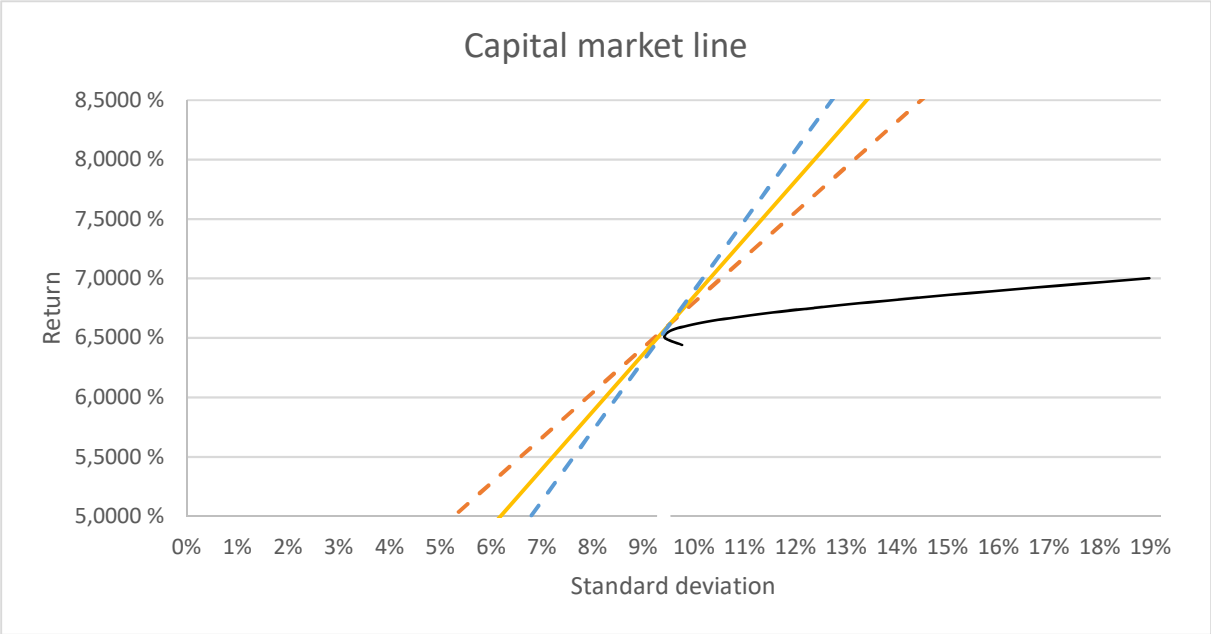


Figure 8: The efficient frontier of the EM and S&P 500 allocation, with three different capital market lines. The capital market lines colour represents the same interest as in Figure 7

Returns	Standard Deviation	% In CC (EM)	% In S&P 500
6,44 %	9,76 %	100,00 %	0,00 %
6,50 %	9,42 %	86,52 %	13,48 %
6,57 %	9,56 %	77,78 %	22,22 %
6,63 %	10,15 %	66,67 %	33,33 %
6,69 %	11,11 %	55,56 %	44,44 %
6,75 %	12,36 %	44,44 %	55,56 %
6,82 %	13,83 %	33,33 %	66,67 %
6,88 %	15,44 %	22,22 %	77,78 %
6,94 %	17,17 %	11,11 %	88,89 %
7,00 %	18,97 %	0,00 %	100,00 %

Table 6: The returns and standard deviation of different allocations between EM and the S&P 500

Our results which show that an investor can diversify a portfolio consisting of shares by including a currency carry strategy is large in line with Burnside et. Al. (2011) findings. In their study of currency carry trading they found, like we did, that currency carry trading could reduce the risk in a portfolio consisting of US shares and currency carry trading.

4.2 Challenges

One challenge we have had with our data and analysis is that we have only compared, and constructed the portfolio from, the S&P 500 and currency carry trading. In reality an investor can diversify the portfolio further by including, amongst other, other stock indexes, corporate bonds etc. Despite this, we still think our results show the effects of diversifying with the carry trade nicely. Furthermore, our portfolio has not included gearing of the positions. An investor utilising the strategy we have described above would usually use gearing to increase the returns to equity. An example of an investment strategy is to invest the portfolio's equity in stocks and bonds, and use this as security for a 100% geared investment in carry trading. NBIM (2014) has illustrated how this can increase the returns while barley increasing risk, see Figure 9. This figure shows the returns to a portfolio when the investor leverages the currency carry investment.

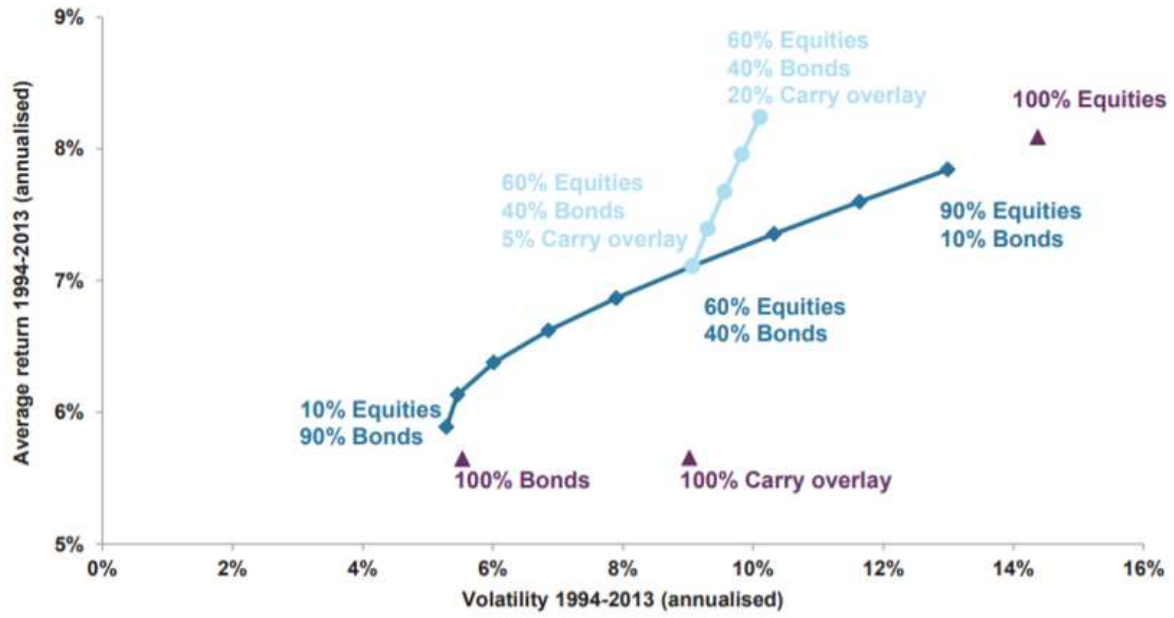


Figure 9: An illustration of how an investor can use currency carry trading and gearing to increase returns while keeping risk low. Source: NBIM (2014)

4.3 Currency Carry Trader's Risk Preferences

In the portfolio construction chapter, we have assumed that the investors are risk averse. We find this assumption natural as most large institutional investors are risk averse, and demand something in return for risk. There are no academic resources who provides a clear answer to this, bur Markovitz (1952) argues that investors should be risk averse.

4.4 G10's Subpar Returns After the Lehman Crisis

One interesting observation regarding the returns from the G10 basket is how little returns it offers after the Lehman crisis of 2007/2008. During the crisis the currency carry portfolios returns were negative, just like the stock market. The difference is that after the crisis the currency carry trade hasn't increased in value for almost ten years. One possible reason for this is that after the crisis several of the G10 currencies have had interest rates of close to zero. Because income from interest is one of the reasons currency carry trading is profitable, interest rates at zero reduce the returns to virtually zero for the trading strategy as well. It is worth noting that Burnside (2011) found that returns to currency carry trading could not be explained by the same factors that usually can explain returns in the stock market, but rather factors such as currency fluctuations. Jordà & Taylor (2012) found that negative returns from

currency carry trading could be countered by implementing a non-linear, slightly more sophisticated model than the standard model we have used in this paper.

5 Conclusion

Throughout this essay we have seen that the currency carry trading strategy has a positive expected return. Furthermore, the strategy's somewhat uncorrelated returns with the stock markets returns makes currency carry trading a valuable addition to a portfolio consisting of stocks. By including an emerging markets currency carry basket in a portfolio an investor can substantially reduce the risk exposure while keeping returns high.

While our models provide some basic concepts there are a couple of weaknesses. First of all, we have not included transaction costs. Secondly, we have only looked at the S&P 500 and not included other indexes or investment instruments. This could be something to look at in another paper in the future.

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