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Summary of Thesis:

Getting the Carry Trade's Jackpot: Finding Indicators of Carry Crash

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I. Introduction

This Working Project explores several questions related to the currency carry trade arbitrage strategy. Firstly, it is studied whether the strategy is profitable or not, especially, after the event of the 2008 global financial crisis. In order to do this, five portfolios of the G10 currencies with different weighting strategies used among literature and by practitioners are investigated. Secondly, the latest literature emphasizes the tail and downside risks intrinsic to the strategy and, thus, several measures of downside risk and, specifically, a drawdown analysis is performed. At last, the final purpose of this work is answering to the following two questions: are there any regime indicator variables that allow to consistently predicting a drawdown on the strategy? How can an investor use these regime indicators to improve his final payoff?

In the currency carry trade an investor borrows in a country with a low interest rate and invests in another with high interest rate, gaining the carry this way. Therefore, such strategy has been presenting high returns and long-run Sharp ratios over time, despite recent losses. Additionally, the most puzzling question is that it is based on an international economics' hypothesis known as the uncovered interest rate parity (UIP) which states that nominal interest rate differentials between countries have a direct relationship with market's expectations of exchange rates' changes.

In that sense, consider for instance the most popular pair for the carry trade in recent years: the Japanese yen as funding currency and the Australian dollar as investment currency. Let us consider that the yield in Australia was 6% higher than in Japan in 2007, and then the AUD/JPY spot exchange was expected to depreciate 6% over the next year. However, empirical studies starting from 1980 have consistently proven this wrong as on average the subsequent currency depreciation did not completely offset the carry from the interest rate differential. Finally, this finding is known as the "forward rate bias" as a result of the rejection of the expectations theory hypothesis.

Furthermore, when undergoing a currency carry trade it is preferable to analyze currencies exposed to a low probability of default which is a risk that an investor is usually not willing to take in this strategy. Thus, it was decided to follow the major literature in that the general approach is to use a basket of the G10 currencies. In addition, most of the studies use a timespan starting after 1973 due to the collapse of the Bretton Woods system when the major currencies began to float against each other. Hence, studies have shown that by investing in this strategy an investor can obtain high

average returns ranging from 3,96% in basic strategies to 6,60% in more complex ones, when considering a time range of 1976-2013. [1]

Therefore, in this Working Project it is intended to investigate the results of several carry trade strategies and the evolution of their performance. Additionally, it is commonly stated that the carry trade strategy was not profitable after the 2008 financial crisis. Taking this into consideration, attention is devoted to a comparison of the results between the pre- and post-crisis periods.

Moreover, after finding that UIP did not hold on average, researchers focused their attention on the risk factors explaining the currency carry trade returns. Nevertheless, returns from different carry trade strategies have hardly been explained by traditional risk factors, thus, leaving it as a puzzle. Hence, due to the long list of studies on these risk factors in the literature, it was preferred not to emphasize this aspect of the carry trade, presenting merely a short analysis of the latter.

Lately, recent studies have focused on an apparent downside of the strategy which is the negative skewness inducing large drawdowns. This pattern has been named as "up by the stairs, down by the elevator" or "picking up nickels in front of a steam roller".[2] Aiming at understanding this component of the carry trade, it was decided to dedicate one chapter to the analysis of four indicators of downside risk.

In conclusion, as these large drawdowns are related to the "carry crashes", its timing is known to be the "jackpot question of the carry trade".[3] Contrary to the investigation of risk factors explaining the carry trade returns, only a few studies explore the hypothesis of using regime indicators to improve the returns of the strategy. Thus, the present thesis' final purpose is to find the regime indicator variables which can used to forecast and avoid the strategy's drawdowns and, thus, improve the strategy's profitability.

II. The Carry Trade portfolios implementation

In this section, the notation and theoretical background that is necessary to proceed to the empirical analysis of the carry trades will be presented. Let S_t be the level of the exchange rate of dollars per unit of a foreign currency, while F_t is the forward exchange rate known today for the exchange of currencies one period-ahead. At the same time,

[1] These are the results of both the EQ and SPW weighting strategies presented in Daniel et al. (2014).
[2] Expression used by Breedon (2001) and the economist in 2007, respectively.
[3] Expression used by A. Ilmanen in his book "Expected Returns: An Investor's Guide to Harvesting Market Rewards" of 2011.

the one-period dollar interest rate is represented by $i_t^{\$}$ and let the one-period foreign currency interest rate be i_t^*.

The carry trade follows the failure of the UIP since if the exchange rate between two countries does not evaluate or depreciate in order to offset the interest rate differential between the latter there will be an arbitrage opportunity. Consider below the UIP:

$$\text{UIP: } \left(1 + i_t^{\$}\right) = \frac{E(S_{t+1})}{S_t}(1 + i_t^*) \tag{1}$$

Therefore, the typical studied strategy in the literature is the one where an investor takes a long (short) position in each currency for which the interest rate is higher (lower) than the interest rate in the United States. The dollar payoff to the carry trade in the absence of transaction costs is written as such:

$$z_{t+1} = \left[(1 + i_t^*)\frac{S_{t+1}}{S_t} - \left(1 + i_t^{\$}\right)\right] y_t \tag{2}$$

where the position the investor takes in each currency (y_t) is:

$$y_t = \begin{cases} +1 \text{ if } i_t^* > i_t^{\$} \\ -1 \text{ if } i_t^* < i_t^{\$} \end{cases} \tag{3}$$

Alternatively, an investor can enter in a carry trade strategy by borrowing or investing one dollar in the foreign currency money market. Consider that when the covered interest rate parity holds, if $i_t^* > i_t^{\$}$ then $F_t < S_t$, that is, the foreign currency is at a discount in the forward market. On the other hand, if $i_t^* < i_t^{\$}$ then $F_t > S_t$ and, thus, the foreign currency is at a premium in the forward market. Finally, the dollar payoff following this method is as it follows:

$$z_{t+1} = \left[\frac{(S_{t+1} - F_t)}{F_t} \times \left(1 + i_t^{\$}\right)\right] y_t \tag{4}$$

where the position the investor takes (y_t) is:

$$y_t = \begin{cases} +1 \text{ if } F_t < S_t \\ -1 \text{ if } F_t > S_t \end{cases} \tag{5}$$

It is worth to notice that when the covered interest parity holds and without transaction costs, both strategies for the implementation of the carry trade are exactly equivalent. If the uncovered interest rate parity holds and the forward rates are unbiased, the carry trade profits should average to zero. Still, recall that the definition of the uncovered interest rate parity ignores that the changes in the values of currencies may be exposed

to risk factors and, therefore, in this situation a risk premium is observed. Thus, the general procedure to incorporate risk aversion in arbitrage models is to examine the stochastic discount factor (SDF) or pricing kernels.

Constructing the carry trade strategies

In this part of this study it will be presented the five carry trade portfolios with different weighting strategies. Firstly, the carry trade strategies vary on the weight which is proportionated to each currency and the most popular is the equally weighted (EW) in that the weights are equal for every currency, where N is the number of available currencies at the period t:

$$w_{j,t}^{EW} = \frac{sign(i_t^j - i_t^\$)}{N} \quad (6)$$

Secondly, it is studied one carry trade strategy suggested in Daniel et al. (2014) which the authors name as speed-weighting (SPW). The idea is that "the fraction of a dollar invested in a particular currency is determined by the interest differential divided by the sum of the absolute values of the interest differentials". Therefore, this strategy privileges currencies with larger interest rates' differentials while at the same time allowing the investment to be scaled to have one dollar spread across the positons:

$$w_{j,t}^{SPW} = \frac{i_t^j - i_t^\$}{\sum_{j=1}^{N_t} |i_t^j - i_t^\$|} \quad (7)$$

Thirdly, a common strategy comes by hedging the exchange risk on the EW strategy by acquiring (selling) forward exchange rate contracts on a currency when entering a long (short) position on that currency, accordingly. In that sense, at t+1 the investor is still exposed to the currency value (S_{t+1}) but now the value he holds of the same currency is not the investment in terms of S_t but in F_t. Finally, it is important to keep in mind that for the previous three strategies in a situation where the sum of the currency weights is not equal to 0, the dollar is used to make this correction. The payoffs are as follows:

$$z_{t+1} = \left[(1 + i_t^*)\frac{S_{t+1}}{F_t} - \left(1 + i_t^\$\right)\right] y_t \quad (8)$$

Fourthly, a different approach which also proved to be highly profitable is suggested by Lustig, Roussanov and Verdelhan (2014) and is called the "dollar care trade" since "investors go long all foreign currencies when the average foreign currency trades at a forward discount and short all foreign currencies when the average foreign currency

trades is at a forward premium." Then, this position is balanced by the investment in the dollar by investing in the US interest rate. Moreover and contrarily to the remaining strategies with the intention of preserving the authors' results equation (4) is used instead of equation (2).

Fourthly, it was used the strategy presented by Antti Ilmanen in his book "Expected Returns: An Investor's Guide to Harvesting Market Rewards" of 2011 where he weights differently the positions on each currency depending on their ranking. That is, the three currencies with highest interest rate differential weight 50%, 30% and 20%, while the three currencies with the lowest will weight: -50%, -30% and -20%, accordingly. Notice however that for the periods when there is no data for 6 currencies, the weights used were 50%, 30%, and their opposites.

Final strategy payoffs using the transaction costs

In the financial world many arbitrage strategies are known for presenting high returns, however, after accounting for the costs of implementing such strategies an investor perceives that there is no arbitrage opportunity after all. Hence, the consideration of the transaction costs when analyzing the carry trades is ultimately important. In that sense, I decided to follow the approach suggested in Lustig, Roussanov, Verdelhan (2011) who use the bid and ask spread of the forward exchange rates, which is also used in Burnside et al. (2011) just with the difference that the latter does not show this construction in logarithm values.

Accordingly, in the portfolios using interest rates the investor when going long on an interest rate must pay the bid price, which is the maximum a buyer is willing to pay; while when shorting an interest rate j one receives the asked price, which is the minimum price a seller is willing to receive. On the other hand, the dollar, which will always balance the final weights, will be taken by the asked price if the foreign currency is longed and by the bid price when the foreign currency is shorted. For illustration, below I present the equation for when going long on a currency considering the hedged EW strategy:

$$z_{j,t+1} = \ln\left(1 + i_t^{j\,b}\right) + s_{t+1}^{j} - \ln\left(f_t^{j\,b}\right) - \ln\left(1 + i_t^{\$\,a}\right) w_{j,t}, \text{for } w_{j,t} > 0 \qquad (9)$$

IV. Results of the Carry Trades

In this section I will describe the results for the carry trade strategies for the period between 1976-2015 and for the period only after the 2008 crisis, which was considered to start on the day of the Chapter 11 filing by Lehman brothers in September of 2008. Furthermore, I compared the carry trade results with the performance of the US equity market.

To begin with, it is important to state that when considering the whole period all the strategies are profitable with and without transaction costs. Before transaction costs the average returns vary from 3,26% for the EW strategy to 6,90% for the dollar carry trade strategy. Moreover, the strategy with second highest returns is the rankings, which is followed by the speed-weighting and lately by the EW hedged with forward exchange rate contracts. Also, for the whole period the average returns of the market are equal to 6,27% and, thus, only the dollar carry trade had a better performance than the latter. Nevertheless, when considering the Sharpe ratio, the Market presents the worst performance with a ratio of 0,37. For the carry trades results vary from 0,97 for the EW-HF strategy to 0,53 to the EW strategy, showing the necessity of hedging the exchange rate risk.

On the other hand, when considering only the period after the 2008 financial crisis strategies lost their solid performance, since after transaction costs the EW and EW-HF strategies were no longer profitable. Additionally, the market performed much better with a Sharpe ratio of 0,51 which compares with 0,20 of the best carry trade strategy, which was the dollar carry trade.

Finally, it is important to notice that the different strategies had a very different performance over time which describes the contrasting dynamics to which they are exposed. It can be observed, however, that the SPW and rankings strategies had roughly a pegged evolution which is similar to the EW-HF portfolio. Nevertheless, the dollar carry trade and the EW portfolios seem to be exposed differently to risk. In that sense, it is highly important to evaluate the risk factors affecting the strategies which I will present in the next two sections.

V. Traditional risk factors

In opposition to many studies in the literature here it is not intended to search for an explanation to the carry trades' excess return. Therefore, I will limit the risk factors to

two: the Fama-French (1993) 3-factor model and the pure FX risk factor as proposed by Lustig, Roussanov and Verdelhan (2011). Finally, to model this exposition to the risk factors it was run a regression of the carry trade return for each strategy, Z_t over the source of risk, F_t, as it follows:

$$Z_t = \alpha + B'F_t + \varepsilon_t \quad (10)$$

Furthermore, since the risk factors are explaining the returns, the α component of the regression represents the abnormal return of the strategy, that is, the measure of the average performance of the carry trades that cannot be explained by the unconditional exposure to the risk factors included in the regression.

Equity Market Risk

In order to analyze if the returns from the carry trade strategies are explained by the equity market risk it was decided to use the three Fama-French (1993) equity market risk factors: (1) excess market return, $R_{MRP,t}$; (2) the Small-Minus-Big factor,$R_{SMB,t}$,; and (3) the High-Minus-Low factor, $R_{HML,t}$,.

As it is mostly common in the literature, it was discovered that the 3 Fama-French factors cannot explain the carry trade returns. Firstly, it is mostly relevant to notice that the alpha for every portfolio is rejected to be equal to zero with a t-statistic ranging from 3,00 to 4,89. Thereafter, as it can be observed for each strategy the t-statistic values of the factors coefficients' range from |0,01| to |0,67| and, thus, by not rejecting that these values are statistically different from zero it cannot be proved that they explain the carry trade's returns. Furthermore, the largest R^2 is equal to 0, 004. Hence, the equity risk factors do not explain the carry trade returns.

Pure FX risk factors

The two pure foreign exchange market risk factors used are proposed by Lustig, Roussanov and Verdelhan (2011) and were further used in Daniel et al. (2014) as explanations for carry trade risk. In their study, 35 currencies are sorted in six portfolios considering their interest rate differentials, given that the currencies with the highest differential are included in the same portfolios, and the opposite is also true for the currencies with the lowest differentials. Hence, from this construction they obtained two risk factors: (1) the average returns on all six currency portfolios, $R_{FX-Mean,t}$; and the difference between the returns of the portfolios 6 and 1, $R_{HML-FX,t}$. Additionally, the

authors add that the correlation of the first principal component with FX-Mean is 0,99; while the correlation of the second principal component with HML-FX is 0,94.

To begin with, for all strategies but the dollar carry trade and SPW, I obtained relatively similar results to Daniel et al. (2014) as they obtain a stronger statistical relation with the HML-FX component, with high t-statistics. Nevertheless, the most important result obtained from these regressions is to notice that it is not rejected that the constant term is equal to 0 for some strategies: EW and rankings with and without transaction costs. This suggests that the returns of these portfolios are fully driven by the HML-FX risk factor. Yet, this result is not surprising given that the construction of these strategies is similar to the carry trade strategy developed in Lustig, Roussanov, and Verdelhan (2014) while the SPW, EW-HF and dollar carry trade are not. The latter explanation is also supported in Daniel et al. (2014) while explaining the strong explanatory power of HML-FX factor. Adding to this, the regressions delivered relatively high R^2 values ranging from 0,06 for the dollar carry trade to 0,71 for the rankings strategy.

Hence, considering everything that was mentioned it is possible to state that strategies such as the equally-weighted and the rankings carry trade can be fully explained by the HML-FX factor, similarly to the authors' results.

VI. Downside risk analysis

The carry trades are known for their high returns but also for their main drawback: the downside risk. In fact a quick observation of the strategies' statistics would tell us that all have a negative skewness of -0,37; -0,27; -0,51; -0,14 and -0,70 for the EW, the SPW, the EW-HF, the dollar carry trade and ranking strategies, respectively. Therefore, all the carry trade strategies are subject to a negative tail risk. In addition, it is very important to relate these values with the ones of the excess kurtosis which were all positive. Therefore, together the results of these two statistical moments present the well-known negative tail risk of the carry trade as the returns follow a leptokurtic distribution which is also skewed to the left.

At last, one should consider that for the same period the market's returns had a much more negative skewness equal to -1,02 suggesting a much higher tail risk. It is puzzling, however, how the EW-HF strategy has a more negative skewness than its unhedged version. In order to develop a deeper study on the downside risk three different indicators will be explored: the Sortino ratio, the drawdown and the pure drawdown.

Sortino ratio

One of the most popular measures of downside risk of an investment is the Sortino ratio which follows the Sharpe ratio in that the only difference is that the former uses solely the volatility of the negative returns, while the latter uses the volatility of the entire sample. Hence, the larger the Sortino ratio the lower is the probability of a big loss.

The values for the Sortino ratio highly vary among strategies given that the highest value is for the EW-HF portfolio equal to 4,62 and the lowest is for the EW strategy equal to 2,62, when considering the values before accounting for the transaction costs. Besides, the dollar carry trade has the second highest Sortino ratio equal to 4,53 which is followed by the one of the SPW strategy of 3,08 and the one of the rankings strategy of 2,69.Still. Even though all the values decrease after considering the transaction costs, the ranking among them does not change. In addition, all the carry trade strategies have a higher ratio than the market portfolio which indicates that the latter has a higher exposure to the downside risk.

Nevertheless, when considering solely the period after the 2008 financial crisis, none of the carry trade strategies has a higher Sortino ratio than the market equal to 1,92, given that, the highest is the one of the dollar carry trade equal to 0,75. This situation is due to the lower average return of the carry trades.

Drawdown and Pure Drawdown analysis

The Sortino ratio does not answer some important questions a drawdown analysis can, such as: which strategy suffered the highest drop in value, or which strategy took more time to recover from a severe fall? In order to answer these questions it was decided to use two indicators used in Daniel et al. (2014), the drawdown and pure drawdown. The drawdown is a broadly used measure defined as the decline of an investment from its historical peak to the lowest through. This is usually measured as a percentage between the peak and through values. It can also be measured as the number of periods it took to get back to the previous peak's value. On the other hand, the pure drawdown is defined as a percentage loss from consecutive negative returns. Again one can measure the number of periods of successive losses.

This study comprises the 10 worst drawdowns and pure drawdowns for each strategy. To begin with, unless for the SPW and EW strategies which have the third and fourth strongest drawdown with maximal magnitude, all the strategies if ranked second for the

strongest drawdown of maximal magnitude also ranked second when considering the second strongest drawdown. The strategy which had the lowest value for the maximal drawdown was the EW-HF equal to 19% and followed by the dollar carry trade with a drawdown of 22%. Also, these were the shortest drawdowns among carry trade strategies lasting 46 and 59 months, respectively. Furthermore, the rankings strategy seems to be the one with higher exposition to this source of downside risk with the strongest drawdown reaching 36% and lasting 68 months. Although, the EW strongest drawdown was the longest and equal to 110 months indicating that despite having not been so strong in terms of magnitude, the strategy did not have the capacity to recover from it so fast. Lastly the strongest drawdown of the SPD was equal to 29% and lasted 58 months.

When comparing these results with the ones for the market we observe that the market has a much stronger exposure to this downside risk measure with the strongest drawdown being equal to 49% and, thus, much higher than all the carry trade strategies. However, it is interesting to notice that among the drawdowns with maximal magnitude it was the shortest lasting 40 months, suggesting that despite suffering more from large loss the market has the strongest capacity to recover from those losses.

As far as pure drawdowns are concerned when considering the one with maximal magnitude among strategies it can be observed that now the dollar carry trade is the strategy resisting more to the downside risk with a value of 9% which lasted 5 months. In second place ranks the EW-HF with a maximal pure drawdown equal to 17% which also lasted 5 months. The strategy that now seems to handle worse the downside risk is the rankings strategy with strongest pure drawdown equal to 39% during 8 months. Consecutively, the EW portfolio has again a lower pure drawdown of maximal magnitude than the SPD of 19% and 26%, accordingly, lasting both 6 months. The latter shows again the weak capacity of EW to recover despite not having the worst relative values for drawdowns and pure drawdowns.

Finally, the market's strongest pure drawdown was of 34% which is not the highest value now since the rankings strategy showed a value of 39%. It is also interesting to notice that once again the market does not stay in a negative position longer than the carry trade positions since this pure drawdown lasted solely 3 months being the shortest among the ones with maximal magnitude.

This analysis motivates the relevance of answering to the question initially asked: how can one get the timing and, therefore, hedge from these events which strongly drive returns down? In the following chapter it will be developed a study on the possible regime indicators capable of informing an investor of the time a drawdown will occur.

VIII. Regime Indicators

In his book "Expected Returns: An Investor's Guide to Harvesting Market Rewards" of 2011, Antti Ilmanen describes the problem of the carry trade as being the downside risk, which is proved by the analysis on the previous section. Furthermore, once we are studying an arbitrage strategy these drawdowns will lead to the unwinding of the carry trade positions. As far as these unwinds have been studied, historically they are known for having lasted long enough to make it possible for investors to use backward-looking indicators in the prediction of next week or next month carry trade performance.

In that sense, the mentioned author presents the possibility of using some variables that allow one investor to avoid such losses which he names as regime indicators or conditioners. The variables he presents are: overcrowded carry positions, overvalued exchange rates from high-yield currencies, rising volatility in exchange rates, tightening liquidity conditions especially in low-yielding "funding currency" currencies and the changes in the stock markets' returns for each currency. All the last indicators have also been used in other literature either by providing a signal for the carry trade positions or as risk factors for the carry trade returns. Finally, when determining to which strategy should this study be performed it was chosen the EW-HF strategy.

In order to use these indicators to provide us with the correct investing signaling it is necessary to find a threshold value that makes those indicators to drive the carry trade returns down. The insight necessary for this study is that for the different regime indicators there may be two regimes: one where the values of these indicators have a positive relationship with the carry trade returns and other where such relationship is negative. Therefore, I developed an econometric process which accounts for two phases: firstly a series of VAR models were obtained describing the relationship among each of the regime indicators and the payoffs of every currency in the carry trade strategy under analysis; and secondly after analyzing the results from the first phase, a threshold autoregressive model is run for the currencies which had statistically and economically significant coefficients.

However, the results for the econometric regressions did not allow for obtaining a threshold for the considered variables. Therefore, it was decided to consider an exogenous threshold specific to each variable with two different methods: firstly, the regime indicator indicates the weight on this currency to stop: “stop-loss discipline”; secondly, the position on the weight is reversed.

Taking into consideration these exogenous thresholds for the whole period under analysis, the real exchange rate, the liquidity conditions and the volatility when used individually as regime indicators with a stop-loss procedure improved the average returns by 0,29%, 0,06% and 0,37%, respectively. Moreover, when considering solely the period after the 2008 financial crisis all the regime indicators, except the one using the volatility of the spot exchange rates while reversing the weights, improved the strategy’s average returns. Additionally, during the same period the one which increased the average returns the most was the equity markets’ regime indicator considering a stop-loss procedure, increasing the EW-HF portfolio returns from 0,37% to 3,03%, before transaction costs.

In the end, I decided to use the three indicators which increased the average returns during the entire period of analysis at the same time. Therefore, the average returns of the EW-HF strategy increased from 4,99% to 5,71% and from 4,12% to 4,88% before and after transaction costs, respectively. It is even more interesting to notice that considering the period after the 2008 financial crisis the average returns after transaction costs became positive increasing from -0,25% to 0,69%. Moreover, as far as the downside risk is concerned and considering the whole period, when using these three regime indicators at the same time the Sortino ratio increased from 4,62 to 5,30 before transaction costs. Also, without accounting for the transaction costs the drawdowns and pure drawdowns decreased from 19% to 17% and 17% to 12%, correspondingly. Although, it was noticed that the strongest drawdown for this strategy was felt on a different period than the EW-HF strategy, which resulted in the fact that it increased the second strongest drawdown from 10% to 16% lasting also 6 months more. This situation describes one of the risks of using the regime indicators mentioned by Antti Ilmanen which is that despite increasing the profitability of the carry trades on average, they can also give false alarm signs such as this one and drive returns down.

VIII. Conclusions

This Working Project provides a review on five different carry trade strategies never analyzed together in the literature. Similarly to Daniel et al. (2014), I conclude that the basic equally weighted carry trade shows the lowest average returns among strategies equal to 3,26% before accounting for transaction costs. Hedging the exchange rate risk of this strategy by purchasing/selling forward contracts on exchange rates increases the profitability of the strategy to 4,99%. More complex strategies such as the speed-weighting and rankings lead to higher average returns of 5,28% and 5,49%, respectively. For the considered time span of 1976-2015 the most profitable portfolio with corresponding average returns of 6,90% was the dollar carry trade which has a higher exposure to the dollar. Only the latter presents higher average returns than the US market, 6,27%, however, all present a higher Sharpe ratio. Another important remark from this Working Project is to notice that despite carry trades having lost their high-profit profile exhibited from the beginning of the 2000's until the global financial crisis, they are still profitable after transaction costs. Three of the five considered strategies had positive returns with the dollar carry trade portfolio achieving the highest average return of 2,27%.

As far as the risks of the carry trades are concerned I obtained similar results to the literature. First, for all the five strategies I find the commonly stated result that the Fama-French (1993) three equity market risk factors are not able to explain the carry trades' returns. The second finding is also in accordance with the literature when considering the Pure FX risk factors presented in Lustig, Roussanov and Verdelhan (2011). It was obtained that three of the five portfolios can be explained by the HML-FX factor which is a carry trade return obtained from a very broad set of currencies. Additionally, some strategies that have a more similar construction to the portfolios presented by the latter authors seem to be fully driven by the same risk factors: the equally-weighted and the rankings carry trade without and without transaction costs.

I also do an analysis of the strategies' downside risk and conclude that different measures indicate contrasting results on which portfolio is less exposed to this source of risk. Nevertheless, it is interesting to notice that the dollar carry trade, which presented the highest average returns, is the strategy which had highest values for the Sortino ratio, as well as, lower Drawdowns and Pure Drawdowns together with the portfolio of

equally weighted hedged with forward exchange rate contracts. Furthermore, the market presented the worst statistics when compared with the five carry trade portfolios.

Another novelty I developed is the study of the regime indicators predicting carry crashes and, therefore, enhancing average returns in the equally weighted strategy hedged by forward exchange rate contracts. Considering a two-step process using first a Vector Autoregressive model with currencies and risk factors and; secondly a Threshold Regression model with the statistically and economically significant variables, no thresholds for any of the five regime indicators were found. Nevertheless, when defining specific thresholds for each variable as to stop the use of a currency or to reverse the position on the latter I obtained promising results. Firstly, I discovered that when considering the entire period from 1976-2015 the real exchange rate of high-yield currencies, the liquidity conditions of "funding currencies" and the volatility of the spot exchange rates when used together and with a stop-loss discipline increase the average returns from 4,99% to 5,71%. Secondly, using these regime indicators allowed the strategy to have positive average returns after accounting for the transaction costs in the period after the 2008 financial crisis of 0,69%, compared with the -0,25% when not using the regime indicators. Besides, for the same period when using equity markets' returns as regime indicator with a stop-loss discipline allowed the strategy to present higher average returns than the dollar carry trade portfolio of 3,03% comparing with the 2,27% of the latter, before accounting for the transaction costs.

Finally, I realized that when using regime indicators the drawdowns and pure drawdowns were reduced on average, however, during 05/1985 and 01/1989 the drawdown for the strategy increased from 10% to 16% and lasted one more month. This result shows the main problem of using regime indicators which is the fact that despite on average improving the portfolios performance it can also induce false alarms leading to non-robust results. A possible explanation for this event is the choice of methodology when applying the thresholds. Therefore, it is recommended that further research is taken on the appropriate econometric models to use when of applying regime switches. It is for that matter advised to use a rolling-windows process due to the broad differences of the carry trades' profitability over time, alongside the development of a more complex T-VAR model. In conclusion, it is clear that even after the instable period after the 2008 financial crisis it is still possible to profit from this market inefficiency and the use of regime indicators enhance the strategy's profitability.