Trading Foreign Exchange Portfolios with Volatility Filters: The Carry Model Revisited

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Abstract

The rejection of the simple risk-neutral efficient market hypothesis in the foreign exchange (FX) market opens the possibility of the profitable use of a carry model taking full advantage of interest rate differentials to trade currencies. A first motivation for this paper is to study whether a simple passive carry model can outperform a typical currency fund manager replicated by dynamic technical Moving Average Convergence and Divergence (MACD) models as in Lequeux and Acar (1998). Secondly, we study whether the addition of volatility filters can further improve the carry model performance.

We consider the period starting from the introduction of the Euro (EUR) on 04/01/1999 through 31/03/2005 (1620 datapoints). To assess the consistency of the carry model performance on a portfolio of the nine most heavily traded exchange rates, the whole review period is further split into two sub-periods. Our results show that in the three periods considered and after inclusion of transaction costs, the simple carry model performs much better than the benchmark MACD model in terms of annualised return, risk-adjusted return and maximum potential loss, while a combined carry/MACD model has the lowest trading volatility. Moreover, the addition of two volatility filters adds significant value to the performance of the three models studied.

Keywords: carry model, currency management, active trading, confirmation filter, interest rate parity, volatility filter.

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1. Introduction

Under the simple risk-neutral efficient market hypothesis, the forward rate is the best unbiased forecast of the future spot rate and equivalently the forward premium (resp. discount) is the optimal predictor of a currency appreciation (resp. depreciation). Numerous articles have tested this hypothesis and there is now a wide consensus that the simple risk-neutral efficient market hypothesis can be rejected (see, for instance, Clarida and Taylor 1997). Yet a parallel finding in the foreign exchange (FX) literature is that empirical exchange rate models cannot outperform a simple random walk forecast (see, for instance, Meese and Rogoff 1983a, b).

If the actual exchange rate change is not equal to the interest rate differential as suggested by the simple risk-neutral efficient market hypothesis, and the future spot exchange rates are not forecastable, a simple trading strategy would therefore be just to take advantage of interest rate differentials. Largely known (and implemented) as 'carry trading' by currency fund managers, this carry strategy entails to always hold the high yield currency and short the corresponding low yield currency in a currency pair.

The motivation for this paper is thus twofold. Firstly, we study whether a simple passive carry model (i.e. where new positions are solely triggered by reversals in interest rate differentials) can effectively outperform a typical currency fund manager replicated by dynamic Moving Average Convergence and Divergence (henceforth MACD) models as in Lequeux and Acar (1998). Moreover, we combine the passive carry model with dynamic MACD models, where the latter operate as a confirmation filter to the former, with an attempt to further enhance performance measures.

Secondly, following Dunis and Miao (2005) who find that volatility confirmation filters can improve performance of MACD models which perform poorly in times of volatile markets, we study whether the addition of such volatility filters can help to improve the carry model performance. Two volatility filters are proposed, namely a 'no-trade' filter where all market positions are closed in volatile periods, and a 'reverse' filter where signals from a simple model are reversed if market volatility is higher than a given threshold.

Our results show that in all the 3 periods considered, when taking transaction costs into account, the simple carry model performs much better than the benchmark MACD model in terms of annualised return, information ratio (a risk-adjusted return measure given by the ratio of annualised return by annualised volatility) and maximum drawdown (a measure of downside risk showing the maximum cumulative loss that could have been incurred on a portfolio), while the combined carry/MACD model has the lowest trading volatility. Moreover, the addition of the two volatility filters suggested adds significant value to the performance of the three models studied.

The paper is organized as follows: section 2 briefly reviews the relevant literature, section 3 describes the data used and the FX portfolio formed, and section 4 documents the carry model and the volatility filters retained. Section 5 presents the empirical results, focusing on the models performance during different periods, and is followed by concluding remarks in section 6.

2. Literature Review

Whether the forward exchange rate is an optimal forecast of the future spot exchange rate is a longstanding question in international finance. In his seminal paper on exchange rate theory, Frenkel (1976) notes that ‘the fundamental relationship that is used in deriving the market measure of inflationary expectations relies on the interest parity theory [which] maintains that in equilibrium the premium (or discount) on a forward contract for foreign exchange for a given maturity is (approximately) related to the interest rate differential. […] The variations of the forward premium on foreign exchange […] may be viewed as a measure of the variations in the expected rate of inflation (as well as the expected rate of change of the exchange rate)’ (p. 210). Amongst others, Frenkel and Johnson (1978) find empirical evidence that this parity holds. Yet, numerous articles have since shown that the forward rate is not an optimal predictor of the future spot exchange rate (see, for instance, Frankel 1980, Bilson 1981 and Taylor 1995). Though rejecting the simple risk-neutral efficient market hypothesis, more recent studies such as Clarida and Taylor (1997) suggest that the term structure of forward premia contains valuable information for forecasting future spot exchange rates.

The predictability of exchange rates has also been the main focus of financial forecasting. So far, a large consensus in the academic literature suggests that exchange rate models cannot outperform a random walk forecast (Clarida *et al.* 2003). For instance, Meese and Rogoff (1983a, b) have clearly shown that predictions of a simple random walk dominate those of standard empirical exchange rate models. Allowing nonlinearity in the exchange rate, Engle and Hamilton (1990) find that out-of-sample forecasts from their segmented-trend models underperform the random walk with drift.

This may not mean that small pockets of predictability cannot be extracted successfully with the proper technical tools. Noting that market volatility has an impact on trading, and models like trend-following systems tend to perform poorly when markets become volatile, Roche and Rockinger (2003) explain that high volatility periods often correlate with periods when prices change direction, and therefore propose a successful volatility filter to reverse the technical trading signals generated when market volatility is high. Dunis and Chen (2005) argue that MACD models perform poorly in volatile markets precisely because volatile markets imply frequent direction changes, thus proposing to stop trading at times of high volatility. Our paper relates to this body of literature in the context of the highly liquid FX markets.

3. Data and Benchmark FX Portfolio

The entire sample period covers from the introduction of the EUR on 04/01/1999 to 31/03/2005 when all existing positions were closed (1620 daily observations). The exchange rates and 1-month interest rates used in this research are daily closing prices obtained from Datastream. To measure the consistency of performance, we split the entire sample period into three periods: the full 6-year period (04/01/1999-31/03/2005), the last 4-year period (02/01/2001-31/03/2005) and the last 2-year period (02/01/2003-31/03/2005).

The daily currency returns r for time period t+1 are calculated as the percentage change of the daily exhange rate p:

$$r_{t+1} = (p_{t+1} - p_t) / p_t$$

Lequeux and Acar (1998) introduce a dynamic currency index (AFX index) to replicate the performance of typical currency fund managers. The index consists of 7 currency futures rates using 3 simple MACD strategies (namely 1 and 32-day, 1 and 61-day and 1 and 117-day) with each MACD taking the same weight in generating trading signals. They found that the AFX index has a high correlation and low tracking error with the performance of typical currency fund managers. Following the same MACD combination strategy, we form our benchmark FX portfolio using currency spot rates since trading volumes in the FX spot market are much higher than those in the futures market. We also expand the portfolio composition to include the 9 most heavily traded major exchange rates according to the recent BIS FX trading survey[1] (they represent over 78% of the USD 1.8 trillion daily FX turnover reported for April 2004) and update the portfolio-weighting scheme using the data from this survey (BIS 2004). Both the asset combination and weights of the FX portfolio are shown in table 1 below.

Table 1 Benchmark FX portfolio allocation

Currency	EUR /USD	USD /JPY	GBP /USD	USD /CHF	USD /CAD	AUD /USD	EUR /GPB	EUR /JPY	EUR /CHF
Weights	35.76%	21.13%	17.49%	5.57%	5.07%	6.42%	3.07%	3.64%	1.85%

4. Carry Model, Conditional Volatility and Filter Rules

4.1 Carry Model

The trading strategy for a carry model is to go long in the high yield currency and to short in the low yield currency. For example, following a simple carry model, investors will be long the EUR/USD rate (i.e. long EUR and short USD) if the EUR interest rate is higher than the corresponding USD interest rate, and short the EUR/USD rate if the USD interest rate is higher.

The carry model generates trading signals solely depending on the corresponding interest rate differentials, which do not change very often. The downside of such a passive trading strategy is that it ignores all other current market information, which can possibly result in intolerable drawdowns. As a matter of fact, all major currency market players watch the market closely and trade actively. Therefore we propose a combined carry/MACD strategy where the MACD combinations retained function as confirmation filters to the carry model signals. We use the symbol $S_{n\,(t+1,t)}$ to denote the trading signals from a specific model at time t for time t+1, where the subscript n points to a given model: n takes the value of 1 for the benchmark MACD model, it takes the value of 2 for the carry model, and 3 for the combined carry/MACD model, so the trading strategy for a carry/MACD model is defined as[2]:

$$S_{3\,(t+1,t)} = \begin{cases} S_{2\,(t+1,t)} & \text{if} \quad S_{1\,(t+1,t)} * S_{2\,(t+1,t)} > 0 \\ 0 & \text{if} \quad S_{1\,(t+1,t)} * S_{2\,(t+1,t)} <= 0 \end{cases}$$

[1] We use the notation of the International Organisation for Standardisation (IOS) for all the exchange rates and interest rates considered.

[2] Note that the combined MACD signal S_1 is either long (+1) or short (-1), while the carry signal S_2 is either long (+1), short (-1) or square (0) in the case where both interest rates are equal.

4.2 Conditional Market Volatility

In this study, we use the time-varying RiskMetrics volatility model to measure conditional market volatility and different trading decisions are adopted when a given level of conditional volatility has been breached. RiskMetrics was developed by JP Morgan (1994) for the measurement, management and control of market risks in its trading, arbitrage and own investment account activities. RiskMetrics volatility can be seen as a special case of the GARCH model of Bollerslev (1986) with pre-determined decay parameters, and it is calculated using the following formula:

$$\sigma^2{}_{(t+1/t)} = \mu * \sigma^2{}_{(t/t-1)} + (1-\mu) * r^2{}_{(t)}$$

where σ^2 is the volatility forecast of a specific asset, r^2 is the squared return of that asset, and μ = 0.94 for daily data as computed in JP Morgan (1994).

Dunis and Miao (2005) find that MACD models produce negative returns most of the time when the underlying market volatility is high. We study whether the performance of the carry model is also affected by market volatilities. The entire sample period is split into 6 volatility regimes, ranging from periods with extremely low volatility to periods experiencing extremely high volatility[3]. The performance of the carry model for different volatility regimes is given in table 2 below for the 9 currency markets under review, in terms of average daily returns.

While the carry model performs reasonably well overall when FX markets are stable, it performs poorly, except for the USD/JPY, when underlying market volatility is extremely high. It also produces more negative returns for most of the markets when volatility is classified as 'medium high' compared with more tranquil periods, thus confirming the findings of Dunis and Miao (2005).

Table 2 Average daily returns of the carry model in periods of different volatility regimes (04/01/1999 – 31/03/2005)

	Extremely Low Vol.	Medium Low Vol.	Lower Low Vol.	Lower High Vol.	Medium High Vol.	Extremely High Vol.
EUR/USD	0.015%	0.025%	0.038%	0.113%	0.007%	-0.101%
USD/JPY	0.030%	0.013%	0.002%	-0.010%	-0.040%	0.010%
GBP/USD	0.021%	0.073%	-0.005%	0.011%	0.029%	-0.042%
USD/CHF	-0.062%	0.003%	0.004%	0.010%	-0.038%	-0.003%
USD/CAD	0.012%	-0.009%	0.018%	0.044%	0.001%	-0.030%
AUD/USD	-0.032%	0.036%	0.037%	0.075%	-0.015%	-0.053%
EUR/GPB	0.060%	0.003%	0.022%	-0.021%	0.026%	-0.115%
EUR/JPY	0.056%	0.038%	-0.038%	0.028%	0.012%	-0.018%
EUR/CHF	0.025%	-0.012%	0.004%	0.002%	-0.021%	-0.005%

[3] Periods with different volatility levels are classified in the following way: we first calculate the rolling historical average volatility and its 'volatility' (measured in terms of standard deviation σ), those periods with volatility forecasts between the average volatility (Avg. Vol.) and average plus one σ of the volatility (Avg. Vol + 1 σ) are classified as 'Lower High Vol. Periods'. Similarly, 'Medium High Vol.' (between Avg. Vol. + 1σ and Avg. Vol. + 2σ) and 'Extremely High Vol.' (above Avg. Vol. + 2σ) periods can be defined. Periods with low volatility are also defined following the same 1σ and 2σ approach, but with a minus sign.

4.3 Volatility Filter Rules

As both the MACD and carry models behave differently in highly volatile markets, a different strategy needs to be adopted when the volatility regime changes. Again, we use the symbol $S_n^{(p)}{}_{(t+1,t)}$ to denote the trading signals from a specific model at time t for time t+1, where the superscript p is the volatility filter imposed on that particular model n: p takes the value of 0 if there is no volatility filter, it takes the value of 1 when the 'no-trade' filter is used and 2 when a 'reverse' filter is implemented.

4.3.1 'No-trade' Strategy

Since both the MACD and carry models tend to perform poorly in volatile markets, following Dunis and Chen (2005), the first filter rule is to stay out of the market when the underlying volatility is forecast to be higher than a certain threshold T. A simple trading rule combined with a 'no-trade' filter can be expressed as:

$$S_n^{(1)}{}_{(t+1,t)} = \begin{cases} S_n^{(0)}{}_{(t+1,t)} & \text{if} \quad \sigma^2_{(t+1,t)} < T \\ 0 & \text{if} \quad \sigma^2_{(t+1,t)} > T \end{cases}$$

4.3.2 'Reverse' Strategy

Dunis and Miao (2005) find that returns generated from MACD signals become negative most of the time when a market experiences high volatility. We also found in section 4.2 above that the carry model performs very poorly under extremely high volatility conditions. Roche and Rockinger (2003) explain that high volatility periods often correlate with periods when prices change direction, and therefore propose to reverse the signals generated when market volatility is forecast to be higher than a chosen threshold. We use this strategy as the second filter superimposed on the original models:

$$S_n^{(2)}{}_{(t+1,t)} = \begin{cases} S_n^{(0)}{}_{(t+1,t)} & \text{if} \quad \sigma^2_{(t+1,t)} < T \\ -\left(S_n^{(0)}{}_{(t+1,t)}\right) & \text{if} \quad \sigma^2_{(t+1,t)} > T \end{cases}$$

5. Empirical Results

Both the benchmark MACD and the combined carry/MACD models generate more trading signals than the passive carry model, so a performance comparison can reach biased results without taking account of the transaction costs incurred. In this study, we follow Lequeux and Acar (1998) to set the transaction cost as 0.03% per round-trip transaction for all exchange rates in the portfolio. Traditional performance measures after the deduction of transaction costs are shown in table 3. It should be noted that in this article, all currency returns are exclusive of interest rate gains generated by holding a specific currency: including such interest rates gains would obviously further enhance the model performances displayed in table 3. Such effects can be more significant in the case of a simple carry model, which always holds a high yield currency. For instance, trading EUR/USD with the simple carry model, the annualised return for the whole 6-year period is 14.78% inclusive

Table 3 Models performance measures

Strategy #1

Benchmark MACD Model	**Without Filter**			**No-Trade Filter**			**Reverse Filter**		
	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03
Performance Statistics	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05
	6-Year	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*
Annualised Net Return	0.36%	-1.07%	-1.06%	1.81%	1.15%	0.62%	3.04%	3.16%	2.04%
Annualised Net Volatility	5.41%	5.37%	5.50%	4.68%	4.62%	4.65%	4.85%	4.75%	4.82%
Net Information Ratio	0.07	-0.20	-0.19	0.39	0.25	0.13	0.63	0.66	0.42
Maximum Drawdown	-14.20%	-14.20%	-14.20%	-10.62%	-10.62%	-10.62%	-9.50%	-9.50%	-9.50%

Strategy #2

Carry Model	**Without Filter**			**No-Trade Filter**			**Reverse Filter**		
	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03
Performance Statistics	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05
	6-Year	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*
Annualised Net Return	5.03%	5.40%	5.02%	5.86%	6.34%	6.42%	6.70%	7.27%	7.82%
Annualised Net Volatility	4.83%	4.35%	4.53%	4.28%	3.93%	3.97%	4.70%	4.44%	4.55%
Net Information Ratio	1.04	1.24	1.11	1.37	1.61	1.62	1.43	1.64	1.72
Maximum Drawdown	-7.26%	-5.05%	-5.05%	-6.37%	-4.22%	-4.22%	-5.51%	-3.81%	-3.81%

Strategy #3

Combined Carry/MACD Model	**Without Filter**			**No-Trade Filter**			**Reverse Filter**		
	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03	02/01/99	02/01/01	02/01/03
Performance Statistics	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05	31/03/05
	6-Year	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*	*6-Year*	*4-Year*	*2-Year*
Annualised Net Return	3.39%	2.45%	2.22%	4.07%	3.76%	3.06%	5.63%	5.92%	5.39%
Annualised Net Volatility	4.28%	4.00%	4.09%	3.65%	3.41%	3.43%	3.98%	3.74%	3.70%
Net Information Ratio	0.79	0.61	0.54	1.12	1.10	0.89	1.41	1.58	1.46
Maximum Drawdown	-7.45%	-7.45%	-7.45%	-4.28%	-4.28%	-4.28%	-3.87%	-3.71%	-3.71%

of interest rate gains compared to 10.88% exclusive of those gains. The risk-adjusted information ratio is 1.49 for the former compared with 1.09 for the latter.

For the three periods and the three basic trading strategies considered, the simple carry model performs much better than the averaged performance of currency fund managers replicated by the benchmark MACD models. Compared to the MACD benchmark, the carry model not only generates higher returns, but also it reduces the investment risk with lower trading volatility and maximum drawdowns. As expected, the combined carry/MACD model, by generating more active trading signals further reduces investment volatility consistently across the different periods. Overall the carry model significantly outperforms the other two models in terms of annualised return and risk-adjusted information ratio.

For each trading strategy, the addition of the two volatility filters further enhances the performance of the three models. As far as the two filters are concerned, the ‘reverse’ filter strategy performs better than the ‘no-trade’ filter strategy in terms of annualised return, information ratio and maximum drawdown, while, not surprsingly, the ‘no-trade’ filter strategy prevails in terms of trading volatility. It is hard to select a real ‘winning’ volatility filter: on the one hand, the ‘no-trade’ strategy enables investors to free funds out of a volatile FX market into other less turbulent financial markets which might further increase overall returns and reduce risk; on the other hand, the ‘reverse’ filter strategy delivers higher returns that can only be met by the ‘no-trade’ strategy in FX markets by the application of leverage with the associated higher transaction costs. It is therefore up to investors to choose the right strategy based on their risk tolerance and investment universe in terms of asset classes. But it is obvious from this research that markets behave differently at high volatility levels and adaptive strategies like the ones suggested here must be adopted during those periods.

What is more, the risk-adjusted information ratios obtained from strategies using the filters proposed are also high in absolute terms, which suggests that the performance results obtained with the volatility filters are not only good when compared to the FX portfolio without filters, they are also attractive as such and actionable in a trading environment.

6. Concluding Remarks

The first motivation for this paper was to study whether a simple passive carry model can outperform typical currency fund managers as replicated by dynamic MACD models following Lequeux and Acar (1998). Our results show that, for the full 6-year period and the 2 sub-periods considered and for the 9 most heavily traded exchange rates, the simple carry model performs significantly better than the benchmark MACD model in terms of annualised return, annualised volatility, information ratio and maximum drawdown. Our empirical findings confirm previous results from the literature that reject the simple risk-neutral efficient market hypothesis that the forward premium/discount is an optimal predictor of future exchange rate appreciation/depreciation.

Our results also show that a carry model performs poorly when market volatility is high and model performances are significantly enhanced with the addition of volatility filters either to close market positions in volatile periods (with a ‘no-trade’ filter), or to reverse the original trading signals if market volatility is higher than a given threshold (with a ‘reverse’ filter).

While it is difficult to distinguish which volatility filter is superior to the other, the information ratios obtained from trading strategies using either filter are high, suggesting that such strategies are indeed attractive and actionable in a trading environment.

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