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Artificial Neural Network Decision Support for Carry Trades

Prüfer: Prof. Dr. Michael H. Breitner



vorgelegt von:

Name:

Christopher Koch



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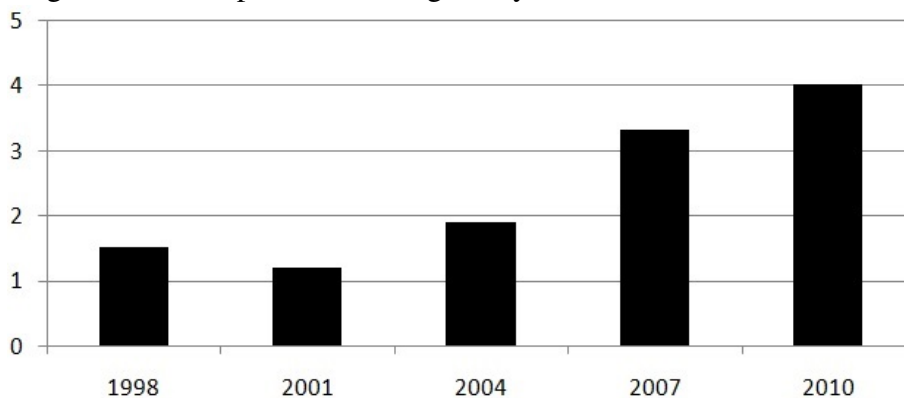
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1 Introduction

In the world of international financial markets the foreign exchange market (fx market or forex) plays an important role for several reasons. For instance, the increased average daily turnover over the past years gives an idea of the enhanced relevance of the market where currencies are traded and is illustrated by Figure 1. With a daily average turnover of almost 4 trillion USD in 2010, the fx market is considered the largest and most liquid financial market in the world.¹ The market is composed of different

Figure 1: Development of average daily FX Turnover in trillion USD



Own illustration based on Bank for International Settlements (2010), p.7.

kinds of transactions. In its "Report on global foreign exchange market activity in 2010" the Bank of International Settlements names four main categories. These are spot transactions, forwards, swaps and options. In 2010, swaps and spot transactions were the most important according to their share of average daily turnover of 45.42% and 37.43% respectively.² Various market participants like institutional investors, central and commercial banks, retail investors, hedge funds, companies and so on enter the market with different intentions, for example the hedging of cash flows that result from international business activities or to accomplish monetary policy actions in the case of central banks. Another reason for acting in the fx market is just to earn speculative profits.³ In the literature there exist some different speculative currency strategies. One of the oldest and most popular is the carry trade.⁴ It is characterized by borrowing funds in a currency that yields low interest rates (funding currency) and to invest these funds in another currency with higher interest yielding assets (target currency). Hence,

¹See Bank for International Settlements (2010), p.7 and Lequeux/Acar (1998), p.312.

²Bank for International Settlements (2010), p.7.

³Bertolini (2011), p.1.

⁴Burnside et al. (2008), p.853.

the carry trade aims to earn the interest difference between the high and low interest yielding currency, the interest differential.⁵ This currency speculation seems to be worth looking at, because it is often associated with relatively high returns.⁶ *”This strategy has received a great deal of attention in the academic literature as researchers struggle to explain its apparent profitability”*.^{7,8} Taking for example the DB G10 Currency Harvest Index of Deutsche Bank, which tracks a classical carry trade portfolio from a pool of ten industrialized countries’ currencies which are exactly the currencies that are used later on in the master thesis, this index yielded an annual return of 9.96%, 22.09% and 10.48% in 2007, 2009 and 2012 respectively.⁹

More in detail, returns to carry trades consist of two components: on the one hand the difference between the high interest and low interest rate and on the other hand the exchange rate return of the corresponding currency pair.¹⁰ Since interest rates are known ex-ante the only uncertain component of carry trade returns remains the exchange rate return. Thus, it seems reasonable to use instruments that might handle this uncertainty. Thereby, anticipating exchange rate movements through forecasting currency returns could provide one opportunity in doing so. However several influences concern the movement of exchange rates. For example political factors, macroeconomic aspects like interest rates, growth and inflation as well as psychological factors because speculation plays a major role in the foreign exchange market. The efficient market hypothesis assumes financial markets to be efficient, resulting in the immediate incorporation of all available information in current prices. However, in the real world economy price adjustments do not necessarily happen right away. Taken together, all these factors do not make an anticipation or even prediction of exchange rates easy.¹¹ Meese and Rogoff (1983) found that the movement of exchange rates of main countries can be well described by a random walk whereas benchmark models like univariate time series models or vector autoregression performed worse.¹² Also Mussa (1979) and Hsieh (1989) mention that spot exchange rates more or less follow a random walk.¹³ In

⁵Galati et al. (2007), p.28.

⁶See for example Pukthuanthong/Thomas/Bazan (2007), Menkhoff et al. (2012), Ça?layan/Pintér (2012).

⁷Burnside et al. (2008), p.853.

⁸It would be interesting to present numbers about the volume of carry trade activities for instance on basis of currency pairs or countries. Unfortunately, data to evaluate the dispersion of carry trade activity simply do not exist since possible measures do not allow the clear breakdown of forex transactions into carry trade transactions and other investment transactions. Thus only vague conclusions are possible. See Curcuru/Vega/Hoek (2010), p.436.

⁹Invesco Powers Shares (2013), pp.1-2.

¹⁰Burnside et al. (2008), p.856.

¹¹Dunis/Williams (2002), p.2.

¹²Meese/Rogoff (1983), p.21.

¹³See Mussa (1979), p.10. and Hsieh (1989), p.339.

that case, an unpredictability of foreign exchange rates would be the consequence.¹⁴ Furthermore, problems arise since inherent processes of price movements are not fully clear and exchange rate data often show non-linear structures, for which reason the use of linear forecasting approaches might be problematic.¹⁵

Bearing these problems in mind, the application of neural networks for forecasting purposes of time series data has received quite a lot of attention in financial literature. Already in 1996 Wong/Bodnovich/Selvi provided a literature overview concerning the business applications of neural networks. They report on 203 articles from 1988 until 1995 that consider the use of neural nets in a business setting, of which approximately one quarter had a financial background.¹⁶ Neural networks have the advantage that they may overcome the above mentioned problem of generating sufficient predictions of foreign exchange data since they provide a useful instrument to replicate non-linear input-output relationships and do not require any presumption about distribution of the data set under consideration.¹⁷ Further, the use of neural networks does not need any considerations about an elementary model that might explain the underlying process in the data.¹⁸ Going back to the carry trade, another feature is that it is often associated with worse performance in times of high exchange rate volatility. For instance, Menkhoff et al. (2012) found a negative comovement of high interest yielding currencies and fx volatility innovations, meaning that when fx volatility increases the currency to go long in a carry trade decreases, resulting in a negative return.¹⁹ Also Dunis/Miao (2007) report that their carry model yields worse performance when fx volatility is high.²⁰ For example, in the subprime crisis of 2008 the aforementioned DB G10 Currency Harvest Fund yielded a return of -27.81%.²¹ To take this into account, filter methodologies can be applied that give signals when volatility is sufficiently high with the purpose of leaving the market at that time.²²

As has just been mentioned both the carry trade and forecasts using artificial neural networks are generally associated with good performance. Thus, motivation for this master thesis arises from combining these two considerations with the purpose of further enhancing returns from carry speculation in the forex market. Therefore, the thesis continues with a literature review where various studies on the one hand concerning

¹⁴See Engel/West (2004), p.3 and Fama (1965), p.34.

¹⁵Dunis/Williams (2002), p.2.

¹⁶Wong/Bodnovich/Selvi (1996), p.303.

¹⁷Lisi/Schiavo (1999). pp.88-89.

¹⁸Wu (1995), p.434.

¹⁹Menkhoff et al. (2012), p.712.

²⁰Dunis/Miao (2007), p.252.

²¹Invesco Powers Shares (2013), p.2.

²²See for example Dunis/Miao (2007)

profits resulting from carry trading and on the other hand with respect to the prediction performance of neural nets are introduced. After that, carry trade returns are considered from a theoretical point of view where uncovered interest rate parity plays a major role. Subsequently, the underlying currency return time series data set is introduced and statistical tests and necessary preprocessing steps are undertaken as well as summary statistics presented. Afterwards, a brief introduction to the topic of neural networks is given and the concrete forecast of the eighteen currency pairs with the neural network software FAUN is done followed by the benchmark model predictions. In section six, the construction of the carry trade portfolio and the trading strategies with the application of the forecasts are explained in detail. The volatility filter is introduced in section seven. Next, evaluation criteria are established and both forecasting accuracy as well as trading performance is appraised based on these criteria. At the end, limitations are presented and finally conclusions and an outlook concerning future research are given. All in all, the master thesis aims to answer the question of whether carry trade profitability can be increased when the concrete position setting is guided by foreign exchange rate return forecasts that are generated with neural networks and thus whether artificial neural networks can give successful decision support for the carry trade.

2 Literature Review

Literature was reviewed with the focus on carry trade profitability, forecasting performance of neural networks and trading performance impacts of volatility filters. It is structured chronologically and does not claim completeness.

Carry trading has received much attention in the finance literature during the past years. Dunis and Miao (2007) considered a carry trading strategy for a portfolio consisting of nine currency pairs from developed countries. The underlying currency data are from the period between January 4th, 1999 and March 31st, 2005 resulting in 1620 observations of daily exchange rate returns.²³ After correcting for transaction costs they report for two, four and six year period annualized returns between 5.02% and 5.40%. After considering risk aspects they report information ratios between 1.04 and 1.24.²⁴

In another study in 2007, Pukthuanthong, Thomas and Bazan simulated the trading of two carry trade portfolios differing in the way resources were allocated. They examined

²³Dunis/Miao (2007), p.251.

²⁴Dunis/Miao (2007), p.253.

in a differentiated way because the studies differ with respect to input data, period, portfolio formation and possible rebalancing, neural network structure, forecasting horizons and so on. But especially none of the studies exactly trades the carry trade guided by neural network predictions of currency returns. Therefore, the literature review more or less has the purpose of illustrating how the profitability of carry trades and the forecasting performance of artificial neural networks are generally assessed from a researcher's point of view.

Lastly, no evaluation is made on whether returns are significant. The reason is that this would go beyond the frame of the master thesis. Levich/Thomas (1993) for example apply a bootstrap method whereby thousands of new exchange rate return series are constructed through resampling of the original time series with the purpose of assessing whether technical trading rules are still profitable when applied to the newly generated time series data samples.¹⁷² As a consequence the findings reported here can only be regarded as valid for the particular time series samples considered here.

9 Conclusions

The master thesis "Artificial Neural Network Decision Support for Carry Trades" combined the currency carry trade with predicted exchange rate returns from artificial neural networks. The literature review showed that both are associated with relatively good trading profitability and forecasting performance. Carry trade returns are composed of the interest differential and the corresponding exchange rate return. Since the exchange rate return is the uncertain component of both, the basic idea was to handle this by means of appropriate forecasts. The used currency return time series data were introduced and necessary and commonly used statistical data preprocessing steps were carried out. Then, in an extensive trial and error process a lot of neural nets for the single neural network and for the hybrid model were computed and in both cases the best 18 were selected. An ARMA benchmark model for each of the 18 currency pairs was also estimated. Based on these models the trading of a comprehensive carry portfolio was simulated and a volatility filter applied. In the end, forecasting accuracy and trading profitability was evaluated. Results showed that while forecasting accuracy on the basis of the RMSE was inferior, the neural network model and the hybrid model delivered the best trading results and fulfilled all profitability criteria. Consequently, both were able to enhance portfolio profitability. For the volatility filter this only holds for the hybrid model. In the financial crisis year

¹⁷²Levich/Thomas (1993), p.452.

2008 which was characterized by generally highly volatile markets the performance of the neural network model was superior compared to the other models. All in all, the results indicate that the application of single neural networks may provide successful decision support for the carry trade.

As mentioned in the limitations section, the test of significance of returns was neglected because this would go beyond the frame of the master thesis. Thus, in further research it would be interesting for instance to carry out a bootstrap approach as done by Levich/Thomas (1993) with the purpose of examining whether reported results also hold for other samples of the time series data and are thus significant. Furthermore, the performance in the crisis year 2008 was examined. Unfortunately, this year is part of the in sample period. Consequently, another interesting approach might be to investigate the performance of the models used here when a period of high volatility is part of the out of sample period. Also, the important impact of volatility on carry trade returns was underlined in the master thesis. However, results showed that the volatility filter was only partly able to improve profitability. Thus, an interesting approach might be the use of a volatility filter based on volatility forecasts generated with artificial neural networks.