The Profitability of Carry Trades: Reality or Illusion?

Po-Hsuan Hsu
Faculty of Business and Economics, University of Hong Kong

Mark P. Taylor
John M School of Business, Washington University in St Louis

Zigan Wang
Faculty of Business and Economics, University of Hong Kong

Abstract: We carry out a large-scale investigation of the profitability of carry trades, using foreign exchange data for 48 countries spanning a period from 1983 to 2016 and employing a stepwise test to counter data-snooping bias. We find that, while we can confirm previous findings that the carry trade is profitable over this long period when a specific carry-trade strategy is selected based on the whole data set, even after controlling for data snooping, when we split the sample into sub-periods, the best carry-trade strategy in one sub-period is generally not profitable in the next sub-period. This finding holds true even when we include learning strategies and stop-loss strategies. Our findings thus highlight the instability of carry trades over long periods and their limitation in the sense that it is hard to predict their performance based on several years of data and therefore to choose a profitable carry-trade strategy ex ante.

JEL Classifications: F31, C53, G15

Keywords: Foreign exchange; trading rules; carry trade; data-snooping bias.

Corresponding author: Mark P. Taylor, John M Olin School of Business, Washington University in St Louis, St Louis, MO 63130, U.S.A. E-mail: Po-Hsuan Hsu (paulhsu@hku.hk), Mark P. Taylor (mark.p.taylor@wustl.edu), and Zigan Wang (wangzg@hku.hk). We are grateful for helpful comments from Phil Dybvig, Ohad Kadan, Hong Liu, Yang Liu, Thomas Maurer, Qi Xu, Guofu Zhou, and participants at the Econometric Society Asian Meeting and Econometric Society China Meeting. We also thank Youan Wang and Po-Yu Liu for excellent research assistance and thank the London branch of BlackRock for providing us with data on midday ask and bid prices of spot and forward foreign exchange rates. All errors are ours.

Electronic copy available at: https://ssrn.com/abstract=3158101

1. Introduction

Carry trades denote a set of mechanical rules for exploiting cross-country differences in interest rates by selling low-interest-rate currencies and buying high-interest-rate currencies. Although uncovered interest parity suggests that exchange rate changes will eliminate the cross-country differences in interest rates, empirical studies have documented that such trading rules consistently generate substantial profits (Menkhoff, Sarno, Schmeling, and Schrimpf, 2012a), mainly because high-interest-rate currencies tend to appreciate rather than depreciate against low-interest-rate currencies. This phenomenon is often referred as the "forward-premium puzzle", since it is a prima facie violation of the simple (risk-neutral) efficient markets hypothesis (Fama, 1984). While prior studies have proposed several *ex post* explanations for such a phenomenon, such the presence of risk aversion,[1] a probably more fundamental question is whether the profitability of carry trades is genuinely statistically significant in the first place.

The first research question we address in this paper, therefore, is whether the empirical evidence on the profitability of carry trades, when the carry-trade strategy is chosen using data since the early 1980s is corroborated when proper allowance is made for the possibility of 'data-snooping'. The second question we address is whether profitable carry-trade strategies in various sub-periods are profitable in ensuing periods, so that profitable carry-trade strategies may in practice be selected based on data covering several years of performance.

The question of the true statistical significance of the profitability of carry trades

[1] An incomplete list of studies in this area includes Lustig and Verdelhan (2007), Brunnermeier, Nagel, and Pedersen (2008), Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011), Christiansen, Ranaldo, and Söderlind (2011), Menkhoff et al. (2012a, 2012b), Jorda and Taylor (2012), Habib and Stracca (2012), Jurek (2014), Lustig, Roussanov, and Verdelhan (2014), and Acharya and Steffen (2015). Most of these studies use a *monthly* data set starting in the early 1980s and spanning a period of 25 years or more.

Electronic copy available at: https://ssrn.com/abstract=3158101

is important because previous empirical studies have not accounted for data-snooping bias. Data snooping arises when researchers apply a large number of parameter choices on a single set of historical data series and eventually can report an individual test result of statistical significance.[2] Prior studies have established the profitability of carry trades by testing the time-series average of the returns from a high-minus-low interest rate portfolio that holds long (short) positions in selected groups of currencies with high (low) interest rates. However, there exist multiple possible ways of constructing such carry-trade portfolios, depending on the selection of currencies, the sorting of portfolios, and the choice of rebalancing periods. Since theory does not specify the parameter choice in the construction of carry-trade portfolios, it is necessary to test a large set of parameter choices. In this paper, we highlight the need to use an appropriate multiple testing framework to make appropriate statistical inferences in this context. In particular, we consider various combinations of selected currencies, various ways of sorting currencies into high and low interest rate groups, and various rebalancing periods. To make appropriate statistical inferences on the profitability of carry trades, we employ reality check tests based on the work of White (2000), Romano and Wolf (2005) and Hsu, Hsu, and Kuan (2010).[3]

We use monthly data of the 1-, 3-, 6-, and 12-month forward and spot exchange rates (allowing for bid and ask spreads) of 48 currencies against the U.S. dollar, covering both emerging and developed markets, to examine the mean return and Sharpe

[2] This problem is also called data mining or over-fitting the data, while many label it as "data snooping", following Lo and MacKinlay (1990), Sullivan, Timmermann, and White (1999), White (2000), and Schwert (2003). Data snooping is a concern in applied economics and finance (e.g. Leamer, 1978, 1983) and there have been methodological developments in econometrics over the past 15 years.

[3] The reality check test developed by White (2000) is the first formal testing method that corrects data-snooping bias for large-scale joint test problems. This method was later improved by Hansen (2005), Romano and Wolf (2005), and Hsu, Hsu, and Kuan (2010) to increase the power in identifying predictive models.

ratio of up to 400 carry-trade strategies. We calculate the mean return and Sharpe ratio of those strategies based on the differentials of U.S. and foreign interest rates and spot foreign exchange rate. Each strategy selects currencies based on the liquidity measured by bid-ask spread, builds positions based on the forward foreign exchange discount (a proxy for interest rate differentials), and holds a portfolio for a certain period. By considering various ways of currency selection, forward discount sorting, and holding periods, we construct a large number of carry-trade strategies (from 100 to 400 strategies) based on different rebalancing frequencies.

Our test results suggest that the profits generated by carry trades are not subject to data snooping bias over the whole 32-year period. The best strategy based on the mean return criterion generates average returns of 18.5% per year among all currencies and 3.35% per year among developed currencies, which are significant at the 1% level. More importantly, we show that over 100 different carry-trade strategies indeed generate significantly positive mean returns. The profitable strategies confirm the robust profitability of carry trades (Menkhoff et al., 2012a). Our data snooping tests also suggest that carry-trade strategies using all currencies provide significantly positive Sharpe ratio when the full data set over 30 years or so is chosen to select the carry-trade strategy. We then test the subsample of currencies restricted to developed markets, which have the largest number of arbitragers and are most liquid. We again find a significant number of carry-trade strategies with significantly positive mean returns: the profitability from carry trades of developed currencies is not subject to data snooping bias. Our large-scale investigation with advanced econometric methodologies thus provides an affirmative answer to the first question.

After confirming the conclusion of Menkhoff et al. (2012a), we then address our second research question, namely whether a profitable strategy in one subsample period is still profitable in the next period. We find that, although our evidence suggests that

some carry-trade strategies generate significant profits in the whole period 1983-2016, it does not necessarily mean that those strategies are significantly lucrative in every year. In fact, our plots show that even the best strategy cannot guarantee positive payoffs in every sub-sample period. Our main concern is that, under performance pressure, would traders really stick to trading strategies that have demonstrated unsatisfactory performance over a window of several years?

To examine these issues, we then conduct out-of-sample tests. We divide the 32-year period from 1983 to 2015 into four 8-year sub-periods and examine whether the best-performing strategies in one sub-period (i.e., in-sample) generate significant able profits in the next sub-period (i.e., out-of-sample), following Levich and Thomas (1993). We find that, in general, the best performing strategy in one period is not profitable in the next out-of-sample period.[4] For example, using the full sample of all currencies, the profitable strategies over the period 1984-1991 are not profitable over the period 1992-1999, and that the profitable strategies over 2000-2007 are not profitable in 2008-2015. Only in one of the three out-of-sample tests do some profitable strategies in 1992-1999 deliver significant profits in 2000-2007. On the other hand, when we consider only developed currencies, we find no strategy generating significant profits in the next out-of-sample period. These findings suggest the limitation for traders to exploit carry trades: when they are under frequent performance review, it is difficult to stick to the same strategies in all years, given the clear fact that even the best strategy cannot persistently generate profits every year. We argue that even if a strategy can be profitable in the whole sample period (32 years), it may not achieve such profitability if the strategy is terminated in the years of poor performance. In reality, most investors will not tolerate a strategy with several years' loss.

[4] For both in- and out-of-sample periods, we employ the multiple testing framework to identify the best performing strategy.

There is a possibility that traders always apply the strategies with best performance in the past rebalancing horizon, which is a dynamic learning and switching process. To examine this possibility, we design learning strategies that switch to the best strategy based on past performance. Depending on rebalancing horizons, we construct 4 to 64 *learning* strategies that track all strategies' performance in the past rebalancing period ("basic strategies" henceforth), and switch to the best performing strategy in the next rebalancing month. The learning strategies may justify the profitability of carry trades by helping investors avoid poor performance in certain years. Our empirical tests, however, suggest the opposite. We first find that these performance-following strategies tend to underperform basic strategies based on reality check tests in the whole sample and in sub-periods. Moreover, their out-of-sample performance is also insignificant in two of three out-of-sample tests. The results indicate that traders cannot improve basic carry-trade strategies by learning.

We also consider stop-loss strategies that close the position after a certain drop and re-enter the market after a certain rise. We find that it cannot resolve the difficulties that the traders must face and cannot help a trader time the market better. Including stop-loss strategies does not change the fact that the best strategies in one sub-period generally do not profit in the next sub-period.

On one hand, therefore, while our empirical evidence based on multiple econometric methodologies confirms that the profitability of carry trades that has been highlighted in previous literature is not subject to data snooping bias, on the other hand, traders will in actuality face severe limitations in fully exploiting such profitability. Performance pressure makes it difficult for traders to insist on strategies that may have been profitable in the past but constantly lose money in current years, and are unlikely to choose strategies that have underperformed in the past, even though these often turn out to be profitable strategies going forward. Our findings highlight the limitation in

exploiting carry trades in practice: traders will have difficulty in remaining faithful to specific carry-trade strategies when their performance has been poor for several years, and attempting to learn from the past and adjust for market downturn does not reduce this limitation.

The rest of the paper is organized as follows. In the next section we discuss the dataset and provide summary statistics, while in Section 3 we provide a brief discussion of the construction of our carry-trade strategies. In Section 4 we describe the reality check test methods we implement for statistical inference. In Section 5 we examine the profitability of carry trades with a series of reality check tests, the profitability results of sub-periods, the profitability results with learning strategies, and the profitability results with stop-loss strategies. Finally, in Section 6 we make some concluding remarks.

2. Data

We use end-of-month data of spot and forward rates of 1, 3, 6, and 12 months. We have 48 currencies' exchanges rates against the U.S. dollar. The 16 developed market currencies, which cover the period pre and post European Monetary Union, are Austrian schilling, Australian dollar, Belgian franc, Canadian dollar, Danish krone, Dutch guilder, euro, French franc, German mark, Italian lira, Japanese yen, New Zealand dollar, Norwegian krone, Swedish krona, Swiss franc, and U.K. pound. The 32 emerging market currencies are Brazilian real, Bulgarian lev, Croatian kuna, Cypriot pound, Czech koruna, Egyptian pound, Finnish markka, Greek drachma, Hong Kong dollar, Hungarian forint, Icelandic krona, Indian rupee, Indonesian rupiah, Irish punt, Israeli shekel, Korean won, Kuwaiti dinar, Malaysian ringgit, Mexican peso, Philippine peso, Polish zloty, Portuguese escudo, Russian ruble, Saudi riyal, Singaporean dollar,

Slovak koruna, Slovenia tolar, South African rand, Spanish peseta, Taiwanese dollar, Thai baht, and Ukrainian hryvnia. Before the inception of the euro on January 1, 1999, we use 16 developed currencies to construct portfolios. After the inception of euro, we use the exchange rates as their fixed exchange rates against euro multiplied by euro exchange rates against the U.S. dollar.

The data were kindly provided by the London office of BlackRock, and comprise bid and ask prices of forward and spot exchange rates based on midday quotations in the London market. In Table 1, we list the sample mean, minimum, maximum, standard deviation, and the available sample period of monthly forward and spot exchange rates of 48 currencies. The earliest sample periods for some currencies start from October 11, 1983. Most of the currency data ends on January 29, 2016. Some European currencies end on December 31, 1998 due to the inception of euro.

To better understand the average profits from currency trading, we also present the changes in spot exchange rates (i.e., the profits from currency appreciation) and the interest differentials measured by forward discounts (i.e., the profits from deposit in foreign currencies) in Table 2, all in monthly frequency. Following Filippou and Taylor (2016), the monthly returns on foreign currencies are defined as the change in the spot exchange rates, and the monthly forward discounts as forward rates minus spot rates scaled by spot rates. Forward discounts reflect the interest rate differential, i.e., the interest rate of the foreign currency minus the interest rate of the U.S. dollar.

Among the 16 developed currencies, we find that the highest average spot rate changes occur in Swiss franc, Japanese yen, and Danish krone (0.0112%, 0.0100%, and 0.0080% per month, respectively), suggesting that these currencies appreciate the most against the U.S. dollar in respective sample periods. On the other hand, the lowest average spot rate changes occur in euro, Canadian dollar, and Italian lira (0.0001%, 0.0003%, and 0.0005% per month, respectively), suggesting that these currencies

appreciate the least against the U.S. dollar in respective sample periods. Among the 32 emerging market currencies, Irish punt, Singaporean dollar, and Slovak koruna appreciate the most against the U.S. dollar on average (0.0060%, 0.0058%, and 0.0053% per month, respectively), and Russian ruble, Ukrainian hryvnia, and South African rand depreciate the most against the U.S. dollar (-0.042%, -0.0352%, and -0.0270% per monthly).

When we focus on forward discounts (i.e., interest differentials), Table 2 shows that 1-month forward discounts available for trading in developed countries range from -0.2190% per month in Japanese yen to 0.3340% in Italian lira. Forward discounts vary greatly across emerging countries. The highest average forward discount is 2.0500% per month in Indonesian rupiah, while the lowest average forward rate is -0.1660% in Singaporean dollar. Similar patterns are found in the 3-, 6-, and 12-month forward discounts.

Figure 1 reveals the relation between exchange rate changes and forward discounts (i.e., interest rate differentials). According to uncovered interest parity (UIP), currencies with higher (lower) interest rates are expected to depreciate (appreciate). To examine if UIP holds on average in our 48 currencies, we plot each currency's spot exchange rate change along the vertical axis and the currency's 1-month forward discount along the horizontal axis in Panel A of Figure 1. We find that spot rate changes are negatively correlated with 1-month forward discounts. Panels B, C, and D confirm the negative correlation based on 3-, 6- and 12-month forward discounts, respectively.

3. Carry-Trade Strategies and Returns

We construct carry-trade strategies in four groups according to rebalancing horizons: 1-, 3-, 6-, and 12-month. We generate 1-month strategies as follows. We first use the middle price between the bid and ask prices to construct the 1-month forward

discount rate in month t as

$$FD = \log(F_t) - \log(S_t), \qquad (1)$$

where F_t denotes the forward exchange rate and S_t denotes the spot exchange rate. Among all currencies, we select the most liquid M currencies (with the smallest bid-ask spreads), which generates N_M possibilities. When we use the sample of all 48 currencies, then M = 48, 46, 44, …, 10 and N_M =20; when we use the sample of 16 developed currencies, then M = 16, 14, 12, 10 and N_M =4. We then rank these M currencies by forward discount rates from the highest to the lowest and sort them into L portfolios (L = 2, 3, 5, $[M/2]$[5], M) and N_L = 5. Hence, we have N_M*N_L strategies. We let $K = N_M$*N_L, which is 100 for all currencies and 20 for developed currencies, and let k denote each carry-trade strategy (k = 1,…,K). For each strategy, we go long every currency with equal weight in the portfolio with the highest forward discount rates ("the highest portfolio"); and we short every currency with equal weight in the portfolio with the lowest forward discount rates ("the lowest portfolio"). In computing monthly return, these portfolios are rebalanced right before the first trading day of every month. For each currency in the highest portfolio (i.e., first borrow USD, then exchange for and hold foreign currency, then exchange back to USD), the monthly return in month $t+1$ is

$$R_{long} = f_t^{bid} - s_{t+1}^{ask}, \qquad (2)$$

where f_t denotes $\log(F_t)$, s_{t+1} denotes $\log(S_{t+1})$, *bid* denotes bid quote, and *ask* denotes ask quote. For each currency in the lowest portfolio (i.e., first borrow foreign currency, then exchange for and hold USD, then exchange back to foreign currency), the monthly return in month $t+1$ is

[5] The function [.] denotes the integer from rounding down the number within the bracket. For example, [2] = 2, [2.3] = 2, [2.7] = 2, [3.1] = 3.

$$R_{short} = -f_t^{ask} + s_{t+1}^{bid}. \quad (3)$$

For currencies that stay in the highest portfolio in both month t and month $t+1$, we follow Menkhoff et al (2012a) and compute the return in month t+1 as

$$R_{long} = f_t^{bid} - s_{t+1}^{middle}. \quad (4)$$

Similarly, for currencies that stay in the lowest portfolio from month t to month $t+1$, we calculate the return as

$$R_{short} = -f_t^{middle} + s_{t+1}^{bid}. \quad (5)$$

After computing the monthly return for each currency in the highest and the lowest portfolios, we calculate the return of the k-th strategy in month $t+1$ by averaging all the returns in the highest and the lowest portfolios in month $t+1$. The k-th strategy has a time-series return in month t ($t = 1, \ldots, T$). As a result, we have a return matrix of dimension $T \times K$ for all 1-month strategies.

For the first part of the 3-month strategies, we adopt the same procedure as the 1-month strategies and generate K strategies. Moreover, we rebalance the portfolio for every three months and calculate the return for every three months. Therefore, we have $[T/3]$ periods and each period lasts three months. As a result, we have a return matrix of order $[T/3] \times K$. We then add the K strategies from the 1-month group to these 3-month strategies by compounding their monthly returns into 3-month returns in the following way. For 1-month returns R_{t+1}, R_{t+2} and R_{t+3}, we construct the compounded 3-month return as $(1+R_{t+1})(1+R_{t+2})(1+R_{t+3})$. This way, we convert the original return $T \times K$ matrix for all 1-month strategies into a return matrix of order $[T/3] \times K$. We then append this matrix to the original $[T/3] \times K$ matrix as designed above. As a result, we have total of $2K$ strategies in the 3-month group with a return matrix of dimension $[T/3] \times 2K$ to be used in the multiple test (to be described in the next section).

Following the same procedure, we are able to generate the 6-month group strategies that consist of $3K$ strategies with a return matrix of order $[T/6] \times 3K$ and the

12-month group strategies that consist of $4K$ strategies with a $[T/12] \times 4K$ return matrix. The 6-month group strategies include all strategies formed on 1-, 3-, and 6-month rebalancing, and the 12-month group strategies include all strategies formed on 1-, 3-, 6-, and 12-month rebalancing.

We conduct tests in each group of carry-trade strategies. When we consider all 48 currencies, there are 100, 200, 300, and 400 carry-trade strategies in the 1-, 3-, 6-, and 12-month groups. When we consider 16 developed currencies, there are 20, 40, 60, and 80 carry-trade strategies in the 1-, 3-, 6-, and 12-month groups.

4. Reality Check and Stepwise Tests

To answer our first research question concerning the possible presence of data snooping, we test if there exist carry-trade strategies that generate significantly positive mean return or Sharpe ratios after correcting for data snooping bias. This is important because, since the construction of carry-trade strategies is not theoretically restricted, there is freedom to select currencies, sort portfolios, and rebalance frequencies and, as a result, there in fact exist multiple alternative hypotheses for the statistical inferences we consider. Simply put, we need to ascertain whether the best performing trading rule chosen from among many is not profitable purely by luck, and this is difficult to do within the traditional of classical statistical framework. Classical statistical inference is based on rejecting the null hypothesis if the likelihood of the observed data under the null hypothesis is low. Searching among competing or trading rules implicitly involves increasing the number of hypotheses tested as underperforming models or rules are discarded. The problem of multiplicity arises from the fact that as we increase the number of hypotheses being tested (even implicitly), we also increase the likelihood of a rare event and, therefore, the likelihood of incorrectly rejecting the null hypothesis of

interest in each competing model or trading rule (i.e., making a Type I error). In other words, good performance detected by rejecting the individual null hypothesis may not really be statistically significant but just based on luck, which has been maximized because of an extensive specification search. In our case, given that we are typically searching among a large number (up to 400) variants of carry-trade trading rules, a skeptic might say that they would have been surprised if we had not found any that performed extremely well.

Applied researchers will recognize this problem as data mining, or over-fitting the data. Concern with the problem of data mining or, as it is now more commonly called, data snooping (because of the increased use of the former term to describe analysis based on so-called 'big data'), has a long history in applied economics and finance (see e.g. Leamer, 1978 and the references therein) and there have been a number of important recent developments in this area which we draw on in our empirical work in order to mitigate this problem.

More formally, let $\boldsymbol{P}=(P_1, P_2, \ldots P_K)$ denote the $1 \times K$ vector in which the k-the element P_k denotes the mean excess return or Sharpe ratio of the k-th strategy for $k=1, \ldots, K$. K denotes the number of all carry-trade strategies considered in each test. Data snooping occurs when a researcher selects the maximal element of the performance vector $\boldsymbol{P}$, say $P_j = Max(P_1, P_2, \ldots P_K)$, and conducts testing with the null hypothesis of this strategy generating zero profits:

$$H_0 : \ P_j = 0 \quad . \tag{6}$$

As test of the null hypothesis (6) is regarded as an "individual test".

As pointed out in White (2000), individual testing of this kind does not take into account the fact that P_j is the *maximal* performance among K strategies. Thus, it is not based on the correct distribution of statistics. In particular, when K is very large, the assumed nominal significance of the test based on individual testing could understate

the true probability of a Type I error for the profitability of carry-trade strategies, because the strategy being tested has already been chosen as the best available. Therefore, an individual test tends to over-reject the null hypothesis due to data snooping bias and thus overestimate the statistical significance of the profitability of carry trades.

To account for exactly such a data-snooping issue, White (2000) proposes a 'reality check' test, which applies bootstrapping to construct the empirical distribution for $\boldsymbol{P}$ so as to test a composite null hypothesis as stated in (7) based on the joint distribution of all elements of $\boldsymbol{P}$:

$$H_0^k : \ P_k \leq 0, \tag{7}$$

where P_k denotes the mean return or Sharpe ratio of the k-th strategy. To test the above composite null hypothesis, we need a multiple testing method that generates appropriate significance levels of the profits of multiple carry-trade strategies. We thus adopt a stepwise test that is based on a series of methodologies based on White's reality check test, including Romano and Wolf (2005), Hansen (2005), and Hsu, Hsu, and Kuan (2010). We first specify the alternative hypotheses for the null hypothesis (7) as:

$$H^k{}_A : \ P_k > 0, \text{for } \ k = 1, \dots, K. \tag{8}$$

The rejection of the k-th individual null hypothesis indicates that the j-th technical strategy is significantly profitable after considering all alternative hypotheses and is thus free of data snooping bias. We specify the stepwise test with a Type I error level α_0 in a certain period (t=1, ..., T) as follows:[6]

1. We compute the monthly return matrix $\boldsymbol{R}$, in which each element R_{kt} denotes

[6] Technically speaking, the error we aim to control for in such a multiple testing framework is the family-wise error, which is defined as the probability of rejecting at least one correct null hypothesis. For example, when we impose a 5% significance level in the testing, we would expect a 5% probability of wrongly rejecting any alternative hypothesis (i.e., identifying any ineffective strategy as profitable ones).

the monthly return of the k-th strategy in each month (k=1,...,K, t=1,...,T).

2. For each strategy k, we compute its performance metric (mean return or Sharpe ratio), P_k, based on $\boldsymbol{R}$.

3. We resample $\boldsymbol{R}$ using the stationary bootstrap method of Politis and Romano (1994), with pre-specified parameter set Q, for B times, and label each resample as $\boldsymbol{R}_b$, b = 1,...,B.

4. For each b, compute the performance metric (P_{kb}) for the k-th technical rule based on resampled $\boldsymbol{R}_b$ and let the loop indicator i = 1.

5. We construct an empirical null distribution for the test statistics as follows:

5.1. For each b, compute $s_{bi} = T^{1/2} \max_{k=1,...,K} [P_{kb} - P_k + P_k \, \boldsymbol{\iota}(T^{1/2}P_k \leq -\sigma_k[2\log[\log(T)])^{1/2}\boldsymbol{)}]$, where $\boldsymbol{\iota}(E)$ denotes the indicator function of the event E and σ_k denotes the standard deviation of the original monthly return series of the k-th strategy. The bound $\boldsymbol{\iota}(T^{1/2}P_k \leq -\sigma_k[2\log[\log(T)]]^{1/2})$ is proposed by Hansen (2005) to re-center the distribution for $\boldsymbol{\Theta}$ to avoid the bias driven by too many "bad" strategies.

5.2. Collect all $\{s_{bi}\}_{b=1,...,B}$, rank them in descending order and then collect its (1– α_0)-th quantile as $q_i(\alpha_0)$.

6. We compare each strategy's $T^{1/2}P_k$ to $q_i(\alpha_0)$, and treat the k-th null hypothesis as rejected at the i-th step if $T^{1/2}P_k > q_i(\alpha_0)$, following Romano and Wolf (2005). We record all information of these rejected strategies and label them rejected at the i-th step. Then, restart from Step 5, let P_k = 0 and P_{kb} = 0 for all rejected hypotheses k, and change the loop indicator from i to i + 1. However, if no strategy is rejected given $q_i(\alpha_0)$, i.e. $T^{1/2}P_k \leq q_i(\alpha_0)$ for remaining j, then stop and go to Step 7.

7. Finally, restore the original P_k from $\boldsymbol{R}$ and estimate each technical rule's marginal p-value, p_k, as the percentile of $T^{1/2}P_k$ in the last $\{s_{bi}\}_{b=1,...,B}$ as an

empirical null distribution.

8. Compare each technical rule's p_k to α_0. If $p_k < \alpha_0$, we claim that j-th strategy is profitable in the sample period at the significance level of α_0. When there exists at least one profitable strategy in the sample period, we claim that carry trades are profitable at the significance level of α_0.

In our empirical tests, we set $\alpha_0 = 0.05$ (i.e., our statistical significance is defined at the 5% level), $Q = 0.9$, and $B = 1000$ following the literature.[7]

5. Tests for the Profitability of Carry-Trade Strategies

In this section, we first examine the profitability of a large set of carry-trade strategies using the reality check test and the stepwise test discussed in the prior section to make appropriate statistical inferences. We then split the whole sample period into four or eight sub-periods and examine the in- and out-of-sample performance of carry-trade strategies across sub-periods. We then consider the learning strategies based on carry trades to capture investors' decisions on switching across different strategies. Finally, we consider stop-loss strategies in which investors will cut the position when a certain level of loss has occurred and will resume the strategies when they recover in profitability.

5.1 Carry-trade strategies in all currencies

To examine whether carry-trade strategies are profitable across our full sample, we implement the reality check and stepwise tests explained in Section 4 to examine the significance of the mean returns and Sharpe ratios of considered strategies. Table 3

[7] We have also performed a range of tests based on different α_0, q, and B, and obtained similar results to those reported in the text.

presents the test results by considering all 48 currencies into portfolios in the whole sample period. The left and right panels are based on mean return and Sharpe ratio, respectively. Within each panel, we have four columns for different groups based on different rebalancing horizons of forward discounts to be used in portfolio construction: we have 1-, 3-, 6-, and 12-month forward discounts. We consider 100, 200, 300, and 400 strategies in the 1-, 3-, 6-, and 12-month group, as discussed in Section 3. We focus on two sets of indicators generated from the stepwise test. The first set includes performance metrics and associated p-values of the best strategy. The second set includes the number of profitable strategies that produce significantly positive performance metrics. We use 5% as the nominal significance level of our tests.

We first list the detail of the best strategy in the upper panel of Table 3, which shows that the strategy (38l, 38p, 1m) performs best on mean return in all four columns. This strategy (38l, 38p, 1m) uses the most liquid 38 currencies among all 48, categorizes them into 38 parts, trades on one currency with the highest forward discount and one with the lowest forward discount, and rebalances every month. In particular, this strategy generates a mean return of 18.5% per year. Moreover, this strategy has Sharpe ratios of 1.421, 0.967, 0.726, and 0.662 in the rebalancing horizons of 1-, 3-, 6-, and 12-months, respectively. To make our results comparable to prior studies, we provide the nominal p-value generated from the simple individual test in the next row. Without taking into consideration data snooping, the strategy strongly rejects the null hypothesis with p-values below 1% in all four columns. In the next two rows, we report the p-values based on the reality check (RC) test and the stepwise test. The p-values remain below 1%, suggesting that the outperformance of the best strategy is not subject to data snooping bias.

To visualize the profitability of the strategy (38l, 38p, 1m), we plot the cumulative value of $1 invested over time in Panel A of Figure 2. It shows that a $1 investment

using the best strategy from the beginning of sample period would have accumulated $225.96 at the end of January 2016, or nearly 18.45% per annum.

We then look for other strategies that are not the first best but nevertheless provide significantly positive mean return. To mitigate sampling bias in bootstrapping, we conduct the reality check test and stepwise tests 500 times, and report the average, minimum, and maximum numbers of profitable carry-trade strategies among these 500 tests that are rejected by the stepwise test. As shown in the lower panel of Table 3, we find that the average numbers of profitable strategies are 100, 200, 223, and 105 in the 1-, 3-, 6-, and 12-month groups, respectively. The average percentage of profitable strategies range from 26.24% to 100%. Overall, our tests suggest a large number of profitable strategies after correcting for data snooping bias. As suggested in Timmermann and Granger (2004), our findings provide strong evidence for the profitability of carry trades using our whole sample period. More importantly, the significant number of profitable strategies suggests that such profitability is not (overly) sensitive to the specific design of carry-trade strategies.

The right panel of Table 3 presents the test results based on the Sharpe ratio as the objective criterion. In the upper part, we find that the strategy (38l, 38p, 1m) is the most profitable strategy in the 1- and 3-month horizons and generates Sharpe ratios of 1.421 and 0.967, respectively. In the 6- and 12-month horizons, the strategy (18l, 3p, 1m) is the most profitable strategy and generates Sharpe ratios of 0.867 and 0.863, respectively. The strategy (18l, 3p, 1m) uses the most liquid 18 currencies among all 48, categorizes them into 3 parts, trades on 6 currencies with the highest forward discount and 6 with the lowest forward discount, and rebalances every month. The nominal p-values, the reality check p-values, and the stepwise test p-values are all below 1%. All these statistics collectively support that the best carry-trade strategies produce significantly positive Sharpe ratios after correcting for data snooping bias. In

addition, Panel B of Figure 2 shows that a $1 investment in the strategy (18l, 3p, 1m) would have grown to $3.43 by the end of January 2016. These numbers reflect nearly 3.92% per annum. In the lower part, we also find a large set of strategies rejected by the null hypothesis, which confirms that the profitability of carry trades is robust across various strategy designs. The average number of significantly profitable strategies rejected ranges from 36 to 200 in the right panel, and the average percentage of profitable strategies range from 9% to 100%.

5.2 Carry-trade strategies in developed currencies

One possible concern with of our findings based on all 48 currencies is that our analysis contains many emerging currencies and the findings may not hold for the generally more liquid currencies in developed markets. In this subsection, we redo all the tests as in Section 5.1 with just the 16 developed market currencies and report the results in Table 4. Due to the smaller size of currencies, the set of strategies is smaller in comparison with Table 3. As a result, we consider totals of 20, 40, 60, and 80 strategies in the 1-, 3-, 6-, and 12- month group, respectively, as discussed in Section 3.

In the upper panel of Table 3, the best strategy based on mean return is the strategy (14l, 7p, 1m), which uses the most liquid 14 currencies among all 16 developed market currencies, categorizes them into 7 parts, trades on two currencies with the highest forward discount and two with the lowest forward discount, and rebalances every month. It generates a mean return of 3.35%, which is statistically significant at the 5% level in all tests based on the nominal p-values, the reality check p-values, and the stepwise test p-values. On the other hand, the best strategy based on Sharpe ratio is the strategy (12l, 5p, 1m), which generates Sharpe ratios of 0.537, 0.490, 0.458, and 0.473 in the 1-, 3-, 6-, and 12-month groups, respectively. This strategy uses the most liquid 12 currencies

among all 16, categorizes them into 5 parts, trades on 2 currencies with the highest forward discount and 2 with the lowest forward discount, and rebalances every month. In contrast to the nominal p-values, the stepwise test p-values suggest insignificant Sharpe ratios, implying that carry trades cannot generate significantly positive returns in liquid currencies after considering return volatility.

Panels A and B of Figure 3 present the cumulative value of a $1 investment in the strategy (14l, 7p, 1m) and the strategy (12l, 5p, 1m), respectively, throughout the sample period. Panel A (B) shows that the $1 investment in the first (second) strategy would have grown to $2.87 ($2.24) by January of 2016, representing an average return of 3.35% (2.55%) per annum.

In the lower panel of Table 3, we find that, on average, 11 to 32 profitable strategies reject the null hypothesis based on mean return. In terms of the percentage of profitable strategies over all strategies, the ratio ranges from 14% to 100%, which again suggests that a substantial portion of carry trades are profitable after correcting for data snooping bias. However, there is no profitable strategy based on Sharpe ratio.

When we compare the statistics reported in Table 4 to their counterparts in Table 3, we find that the magnitude of profits generated from developed currencies is in general smaller than that generated from all 48 currencies. It is not surprising because by definition, there will be more risky arbitragers exploiting opportunities in more liquid, developed market currencies.

5.3 Sub-period analysis

So far, our findings confirm the profitability of carry trades in the whole sample period. Our second question, however, is whether carry trade traders could have realistically chosen a strategy conditional on the recent history of the strategy—or even

with learning—such that the strategy continued to be profitable. As shown in Figures 2 and 3, even the best strategies cannot generate positive profit every year. Under performance pressure, can currency traders really insist on those strategies regardless of their tentative poor performance? The question is difficult to answer because ex ante a trader does not know which strategy will be profitable when she starts at the beginning of our sample period.

One way is to examine the profitability of carry-trade strategies in the out-of-sample periods, following Levich and Thomas (1993). We first cut the whole sample period 1983-2015 into four sub-periods of eight years, and then examine if the best-performing carry-trade strategy in one in-sample sub-period can generate profits in the next out-of-sample sub-period.[8] Specifically, we consider the following four sub-periods: 1984-1991, 1992-1999, 2000-2007, and 2008-2015.

Table 5 reports both in-sample and out-of-sample test results using all 48 currencies. In Panel A, we first conduct the same test as in Table 3 for the in-sample period 1984-1991. We then record all strategies that produce significantly positive profits in eight specifications based on different combinations of performance metrics and rebalancing horizons and track their out-of-sample performance in the next sub-period 1992-1999. For example, the best strategy based on mean return and 1-month group is the strategy (10l, 3p, 1m), which generates an average annual return of 4.46% with a nominal p-value of 0.000 and a stepwise test p-value of 0.125 in the in-sample period 1984-1991. However, the strategy does not maintain its outstanding performance in the next sub-period (1992-1999) as its average mean return of 4.31% is insignificant in the stepwise test (p-value = 0.402).

[8] We also cut the whole sample period into eight sub-periods of four years and obtain consistent and robust results. Menkhoff and Taylor (2007) review empirical literature on technical analysis in foreign exchange markets and suggest that technical trading rules may have become less profitable over time.

Figure 4 uses the best strategies in the first columns of Table 5 as the example to illustrate the change in profitability by presenting the cumulative value from a $1 investment in this strategy in both sub-periods. In Panel A of Figure 4, the value is almost flat in the first 7 years in the second period and only surges in 1999, confirming the illusive pattern of carry trade profitability. It is perhaps difficult to believe that traders would have continued to pursue the strategy for seven years without making substantial profits. Moreover, when we plot the cumulative value from a $1 investment in another best strategy (18l, 9p, 3m) identified in the 3-month horizon, we find almost no price increase in the next sub-period.

In Panel B of Table 5, we find that some significantly profitable strategies in the in-sample period 1992-1999 do perform well in the next sub-period 2000-2007. For example, the best strategy based on mean return in the 1-month group is the strategy (34l, 34p, 1m), which generates an average annual return of 19.48% with a nominal p-value of 0.002 and a stepwise test p-value of 0.003 in the in-sample period. In the next sub-period, we find that the strategy maintains its outstanding performance as its average annual return is 50.26%, which is significantly positive in the stepwise test. Also, in the lower part of the first column of Table 5 Panel B, we report that there are on average 46 strategies with significantly positive mean return in the in-sample period, and all those strategies appear to be significantly profitable in the next sub-period. Panel B of Figure 4 confirms all these results by showing the cumulative value from a $1 investment in this strategy in the strategy (34l, 34p, 1m).

However, such significant out-of-sample performance is very limited as it only exists in the mean return criterion and in the 1- and 3-month groups of Panel B (i.e., the first two columns). We do not find a significantly profitable strategy in the in-sample period for the rest of Panel B. The best performing strategies cannot reject the null hypothesis when we consider the mean return criterion in the 6- and 12-month groups

(i.e., the third and fourth columns) or when we consider the Sharpe ratio criterion in the 1-, 3-, 6-, and 12-month groups (i.e., the fifth to the eighth columns); for these cases, we do not test their out-of-sample performance.

Again, we do not find out-of-sample profitability in Panel C of Table 5. For example, the best strategy based on mean return and 1-month rebalancing horizon is the strategy (48l, 24p, 1m), which generates an average annual return of 53.05% with a nominal p-value of 0.000 and a stepwise test p-value of 0.000 in the in-sample period. However, we find that the strategy does not maintain its outstanding performance in the next sub-period (2008-2015) as its average annual return is 0.62%, which is insignificant in all tests. In Panel C of Figure 4, the cumulative value from a $1 investment in the best strategy (48l, 24p, 1m) has substantial increase in the in-sample period (2000-2007) but not in the out-of-sample period (2008-2015). Moreover, despite 100 significantly profitable strategies in the in-sample period, only an average of 8.6 strategies are profitable in the out-of-sample period. Other columns in Panel C of Table 5 also confirm this finding.

We test for just the 16 developed currencies in Table 6. Compared to Table 5, there are fewer profitable strategies: consistent with the results reported in Tables 3 and 4, we find fewer profitable strategies in developed currencies, likely due to the fierce competition among risky arbitragers in those markets.[9] The out-of-sample performance of developed currencies is weaker than that of all currencies reported in Table 5. None of the profitable strategies in 1984-1991 is profitable in 1992-1999 (Panel A), no profitable strategies exist in 1992-1999 (Panel B), and none of the profitable strategies in 2000-2007 is profitable in 2008-2015 (Panel C).

[9] As shown in prior studies about technical analysis, it has become very difficult if not impossible to make significant predictability in developed currencies since the early 1990s (LeBaron, 2002; Olson, 2004; Menkhoff and Taylor, 2007; Neely, Weller, and Ulrich, 2009).

Using the best strategies in the first columns of Panels A to C of Table 6 as the example, we present their cumulative value from a $1 investment in Panels A to C of Figure 5, respectively. The steady growth in the in-sample periods does not last in the out-of-sample periods in Panels A and C.

Overall, Tables 5 and 6 show the difficulty in selecting carry-trade strategies that are profitable in out-of-sample periods, which casts doubt on whether carry trade traders can really exploit the whole-sample best strategies throughout all years. Even though there exist profitable strategies throughout the whole sample, currency traders will in reality be confronted with various issues such as performance pressure. It is therefore difficult to imagine how they would discipline themselves to stick with certain specific strategies across all years or to gain management support for doing so in the face of several years of poor performance.

A possible explanation of our findings is the unavoidable 'self-destruction' process proposed by Timmermann and Granger (2004) and Timmermann (2008): profitable trading strategies will be used by more market participants, therefore the arbitrage profits will disappear as a result.[10] A similar argument has been proposed and empirically supported in stock markets: Schwert (2003) and McLean and Pontiff (2016) report that seemingly profitable patterns become weaker after being documented by academic papers.

5.4 Learning strategies

We net turn to a consideration of traders' learning processes. Although the profitability of carry-trade strategies is in general hard to replicate out-of-sample,

[10] It is also related to Adaptive Markets Hypothesis (Lo, 2004; Neely, Weller and Ulrich, 2009) suggesting that the profitability of trading strategies decay over time at a rate determined by the speed with which more and more traders uncover such strategies.

traders may be able to switch strategies to avoid some bad years and still make profits out of carry trades. To examine this possibility, we design learning strategies to capture traders' realistic choices under performance pressure.

Under rebalancing horizons of 1-, 3-, 6-, and 12-months, we construct 64, 25, 16, and 4 learning strategies, respectively. These learning strategies track the periodic performance of all strategies we consider earlier ("basic strategies" henceforth), and switch to the best performing strategy in every rebalancing month. The details of learning strategies are in the Appendix. We then add these learning strategies to the basic strategies and examine the profitability of all carry-trade strategies including both learning and basic strategies.

We can see that these learning strategies also appear to be significantly profitable using the whole sample period 1984-2015 in Table 7. For example, in the first column in Panel A for all currencies, for all 164 strategies (including 100 basic strategies and 64 learning strategies) we significantly reject the null hypothesis. In the first column in Panel B for developed currencies, all 84 strategies (including 20 basic strategies and 64 learning strategies) we also significantly reject the null hypothesis.

We then examine the profitability of learning strategies in sub-periods as we did in Section 5.3 and find the same pattern. In Panel A of Table 8, only some profitable strategies exist in 1984-1991 (when we use Sharpe ratio criterion in the 1-, 3-, and 12-month groups) but they are not profitable in 1992-1999. In Panel C, almost all profitable strategies identified in 2000-2007 cannot perform well in 2008-2015. Nevertheless, as shown in Panel B, some profitable strategies in 1992-1999 are found to deliver significant profits in 2000-2007 (when we use the mean return criterion in the 1- and 3-month groups). These results are largely consistent with Table 5. In Table 9, we conduct similar sub-period analyses but focus on more liquid, developed currency markets. In accordance with the results reported in Table 6, we find that no profitable strategy in

the in-sample period or no profitable strategy identified in in-sample periods being able to generate profits in the out-of-sample periods.

Our findings that learning strategies cannot generate significant profits in out-of-sample periods suggest that traders are unable to improve basic carry-trade strategies by being adaptive.

5.5 Stop-loss strategies

Finally, yet importantly, we investigate the performance of carry-trade strategies using mean return and Sharpe ratio criteria when assuming implementation of stop-loss rules. In Table 10, we present the results when assuming a trader stops an operating strategy when the portfolio value drops by 10% compared to either its highest historical value within a specific review period (Panel A), or its portfolio value before the review period, and resumes the strategy when the portfolio value goes back up by 10%. The benchmark strategy for all 48 currencies is (48l, 5p, 1m) and the one for developed 15 currencies is (15l, 5p, 1m).

Assuming a 6-month review period and the strategy (48l, 5p, 1m) on all 48 currencies, a trader stops the strategy when she finds the portfolio value lower than its highest value within 6 months by 10% (the maximum drawdown is 10%); she resumes the strategy when she finds the portfolio value higher than its lowest value within 6 months by 10%. Panel A in Table 10 shows that such as stop-loss strategy gives a mean return of 4.64%, even lower than the benchmark return without it (5.45%). The Sharpe ratio with such a stop-loss threshold (1.211) is indeed higher than the benchmark (1.082), mainly because it helps avoid greater volatility. When we apply this stop-loss strategy with 6-month review period on 15 developed currencies, the results are worse: both mean return and Sharpe ratio are lower than benchmark indicators.

In Panel B of Table 10, we assume that the trader compares the portfolio value not with the highest value, but simply with its value before the review period. We assume that she stops the strategy when she finds the portfolio value lower than its value 6 months ago by 10%, and she resumes the strategy when she finds the portfolio value higher than its value 6 months ago by 10%. With such a stop-loss strategy, the mean return of 4.64% is lower than the benchmark return without it (5.45%). The Sharpe ratio with such a stop-loss threshold (1.211) is indeed higher than the benchmark (1.082).

We thus find that a stop-loss strategy cannot help a carry trade trader time the market significantly better.

6. Conclusion

In this paper, we use a large data set of 48 currencies in developed and emerging economies to examine the profitability of carry trades in a 32-year period from 1983 to early 2016, and the performance of the best strategy in each 8-year sub-period in the next sub-period. By constructing various carry-trade strategies based on currency selection, portfolio sorting and period rebalance, and using advanced econometric methods including the reality check and the stepwise test to control for data snooping, we make appropriate statistical inferences on the profitability of carry trades. Our findings confirm that carry-trade strategies are indeed profitable in the whole 32-year sample period. One contribution of this paper is to confirm that the carry trade profits previously documented in the literature are not subject to data snooping bias.

Our main contribution, however, is the result that traders would have found it extremely difficult, ex ante, to choose a carry-trade strategy that would have been consistently profitable throughout the whole sample. When we split the whole sample period into four 8-year sub-periods, we find that, in general, a significantly profitable

strategy in one sub-period (in-sample period) is not profitable in the next sub-period (out-of-sample period). These findings suggest the limitation for traders to exploit carry trades: given that traders will be subject to performance review, it is difficult to see how they would stick to the same strategies in all years, given the fact that even the best carry-trade strategy cannot persistently generate profits over every sub-period and different carry-trade strategies are profitable in different sub-periods. Thus, even if *ex post* a carry-trade strategy can be profitable in the whole sample period since the early 1980s in an in-sample test, the consistent implementation of such a strategy by traders faced with periods of several years of loss during sub-periods would have been unlikely as it would likely have been terminated after several years of poor performance.

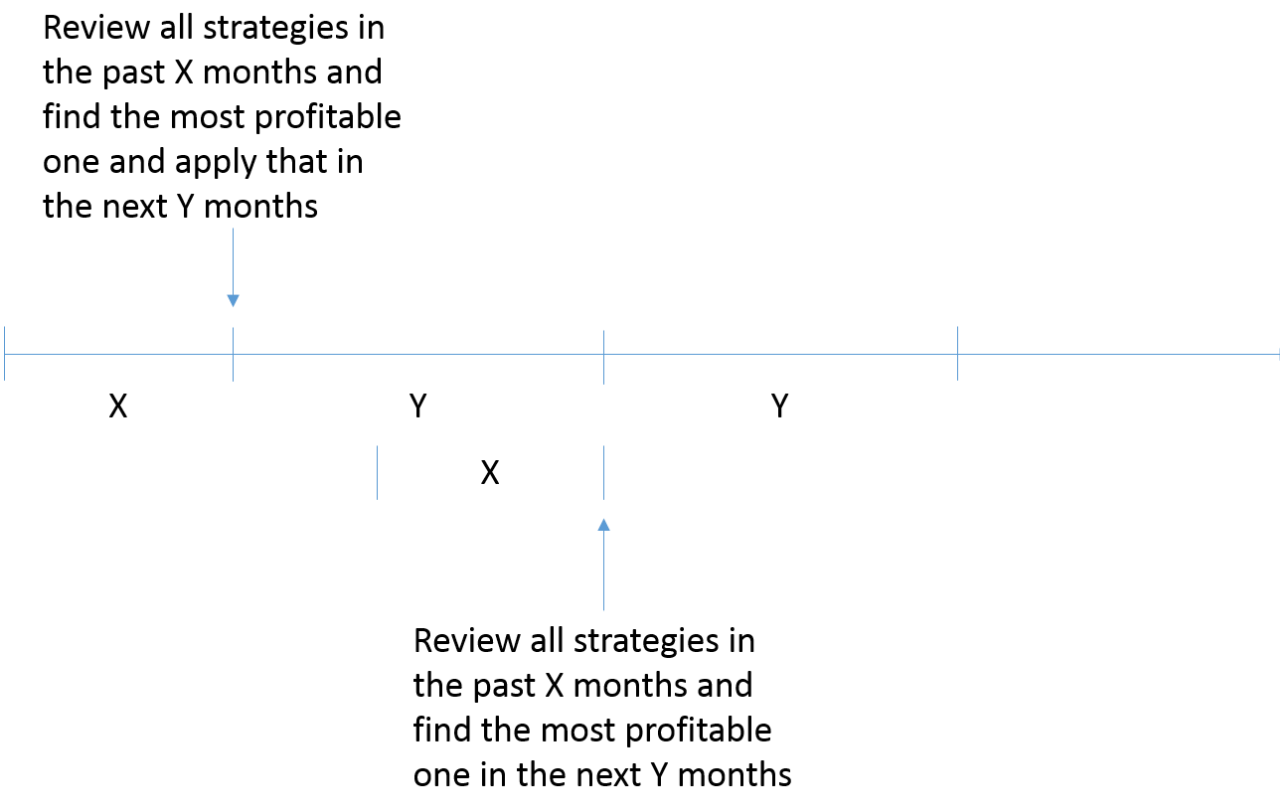
To test the robustness of our findings, we additionally included both learning strategies and stop-loss strategies into the strategy pool used in main analysis. The learning strategies allow for dynamic adjustment by applying the strategies with best performance in the past rebalancing horizon to the next rebalancing horizon. The stop-loss rules allow for closing positions when the strategy suffers from a certain loss and reactivating the strategy when the performance recovers to a certain level. We find that neither learning strategies nor stop-loss strategies help improve the out-of-sample sub-period performance of carry trades.

Our findings thus highlight the limitation in exploiting from carry trades in actual practice. While we corroborate previous findings that carry trades have been significantly profitable when considered over the whole period since the early 1980s, even after controlling for data-snooping bias, traders subject to performance review would have had difficulty in consistently applying a single carry-trade strategy over the whole period (because they would have encountered several years of loss during the whole period) and would have found it difficult to select profitable carry-trade strategies based on performance in previous years.

Appendix: the construction of learning strategies

In Tables 7 to 9, we describe the learning strategies. For each learning strategy, at the end of X months, it reviews the performance of all the strategies in the past X months and applies the most profitable strategy in the next Y months. At the end of X+Y months, it will again review the performance of all the strategies in the past X months, and apply the most profitable one in the next Y months from X+Y to X+2Y months.

The following graph illustrates the review and application of strategies. Although the length of X appears shorter than that of Y in this illustration, the length of X can be equal to or greater than that of Y in our tests.



For the set of 1-month strategies (i.e., the 1-month group), X equals 1, 2, 3, 4, 6, 12, 18, or 24, and Y equals 1, 2, 3, 4, 6, 12, 18, or 24, and the combination generates

8*8=64 learning strategies.

For the set of 3-month strategies (i.e., the 3-month group), X equals 3, 6, 12, 18, or 24, and Y equals 3, 6, 12, 18, or 24, and the combination generates 5*5=25 learning strategies.

For the set of 6-month strategies (i.e., the 6-month group), X equals 6, 12, 18, or 24, and Y equals 6, 12, 18, or 24, and the combination generates 4*4=16 learning strategies.

For the set of 12-month strategies (i.e., the 12-month group), X equals 12 or 24, and Y equals 12 or 24, and the combination generates 2*2=4 learning strategies.

When we include the learning strategies in our analyses for all 48 currencies, we have total 100, 200, 300, and 400 basic strategies in the 1-, 3-, 6-, and 12-month groups. When we add 64, 25, 16, and 4 learning strategies to those basic strategies, we have 164, 225, 316, and 404 carry-trade strategies to be tested in each group.

When we include the learning strategies in our analyses for the 16 developed market currencies, we have total 20, 40, 60, and 80 basic strategies in the 1-, 3-, 6-, and 12-month groups. When we add 64, 25, 16, and 4 learning strategies to those basic strategies, we have 84, 65, 76, and 84 carry-trade strategies to be tested in each group.

References

Allen, H. L., and M. P. Taylor. 1990. Charts, Noise and Fundamentals in the London Foreign Exchange Market. *Economic Journal* 100: 49-59.

Bajgrowicz, P., and O. Scaillet. 2012. Technical Trading Revisited: False Discoveries, Persistence Tests, and Transaction Costs. *Journal of Financial Economics* 106: 473-491.

Barras, L., O. Scaillet, and R. Wermers. 2010. False Discoveries in Mutual Fund Performance: Measuring Luck in Estimated Alphas. *Journal of Finance* 65: 179-216.

Blume, L., D. Easley, and M. O'Hara. 1994. Market Statistics and Technical Analysis: The Role of Volume. *Journal of Finance* 49: 153-181.

Brown, D. P., and R. H. Jennings. 1989. On Technical Analysis, *Review of Financial Studies* 2: 527-551.

Brunnermeier, M.K., Stefan Nagel and Lasse Pedersen "Carry Trades and Currency Crashes", *NBER Macroeconomics Annual* 2008, Vol. 23, pp. 313-347.

Burnside, C., M. Eichenbaum, and S. Rebelo. 2007. The Returns to Currency Speculation in Emerging Markets. *American Economic Review Papers and Proceedings* 97: 333-338.

Fama, Eugene F.,1984, Forward and spot exchange rates, Journal of Monetary Economics 14, 319–338.

Frankel, J. A., and K. A. Froot. 1990. Chartists, Fundamentalists, and Trading in the Foreign Exchange Market. *American Economic Review Papers and Proceedings* 80: 181-185.

Froot, K. A., and R. H. Thaler. 1990. Anomalies: Foreign Exchange. *Journal of Economic Perspectives* 4: 179-192.

Grossman, S.J., and J. E. Stiglitz. 1980. On the Impossibility of Informationally Efficient Markets. *American Economic Review* 70: 393-408.

Hansen, P. R. 2005. A Test for Superior Predictive Ability. *Journal of Business and Economic Statistics* 23: 365-380.

Henderson, C. 2002. *Currency Strategy: The Practitioner's Guide to Currency Investing, Hedging and Forecasting*. John Wiley and Sons, Chichester.

Hodrick, R. J., and S. Srivastava. 1986. The Covariation of Risk Premiums and Expected Future Spot Exchange Rates. *Journal of International Money and Finance* 5: S5-S21.

Hsu, P.-H., Y.-C. Hsu, and C.-M. Kuan. 2010. Testing the Predictive Ability of Technical Analysis Using A New Stepwise Test Without Data-snooping Bias. *Journal of Empirical Finance* 17: 471-484.

Hsu, P.-H., and C.-M. Kuan. 2005. Reexamining the Profitability of Technical Analysis with Data-snooping Checks. *Journal of Financial Econometrics* 3: 606-628.

Jensen, M. C., and G. A. Benington. 1970. Random Walks and Technical Theories: Some Additional Evidence. *Journal of Finance* 25: 469-482.

Kho, B. C. 1996. Time-varying Risk-premia, Volatility, and Technical Trading Rule Profits: Evidence from Foreign Currency Futures Markets. *Journal of Financial Economics* 41: 249-290.

Leamer, E. E. 1978. *Specification Searches: Ad Hoc Inference with Nonexperimental Data.* John Wiley and Sons, New York, NY.

Leamer, E. E. 1983. Let's Take the Con Out of Econometrics. *American Economic Review* 73: 31-43.

LeBaron, B. 1999. Technical Trading Rule Profitability and Foreign Exchange Intervention. *Journal of International Economics* 49: 125-143.

LeBaron, B. 2002. Technical Trading Profitability in Foreign Exchange Markets in the 1990s, Working Paper, Brandeis University.

Lequeux, P., and E. Acar. 1998. A Dynamic Index for Managed Currencies Funds Using CME Currency Contracts. *European Journal of Finance* 4: 311-330.

Levich, R. M., and L. R. Thomas. 1993. The Significance of Technical Trading-rule Profits in the Foreign Exchange Market: A Bootstrap Approach. *Journal of International Money and Finance* 12: 451-474.

Levy, R. A. 1967. Relative Strength as a Criterion for Investment Selection. *Journal of Finance* 22: 595-610.

Lo, A. W. 2004. The Adaptive Markets Hypothesis: Market Efficiency from an Evolutionary Perspective. *Journal of Portfolio Management* 30: 15-29.

Lo, A. W., and A. C. MacKinlay. 1990. Data-snooping Biases in Tests of Financial Asset Pricing Models. *Review of Financial Studies* 3: 431-467.

Lustig, H.; N. Roussanov; and A. Verdelhan. "Countercyclical Currency Risk Premia and the Dollar Carry Trades." *Journal of Financial Economics*, 111 (2014), 527-553.

Lustig, H., and A. Verdelhan. "The Cross Section of Foreign Currency Risk Premia and Consumption Growth Risk." *American Economic Review*, 97 (2007), 89–117.

Lyons, R. K. 2001. *The Microstructure Approach to Exchange Rates.* MIT Press, Cambridge, MA.

McLean, R. D., and J. Pontiff. 2016. Does Academic Research Destroy Stock Return Predictability? *Journal of Finance* 71: 5-32.

Melvin, M., and M. P. Taylor. 2009. The Crisis in the Foreign Exchange Market. *Journal of International Money and Finance* 28: 1317-1330.

Menkhoff, L., and M. P. Taylor. 2007. The Obstinate Passion of Foreign Exchange Professionals: Technical Analysis. *Journal of Economic Literature* 45: 936-972.

Menkhoff, L., Sarno, L., Schmeling, M., & Schrimpf, A. (2012a). Carry Trades and Global Foreign Exchange Volatility. *The Journal of Finance*, 67(2), 681-718.

Menkhoff, L., Sarno, L., Schmeling, M., & Schrimpf, A. (2012b). Currency Momentum Strategies. *Journal of Financial Economics*, 106(3), 660-684.

Menkhoff, L., Sarno, L., Schmeling, M., and Schrimpf, A. (2016). Currency Value. *Review of Financial Studies*, 30(2), 416-441.

Neely, C. J. 2002. The Temporal Pattern of Trading Rule Returns and Exchange Rate Intervention: Intervention Does Not Generate Technical Trading Profits. *Journal of International Economics* 58: 211-232.

Neely, C. J., P. A. Weller, and R. Dittmar. 1997. Is Technical Analysis Profitable in the Foreign Exchange Market? A Genetic Programming Approach. *Journal of Financial and Quantitative Analysis* 32: 405-436.

Neely, C. J., and P. A. Weller. 2001. Technical Analysis and Central Bank Intervention. *Journal of International Money and Finance* 20: 949-970.

Neely, C. J., and P. A. Weller. 2003. Intraday Technical Trading in the Foreign Exchange Market. *Journal of International Money and Finance* 22: 223-237.

Neely, C.J., and P.A. Weller, P.A. 2012. Technical Analysis in the Foreign Exchange Market. In: J. James, I.W. Marsh and L. Sarno, (Eds). *Handbook of Exchange Rates*. John Wiley, Hoboken, NJ, John Wiley: 343-374.

Neely, C. J., and P. A. Weller. 2013. Lessons from the Evolution of Foreign Exchange Trading Strategies. *Journal of Banking & Finance*, 37: 3783-3798.

Neely, C. J., P. A. Weller, and M. Ulrich. 2009. The Adaptive Markets Hypothesis: Evidence from the Foreign Exchange Market. *Journal of Financial and Quantitative Analysis* 44: 467-488.

Olson, D., 2004. Have Trading Rule Profits in the Currency Markets Declined Over Time? *Journal of Banking and Finance* 28: 85-105.

Politis, D. N., and J. P. Romano. 1994. The Stationary Bootstrap. *Journal of the American Statistical Association* 89: 1303-1313.

Qi, M., and Y. Wu. 2006. Technical Trading-rule Profitability, Data Snooping, and Reality Check: Evidence from the Foreign Exchange Market. *Journal of Money, Credit and Banking* 30: 2135-2158.

Romano, J. P., and M. Wolf. 2005. Stepwise Multiple Testing as Formalized Data Snooping, *Econometrica* 73: 1237-1282.

Sager, M. J., and M. P. Taylor. 2006. Under the Microscope: The Structure of the Foreign Exchange Market. *International Journal of Finance and Economics* 11: 81-95.

Sager, M. J., and M. P. Taylor. 2008. Commercially Available Order Flow Data and Exchange Rate Movements: Caveat Emptor. *Journal of Money, Credit and Banking* 40: 583-625.

Schwert, G. W. 2003. Anomalies and Market Efficiency, In: Constantinides, G. M., M. Harris, and R. M. Stulz (Eds.) *Handbook of the Economics of Finance*. Elsevier, Amsterdam: 937-972.

Sharpe, W. F. 1966. Mutual Fund Performance. *Journal of Business* 39: 119-138.

Sullivan, R., A. Timmermann, and H. White. 1999. Data Snooping, Technical Trading Rule Performance, and the Bootstrap. *Journal of Finance* 54: 1647-1691.

Taylor, M. P., and H. L. Allen. 1992. The Use of Technical Analysis in the Foreign Exchange Market. *Journal of International Money and Finance* 11: 304-314.

Timmermann, A. 2008. Elusive Return Predictability. *International Journal of Forecasting* 24: 1-18.

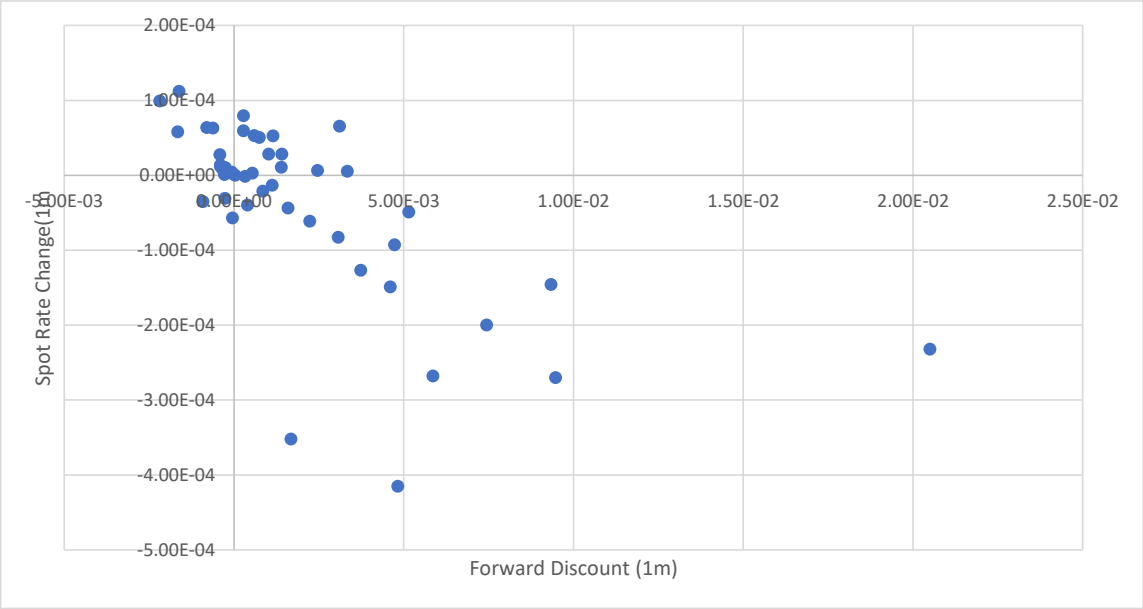
Timmermann, A., and C. W. J. Granger. 2004. Efficient Market Theory and Forecasting. *International Journal of Forecasting* 20: 15-27.

White, H. 2000. A Reality Check for Data Snooping. *Econometrica* 68: 1097-1126.

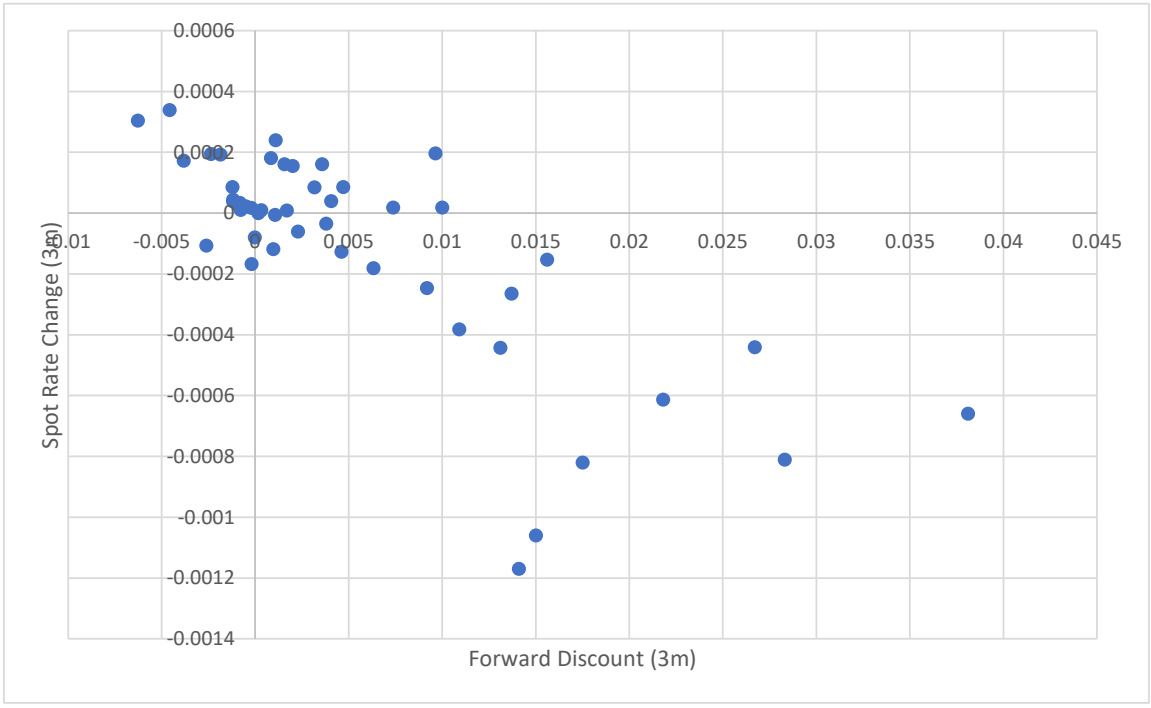
Figure 1: 4 panels for the spot rate change (Y-axis) and 1-, 3-, 6-, and 12-month forward discounts (X-axis)

Using the spot exchange rates and 1-3, 3-, 6-, and 12-month forward rates (against the US dollar) of 48 currencies, we plot each currency's 1-, 3-, 6-, and 12-month spot exchange rate change along the vertical axis and the currency's 1-, 3-, 6-, or 12-month forward discount along the horizontal axis in Panels A, B, C, and D, respectively. We use end-of-month data of spot and forward rates of 1, 3, 6, and 12 months.

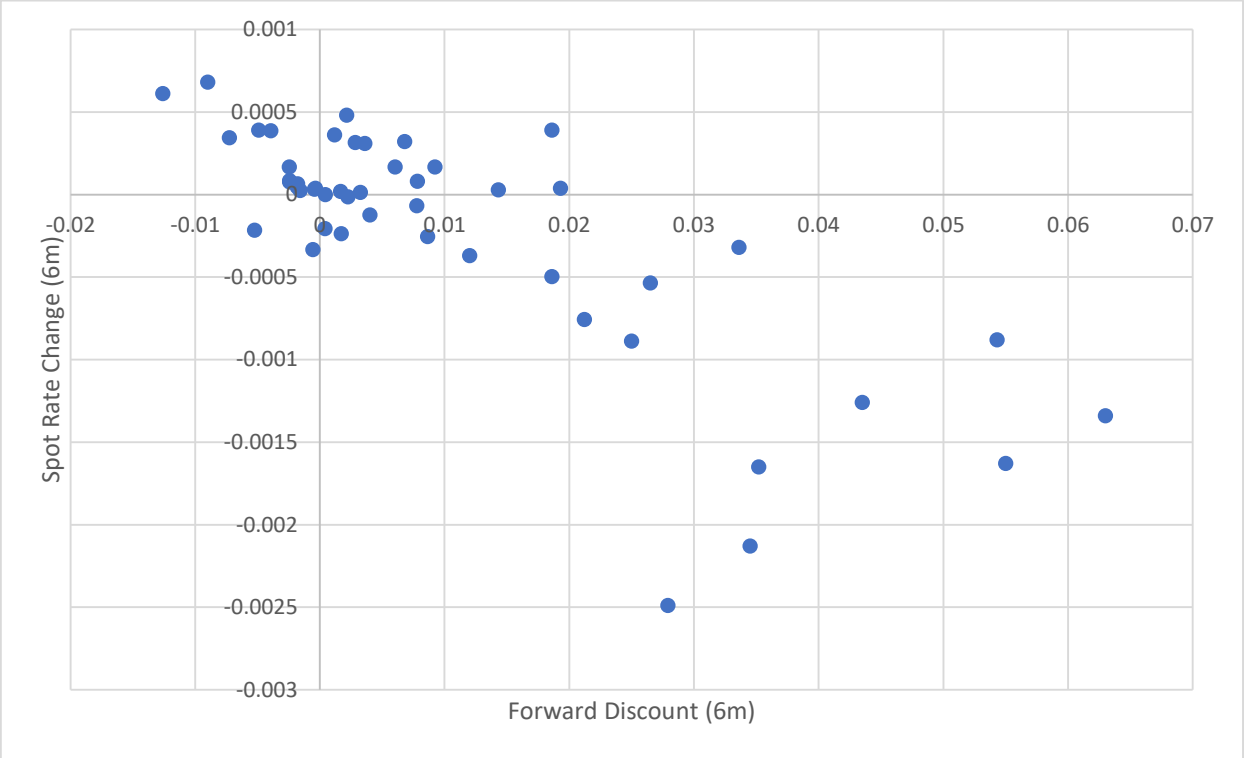
Panel A



Panel B



Panel C



Panel D

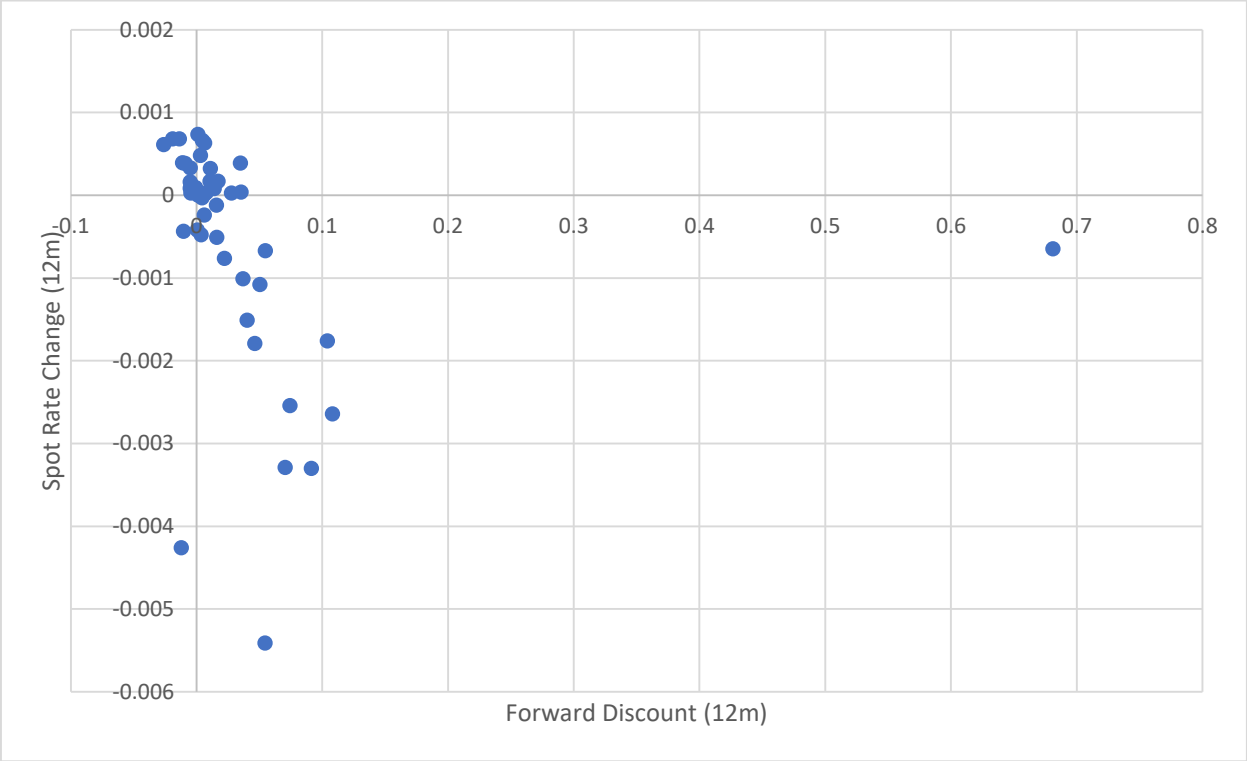
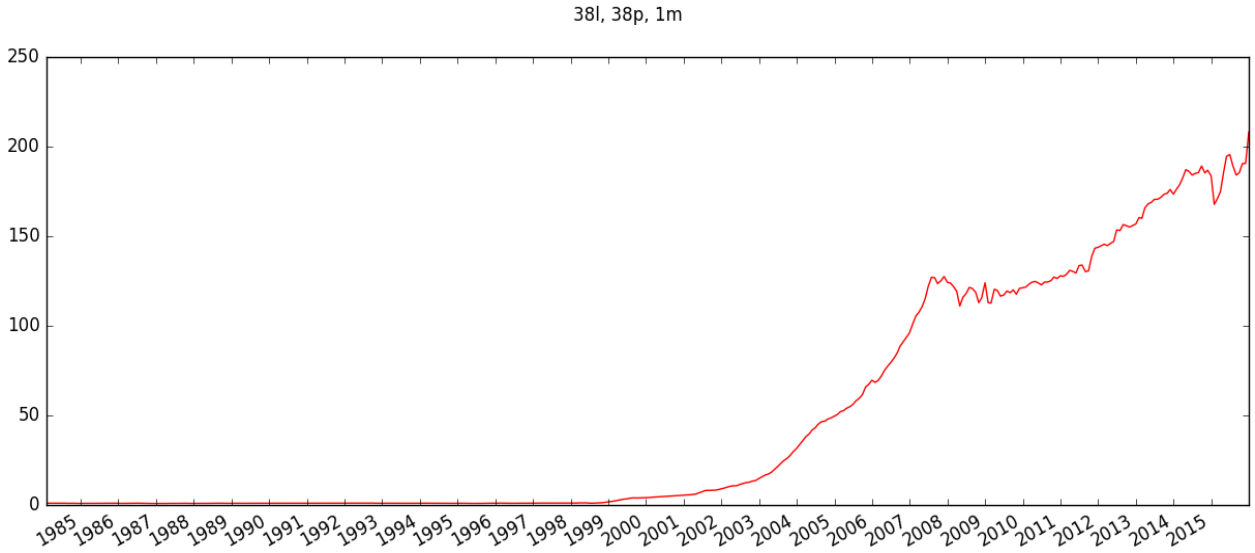


Figure 2: Cumulative value of $1 investment in the best strategy based on mean returns and Sharpe ratios: all currencies

Panel A: the strategy (38l, 38p, 1m)

Panel A shows the cumulative value of $1 invested in the strategy (38l, 38p, 1m) from the beginning of our sample period. Panel B shows the cumulative value of $1 invested in the strategy (18l, 3p, 1m) from the beginning of our sample period. These two strategies are the best-performing strategies based on mean return and Sharpe ratio, respectively, from Table 3.



Panel B: the strategy (18l, 3p, 1m)

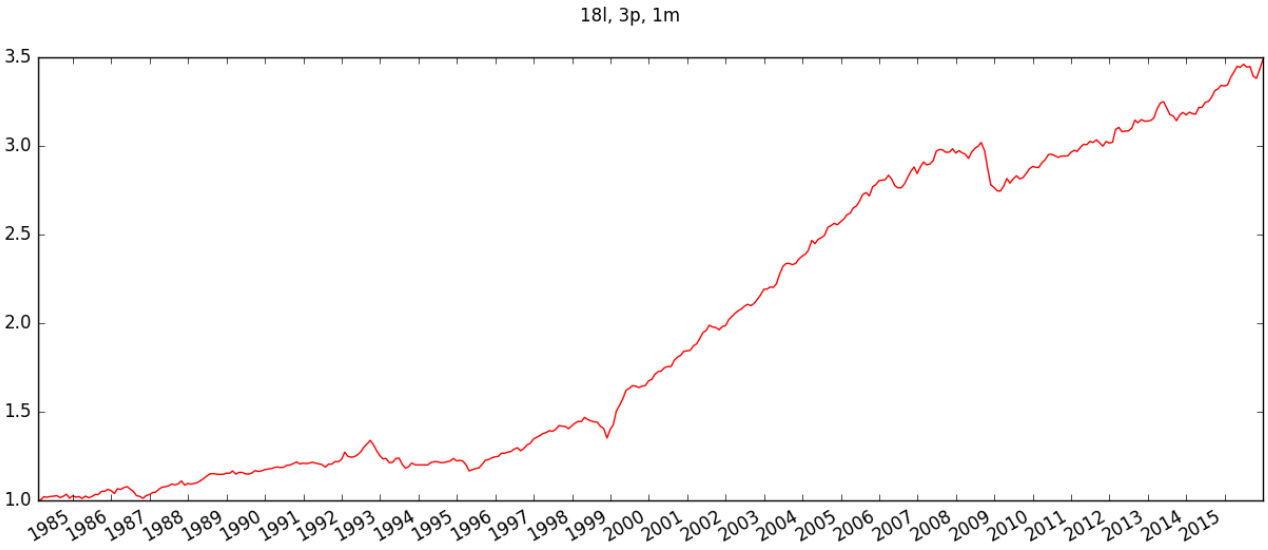
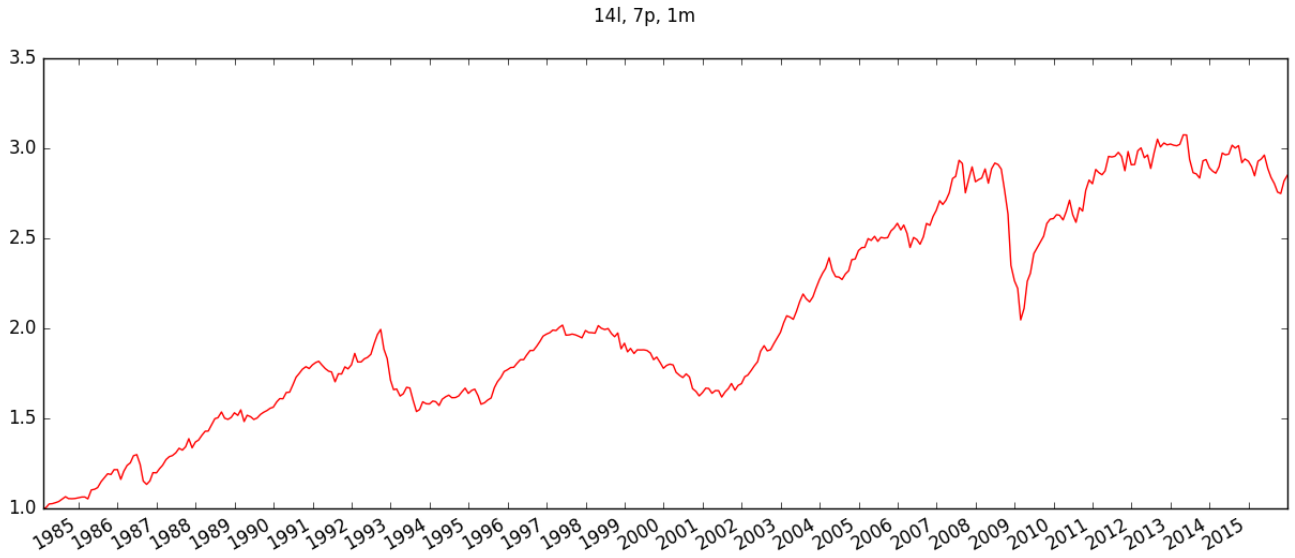


Figure 3: Cumulative value of $1 investment in the best strategy based on mean returns and Sharpe ratios: developed currencies

Panel A shows the cumulative value of $1 invested in the strategy (14l, 7p, 1m) from the beginning of our sample period. Panel B shows the cumulative value of $1 invested in the strategy (12l, 5p, 1m) from the beginning of our sample period. These two strategies are the best-performing strategies based on mean return and Sharpe ratio, respectively, from Table 4.

Panel A: the strategy (14l, 7p, 1m)



Panel B: the strategy (12l, 5p, 1m)

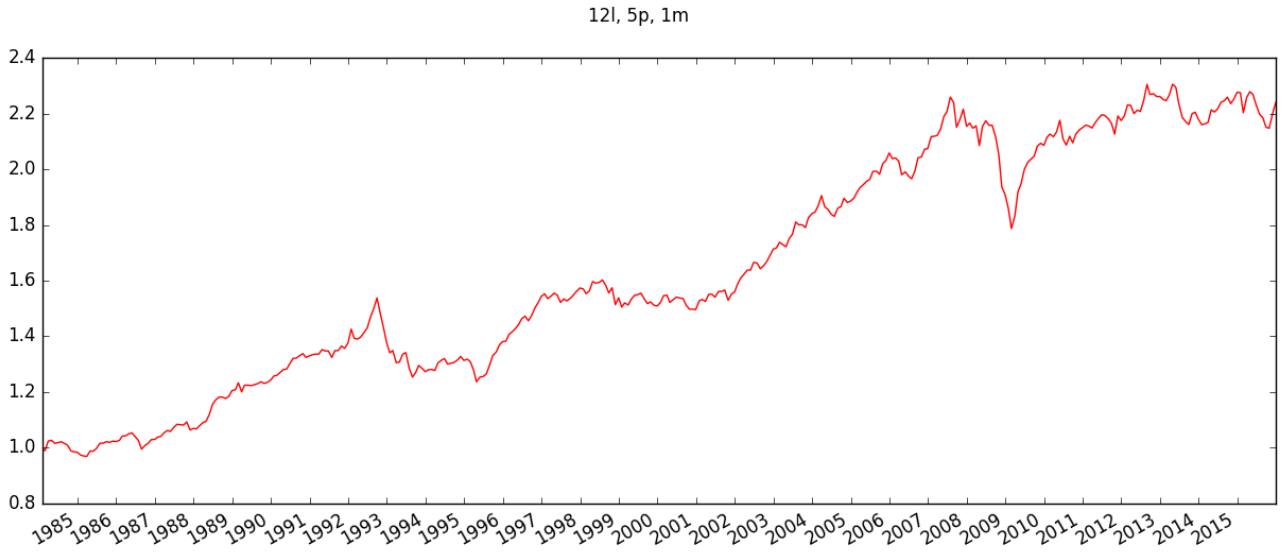
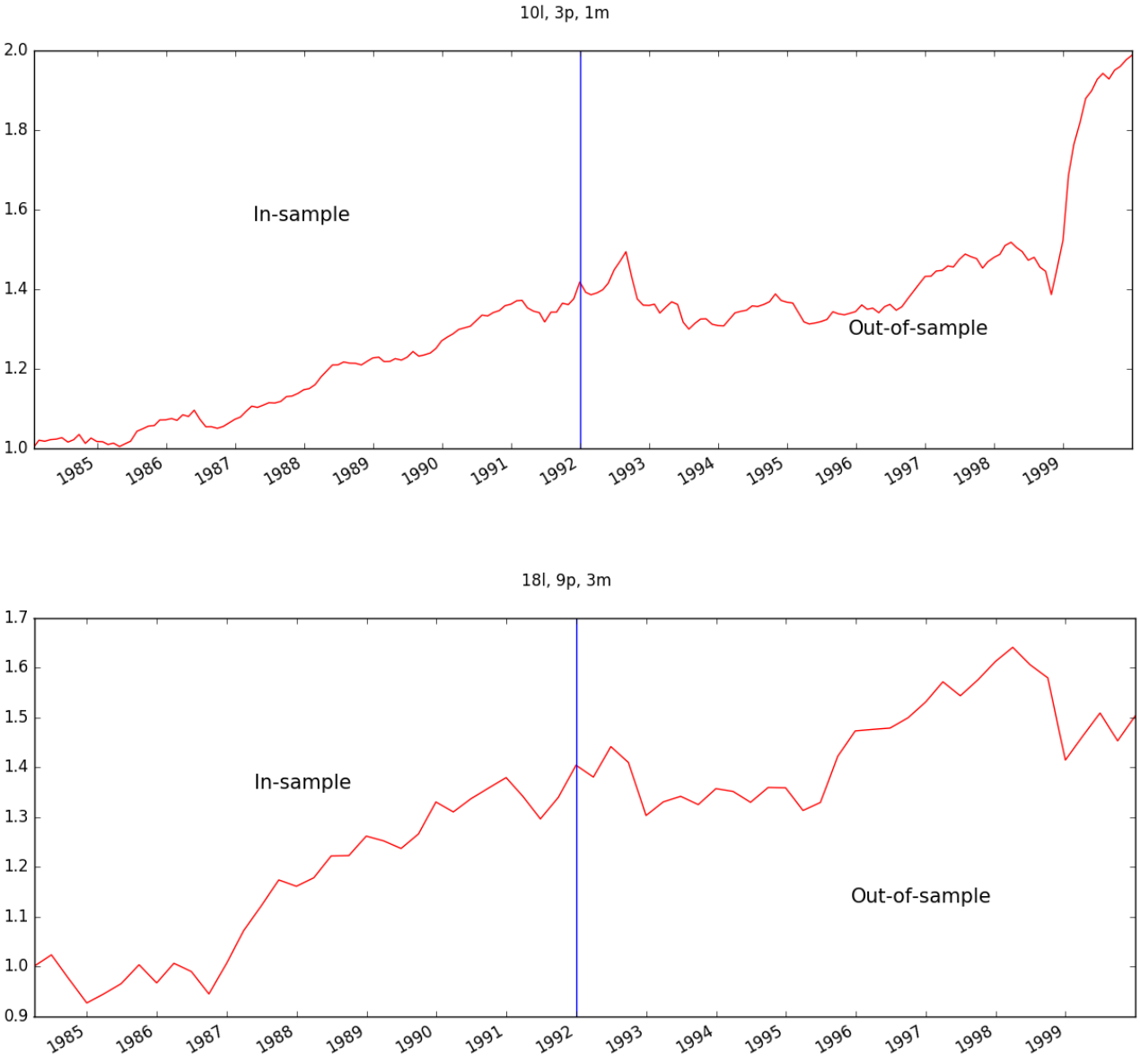


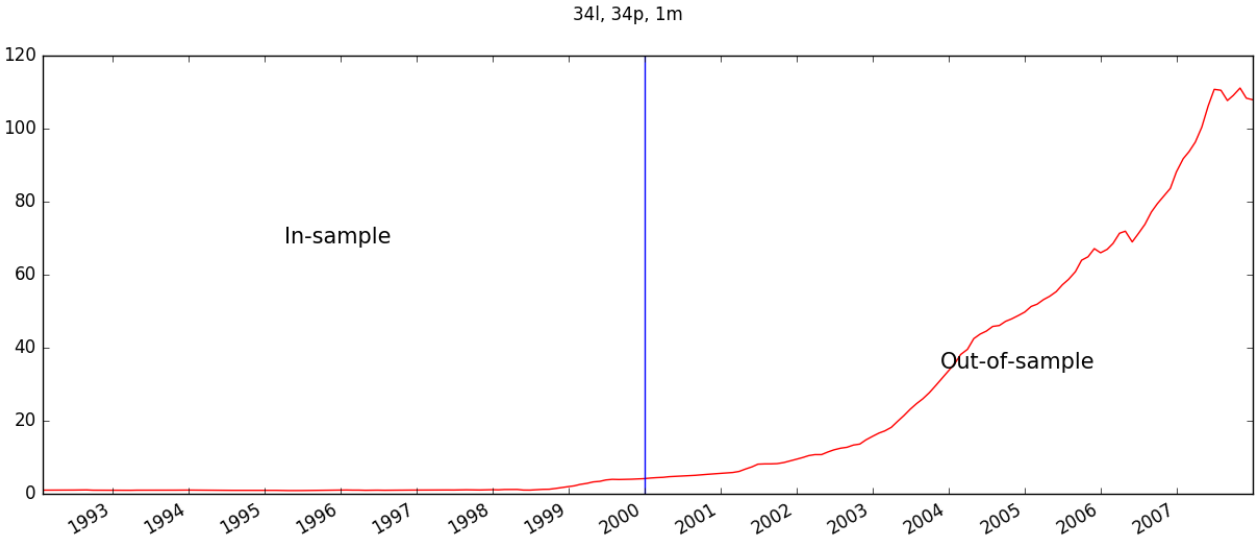
Figure 4: Cumulative value of $1 investment in the best strategy identified in the in-sample period and its performance in the out-of-sample period: all currencies

Panels A, B, and C of Figure 4 are the cumulative value of $1 invested in the best strategies in the first columns of Panels A, B, and C of Table 5, respectively, from the beginning of respective in-sample period.

Panel A: In-sample period is 1984-1991, and out-of-sample period is 1992-1999



Panel B: In-sample period is 1992-1999, and out-of-sample period is 2000-2007



Panel C: In-sample period is 2000-2007, and out-of-sample period is 2008-2015

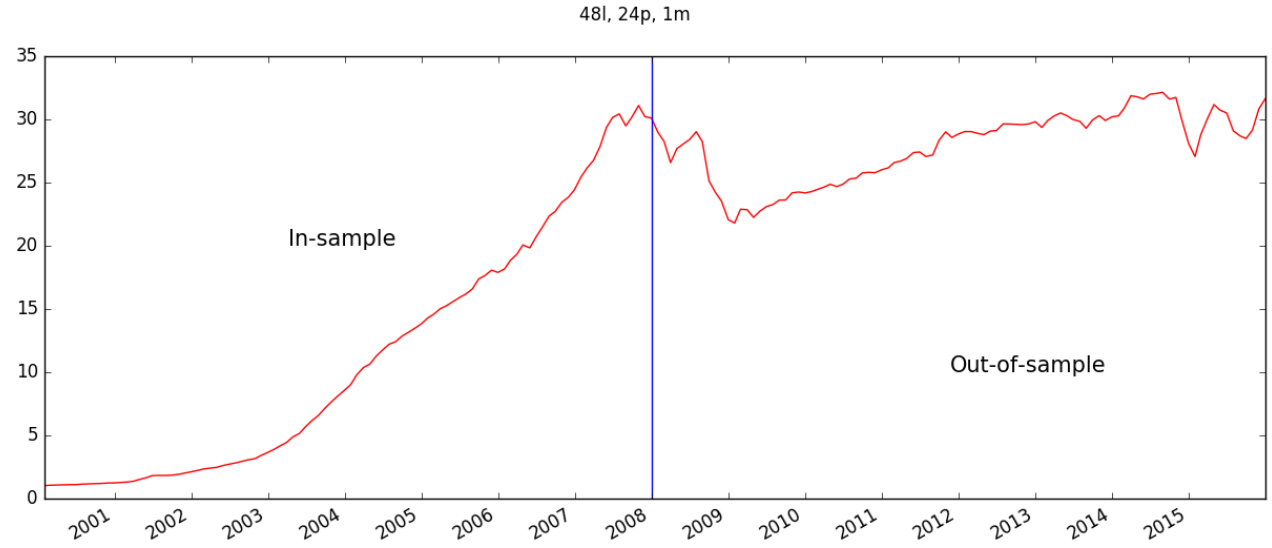
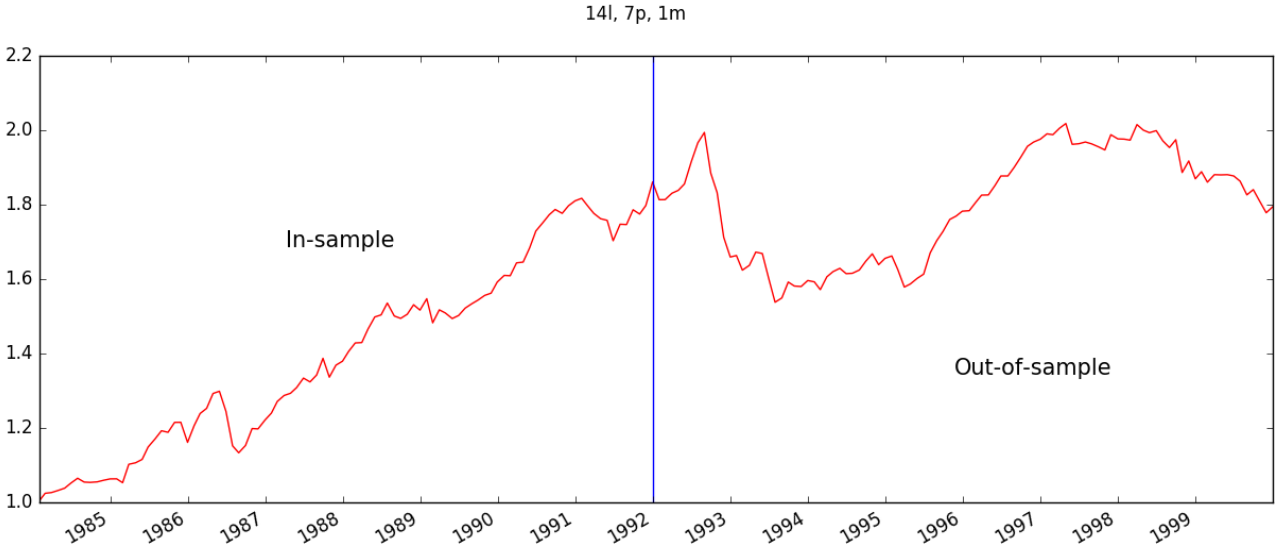


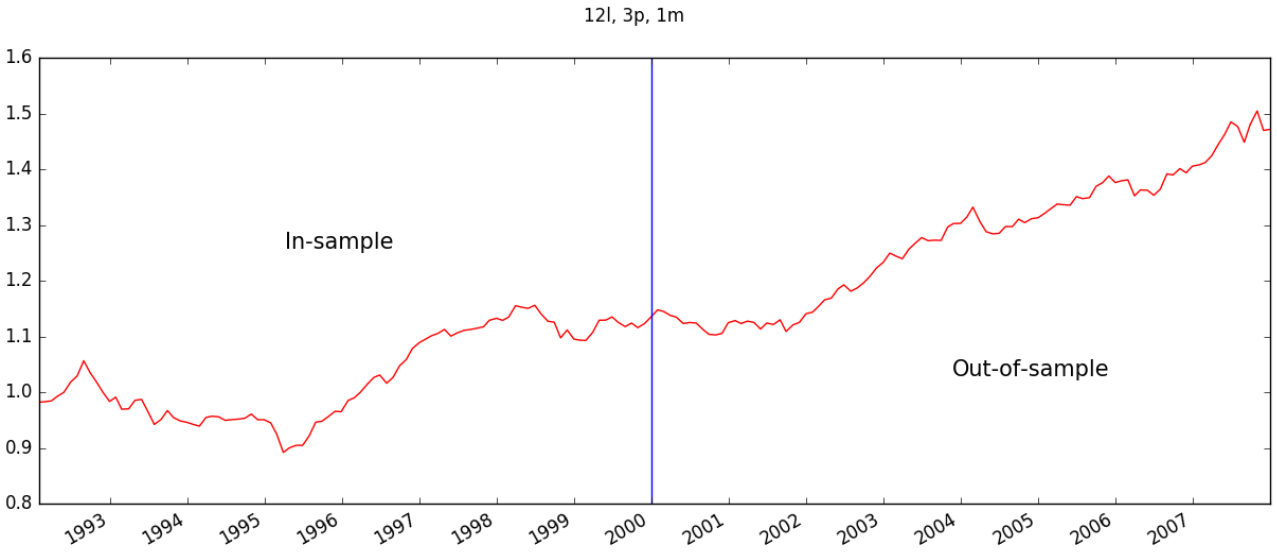
Figure 5: Cumulative value of $1 investment in the best strategy identified in the in-sample period and its performance in the out-of-sample period: developed currencies

Panels A, B, and C of Figure 5 are the cumulative value of $1 invested in the best strategies in the first columns of Panels A, B, and C of Table 6, respectively, from the beginning of respective in-sample period.

Panel A: In-sample period is 1984-1991, and out-of-sample period is 1992-1999



Panel B: In-sample period is 1992-1999, and out-of-sample period is 2000-2007



Panel C: In-sample period is 2000-2007, and out-of-sample period is 2008-2015

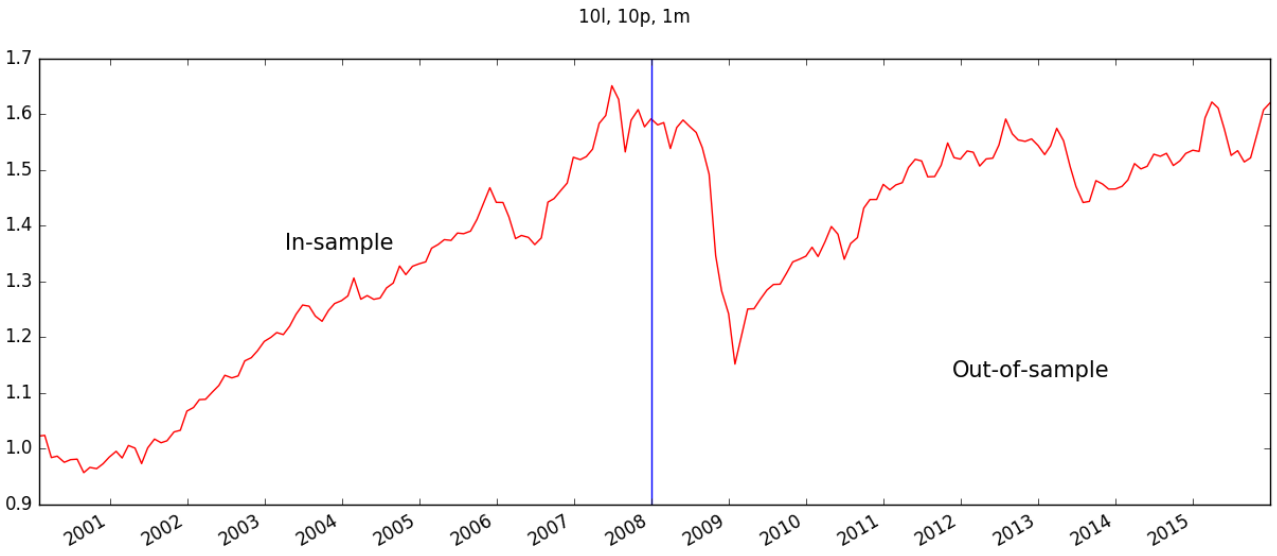


Table 1: Summary Statistics of the Level of Spot and Forward Rates

We list the sample mean, minimum, maximum, standard deviation, and the available sample period of end-of-month monthly spot exchange rate, 1-month, 3-month, 6-month, and 12-month forward exchange rates of 48 currencies (against the US dolloar). The data are based on midday quotations in the London market. Panel A includes 16 developed market currencies, and Panel B includes 32 emerging currencies.

	Spot Rate				1-month Forward Rate				3-month Forward Rate				6-month Forward Rate				12-month Forward Rate				
	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Sample Period
Australia	1.35	2.07	0.908	0.231	1.36	2.07	0.911	0.231	1.36	2.07	0.918	0.231	1.37	2.07	0.929	0.23	1.39	2.08	0.918	0.231	12/14/1984-01/29/2016
Austria	11.5	16.6	8.61	1.72	11.6	16.6	8.62	1.8	11.6	16.5	8.65	1.8	11.6	16.5	8.69	1.79	11.6	16.5	8.76	1.78	12/31/1996-01/29/2016
Belgium	33.7	48.7	25.2	5.06	34.1	48.6	25.3	5.28	34.1	48.5	25.3	5.27	34	48.3	25.5	5.25	33.9	48.3	25.7	5.21	12/31/1996-01/29/2016
Canada	1.26	1.61	0.917	0.169	1.26	1.61	0.916	0.169	1.26	1.61	0.916	0.169	1.27	1.61	0.916	0.168	1.27	1.62	0.917	0.168	12/14/1984-01/29/2016
Denmark	6.53	12.4	4.66	1.18	6.53	12.4	4.67	1.18	6.53	12.4	4.68	1.18	6.54	12.4	4.7	1.19	6.55	12.4	4.73	1.19	12/14/1984-01/29/2016
Europe	0.841	1.21	0.625	0.137	0.84	1.21	0.626	0.137	0.84	1.2	0.627	0.137	0.839	1.2	0.63	0.136	0.837	1.2	0.635	0.135	01/05/1999-01/29/2016
France	5.83	10.6	4.1	1.11	6.19	10.6	4.77	1.22	6.21	10.6	4.78	1.23	6.23	10.6	4.78	1.24	6.26	10.7	4.78	1.26	10/11/1983-12/31/1998
Germany	1.75	3.45	1.22	0.387	1.87	3.44	1.35	0.455	1.87	3.42	1.35	0.449	1.86	3.39	1.34	0.439	1.85	3.32	1.33	0.42	10/11/1983-12/31/1998
Italy	1.57e+03	2.34e+03	1.06e+03	254	1.51e+03	2.15e+03	1.08e+03	226	1.52e+03	2.17e+03	1.1e+03	225	1.53e+03	2.2e+03	1.12e+03	224	1.55e+03	2.24e+03	1.15e+03	223	05/02/1984-12/31/1998
Japan	124	263	75.7	254	123	262	75.7	36.6	123	261	75.6	36.4	122	259	75.4	36.1	120	254	75.1	35.3	10/11/1983-01/29/2016
Netherlands	1.97	3.91	1.38	0.438	2.11	3.9	1.51	0.516	2.1	3.89	1.51	0.51	2.1	3.86	1.5	0.501	2.08	3.8	1.49	0.482	10/11/1983-12/31/1998
New Zealand	1.64	2.55	1.13	0.305	1.65	2.55	1.14	0.306	1.66	3.7	1.14	0.31	1.67	3.69	1.15	0.314	1.7	3.66	1.18	0.319	12/14/1984-01/29/2016
Norway	6.86	9.83	4.95	0.965	6.87	9.85	4.96	0.969	6.89	9.9	4.99	0.976	6.92	9.94	5.03	0.985	6.98	9.99	5.1	1	12/14/1984-01/29/2016
Sweden	7.37	11	5.08	1.13	7.38	11	5.14	1.13	7.39	11	5.23	1.12	7.41	11	5.35	1.11	7.44	11.1	5.57	1.09	12/14/1984-01/29/2016
Switzerland	1.38	2.92	0.729	0.37	1.38	2.91	0.728	0.368	1.38	2.89	0.726	0.364	1.37	2.86	0.725	0.359	1.35	2.79	0.745	0.347	10/11/1983-01/29/2016
United Kingdom	0.622	0.95	0.474	0.0657	0.623	0.954	0.474	0.0657	0.624	0.961	0.475	0.0656	0.627	0.965	0.477	0.0654	0.63	0.968	0.48	0.0647	10/11/1983-01/29/2016

	Spot Rate				1-month Forward Rate				3-month Forward Rate				6-month Forward Rate				12-month Forward Rate				
	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Sample Period
Brazil	2.01	4.21	0.826	0.714	2.23	4.25	1.54	0.534	2.26	4.34	1.55	0.551	2.31	4.48	1.58	0.576	2.48	4.69	1.66	0.597	07/11/2000-01/29/2016
Bulgaria	1.64	2.35	1.22	0.264	1.5	1.86	1.23	0.124	1.5	1.85	1.23	0.122	1.5	1.84	1.24	0.119	1.51	1.83	1.26	0.111	04/07/2004-01/29/2016
Croatia	6.28	9.09	4.52	1.02	5.71	7.26	4.53	0.528	5.72	7.26	4.55	0.522	5.74	7.26	4.59	0.514	5.79	7.26	4.65	0.502	03/29/2004-01/29/2016
Cyprus	0.491	0.689	0.366	0.0736	0.447	0.556	0.367	0.0364	0.447	0.556	0.368	0.0362	0.447	0.555	0.369	0.0359	0.447	0.552	0.372	0.0351	03/29/2004-01/29/2016
Czech	25.7	42	14.5	6.67	25.6	42	14.5	7.04	25.6	41.9	14.5	7.11	25.7	41.8	14.5	7.2	25.8	41.7	14.6	7.39	12/31/1996-01/29/2016
Egypt	5.18	8.03	3.38	1.35	6.21	8.5	5.29	0.758	6.32	9.2	5.31	0.845	6.5	9.82	5.38	0.957	6.82	10.6	5.46	1.13	03/29/2004-01/29/2016
Finland	4.99	7.17	3.72	0.747	5.02	7.16	3.73	0.777	5.02	7.14	3.74	0.775	5.01	7.12	3.75	0.773	5	7.12	3.78	0.767	12/31/1996-01/29/2016
Greece	279	410	213	43.7	286	410	213	43.8	286	410	214	44	286	408	215	44.2	287	408	217	44.4	12/31/1996-01/29/2016
Hong Kong	7.77	8.32	7.7	0.0299	7.77	8.77	7.69	0.0341	7.77	9.72	7.61	0.06	7.77	11	7.51	0.0958	7.77	10.3	7.42	0.0973	10/11/1983-01/29/2016
Hungary	210	317	99.3	46.8	226	318	145	34.5	227	321	146	34.8	230	325	148	35.2	235	331	151	35.8	10/27/1997-01/29/2016
Iceland	93.8	148	58.5	25	102	149	58.8	27.3	103	150	59.4	27.4	104	151	60.2	27.6	107	159	61.9	27.7	03/29/2004-01/29/2016
India	45.7	68.2	31.4	8.39	48.4	68.7	36.2	6.98	48.8	69.7	36.3	7.19	49.3	70.9	36.3	7.48	50.3	73	36.4	8.04	10/27/1997-01/29/2016
Indonesia	8.38e+03	1.66e+04	2.1e+03	3.13e+03	9.52e+03	1.71e+04	2.37e+03	2.11e+03	9.68e+03	1.83e+04	2.4e+03	2.17e+03	9.92e+03	2e+04	2.43e+03	2.27e+03	1.03e+04	2.21e+04	2.51e+03	2.5e+03	12/31/1996-01/29/2016
Ireland	0.67	1.11	0.492	0.102	0.657	0.737	0.591	0.0364	0.657	0.737	0.592	0.0367	0.658	0.736	0.592	0.0368	0.657	0.735	0.592	0.0357	10/29/1993-12/31/1998
Israel	3.88	5	2.94	0.493	3.93	4.73	3.22	0.362	3.93	4.73	3.22	0.362	3.93	4.73	3.23	0.362	3.94	4.74	3.26	0.364	03/29/2004-01/29/2016
Kuwait	0.293	0.309	0.264	0.0108	0.293	0.309	0.264	0.0114	0.293	0.309	0.263	0.0116	0.293	0.31	0.261	0.0118	0.294	0.312	0.257	0.0123	12/31/1996-01/29/2016
Malaysia	3.44	5.43	2.44	0.567	3.58	4.72	2.47	0.41	3.62	4.75	2.48	0.441	3.69	4.83	2.48	0.502	3.78	4.96	2.5	0.575	12/31/1996-01/29/2016
Mexico	10.6	18.6	3.1	2.74	11.4	18.7	7.8	1.99	11.5	18.7	7.96	1.95	11.7	18.9	8.2	1.9	12.1	19.1	8.62	1.81	12/31/1996-01/29/2016
Philippines	43.3	56.4	23.4	9.07	46.1	56.8	26.3	6.43	46.4	57.5	26.4	6.5	46.8	58.6	26.6	6.63	47.7	60.7	26.9	6.98	12/31/1996-01/29/2016
Poland	3.33	4.71	2.03	0.561	3.26	4.25	2.03	0.473	3.27	4.31	2.04	0.48	3.29	4.39	2.06	0.491	3.33	4.52	2.09	0.508	02/11/2002-01/29/2016
Portugal	168	242	125	25	169	242	126	26.2	169	241	126	26.2	169	240	127	26.1	169	240	128	25.9	12/31/1996-01/29/2016
Russia	28.1	84.1	4.82	12	33	84.8	23.1	10.6	33.3	86.1	23.2	11	33.9	88.4	23.3	11.5	34.9	92.2	23.6	12.5	03/29/2004-01/29/2016
Saudi Arabia	3.75	3.77	3.71	0.00213	3.75	3.77	3.69	0.00335	3.75	3.78	3.67	0.00628	3.75	3.8	3.65	0.0107	3.75	3.85	3.61	0.0208	12/31/1996-01/29/2016
Singapore	1.63	2.31	1.2	0.265	1.63	2.3	1.2	0.264	1.62	2.29	1.2	0.262	1.62	2.27	1.19	0.258	1.61	2.23	1.19	0.253	12/14/1984-01/29/2016
Slovakia	30.9	52.5	19	8.97	27.2	48.8	19	6.67	27.3	49.3	19	6.78	27.3	49.9	19	6.93	27.4	50.9	19.2	7.18	02/11/2002-01/29/2016
Slovenia	192	261	150	24.8	184	228	150	15.2	184	227	151	15.1	184	227	151	14.9	308	362	245	30.3	03/29/2004-01/29/2016
South Africa	5.77	16.9	1.11	3.04	5.84	19.1	1.12	3.09	5.96	36.9	1.13	3.22	6.14	65.1	1.15	3.45	6.35	20.1	1.16	3.56	10/11/1983-01/29/2016
South Korea	1.09e+03	1.96e+03	756	174	1.11e+03	1.57e+03	899	110	1.11e+03	1.56e+03	896	110	1.11e+03	1.55e+03	894	110	1.11e+03	1.51e+03	893	111	02/11/2002-01/29/2016
Spain	139	201	104	20.8	141	200	104	21.7	141	200	105	21.7	140	199	105	21.7	140	199	106	21.5	12/31/1996-01/29/2016
Taiwan	31.2	35.2	25.1	2.46	31.9	35.4	27.3	1.85	31.8	35.7	27.3	1.86	31.7	36.3	27.3	1.89	31.6	36.9	27.4	1.95	12/31/1996-01/29/2016
Thailand	34.8	56.5	23.9	6.01	36.4	57.2	24.9	4.99	36.5	58.5	25.5	5.03	36.6	60.6	25.7	5.11	36.9	64.8	26.1	5.29	12/31/1996-01/29/2016
Ukraine	7.44	33	3.68	4.3	8.45	33.1	4.54	4.64	8.57	33.4	4.62	4.72	8.71	33.5	4.73	4.71	7.44	13.1	4.91	1.75	04/07/2004-01/29/2016

Table 2: Summary Statistics of the Change of Spot and Forward Rates

We list the sample mean, minimum, maximum, standard deviation, and the available sample period of the change in end-of-month spot exchange rates and the change in end-of-month 1-month forward exchange rates of 48 currencies (against the US dolloar). The data are based on midday quotations in the London market. Panel A includes 16 developed market currencies, and Panel B includes 32 emerging currencies.

	1-month Forward Discount				1-month Spot Rate Change				
	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Sample Period
Europe	-0.000287	0.00808	-0.0182	0.00129	1.03e-06	0.0434	-0.0252	0.00628	01/05/1999-01/29/2016
Canada	0.000539	0.00907	-0.00763	0.00139	2.93e-06	0.0589	-0.0317	0.00457	12/14/1984-01/29/2016
Italy	0.00334	0.0251	-0.01	0.00277	5.29e-06	0.052	-0.0641	0.00642	03/09/1984-12/31/1998
Australia	0.00246	0.0257	-0.0141	0.00249	6.19e-06	0.0642	-0.0802	0.00734	12/14/1984-01/29/2016
United Kingdom	0.00139	0.0205	-0.0154	0.0019	1.08e-05	0.0575	-0.0379	0.00607	10/11/1983-01/29/2016
Austria	-0.000403	0.022	-0.00681	0.00117	1.18e-05	0.0472	-0.0377	0.00618	01/03/1994-01/29/2016
Belgium	-0.000401	0.0219	-0.00682	0.00117	1.34e-05	0.0472	-0.0377	0.00615	12/31/1996-01/29/2016
Sweden	0.00102	0.0515	-0.0191	0.00286	2.81e-05	0.0637	-0.0584	0.00696	12/14/1984-01/29/2016
Norway	0.00141	0.0325	-0.072	0.00295	2.83e-05	0.0676	-0.0661	0.00706	12/14/1984-01/29/2016
France	0.00115	0.0249	-0.0162	0.00267	5.27e-05	0.0596	-0.0358	0.00648	10/11/1983-12/31/1998
Netherlands	-0.000625	0.0216	-0.0175	0.00282	6.3e-05	0.0577	-0.0302	0.00652	10/11/1983-12/31/1998
Germany	-0.000808	0.0295	-0.017	0.00293	6.38e-05	0.0603	-0.0299	0.00655	10/11/1983-12/31/1998
New Zealand	0.00311	0.0698	-0.016	0.00345	6.56e-05	0.0653	-0.0792	0.00772	12/14/1984-01/29/2016
Denmark	0.000278	0.0246	-0.0136	0.00261	7.95e-05	0.0593	-0.0294	0.00647	12/14/1984-01/29/2016
Japan	-0.00219	0.0279	-0.0457	0.00235	9.93e-05	0.0565	-0.0335	0.00664	10/11/1983-01/29/2016
Switzerland	-0.00162	0.0149	-0.025	0.00228	0.000112	0.135	-0.0854	0.0073	10/11/1983-01/29/2016

	1-month Forward Discount				1-month Spot Rate Change				
	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Sample Period
Russia	0.00482	0.0757	-0.00471	0.00759	-0.000415	0.393	-0.338	0.0149	03/07/1996-01/29/2016
Ukraine	0.00168	0.0452	-0.176	0.0184	-0.000352	0.245	-0.317	0.0125	12/02/1998-01/29/2016
South Africa	0.00947	0.89	-0.0247	0.0208	-0.00027	0.111	-0.12	0.00958	10/12/1983-01/29/2016
Mexico	0.00586	0.038	0.000687	0.005	-0.000268	0.16	-0.171	0.00877	01/03/1994-01/29/2016
Indonesia	0.0205	0.189	-0.192	0.0466	-0.000232	0.25	-0.21	0.0136	01/03/1994-01/29/2016
Brazil	0.00744	0.0151	-0.00189	0.00284	-0.0002	0.127	-0.0923	0.00966	07/01/1994-01/29/2016
Hungary	0.0046	0.0141	-0.000739	0.00289	-0.000149	0.0533	-0.0611	0.00815	01/03/1994-01/29/2016
Egypt	0.00934	0.0856	-0.000886	0.0112	-0.000146	0.0255	-0.144	0.0032	12/09/1994-01/29/2016
India	0.00373	0.0157	-0.00478	0.00237	-0.000127	0.0311	-0.0335	0.00367	01/03/1994-01/29/2016
Iceland	0.00473	0.015	-0.00255	0.00191	-9.3e-05	0.141	-0.126	0.00854	05/27/1997-01/29/2016
Philippines	0.00307	0.0339	-0.00342	0.00274	-8.27e-05	0.124	-0.106	0.00517	01/03/1994-01/29/2016
Poland	0.00223	0.00808	-0.00307	0.00179	-6.13e-05	0.0693	-0.0549	0.00795	01/04/1995-01/29/2016
Slovenia	-4.42e-05	0.00328	-0.00344	0.000885	-5.7e-05	0.0472	-0.0377	0.00629	05/27/1997-01/29/2016
Malaysia	0.00515	0.0396	-0.272	0.0491	-4.91e-05	0.143	-0.3	0.00697	01/03/1994-01/29/2016
Thailand	0.00159	0.061	-0.00344	0.00381	-4.38e-05	0.0745	-0.086	0.00539	01/03/1994-01/29/2016
Israel	0.000393	0.00262	-0.00236	0.000852	-3.98e-05	0.0292	-0.0446	0.00456	01/03/1994-01/29/2016
Taiwan	-0.000914	0.0158	-0.0146	0.00227	-3.52e-05	0.0272	-0.0421	0.00274	01/03/1994-01/29/2016
South Korea	-0.000271	0.00343	-0.0291	0.0027	-3.09e-05	0.219	-0.135	0.00873	01/03/1994-01/29/2016
Greece	0.000848	0.0308	-0.00682	0.0022	-2.13e-05	0.0472	-0.0762	0.00622	01/03/1994-01/29/2016
Croatia	0.00112	0.0184	-0.00267	0.00244	-1.34e-05	0.0483	-0.0372	0.00643	05/27/1997-01/29/2016
Kuwait	0.000321	0.00598	-0.00357	0.000853	-1.69e-06	0.0368	-0.0355	0.00166	01/03/1994-01/29/2016
Saudi Arabia	3.61e-05	0.00293	-0.00428	0.000486	-2e-08	0.00528	-0.00583	0.000229	01/03/1994-01/29/2016
Bulgaria	-6.24e-05	0.00477	-0.00233	0.00134	2.44e-06	0.0472	-0.0377	0.00621	12/02/1998-01/29/2016
Cyprus	-6.84e-05	0.00407	-0.00338	0.00105	4.13e-06	0.0474	-0.0376	0.00615	05/27/1997-01/29/2016
Spain	-0.000268	0.0227	-0.00682	0.00108	5.54e-06	0.0472	-0.0377	0.00606	01/03/1994-01/29/2016
Hong Kong	-0.000342	0.0541	-0.009	0.00162	8.07e-06	0.02	-0.0111	0.000571	10/12/1983-01/29/2016
Portugal	-0.000262	0.0231	-0.00682	0.00109	1.02e-05	0.0472	-0.0377	0.0061	01/03/1994-01/29/2016
Finland	-0.000419	0.0158	-0.00682	0.00117	2.75e-05	0.0472	-0.0377	0.00612	01/03/1994-01/29/2016
Czech	0.00074	0.0295	-0.00993	0.00279	5.05e-05	0.0534	-0.0791	0.00745	12/12/1994-01/29/2016
Slovakia	0.00059	0.00581	-0.00294	0.00182	5.28e-05	0.0472	-0.062	0.00664	02/04/1997-01/29/2016
Singapore	-0.00166	0.0324	-0.0448	0.00239	5.78e-05	0.0414	-0.0267	0.0034	12/17/1984-01/29/2016
Ireland	0.000276	0.00954	-0.0202	0.00131	5.95e-05	0.0575	-0.0851	0.00651	12/17/1984-01/29/2016

Table 3: The Performance of Carry Trades Strategies in the Whole Sample: All Currencies

This table presents the profitability of carry trades based on all 48 currencies in the whole sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 100, 200, 300, and 400 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy. In the panel titled "All profitable strategies", we list the average, minimum, and maximum number of profitable carry trade strategies from 500 stepwise tests. We use 5% significance level in our tests. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Performance Metric	**Mean Return**				**Sharpe Ratio**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	100	200	300	400	100	200	300	400
Best Strategies								
Description	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(18l, 3p, 1m)	(18l, 3p, 1m)
Mean Return	18.46%	18.46%	18.46%	18.46%	18.46%	18.46%	3.92%	3.92%
Sharpe Ratio	1.421	0.967	0.726	0.662	1.421	0.967	0.867	0.863
Nominal p-value	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001
All profitable strategies								
Average number from 500 tests	100.0	200.0	223.1	104.9	100.0	200.0	114.1	36.2
Minimum number from 500 tests	100	200	210	80	100	200	106	21
Maximum number from 500 tests	100	200	233	125	100	200	124	54
Average number of profitable strategies / all strategies	100%	100%	74.36%	26.24%	100%	100%	38.04%	9.04%

Table 4: The Performance of Carry Trades Strategies in the Whole Sample: Developed Currencies

This table presents the profitability of carry trades based on 16 developed currencies in the whole sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 20, 40, 60, and 80 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy. In the panel titled "All profitable strategies", we list the average, minimum, and maximum number of profitable carry trade strategies from 500 stepwise tests. We use 5% significance level in our tests. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Performance Metric	**Mean Return**				**Sharpe Ratio**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	20	40	60	80	20	40	60	80
Best Strategies								
Description	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)
Mean Return	3.35%	3.35%	3.35%	3.35%	2.55%	2.55%	2.55%	2.55%
Sharpe Ratio	0.509	0.482	0.433	0.443	0.537	0.490	0.458	0.473
Nominal p-value	0.004	0.007	0.017	0.018	0.003	0.006	0.012	0.012
Reality check p-value	0.005	0.013	0.021	0.019	0.005	0.013	0.020	0.019
Stepwise test p-value	0.004	0.007	0.015	0.012	0.097	0.218	0.281	0.231
All profitable strategies								
Average number from 500 tests	20.0	32.3	12.4	11.1	0.0	0.0	0.0	0.0
Minimum number from 500 tests	19	13	4	4	0	0	0	0
Maximum number from 500 tests	20	38	30	23	0	0	0	0
Average number of profitable strategies / all strategies	100%	80.85%	20.62%	13.88%	0%	0%	0%	0%

Table 5: The Sub-period Performance of Carry Trades Strategies: All Currencies

This table presents the profitability of carry trades based on all 48 currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 100, 200, 300, and 400 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(10l, 3p, 1m)	(18l, 9p, 3m)	(18l, 9p, 3m)	(18l, 9p, 3m)	(10l, 3p, 1m)	(10l, 3p, 1m)	(10l, 3p, 1m)	(14l, 3p, 1m)
Mean Return or Sharpe Ratio	4.46%	4.34%	4.34%	4.34%	1.431	1.348	1.137	2.769
Nominal p-value	0.000	0.066	0.098	0.085	0.000	0.001	0.006	0.000
Reality check p-value	0.000	0.166	0.219	0.120	0.000	0.001	0.006	0.000
Stepwise test p-value	0.125	0.132	0.153	0.183	0.017	0.025	0.082	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	4.31%	-	-	-	0.683	0.550	0.465	0.488
Nominal p-value	0.056	-	-	-	0.056	0.130	0.208	0.210
Reality check p-value	0.126	-	-	-	0.127	0.347	0.513	0.620
Stepwise test p-value	0.402	-	-	-	0.509	0.754	0.864	0.872
All profitable strategies (in-sample)								
Average number from 500 tests	0.0	-	-	-	1.0	1.0	0.0	21.0
Average number of profitable strategies / all strategies	0%	-	-	-	1.00%	0.50%	0.00%	5.24%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	-	-	-	0	0	0	0
Average number of profitable strategies / all strategies	0%	-	-	-	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 3m)	(32l, 32p, 3m)	(32l, 32p, 3m)
Mean Return or Sharpe Ratio	19.48%	19.48%	19.48%	19.48%	1.125	0.918	0.685	0.713
Nominal p-value	0.002	0.047	0.141	0.150	0.002	0.014	0.072	0.083
Reality check p-value	0.008	0.159	0.392	0.472	0.008	0.055	0.229	0.259
Stepwise test p-value	0.003	0.033	0.088	0.084	0.096	0.300	0.623	0.608
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	50.26%	50.26%	-	-	4.503	2.257	-	-
Nominal p-value	0.000	0.000	-	-	0.000	0.000	-	-
Reality check p-value	0.000	0.000	-	-	0.000	0.000	-	-
Stepwise test p-value	0.000	0.000	-	-	0.000	0.000	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	46.3	8.0	-	-	1.0	1.0	-	-
Average number of profitable strategies / all strategies	46.29%	4.00%	-	-	1.00%	0.50%	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	46.3	8.0	-	-	0	0	-	-
Average number of profitable strategies / all strategies	46.29%	4.00%	-	-	0%	0%	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(38l, 38p, 1m)	(12l, 5p, 1m)	(14l, 5p, 1m)	(18l, 5p, 3m)
Mean Return or Sharpe Ratio	53.05%	53.05%	53.05%	53.05%	4.957	3.234	2.781	3.307
Nominal p-value	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.62%	0.62%	0.62%	0.62%	0.812	0.524	0.337	0.155
Nominal p-value	0.747	0.754	0.752	0.761	0.024	0.148	0.355	0.674
Reality check p-value	0.889	0.893	0.912	0.876	0.097	0.399	0.706	0.840
Stepwise test p-value	0.821	0.827	0.855	0.785	0.649	0.863	0.946	0.981
All profitable strategies (in-sample)								
Average number from 500 tests	100.0	200.0	300.0	400.0	100.0	200.0	300.0	400.0
Average number of profitable strategies / all strategies	100%	100%	100%	100%	100%	100%	100%	100%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	8.6	6.9	1.3	0.0	0.0	0.0	0.0	0.8
Average number of profitable strategies / all strategies	8.57%	3.43%	0.44%	0%	0%	0%	0%	0.27%

Table 6: The Sub-period Performance of Carry Trades Strategies: Developed Currencies

This table presents the profitability of carry trades based on 16 developed currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 20, 40, 60, and 80 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)
Mean Return or Sharpe Ratio	8.07%	8.07%	8.07%	8.07%	1.214	1.256	1.245	2.061
Nominal p-value	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001
Reality check p-value	0.002	0.001	0.002	0.000	0.002	0.001	0.002	0.000
Stepwise test p-value	0.002	0.000	0.002	0.005	0.036	0.036	0.034	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-0.45%	-0.45%	-0.45%	-0.45%	-0.042	-0.035	-0.022	-0.031
Nominal p-value	0.906	0.923	0.950	0.932	0.906	0.923	0.950	0.932
Reality check p-value	0.780	0.806	0.744	0.787	0.779	0.806	0.745	0.788
Stepwise test p-value	0.789	0.811	0.749	0.799	0.911	0.934	0.915	0.956
All profitable strategies (in-sample)								
Average number from 500 tests	17.0	12.2	12.2	8.7	2.2	2.0	2.0	8.0
Average number of profitable strategies / all strategies	85.03%	30.50%	20.26%	10.92%	10.76%	4.95%	3.33%	9.97%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	0	0	0	0	0	0	0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(12l, 3p, 1m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(12l, 3p, 1m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(10l, 5p, 3m)
Mean Return or Sharpe Ratio	1.59%	2.21%	2.21%	2.21%	0.396	0.406	0.380	0.398
Nominal p-value	0.265	0.260	0.300	0.297	0.265	0.260	0.300	0.297
Reality check p-value	0.290	0.305	0.289	0.283	0.286	0.305	0.287	0.281
Stepwise test p-value	0.409	0.346	0.362	0.342	0.536	0.591	0.574	0.575
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-	-	-	-	-	-	-	-
Nominal p-value	-	-	-	-	-	-	-	-
Reality check p-value	-	-	-	-	-	-	-	-
Stepwise test p-value	-	-	-	-	-	-	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	-	-	-	-	-	-	-	-
Average number of profitable strategies / all strategies	-	-	-	-	-	-	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	-	-	-	-	-	-	-	-
Average number of profitable strategies / all strategies	-	-	-	-	-	-	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(10l, 10p, 1m)	(10l, 10p, 3m)	(12l, 6p, 6m)	(10l, 10p, 12m)	(10l, 5p, 1m)	(10l, 10p, 1m)	(10l, 3p, 6m)	(10l, 10p, 3m)
Mean Return or Sharpe Ratio	5.99%	6.20%	6.30%	6.58%	1.076	1.101	1.100	2.230
Nominal p-value	0.003	0.004	0.011	0.001	0.003	0.004	0.007	0.000
Reality check p-value	0.003	0.003	0.005	0.000	0.003	0.003	0.002	0.000
Stepwise test p-value	0.002	0.003	0.005	0.002	0.003	0.003	0.002	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.22%	-0.64%	-0.42%	-1.64%	0.101	0.070	-0.131	-0.022
Nominal p-value	0.849	0.906	0.964	0.728	0.775	0.843	0.717	0.952
Reality check p-value	0.618	0.771	0.700	0.805	0.578	0.661	0.822	0.715
Stepwise test p-value	0.594	0.793	0.687	0.874	0.632	0.681	0.835	0.750
All profitable strategies (in-sample)								
Average number from 500 tests	20.0	40.0	60.0	80.0	20.0	40.0	60.0	80.0
Average number of profitable strategies / all strategies	100%	100%	100%	100%	100%	100%	100%	100%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%

Table 7: The Performance of Carry Trades Strategies (including Learning Strategies) in the Whole Sample

This table presents the profitability of carry trades (including learning strategies) based on all 48 currencies (Panel A) and 16 developed currencies (Panel B) in the whole sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. In Panel A, we consider 164, 225, 316, and 404 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In Panel B, we consider 84, 65, 76, and 84 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy. In the panel titled "All profitable strategies", we list the average, minimum, and maximum number of profitable carry trade strategies from 500 stepwise tests. We use 5% significance level in our tests. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A: All Currencies

Performance Metric	**Mean Return**				**Sharpe Ratio**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	164	225	316	404	164	225	316	404
Best Strategies								
Description	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(38l, 38p, 1m)	(18l, 3p, 1m)	(18l, 3p, 1m)
Mean Return	18.46%	18.46%	18.46%	18.46%	18.46%	18.46%	3.92%	3.92%
Sharpe Ratio	1.421	0.967	0.726	0.662	1.421	0.967	0.867	0.863
Nominal p-value	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001
All profitable strategies								
Average number from 500 tests	164.0	225.0	228.4	105.5	164.0	225.0	117.2	36.4
Minimum number from 500 tests	164	225	215	74	164	225	109	12
Maximum number from 500 tests	164	225	239	125	164	225	127	55
Average number of profitable strategies / all strategies	100%	100%	72.28%	26.10%	100%	100%	37.09%	9.01%

Panel B: Developed Currencies

Performance Metric	Mean Return				Sharpe Ratio			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	84	65	76	84	84	65	76	84
Best Strategies								
Description	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)	(12l, 5p, 1m)
Mean Return	3.35%	3.35%	3.35%	3.35%	2.55%	2.55%	2.55%	2.55%
Sharpe Ratio	0.509	0.482	0.433	0.443	0.537	0.490	0.458	0.473
Nominal p-value	0.004	0.007	0.017	0.018	0.003	0.006	0.012	0.012
Reality check p-value	0.006	0.014	0.021	0.019	0.006	0.014	0.021	0.019
Stepwise test p-value	0.005	0.008	0.017	0.012	0.178	0.258	0.296	0.230
All profitable strategies								
Average number from 500 tests	84.0	23.6	10.3	12.0	0.0	0.0	0.0	0.0
Minimum number from 500 tests	80	9	4	5	0	0	0	0
Maximum number from 500 tests	84	48	22	27	0	0	0	0
Average number of profitable strategies / all strategies	99.97%	36.36%	13.57%	14.31%	0%	0%	0%	0%

Table 8: The Sub-period Performance of Carry Trades Strategies (including Learning Strategies): All Currencies

This table presents the profitability of carry trades (including learning strategies) based on all 48 currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 164, 225, 316, and 404 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(10l, 3p, 1m)	(18l, 9p, 3m)	(18l, 9p, 3m)	(18l, 9p, 3m)	(10l, 3p, 1m)	(10l, 3p, 1m)	(10l, 3p, 1m)	(14l, 3p, 1m)
Mean Return or Sharpe Ratio	4.46%	4.34%	4.34%	4.34%	1.431	1.348	1.137	2.769
Nominal p-value	0.000	0.066	0.098	0.085	0.000	0.001	0.006	0.000
Reality check p-value	0.000	0.183	0.246	0.128	0.000	0.001	0.007	0.000
Stepwise test p-value	0.141	0.139	0.155	0.191	0.019	0.028	0.104	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	4.31%	-	-	-	0.683	0.550	0.465	0.488
Nominal p-value	0.056	-	-	-	0.056	0.130	0.208	0.210
Reality check p-value	0.126	-	-	-	0.126	0.348	0.512	0.621
Stepwise test p-value	0.403	-	-	-	0.508	0.756	0.865	0.871
All profitable strategies (in-sample)								
Average number from 500 tests	0.0	-	-	-	13.0	1.1	0.0	20.7
Average number of profitable strategies / all strategies	0%	-	-	-	7.93%	0.49%	0%	5.12%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	-	-	-	0	0	0	0
Average number of profitable strategies / all strategies	0%	-	-	-	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 1m)	(34l, 34p, 3m)	(32l, 32p, 3m)	(32l, 32p, 3m)
Mean Return or Sharpe Ratio	19.48%	19.48%	19.48%	19.48%	1.125	0.918	0.685	0.713
Nominal p-value	0.002	0.047	0.141	0.150	0.002	0.014	0.072	0.083
Reality check p-value	0.008	0.158	0.392	0.471	0.008	0.056	0.230	0.258
Stepwise test p-value	0.003	0.032	0.088	0.083	0.096	0.300	0.625	0.606
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	50.26%	50.26%	-	-	4.503	2.257	-	-
Nominal p-value	0.000	0.000	-	-	0.000	0.000	-	-
Reality check p-value	0.000	0.000	-	-	0.000	0.000	-	-
Stepwise test p-value	0.000	0.000	-	-	0.000	0.000	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	64.8	8.0	-	-	0	0	-	-
Average number of profitable strategies / all strategies	39.51%	3.56%	-	-	0%	0%	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	64.8	8.0	-	-	0	0	-	-
Average number of profitable strategies / all strategies	39.51%	3.56%	-	-	0%	0%	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(38l, 38p, 1m)	(12l, 5p, 1m)	(14l, 5p, 1m)	(18l, 5p, 3m)
Mean Return or Sharpe Ratio	53.05%	53.05%	53.05%	53.05%	4.957	3.234	2.781	3.307
Nominal p-value	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.62%	0.62%	0.62%	0.62%	0.812	0.524	0.337	0.155
Nominal p-value	0.747	0.754	0.752	0.761	0.024	0.148	0.355	0.674
Reality check p-value	0.890	0.892	0.912	0.876	0.099	0.400	0.706	0.841
Stepwise test p-value	0.823	0.825	0.855	0.785	0.650	0.863	0.946	0.981
All profitable strategies (in-sample)								
Average number from 500 tests	164.0	225.0	316.0	404.0	164.0	225.0	316.0	404.0
Average number of profitable strategies / all strategies	100%	100%	100%	100%	100%	100%	100%	100%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	10.1	6.8	1.3	0.0	0.0	0.0	0.8	0.0
Average number of profitable strategies / all strategies	6.17%	3.01%	0.40%	0%	0%	0%	0.26%	0%

Table 9: The Sub-period Performance of Carry Trades Strategies (including Learning Strategies): Developed Currencies

This table presents the profitability of carry trades (including learning strategies) based on 16 developed currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 84, 65, 76, and 84 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m)
Mean Return or Sharpe Ratio	8.07%	8.07%	8.07%	8.07%	1.214	1.256	1.245	2.061
Nominal p-value	0.001	0.001	0.003	0.001	0.001	0.001	0.003	0.001
Reality check p-value	0.002	0.002	0.002	0.000	0.002	0.002	0.002	0.000
Stepwise test p-value	0.002	0.001	0.003	0.004	0.059	0.048	0.038	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-0.45%	-0.45%	-0.45%	-0.45%	-0.042	-0.035	-0.022	-0.031
Nominal p-value	0.906	0.923	0.950	0.932	0.906	0.923	0.950	0.932
Reality check p-value	0.780	0.806	0.744	0.787	0.780	0.806	0.745	0.788
Stepwise test p-value	0.789	0.811	0.749	0.799	0.912	0.934	0.916	0.956
All profitable strategies (in-sample)								
Average number from 500 tests	26.8	13.8	13.2	10.0	0.3	1.3	1.9	9.0
Average number of profitable strategies / all strategies	31.90%	21.17%	17.31%	11.85%	0.30%	1.98%	2.56%	10.66%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	0	0	0	0	0	0	0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(12l, 3p, 1m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(12l, 3p, 1m)	(10l, 5p, 3m)	(10l, 5p, 3m)	(10l, 5p, 3m)
Mean Return or Sharpe Ratio	1.59%	2.21%	2.21%	2.21%	0.396	0.406	0.380	0.398
Nominal p-value	0.265	0.260	0.300	0.297	0.265	0.260	0.300	0.297
Reality check p-value	0.288	0.304	0.287	0.282	0.288	0.303	0.286	0.282
Stepwise test p-value	0.407	0.345	0.360	0.340	0.536	0.590	0.574	0.576
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-	-	-	-	-	-	-	-
Nominal p-value	-	-	-	-	-	-	-	-
Reality check p-value	-	-	-	-	-	-	-	-
Stepwise test p-value	-	-	-	-	-	-	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	-	-	-	-	-	-	-	-
Average number of profitable strategies / all strategies	-	-	-	-	-	-	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	-	-	-	-	-	-	-	-
Average number of profitable strategies / all strategies	-	-	-	-	-	-	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(1r, 4f, 1m)	(3r, 6f, 3m)	(6r, 24f, 6m)	(10l, 10p, 12m)	(1r, 2f, 1m)	(3r, 18f, 3m)	(10l, 3p, 6m)	(10l, 10p, 3m)
Mean Return or Sharpe Ratio	5.99%	6.20%	6.30%	6.58%	1.076	1.101	1.100	2.230
Nominal p-value	0.003	0.004	0.011	0.001	0.003	0.004	0.007	0.000
Reality check p-value	0.003	0.003	0.005	0.000	0.003	0.003	0.003	0.000
Stepwise test p-value	0.002	0.003	0.005	0.002	0.003	0.003	0.003	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.13%	-0.64%	-0.42%	-1.64%	0.102	0.070	-0.131	-0.022
Nominal p-value	0.878	0.906	0.964	0.728	0.773	0.843	0.717	0.952
Reality check p-value	0.639	0.771	0.702	0.805	0.585	0.661	0.823	0.716
Stepwise test p-value	0.618	0.792	0.689	0.875	0.645	0.682	0.836	0.750
All profitable strategies (in-sample)								
Average number from 500 tests	84.0	65.0	76.0	84.0	84.0	65.0	76.0	84.0
Average number of profitable strategies / all strategies	100%	100%	100%	100%	100%	100%	100%	100%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%

Table 10: The Performance of Carry Trades Strategies (including Stop-loss Strategies) in the Whole Sample

This table presents the profitability of carry trades (including stop-loss strategies) based on all 48 currencies (Panel A) and 16 developed currencies (Panel B) in the whole sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. In Panel A, we consider 1300, 2600, 3900, and 3600 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In Panel B, we consider 260, 520, 780, and 720 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy. In the panel titled "All profitable strategies", we list the average, minimum, and maximum number of profitable carry trade strategies from 500 stepwise tests. We use 5% significance level in our tests. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A: All Currencies

Performance Metric	**Mean Return**				**Sharpe Ratio**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	1300	2600	3900	3600	1300	2600	3900	3600
Best Strategies								
Description	(38l, 38p, 1m)	(38l, 38p, 1m, 6r, 5%a)	(38l, 38p, 1m, 6r, 5%a)	(38l, 38p, 1m, 12r, 5%a)	(38l, 19p, 1m, 6r, 5%h)	(14l, 14p, 3m, 6r, 5%a)	(16l, 16p, 3m, 6r, 5%a)	(18l, 3p, 3m, 12r, 5%a)
Mean Return	18.46%	19.48%	21.08%	19.55%	13.88%	6.29%	7.05%	3.12%
Sharpe Ratio	1.421	1.076	0.836	0.704	1.613	1.238	1.118	1.046
Nominal p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
All profitable strategies								
Average number from 500 tests	1025.0	2020.0	1127.0	1152.0	1024.0	1652.0	552.0	210.0
Minimum number from 500 tests	1025	2020	1127	1152	1024	1652	552	210
Maximum number from 500 tests	1025	2020	1127	1152	1025	1652	552	210
Average number of profitable strategies / all strategies	79%	78%	28.90%	32.00%	79%	64%	14.15%	5.83%

Panel B: Developed Currencies

Performance Metric	Mean Return				Sharpe Ratio			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Number of Strategies	260	520	780	720	260	520	780	720
Best Strategies								
Description	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m, 12r, 5%a)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 3m, 6r, 5%a)	(10l, 10p, 1m, 12r, 5%a)
Mean Return	4.41%	5.37%	5.79%	4.95%	4.41%	5.37%	5.38%	4.39%
Sharpe Ratio	0.848	1.068	1.014	0.876	0.848	1.068	1.048	0.993
Nominal p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000
All profitable strategies								
Average number from 500 tests	123.5	144.5	211.7	210.4	4.3	35.9	93.0	120.6
Minimum number from 500 tests	105	97	173	138	3	29	68	91
Maximum number from 500 tests	137	237	323	287	5	49	116	179
Average number of profitable strategies / all strategies	47%	28%	27%	29%	2%	7%	12%	17%

Table 11: The Sub-period Performance of Carry Trades Strategies (including Stop-loss Strategies): All Currencies

This table presents the profitability of carry trades (including stop-loss strategies) based on 16 developed currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 1300, 2600, 3900, and 3600 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(10l, 3p, 1m)	(18l, 9p, 1m, 6r, 5%a)	(18l, 9p, 1m, 6r, 5%a)	(18l, 9p, 3m)	(10l, 3p, 1m)	(10l, 3p, 1m)	(18l, 9p, 1m, 6r, 5%a)	(14l, 3p, 1m)
Mean Return or Sharpe Ratio	0.045	0.049	0.069	0.043	1.431	1.348	1.380	2.769
Nominal p-value	0.000	0.033	0.001	0.085	0.000	0.001	0.001	0.000
Reality check p-value	0.000	0.303	0.000	0.150	0.000	0.000	0.000	0.000
Stepwise test p-value	0.142	0.030	0.000	0.343	0.030	0.060	0.051	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.043	0.077	0.079	-	0.683	0.550	0.638	0.488
Nominal p-value	0.056	0.033	0.091	-	0.056	0.130	0.091	0.210
Reality check p-value	0.322	0.525	0.363	-	0.322	0.777	0.363	0.838
Stepwise test p-value	0.475	0.426	0.381	-	0.775	1.000	0.859	1.000
All profitable strategies (in-sample)								
Average number from 500 tests	0.0	14.0	14.0	-	13.0	0.0	0.0	189.0
Average number of profitable strategies / all strategies	0.00%	0.54%	0%	-	1.00%	0.00%	0%	5.25%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	0	0	-	0	0	0	0
Average number of profitable strategies / all strategies	0%	0%	0%	-	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(34l, 34p, 1m)	(34l, 34p, 1m, 6r, 5%a)	(34l, 34p, 1m, 6r, 5%a)	(34l, 34p, 1m, 12r, 5%a)	(34l, 34p, 1m, 6r, 5%a)	(24l, 3p, 1m, 6r, 5%a)	(34l, 3p, 1m, 6r, 5%a)	(18l, 9p, 3m, 12r, 5%a)
Mean Return or Sharpe Ratio	0.195	0.204	0.240	0.216	1.150	1.247	1.094	0.873
Nominal p-value	0.002	0.033	0.087	0.119	0.002	0.001	0.007	0.043
Reality check p-value	0.030	0.525	0.363	0.685	0.030	0.030	0.081	0.150
Stepwise test p-value	0.000	0.090	0.000	0.060	0.202	0.384	0.291	0.667
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.503	-	0.503	-	4.503	2.195	-	-
Nominal p-value	0.000	-	0.000	-	0.000	0.000	-	-
Reality check p-value	0.000	-	0.000	-	0.000	0.000	-	-
Stepwise test p-value	0.000	-	0.000	-	0.000	0.000	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	408	-	124	-	0	0	-	-
Average number of profitable strategies / all strategies	31%	-	3%	-	0%	0%	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	408	-	124	-	0	0	-	-
Average number of profitable strategies / all strategies	31%	-	3%	-	0%	0%	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(48l, 24p, 1m)	(38l, 38p, 1m)	(12l, 5p, 1m)	(12l, 12p, 1m, 6r, 5%a)	(18l, 5p, 3m)
Mean Return or Sharpe Ratio	53.05%	53.05%	53.05%	53.05%	4.957	3.234	2.787	3.307
Nominal p-value	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	0.62%	0.62%	0.62%	0.62%	0.812	0.524	1.023	0.155
Nominal p-value	0.747	0.754	0.752	0.761	0.024	0.148	0.011	0.674
Reality check p-value	1.000	1.000	1.000	0.979	0.252	0.829	0.072	0.979
Stepwise test p-value	0.979	1.000	0.978	0.919	0.958	1.000	0.495	1.000
All profitable strategies (in-sample)								
Average number from 500 tests	1004.0	2098.0	3584.0	1217.0	1004.0	2098.0	3583.0	2794.0
Average number of profitable strategies / all strategies	77%	81%	92%	34%	77%	81%	92%	78%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	21.3	50.0	24.0	0.0	0.0	2.0	33.0	10.0
Average number of profitable strategies / all strategies	1.64%	1.92%	0.62%	0%	0%	0%	0.85%	0%

Table 12: The Sub-period Performance of Carry Trades Strategies (including Stop-loss Strategies): Developed Currencies

This table presents the profitability of carry trades (including stop-loss strategies) based on 16 developed currencies in an in-sample period and the subsequent out-of-sample period. The left and right panels are based on mean return criterion and Sharpe ratio criterion, respectively. Within each panel, we have four columns for different groups of carry trade strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 260, 520, 780, and 720 carry trade strategies in the 1-, 3-, 6-, and 12-month group in each column. In the panel titled "Best Strategies (in-sample)", we list the description, mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the in-sample period. In the panel titled "Out-of-sample performance of the best strategies", we list the mean return, Sharpe ratio, nominal p-value, reality check p-value, and stepwise test p-value of the best-performing strategy in the out-of-sample period. In the panel titled "All profitable strategies (in-sample)", we list the average, minimum, and maximum number of profitable carry trade strategies in the in-sample period from 500 stepwise tests based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered. In the panel titled "Out-of-sample performance of all profitable strategies", we list the average, minimum, and maximum number of the in-sample profitable carry trade strategies from 500 stepwise tests in the out-of-sample based on 5% significance level. In the bottom row, we provide the ratio of the average number of profitable carry trade strategies to the total number of carry trade strategies considered.

Panel A

In-sample: Period 1 (1984.1.1 – 1991.12.31)

Out-of-sample: Period 2 (1992.1.1 - 1999.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(14l, 7p, 1m)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 1m)	(14l, 7p, 1m)	(14l, 7p, 1m, 6r, 5%a)	(14l, 7p, 3m, 6r, 5%a)	(14l, 7p, 1m)
Mean Return or Sharpe Ratio	0.081	0.083	0.089	0.081	1.214	1.666	1.589	2.061
Nominal p-value	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.001
Reality check p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Stepwise test p-value	0.000	0.000	0.000	0.000	0.110	0.010	0.010	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-0.45%	2.72%	3.08%	-0.45%	-0.042	0.724	0.772	-0.031
Nominal p-value	0.906	0.049	0.055	0.932	0.906	0.049	0.045	0.932
Reality check p-value	0.960	0.171	0.241	0.910	0.960	0.171	0.211	0.910
Stepwise test p-value	0.970	0.360	0.400	0.920	0.980	0.649	0.631	1.000
All profitable strategies (in-sample)								
Average number from 500 tests	72.0	104.0	84.0	21.0	0.0	7.0	18.0	36.0
Average number of profitable strategies / all strategies	27.69%	20.00%	10.77%	2.92%	0.00%	1.35%	2.31%	5.00%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0	1	0	0	0	0	0	0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%

Panel B

In-sample: Period 2 (1992.1.1 - 1999.12.31)

Out-of-sample: Period 3 (2000.1.1 - 2007.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(10l, 5p, 1m, 6r, 5%a)	(10l, 10p, 3m, 6r, 5%h)	(10l, 10p, 6m, 6r, 5%a)	(14l, 14p, 6m, 12r, 5%a)	(12l, 3p, 1m, 6r, 5%a)	(12l, 6p, 3m, 6r, 5%h)	(10l, 5p, 1m, 6r, 5%a)	(14l, 14p, 6m, 12r, 5%a)
Mean Return or Sharpe Ratio	2.36%	5.09%	5.67%	3.28%	0.654	1.088	0.971	0.645
Nominal p-value	0.069	0.006	0.025	0.111	0.067	0.004	0.015	0.111
Reality check p-value	0.288	0.010	0.130	0.180	0.288	0.000	0.100	0.180
Stepwise test p-value	0.429	0.031	0.131	0.231	0.650	0.131	0.321	0.530
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	-	1.90%	-	-	-	1.121	-	-
Nominal p-value	-	0.166	-	-	-	0.003	-	-
Reality check p-value	-	0.321	-	-	-	0.000	-	-
Stepwise test p-value	-	0.352	-	-	-	0.040	-	-
All profitable strategies (in-sample)								
Average number from 500 tests	-	4	-	-	-	0	-	-
Average number of profitable strategies / all strategies	-	1%	-	-	-	0%	-	-
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	-	2	-	-	-	0	-	-
Average number of profitable strategies / all strategies	-	0%	-	-	-	0%	-	-

Panel C

In-sample: Period 3 (2000.1.1 - 2007.12.31)

Out-of-sample: Period 4 (2008.1.1 - 2015.12.31)

Performance Metric	**Mean Return**				**Sharpe Ratio**			
Rebalancing Horizon	**1m**	**3m**	**6m**	**12m**	**1m**	**3m**	**6m**	**12m**
Best Strategies (in-sample)								
Description	(12l, 6p, 1m, 6r, 5%a)	(12l, 6p, 1m, 6r, 5%a)	(12l, 6p, 1m, 6r, 5%a)	(10l, 10p, 12m)	(12l, 6p, 1m, 6r, 5%a)	(12l, 6p, 3m, 12r, 5%a)	(10l, 10p, 1m, 6r, 5%a)	(10l, 10p, 3m)
Mean Return or Sharpe Ratio	6.62%	6.90%	6.99%	6.58%	1.268	1.201	1.211	2.230
Nominal p-value	0.001	0.002	0.008	0.001	0.001	0.002	0.004	0.000
Reality check p-value	0.000	0.000	0.010	0.000	0.000	0.000	0.010	0.000
Stepwise test p-value	0.000	0.000	0.010	0.000	0.000	0.040	0.030	0.000
Out-of-sample performance of the best strategies								
Mean Return or Sharpe Ratio	2.48%	3.69%	4.27%	-1.64%	0.469	0.385	0.502	-0.022
Nominal p-value	0.188	0.050	0.062	0.728	0.188	0.284	0.176	0.952
Reality check p-value	0.408	0.191	0.260	0.980	0.408	0.681	0.600	0.950
Stepwise test p-value	0.388	0.191	0.180	1.000	0.658	0.850	0.930	0.980
All profitable strategies (in-sample)								
Average number from 500 tests	129.0	281.0	290.0	518.0	129.0	38.3	16.0	518.0
Average number of profitable strategies / all strategies	50%	54%	37%	72%	50%	7%	2%	72%
Out-of-sample performace of all profitable strategies								
Average number from 500 tests	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average number of profitable strategies / all strategies	0%	0%	0%	0%	0%	0%	0%	0%