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Abstract

We carry out a large-scale investigation of the out-of-sample profitability of in-sample profitable carry trade strategies, using foreign exchange data for 48 countries spanning a period from 1983 to 2015 and employing reality check and stepwise tests to correct for data-snooping bias (the factor of luck in model selection). Carry trade strategies chosen as profitable in one period are generally not profitable in an ensuing out-of-sample sample period, especially after correcting for data-snooping, and even after allowing for learning and stop-loss strategies. Any evidence of consistency in carry trade profitability that is found is concentrated in a relatively brief historical period, 2001-2005. We further investigate particular currency pairs that may drive the out-of-sample profitability during this period, and find their performance to be unstable in general. Our findings thus highlight the instability and the factor of luck in generating profits from carry trades.

JEL Classification: F31, C53, G15

Keywords: foreign exchange, carry trade, Data-snooping bias

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The Out-of-Sample Performance of Carry Trades

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ABSTRACT

We carry out a large-scale investigation of the *out-of-sample* profitability of *in-sample* profitable carry trade strategies, using foreign exchange data for 48 countries spanning a period from 1983 to 2015 and employing reality check and stepwise tests to correct for data-snooping bias (the factor of luck in model selection). Carry trade strategies chosen as profitable in one period are generally not profitable in an ensuing out-of-sample sample period, especially after correcting for data-snooping, and even after allowing for learning and stop-loss strategies. Any evidence of consistency in carry trade profitability that is found is concentrated in a relatively brief historical period, 2001-2005. We further investigate particular currency pairs that may drive the out-of-sample profitability during this period, and find their performance to be unstable in general. Our findings thus highlight the instability and the factor of luck in generating profits from carry trades.

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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 subsequently offset the gains from exploiting cross-country differences in interest rates, empirical studies have documented that such trading strategies 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 as the presence of risk aversion,[1] a probably more fundamental question to ask is whether *ex-post* profitable carry trade strategies can be chosen *ex-ante*, or whether carry trade profitability is in fact due to luck, parameter selection, or a fortuitous choice of sample period.

In this paper, we examine the practical profitability of carry trades by combining out-of-sample tests of performance and reality check and stepwise tests for the presence of data-snooping in the selection of carry trade strategies (i.e. the factor of luck in choosing a strategy that performed well during a particular period). On the one hand, we split the whole sample period (1983 to 2015) into sub-periods and rolling windows and examine whether carry trades strategies' profitability from one period lasts into the ensuing, out-of-sample period. On the other hand, we follow the literature (e.g. Neely, Rapach, Tu, and Zhou, 2014) and employ the reality check and

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[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. On the other hand, Doskov and Swinkels (2015) report markedly lower profitability of carry trades from a long-term perspective using 20 currencies in the 1900-2012 period.

stepwise tests to correct for data-snooping bias, which is an issue that has hitherto gone unexamined in prior studies of the carry trade.[2] Data snooping bias 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.[3] 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, in practice, 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 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 and stepwise tests based on the work of White (2000), Romano and Wolf (2005) and Hsu, Hsu, and Kuan (2010).[4]

We use monthly data on 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 ratio of up to 400 carry trade strategies. We calculate the mean return and Sharpe ratio of those strategies based on the differentials of the U.S. and foreign

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[2] At first sight, one may think that data-snooping bias may not a major problem for carry trades strategies because their parameter combinations are not as many as technical trading strategies. However, as our results show, many strategies' profitability is found to be insignificantly profitable after data-snooping corrections using reality check and stepwise tests. Throughout this paper, we use the term "insignificantly profitable" to describe the carry trades strategies that generate positive returns but do not pass the data-snooping tests, which means that these strategies' profitability is due to luck and selection of particular parameters.

[3] 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 a number of methodological developments in econometrics over the past two decades to deal with it.

[4] 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.

interest rates and spot foreign exchange rate. Each strategy selects currencies based on liquidity measured by the relative (i.e., percentage) 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 methods and combinations of currency selection, forward discount sorting, and holding periods, we construct a large number of carry trades strategies (from 100 to 400 basic strategies) based on different rebalancing frequencies.[5]

We examine the out-of-sample profitability of carry trades by conducting various tests. Firstly, in a straightforward and intuitive approach, following the classic study of Levich and Thomas (1993), we divide the 32-year period from 1983 to 2015[6] into four 8-year sub-periods and examine whether the best-performing strategies in one sub-period (i.e., in-sample) generate significant profits in the next sub-period (i.e., out-of-sample), both under the reality check and stepwise tests. We find that, in general, the best performing strategy in one period is not profitable in the next (out-of-sample) period. 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 the profitable strategies over 2000-2007 are not profitable in 2008-2015. While some profitable strategies in 1992-1999 deliver significant profits in 2000-2007, when we consider only developed currencies, we find no strategy generating significant profits in the ensuing, 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. Moreover, even if some strategy may be profitable in the whole sample period (32 years), in practice it would probably be terminated during the extended periods of poor performance that it undergoes and

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[5] Once we consider learning and stop-loss strategies, the number of carry trade strategies extends to 900 to 3600.

[6] Our data end in early 2016.

that we document: in reality, most investors will not tolerate a strategy with several years' loss and will experience a loss of liquidity and 'limits to arbitrage' (Shleifer and Vishny, 1997).[7] In robustness tests, we include 1) learning strategies that allow the traders to dynamically switch the strategies and 2) stop-loss strategies that allow traders to close the position after a certain drop and re-enter the market after a certain rise, but the main conclusions are robust and remain unaffected when we use the resulting extended set of carry trade strategies (from 900 to 3600 strategies).

As described so far, our analysis amounts to taking the best performing strategy during a specific eight-year periods (1984-1991, 1992-1999, and 2000-2007) and testing its profitability over the ensuing eight-year period (i.e. in 1992-1999, 2000-2007, and 2008-2015 respectively). We then extend this approach to comprehensively investigate the out-of-sample profitability of *every* strategy based on the past *X* years (*X=1* to 8 years) on the next *Y* years (*Y=1* to *8* years) in *every* year of the sample period. Our results from this extensive analysis highlight the difficulty of learning the correct strategy to use at an given period, and reveal that any year-to-year consistency in the profitability of carry trades tends to concentrate in a relatively brief historical period, 2001-2005.

Next, we dig deeper and further examine the driving force behind the significant—albeit short-lived—carry trade profitability in the 2001-2005 period. We first look into currencies that are more often included in profitable strategies, and find that carry trades using these currencies alone do *not* generate significant profits. We then focus on some "seemingly promising" currency pairs in which the longed currency "consistently" appreciated against the shorted currency in each year between 2001 and 2005 and the annual interest rate in the longed currency's country exceeds that in the shorted one's by 3%. Among all possible combinations, only a very small number of strategies—such as going long Hungarian forint and shorting the Japanese

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[7] See, for example, Hong and Stein (2007, p. 110): "A professional manager has to worry that poor short-run performance will lead to withdrawals from his fund, causing that asset manager to become liquidity-constrained and unable to hang on to even those positions that in the long run are likely to be winners (Shleifer and Vishny, 1997)."

yen—provide persistent returns in 2001-2005. As a result, it is difficult for traders to "judge" which currencies or currency pairs will work, even in the best years for carry traders.

In addition to our contribution to the literature on the profitability of carry trades, in this paper we argue that traders will in practice 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 thus highlight the limitation in exploiting carry trades in practice: traders will have difficulty in remaining faithful to specific carry trades strategies when their performance has been poor for several years, and attempting to learn from the past and to adjust for market downturn does not reduce this limitation. To put it another way, profitable carry trades strategies may be found in back-tests *ex-post*, but they are difficult to be learned *ex-ante*.

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 basic carry trades strategies. In Section 4 we describe the reality check test methods we implement for statistical inference. In Section 5 we examine the out-of-sample profitability of carry trades with a series of reality check and stepwise tests. Section 6 investigates the currencies and currency pairs that possible drive the out-of-sample profitability. Section 7 concludes.

2. Foreign Exchange Data

We use end-of-month data on 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, South 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. Although some markets such as Hong Kong and South Korea are regarded as developed in 2016, they were not in the 1980s, therefore we list them as emerging markets. Before the inception of the euro on January 1, 1999, we use 16 developed currencies to construct portfolios. After the inception of the 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 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 end on January 29, 2016. Some European currencies end on December 31, 1998 due to the inception of the euro.

To better understand the average profits from currency trading, we also present the changes in spot exchange rates (i.e., the returns from currency appreciation) and the interest differentials measured by forward discounts (i.e., the uncovered returns from domestic-foreign interest arbitrage) 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.

Appendix Figure A1 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 A1. 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 trades 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 relative bid-ask spreads in month t, defined as (ask – bid)/middle), 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, $[M/2]$[8], 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 trades 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

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[8] The function [.] denotes the integer from rounding down the number within the bracket. For example, [2.0] = 2, [2.3] = 2, [2.7] = 2, [3.1] = 3.

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

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

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

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

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

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

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, ..., *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 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 a 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 tests (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 trades strategies. When we consider all 48 currencies, there are 100, 200, 300, and 400 carry trades strategies in the 1-, 3-, 6-, and 12-month groups. When we consider 16 developed currencies, there are 20, 40, 60, and 80 carry trades strategies in the 1-, 3-, 6-, and 12-month groups.

4. Reality Check and Stepwise Tests

Testing the possible presence of data snooping is important because, since the construction of carry trades 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 profitable trading strategies chosen from among many is not profitable by luck, and this is difficult to do within the tradition of the 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 trading strategies 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 trades strategies, a skeptic might say that he would be surprised if we had not found any that performed 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 (e.g. Leamer, 1978 and the references therein) and there have been important recent development in this area.

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 return or Sharpe ratio of the k-th strategy for $k=1,\ldots, K$. K denotes the number of all carry trades 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:

$$H_0 : \ P_j = 0 \quad . \qquad (6)$$

A 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 could be the *maximal* performance among K strategies when researchers intend to report significant results. 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 trades 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 $\boldsymbol{P}$:

$$H_0^k : \ P_k \leq 0, \qquad (7)$$

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 trades 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:

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

The rejection of the k-th individual null hypothesis indicates that the k-th 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:[9]

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

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[9] 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 $\boldsymbol{R}_b, b = 1, \ldots, B$.

4. For each b, compute the performance metric (P_{kb}) for the k-th strategy 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 $s_{bi} = T^{1/2}\max_{k=1,\ldots,K}[P_{kb} - P_k + P_k\mathbf{1}(T^{1/2}P_k \leq -\sigma_k[2\log[\log(T)]]^{1/2})]$, where $\mathbf{1}(E)$ 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 $\mathbf{1}(T^{1/2}P_k \leq -\sigma_k[2\log[\log(T)]]^{1/2})$ 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 $\{s_{bi}\}_{b=1,\ldots,B}$, rank them in descending order and then collect its $(1 - \alpha_0)$-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 strategy's marginal p-value, p_k, as the percentile of $T^{1/2}P_k$ in the last $\{s_{bi}\}_{b=1,\ldots,B}$ as an empirical null distribution.

8. Compare each strategy's p_k to α_0. If $p_k < \alpha_0$, we claim that k-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 $\alpha_0 = 0.05$ and our statistical significance is defined at the 5% level, Q = 0.9, and B = 1000, following the literature.[10]

If a strategy earns positive profit but is unable to pass the data-snooping tests, its profitability is likely due to luck and parameter selection.

5. Significance of Out-of-sample Profitability

In this section, we examine the profitability of a large set of carry trades strategies and its significance using the reality check test and the stepwise test. In the first and naïve step, we split the whole sample period (1983-2015) into four sub-periods and examine the in- and out-of-sample performance of carry trades strategies in each sub-period. Next, we make a more rigorous analysis by testing a comprehensive set of carry trades strategies applied in every year.

5.1. Profitability in 8-year Sub-periods

To use a naïve approach as an introduction, we first cut the whole sample period 1983-2015 into four sub-periods of eight years, and then examine if the best-performing carry trades strategy in one in-sample sub-period can generate profits in the next out-of-sample sub-period.[11] Specifically, we consider the following four sub-periods: 1984-1991, 1992-1999, 2000-2007, and 2008-2015.

Table 3 reports both in-sample and out-of-sample test results using all 48

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[10] 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.

[11] 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 the empirical literature on technical analysis in foreign exchange markets and suggest that technical trading rules may have become less profitable over time.

currencies. In Panel A, we first present the test results of 48-currency portfolios for the in-sample period 1984-1991. The left and right panels are based on mean return and Sharpe ratio as performance criteria, respectively. Within each panel, we have four columns for different groups based on four different rebalancing horizons of 1-, 3-, 6-, and 12-month forward discounts to be used in portfolio construction, and we consider 100, 200, 300, and 400 strategies, respectively, as discussed in Section 3. We focus on two sets of indicators generated from the stepwise test: 1) performance metrics and associated p-values of the best strategy, and 2) the number of profitable strategies that produce significantly positive performance metrics. We use 5% as the nominal significance level of our tests.

The upper part of the table ("Best Strategies (in-sample)") shows that the strategy (10l, 3p, 1m) performs the best on mean return based on 1-month rebalancing horizon. This strategy (10l, 3p, 1m) uses the most liquid 10 currencies among all 48, categorizes them into 3 parts, trades on one currency with the highest forward discount and one with the lowest forward discount, and rebalances every one month. In particular, this strategy generates an in-sample mean return of 4.46% per year.

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 considering data snooping, the strategy strongly rejects the null hypothesis with p-values below 1% in all columns. In the next two rows, we report the p-values based on the reality check 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 *in the in-sample period*, which means that the in-sample profitability is significant and not due to luck. However, the profitability of the strategy (10l, 3p, 1m) is insignificant in the out-of-sample period,[12] reflected by the nominal, reality check, and stepwise test p-values all above 5% (0.056, 0.126, and 0.402, respectively). It indicates that the 4.31%

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[12] As discussed earlier, we use the term "insignificantly profitable" to describe the carry trades strategies that generate positive returns but do not pass the data-snooping tests, which means that these strategies' profitability is due to luck and selection of particular parameters.

out-of-sample mean return is very likely due to luck and selection of particular parameters, while the carry trades strategy models are generally not profitable in the out-of-sample period.

In the columns denoted “3m”, “6m” and “12m” under “Mean Return”, the in-sample best strategies’ p-values are all above 5%, indicating that no mean return strategies are significantly profitable based on the 3-, 6- and 12-month rebalancing horizons.

We then look for other strategies that are not the first best but nevertheless provide a significantly positive mean return. To mitigate sampling bias in bootstrapping, we conduct the data-snooping tests 500 times, and report the average, minimum, and maximum numbers of profitable carry trades strategies among these 500 tests that are rejected by the tests. In the lower part of the table (“Out-of-sample performance of all profitable strategies”), the average numbers of profitable strategies are 100, 200, 223, and 105 in the 1-, 3-, 6-, and 12-month groups, respectively, and the average percentage of profitable strategies from 500 simulations is 0%. Therefore, none of the mean return strategies is significantly profitable in the out-of-sample period (1992-1999) after correcting for data snooping bias.

The right panel of Table 3 Panel A presents the test results based on the Sharpe ratio as the other criterion. Similarly, all these statistics organized similarly to the left panel collectively support that the carry trade strategies do not produce significantly positive Sharpe ratios after correcting for data snooping bias. Failing to pass the data-snooping tests means that even though there exist some strategies making profits in the out-of-sample period, their profitability is likely due to luck.

In Panel B of Table 3, 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 3 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.

However, such significant out-of-sample profitability 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 3. 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. 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 3 also confirm this finding.

We test for just the 16 developed currencies in Appendix Table A1. Compared to Table 3, there are fewer profitable strategies in developed currencies, likely due to the fierce competition among risky arbitragers in those markets.[13] The out-of-sample

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

performance of developed currencies is weaker than that of all currencies reported in Table 3. 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).

Using the best strategies in the first columns of Panels A to C of Appendix Table A1 as the example, we present their cumulative value from a $1 investment in Panels A to C of Appendix Figure A2, 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 3 and A1 show the difficulty in selecting carry trades strategies that are profitable in out-of-sample periods, which casts doubt on whether carry trades 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 continue to enjoy 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.[14] 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.

5.1.1. Learning Strategies

We next consider traders' learning processes. Although the profitability of carry

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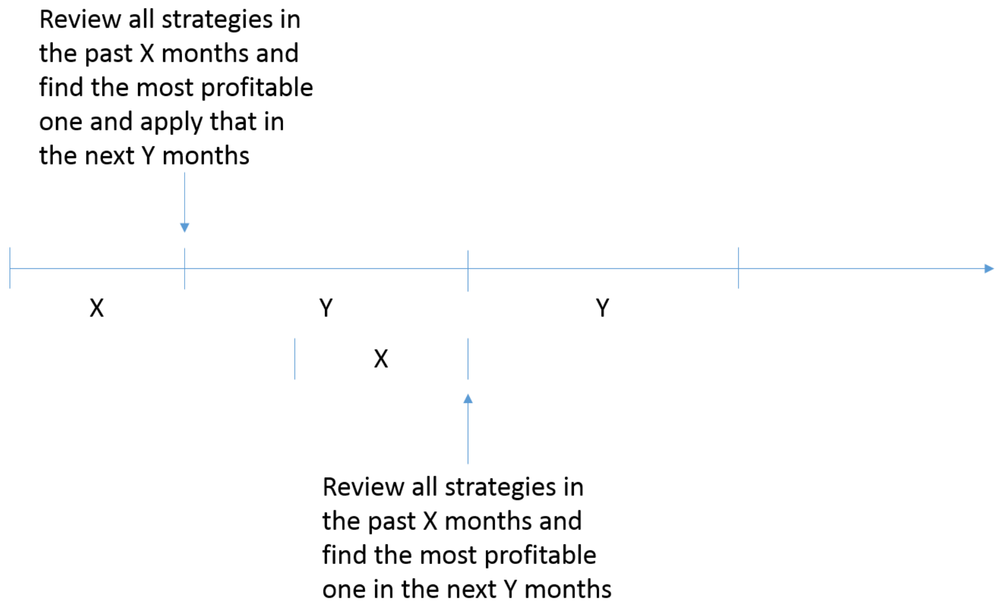
[14] It is also related to Adaptive Markets Hypothesis (Lo, 2004; Neely, Weller, and Ulrich, 2009; Hsu, Taylor, and Wang, 2016) suggesting that the profitability of trading strategies decays over time at a rate determined by the speed with which more and more traders uncover such strategies.

trades strategies is in general hard to replicate out-of-sample, 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 as follows to capture traders' realistic choices under performance pressure. The rolling-window approach is similar to many studies including LeBaron (2000).

1. 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*+2*Y* months.
2. 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.
3. For 1-month strategies (i.e., the 1-month group), *X* = 1, 2, 3, 4, 6, 12, 18, or 24, and Y = 1, 2, 3, 4, 6, 12, 18, or 24, and the combination generates 8*8=64 learning strategies. For 3-month strategies, X = 3, 6, 12, 18, or 24, and Y = 3, 6, 12, 18, or 24, and the combination generates 5*5=25 learning strategies. For 6-month strategies, X = 6, 12, 18, or 24, and Y = 6, 12, 18, or 24, and the combination generates 4*4=16 learning strategies. For 12-month strategies, X = 12 or 24, and Y = 12 or 24, and the combination generates 2*2=4 learning strategies.
4. 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 trades strategies to be tested in each group.
5. 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 trades strategies to be tested in each group.



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. We then add these learning strategies to the basic strategies and examine the profitability of all carry trades strategies including both learning and basic strategies.

We examine the profitability of learning strategies in 4 sub-periods as we did in Section 5.1 and find the same pattern. In Panel A of Appendix Table A2, only some profitable strategies exist in 1984-1991 (when we use the 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 3. In Appendix Table A3, we conduct similar sub-period analyses but focus on more liquid, developed currency markets. In accordance with the results reported in Appendix Table A1, 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 out-of-sample periods.

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

5.1.2. Stop-loss Strategies

Next, we investigate whether the performance of carry trades strategies can improve when assuming implementation of stop-loss rules. We consider a different number of months' performance for review (denoted as *r*) and two types of stop-loss rules (denoted as *a* or *h*). In the stop-loss strategies, we assume that a trader stops an operating strategy when the portfolio value drops by 5% (or 10%) compared to either its portfolio value before the review period (denoted as *a*), or its highest historical value within a specific review period (denoted as *h*), and resumes the strategy when the portfolio value goes back up by 5% (or 10%). For example, the strategy (14l, 7p, 1m, 6r, 5%a) means to select the 14 most liquid currencies, divide them into 7 parts, rebalance every 1 month, review the past 6-month performance at the rebalance date, and stop the strategy whenever the net worth is 5% below that 6 months ago. The first four steps of strategy (14l, 7p, 1m, 6r, 5%h) are the same, but this strategy (the last parameter is denoted as *h*) stops whenever the net worth is 5% below the highest net worth in the past 6 months and resumes when the portfolio value is higher than its lowest value within 6 months by 5%.

The number of strategies become much larger because of the additional two parameters (*a* and *h*). For example, for each basic 1-month strategy in the main text, the total number of strategies = 1 (original strategy) + 2 (stop-loss threshold, 5% or 10%) * 2 (types, denoted as *a* or *h*) * 3 (number of review months, 6 or 12 or 24 months) = 13. So the total number of strategies = 100*13 = 1300. For each basic 12-month strategy in the main text, the total number of strategies = 1 (original strategy) + 2 (stop-loss threshold, 5% or 10%) * 2 (types, denoted as *a* or *h*) * 2 (number of review months, 12 or 24 months) = 9. So the total number of strategies = 400*9 = 3600.

Table A4 and A5 confirm previous results. Profitable strategies in one 8-year sub-period are unlikely to continue the profitability and pass the data-snooping tests in the next 8 years. Being unable to pass the data-snooping tests means that even there exist some strategies making profits in the out-of-sample period, such profitability is likely due to luck. Therefore, we conclude that stop-loss strategies cannot help a carry trade trader time the market significantly better.

5.2. A Comprehensive Analysis of Out-of-sample Profitability

We now expand the above naïve approach to comprehensively investigate the profitability of *every* profitable strategy during a certain number of the past X years (e.g. 1 year or 8 years) on the next Y years in *every* year. Table 4 presents the results of applying mean return profitable strategies in the past one year to the next N years (N equals from 1 to 8). The first column indicates the year of doing the out-of-sample test. Other rows present the values for each N, and the values indicate the percentage of profitable strategies in the past one year that continues to make profits in the next N years and pass data-snooping tests. The values in parentheses denote the average mean returns of all profitable strategies. For example, in the row with year 2006, the value in the columns indicates that among all profitable carry trades strategies in 2005, 3.62% of them (Column 1) are also profitable and pass data-snooping tests in 2006, 21.28% of them (Column 2) are profitable and pass data-snooping tests from 2006 to 2007, and none (0% in Column 3) is profitable and passes tests from 2006 to 2008.

In Appendix Table A6 Panels A to G, we present the percentages of mean return out-of-sample profitable strategies in the past 2, 3, ..., 8 years that continue to be profitable in the next 1, 2, ..., 8 years and pass data-snooping tests. In Table A7 Panels A to H, we present the percentages of Sharpe ratio profitable strategies in the past 1, 2, ..., 8 years that continue to be profitable in the next 1, 2, ..., 8 years and pass data-snooping tests.

Table 5 summarizes all above out-of-sample profitability tests by presenting the average percentages of strategies that continue to profit in Columns 1 and 5. Each number in Column 1 indicates the average percentages of strategies that continue to profit from Table 4 and all panels in Table A6. For example, 5.42% in Column 1 in 2006 is the average of all values in the row 2006 in Table 4 and all panels in Table A6. We also present out-of-sample profitable strategies' average (Columns 2 and 6), maximum (Columns 3 and 7) and minimum annualized returns (Columns 4 and 8). In the years that out-of-sample profitability is obtained, the mean returns are mostly below 1%.

Our results in Table 5 further suggest the difficulty of learning the correct strategy to use from the past successful experience. In over 15 years between 1985 and 2000, *none* but two (1989 and 1998) of the previously mean return profitable strategies is profitable in the following years, even the best strategies previously used. Only between 2002 and 2004, over half of previously mean return profitable strategies can profit in the following years. When the criterion is the Sharpe ratio, only in years 2002 and 2003, over half of the previously profitable strategies continue to make out-of-sample profits.

5.2.1. Developed Currencies

In Table 6, we repeat the same calculation as in Table 5 but only focus on currencies in developed markets. The unprofitability in the out-of-sample periods is more obvious. Only in 8 (or 7) years, the average percentages of out-of-sample mean return (or Sharpe ratio) profitable strategies are above zero.[15] In *none* of these years, the average percentages of out-of-sample profitable strategies are above 30%, either for mean return or Sharpe ratio profitability. The results show that in most years, using past winner strategies in developed currencies cannot continue to profit.

The average percentages for mean return out-of-sample profitable strategies using all currencies and developed currencies are visualized in Figure 1. The average percentages by year for Sharpe ratio out-of-sample profitable strategies are visualized

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[15] The eight years for out-of-sample mean return profitable strategies include 1988-1990, 1993, 1998, and 2003-2005. The seven years for out-of-sample Sharpe ratio profitable strategies include 1985, 1989-1990, 1998, and 2003-2005.

in Figure 2. We observe two peaks (1988-1991 and 2001-2005) in both figures. We are particularly interested in the 2001-2005 peak as it echoes the observation that the best strategy in the 1992-1999 period continues to create profits in the out-of-sample period (2000-2007), which is so far the only evidence for the out-of-sample profitability we find.

6. Currencies that Possibly Drive the Profitability

In this section, we look into details of the chosen strategies in and around the profitable years (we focus on the period between 2001 and 2005) and investigate the key currency pairs that drive such profitability and, and more importantly, the reasons behind them. To be more specific, we attempt to find currencies and currency pairs that appear promising for carry traders and examine whether they indeed deliver profit.

Our first approach is to identify currencies that frequently appear in either the long side or the short side of profitable strategies. To implement this, we first find the profitable 1-month strategies that pass the tests in each month between January 2001 and December 2005 from all 100 basic strategies and the currencies that those strategies exploit the most in their long and short portfolios.[16] If strategy it, balanced in month t and i = 1, 2, ..., 100, is profitable and passes tests in the past x years and profitable in the next y years, we denote $\mathbf{1}(\text{profitable})_{itxy} = 1$, otherwise it equals zero. Then we count the number of tests this strategy's profitability passes the data-snooping tests in the 500 tries in the next y years, and calculate the ratio. Then for the role of each currency c in out-of-sample profitability, we calculate its *net* probability that equals the probability of currency c being used in long portfolios minus the probability of currency c being used in short portfolios. We formulate the calculation

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[16] We do not report learning or stop-loss strategies in this stage for the balance of different styles of carry trades; nevertheless, the results are robust when we include them in the test.

as follows:

$$p_{ct} = \frac{1}{100}\frac{1}{64}\sum_{i=1}^{100}\sum_{x=1}^{8}\sum_{y=1}^{8}\frac{n_{itxy}}{500} \times \mathbf{1}(\text{profitable})_{itxy} \times [\mathbf{1}(\text{long})_{citxy} - \mathbf{1}(\text{short})_{citxy}] \ ,$$

where n_{itxy} reflects how many times strategy *it* for the past 2 years and the next 3 years passes data-snooping tests out of the 500 tries, $\mathbf{1}(\text{long})_{itxy}$ equals one if currency c exists in the long position of the strategy (and zero otherwise), and $\mathbf{1}(\text{short})_{itxy}$ equals one if currency c exists in the short position of the strategy (and zero otherwise). For example, if a strategy *it* is profitable in the past 2 years, its profitability in the next 3 years passes the data-snooping tests for 400 times (n_{itxy}=400), and Japanese yen (JPY) is in this strategy's long portfolio, then JPY's probability in month *t* is 400/500 = 0.8 for this particular *i*-*x*-*y* combination. Then we average across all 100 strategies' 64 combinations of x and y to calculate the net probably of JPY being used in all 1-month strategies. Theoretically, p_{ct} ranges from -1 to 1. A positive number indicates that the currency *c* is more likely being longed in strategies, while a negative number indicates that the currency *c* is more likely being shorted in strategies.

Table 7 presents the most longed and shorted currencies. The criterion for profitability is mean return in Panel A and Sharpe ratio in Panel B. For a better presentation, we delete the currencies that are never used in any strategies between 2001 and 2005. The most shorted currency in both mean return and Sharpe ratio criteria is Japanese yen and the most longed ones include Korean won and Hungarian forint.

Are all strategies that long the most longed currencies and short the most shorted currencies significantly profitable? In unreported tests, we examine 100 currency pairs' profitability and data-snooping test results of the 10 most longed and 10 most shorted currencies' combination. These currency pairs do not generate significant profits. As a result, our analysis of Table 7 suggests that the frequencies of particular currencies or currency pairs being included in profitable strategies do not explain profitability.

Our second approach is to identify currency pairs that appear promising ex-ante. In particular, we focus on currency pairs in which the longed currency appreciated against the shorted currency in each year between 2001 and 2005 and the longed currency's country has a significantly higher annual interest rate compared to the shorted one's by at least 3%. We choose the period between 2001 and 2005 because the average percentages of out-of-sample profitable strategies shown in Table 5 concentrate in this period. We list all currency pairs satisfying the above requirements in Table 8. The value in each cell represents the proportion of months between 2001 and 2005 that the currency in the vertical axis ("the longed currency") appreciate against the currency in the horizontal axis ("the shorted currency") and the longed currency's interest rate is higher than the shorted one's by 3%. For example, in the first column "AUS" and the row "HUN", the value 0.46 indicates that in 46% of months in the 2001-2005 period, Hungarian forint appreciates against Australian dollar, and the interest rate in Hungary exceeds that in Australia by 3%. The cells with value higher than zero are colored. Darker color indicates higher percentage.

Do the currency pairs with values higher than zero necessarily generate significant profit? No. Although a higher proportion of months satisfying both the exchange rate and interest rate conditions helps, we need to examine if profitability based on such information lasts long. We illustrate two currency pairs as follows. Figures 3 and 4 depict the interest rates and exchange rates of two currency pairs: 1) longing Hungarian forint and shorting Japanese yen, and 2) longing Philippine peso and shorting Japanese yen. Figure 3 shows that interest rates of both Hungarian forint and Philippine peso are much higher than that of Japanese yen between 2001 and 2005. In addition, as shown in Figure 4, Hungarian forint "consistently" appreciated against Japanese yen, while the exchange rate between Philippine peso and Japanese yen fluctuated – although it appreciated for some time, it depreciated more after. The consequence is that while longing Hungarian forint and shorting Japanese yen generates significant profits as Panel A of Figure 5 shows, longing Philippine peso and shorting Japanese yen does not (as shown in Panel B) despite that Philippine peso had a high interest rate.

Among all possible currency pairs, only a very small number of currency pairs like Hungarian forint and Japanese yen satisfies both the exchange rate and interest rate conditions and produces profits for several years. Our analyses suggest that it is difficult to predict which currency pair will satisfy both conditions in the future and how long its profits will last; therefore, it is difficult to make profits from some "seemingly promising" currency pairs.

As a result, by considering two approaches to identify promising currencies and currency pairs and examining their out-of-sample profitability, we find it fairly challenging for traders to gain from such currencies. Our findings thus cast more doubt on the out-of-sample profitability of carry trades.

7. Conclusion

In this paper, we use a large data set of 48 currencies in developed and emerging economies to examine the out-of-sample profitability of in-sample profitable carry trades strategies in a 32-year period from 1983 to early 2016 with correction for data-snooping bias. By constructing various carry trade strategies based on currency selection, portfolio sorting and rebalancing frequency, and using advanced econometric methods including the reality check and stepwise tests, we make appropriate statistical inferences on the out-of-sample unprofitability of carry trade strategies which are profitable in-sample.

The main contribution of this paper is to point out that it is difficult for traders to choose a previously profitable carry trade strategy that will continue to perform well in the future. In an illustrative example, 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) cannot provide statistically significant profit in the next sub-period (out-of-sample period). Including learning strategies and stop-loss strategies does not improve the out-of-sample profitability.

We then implement a more comprehensive analysis of out-of-sample profitability to confirm our finding by expanding the above naïve approach to a large combination of in-sample windows (1 to 8 years) and out-of-sample windows (1 to 8 years). In every year between 1985 and 2000, the majority of the previously profitable strategies are not significantly profitable in the ensuing period. This lack of profitability becomes even more evident when we only trade developed currencies. Our out-of-sample analysis thus suggests that in most years, past successful strategies do not continue to be profitable.

To better understand the driving force of significant carry trades profitability in the out-of-sample period, we look into currencies that frequently appear in profitable strategies but find that trading these currencies does not generate significant profits. We then focus on promising currency pairs in which the longed currency “consistently” appreciates against the shorted currency in each year between 2001 and 2005 and the longed currency’s country has a significantly higher annual interest rate compared to the shorted one’s by at least 3%. Only a very small number of strategies like longing Hungarian forint and shorting Japanese yen provide persistent returns in 2001-2005. As a result, it is difficult for carry trades investors to rely on currency-related information to generate out-of-sample profitability.

Our findings thus highlight the limitation in exploiting from carry trades in actual practice for two reasons: first, carry trade strategies that perform well in the past are unlikely to generate out-of-sample profit. Second, even if some carry trades strategies appear profitable in the long run, this is most probably due to luck and parameter selection rather than a discovery of market inefficiency.

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Figure 1: Proportion of Mean Return Profitable Strategies That Are Also Profitable Out-of-sample

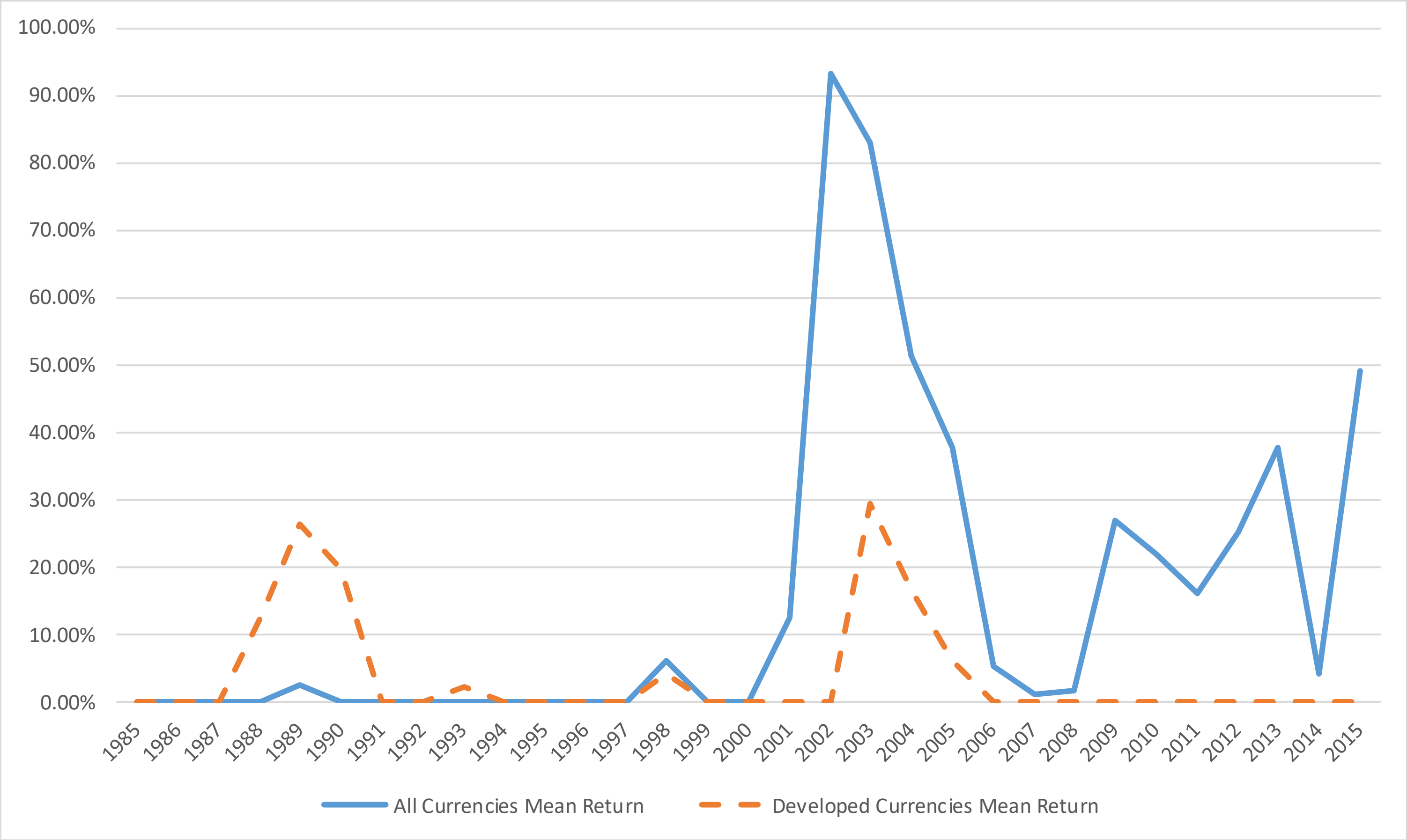


Figure 2: Proportion of Sharpe Ratio Profitable Strategies That Are Also Profitable Out-of-sample

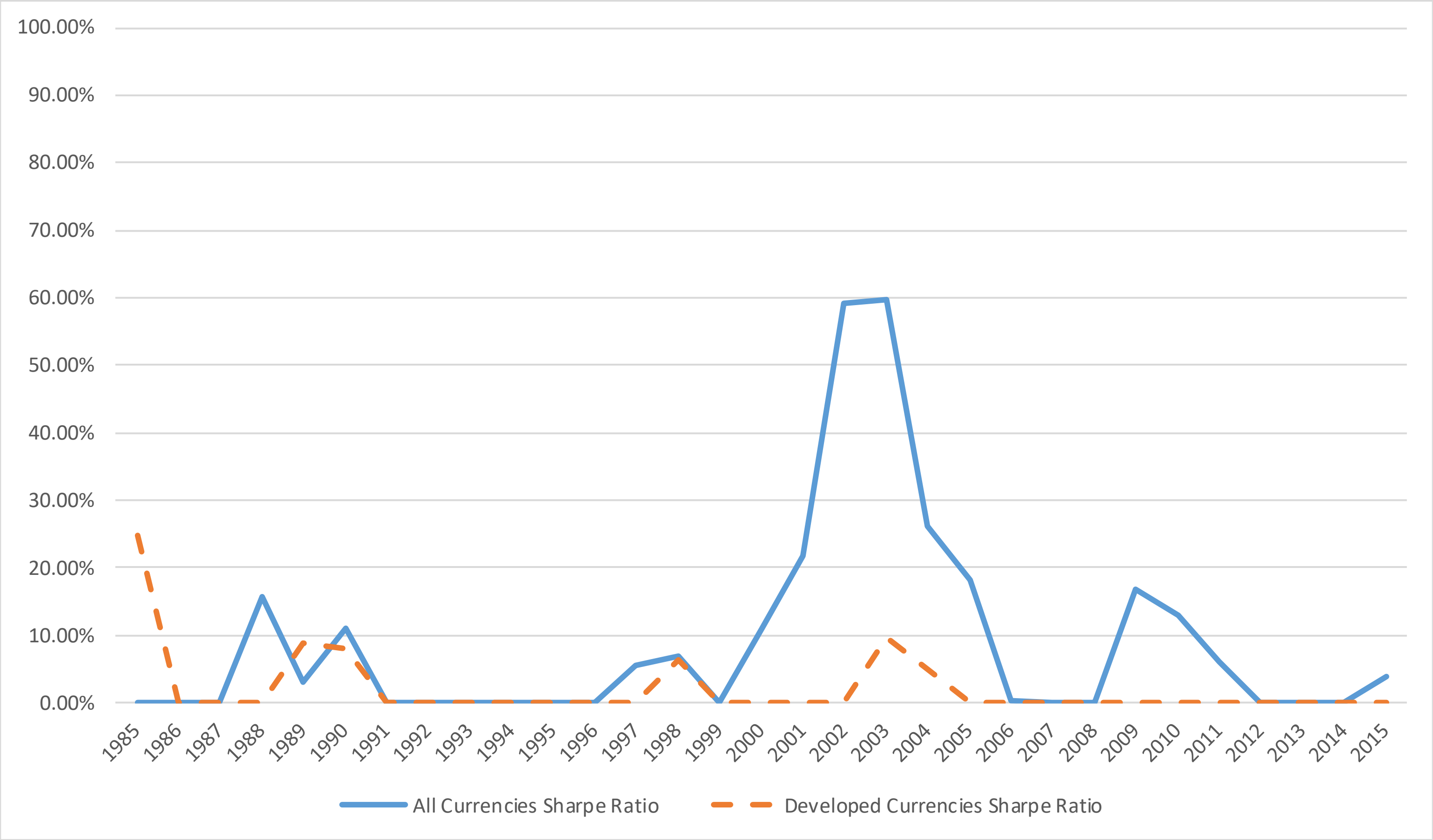


Figure 3: Daily Interest Rate of Hungary, Phillippines and Japan: 2001-2005

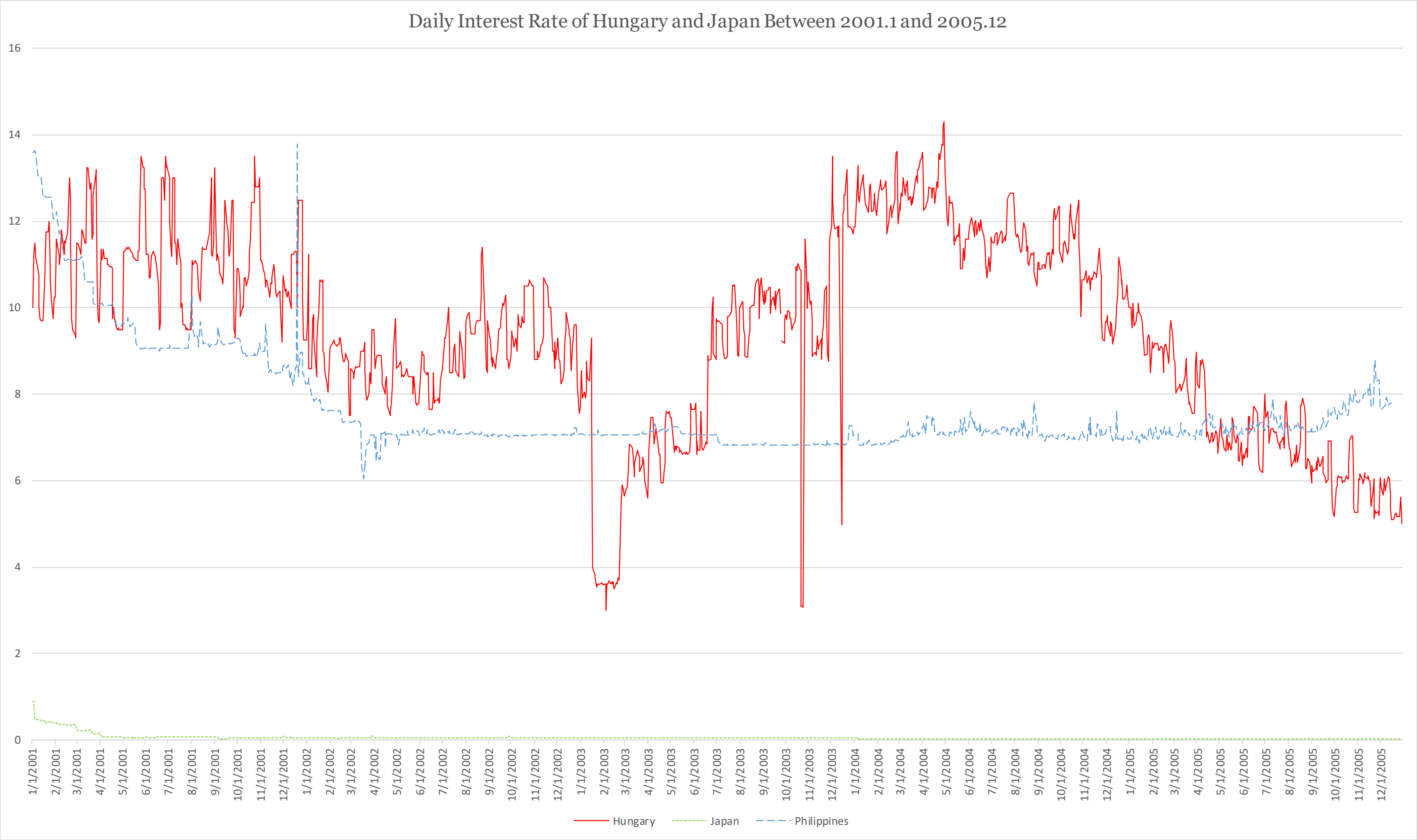
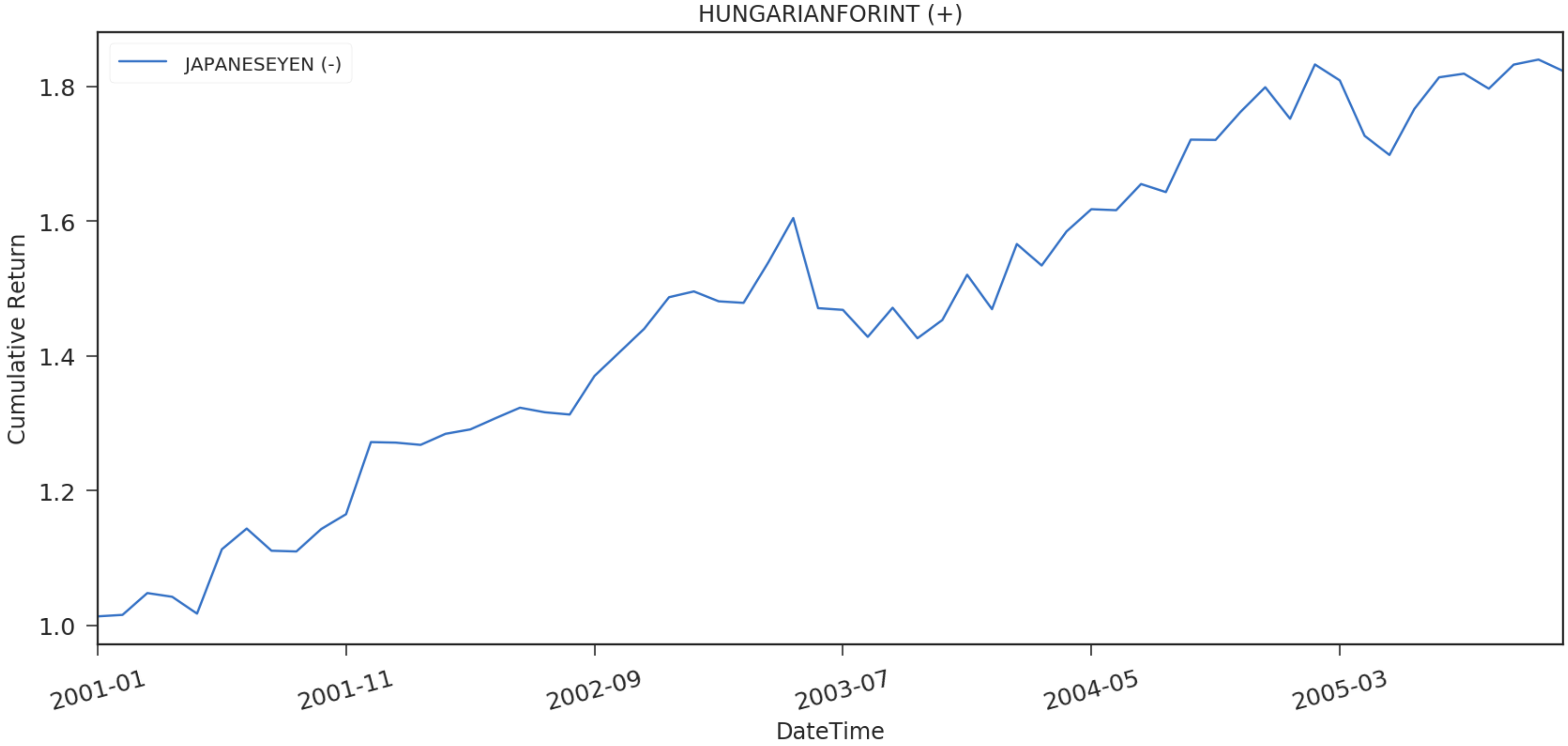


Figure 4: Exchange Rate of Hungarian Forint and Philippine Peso Against Japanese Yen: 2001-2005

Figure 5: Profitability of Hungarian Forint and Philippine Peso Against Japanese Yen: 2001-2005

Panel A: Hungarian Forint Against Japanese Yen



Panel B: Philippine Peso Against Japanese Yen

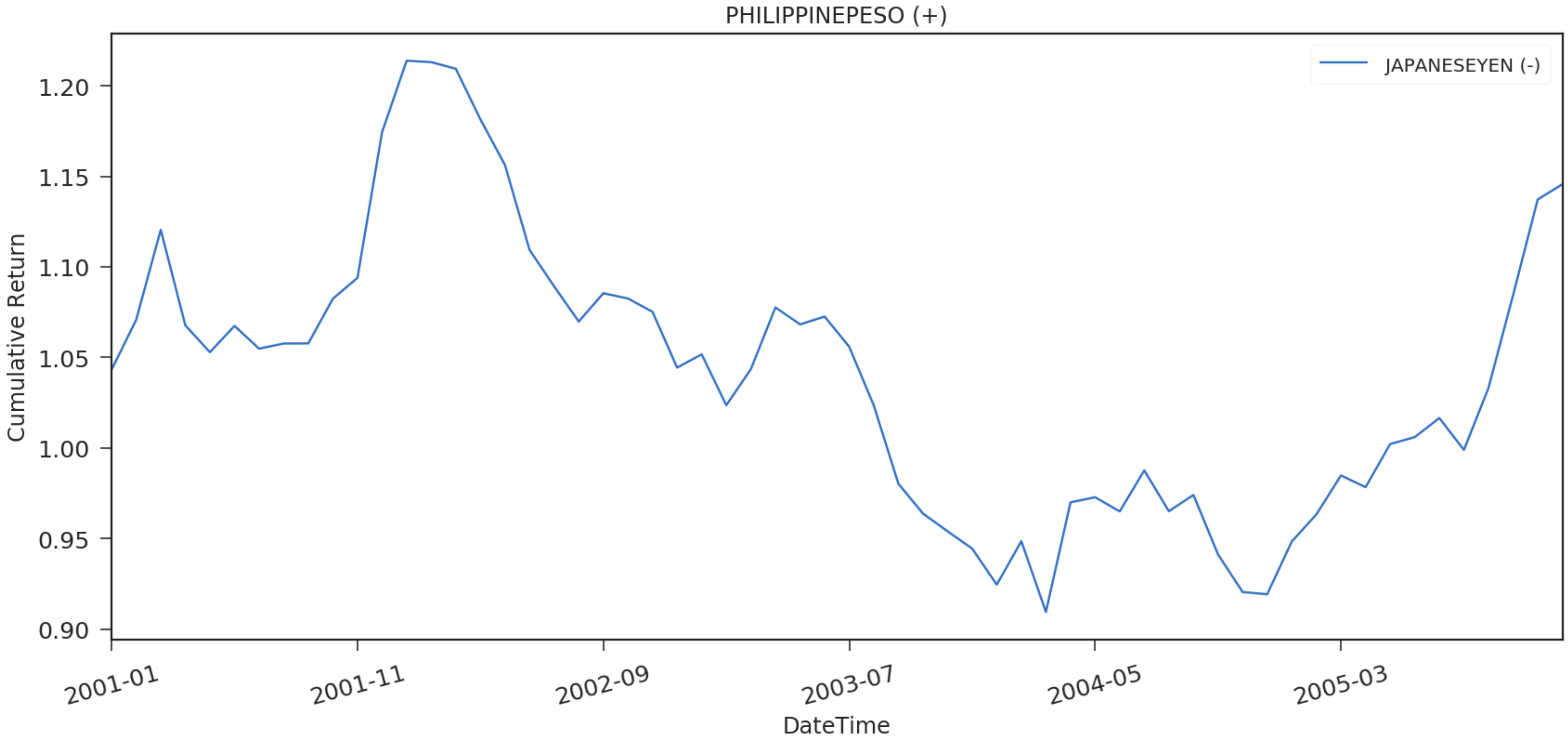


Table 1: Summary Statistics of the Level of Spot and Forward Rates

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 dollar), including 16 currencies in developed economies (Panel A) and 32 currencies in emerging economies (Panel B). 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.

Panel A: Developed 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

Panel B: 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
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 dollar), including 16 currencies in developed economies (Panel A) and 32 currencies in emerging economies (Panel B). 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.

Panel A: Developed 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

Panel B: Emerging Currencies

	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: Out-of-sample Profitability of Profitable Strategies in Four Sub-period: 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 trades strategies based on 1-, 3-, 6-, and 12-month forward discounts. We consider 100, 200, 300, and 400 carry trades 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 trades 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 trades strategies to the total number of carry trades 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 trades 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 trades strategies to the total number of carry trades 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 4: Applying Mean Return Profitable Strategies in Past 1 Year to Next N Years

This table lists the results of applying mean return profitable strategies in the past one year to the out-of-sample next N years where N equals from 1 to 8. The first column indicates the year of doing the out-of-sample test. Other rows present the values for each N, and the values indicate the percentage of profitable strategies in the past one year that continues to make profit in the next N years and pass data-snooping tests. The values in parentheses denote the average mean returns of all profitable strategies.

	Past 1 year profitable strategies applied to next N years							
N	1	2	3	4	5	6	7	8
1985	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1986	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1987	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1988	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1989	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1990	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1991	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1992	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1993	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1994	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1995	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1996	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1997	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1998	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
1999	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
2000	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
2001	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
2002	85.71% (2.50%)	85.71% (3.01%)	85.71% (2.45%)	100.00% (2.19%)	98.57% (1.91%)	100.00% (1.74%)	82.14% (1.26%)	82.14% (1.18%)
2003	68.46% (2.50%)	95.87% (1.73%)	100.00% (1.57%)	100.00% (1.24%)	100.00% (1.17%)	45.45% (0.76%)	46.28% (0.75%)	55.37% (0.70%)
2004	70.30% (1.23%)	100.00% (1.22%)	100.00% (1.02%)	100.00% (0.96%)	27.27% (0.51%)	29.09% (0.55%)	40.00% (0.53%)	72.73% (0.54%)
2005	100.00% (1.47%)	100.00% (1.21%)	100.00% (1.12%)	0.00% (0.00%)	0.00% (0.00%)	15.38% (0.20%)	50.55% (0.56%)	53.26% (0.57%)
2006	3.62% (0.28%)	21.28% (0.36%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	2.98% (0.07%)	9.57% (0.18%)
2007	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	41.18% (0.10%)	0.00% (0.00%)
2008	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)
2009	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	
2010	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)		
2011	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)			
2012	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)				
2013	0.00% (0.00%)	0.00% (0.00%)	0.00% (0.00%)					
2014	0.00% (0.00%)	66.67% (0.80%)						
2015	0.00% (0.00%)							

Table 5: Out-of-sample Profitability of Profitable Strategies: All Currencies

This table summarizes all out-of-sample profitability tests by presenting the average percentages of strategies that continue to profit (Columns 1 and 5) and their average (Columns 2 and 6), maximum (Columns 3 and 7) and minimum annualized returns (Columns 4 and 8). For example, the numbers in Column 1 are the averages of Table 4 and all panels in Table A6; the numbers in Column 1 are the averages of all panels in Table A7. Each year's number indicates the average success rate of all past years' strategies in the future years. Columns 1-4 use mean return as the profitability criterion and Columns 5-8 use Sharpe ratio.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean Return as Profitability Criterion				Sharpe Ratio as Profitability Criterion			
	Average Profitable Strategies %	Mean Return	Max Return	Min Return	Average Profitable Strategies %	Mean Return	Max Return	Min Return
1985	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1986	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1987	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1988	0.00%	0.00%	0.00%	0.00%	15.63%	0.06%	0.55%	0.00%
1989	2.50%	0.01%	0.20%	0.00%	3.06%	0.02%	0.32%	0.00%
1990	0.00%	0.00%	0.00%	0.00%	11.04%	0.05%	0.59%	0.00%
1991	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1992	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1993	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1994	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1995	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1996	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1997	0.00%	0.00%	0.00%	0.00%	5.48%	0.02%	0.34%	0.00%
1998	6.25%	0.01%	0.24%	0.00%	7.03%	0.02%	0.28%	0.00%
1999	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2000	0.00%	0.00%	0.00%	0.00%	10.94%	0.02%	0.31%	0.00%
2001	12.40%	0.24%	2.64%	0.00%	21.88%	0.05%	0.44%	0.00%
2002	93.28%	2.09%	3.67%	0.91%	59.10%	0.63%	2.95%	0.00%
2003	83.05%	1.64%	4.08%	0.70%	59.70%	0.98%	2.67%	0.48%
2004	51.29%	0.66%	1.23%	0.28%	26.11%	0.29%	0.90%	0.00%
2005	37.71%	0.42%	1.47%	0.00%	18.10%	0.23%	0.91%	0.00%
2006	5.42%	0.13%	0.54%	0.00%	0.23%	0.06%	0.46%	0.00%
2007	1.06%	0.02%	0.48%	0.00%	0.00%	0.00%	0.00%	0.00%
2008	1.74%	0.02%	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%
2009	27.06%	0.21%	0.85%	0.00%	16.70%	0.17%	0.83%	0.00%
2010	21.97%	0.19%	0.88%	0.00%	12.95%	0.11%	0.89%	0.00%
2011	16.05%	0.15%	0.97%	0.00%	5.96%	0.06%	0.79%	0.00%
2012	25.15%	0.18%	0.94%	0.00%	0.00%	0.00%	0.00%	0.00%
2013	37.68%	0.32%	0.91%	0.00%	0.00%	0.00%	0.00%	0.00%
2014	4.17%	0.05%	0.80%	0.00%	0.00%	0.00%	0.00%	0.00%
2015	49.17%	0.97%	2.17%	0.00%	3.79%	0.07%	0.57%	0.00%
Average	15.35%	0.24%	0.72%	0.06%	8.96%	0.09%	0.45%	0.02%

Table 6: Out-of-sample Profitability of Profitable Strategies: Developed Currencies

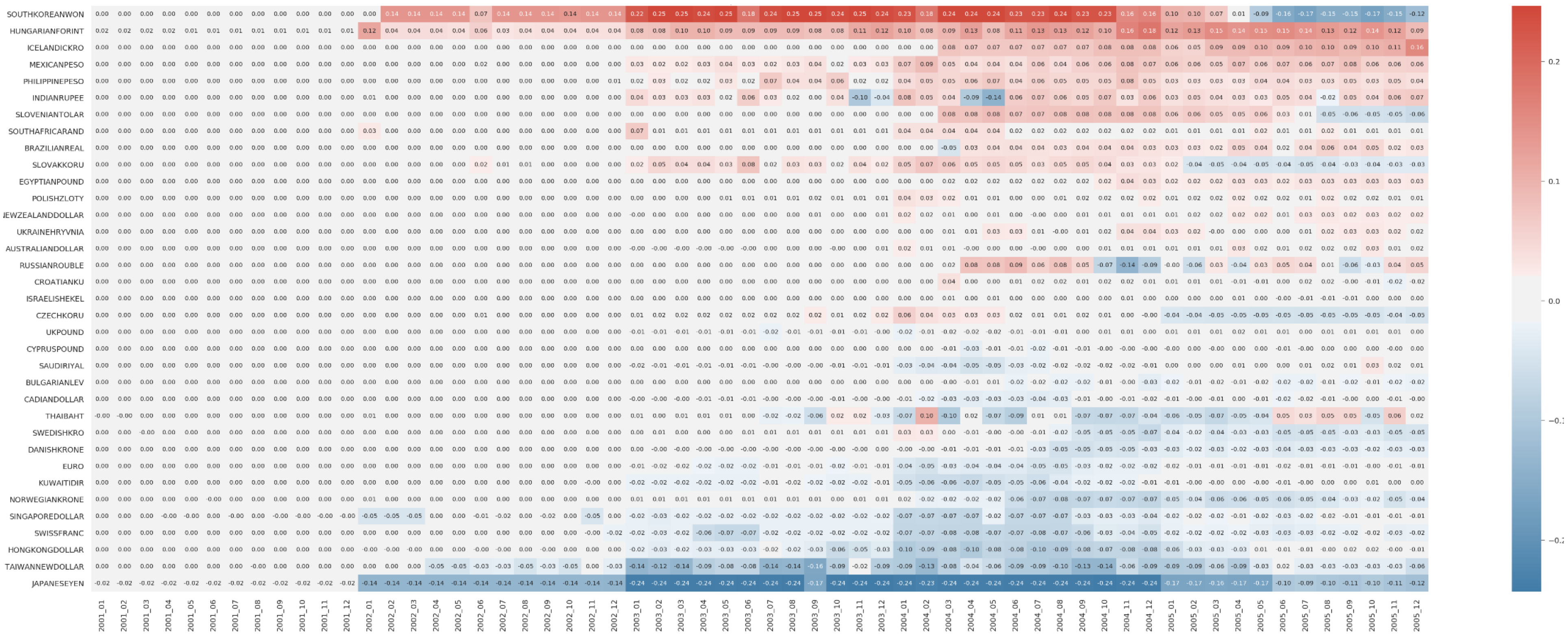
This table summarizes all out-of-sample profitability tests by presenting the average percentages of strategies using only developed currencies that continue to profit (Columns 1 and 5) and their average (Columns 2 and 6), maximum (Columns 3 and 7) and minimum annualized returns (Columns 4 and 8). Each year's number indicates the average success rate of all past years' strategies in the future years. Columns 1-4 use mean return as the profitability criterion and Columns 5-8 use Sharpe ratio.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mean Return as Profitability Criterion				Sharpe Ratio as Profitability Criterion			
	Average Profitable Strategies %	Mean Return	Max Return	Min Return	Average Profitable Strategies %	Mean Return	Max Return	Min Return
1985	0.00%	0.00%	0.00%	0.00%	24.81%	0.15%	0.64%	0.00%
1986	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1987	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1988	12.50%	0.09%	0.80%	0.00%	0.00%	0.00%	0.00%	0.00%
1989	26.29%	0.14%	0.74%	0.00%	8.86%	0.03%	0.41%	0.00%
1990	19.66%	0.14%	1.08%	0.00%	8.10%	0.04%	0.52%	0.00%
1991	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1992	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1993	2.20%	0.01%	0.33%	0.00%	0.00%	0.00%	0.00%	0.00%
1994	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1995	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1996	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1997	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1998	4.27%	0.01%	0.24%	0.00%	6.25%	0.01%	0.23%	0.00%
1999	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2000	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2001	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2002	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2003	29.40%	0.11%	0.54%	0.00%	9.73%	0.05%	0.46%	0.00%
2004	16.76%	0.10%	0.41%	0.00%	4.91%	0.02%	0.34%	0.00%
2005	6.11%	0.07%	0.55%	0.00%	0.01%	0.00%	0.02%	0.00%
2006	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2007	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2008	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2009	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2010	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2011	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2012	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2013	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2014	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2015	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Average	3.78%	0.02%	0.15%	0.00%	2.02%	0.01%	0.08%	0.00%

Table 7: Mostly Longed and Shorted Currencies in Strategies: 2001-2005

This table presents the most often longed and shorted currencies. The criterion for profitability is mean return in Panel A and Sharpe ratio in Panel B. For better presentation, we delete the currencies that are never used in any strategies between 2001 and 2005. To implement this, we first find the profitable 1-month strategies that pass the tests in each month between January 2001 and December 2005 from all 100 strategies (not including learning or stop-loss strategies, but the results are robust when including them). If strategy *it*, balanced in month t and i = 1, 2, ..., 100, is profitable and passes tests in the past x years and profitable in the next y years, we denote $\mathbf{1}(\text{profitable})_{itxy} = 1$, otherwise it equals zero. Then we count the number of tests this strategy's profitability passes the data-snooping tests in the 500 tries in the next y years, and calculate the ratio. Then for each currency c in each significantly profitable strategy *it*'s long and short portfolios, we calculate the average probability of this currency being used in all strategies' long and short portfolios. More particularly, we calculate the *net* probability that equals the probability of being used in long portfolios minus the probability of being used in short portfolios, and present the probability in each cell.

Panel A: Mean Return



	2001_01	2001_02	2001_03	2001_04	2001_05	2001_06	2001_07	2001_08	2001_09	2001_10	2001_11	2001_12	2002_01	2002_02	2002_03	2002_04	2002_05	2002_06	2002_07	2002_08	2002_09	2002_10	2002_11	2002_12	2003_01	2003_02	2003_03	2003_04	2003_05	2003_06	2003_07	2003_08	2003_09	2003_10	2003_11	2003_12	2004_01	2004_02	2004_03	2004_04	2004_05	2004_06	2004_07	2004_08	2004_09	2004_10	2004_11	2004_12	2005_01	2005_02	2005_03	2005_04	2005_05	2005_06	2005_07	2005_08	2005_09	2005_10	2005_11	2005_12
SOUTHKOREANWON	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.14	0.07	0.14	0.14	0.14	0.14	0.14	0.14	0.22	0.25	0.25	0.24	0.25	0.18	0.24	0.25	0.25	0.24	0.25	0.24	0.23	0.18	0.24	0.24	0.24	0.23	0.23	0.24	0.23	0.23	0.16	0.16	0.10	0.10	0.07	0.01	-0.09	-0.16	-0.17	-0.15	-0.15	-0.17	-0.15	-0.12
HUNGARIANFORINT	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.12	0.04	0.04	0.04	0.04	0.06	0.03	0.04	0.04	0.04	0.04	0.04	0.08	0.08	0.10	0.10	0.09	0.09	0.09	0.09	0.08	0.08	0.11	0.12	0.10	0.08	0.09	0.13	0.08	0.11	0.13	0.13	0.12	0.10	0.16	0.18	0.12	0.13	0.15	0.14	0.15	0.15	0.14	0.13	0.12	0.14	0.12	0.09
ICELANDICKRO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.06	0.05	0.09	0.09	0.10	0.09	0.10	0.10	0.09	0.10	0.11	0.16
MEXICANPESO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.03	0.04	0.03	0.02	0.03	0.04	0.02	0.03	0.03	0.07	0.09	0.05	0.04	0.04	0.04	0.06	0.04	0.06	0.06	0.08	0.07	0.06	0.06	0.05	0.07	0.06	0.07	0.06	0.07	0.08	0.06	0.06	0.06
PHILIPPINEPESO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.02	0.02	0.03	0.02	0.07	0.04	0.04	0.06	0.02	0.02	0.04	0.05	0.05	0.06	0.07	0.04	0.06	0.05	0.05	0.05	0.08	0.05	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.05	0.03	0.05	0.04
INDIANRUPEE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.03	0.03	0.02	0.06	0.03	0.02	0.00	0.04	-0.10	-0.04	0.08	0.05	0.04	-0.09	-0.14	0.06	0.07	0.06	0.05	0.07	0.03	0.06	0.03	0.05	0.04	0.03	0.03	0.05	0.04	-0.02	0.05	0.04	0.06	0.07
SLOVENIANTOLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.08	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.06	0.06	0.05	0.05	0.06	0.03	0.01	-0.05	-0.06	-0.05	-0.05	-0.06
SOUTHAFRICARAND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01
BRAZILIANREAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	0.03	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.05	0.04	0.02	0.04	0.06	0.04	0.05	0.02	0.03
SLOVAKKORU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.05	0.04	0.04	0.03	0.08	0.02	0.03	0.03	0.02	0.04	0.02	0.05	0.07	0.06	0.05	0.05	0.05	0.03	0.05	0.05	0.04	0.03	0.03	0.02	-0.04	-0.05	-0.04	-0.05	-0.04	-0.05	-0.04	-0.03	-0.04	-0.03	-0.03
EGYPTIANPOUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
POLISHZLOTY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.04	0.03	0.02	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01
JEWZEALANDDOLLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.02	0.01	0.00	0.01	0.00	-0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.03	0.03	0.02	0.03	0.02	0.02
UKRAINEHRYVNIA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.03	0.01	-0.00	0.01	0.02	0.04	0.04	0.03	0.02	-0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.02	0.02
AUSTRALIANDOLLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	-0.00	0.00	0.01	0.02	0.01	0.01	-0.00	0.00	0.00	-0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.02	0.02	0.03	0.01	0.02
RUSSIANROUBLE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.08	0.09	0.06	0.08	0.05	-0.07	-0.14	-0.09	-0.00	-0.06	0.03	-0.04	0.03	0.05	0.04	0.01	-0.06	-0.03	0.04	0.05
CROATIANKU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	-0.01	-0.01	0.00	0.02	0.02	-0.00	-0.01	-0.02	-0.02
ISRAELISHEKEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	-0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00
CZECHKORU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.06	0.04	0.03	0.03	0.03	0.02	0.01	0.01	0.02	0.01	0.00	-0.00	-0.04	-0.04	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.04	-0.05
UKPOUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01	-0.00	-0.02	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
CYPRUSPOUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	-0.01	-0.01	-0.02	-0.01	-0.01	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	0.00	0.00	-0.01	-0.00	0.00	0.00	0.00	-0.00	0.00
SAUDIRIYAL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.03	-0.04	-0.04	-0.05	-0.05	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.01	0.03	0.02	0.01
BULGARIANLEV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.01	0.01	-0.02	-0.02	-0.02	-0.02	-0.01	-0.00	-0.03	-0.02	-0.01	-0.02	-0.01	-0.02	-0.02	-0.02	-0.01	-0.02	-0.01	-0.02	-0.02
CADIANDOLLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.00	-0.00	-0.00	-0.01	-0.00	-0.00	-0.01	-0.02	-0.03	-0.03	-0.03	-0.03	-0.04	-0.03	-0.01	-0.00	-0.01	-0.02	-0.01	-0.00	-0.01	0.00	-0.01	-0.02	-0.02	-0.01	-0.00	0.00	-0.01	-0.00
THAIBAHT	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	-0.02	-0.02	-0.06	0.02	0.02	-0.03	-0.07	0.10	-0.10	0.02	-0.07	-0.09	0.01	0.01	-0.07	-0.07	-0.07	-0.04	-0.06	-0.05	-0.07	-0.05	-0.04	0.05	0.03	0.05	0.05	-0.05	0.06	0.02
SWEDISHKRO	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.00	-0.01	-0.00	-0.00	-0.01	-0.02	-0.05	-0.05	-0.05	-0.07	-0.04	-0.02	-0.04	-0.03	-0.03	-0.05	-0.05	-0.05	-0.03	-0.03	-0.05	-0.05
DANISHKRONE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	-0.00	-0.01	-0.01	-0.01	-0.01	-0.03	-0.05	-0.05	-0.05	-0.05	-0.03	-0.03	-0.02	-0.03	-0.02	-0.03	-0.04	-0.03	-0.03	-0.03	-0.02	-0.03	-0.03
EURO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.04	-0.05	-0.03	-0.04	-0.04	-0.04	-0.05	-0.05	-0.03	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.02	-0.01	-0.01	-0.01	-0.00	-0.01	-0.01
KUWAITIDIR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01	-0.02	-0.02	-0.02	-0.02	-0.01	-0.05	-0.06	-0.06	-0.07	-0.05	-0.05	-0.06	-0.04	-0.02	-0.02	-0.02	-0.01	-0.01	-0.00	-0.00	0.00	-0.00	-0.01	-0.00	0.00	0.00	0.01	0.00	0.00
NORWEGIANKRONE	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02	-0.02	-0.02	-0.02	-0.02	-0.06	-0.07	-0.08	-0.07	-0.07	-0.07	-0.07	-0.05	-0.04	-0.06	-0.06	-0.05	-0.06	-0.05	-0.04	-0.03	-0.02	-0.05	-0.04
SINGAPOREDOLLAR	0.00	0.00	0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.05	-0.05	-0.05	0.00	0.00	-0.01	-0.02	0.00	-0.02	0.00	-0.05	0.00	-0.02	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.07	-0.07	-0.07	-0.07	-0.02	-0.07	-0.07	-0.07	-0.03	-0.03	-0.03	-0.04	-0.02	-0.02	-0.02	-0.01	-0.02	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01
SWISSFRANC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.02	-0.02	-0.03	-0.02	-0.06	-0.07	-0.07	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.07	-0.07	-0.08	-0.08	-0.07	-0.07	-0.08	-0.07	-0.06	-0.03	-0.04	-0.05	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.03	-0.02
HONGKONGDOLLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.00	-0.00	0.00	-0.00	0.00	0.00	0.00	-0.02	-0.03	-0.02	-0.03	-0.03	-0.03	-0.02	-0.02	-0.03	-0.06	-0.05	-0.03	-0.10	-0.09	-0.08	-0.10	-0.08	-0.08	-0.10	-0.09	-0.08	-0.07	-0.08	-0.08	-0.06	-0.03	-0.03	-0.03	0.01	-0.01	-0.01	-0.00	0.02	0.02	-0.00	-0.01
TAIWANNEWDOLLAR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	-0.05	-0.03	-0.03	-0.05	-0.03	-0.05	0.00	-0.03	-0.14	-0.12	-0.14	-0.09	-0.08	-0.08	-0.14	-0.14	-0.16	-0.09	-0.02	-0.09	-0.09	-0.13	-0.08	-0.04	-0.06	-0.09	-0.09	-0.10	-0.13	-0.14	-0.06	-0.09	-0.09	-0.09	-0.06	-0.09	-0.03	0.02	-0.03	-0.03	-0.03	-0.03	-0.03	-0.06
JAPANESEYEN	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.14	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.17	-0.24	-0.24	-0.24	-0.24	-0.23	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.17	-0.17	-0.16	-0.17	-0.17	-0.10	-0.09	-0.10	-0.11	-0.10	-0.11	-0.12

Panel B: Sharpe Ratio

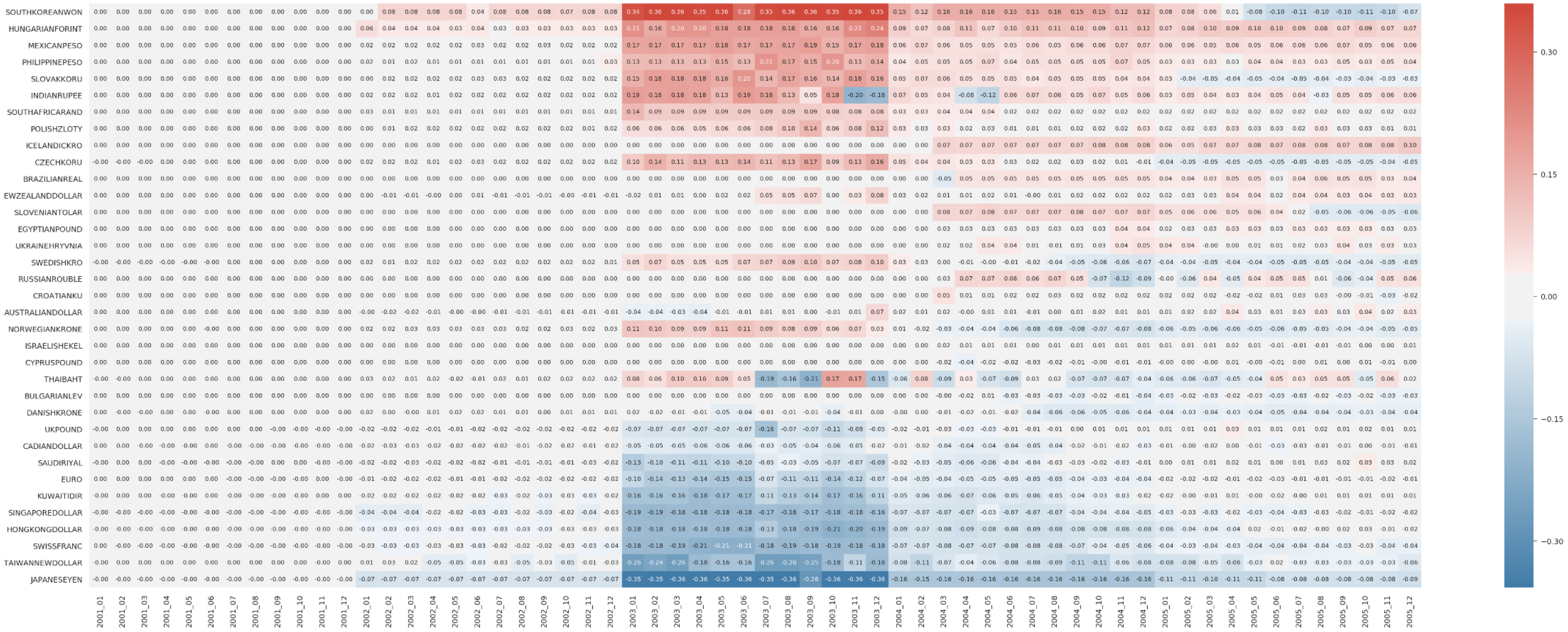
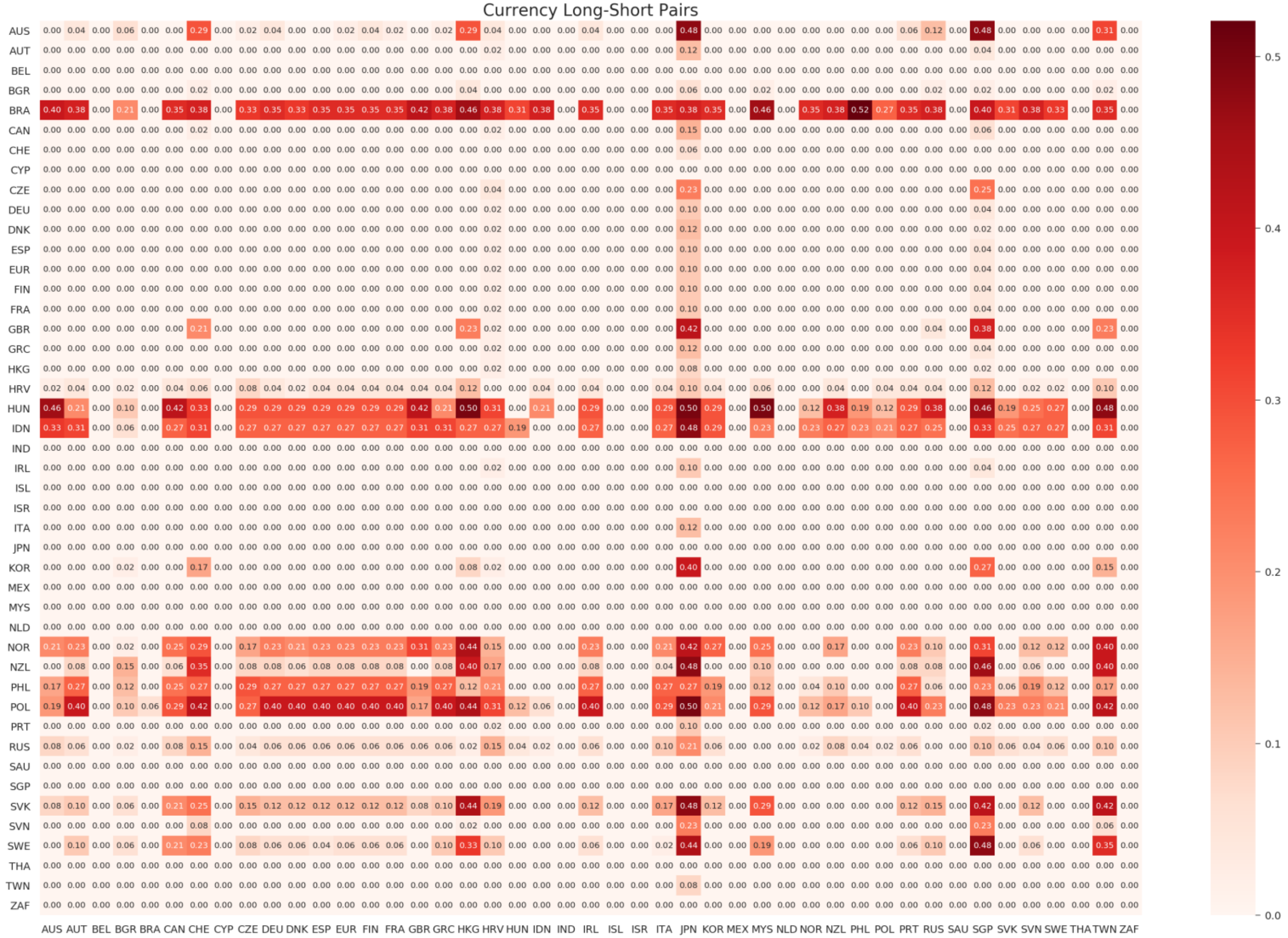


Table 8: Currency Pairs Satisfying Exchange Rate and Interest Rate Conditions: 2001-2005

In this table, the value in each cell represents the proportion of months between 2001 and 2005 that the currency in the vertical axis (“the longed currency”) appreciate against the currency in the horizontal axis (“the shorted currency”) and the longed currency’s interest rate is higher than the shorted one’s by 3%.



	AUS	AUT	BEL	BGR	BRA	CAN	CHE	CYP	CZE	DEU	DNK	ESP	EUR	FIN	FRA	GBR	GRC	HKG	HRV	HUN	IDN	IND	IRL	ISL	ISR	ITA	JPN	KOR	MEX	MYS	NLD	NOR	NZL	PHL	POL	PRT	RUS	SAU	SGP	SVK	SVN	SWE	THA	TWN	ZAF
AUS	0.00	0.04	0.00	0.06	0.00	0.00	0.29	0.00	0.02	0.04	0.00	0.00	0.02	0.04	0.02	0.00	0.02	0.29	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.12	0.00	0.48	0.00	0.00	0.00	0.00	0.31	0.00
AUT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
BEL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BGR	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00
BRA	0.40	0.38	0.00	0.21	0.00	0.35	0.38	0.00	0.33	0.35	0.33	0.35	0.35	0.35	0.35	0.42	0.38	0.46	0.38	0.31	0.38	0.00	0.35	0.00	0.00	0.35	0.38	0.35	0.00	0.46	0.00	0.35	0.38	0.52	0.27	0.35	0.38	0.00	0.40	0.31	0.38	0.33	0.00	0.35	0.00
CAN	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
CHE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CYP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CZE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
DEU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
DNK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
ESP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
EUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
FIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
FRA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
GBR	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.38	0.00	0.00	0.00	0.00	0.23	0.00
GRC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
HKG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
HRV	0.02	0.04	0.00	0.02	0.00	0.04	0.06	0.00	0.08	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.04	0.12	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.04	0.10	0.04	0.00	0.06	0.00	0.00	0.04	0.00	0.04	0.04	0.04	0.00	0.12	0.00	0.02	0.02	0.00	0.10	0.00
HUN	0.46	0.21	0.00	0.10	0.00	0.42	0.33	0.00	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.42	0.21	0.50	0.31	0.00	0.21	0.00	0.29	0.00	0.00	0.29	0.50	0.29	0.00	0.50	0.00	0.12	0.38	0.19	0.12	0.29	0.38	0.00	0.46	0.19	0.25	0.27	0.00	0.48	0.00
IDN	0.33	0.31	0.00	0.06	0.00	0.27	0.31	0.00	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.31	0.31	0.27	0.27	0.19	0.00	0.00	0.27	0.00	0.00	0.27	0.48	0.29	0.00	0.23	0.00	0.23	0.27	0.23	0.21	0.27	0.25	0.00	0.33	0.25	0.27	0.27	0.00	0.31	0.00
IND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IRL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
ISL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ISR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ITA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KOR	0.00	0.00	0.00	0.02	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.15	0.00
MEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MYS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NLD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOR	0.21	0.23	0.00	0.02	0.00	0.25	0.29	0.00	0.17	0.23	0.21	0.23	0.23	0.23	0.23	0.31	0.23	0.44	0.15	0.00	0.00	0.00	0.23	0.00	0.00	0.21	0.42	0.27	0.00	0.25	0.00	0.00	0.17	0.00	0.00	0.23	0.10	0.00	0.31	0.00	0.12	0.12	0.00	0.40	0.00
NZL	0.00	0.08	0.00	0.15	0.00	0.06	0.35	0.00	0.08	0.08	0.06	0.08	0.08	0.08	0.08	0.00	0.08	0.40	0.17	0.00	0.00	0.00	0.08	0.00	0.00	0.04	0.48	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.46	0.00	0.06	0.00	0.00	0.40	0.00
PHL	0.17	0.27	0.00	0.12	0.00	0.25	0.27	0.00	0.29	0.27	0.27	0.27	0.27	0.27	0.27	0.19	0.27	0.12	0.21	0.00	0.00	0.00	0.27	0.00	0.00	0.27	0.27	0.19	0.00	0.12	0.00	0.04	0.10	0.00	0.00	0.27	0.06	0.00	0.23	0.06	0.19	0.12	0.00	0.17	0.00
POL	0.19	0.40	0.00	0.10	0.06	0.29	0.42	0.00	0.27	0.40	0.40	0.40	0.40	0.40	0.40	0.17	0.40	0.44	0.31	0.12	0.06	0.00	0.40	0.00	0.00	0.29	0.50	0.21	0.00	0.29	0.00	0.12	0.17	0.10	0.00	0.40	0.23	0.00	0.48	0.23	0.23	0.21	0.00	0.42	0.00
PRT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
RUS	0.08	0.06	0.00	0.02	0.00	0.08	0.15	0.00	0.04	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.02	0.15	0.04	0.02	0.00	0.06	0.00	0.00	0.10	0.21	0.06	0.00	0.00	0.00	0.02	0.08	0.04	0.02	0.06	0.00	0.00	0.10	0.06	0.04	0.06	0.00	0.10	0.00
SAU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SGP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SVK	0.08	0.10	0.00	0.06	0.00	0.21	0.25	0.00	0.15	0.12	0.12	0.12	0.12	0.12	0.12	0.08	0.10	0.44	0.19	0.00	0.00	0.00	0.12	0.00	0.00	0.17	0.48	0.12	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.12	0.15	0.00	0.42	0.00	0.12	0.00	0.00	0.42	0.00
SVN	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.06	0.00
SWE	0.00	0.10	0.00	0.06	0.00	0.21	0.23	0.00	0.08	0.06	0.06	0.04	0.06	0.06	0.06	0.00	0.10	0.33	0.10	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.44	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.06	0.10	0.00	0.48	0.00	0.06	0.00	0.00	0.35	0.00
THA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TWN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ZAF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00