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Weak-Form Efficiency in Currency Markets

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Many past studies have found that currencies trend, so technical trading rules produced statistically and economically significant profits. In other words, foreign exchange markets were weak-form inefficient. The study reported here reexamined this phenomenon with use of a new database of currency futures for 1975–2006 that includes old and newly liquid currencies. The findings from the recent data are contradictory. The profitability of trend following eroded for major currencies and their associated cross exchange rates around the mid-1990s. Newly liquid currencies after 2000 do trend, however, just as major currencies did in earlier years. The evidence is consistent with early weak-form inefficiency followed by vanishing trends as traders learn and adapt their strategies.

Roughly 90 percent of foreign exchange traders base their positions at least partially on technical trading rules, and 30–40 percent of traders use technical rules as their principal tool.[1] Some of these systems are quite exotic—looking into the data for "head and shoulders" patterns or "double bottoms"; others use the Fibonacci number sequence. For many technical traders, the basic idea is "the trend is your friend." That is, traders believe exchange rates exhibit inertia in such a way that a positive move in one period is likely to be followed by a positive move in the subsequent period. Surprisingly, academic tests of weak-form foreign exchange market efficiency have supported technical traders. Using long time series of historical data, many studies have found that trend-following trading produced statistically and economically significant profits.[2] This outcome is in stark contrast with the conventional results found in other markets and flies in the face of respected theory (see Samuelson 1965).

The purposes of the study reported here were to update earlier results on trend-following trading by using data subsequent to the 1990s, to compare the results with those of prior periods, and to compare the behavior of the major exchange rates with cross exchange rates, exchange rates of the less liquid currencies, and exchange rates for currencies that have only recently become liquid. To the best of our knowledge, this study is the first on technical rules that uses so many different currency combinations and includes newly liquid currencies. These new results help us explore the causes of trending: Is it anomalous, characteristic only of the 1970s and 1980s, or a general feature of newly trading exchange rates?

In the existing literature, researchers have used spot exchange rates and the studies support the profitability of technical trading. These studies do have some drawbacks. First, most do not measure statistical significance. Second, many assume that exchange rate volatility is constant. In the study reported here, we applied a bootstrap method devised by Levich and Thomas (1993). Third, using spot rates is inferior to using currency futures because futures prices reflect the contemporaneous interest differential between the foreign currency and the base currency. When currency futures are used, there is no need for overnight interest rates on spot interbank deposits. Therefore, we used currency futures. The only drawback is that futures are more expensive to obtain and are available for shorter time spans. Fourth, previous studies covered a limited number of currencies. We used futures contracts for all liquid, illiquid, and newly liquid currencies that were available in the market. Major liquid currencies used in this study are the euro (and for earlier periods, the German mark), British pound, Japanese yen, Swiss franc, Canadian dollar, and Australian dollar, for which data are available since 1973. Finally, unlike previous studies, we examined all possible cross exchange rates and possible *numeraires* of liquid currencies.

We examined a variety of momentum-based trading rules to reduce the odds that any given rule we chose might be particularly bad or particularly good by chance. We also looked at moving-average crossover rules, which are especially favored by technical traders.

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Forecasting Exchange Rates

The most obvious way to forecast exchange rates is to use a structural model; these models have many different forms. Some emphasize current account balances, whereas others use growth rates in relative money supplies, and still others focus on the stocks of assets held in various currencies. Unfortunately, Meese and Rogoff (1983a, 1983b) showed that none of the contending models is able to forecast better than a simple random walk, and subsequent papers failed to refute the basic Meese–Rogoff results.

Of course, the simplest available forecast for portfolio managers, traders, and hedgers might be the forward foreign exchange rate. If the forward rate were an unbiased predictor of the future spot rate, then the problem of forecasting future rates would be substantially solved. Unfortunately, careful tests have decisively rejected this hypothesis (see Bilson 1981; Hansen and Hodrick 1980). Moreover, the unbiased conjecture of the hypothesis is inconsistent with Siegel's Paradox, which holds that, for example, the expected future euro/dollar exchange rate does not equal the inverse of the expected future dollar/euro rate. As a result, no single, consistent, unbiased rate can exist for both.

Surprisingly, where structural models have failed, technical trading models have succeeded. Dooley and Shafer (1983) and Sweeney (1986) were among the first to report that trend-following models seem to be more successful than a random walk would predict. Other researchers, including Levich and Thomas (1993), who used a bootstrap technique to test for statistical significance, also reported success with technical trading models. Neely and Weller (1999) showed that trending existed in the European Monetary System, and Cheung and Wong (1997) reported that Asian currencies also seemed to trend. Okunev and White (2003) examined the performance of momentum trading strategies for eight major currencies and found that such strategies were profitable from the 1970s through the 1990s. Schulmeister (2005) found that trending existed for the dollar/euro rate until 2002.

Cialenco and Protopapadakis (2006) examined filter and moving-average rules for eight currencies and found, however, that out-of-sample profits have almost disappeared and are never significant. A recent study by Neely, Weller, and Ulrich (forthcoming) also found that profits from technical rules have disappeared. They argued that this finding is consistent with Lo's (2004) "adaptive market hypothesis" but not with the efficient market hypothesis. Liu (2007) argued that trend-trading profitability has disappeared because underlying exchange rates have become more random and the currencies priced more efficiently since the introduction of currency futures contracts.[3]

Almost all of the tests were performed on data prior to 2000, and there is some evidence that since that time, trend-following behavior has diminished.[4] Therefore, the time is ripe to examine whether exchange rate trending has extended into the 21st century.

Data and Methodology

Many trading rules can capture trends. Some practitioners believe that the trader should focus on extracting the "best" rules. And there is some evidence that genetic algorithms can improve on simple trading rules. But most tests do not support the notion that the best rules in one period are also the best in subsequent periods. Levich and Thomas (1993) examined three types of rules—momentum rules, moving-average crossover rules, and filter rules—and found little difference in the rules' efficacy. Schulmeister (2005) examined 1,064 trading rules and conducted a test in which the best 25 trading rules in one period were used in the subsequent period. He found little out-of-sample support that such an approach was successful. Olson (2004) optimized a moving-average rule for five-year in-sample periods and tested it over subsequent five-year out-of-sample periods. He concluded that this procedure was unsuccessful, at least with recent data.

To avoid a data-snooping bias, a trading rule must be chosen before any data tests are run. In other words, a trading rule can always be found that would have worked had it been known in advance and that will work within the selected sample. Because selecting or favoring such rules biases the results in favor of a positive finding, all the trading rules we used and report were selected in advance before they were applied to the data.

We started with *momentum rules*. Each momentum rule had a single parameter, N. To construct a momentum rule, we compared the current value of a currency futures contract with its value N days in the past. In practice, we first converted the futures data to index values. If the current index value exceeded the lagged value, the trading signal was positive and the currency was bought and held until the signal changed. If the current value was less than the N-day lagged value, then the trading signal was negative, the currency was sold, and the short position was held until the signal changed. Occasionally, the current and lagged values were equal, so the trader held no position. We used *25 rules*, in which we varied N as $N = 5, 10, 15, \ldots, 125$. For a single currency, 4 percent of our capital was assigned to each of the 25 rules. In the portfolio of six currencies, each rule governed 0.67 percent of the capital.[5]

Table 1. Liquid Currencies' Performance: Momentum Trend-Trading Strategy, 1975–2006

Currency	1975–2006	1975–99	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Japanese yen								
Mean of profits (%)	5.61	7.36	11.22	4.82	10.52	2.85	7.40	–1.08
Volatility (%)	8.28	8.63	7.06	8.71	8.62	8.01	10.40	6.77
t-Statistic	3.83	4.26	3.55	1.24	2.73	0.80	1.59	–0.42
p-Value	0.00	0.00	0.00	0.07	0.00	0.21	0.05	0.47
Information ratio	0.68	0.85	1.59	0.55	1.22	0.36	0.71	–0.16
α (%)	5.27	7.68	10.10	5.20	10.47	3.12	7.04	–1.11
t-Statistic, 2 periods: 3.16								
p-Value, 2 periods: 0.00								
German mark/euro								
Mean of profits (%)	5.54	6.11	7.05	6.40	7.79	0.48	8.83	3.37
Volatility (%)	12.88	13.96	6.73	8.49	9.62	8.89	26.18	7.43
t-Statistic	2.43	2.20	2.35	1.68	1.81	0.11	0.76	1.19
p-Value	0.00	0.00	0.00	0.04	0.02	0.64	0.23	0.08
Information ratio	0.43	0.44	1.05	0.75	0.81	0.05	0.34	0.45
α (%)	5.37	6.16	6.74	5.92	7.55	0.49	9.44	3.23
t-Statistic, 2 periods: 2.43								
p-Value, 2 periods: 0.02								
British pound								
Mean of profits (%)	2.48	3.09	9.95	7.25	2.27	1.41	–5.38	0.14
Volatility (%)	7.79	8.19	7.10	8.83	9.72	9.28	5.15	5.97
t-Statistic	1.81	1.90	3.13	1.83	0.51	0.34	–2.35	0.05
p-Value	0.02	0.02	0.00	0.02	0.40	0.55	0.00	0.72
Information ratio	0.32	0.38	1.40	0.82	0.23	0.15	–1.05	0.02
α (%)	2.34	2.90	10.65	7.63	2.31	1.49	–5.76	0.13
t-Statistic, 2 periods: 3.28								
p-Value, 2 periods: 0.00								
Swiss franc								
Mean of profits (%)	3.85	5.01	8.82	5.93	7.05	3.15	0.12	–0.56
Volatility (%)	9.10	9.44	8.25	10.10	10.57	9.89	8.13	7.65
t-Statistic	2.38	2.65	2.39	1.32	1.50	0.72	0.02	–0.19
p-Value	0.00	0.00	0.00	0.35	0.06	0.28	0.77	0.60
Information ratio	0.42	0.53	1.07	0.59	0.67	0.32	0.01	–0.07
α (%)	3.63	5.11	7.95	6.00	7.38	3.13	0.09	–0.55
t-Statistic, 2 periods: 2.93								
p-Value, 2 periods: 0.00								
Canadian dollar								
Mean of profits (%)	0.51	0.59	3.68	0.56	0.51	0.11	–1.91	0.21
Volatility (%)	3.88	3.44	3.06	2.95	3.85	3.51	3.75	5.24
t-Statistic	0.74	0.85	2.68	0.42	0.29	0.07	–1.14	0.11
p-Value	0.23	0.17	0.00	0.47	0.58	0.75	0.15	0.64
Information ratio	0.13	0.17	1.20	0.19	0.13	0.03	–0.51	0.04
α (%)	0.47	0.56	3.45	0.51	0.55	0.14	–1.74	0.19
t-Statistic, 2 periods: 2.26								
p-Value, 2 periods: 0.03								
Australian dollar								
Mean of profits (%)	–0.06	–0.57			4.59	–1.16	–1.83	0.87
Volatility (%)	7.55	7.23			9.36	6.27	7.26	8.10
t-Statistic	–0.05	–0.04			1.10	–0.42	–0.56	0.29
p-Value	0.72	0.73			0.17	0.47	0.35	0.58
Information ratio	–0.01	–0.01			0.49	–0.19	–0.25	0.11
α (%)	–0.04	–0.36			4.24	–1.07	–1.71	0.93
t-Statistic, 2 periods: 2.08								
p-Value, 2 periods: 0.05								

(continued)

Table 1. Liquid Currencies' Performance: Momentum Trend-Trading Strategy, 1975–2006 (continued)

Currency	1975–2006	1975–99	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Portfolio								
Mean of profits (%)	2.99	4.43	8.14	4.99	5.46	1.14	1.21	0.48
Volatility (%)	4.82	4.98	3.92	5.00	5.73	4.24	5.74	4.13
t-Statistic	3.51	4.45	4.64	2.23	2.13	0.60	0.47	0.31
p-Value	0.00	0.00	0.00	0.00	0.08	0.32	0.43	0.57
Information ratio	0.62	0.89	2.08	1.00	0.95	0.27	0.21	0.12
α (%)	2.90	3.99	7.89	5.39	5.02	1.07	1.18	0.50
t-Statistic, 2 periods: 2.88								
p-Value, 2 periods: 0.00								

Notes: "Mean of profits" is the mean annualized percentage return to the rule. "Volatility" is the standard deviation of the annual percentage returns. The *t*-statistic tests the null hypothesis that the mean annual return is zero. We applied the Newey–West standard errors in computing the *t*-statistic. The *p*-value is from the test of the null hypothesis that the mean return of the technical trading strategy equals the return of a random series generated from bootstrapping; low *p*-values reject the null hypothesis. The value α represents risk-adjusted returns from regressing annualized daily average trend-trading returns on the four risk factors given in the text. The "*t*-Statistic, 2 periods" provides the *t*-statistic for the null hypothesis that the annual excess returns in 1975–1989 and the annual excess returns in 1990–2006 are equal; the "*p*-Value, 2 periods" is for the null hypothesis that the annual excess returns in 1975–1989 and those in 1990–2006 are equal. Data for the Australian dollar are available only since 1985; thus, the *t*-Statistic, 2 periods and *p*-Value, 2 periods for the Australian dollar are for the null hypothesis that the annual excess returns in 1985–1989 and those in 1990–2006 are equal.

analysis. (We avoided splitting the sample on the basis of the strength and weakness of foreign currency, which may affect the profitability of technical trend trading.)

As Table 1 shows, trend trading the yen produced the greatest profits in the early years, more modest profits as late as 1995–1999, and losses after 2000. In fact, the post-2000 period was the only subperiod in which trend trading the yen failed to produce a gain.

The best years for trend trading the German mark and euro were, as for the yen, the early years of floating exchange rates. Trend trading the mark became unprofitable, however, as early as the late 1990s. Although the euro managed to produce a significant gain post-2000, it is the only currency to do so. In light of results we will report later, it is interesting to note that the euro was a "new" currency in 2000.

The British pound also tells a story similar to that of the yen, although since 2000, trend trading the pound has broken even with modest volatility.

The Swiss franc performed much like the other currencies—exhibiting early profits that vanished in the later subperiods.

The Canadian dollar and the Australian dollar have never been spectacular profit makers; they produced profits only in the very early years of floating rates and continued their generally mediocre performance after 2000. Note that futures contracts on the Australian dollar were not traded before the 1985–89 subperiod.

The portfolio of currencies produced remarkably high information ratios prior to 1990, but profits began declining in the early 1990s and were small in the 2000–06 period.

As can be seen from these results, trend-following trading has clearly been a bust since 2000. For some currencies, the tough times began even earlier, during the 1990s.

Moving-Average Crossover Strategy. Although trend-based trading was profitable from 1975 to 2006, the results reveal no marked difference between momentum trend trading and using moving-average crossover rules. As **Table 2** shows, changing rules to use moving-average crossovers did not alter the basic finding that the major currencies stopped trending in the 21st century.

Reading across each row reveals the usual pattern: Trend profits in the major currencies were favorable in the early years of floating rates, but the post-2000 trading results look like the result of chance.

Further Observations. Tables 1 and 2 also suggest the following observations:

First, for the momentum rules after 2000, profits for all currencies except the euro were negative or negligible. The Japanese yen would have produced attractive profits had the reverse rules—countertrend trading—been used, but it is highly unlikely that a trader would have had reason to expect the yen pattern in advance.

Second, for the moving-average rules, the information ratios were negative for four out of six individual currencies during 1995–1999 and 2000–2006. And for 2000–2006, the information ratio for the portfolio was also negative. Weak-form market efficiency implies zero profits and zero information ratios, so Table 2 provides some evidence that traders are now somewhat overreacting to trends.

Table 2. Liquid Currencies' Performance: Trend Trading Using Moving-Average Rules, 1975–2006

Currency	1975–2006	1975–99	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Japanese yen								
Mean of profits (%)	6.38	8.65	11.10	4.81	11.47	5.82	10.04	–2.29
Volatility (%)	8.52	8.81	7.11	8.69	8.91	8.24	10.69	7.33
t-Statistic	4.24	4.91	3.49	1.24	2.88	1.58	2.10	–0.83
p-Value	0.00	0.00	0.00	0.07	0.00	0.05	0.02	0.20
Information ratio	0.75	0.98	1.56	0.55	1.29	0.71	0.94	–0.31
α (%)	5.34	7.63	11.86	5.11	10.54	2.80	7.82	–1.17
t-Statistic, 2 periods: 2.85								
p-Value, 2 periods: 0.00								
German mark/euro								
Mean of profits (%)	5.90	6.86	6.81	6.58	9.77	0.79	10.37	2.20
Volatility (%)	14.68	15.98	6.90	8.91	9.99	9.27	31.03	7.94
t-Statistic	2.27	2.15	2.21	1.65	2.19	0.19	0.75	0.73
p-Value	0.00	0.02	0.00	0.04	0.00	0.60	0.23	0.23
Information ratio	0.40	0.43	0.99	0.74	0.98	0.09	0.33	0.28
α (%)	5.53	7.03	6.90	6.66	9.15	0.78	9.77	2.25
t-Statistic, 2 periods: 2.69								
p-Value, 2 periods: 0.01								
British pound								
Mean of profits (%)	2.72	3.48	11.03	7.80	3.31	1.21	–5.90	–0.17
Volatility (%)	8.19	8.56	7.49	9.14	10.21	9.39	5.84	6.59
t-Statistic	1.88	2.03	3.29	1.91	0.72	0.29	–2.26	–0.07
p-Value	0.02	0.03	0.00	0.02	0.28	0.58	0.00	0.75
Information ratio	0.33	0.41	1.47	0.85	0.32	0.13	–1.01	–0.03
α (%)	2.58	3.21	11.90	7.77	3.16	1.13	–6.13	–0.18
t-Statistic, 2 periods: 3.36								
p-Value, 2 periods: 0.00								
Swiss franc								
Mean of profits (%)	3.60	4.60	6.70	6.31	7.98	2.55	–0.51	–0.22
Volatility (%)	9.48	9.76	8.41	10.29	10.94	10.15	8.76	8.33
t-Statistic	2.15	2.35	1.79	1.36	1.63	0.56	–0.13	–0.08
p-Value	0.02	0.00	0.02	0.18	0.05	0.35	0.62	0.71
Information ratio	0.38	0.47	0.80	0.61	0.73	0.25	–0.06	–0.03
α (%)	3.32	4.49	7.06	6.83	7.76	2.44	–0.46	–0.24
t-Statistic, 2 periods: 2.97								
p-Value, 2 periods: 0.00								
Canadian dollar								
Mean of profits (%)	1.01	1.25	3.52	0.89	1.58	1.22	–0.96	0.11
Volatility (%)	4.10	3.62	3.11	3.14	3.98	3.70	4.05	5.58
t-Statistic	1.41	1.70	2.53	0.63	0.89	0.74	–0.54	0.05
p-Value	0.10	0.03	0.00	0.31	0.16	0.23	0.37	0.72
Information ratio	0.25	0.34	1.13	0.28	0.40	0.33	–0.24	0.02
α (%)	1.06	1.30	3.61	0.93	1.72	1.26	–0.92	0.10
t-Statistic, 2 periods: 2.15								
p-Value, 2 periods: 0.04								
Australian dollar								
Mean of profits (%)	–0.85				–0.18	–0.09	–1.02	–1.44
Volatility (%)	8.03				9.62	6.83	7.67	8.73
t-Statistic	–0.52				–0.04	–0.02	–0.29	–0.45
p-Value	0.39				0.73	0.77	0.58	0.46
Information ratio	–0.11				–0.02	–0.01	–0.13	–0.17
α (%)	–0.92				–0.19	–0.14	–0.97	–1.37
t-Statistic, 2 periods: 1.96								
p-Value, 2 periods: 0.05								

(continued)

Table 2. Liquid Currencies' Performance: Trend Trading Using Moving-Average Rules, 1975–2006 (continued)

Currency	1975–2006	1975–99	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Portfolio								
Mean of profits (%)	3.13	4.97	7.83	5.28	5.66	1.92	2.00	–0.30
Volatility (%)	6.08	6.27	4.34	5.97	6.98	5.91	7.65	4.93
t-Statistic	3.79	3.95	4.05	1.97	2.19	0.87	0.76	–0.19
p-Value	0.00	0.00	0.00	0.02	0.00	0.16	0.22	0.60
Information ratio	0.67	0.79	1.81	0.88	0.98	0.39	0.34	–0.07
α (%)	2.83	5.42	8.53	5.21	5.84	1.96	1.93	–0.27
t-Statistic, 2 periods: 2.76								
p-Value, 2 periods: 0.00								

Note: See the notes to Table 1.

Should the negative results become larger and be consistent, they may provide an opportunity for countertrend traders.

The results suggest that currency markets probably became weak-form efficient sometime during the late 1990s and have remained so since 2000.

For the analysis, we calculated mean trading profits and, as a measure of risk-adjusted returns, information ratios. We tested the statistical significance of mean trading profits by computing *t*-statistics by using the Newey–West standard errors to adjust for autocorrelation. The results of these tests are given in Tables 1 and 2.

In addition, Tables 1 and 2 report *p*-values, which are based on the bootstrap method (see Appendix A).

In the next-to-last rows of each panel in Tables 1 and 2, we report the *t*-statistics of the difference in profits between the 1975–89 period and 1990–2006. For all six currencies, these tests confirm that there was a significant difference in trading profits between these two time periods. The profitability of technical trading has declined over time, and the results are significant for six major currencies.

Robustness Tests. In this section, we discuss a battery of robustness tests on the liquid currencies' data.

□ *Adjusting for risk.* Tables 1 and 2 provide information ratios, but the information ratio does not take into account the joint distribution between trading returns and other factors. As a result, in addition to reporting the information ratio, we computed and report in the tables Jensen's alpha from the multifactor model as it has been applied by several previous researchers.[9] Alpha is a constant term controlling for systematic risks.

To compute alpha, we regressed annualized daily average trend-trading returns on four risk factors. Three of them are the annualized daily excess returns over the risk-free rates for the MSCI total stock return indices of Germany, Japan, and the United States. These three risk factors are the returns correlated with the market portfolio. Based on the capital asset pricing model, they are undiversifiable and should have positive returns. The fourth risk factor is the mean squared daily return over the previous five business days, which measures time-varying risk.

Alpha represents risk-adjusted returns and should have a value close to that of the unadjusted returns if the profitability of the technical trading rule is not explained by systematic risks. We compared alphas over time and found that the factor loadings were quite small and their *p*-values showed insignificance.

Overall, these results imply that a multifactor model does not explain the variation in profitability of technical trading rules over time and that systematic risk is not a possible explanation for high returns. Moreover, we found that α decreased over time and was close in magnitude to the mean trading profit. This result seems to support an argument that investors learn over time.

□ *Bootstrap results.* To confirm the robustness of our results, we applied Levich and Thomas's (1993) bootstrap approach to test the random behavior of exchange rates and the profitability of the technical trading rules. Appendix A provides the details. The Levich and Thomas tests do not depend on assumptions about the distribution process underlying changes in exchange rates. A bootstrap resamples thousands of new series of pseudo exchange rates. Each new series is constructed from randomly reordering the original series. We calculated the profitability of the trading rule under each series and then assessed the significance of trading-rule profits from the original series by comparing the results with the results derived from the thousands of randomly generated series. The resulting *p*-values compare the profitability of a technical trading rule with the means of its simulated distribution rather than with zero.

In all cases, the average profit in the simulated series was very small and insignificantly different from zero.[10] Most of the simulated average profits are negative. These results imply that the actual exchange rate series contained significant departures from serial independence that allowed technical trading rules to be profitable. If the actual series had been generated as randomly as the simulated series, average profits would have been close to zero. Overall, the results from bootstrapping support the conclusion that the profitability of the technical trading rules is unlikely to have occurred by chance.

■ *Out-of-sample tests.* The existing literature on trading rules reports large abnormal returns computed over entire sample periods instead of choosing the best rule from an initial period and then testing that rule in an out-of-sample period (e.g., Olson 2004). We, however, investigated whether the results of our trading rules held out of sample. At the end of each year, we assumed the trader selected strategies on the basis of the past two years' performance—that is, from year $t-2$ to year t. Then, the trader implemented these strategies from year t to year $t+1$ and updated the strategies annually. Therefore, the trading strategies were selected on the basis of past performance and the returns are out of sample.

We found evidence that the excess returns have declined over time in both the in-sample and out-of-sample periods. Our out-of-sample results, shown in **Table 3** (for the momentum trend trading) and **Table 4** (for trading using moving-average rules) agree with the results shown in Tables 1 and 2.

Tests of Hypotheses. Even though trend-following profits have disappeared, that does not mean they will not return. Therefore, currency traders are interested in *why* the strategies worked for more than 20 years. There are four contending hypotheses: (1) The strategies only *seem* successful because data mining was implicitly at work, (2) central bankers were manipulating exchange rates, (3) profits declined on paper because transaction costs have declined, and (4) profits declined after research on the profitable strategies was published and traders learned how to exploit the patterns.

■ *Implicit data mining.* This hypothesis contends that because so many times series have been examined by researchers, it was inevitable that one such collection of series—as it happened, dollar exchange rates—would appear to support weak-form inefficiency in the currency market. The bootstrapped p-values show, however, that the returns to using our technical rules are higher than those to randomly selected rules. In the next section, we show the results of trend-trading profits for cross exchange rates for various currency combinations. The results support the main results; thus, our findings should not be attributed to data mining.

■ *Exchange market intervention.* This view holds that central bankers attempt to manipulate exchange rates by smoothing out changes but that in doing so, they suffer losses to trend-following traders who exploit such moves.[11] LeBaron (1999) found a decrease in exchange rate predictability after removing periods in which the U.S. Federal Reserve Board (Fed) was active. In contrast to our study, he used the spot rate data for 1979–1992 and Fed market intervention.

These studies did not carefully investigate the timing of the intervention in relation to the profitability of technical trading. A more recent study by Neely (2002) examined high-frequency data and found that market intervention is a *response* to the profitability of technical-trading rules; intervention does not generate technical-trading profits.

No existing literature has examined the intervention effect in the most recent period, whereas our study examined the effect from 1983 through 2006. To examine whether the profitability of trend-trading strategies around intervention changed in the more recent period and whether Neely's finding still holds, we used five "intervention series" from four monetary authorities—Australia, Germany/Europe, Japan, and the United States. The interventions of Australia, Germany/Europe, and Japan were conducted in the respective national currencies against the U.S. dollar. The monetary intervention data are publicly available from the central bank of each country. For the United States, the Fed provides daily Federal Reserve System sales (negative) and purchases (positive) of the U.S. dollar (in millions) against the mark/euro (DEM/EURO) and yen (JPY) in the foreign exchange market. We have the intervention data from 1 July 1983 through December 2006.

The U.S. and European central banks stopped market interventions in August 1995 except for two times when the Fed intervened —once in June 1998 and once in September 2000—and four times during September 2000 to November 2000 when the European central bank intervened in the foreign exchange market. In contrast, the Japanese central bank has increased intervention in recent years, and Fatum and Hutchison (2003) found that this central bank's intervention in the foreign exchange market has been the greatest by far in the world.

To test this hypothesis, we removed the intervention days and repeated our experiments with the two trading strategies. We followed LeBaron's (1999) procedure by removing returns from day

Table 3. Out-of-Sample Performance of Liquid Currencies: Momentum Trend-Trading Strategy, 1977–2006

Currency	1977–2006	1977–99	1977–79	1980–84	1985–89	1990–94	1995–99	2000–06
Japanese yen								
Mean of profits (%)	4.77	6.52	14.50	3.42	12.53	3.13	5.49	–0.76
Volatility (%)	7.83	10.53	5.55	9.85	11.14	6.76	10.10	7.26
t-Statistic	3.34	2.97	4.53	0.78	2.52	1.04	1.22	–0.28
p-Value	0.00	0.00	0.00	0.21	0.00	0.18	0.08	0.58
Information ratio	0.61	0.62	2.61	0.35	1.12	0.46	0.54	–0.10
α (%)	5.09	6.34	14.97	3.41	11.52	2.99	5.66	–0.81
t-Statistic, 2 periods: 2.81								
p-Value, 2 periods: 0.00								
German mark/euro								
Mean of profits (%)	6.07	7.17	5.57	5.35	8.95	0.45	8.61	2.38
Volatility (%)	13.01	9.87	6.70	6.95	7.42	9.10	29.46	7.45
t-Statistic	2.56	3.48	1.44	1.72	2.70	0.11	0.65	0.85
p-Value	0.00	0.00	0.08	0.02	0.00	0.64	0.31	0.17
Information ratio	0.47	0.73	0.83	0.77	1.21	0.05	0.29	0.32
α (%)	6.19	7.21	6.11	5.31	9.53	0.27	8.78	2.16
t-Statistic, 2 periods: 2.16								
p-Value, 2 periods: 0.01								
British pound								
Mean of profits (%)	2.17	3.60	7.95	5.40	1.63	1.73	–4.21	0.13
Volatility (%)	8.72	8.95	7.13	8.39	7.74	11.35	3.63	4.63
t-Statistic	1.36	1.93	1.93	1.44	0.47	0.34	–2.59	0.07
p-Value	0.18	0.02	0.02	0.08	0.43	0.55	0.00	0.75
Information ratio	0.25	0.40	1.12	0.64	0.21	0.15	–1.16	0.03
α (%)	2.36	3.49	7.82	4.94	1.75	1.82	–3.84	0.12
t-Statistic, 2 periods: 2.72								
p-Value, 2 periods: 0.00								
Swiss franc								
Mean of profits (%)	3.08	4.17	11.29	6.82	8.96	3.87	0.14	–0.47
Volatility (%)	11.70	8.75	9.45	10.28	7.99	11.89	9.27	6.42
t-Statistic	1.44	2.29	2.07	1.48	2.51	0.73	0.03	–0.19
p-Value	0.08	0.00	0.02	0.07	0.00	0.25	0.75	0.60
Information ratio	0.26	0.48	1.19	0.66	1.12	0.33	0.02	–0.07
α (%)	3.06	3.88	11.06	6.34	9.27	3.80	0.15	–0.50
t-Statistic, 2 periods: 3.17								
p-Value, 2 periods: 0.00								
Canadian dollar								
Mean of profits (%)	0.65	0.50	3.14	0.63	0.56	0.12	–2.30	0.17
Volatility (%)	4.16	2.67	2.81	2.47	3.84	4.16	3.55	3.80
t-Statistic	0.86	0.90	1.94	0.57	0.33	0.06	–1.45	0.12
p-Value	0.17	0.15	0.02	0.34	0.56	0.74	0.08	0.63
Information ratio	0.16	0.19	1.12	0.26	0.15	0.03	–0.65	0.04
α (%)	0.70	0.46	3.29	0.69	0.54	0.13	–2.10	0.17
t-Statistic, 2 periods: 2.04								
p-Value, 2 periods: 0.02								
Australian dollar								
Mean of profits (%)	–0.05				3.42	–0.90	–1.80	1.08
Volatility (%)	8.71				11.10	6.36	8.66	6.11
t-Statistic	–0.03				0.53	–0.32	–0.46	0.47
p-Value	0.75				0.38	0.56	0.44	0.43
Information ratio	–0.01				0.31	–0.14	–0.21	0.18
α (%)	–0.08				3.29	–0.88	–1.69	1.01
t-Statistic, 2 periods: 1.96								
p-Value, 2 periods: 0.02								

(continued)

Table 3. Out-of-Sample Performance of Liquid Currencies: Momentum Trend-Trading Strategy, 1977–2006 (continued)

Currency	1977–2006	1977–99	1977–79	1980–84	1985–89	1990–94	1995–99	2000–06
Portfolio								
Mean of profits (%)	2.78	4.39	8.49	4.32	6.01	1.40	0.99	0.42
Volatility (%)	5.17	3.84	4.69	4.07	4.74	5.44	5.94	5.01
Information ratio	2.95	5.49	4.05	2.38	2.83	0.58	0.37	0.22
t-Statistic	0.00	0.00	0.00	0.00	0.00	0.33	0.53	0.60
p-Value	0.54	1.14	1.81	1.06	1.27	0.26	0.17	0.08
Information ratio	2.92	4.70	7.84	4.29	6.55	1.43	0.97	0.42
α (%)	2.69	4.30	8.54	4.18	5.86	1.47	1.04	0.49
t-Statistic, 2 periods: 2.58								
p-Value, 2 periods: 0.00								

Notes: See the notes to Table 1.

$t-1$ to day t when an intervention occurred at day t. The results, in **Table 5**, show a decrease in profits but the mean is still significant for the entire sample period. After we deleted intervention periods in 1983–1992, however, mean profits became insignificant. This finding suggests that some profits in the more recent periods are attributable to intervention but not to the same extent as in the earlier periods.

Interventions may perturb markets for several days; therefore, we conducted an additional test by omitting two days before and after the intervention (day $t-2$ to day $t+2$). The results did change from those when we removed returns from day $t-1$ to day t. The profits and their significance levels were less than those when we removed day $t-1$ to day t but were still significant at the 10 percent level. Overall, the impact of central bank activity on exchange rate predictability seems to have changed in recent years, possibly because of the reduced frequency of intervention except by the Japanese central bank. Moreover, central banks now concentrate mainly on controlling inflation, not on controlling exchange rates.[12]

■ *Decline in transaction costs.* The disappearance of large trading profits may be explained by a decline in transaction costs.[13] Mizrach and Neely (forthcoming) found that transaction costs have

Table 4. Out-of-Sample Performance of Liquid Currencies: Trend Trading Using Moving-Average Rules, 1977–2006

Currency	1977–2006	1977–99	1977–79	1980–84	1985–89	1990–94	1995–99	2000–06
Japanese yen								
Mean of profits (%)	5.07	8.55	11.00	5.32	9.71	5.26	12.68	–2.92
Volatility (%)	9.58	9.16	8.29	8.55	8.82	7.83	9.03	9.27
t-Statistic	2.90	4.48	2.30	1.39	2.46	1.50	3.14	–0.83
p-Value	0.00	0.00	0.00	0.11	0.00	0.06	0.00	0.20
Information ratio	0.53	0.93	1.33	0.62	1.10	0.67	1.40	–0.31
α (%)	5.34	8.93	10.91	5.38	10.02	5.39	11.96	–3.13
t-Statistic, 2 periods: 2.34								
p-Value, 2 periods: 0.00								
German mark/euro								
Mean of profits (%)	5.56	4.89	6.18	5.65	7.94	0.86	11.39	2.47
Volatility (%)	13.67	15.92	8.60	8.89	10.77	10.57	35.76	5.80
t-Statistic	2.23	1.47	1.24	1.42	1.65	0.18	0.71	1.13
p-Value	0.00	0.07	0.10	0.09	0.05	0.61	0.29	0.16
Information ratio	0.41	0.31	0.72	0.64	0.74	0.08	0.32	0.43
α (%)	5.65	5.06	6.39	5.01	8.22	0.93	11.68	2.64
t-Statistic, 2 periods: 1.81								
p-Value, 2 periods: 0.02								

(continued)

Table 4. Out-of-Sample Performance of Liquid Currencies: Trend Trading Using Moving-Average Rules, 1977–2006 (continued)

Currency	1977–2006	1977–99	1977–79	1980–84	1985–89	1990–94	1995–99	2000–06
British pound								
Mean of profits (%)	1.97	3.48	10.04	7.09	2.69	1.42	–6.73	–0.21
Volatility (%)	7.77	10.74	5.29	9.19	9.19	11.19	4.40	7.48
t-Statistic	1.39	1.55	3.29	1.73	0.65	0.28	–3.42	–0.07
p-Value	0.11	0.06	0.00	0.02	0.31	0.58	0.00	0.75
Information ratio	0.25	0.32	1.90	0.77	0.29	0.13	–1.53	–0.03
α (%)	1.89	3.23	10.88	7.26	2.46	1.28	–6.31	–0.23
t-Statistic, 2 periods: 3.46								
p-Value, 2 periods: 0.00								
Swiss franc								
Mean of profits (%)	3.88	4.54	6.04	4.49	6.18	3.15	–0.38	–0.24
Volatility (%)	11.92	10.88	10.51	11.87	13.69	9.58	9.00	7.83
t-Statistic	1.78	2.00	1.00	0.85	1.01	0.74	–0.09	–0.08
p-Value	0.02	0.02	0.19	0.17	0.09	0.23	0.68	0.71
Information ratio	0.33	0.42	0.57	0.38	0.45	0.33	–0.04	–0.03
α (%)	4.18	4.18	5.49	4.06	5.91	2.86	–0.27	–0.15
t-Statistic, 2 periods: 2.93								
p-Value, 2 periods: 0.00								
Canadian dollar								
Mean of profits (%)	0.76	1.35	4.46	0.76	1.33	0.98	–0.72	0.11
Volatility (%)	3.99	3.97	2.94	3.41	4.61	3.68	4.76	5.53
t-Statistic	1.04	1.63	2.63	0.50	0.65	0.60	–0.34	0.05
p-Value	0.18	0.05	0.00	0.41	0.31	0.32	0.55	0.72
Information ratio	0.19	0.34	1.52	0.22	0.29	0.27	–0.15	0.02
α (%)	0.65	1.47	4.20	0.70	1.45	0.81	–0.67	0.19
t-Statistic, 2 periods: 2.04								
p-Value, 2 periods: 0.02								
Australian dollar								
Mean of profits (%)	–0.84				–0.13	–0.07	–1.08	–1.65
Volatility (%)	5.78				9.03	7.35	9.79	7.17
t-Statistic	–0.65				–0.02	–0.02	–0.25	–0.61
p-Value	0.31				0.77	0.77	0.59	0.32
Information ratio	–0.15				–0.01	–0.01	–0.11	–0.23
α (%)	–0.76				–0.08	–0.12	–0.86	–1.50
t-Statistic, 2 periods: 1.55								
p-Value, 2 periods: 0.06								
Portfolio								
Mean of profits (%)	2.73	4.56	7.54	4.66	4.62	1.93	2.53	–0.41
Volatility (%)	5.15	4.90	3.13	7.00	4.89	7.19	9.48	3.79
t-Statistic	2.91	4.47	4.17	1.49	2.11	0.60	0.60	–0.28
p-Value	0.00	0.00	0.00	0.05	0.00	0.16	0.30	0.58
Information ratio	0.53	0.93	2.41	0.67	0.94	0.27	0.27	–0.11
α (%)	2.91	3.73	6.11	4.91	4.35	2.61	2.82	–0.47
t-Statistic, 2 periods: 2.71								
p-Value, 2 periods: 0.00								

Note: See the notes to Table 1.

Table 5. Liquid Currencies' Performance from Trend-Trading Strategies Conditional on Removing Periods of Intervention, 1983–2006
(monetary authority in parentheses)

Measure	JPY/USD (United States)	JPY/USD (Japan)	EUR/USD (United States)	EUR/USD (Europe)	AUD/USD (Australia)
A. All observations: Momentum trend-trading rules					
Mean of profits (%)	5.28	5.28	5.16	5.16	–0.06
Volatility (%)	8.17	8.17	12.91	12.91	7.55
t-Statistic	3.17	3.17	1.96	1.96	–0.04
p-Value	0.00	0.00	0.02	0.02	0.73
Information ratio	0.65	0.65	0.40	0.40	–0.01
α (%)	5.10	5.10	5.46	5.46	–0.06
Date	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	4/Mar/85–31/Dec/06
B. All observations: Moving-average rules					
Mean of profits (%)	8.08	8.08	6.92	6.92	–0.85
Volatility (%)	9.10	9.10	14.51	14.51	8.03
t-Statistic	5.02	5.02	2.70	2.70	–0.60
p-Value	0.00	0.00	0.00	0.00	0.32
Information ratio	0.89	0.89	0.48	0.48	–0.11
α (%)	8.74	8.74	7.06	7.06	–0.92
Date	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	1/Jul/83–31/Dec/06	4/Mar/85–31/Dec/06
C. Days of intervention removed: Momentum trend-trading rules					
Mean of profits (%)	4.21	3.74	4.55	3.86	–0.11
Volatility (%)	6.20	6.80	12.80	14.10	7.20
t-Statistic	2.92	3.03	1.45	1.32	–0.03
p-Value	0.00	0.00	0.08	0.20	0.75
Information ratio	0.60	0.62	0.30	0.27	–0.01
α (%)	4.00	3.90	4.69	3.98	–0.17
Markov *p*-value	0.16	0.11	0.18	0.14	0.23
D. Days of intervention removed: Moving-average rules					
Mean of profits (%)	6.87	6.25	6.08	5.63	–0.94
Volatility (%)	9.80	9.00	14.80	14.20	7.80
t-Statistic	3.40	3.48	1.85	1.93	–0.36
p-Value	0.00	0.00	0.02	0.02	0.54
Information ratio	0.69	0.71	0.38	0.39	–0.08
α (%)	7.52	5.69	6.21	5.23	–0.82
Markov *p*-value	0.15	0.11	0.19	0.13	0.25

Notes: See the notes to Table 1. The Markov *p*-value is the simulated *p*-value for the test of the null hypothesis that the change in the mean annual return from Panel A to Panel C and from Panel B to Panel D would have been as great by randomly removing returns.

been significantly lower in many markets, including the foreign exchange markets, since the mid-1990s. Moreover, Neely, Weller, and Ulrich (forthcoming) found that the bid–ask spreads of spot transactions have decreased to 2 bps or less for transactions between $5 million and $50 million. Because we had already deducted transaction costs in our empirical work, however, our results should not be attributable to a decline in such costs.

■ *Learning following research publication.* Research about trend following in dollar exchange rates was first published during the 1980s. So, traders since that time were able to exploit this strategy—until all the profits eroded and the proverbial golden goose was killed.

Indeed, from the results so far, the reason for the decreased profits from technical trading appears to be that investors learn. For this reason, the Australian dollar and the Canadian dollar markets became weak-form efficient a decade before the much larger and more liquid Japanese yen market. The reason could be the more frequent interventions by the Japanese central bank, but we showed that the trading profits were still significant

after returns during intervention dates were removed, even though the magnitude of profits decreased. As a result, although the Japanese central bank intervention had an impact on exchange rates, it was less in the recent period.[14]

Cross-Exchange-Rate Empirical Results: Liquid Currencies

The results we have presented so far in this article are insufficient to confirm or deny these hypotheses, but we can seek other evidence to distinguish among them.

Even if we suppose that dollar exchange rates trended (or seemed to trend) for a period of 20 years only by chance, we have no reason to suspect that cross exchange rates would also trend, nor is it likely that a critical number of the world's central bankers were intervening enough to produce trend-following behavior in the many cross exchange rates. If cross exchange rates initially trended but then ceased to do so as traders learned about the opportunity and exploited it, this finding will best support the fourth hypothesis.

We examined momentum trend trading for all cross exchange rates among the major currencies, the results of which are summarized in **Table 6**.[15] The results for applying moving-average crossover rules to cross rates are shown in **Table 7**. As can be seen by the results for both trend-trading strategies, 80 percent of all cross rates (that is, 12 of 15 cross rates) provided negative profits in 2000–2006 and 2 cross rates had profits close to zero in that period. The results for these cross exchange rates mirror those for the major dollar exchange rates: Profits were obtainable in the early years but vanished in subsequent periods.

Table 6. Information Ratios of Cross Exchange Rates: Momentum Trend Trading

Exchange	1975–2006	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Canadian dollar per British pound							
Information ratio	0.34	1.49	0.61	0.22	0.33	–0.57	0.05
t-Statistic	1.92	3.33	1.36	0.49	0.74	–1.27	0.13
p-Value	0.02	0.00	0.18	0.51	0.23	0.06	0.62
Swiss franc per British pound							
Information ratio	0.28	0.54	1.16	–0.21	–0.68	0.2	0.34
t-Statistic	1.58	1.21	2.59	–0.47	–1.52	0.45	0.90
p-Value	0.06	0.08	0.00	0.43	0.06	0.46	0.15
German mark/euro per British pound							
Information ratio	0.36	0.69	0.76	0.95	0.07	0.49	–0.62
t-Statistic	2.04	1.54	1.70	2.12	0.16	1.10	–1.64
p-Value	0.02	0.06	0.03	0.02	0.62	0.17	0.05
Japanese yen per British pound							
Information ratio	0.42	1.64	0.57	–0.06	0.52	0.59	–0.75
t-Statistic	2.38	3.67	1.27	–0.13	1.16	1.32	–1.98
p-Value	0.00	0.00	0.05	0.62	0.35	0.11	0.02
Australian dollar per British pound							
Information ratio	–0.07			0.09	–0.12	0.05	–0.17
t-Statistic	–0.40			0.20	–0.27	0.11	–0.45
p-Value	0.55			0.60	0.58	0.64	0.46
Swiss franc per Canadian dollar							
Information ratio	0.39	1.1	0.25	0.69	0.47	0.07	–0.15
t-Statistic	2.21	2.46	0.56	1.54	1.05	0.16	–0.40
p-Value	0.00	0.00	0.35	0.06	0.18	0.62	0.51

(continued)

Table 6. Information Ratios of Cross Exchange Rates: Momentum Trend Trading (continued)

Exchange	1975–2006	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Euro per Canadian dollar							
Information ratio	–0.39	–1.38	–0.51	–0.85	–0.15	–0.32	0.06
t-Statistic	–2.21	–3.09	–1.14	–1.90	–0.34	–0.72	0.16
p-Value	0.00	0.00	0.15	0.02	0.55	0.28	0.62
Japanese yen per Canadian dollar							
Information ratio	0.63	1.76	0.51	0.99	0.55	0.57	–0.32
t-Statistic	3.56	3.94	1.14	2.21	1.23	1.27	–0.85
p-Value	0.00	0.00	0.15	0.00	0.07	0.05	0.17
Australian dollar per Canadian dollar							
Information ratio	–0.4			–0.35	–0.52	–0.76	–0.09
t-Statistic	–2.26			–0.78	–1.16	–1.70	–0.24
p-Value	0.02			0.21	0.11	0.03	0.59
German mark/euro per Swiss franc							
Information ratio	0.26	1.08	0.47	0.58	–0.12	0.41	–0.49
t-Statistic	1.47	2.41	1.05	1.30	–0.27	0.92	–1.30
p-Value	0.07	0.00	0.18	0.35	0.58	0.20	0.86
Japanese yen per Swiss franc							
Information ratio	0.31	0.54	0.78	0.62	0.35	0.37	–0.48
t-Statistic	1.75	1.21	1.74	1.39	0.78	0.83	–1.27
p-Value	0.02	0.08	0.02	0.11	0.21	0.20	0.05
Australian dollar per Swiss franc							
Information ratio	0.12			0.86	0.05	0.22	–0.19
t-Statistic	0.68			1.92	0.11	0.49	–0.50
p-Value	0.35			0.02	0.64	0.41	0.41
Euro per Japanese yen							
Information ratio	0.38	1.12	1.04	0.66	0.14	0.51	–0.38
t-Statistic	2.15	2.50	2.33	1.48	0.31	1.14	–1.01
p-Value	0.02	0.00	0.00	0.06	0.57	0.15	0.19
Australian dollar per Japanese yen							
Information ratio	0.11			0.15	0.16	0.4	–0.26
t-Statistic	0.62			0.34	0.36	0.89	–0.69
p-Value	0.39			0.55	0.54	0.16	0.30
Australian dollar per euro							
Information ratio	0.15			0.89	–0.15	0.38	–0.39
t-Statistic	0.85			1.99	–0.34	0.85	–1.03
p-Value	0.30			0.02	0.55	0.17	0.18

Notes: Data were not available for every currency for every date. The data for the Australian dollar start in 1985. The *t*-statistic is for the null hypothesis that the mean annual return is zero. We applied the Newey–West standard errors in computing the *t*-statistic. The *p*-value is the bootstrapped *p*-value for the test of the null hypothesis that the mean return of technical trading strategies equals the return of random series generated from bootstrapping. A low *p*-value rejects the null hypothesis.

Table 7. Information Ratios of Cross Exchange Rates: Trend Trading Using Moving Average Rules

Exchange	1975–2006	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Canadian dollar per British pound							
Information ratio	0.29	1.51	0.72	0.08	0.21	–0.44	–0.21
t-Statistic	1.64	3.38	1.61	0.18	0.47	–0.98	–0.56
p-Value	0.04	0.00	0.05	0.61	0.43	0.14	0.35
Swiss franc per British pound							
Information ratio	0.32	0.77	1.20	–0.01	–0.81	0.19	0.22
t-Statistic	1.81	1.72	2.68	–0.02	–1.81	0.42	0.58
p-Value	0.02	0.02	0.00	0.77	0.02	0.47	0.33
Euro per British pound							
Information ratio	0.41	0.71	0.67	0.95	0.21	0.55	–0.54
t-Statistic	2.32	1.59	1.50	2.12	0.47	1.23	–1.43
p-Value	0.00	0.06	0.06	0.02	0.43	0.07	0.09
Japanese yen per British pound							
Information ratio	0.33	1.50	0.49	–0.15	0.28	0.66	–0.75
t-Statistic	1.87	3.35	1.10	–0.34	0.63	1.48	–1.98
p-Value	0.02	0.00	0.17	0.55	0.31	0.06	0.02
Australian dollar per British pound							
Information ratio	–0.17			–0.73	–0.16	0.15	–0.28
t-Statistic	–0.80			–1.63	–0.36	0.34	–0.74
p-Value	0.21			0.04	0.54	0.55	0.23
Swiss franc per Canadian dollar							
Information ratio	0.32	0.97	0.17	0.64	0.36	–0.06	–0.07
t-Statistic	1.81	2.17	0.38	1.43	0.80	–0.13	–0.19
p-Value	0.02	0.01	0.52	0.08	0.21	0.62	0.60
Euro per Canadian dollar							
Information ratio	–0.39	–1.38	–0.51	–0.85	–0.15	–0.32	0.06
t-Statistic	–2.21	–3.09	–1.14	–1.90	–0.34	–0.72	0.16
p-Value	0.02	0.00	0.20	0.02	0.57	0.33	0.63
Japanese yen per Canadian dollar							
Information ratio	0.56	1.59	0.59	0.98	0.64	0.37	–0.45
t-Statistic	3.17	3.56	1.32	2.19	1.43	0.83	–1.19
p-Value	0.00	0.00	0.32	0.02	0.31	0.53	0.42
Australian dollar per Canadian dollar							
Information ratio	–0.24			0.04	–0.10	–0.83	0.02
t-Statistic	–1.13			0.09	–0.22	–1.86	0.05
p-Value	0.59			0.73	0.67	0.20	0.77
Euro per Swiss franc							
Information ratio	0.28	1.24	0.53	0.63	–0.03	0.41	–0.24
t-Statistic	1.58	2.77	1.19	1.41	–0.07	0.92	–0.63
p-Value	0.06	0.00	0.08	0.10	0.75	0.20	0.31
Japanese yen per Swiss franc							
Information ratio	0.23	0.47	0.42	0.56	0.19	0.35	–0.33
t-Statistic	1.30	1.05	0.94	1.25	0.42	0.78	–0.87
p-Value	0.59	0.43	0.47	0.35	0.60	0.54	0.56
Australian dollar per Swiss franc							
Information ratio	0.13			–0.34	0.13	0.46	–0.09
t-Statistic	0.61			–0.76	0.29	1.03	–0.24
p-Value	0.32			0.22	0.58	0.18	0.59

(continued)

Table 7. Information Ratios of Cross Exchange Rates: Trend Trading Using Moving Average Rules (continued)

Exchange	1975–2006	1975–79	1980–84	1985–89	1990–94	1995–99	2000–06
Euro per Japanese yen							
Information ratio	0.48	1.18	0.99	0.74	0.47	0.50	–0.23
t-Statistic	2.72	2.64	2.21	1.65	1.05	1.12	–0.61
p-Value	0.00	0.00	0.00	0.04	0.18	0.16	0.32
Australian dollar per Japanese yen							
Information ratio	–0.05			–1.07	–0.01	0.29	–0.18
t-Statistic	–0.23			–2.39	–0.02	0.65	–0.48
p-Value	0.59			0.00	0.77	0.31	0.42
Australian dollar per euro							
Information ratio	0.06			0.37	–0.27	0.40	–0.27
t-Statistic	0.28			0.83	–0.60	0.89	–0.71
p-Value	0.58			0.20	0.32	0.16	0.29

Note: See the notes to Table 6.

Performance of Newly Liquid Currencies

Although the evidence so far seems to indicate that the disappearance of trend-following profits resulted from the fact that market participants correctly identified the opportunity and adapted their trading styles accordingly, why trend trading remained profitable for so long remains baffling. But we have one more piece of evidence that can be examined to support or undermine the learning hypothesis. In recent years, globalization has produced a new set of liquid currencies and associated currency futures contracts. If time is needed for traders to learn how to exploit such circumstances, then these new currencies may trend in their early years. If trending does not occur for them, the hypothesis that the earlier trending in foreign exchange markets we found was merely an anomaly will be supported. If trending does occur for them, that will support the hypothesis that currency markets typically start out weak-form inefficient and later become efficient as traders learn and adapt.

The newly liquid currency futures contracts used in this study—the Brazilian real, Mexican peso, Russian ruble, New Zealand dollar, and South African rand—constitute *all* the currency futures of open economies for which data are available from 2000. These results can be compared directly with the results in the 2000–06 subperiod for major currencies and cross exchange rates. The results of applying the momentum rules and the moving-average rules are summarized in **Table 8.**

Surprisingly for anyone who believes in the efficient market hypothesis, trend trading the "new" currencies (except for the Mexican peso) has proven profitable. So, the recent results for these currencies mirror the results for trading the major currencies during early years.

Performance of Illiquid Currencies

We also carried out our tests applying the momentum rules and the moving-average rules to the *illiquid* currencies for which data are available since 1980—namely, the Chilean peso, Indonesian rupiah, South Korean won, Philippine peso, Indian rupee, Singapore dollar, Thai baht, Taiwanese dollar, and Venezuelan bolivar. The results are reported in **Table 9** and **Table 10**. These results agree partially with those for the more liquid currencies. The information ratios of the nine currencies (except for the Philippine peso, Thai baht, and Indian rupee) decrease over time; trading profits show no trend. The trading profits for the Philippine peso are insignificant, and information ratios of the Indian rupee and Thai baht show no trend.

In addition, we applied the trading rules to eight other European currencies—the Czech koruna, Danish krone, Hungarian florint, Icelandic krona, Norwegian krone, Polish zloty, Swedish krona, and Turkish lira against the U.S. dollar and euro. These results are provided in the supplemental materials linked to this article on the *FAJ* website (see Note 15). The information ratios of these currencies, except for the Icelandic krona and Turkish lira, are not significant. Their annual information ratios from 1999 to 2006 are marginal. The results are consistent for both trading strategies and did not change whether we computed profits against the U.S. dollar or the euro as the base currency.

Table 8. Newly Liquid Currencies: Information Ratios of Trend Trading Strategies, 2000–06

Strategy	Brazilian Real	Mexican Peso	New Zealand Dollar	South African Rand	Russian Ruble	Portfolio Performance
A. Momentum trend-trading rules						
Mean of profits (%)	24.05	–1.63	6.05	15.63	6.10	10.04
Volatility (%)	26.33	7.77	10.20	22.29	6.49	9.76
t-Statistic	2.42	–0.56	1.56	1.85	2.49	2.72
p-Value	0.00	0.35	0.06	0.02	0.00	0.00
Information ratio	0.91	–0.21	0.59	0.70	0.94	1.03
α (%)	24.68	–1.65	5.87	14.92	5.74	11.04
B. Moving-average rules						
Mean of profits (%)	22.04	–0.69	7.03	19.39	6.40	10.77
Volatility (%)	21.56	6.78	9.84	14.87	6.20	8.36
t-Statistic	2.70	–0.26	1.88	3.45	2.73	3.41
p-Value	0.00	0.56	0.02	0.00	0.00	0.00
Information ratio	1.02	–0.10	0.71	1.30	1.03	1.29
α (%)	22.38	–0.73	6.78	19.63	6.17	11.12

Note: See the notes to Table 1.

Table 9. Performance of Less Liquid Currencies: Momentum Trend-Trading Strategy, 1980–2006

Currency	1980–84	1985–89	1990–94	1995–99	2000–06
Chilean peso					
Mean of profits (%)	18.19	3.82	6.15	3.57	5.15
Volatility (%)	15.55	3.25	7.11	4.66	6.88
t-Statistic	2.62	2.63	1.93	1.71	1.98
p-Value	0.00	0.00	0.02	0.03	0.02
Information ratio	1.17	1.18	0.86	0.77	0.75
α (%)	16.96	3.65	6.33	3.36	4.95
Indonesian rupiah					
Mean of profits (%)			1.49	25.72	6.54
Volatility (%)			1.67	35.86	9.74
t-Statistic			2.00	1.60	1.78
p-Value			0.00	0.05	0.02
Information ratio			0.89	0.72	0.67
α (%)			1.54	27.19	6.36
Korean won					
Mean of profits (%)	4.67	6.88	2.38	13.23	1.87
Volatility (%)	1.09	2.26	2.92	20.60	5.44
t-Statistic	9.58	6.81	1.82	1.44	0.91
p-Value	0.00	0.00	0.02	0.08	0.20
Information ratio	4.28	3.04	0.82	0.64	0.34
α (%)	5.01	7.07	2.49	12.19	1.71
Philippine peso					
Mean of profits (%)			4.87	7.70	3.79
Volatility (%)			9.88	10.97	6.40
t-Statistic			1.10	1.57	1.56
p-Value			0.17	0.06	0.06
Information ratio			0.49	0.70	0.59
α (%)			5.31	8.36	3.63

(continued)

Table 9. Performance of Less Liquid Currencies: Momentum Trend-Trading Strategy, 1980–2006 (continued)

Currency	1980–84	1985–89	1990–94	1995–99	2000–06
Indian rupee					
Mean of profits (%)	6.08	2.75	7.52	3.66	3.29
Volatility (%)	4.58	5.83	8.71	4.56	2.43
t-Statistic	2.97	1.05	1.93	1.79	3.58
p-Value	0.00	0.18	0.02	0.02	0.00
Information ratio	1.33	0.47	0.86	0.80	1.35
α (%)	6.03	2.91	7.59	3.94	3.00
Singapore dollar					
Mean of profits (%)	1.98	2.41	3.90	1.09	0.23
Volatility (%)	3.55	3.85	3.23	5.49	3.17
t-Statistic	1.25	1.40	2.70	0.44	0.19
p-Value	0.13	0.10	0.00	0.46	0.13
Information ratio	0.56	0.63	1.21	0.20	0.07
α (%)	2.06	2.39	3.64	1.17	0.25
Thai baht					
Mean of profits (%)	1.63	0.29	0.19	5.70	4.51
Volatility (%)	2.86	4.49	2.18	13.77	4.10
t-Statistic	1.27	0.14	0.19	0.93	2.91
p-Value	0.12	0.62	0.60	0.20	0.00
Information ratio	0.57	0.06	0.09	0.41	1.10
α (%)	1.51	0.28	0.19	6.19	4.33
Taiwanese dollar					
Mean of profits (%)	1.18	7.99	2.81	4.04	2.04
Volatility (%)	0.64	2.71	2.36	4.71	3.02
t-Statistic	4.12	6.59	2.66	1.92	1.79
p-Value	0.00	0.00	0.00	0.02	0.02
Information ratio	1.84	2.95	1.19	0.86	0.68
α (%)	1.16	8.59	2.83	4.36	2.23
Venezuelan bolivar					
Mean of profits (%)			23.41	8.67	10.67
Volatility (%)			10.58	8.87	16.21
t-Statistic			4.95	2.19	1.74
p-Value			0.00	0.00	0.02
Information ratio			2.21	0.98	0.66
α (%)			25.68	8.34	9.79
Portfolio performance					
Mean of profits (%)	1.97	4.15	5.57	4.76	4.29
Volatility (%)	4.64	1.68	1.98	4.36	2.64
t-Statistic	4.13	6.07	6.13	2.06	4.29
p-Value	0.00	0.00	0.00	0.02	0.00
Information ratio	1.85	2.71	2.74	0.92	1.62
α (%)	1.88	4.07	5.12	5.17	3.93

Note: See the notes to Table 1.

Table 10. Performance of Less Liquid Currencies: Trend-Trading Strategy Using Moving-Average Rules, 1980–2006

Currency	1980–84	1985–89	1990–94	1995–99	2000–06
Chilean peso					
Mean of profits (%)	14.47	3.49	6.31	5.46	6.84
Volatility (%)	13.70	3.74	7.54	4.90	7.04
t-Statistic	2.36	2.09	1.87	2.49	2.57
p-Value	0.01	0.02	0.02	0.01	0.01
Information ratio	1.06	0.93	0.84	1.11	0.97
α (%)	13.65	3.56	6.05	5.11	7.18
Indonesian rupiah					
Mean of profits (%)			1.93	26.95	7.12
Volatility (%)			1.72	37.64	10.23
t-Statistic			2.51	1.60	1.84
p-Value			0.01	0.05	0.02
Information ratio			1.12	0.72	0.70
α (%)			1.79	24.54	6.89
Korean won					
Mean of profits (%)	4.91	6.83	2.88	15.00	3.02
Volatility (%)	1.11	2.27	2.93	21.34	5.57
t-Statistic	9.89	6.73	2.20	1.57	1.43
p-Value	0.00	0.00	0.01	0.06	0.09
Information ratio	4.42	3.01	0.98	0.70	0.54
α (%)	4.47	7.21	2.99	15.54	3.01
Philippine peso					
Mean of profits (%)			7.02	10.17	3.72
Volatility (%)			10.42	11.64	6.64
t-Statistic			1.51	1.95	1.48
p-Value			0.06	0.02	0.06
Information ratio			0.67	0.87	0.56
α (%)			6.71	10.85	3.56
Indian rupee					
Mean of profits (%)	5.99	2.09	8.58	4.58	3.72
Volatility (%)	4.83	6.67	8.72	4.60	2.51
t-Statistic	2.77	0.70	2.20	2.23	3.92
p-Value	0.00	0.30	0.01	0.01	0.00
Information ratio	1.24	0.31	0.98	1.00	1.48
α (%)	6.00	1.96	8.72	4.98	3.44
Singapore dollar					
Mean of profits (%)	0.83	1.62	3.90	2.82	-0.40
Volatility (%)	3.70	3.71	3.38	6.07	3.36
t-Statistic	0.50	0.98	2.58	1.04	-0.31
p-Value	0.41	0.19	0.01	0.18	0.57
Information ratio	0.22	0.44	1.15	0.46	-0.12
α (%)	0.88	1.74	3.59	2.77	-0.44
Thai baht					
Mean of profits (%)	3.61	0.32	0.12	9.96	4.27
Volatility (%)	6.58	4.04	2.32	13.20	4.21
t-Statistic	1.23	0.18	0.12	1.69	2.68
p-Value	0.13	0.61	0.63	0.04	0.01
Information ratio	0.55	0.08	0.05	0.75	1.01
α (%)	3.58	0.31	0.13	8.99	4.29

(continued)

Table 10. Performance of Less Liquid Currencies: Trend-Trading Strategy Using Moving-Average Rules, 1980–2006 (continued)

Currency	1980–84	1985–89	1990–94	1995–99	2000–06
Taiwanese dollar					
Mean of profits (%)	1.08	8.14	3.24	5.20	2.75
Volatility (%)	0.62	2.79	2.48	4.74	3.07
t-Statistic	3.90	6.52	2.92	2.45	2.37
p-Value	0.00	0.00	0.00	0.01	0.01
Information ratio	1.74	2.92	1.31	1.10	0.90
α (%)	1.06	8.13	3.12	4.69	2.57
Venezuelan bolivar					
Mean of profits (%)			16.74	0.60	12.02
Volatility (%)			11.58	13.15	16.95
t-Statistic			3.23	0.10	1.88
p-Value			0.00	0.67	0.02
Information ratio			1.45	0.05	0.71
α (%)			16.40	0.57	11.83
Portfolio performance					
Mean of profits (%)	3.23	4.09	5.47	5.16	4.76
Volatility (%)	8.54	10.81	14.49	13.65	12.59
t-Statistic	3.54	5.28	5.25	1.68	4.49
p-Value	0.00	0.00	0.00	0.04	0.00
Information ratio	1.58	2.36	2.35	0.75	1.70
α (%)	3.20	4.07	5.26	5.52	4.53

Notes: See the notes to Table 1.

Taken together, the results for liquid currencies, their cross exchange rates, newly liquid currencies, and illiquid currencies support the hypothesis that investors take time to learn.

Conclusion

Although we confirmed earlier findings that trend-following trading rules once worked, we found that profitability has been negligible since 2000 for the British pound, Swiss franc, Japanese yen, and Canadian dollar (based on U.S. dollar futures prices). In fact, for these currencies, one can say that trend following has been worthless since 2000, which supports the assertion that the major currency markets have become weak-form efficient after many years of inefficiency.

We do not know why currencies trend. One hypothesis is that early markets were inefficient simply because inefficiency is a characteristic of immature markets. We presented additional evidence, however, that calls this hypothesis into question. First, cross exchange rates show the same pattern as dollar exchange rates—profits in the early years followed by an erosion of profits in later years. This pattern means that the dollar exchange rate results are unlikely to be a consequence of chance or implicit data mining of the 1972–2000 period. In addition, the results do not support the hypothesis that trending was largely a result of central bank intervention. Second, although trending in the major currencies has vanished, newly liquid exchange rates have been profitable for trend traders in recent years. This finding suggests that trending is a feature of all newly trading currencies, and based on the experience of the major currencies, we expect these profits to vanish in time.

We are enormously indebted to Richard Roll for insightful and constructive criticism.

This article qualifies for 1 CE credit.

Appendix A. Bootstrap Approach

We applied the Levich and Thomas (1993) bootstrap approach. Each series of futures prices of length $I + 1$ corresponded to a series of log price changes of length I. These N observations could be arranged in $J = I!$ separated sequences; each sequence ($j = 1,\ldots, J$) corresponded to a unique profit measure $[\pi(j,k)]$ under trading rule k for $k = 1,\ldots, K$.

For each currency, we generated a new comparison series (a shuffled series), by making a random rearrangement of price changes in the original series. By operating on the sequence of price changes, we constrained the starting and ending price levels of the new series to be exactly as their values in the original data. Because the original data were randomly rearranged, the new series had the same distributional properties as the original series. Nevertheless, the time-series properties of the new data were made random. As a consequence, this simulation created one of the many paths that the exchange rate might have followed from its level on the starting day of the sample until the ending day, with the original distribution of price changes held constant.

We repeated this process of randomly shuffling the series of returns 10,000 times for each currency, thus generating 10,000 identically and independently distributed drawings for all $j = 1, \ldots, J$ possible sequences. Each of the 10,000 paths bore the same distributional properties as the original series, but the time series were scrambled with each path. We drew each path independently of the other paths. Each technical rule (all moving-average and momentum trading) was applied to each of the 10,000 random series, and profits $[\pi(j,k)]$ were measured.

This procedure generated an empirical distribution of profits. We could compare the profits from the randomly generated, shuffled series with the profits of the original series. Under the null hypothesis, if there was no information in the original sequence of data, then the profits obtained from trading in the original series should not have been significantly different from the profits available in the shuffled series. The null hypothesis that there was no information in the original time series of data was rejected at the α percent level if the profits obtained in the original series were greater than the α percent cutoff level of the empirical distribution.

Notes

1. See Taylor and Allen (1992) for survey results. Schulmeister (2005) cites similar figures.
2. See Dooley and Shafer (1983); Sweeney (1986); Levich and Thomas (1993); LeBaron (1999); Neely and Weller (1999).
3. Good summaries of the early literature on trend-following behavior in exchange markets may be found in LeBaron (1999) and Park and Irwin (2007).
4. Olson (2004) examined data through 2002 and found that trend-trading profits had dropped from previous periods.
5. Our procedure ensured that some rules were "fast" (that is, they traded often) and others were "slow." For 1975–2006, the number of trades for fast (slow) rules was about 1,135 (264) for the Swiss franc, 851 (226) for the British pound, 839 (199) for the Canadian dollar, 1,152 (208) for the Japanese yen, 1,123 (258) for the euro, and 680 (167) for the Australian dollar. The Australian dollar had the lowest number of trades because its starting year was 1987 instead of 1972 as it was for the other currencies. Fast rules are 5-day, 10-day, and 125-day rules; slow rules are 115-day, 120-day, and 125-day rules. The number of trades for fast rules represents the summation of trades under 5-day, 10-day, and 125-day rules divided by 3, which is the total number of fast rules.
6. We included 200-day moving averages because some trends may extend over years. See, for example, Engel and Hamilton (1990).
7. This timing of the purchase or sale biased the results somewhat against the trading rules. Allowing same-day trading had no material effect, however, on our results.
8. Some may doubt that the true population of information ratios is high and suspect that the poor performance during 2000–2006 is caused by a "bad" sample draw. To address this concern, we implemented a bootstrap methodology to compare the profitability of the technical trading rule with the profitability of the simulation distribution. We thank the referee for pointing out this concern.
9. Cornell and Dietrich (1978); Sweeney (1986); Taylor (1992); Neely (1997); Neely, Weller, and Dittmar (1997); Neely, Weller, and Ulrich (forthcoming).
10. The detailed results are available as Table S1 in supplemental material in the *FAJ* area of www.cfapubs.org.
11. See Friedman (1953); Dooley and Shafer (1983); Corrado and Taylor (1986); Sweeney (1986); Kritzman (1989); Szakmary and Mathur (1997); Saacke (2002); Sapp (1999); Martin (2001).
12. We thank Richard Roll for this comment.
13. We thank a referee for this point.
14. We thank a referee for raising this issue.
15. Details for each cross exchange rate shown in the tables in this section are available as supplemental material in the *FAJ* area of www.cfapubs.org.

References

Bilson, J.F.O. 1981. "The 'Speculative Efficiency' Hypothesis." *Journal of Business*, vol. 54, no. 3 (July):435–451.

Cheung, Y.W., and C.Y.P. Wong. 1997. "The Performance of Trading Rules on Four Asian Currency Exchange Rates." *Multinational Finance Journal*, vol. 1, no. 1 (March):1–22.

Cialenco, I., and A. Protopapadakis. 2006. "Has Competition Eliminated Technical Trading Rules Profits in the Foreign Exchange Market? Evidence from Eight Currencies." Working paper, University of Southern California (http://ssrn.com/abstract=947589).

Cornell, W.B., and J.K. Dietrich. 1978. "The Efficiency of the Market for Foreign Exchange under Floating Exchange Rates." *Review of Economics and Statistics*, vol. 60, no. 1 (February):111–120.

Corrado, C.J., and D. Taylor. 1986. "The Cost of a Central Bank Leaning against a Random Walk." *Journal of International Money and Finance*, vol. 5, no. 3 (September):303–314.

Dooley, M.P., and J. Shafer. 1983. "Analysis of Short-Run Exchange Rate Behavior: March 1973–November 1981." In *Exchange Rate and Trade Instability*. Edited by D. Bigman and T. Taya. Cambridge, MA: Ballinger Publishing.

Engel, C., and J.D. Hamilton. 1990. "Long Swings in the Dollar: Are They in the Data and Do Markets Know It?" *American Economic Review*, vol. 80, no. 4 (September):689–713.

Fatum, R., and M.M. Hutchison. 2003. "Is Sterilised Foreign Exchange Intervention Effective after All? An Event Study Approach." *Economic Journal*, vol. 113, no. 487 (April):390–411.

Friedman, M. 1953. "The Case for Flexible Exchange Rates." In *Essays in Positive Economics*. Chicago: University of Chicago Press.

Hansen, L.P., and R.J. Hodrick. 1980. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis." *Journal of Political Economy*, vol. 88, no. 5 (October):829–853.

Kritzman, M. 1989. "Serial Dependence in Currency Returns: Investment Implications." *Journal of Portfolio Management*, vol. 16, no. 1 (Fall):96–102.

LeBaron, B. 1999. "Technical Trading Rule Profitability and Foreign Exchange Intervention." *Journal of International Economics*, vol. 49, no. 1 (October):125–143.

Levich, R.M., and L.R. Thomas. 1993. "The Significance of Technical Trading-Rule Profits in the Foreign Exchange Market: A Bootstrap Approach." *Journal of International Money and Finance*, vol. 12, no. 5 (October):451–474.

Liu, S. 2007. "Currency Derivatives and Exchange Rate Forecastability." *Financial Analysts Journal*, vol. 63, no. 4 (July/August):72–78.

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

Martin, A.D. 2001. "Technical Trading Rules in the Spot Foreign Exchange Markets of Developing Countries." *Journal of Multinational Financial Management*, vol. 11, no. 1 (February):59–68.

Meese, R.M., and K. Rogoff. 1983a. "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics*, vol. 14, no. 1–2 (February):3–24.

———. 1983b. "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" In *Exchange Rates and International Macroeconomics*. Edited by J.A. Frenkel. Chicago: University of Chicago Press.

Mizrach, B., and C.J. Neely. Forthcoming. "Information Shares in the US Treasury Market." *Journal of Banking & Finance*.

Neely, C.J. 1997. "Technical Analysis in the Foreign Exchange Market: A Layman's Guide." *Federal Reserve Bank of St. Louis Review*, vol. 79, no. 5 (September/October):23–38.

———. 2002. "The Temporal Pattern of Trading Rule Returns and Exchange Rate Intervention: Intervention Does Not Generate Technical Trading Profits." *Journal of International Economics*, vol. 58, no. 1 (October):211–232.

Neely, C.J., and P.A. Weller. 1999. "Technical Trading Rules in the European Monetary System." *Journal of International Money and Finance*, vol. 18, no. 3 (June):429–458.

Neely, C.J., P.A. Weller, and R. Dittmar. 1997. "Is Technical Analysis in the Foreign Exchange Market Profitable? A Genetic Programming Approach." *Journal of Financial and Quantitative Analysis*, vol. 32, no. 4 (December):405–426.

Neely, C.J., P.A. Weller, and J. Ulrich. Forthcoming. "The Adaptive Markets Hypothesis: Evidence from the Foreign Exchange Market." *Journal of Financial and Quantitative Analysis*.

Okunev, J., and D. White. 2003. "Do Momentum-Based Strategies Still Work in Foreign Currency Markets?" *Journal of Financial and Quantitative Analysis*, vol. 38, no. 2 (June):425–447.

Olson, D. 2004. "Have Trading Rule Profits in the Currency Markets Declined over Time?" *Journal of Banking & Finance*, vol. 28, no. 1 (January):85–105.

Park, C., and S.H. Irwin. 2007. "What Do We Know about the Profitability of Technical Analysis?" *Journal of Economic Surveys*, vol. 21, no. 4 (September):786–826.

Saacke, P. 2002. "Technical Analysis and the Effectiveness of Central Bank Intervention." *Journal of International Money and Finance*, vol. 21, no. 4 (August):459–479.

Samuelson, P.A. 1965. "Proof That Properly Anticipated Prices Fluctuate Randomly." *Industrial Management Review*, vol. 6, no. 2 (Spring):41–49 (now *Sloan Management Review*).

Sapp, S. 1999. "The Role of Central Bank Intervention in the Profitability of Technical Analysis in the Foreign Exchange Market." Manuscript, University of Western Ontario.

Schulmeister, S. 2005. "Components of the Profitability of Technical Currency Trading." Working paper, Austrian Institute of Economic Research.

Sweeney, R.J. 1986. "Beating the Foreign Exchange Market." *Journal of Finance*, vol. 41, no. 1 (March):163–182.

Szakmary, A.C., and I. Mathur. 1997. "Central Bank Intervention and Trading Rule Profits in Foreign Exchange Markets." *Journal of International Money and Finance*, vol. 16, no. 4 (August):513–535.

Taylor, M.P., and H. Allen. 1992. "The Use of Technical Analysis in the Foreign Exchange Market." *Journal of International Money and Finance*, vol. 11, no. 3 (June):304–314.

Taylor, S.J. 1992. "Rewards Available to Currency Futures Speculators: Compensation for Risk or Evidence of Inefficient Pricing?" *Economic Record*, vol. 68, no. sl (December):105–116.