The Performance of Trading Rules on Four Asian Currency Exchange Rates*

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This article evaluates the performance of filter rules on four Asian exchange rates against the U.S. dollar. Risk premiums derived from the choice under uncertainty model and the GARCH specification are used to construct the risk–adjusted return series. Results show that risk premiums have significant implications for the performance of filter rules. Further, even if investors can tolerate some risk, transaction costs can further eliminate most of the remaining profitable trading opportunities.

I. Introduction

Because of their popularity among traders in financial markets and their implications for market efficiency, the performance of technical trading rules is a subject of intensive research interest. The first widely used and discussed trading rule is, perhaps, the Dow Theory named after Charles H. Dow, one of the founders of Dow Jones and Company. In fact, traders are still referring to this technique when making trading decisions (Kansas 1996).[1]

The popularity of technical trading rules is reflected in several survey studies. In a survey that covers leading participants from around the world, Group of Thirty (1985) reports 97% of bank respondents and 87% of securities

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1. See Sheimo (1989) for the recent developments of the Dow Theory.

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houses believe the use of technical trading models has a significant impact on the foreign exchange market, even though 12% of the respondents indicate the best way to describe their trading behavior is by trading against the technical resistance and support levels. In their study of the London foreign exchange market, Taylor and Allen (1992) find that over 90% of dealers use some form of technical analysis in formulating their short–term trading activity. Cheung and Wong (1996) also find that the use of technical trading rules is quite common among dealers in the Hong Kong, Singapore, and Tokyo foreign exchange markets.[2]

A class of trading rules that is commonly examined in academic research is the filter rule, which is also known as the Alexander filter.[3] Similar to other technical rules, a filter rule is essentially a trend following trading strategy – to hold the asset when its price is going up and maintain a short or neutral position when the price is weakening. To implement this trading rule, only information on price trends in the past is required to generate buying and selling signals. Obviously, the performance of this trading rule depends crucially on whether there are well–defined trends in the asset price.

According to the weak form of efficient markets hypothesis, information about past price movements and trends of a competitively traded financial asset does not help predict its future prices. However, results from studies on the profitability of filter rules on exchange rates tend to contradict the weak form efficiency hypothesis. For example, Logue and Sweeney (1977) report substantial filter rule trading profits even though they detect no significant serial correlation in the U.S. dollar/French franc exchange rate. Dooley and Shafer (1976, 1983) find filter rules generate substantial profits on nine exchange rates and in various sample periods. Sweeney (1986) provides another set of extensive results on filter rule profitability. More recent studies on the performance of filter rules on exchange rates include Levich and Thomas (1993) and Taylor (1994).

There are two diametrically opposed views on the evidence of profitable filter trading rules. Followers of the efficient markets hypothesis suggest the reported trading profits are spurious and could be accounted for if the issues of transaction costs, data mining, and risk premiums are properly addressed. On the other hand, critics argue that the empirical evidence clearly supports momentum trading because the reported trading profits are not isolated

2. According to the latest Bank of International Settlements survey (1996), Tokyo, Singapore, and Hong Kong are the third-, the fourth-, and the fifth-largest foreign exchange markets in the world in terms of trading volume. The United Kingdom and the United States rank first and second among all surveyed countries and areas.

3. Using common stock price data, Alexander (1961, 1964) are the two pioneer studies of the performance of this trading rule.

instances and are larger than the usual measures of transaction costs and risk premiums. Further, it is believed that the price patterns that lead to profitable filter rules are related to news transmission mechanisms and nonlinear dynamics.

This study adds to the filter rule literature in the following manner. We investigate the profitability of filter rules on Asian Pacific exchange rates. Specifically, the exchange rates of Japanese yen (JY), Singapore dollar (S$), Malaysian ringgit (RM), and New Taiwan dollar (NT$) against the U.S. dollar are considered. These four exchange rates are determined in markets that have different levels of market breadth and depth. This choice of exchange rates is in contrast to previous studies that mainly focused on dollar exchange rates of currencies of major industrialized countries. Our study, thus, provides some complementary results on the filter rule performance and sheds light on the generality of the profitability of filter rule trading.

Another salient feature of the current study is the risk premium it uses to evaluate the trading rule performance. In the literature, there are different ways to allow for risk premium in evaluating filter rules. Some studies assume a zero or a constant risk premium even though the existing empirical evidence tends to support a time varying risk premium.[4] Some studies use the difference between exchange rate change and interest rate differential as a proxy for the time varying risk premium, which can generate both positive and negative risk premiums. However, under the risk aversion assumption and the observation that trading foreign exchange is a risky venture, investors always demand a positive risk premium.

In this paper, we pursue a different approach to model the risk premium in trading foreign exchange. The choice under uncertainty framework is used to assess risk premiums. An advantage of this approach is that the risk premium is explicitly expressed as a function of the investor's preference and the level of risk. Also, the choice under uncertainty framework will always give a positive risk premium under the risk aversion assumption. Risk premiums generated from four utility functions and various risk aversion parameters are used to gauge the sensitivity of our empirical results to different choices of risk preferences. The risk level that is required to calculate risk premiums is measured using the generalized autoregressive conditional heteroskedastic (GARCH) model. In addition to risk premium adjustment, we consider effects of transaction costs on evaluating trading profitability.

The remainder of the paper is organized as follows. The next section provides some background information on the financial markets in the four Asian Pacific countries. Section 3 introduces the filter rule and also briefly

4. For example, see Fama (1984) and Cheung (1993).

discusses the choice under uncertainty framework and derives the risk premium. Empirical results are presented in section 4. Section 5 offers some concluding remarks.

II. The Asian Pacific Financial Markets[5]

In recent years, the financial markets in Japan, Malaysia, Singapore, and Taiwan have undergone rapid changes to foster domestic economic growth and to attract foreign capital. These financial markets, which used to be characterized by various forms of financial repression (such as segmented financial markets, credit and interest rate controls, and foreign exchange controls), have been gradually liberalized. As a result, these markets have become more open to foreign investors and more integrated with the global financial market. The deregulation process began effectively in the early 1980s. For instance, Japan eased capital and exchange controls between 1980 and 1984 and relaxed restrictions on foreign currency deposits held by residents in the 1990s. In a bid to be an international finance center, Singapore abolished most capital and exchange controls in the early 1980s. Malaysia, on the other hand, adopted a more gradual approach. The country started to reduce foreign exchange controls in the early 1970s. Firms were required to surrender export proceeds until the early 1990s. Some restrictions on capital outflow remain in effect, however. For example, capital outflow is not allowed to be financed by local borrowing. Further, Malaysian financial institutions must obtain approval before they can lend to foreign entities. Compared with the other three countries, Taiwan has been relatively slow in liberalizing its financial markets. Considerable capital and exchange controls, such as the requirement of surrendering export proceeds, restrictions on residents' foreign currency deposits, and foreign borrowing and lending permits, were in place until the late 1980s. Several measures were implemented in 1987 to liberalize financial markets. One of these measures was to allow residents to freely hold and utilize foreign exchange.

Of the four currencies, the Japanese yen (JY) is the most actively traded in the global foreign exchange market. Though the Bank of Japan intervenes when JY moves erratically and deviates significantly from its fundamental value, no explicit control is imposed on the exchange rate. The linkage with the global foreign exchange market was further enhanced in February 1985 when foreign exchange brokers were allowed to engage in the international

5. Materials in this section are drawn from Akdogan (1995), Euromoney (1993a, b), Hong Kong Monetary Authority (1995), Kim (1993), Monetary Authority of Singapore (1989), and Tatewaki (1991).

brokerage business. In essence, the JY exchange rate is mainly determined by the supply and demand in the global foreign exchange market.

On the other hand, trading of the other three currencies is mostly concentrated in the respective national markets. After the flotation of the Singapore dollar (S$) in 1973, banks in Singapore became free to trade in all currencies (against S$) without any restrictions on amount and maturity.[6] Although there are no explicit restrictions on foreign exchange dealings, it is the policy of the Monetary Authority of Singapore to monitor the S$ exchange rate and target its (real) value to a basket of currencies to maintain export competitiveness and to curb imported inflation.

The Malaysian ringgit (RM) and New Taiwan dollar (NT$) are traded in a more regulated environment. Depending on the limits approved by the Controller of Foreign Exchange, commercial banks in Malaysia are restricted to hold a maximum foreign exchange position in the range of RM10 million to RM150 million. The authorities can introduce additional measures in response to perceived unfavorable and destabilizing market conditions. For example, in January and February 1994, the central bank of Malaysia implemented a series of policies including administrative controls to fight off the appreciation pressure from short–term capital inflow. These exchange controls were gradually removed and totally abandoned in August of the same year.

The NT$ was pegged to the U.S. dollar until 1978. After 1978, the currency was allowed to float within a 2.25% band around the official rate determined by the Central Bank of China. The limit on daily trading range was abolished when a new foreign exchange system was introduced on April 3, 1989. Exchange rates in the interbank market and for retail transactions with an amount larger than US$30,000 (reduced to US$10,000 on July 24, 1989) can be freely negotiated. The maximum foreign currency short position limit was doubled to US$6 million on December 20, 1989.[7] Further, in February 1990, Taiwan adopted the international practice of settling spot exchange rate transactions two business days after the trading day.

Table 1 classifies the exchange rate arrangements of these four countries during the sample periods considered in this study. The classification of Japan, Singapore, and Malaysia is based on various issues of the *Annual Report on Exchange Arrangements and Exchange Restrictions* and the *International Financial Statistics*, both published by the International Monetary Fund. No classification for Taiwan is available as it ceased to be a member of the International Monetary Fund in 1972, thus it is labeled by the authors.

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6. However, Singapore has various regulations separating its domestic banking sector from the offshore market. Banks licensed to operate in the offshore market are not allowed to trade in S$. Also, currency swaps larger than S$ 5 million and loans to non–residents (or for uses outside Singapore) in excess of S$ 5 million require approval.

7. The limit on long foreign currency position was lifted on August 24, 1984.

TABLE 1. Exchange Rate Arrangement Classification

	Exchange Rate Arrangement
Japan	Independent Floating
Malaysia	Currency Composite and Managed Floating
Singapore	Currency Composite and Managed Floating
Taiwan	Managed Floating

Note: The classification of Japan, Singapore, and Malaysia is based on International Monetary Fund publications (Annual Report on Exchange Arrangements and Exchange Restrictions and International Financial Statistics, various issues) while that of Taiwan is provided by the authors.

III. Methodology

A. Filter Rule

Since the countries under examination typically have more stringent controls on capital outflow than inflow, we consider the case in which a U.S. investor adopts the long–position–only approach (Sweeney 1986) to invest in an Asian currency. At each time period, the investor has to decide whether to hold the Asian currency or a safe U.S. asset, say a treasury bill. A *X*% filter rule generates buying and selling signals as follows. The investor buys the Asian currency when its exchange rate (expressed as U.S. dollar per Asian currency) has risen by *X*% from the most recent trough. This long position is liquidated when the exchange rate has dropped by *X*% from its most recent peak and, then, the proceeds are invested in the safe U.S. asset.

The trend following filter rule does not capture the top or the bottom of exchange rate movements. Instead, the rule is based on market momentum considerations and makes a profit only if the market momentum identified by the *X*% movement can carry the long position to make a sizable profit. Possible false upward or downward trend signals are supposed to be filtered out by the *X*% rule requirement. Among other things, the success of a *X*% filter rule depends on exchange rate persistence and the ability of the *X*% rule to eliminate false signals. Both the filter size and the relative magnitude of the random component and the trend component in exchange rates determine the rule's ability to filter out false signals.

Filter rule trading profits are usually compared with returns from a buy–and–hold strategy. A finding of filter rules outperforming the buy–and–hold strategy is interpreted as evidence against the efficient markets hypothesis (Alexander 1961). It is, however, generally agreed that a meaningful comparison between these two types of trading strategies should allow for differences in risk and transaction costs. Typically, a filter rule switches an investment in and out of risky assets more frequently than the buy–and–hold strategy. In section 4, we compare the performance of these two trading strategies with and without adjustments for risk and transaction costs.

B. Risk Premium

Suppose the investor has a utility function $U(W_t)$, where W_t represents wealth at the end of time t. At the beginning of time t, the initial wealth, one period U.S. risk–free interest rate, and one period foreign risk–free interest rate are denoted as W_{t-1}, R_{t-1}, and R^*_{t-1}. If the initial wealth earns a rate of return R_{t-1}, the end of period wealth is

$$W_t = W_{t-1} + R_{t-1}W_{t-1} \tag{1}$$

Alternatively, if the wealth is invested in the Asian currency, W_t is given by

$$W_t = \tilde{W}_t = W_{t-1} + \Delta s^*_t W_{t-1} \tag{2}$$

where

$$\Delta s^*_t = \Delta s_t + R^*_{t-1}$$

Δs^*_t measures the rate of return on holding the Asian currency, $\Delta s_t = \ln(S_t) - \ln(S_{t-1})$, where S_t is the exchange rate at time t. Given the uncertainty in exchange rate movements, we assume $\Delta s^*_t W_{t-1}$ is a random variable. Further we assume it has a finite conditional mean and a conditional variance equal to that of $\Delta s_t W_{t-1}$ at the beginning of the period.

The risk premium, π, that makes the investor indifferent to receiving the certain W_t or the uncertain $\tilde{W}_t$ with the expected value W_t, is (Pratt, 1964)

$$\Pi = -[W^2_{t-1} U''/2U'] \sigma^2_{t/t-1} \tag{3}$$

where $\sigma^2_{t/t-1}$ is the conditional variance of Δs_t, U' and U'' are, respectively, the first and second order derivatives.[8] The risk premium per unit wealth is

$$\pi = -[W_{t-1} U''/2U']\sigma^2_{t/t-1} \tag{4}$$

8. A sufficient regularity condition is that U has a bounded and continuous third derivative over the range of Δs_t.

$-[U''/U']$ and $-[W_{t-1}U''/U']$ are, respectively, the Arrow–Pratt measures of absolute and relative risk aversion. The investor is only interested in the expected value and is oblivious to risk if she is risk neutral (i.e., $-[U''/U'] \equiv 0$) In this case, the investor is indifferent to investing in the safe U.S. asset or the risky foreign asset. However, for a risk averse investor, $-[U''/U'] > 0$. In this case, a risk premium is required to compensate for assuming the risk in currency trading. The magnitude of risk premium is jointly determined by the investor's attitude towards risk ($U(.)$), the level of risk ($\sigma^2_{t/t-1}$), and the wealth (W_{t-1}). On the other hand, the risk premium as a percentage of wealth depends on the relative risk aversion coefficient and the risk measured by $\sigma^2_{t/t-1}$. Thus, a portion of the return from investing in the Asian currency should be appropriately interpreted as reward for bearing risk.

TABLE 2. Utility Functions and their Relative Risk Aversion Coefficients

Utility Function	Relative Risk Aversion	Parameter
Logarithmic function		
$U(W) = \ln(W)$	1	*n/a*
Isoelastic function		
$U(W) = W^{1-\delta}/(1-\delta)$ $\delta > 0, \delta \neq 1$	δ	$\delta = 10$
Exponential function		
$U(W) = -\gamma^{-1}e^{-\gamma W}$ $\gamma > 0$	γW	$\gamma = 5$
Quadratic function		
$U(W) = \alpha W - \beta W^2$ $\alpha > 0, \beta = 1$ $0 < W < \alpha/2$	$2\beta W/(\alpha - 2\beta W)$	$\alpha = 10$

For a risk averse investor, the risk premium depends on the functional form of $U(.)$ and the measure of $\sigma^2_{t/t-1}$. To evaluate the sensitivity of the empirical result on the choice of $U(.)$, we consider four utility functions that are commonly considered in the literature. These functions are listed in table 2. The selected coefficients of relative risk aversion, which are determined by the parameters of $U(.)$, cover the range of relative risk aversion estimates typically reported in the literature.[9] Specifically, the coefficients of relative risk aversion for the logarithmic and quadratic utility functions are on the lower end of the reported range while the other two are in the middle and upper ranges.

Because of its excellent record in modeling exchange rate conditional heteroskedasticity, the class of GARCH models is used to capture $\sigma^2_{t/t-1}$. The GARCH approach, together with utility functions given in table 2, is used to generate risk premiums and evaluate trading strategies.

IV. Empirical Results

A. Data and Preliminary Analysis

The daily U.S. dollar exchange rates of JY, RM, S$, and NT$ are collected from DataStream. The federal fund rate is used as a proxy for the U.S. risk–free rate. National overnight interest rates are used as proxies for the Japan and Singapore risk–free rates. These interest rate data are also retrieved from DataStream. Overnight interest rate data for Taiwan are obtained from various issues of the *Financial Statistics Monthly* published by the Central Bank of China. Due to data availability, monthly RM interest rates are used in place of overnight rates. The sample periods, which are mainly determined by the developments in the national financial sectors discussed in the previous section and data availability, are listed in table 3. For instance, data on RM after January 1994 are not included because of the severe exchange controls imposed by the authorities. The Taiwanese sample only starts in 1990 because of the impediments in exchange trading which existed in the 1980s.

Some descriptive statistics on the exchange rate change series are presented in table 4. All these exchange rate series have a mean very close to zero. Based on the sample standard deviation and data range, the JY has the highest variability, probably due to the fact that the central banks in the other three countries are more ready to intervene and smooth exchange rate movements. The sample skewness and kurtosis coefficients of these four exchange rates are all significantly different from those of a normal random variable. The sample autocorrelations of exchange rate changes are generally small. But for some currencies, statistically significant autocorrelation coefficients are detected. On the other hand, the autocorrelation coefficients computed from the squared exchange rate change series (not reported) are both large and statistically significant, indicating the possibility of an ARCH element in these exchange rate series.

9. See, for example, Lucas (1987).

TABLE 3. Sample Periods

	Sample Period	
Japan	1/7/1986–3/31/1995	(8/17/90)
Malaysia	10/8/1987–1/31/1994	(12/3/1990)
Singapore	1/9/1987–/31/1995	(3/20/1991)
Taiwan	4/19/1990–/31/1995	(2/10/1993)

Note: The date used to split the sample in two (roughly) equal sub-samples is given in parentheses next to the sample period.

TABLE 4. Descriptive Statistics of Exchange Rate Changes

	Japanese yen	Malaysian ringgit	Singapore dollar	New Taiwan dollar
NOBS	2395	1643	2186	1438
MEAN	.0341*	–.0055	.0199**	.0025
SDEV	.6931	.2273	.2545	.2564
MAX	5.4218	1.709	2.2502	3.9210
MIN	–4.1339	–2.374	–2.0232	–3.9633
SKEW	.4439**	–.9599**	.3906**	–1.7261**
KUR	8.0224**	22.1234**	10.7048**	116.7027**
RHO(1)	–.0265	.0545	–.1251**	.0231
RHO(2)	.0045	.0149	–.0338	–.0527
RHO(3)	–.0079	.0086	.0233	.0311
RHO(4)	.0015	–.0849	.0171	.0948*
RHO(5)	–.0099	–.0425	.0206	.0346

Note: NOBS is the number of observations, MEAN is the mean, SDEV is the standard deviation, MAX is the maximum, MIN is the minimum, SKEW is the skewness, KUR is the kurtosis, and RHO(k) is the k^{th} autocorrelation coefficient. *Statistical significant at the 5%; **statistical significant at the 1% level.

To providemore formal evidence on serial correlation and conditional heteroskedasticity, we fit an AR(p) model with GARCH(r,s) errors to the exchange rate data. The AR(p)–GARCH(r,s) model is extensively used in the exchange rate literature and is given by[10]

$$\Delta s_t = c + \varphi_1 \Delta s_{t-1} + \ldots + \varphi_p \Delta s_{t-p} + \varepsilon_t \quad (5)$$

$$\varepsilon_{t/t-1} \sim N(0, h_t),$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \ldots + \alpha_r \varepsilon^2_{t-r} + \beta_1 h^2_{t-1} + \ldots + \beta_s h^2_{t-s}.$$

The following strategy is used to determine the lag parameters *p*, *r*, and *s*. First an AR(1) model with GARCH(1,1) term is fitted to the data. Then the Box–Pierce statistics computed from the standardized residuals and their squares are used to infer the adequacy of the fitted model. Additional lags are included in the original conditional mean and variance specification until the resulting standardized residuals pass the Box–Pierce tests. The models selected to describe data on exchange rate changes are summarized in table 5.

The JY is the only currency that exhibits no significant conditional mean dynamics. The other three exchange rate change series have significant serial correlations up to the fourth lag. The significant correlation pattern may bias the performance comparison in favor of trend following filter rules. JY, RM, and S$ exhibit high persistence in their conditional variances. The sum of the GARCH coefficients is close to one – a phenomenon consistent with results in the literature. Compared with JY, the other three currencies have a more complicated conditional variance dynamics. This complex conditional volatility can make it more difficult for the filter rules to separate true signals from false ones.

B. Buy–and–Hold Strategy

The one–period excess return (return in excess of the U.S. federal fund rate) of the buy–and–hold policy is given by

$$R_{bh} = \Delta s_t - (R_{t-1} - R^*_{t-1}) \quad (6)$$

The risk premium required to compensate the investor to assume the foreign exchange rate risk is given by equation 4 in section III.B. The conditional variance computed from the GARCH models reported in the previous subsection is used as a proxy for the risk.

10. Note that the consistency of the parameter estimates does not depend on the normality assumption in equation 5; e.g., Bollerslev and Wooldridge (1992).

TABLE 5. The Estimated AR(p)–GARCH(r,s) Models

	Japanese yen	Malaysian ringgit	Singapore dollar	New Taiwan dollar
c	2.2700	.2569	2.3131	–.5711
	(1.95)	(.66)	(4.76)	(–.56)
φ_1		–.0559	–.0987	.0686
		(–2.1)	(–4.0)	(1.20)
φ_2		.0539	–.0507	–.0466
		(1.94)	(–2.4)	(–.79)
φ_3		.0346	.0328	–.0082
		(1.32)	(1.36)	(–.17)
φ_4				.0804
				(2.37)
α_0	.0220	.0035	.0042	.0403
	(6.36)	(10.8)	(7.56)	(15.1)
α_1	.0424	.2287	.1578	.1713
	(8.70)	(13.5)	(13.5)	(9.09)
β_1	.9132	.3570	.1083	.2963
	(89.7)	(6.18)	(4.02)	(6.57)
β_2		.3591	.6782	
		(7.46)	(25.5)	
$Q(5)$	1.68	3.81	5.94	3.25
$Q^2(5)$	4.58	1.71	1.68	.03

Note: Maximum likelihood estimates of the AR–GARCH model $\Delta s_t = c + \varphi_1 \Delta s_{t-1} + ... + \varphi_p \Delta s_{t-p} + \varepsilon_t$, $\varepsilon_{t/t-1} \sim N(0, h_t)$, $h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + ... + \alpha_r \varepsilon^2_{t-r} + \beta_1 h^2_{t-1} + ... + \beta_s h^2_{t-s}$ are reported. The lag parameters p, r and s are determined by information criteria and diagnostic tests. t–statistics are given in parentheses below the estimates. $Q(5)$ and $Q^2(5)$ are the Box–Pierce statistics computed from the first five autocorrelation coefficients of the standardized residuals and their squares.

Table 6 compares some descriptive statistics of R_{bh} and risk premiums per unit wealth computed under different utility function specifications. A few observations are in order. First, the average magnitudes of risk premiums have a wide variation across utility functions. The magnitude is directly proportional to the measure of risk aversion. In some cases, the average risk premium is larger than the average excess return from the buy–and–hold policy. Second, compared with the buy–and–hold excess return series, the risk premiums tend to have a smaller sample variance but a larger skewness and kurtosis coefficient. Third, the sample autocorrelations indicate that the risk premiums exhibit a high degree of persistence. This can be attributed to the persistence in the conditional variance characterized by GARCH models. On the other hand, there is little evidence of serial correlation in the buy–and–hold excess return data.

TABLE 6. Descriptive Statistics of the Excess Returns from the Buy–and–Hold Strategy and the Associated Risk Premiums

		Risk Premium			
	BUYHOLD	LOGU	ISOU	EXPU	QRAU
A. Japanese Yen					
MEAN	.0299*	.0024**	.0243**	.0212**	.0014**
SD	.6932	.0008	.0078	.0094	.0008
MAX	5.4118	.0085	.0848	.1170	.0105
MIN	–4.1326	.0014	.0137	.0094	.0005
SKEW	.4416**	2.5394**	2.5394**	3.9230**	4.4643**
KUR	8.0161**	13.5350**	13.5350**	28.1027**	35.2500**
RHO(1)	–.0262	.9387**	.9388**	.9492**	.9569**
RHO(2)	.0048	.8801**	.8801**	.9003**	.9160**
RHO(3)	–.0077	.8244**	.8244**	.8524**	.8747**
RHO(4)	.0017	.7683**	.7683**	.8047**	.8340**
RHO(5)	–.0097	.7197**	.7197**	.762**	.7968**
B. Malaysian Ringgit					
MEAN	–.0052	.0003**	.0027**	.0015**	.0001**
SD	.2277	.0005	.0051	.0031	.0002
MAX	1.7065	.0095	.0954	.0581	.0031
MIN	–2.3643	.0001	.0006	.0003	.0001
SKEW	–.9264**	8.8818**	8.8818**	9.4098**	9.5375**
KUR	21.7061**	110.2200**	110.2200**	120.8500**	123.2690**
RHO(1)	.0579	.8482**	.8481**	.8569**	.8593**
RHO(2)	.0187	.7658**	.7658**	.7773**	.7806**
RHO(3)	.0125	.7117**	.7117**	.7273**	.7319**
RHO(4)	–.0811	.6509**	.6509**	.6672**	.672**
RHO(5)	–.0387	.6137**	.6137**	.6323**	.6376**
C. Singapore Dollar					
MEAN	.0135	.0003**	.0033**	.0024**	.0001**
SD	.2547	.0002	.0027	.0022	.0001
MAX	2.2435	.0040	.0402	.0376	.0024
MIN	–2.0316	.0001	.0011	.0006	.00003
SKEW	.3924**	4.7061**	4.7061**	5.724**	6.3129**
KUR	10.6895**	42.6470**	42.647**	63.792**	77.519**
RHO(1)	–.1236**	.6444**	.6444**	.6443**	.6439**
RHO(2)	–.0327	.8127**	.8127**	.8180**	.8206**
RHO(3)	.0240	.5778**	.5778**	.579**	.5798**
RHO(4)	.0182	.6613**	.6613**	.6668**	.6699**
RHO(5)	.0218	.5066**	.5066**	.5000**	.5108**

(*Continued*)

TABLE 6. (Continued)

		Risk Premium			
	BUYHOLD	LOGU	ISOU	EXPU	QRAU
D. New Taiwan Dollar					
MEAN	.0078	.0004**	.0037**	.0022**	.0001**
SD	.2565	.0006	.0064	.0034	.0002
MAX	3.9108	.0138	.1377	.0744	.0038
MIN	–3.9573	.0003	.0029	.0015	.0001
SKEW	–1.7764**	17.5360**	17.5360**	17.5270**	17.4934**
KUR	116.5119**	340.4100**	340.4100**	341.2710**	340.9040**
RHO(1)	.0232	.3251**	.3251**	.3212**	.32058**
RHO(2)	–.0528	.1059**	.1059**	.1001**	.0991**
RHO(3)	.0308	.0395	.0395	.0336	.0326
RHO(4)	.0944*	.0215	.0215	.0150	.0139
RHO(5)	.0338	.0104	.0104	.0038	.0026

Note: Descriptive statistics of returns on the buy–and–hold strategy are given in the "BUYHOLD" column. The columns labeled "LOGU," "ISOU," "EXPU," and "QRAU" give the descriptive statistics of risk premiums calculated under logarithmic utility, Isoelastic utility, exponential utility, and quadratic utility. The notation ln the first column is MEAN = mean, SDEV = standard deviation, MAX= maximum, MIN = minimum, SKEW = skewness, KUR = kurtosis, and RHO(k) = k–th autocorrelation coefficient. Statistical significance at the 5% and the 1% level is indicated, respectively, by "*" and "**."

Table 7 summarizes the excess returns from the buy–and–hold policy. In each cell, a heteroskedasticity and serial correlation consistent t–statistic is reported beneath the excess rate of return.[11] Before adjusting for risk premium, the buy–and–hold strategy yields a significant excess return (at the 5% level) in the cases of JY and S$.[12] In other cases, no significant profit in excess of the U.S. federal fund rate is found.

11. In this study, heteroskedasticity and serial correlation consistent t–statistics are used to infer the statistical significance of trading rule profits. The bootstrap method is an alternative way to evaluate the statistical significance (see, for example, Kho 1996). However, note that the properties of bootstrap estimates are typically developed under the assumption of i.i.d. errors and are not known for the dependent and conditional heteroskedastic processes that we used to model exchange rates in this study.

12. As pointed out by the referee, a more stringent significance level, say 1%, will considerably weaken the evidence of profitable buy–and–hold and filter rule strategies. Further, the use of a 1% critical level will strengthen the evidence that there is no substantial difference in the performance of the buy–and–hold and filter rule investment strategies given in the subsequent sections.

TABLE 7. Excess Returns from the Buy–and–Hold Strategy

		Risk Adjusted			
	BUYHOLD	LOGU	ISOU	EXPU	QRAU
Japanese	.0299	.0275	.0057	.0087	.0286
yen	(2.11)	(1.94)	(.40)	(.62)	(2.02)
Malaysian	–.0052	–.0055	–.0079	–.0067	–.0053
ringgit	(–.93)	(–.98)	(–1.40)	(–1.19)	(–.94)
Singapore	.0135	.0132	.0102	.0116	.0134
dollar	(2.49)	(2.42)	(1.87)	(2.05)	(2.46)
New Taiwan	.0078	.0074	.0041	.0056	.0077
dollar	(1.15)	(1.09)	(.61)	(.83)	(1.13)

Note: Returns on the buy–and–hold strategy without adjusting for risk premiums are given in the column "BUYHOLD." Returns adjusted for risk premiums based on logarithmic utility, isoelastic utility, exponential utility, and quadratic utility are given in the columns labeled "LOGU," "ISOU," "EXPU," and "QRAU." Heteroskedasticity and serial correlation consistent t-statistics are reported in parentheses.

The significance of excess returns on holding these Asian currencies weakens when currency risk is considered. When the excess returns are adjusted by risk premiums calculated according to the isoelastic utility function, the number of significant cases drops to zero. The decrease in significance is also observed under other utility function specifications. Note that transaction costs are not considered in this case as they are quite small for the buy–and–hold policy.

Overall, the results in tables 6 and 7 illustrate that risk compensation is an important factor for evaluating investment performance. Depending on the tolerance level, risk premium adjustment can turn a significant positive excess return to an insignificant one.

C. Filter Rules

Following the long–position–only approach, the investor purchases the Asian currency when the filter rule issues a buying signal. In response to a selling signal, the investor will liquidate the position and hold safe U.S. dollar assets. In this study, we consider trading rules with .5%, 1%, and 1.5% filters.

Table 8 provides some summary statistics related to filter rule trading. Using the filter rules, the investor holds the Asian currencies for over half of the sample periods. The number of trades, as expected, decreases as the filter size increases. The number of JY transactions is larger than those of the other currencies. This is in line with the result that JY is the most volatile currency (see table 4). The average returns on holding JY, S$, and NT$ following the filter rules are larger than the average U.S. federal fund rate.

Excess returns from adopting filter trading rules on these Asian currencies with and without adjustment for risk premiums are summarized in table 9. Before adjusting for risk premiums, there are four cases (three currencies) in which the filter rules yield profits that are significantly higher than those from just holding the alternative safe U.S. asset. In contrast to previous studies (Fama and Blume 1984; Sweeney 1986; Levich and Thomas 1993), small filters do not always give the best results. While the .5% filter rule generates the highest profit on NT$ trading, the 1% and 1.5% filter rules yield the best results on JY and S$ investments.

TABLE 8. Filter Rule Trading Summary Statistics

		.5%	1%	1.5%
Japanese yen	TRADE	269	142	95
	FREQ	51.19%	49.81%	51.98%
	RUSD	.0165	.0168	.0170
	RACU	.0454	.0604	.0398
Malaysian ringgit	TRADE	46	18	11
	FREQ	50.03%	51.80%	49.69%
	RUSD	.0184	.0181	.0194
	RACU	.0180	.0154	.0158
Singapore dollar	TRADE	86	29	15
	FREQ	65.69%	71.21%	74.05%
	RUSD	.0162	.0166	.0175
	RACU	.0240	.0311	.0307
New Taiwan dollar	TRADE	32	11	8
	FREQ	53.69%	55.04%	36.35%
	RUSD	.0149	.0136	.0149
	RACU	.0321	.0315	.0286

Note: The table reports trading statistics for x% filter rules where x = .5, 1, and 1.5. The row labeled "TRADE" gives the number of trades, "FREQ" gives the percentage of time holding the Asian currency, "RUSD" gives the average return on holding the safe U.S. asset, and "RACU" gives the average return on holding the Asian currency unit. All the average returns are significant at the 1% level.

Table 9 also shows that the adjustment for risk premiums can turn a significant positive excess return to an insignificant one and, in one case, to a loss. The change in significance is most prominent when the isoelastic utility function is considered. Under this utility function, the number of significant excess returns decreases to zero. Allowing for risk premiums under other utility function specifications also reduces the significance of filter rule trading profits.

TABLE 9. Excess Returns from Filter Rule Trading (No Transaction Costs)

			Risk Adjusted			
	X%	Filter Rule	LOGU	ISOU	EXPU	QRAU
Japanese yen	.5%	.0148	.0136	.0022	.0050	.0143
		(1.46)	(1.34)	(.22)	(.49)	(1.40)
	1.0%	.0220	.0208	.0097	.0114	.0214
		(2.09)	(1.97)	(.92)	(1.08)	(2.02)
	1.5%	.0124	.0111	–.0053	.0024	.0118
		(1.15)	(1.04)	(–.5)	(.23)	(1.10)
Malaysian ringgit	.5%	.0014	.0013	.0002	.0007	.0014
		(.39)	(.36)	(.05)	(.19)	(.38)
	1.0%	–.0001	–.0002	–.0013	–.0008	–.0001
		(–.02)	(–.05)	(–.35)	(–.21)	(–.03)
	1.5%	.0009	.0007	–.0004	.0001	.0008
		(.24)	(.21)	(–.11)	(.04)	(.23)
Singapore dollar	.5%	.0051	.0048	.0029	.0037	.0050
		(1.18)	(1.13)	(.68)	(.85)	(1.16)
	1.0%	.0107	.0104	.0084	.0091	.0106
		(2.38)	(2.33)	(1.87)	(2.03)	(2.36)
	1.5%	.0110	.0107	.0087	.0094	.0109
		(2.47)	(2.41)	(1.94)	(2.10)	(2.45)
New Taiwan Dollar	.5%	.0094	.0092	.0074	.0082	.0093
		(2.33)	(2.28)	(1.84)	(2.04)	(2.31)
	1.0%	.0087	.0085	.0067	.0075	.0086
		(1.82)	(1.78)	(1.41)	(1.58)	(1.81)
	1.5%	.0051	.0050	.0037	.0043	.0051
		(1.13)	(1.10)	(.83)	(.95)	(1.12)

Note: Returns of filter rule trading in excess of the U.S. risk–free rate are given in the "Filter Rule" column. Filter rule trading returns adjusted for risk premiums based on logarithmic utility, isoelastic utility, exponential utility, and quadratic utility are given in the columns labeled "LOGU," "ISOU," "EXPU," and "QRAU." Heteroskedasticity and serial correlation consistent t–statistics are reported in parentheses.

Effects of transaction costs on trading profits are reported in table 10. Following Sweeney (1986), transaction costs for a round trip transaction are assumed to be one–eighth of 1%.[13] Results reported in the "FILTER RULE" column indicate that profitable opportunities for trading JY and NT$ disappear once transaction costs are included though they still exist in S$ trading.

13. Note that transaction costs in these currencies can be higher than one–eighth of 1%. For instance, these currencies (with the exception of JY) are typically traded with a wide bid–ask spread.

TABLE 10. Excess Returns from Filter Rule Trading (with Transaction Costs)

	X%	Filter Rule	Risk Adjusted LOGU	ISOU	EXPU	QRAU
Japanese yen	.5%	.0008 (.08)	–.0005 (–.05)	–.0118 (–1.2)	–.0090 (–.89)	.0002 (.02)
	1.0%	.0146 (1.38)	.0134 (1.27)	.0023 (.22)	.0040 (.35)	.0139 (1.32)
	1.5%	.0074 (.69)	.0061 (.57)	–.0055 (–.51)	–.0025 (–.24)	.0068 (.64)
Malaysian ringgit	.5%	–.0021 (–.59)	–.0023 (–.63)	–.0033 (–.94)	–.0028 (–.80)	–.0021 (–.60)
	1.0%	–.0014 (–.40)	–.0016 (–.43)	–.0026 (–.73)	–.0021 (–.59)	–.0015 (.41)
	1.5%	.0000 (.00)	–.0001 (–.03)	–.0012 (–.34)	–.0007 (–.20)	–.0000 (–.01)
Singapore dollar	.5%	.0001 (.03)	–.0008 (–.02)	–.0020 (–.47)	–.0013 (–.29)	.0001 (.01)
	1.0%	.0090 (2.01)	.0088 (1.96)	.0067 (1.50)	.0074 (1.66)	.0089 (1.99)
	1.5%	.0101 (2.27)	.0099 (2.22)	.0078 (1.75)	.0085 (1.91)	.0100 (2.25)
New Taiwan dollar	.5%	.0066 (1.64)	.0064 (1.59)	.0046 (1.15)	.0054 (1.35)	.0065 (1.62)
	1.0%	.0077 (1.62)	.0075 (1.58)	.0058 (1.21)	.0066 (1.38)	.0077 (1.61)
	1.5%	.0044 (.98)	.0043 (.95)	.0030 (.67)	.0036 (.80)	.0044 (.97)

Note: Returns of filter rule trading in excess of the U.S. risk–free rate and adjusted for trading costs are given in the "FILTER RULE" column. Returns adjusted for both transaction costs and risk premiums based on logarithmic utility, isoelastic utility, exponential utility, and quadratic utility are given in the columns labeled "LOGU," "ISOU," "EXPU," and "QRAU." Heteroskedasticity and serial correlation consistent t–statistics are reported in parentheses.

When both transaction costs and risk premiums are incorporated, the profit opportunity shrinks further as the significance level of excess returns shows a drastic decline and the number of losing trading cases rises noticeably, especially in the case of JY. In table 10, significant excess returns are only found among the utility functions that have the lowest degree of risk aversion.

Compared with results from the buy–and–hold strategy (table 7), the performance of filter rules is better in the case of NT$ and worse in the cases of JY and S$. Both buy–and–hold and filter rule strategies yield insignificant excess returns on RM. It is interesting to note that the filter rules do not perform better in the cases of RM and S$, where significant serial correlations are detected (table 5). Apparently, the filter rules are not able to benefit from trends generated by such serial correlations. One possible explanation is that these trends are contaminated by high conditional volatility. The relative performance of the buy–and–hold strategy on JY and S$ can be explained by the steady appreciation of these two currencies against the U.S. dollar as indicated by the significant intercept terms in table 5.

Once adjusted for risk premiums and transaction costs, returns from both trading strategies are very close to each other. For example, the filter rule does not outperform the buy–and–hold strategy in the case of NT$ once risk premiums and transaction costs are taken into account. Overall, there is no strong evidence of the superiority of the filter rules over the buy–and–hold policy or *vice versa*.[14]

We also split the samples into two equal halves and conduct the analysis. The results, which are available from the authors, are essentially the same as those from the full samples. Specifically, trading profits from both the buy–and–hold and filter rule strategies decrease substantially and become insignificantly different from the federal fund rate once risk premiums and transaction costs are taken into account.

V. Concluding Remarks

In this study, we evaluate the performance of filter rules on four Asian currency exchange rates against the U.S. dollar. Using the choice under uncertainty framework, we derive the risk premium required to compensate an investor for assuming the risk of investing in Asian currencies. Risk premiums based on four different utility functions, various risk aversion parameters, and GARCH–type conditional variances are used to illustrate the implications of risk premium adjustment on filter rule evaluation.

We found that the risk premium has a non–negligible affect on the overall trading rule performance. For instance, once the risk premium is accounted for, excess returns from filter rules decline substantially. For a utility function that has a strong degree of risk aversion, the risk adjustment can turn a profitable situation into a losing one. When both risk premiums and transaction costs are

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14. We also tested whether the filter rule returns are statistically better than the corresponding buy–and–hold returns. The results, which are available from the authors, indicate no significance difference between these two types of returns.

considered, the performance of filter rules is further weakened. Moreover, results from filter rules do not dominate those from a buy–and–hold policy, especially when the returns are adjusted for both risk premiums and transaction costs.

There are a few implications from these results. First, it is important to consider the risk from the investor's perspective in evaluating trading rule profits. If the potential risk is considered, a risk averse investor may be willing to give up possible trading profits to avoid the risk. Further, even if an investor can tolerate some risk, transaction costs can eliminate most of the remaining profitable trading opportunities.

Second, our results indicate that the superior performance of filter rules reported in the literature, which is usually derived from industrialized country exchange rates that are quite homogeneous and are characterized as free float or managed float rates, may not carry over to a wider group of currencies. Thus, a possible extension is to apply the technique proposed in this study to evaluate the performance of filter rules on industrialized country exchange rates.

Third, for the exchange rates considered, there is no substantial difference in the performance of the buy–and–hold strategy and filter rule trading. The filter rules do not exploit trend patterns in these exchange rates and generate returns higher than those from the passive buy–and–hold policy. That is, there is no substantial evidence against the efficient markets hypothesis. It is also noted that taxes are not considered here. We anticipate that capital gains taxes will further weaken the performance of filter trading rules.

References

Akdogan, H. 1995. *The Integration of International Capital Markets*. Brookfield Vt.: Edward Elgar Publishing.

Alexander, S. S. 1961. Price movements in speculative markets, trends or random walks. *Industrial Management Review* 2: 7–26.

Alexander, S. S. 1964. Price movements in speculative markets, trends for random walks. *Industrial Management Review* 5: 25–46.

Bank for International Settlements. 1996. *Central Bank Survey of Foreign Exchange and Derivatives Market Activity*. Basle: Bank for International Settlements, Monetary and Economic Department.

Bollerslev, T., and Wooldridge, J. 1992. Quasi–maximum likelihood estimators and inference in dynamic models with time–varying covariances. *Econometric Reviews* 11: 143–172.

Cheung, Y. W., 1993. Exchange rate premiums. *Journal of International Money and Finance* 12: 182-194.

Cheung, Y. W., and Wong, C. Y.–P. 1996. Foreign exchange markets in Hong Kong, Japan, and Singapore. Working paper. Santa Cruz: University of California and City University of Hong Kong.

Dooley, M. P., and Shafer, J. 1976. Analysis of short–run exchange rate behavior: March 1973 to September 1975. *International Finance Discussion Paper* 123. Washington, D.C.: Federal Reserve Board.

Dooley, M. P., and Shafer, J. 1983. Analysis of short–run exchange rate behavior: March 1973 to November 1981. Chapter 3. In D. Bigman, and T. Taya (eds). *Exchange Rate and Trade Instability*. Cambridge: Ballinger Publishing.

Euromoney. 1993a. *The Corporate Finance/Treasury Manager Foreign Exchange Yearbook 1993*. London: Euromoney.

Euromoney. 1993b. *The Goldman Sach Handbook of Foreign Exchange*, Part II. London: Euromoney.

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

Fama, E. F., and Blume, M. 1984. Filter rules and stock market trading. *Journal of Business* 39: 226–41.

Group of Thirty. 1985. *The Foreign Exchange Market in the 1980's – The Views of Market Participants*. New York: Group of Thirty.

Hong Kong Monetary Authority. 1995. *Proceedings of the Eleventh Pacific Basin Central Bank Conference on "Monetary and Exchange Rate Management with International Capital Mobility."* Hong Kong: Hong Kong Monetary Authority.

International Monetary Fund. Various issues. *Annual Report on Exchange Arrangements and Exchange Restrictions*. Washington, D.C.: International Monetary Fund.

International Monetary Fund. Various issues. *International Financial Statistics*. Washington, D.C.: International Monetary Fund.

Kansas, D. 1996. Amid Stocks' Gyrations, 'The Dow Theorists' Fret. *Wall Street Journal* (January 23).

Kho, B. C. 1996. Time–varying risk premia, volatility, and technical trading rule profits: Evidence from foreign currency futures markets. *Journal of Financial Economics* 41: 249–290.

Kim, S. B. 1993. Do capital controls affect the response of investment to saving? Evidence from the Pacific Basin. *Economic Review*, Federal Reserve Bank of San Francisco: 23–39.

Levich, R. M., and Thomas, L. R. 1993. The significance of technical trading–rule profits in the foreign exchange market: A bootstrap approach. *Journal of International Money and Finance* 12: 451–474.

Logue, D. E., and Sweeney, R. J. 1977. White noise in imperfect markets: The case of the Franc/Dollar exchange rate. Journal of Finance 32: 761–768.

Lucas, R.E., Jr. 1987. *Models of Business Cycle*. New York: Basil Blackwell.

Monetary Authority of Singapore. 1989. *The Financial Structure of Singapore*, 3rd edition. Singapore: Monetary Authority of Singapore.

Pratt, J. W. 1964. Measures of risk aversion. *Econometrica* 32: 122–137.

Sheimo, M. D. 1989. *Dow Theory Redux*. Chicago: Probus Publishing Company.

Sweeney, R. 1986. Beating the foreign exchange market. *Journal of Finance* 41: 163–182.

Tatewaki, K. 1991. *Banking and Finance in Japan – An Introduction to the Tokyo Market*. New York: Routledge.

Taylor, M. P., and Allen, H. 1992. The use of technical analysis in the foreign exchange

market. *Journal of International Money and Finance* 11: 304-314.
Taylor, S. J. 1994. Trading futures using a channel rule: A study of the predictive power of technical analysis with currency examples. *Journal of Futures Markets* 14: 215-235.