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"Speculation, Trading Rule Profits, Interest Rates and Risk"

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SPECULATION, TRADING RULE PROFITS, INTEREST RATE DIFFERENTIALS, AND RISK

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1. Introduction

This paper examines filter rule tests of the speculative efficiency of markets, particularly the issues of how risk and interest rate differentials should be included in such tests of speculation and used in judging their results.

Filter rules are mechanical buy-and-sell trading strategies that are intended as simple versions of stock markets' chartists' or technicians' analysis. They often take the form "Buy if the price rises X% above its previous low; sell if the price falls Y% below its previous high." The X and Y are intended to filter out random movements, to focus on significant trends. Instead of examining total profits to filter rules versus the return to buying and holding the asset, this paper examines the average daily return to filter rules versus that to buy-and-hold, and statistical tests of significance are developed.

One issue is whether the filter rules should look at profits from going from cash in one country to cash in another, or should look at profits using interest-earning assets in each country. Using the U.S. dollar - DM exchange rate as an example, it turns out that it does not matter whether interest rates are included or ignored. Intuitively, the interest rate differential changes the average return to both the filter rule and buy-and-hold but does not change their relative performance or any significant difference in performance.

When filter rule profits have been found in spot exchange markets, it has often been argued that perhaps the profits are due to risk. It turns out that the model of risk examined here explains the return only to the buy-and-hold strategy, but not to the filter rule. In fact, significant filter rule profits are an idictment of the risk model, since it does not predict such profits. On the other hand, once significant profits are found, the risk model can be used to evaluate the profitability of speculating in these markets, and as a buy-product reducing these profits.

2. Risk, and Interest Rate Differentials

This paper discusses how trading rule profits might be judged statistically significant, and how they might be evaluated in light of the risk borne in earning them. Tests of U.S. stock markets reported zero or negative profits (after transaction costs) for such trading strategies.[1] This paper, however, focuses on the foreign exchange markets for the U.S. dollar, where a number of studies have found some substantial filter rule profits.[2] Some authors have argued that these measured profits might not be excessive, and hence the market might still be efficient, in light of the risk to speculators who might attempt to try to profit in these markets and hence reduce such returns.[3] A "beta" analysis of such risk is often suggested, and has been used, e.g., by Cornell and Dietrich.[4]

The question raised is, what return to stabilizing speculation is justified in these markets by the capital asset pricing model (CAPM) if the market is efficient? The present paper argues that when alternative assets are defined appropriately in terms of observable yields, the expected value of filter rule profits is zero in the CAPM context (Section 4). Furthermore, systematic excess profits cannot be explained by resorting to risk; using CAPM analysis cannot explain seeming inefficiencies. Rather, assuming there is inefficiency, the CAPM can be used to evaluate the attractiveness to speculators of trading strategies to exploit this inefficiency (and as a by-product, reduce it).

In particular, the CAPM is of use in explaining returns to a buy-and-hold strategy in terms of the systematic risk of foreign exchange, but has nothing to say in explaining excess returns from a trading strategy over buy-and-hold.

Filter rule profits can be used in a weak-form test of market efficiency. However, they can also be used to test the CAPM itself. In essence, a trading rule beats buy-and-hold if it takes the speculator out of the market on days that give below-average rates of return. This can happen systematically only if the excess return on the overall market or the error term on the market model can be forecast, both of which would violate the CAPM. The filter rule tests discussed below are then also tests of the CAPM. It seems that the U.S. dollar - DM exchange market is inefficient (Section 3), and thus the implications of the CAPM are rejected for this market.

It is sometimes argued that trading rule tests of spot exchange market efficiency should use interest-earning assets as investments in each country, rather than comparing trading rule versus buy-and-hold returns based on holding cash in each country. In principle, this is a serious objection. However, empirically the differences in returns to trading rules versus buy-and-hold seems to be only very little affected by whether such interest earnings are included. (The average return to both strategies is significantly affected, but not their relative returns.) It is difficult to obtain matching, high-quality data on daily exchange rates and one-day interest rates for both countries. However, this study presents results for 1289 trading days from 1975-1980, for the dollar-DM exchange rate, the Federal funds rate and the Frankfurt interbank borrowing rate. The results below show that the inclusion of interest rates makes very little difference. It is conjectured this is true for all non-pegged rates of the period since generalized floating began in March, 1973.

A second, frequent, objection is that the relevant standard of efficiency is the interaction of spot and forward foreign exchange markets. In the early years of the generalized float (with heavy intervention), it was often argued that efficiency required the forward rate to be an unbiased predictor of the future spot rate. More recently it has been recognized that legitimate risk premia may exist and the unbiased property is not required for efficiency.[5] Hence, interest has waned in comparing the joint behavior of spot versus forward exchange rates to judge efficiency.

Nevertheless, a common view is that spot rates by themselves have little to say about efficiency, or are at least deficient in allowing judgment of an exchange market's efficiency. One strand of this argument is that changes in the spot exchange rate may show patterns of serial correlation even if the market is efficient.[6] This is true; however, if the process generating these spot rate changes is stationary, any patterns must be explicable by interest, storage and transaction costs.[7] Another strand argues that, whatever the properties of the spot market, efficiency requires that one not be able to make systematic profits in playing across spot and futures markets. However, this paper argues (Section 5) that appropriate filter rule tests of spot market efficiency are in fact equivalent to tests of the joint efficiency of both spot and forward markets in a world where interest parity holds.

3. Efficiency in the Spot Exchange Market

This section develops two tests of the significance of trading rule profits. One test considers holding only cash in either country; the other considers holding interest earning assets. Empirically, the tests turn out to be virtually identical, so that the simpler test involving holding cash can be used in place of the more difficult test using interest earning assets.

Consider two countries, say the U.S. and Germany, where changes in the dollar price of DMs is a random variable $u_t = \alpha_t + e_t$, where α_t is a (possibly) non-stationary mean, $\underline{e}$ is a white random variable, $E(u_t) = \alpha_t \gtrless 0$, $E(u_t - \alpha_t)^2 = \sigma_e^2$, $E(e_t e_{t+j}) = 0$ for $j \neq 0$. Let the nominal risk-free yield on government securities, for the period length considered, be $r_{d,t}$ in the U.S. and $r_{f,t}$ in Germany for each period $\underline{t}$. The (approximate) per period differential for holding funds in Germany versus the U.S. is $u_t - (r_{d,t} - r_{f,t})$. Letting $(r_{d,t} - r_{f,t}) = \alpha_t'$, then $E[u-(r_d - r_f)] = \alpha_t - \alpha_t'$. Note that α_t' is deterministic in the sense that $r_d - r_f$ is known with certainty at the start of each period.

Filter Rule Tests. Profits from filter rules (relative to buy-and-hold) have often been used to judge efficiency of financial markets, including exchange markets. Past efforts have suffered from lack of statistical significance tests. However, two tests of the significance of filter rule results are suggested here, based on Sweeney.[8]

The first uses the normalized rate of return $u + (r_f - r_d)$ for buy-and-hold and for days "in" the market, and uses $(r_d - r_d) = 0$ for days "out" when the filter rule has the investor out of the market. This test assumes $u_t + (r_{f,t} - r_{d,t})$ is stationary, implying $\alpha - \alpha'$ is constant, though allowing α (and hence α') to vary over time.[9] Since it may be that $E[u + (r_f - r_d)] = (\alpha - \alpha') \neq 0$, the zero-mean test statistic used is $X = a_F - a + fa$, where a_F is the return to the filter rule, $\frac{1}{N} \sum_{i}^{N_{in}} [u_i + (r_{f,i} - r_{d,i})$; $\underline{a}$ is the return to buy-and-hold, $\frac{1}{N}\sum_{j}^{N}[u_j + (r_{f,j}-r_{d,j})]$; N is the total number of days, N_{in} is the number of days "in"; N_{out} the number of days "out", $N \equiv N_{in} + N_{out}$; and $f = N_{out}/N$.

Then,

$$(1)\quad X = \frac{1}{N}\sum^{N_{in}}[u + (r_f-r_d)] - \frac{1}{N}\sum^{N}[u + (r_f-r_d)] + f\frac{1}{N}\Sigma u + (r_f-r_d)]$$

$$= \frac{1}{N}\sum_{i}^{N_{in}}[\alpha_i+\varepsilon_i-\alpha_i'] - \{\frac{1}{N}\sum_{i}^{N_{in}}[\alpha_i+\varepsilon_i-\alpha_i'] + \frac{1}{N}\sum_{j}^{N_{out}}[\alpha_j+\varepsilon_j-\alpha_j']\}$$

$$+ f\{\frac{1}{N}\sum^{N_{in}}[\alpha_i+\varepsilon_i-\alpha_i'] + \frac{1}{N}\sum^{N_{out}}[\alpha_j+\varepsilon_j-\alpha_j']\} = -\frac{1}{N}\sum^{N_{out}}[\alpha_j+\varepsilon_j-\alpha_j']$$

$$+ f\{\frac{1}{N}\sum^{N_{in}}[\alpha_i+\varepsilon_i-\alpha_i'] + \frac{1}{N}\sum^{N_{out}}[\alpha_j+\varepsilon_j-\alpha_j']\}.$$

Thus, since $\alpha_i - \alpha'_i$ equals a constant, say, $\alpha - \alpha'$,

$$EX = -\frac{N_{out}}{N}(\alpha-\alpha') + f\{\frac{N_{in}}{N}(\alpha-\alpha') + \frac{N_{out}}{N}(\alpha-\alpha')\}$$

$$= (\alpha-\alpha')[-f + f(1-f) + f)] = (\alpha-\alpha')(-f + f - f^2 + f^2) = 0;$$

inclusion of the term fa in X ensures EX = 0 even if $(\alpha-\alpha') \neq 0$. Further,

$$\sigma_X^2 = E\{- \frac{1-f}{N} \sum^{N_{out}} [u_j + (r_f - r_d)] + \frac{f}{N} \sum^{N_{in}} [u_i + (r_f - r_d)]\}^2$$

$$= \frac{(1-f)^2}{N} \frac{N_{out}}{N} \sigma_e^2 + \frac{f^2}{N} \frac{N_{in}}{N} \sigma_e^2 = \frac{\sigma_e^2}{N} [(1-f)^2 f + (1-f)]$$

$$= \frac{\sigma_e^2}{N} [(1-2f + f2)f + f^2 - f^3] = \frac{\sigma_e^2}{N} (f - 2f^2 + f^3 + f^2 - f^3)$$

$$= \frac{\sigma_e^2}{N} (f - f^2) = \frac{\sigma_e^2}{N} f(1-f),$$

and hence,

$$\sigma_X = \frac{\sigma_e}{N^{\frac{1}{2}}} [f(1-f)]^{\frac{1}{2}}.$$

The second test looks only at u_t for buy-and-hold and for days "in" the market, and zero for days "out" of the market due to the filter rule. As before, the test assumes u is stationary, in particular, this implies α is constant. The test statistic is $X' = a_F' - a' + fa'$, where

$$a_F' = \frac{1}{N} \sum_i^{N_{in}} u_i, \quad a' = \frac{1}{N} \sum_j^{N} u_j,$$ with f as before. Then,

$$(2) \quad X' = \frac{1}{N} \sum^{N_{in}} u_i - \{\frac{1}{N} \sum^{N_{in}} u_i + \frac{1}{N} \sum^{N_{out}} u_j\} + f \{\frac{1}{N} \sum^{N_{in}} u_i + \frac{1}{N} \sum^{N_{out}} u_j\}$$

$$= - \frac{1}{N} \sum^{N_{out}} [e_i + \alpha] \quad + f\{\frac{1}{N} \sum^{N_{in}} [e_i + \alpha] \quad + \frac{1}{N} \sum^{N_{out}} [e_j + \alpha]\},$$

$$EX' = \{-f + f((1-f) + f)\} \quad \alpha = 0.$$

It can be shown that

$$\sigma_{X'} = \frac{\sigma_e}{N^{1/2}} [f(1-f)]^{1/2} ,$$

just as before.

If expected depreciation α and the differential $r_d - r_f = \alpha'$ are constant, or variations are slight enough that they can be taken as constant, then the two tests are identical; either can be used with precisely the same results. If α' is not constant, but $(\alpha-\alpha')$ is reasonably taken as constant with changes in α' and α essentially offsetting each other, then using the series $u_t + (r_f - r_d)$ will give more efficient estimates of σ than simply using the u's. Finally, suppose that both α and α' are non-stationary, and so is $(\alpha-\alpha')$. If, however, changes in α and α' on average tend to somewhat offset each other, once again using the first test provides a more efficient estimate of σ.[10]

Which test, for X or X', is better to use? X' is certainly more convenient in terms of limited availability of suitable daily interest rate data. In practical terms, the choice between these two tests makes little difference in the case examined here. Taking account of interest rate differentials reduces both the filter rule's and buy-and-hold's rate of return, and roughly proportionately. Hence the value and significance of X is not greatly different from that of X'. In principle, taking account of the interest rate differential could drastically affect X versus X'. This seems not to happen here because the percentage change in the exchange rate is so volatile relative to the interest rate differential. This is very likely to be so for most exchange markets.

Empirical Results.

The data used here were kindly provided by the Board of Governors of the Federal Reserve System. After cleaning, there remained 1289 trading days between 1975 and 1980. Daily data on the dollar-DM exchange rate, the overnight Federal funds rate and the one-day Frankfurt interbank loan rate were cleaned carefully and checked with other sources. However, the three series were not collected at exactly the same time as each other. Further, some rates are averages across firms, and may not be actual trading data. Nevertheless, the quality of the data seems adequate (and in any case it was not possible to obtain better data or indeed obtain data for comparable experiments for other countries). In particular, the intra-day variability of the interest rate differential seems small enough (on the basis of casual observation) that conclusions below would not be altered if simultaneously collected data were used.

The mean percentage rate of change of the exchange rate on a daily basis is $[(Ex_t - Ex_{t-1})/Ex_{t-1}] \cdot 100 = .027$, while the mean interest rate differential on the basis of 262 business days per year is $(i_{DM} - i_\$)/262 = -.0113$. However, the variances are much more divergent, with that for the exchange rate .270, and the differential's .0000875. Consequently, as Table 1 shows, the mean and variance for $(\Delta Ex/Ex) \cdot 100$ are .027 and .270 while for $[(\Delta Ex/Ex) \cdot 100 + (i_{DM} - i_\$)/262]$ they are .016 and .271.

In intuitive terms, note that if $(i_{DM} - i_\$)$ is constant and $E[(\Delta Ex/Ex) \cdot 100] = i_\$ - i_{DM}$, or $\alpha = \alpha'$, the tests are identical, $X \equiv X'$. This follows from (1) and (2). Indeed, if $(i_\$ - i_{DM})$

whatever is α, then is simply any constant, $X = X'$. However, the differential $(i_{DM}-i_{\$})$ is not constant. Table 1 shows that $i_{DM}-i_{\$}$ can be (very) roughly approximated as a random walk. In other words, $\Delta\alpha'$ is roughly approximately a white noise. Since economic theory says α and α' ought to be closely related, α ought to also wander randomly. There is, however, little indication of this in the pattern of serial correlation in $(\Delta Ex/Ex)\cdot 100$ in Table 1. Supposing that $\Delta\alpha \approx \Delta\alpha'$, the empirical results are due to the fact that the variance of $(\Delta Ex/Ex)\cdot 100$ is so much larger than that of $(i_{DM}-i_{\$})/262$ that the latter is swamped. It is in this sense that the difference between X and X' is in practice negligible.

Since the mean $(\Delta Ex/Ex)\cdot 100 = .027$ and the mean $(i_{DM}-i_{\$})/262 = -.0113$, the mean $[(\Delta Ex/Ex)\cdot 100 + (i_{DM}-i_{\$})/262] = .016$. However, the adjustment factor in X and X' based on $f = N_{out}/N$ roughly compensates for this in Table 2.

The results for X' in Table 2 show $X = .014$ is (borderline) significant at the 95% confidence level, and thus both the 0.5% and 1.0% filters give significant profits. With X, the significance value is still $X' = .014$, since the estimate $\hat{\sigma}_X$ is computed as .027 from exchange rate data and .0271 from exchange rate data adjusted for the interest rate differential. It is notable that X and X' are virtually identical.

Intuitively, if α' were constant, then X and X' would be identical. α' is not constant, but relative to other sources of variability in X its variations are so trivial that for all practical purposes α' can be treated as constant and hence X' can be used instead of X. It appears that this can be validly generalized to any exchange rate that is not tightly pegged to the dollar by appealing to casual scanning of average exchange rate changes and interest rate differentials and their volatility. There has certainly been substantial intervention in the dollar-DM market, so the management under the current float does not seem to make use of X' (instead of X) invalid.

4. Are Filter Rule Profits Explicable By Risk?

A number of authors, for example Cornell and Dietrich,[11] and Levich,[12] have conjectured that existence of observed filter rule profits (relative to buy-and-hold) may be due to the risk involved in speculative efforts to exploit them (and hence reduce them as a side effect). Indeed, this risk has sometimes been cast in the CAPM framework.[13] This section evaluates this line of reasoning.

The CAPM. The CAPM implies the expected value relationship

$$(3)\quad \alpha - \alpha' = \beta(ER_m - r_d),$$

where R_m is the return on "the" market, $\alpha - \alpha'$ is the expected excess return on holding the foreign short term asset, and $ER_m - r_d$ is the expected excess return on the domestic market. ⟶

However, work on international CAPMs indicates that a single market factor may not be adequate in an open country context, and even if a single market measure can be used, it is not clear how this market should be defined from the point of view of the resident of a particular country.[14] However, to get on with the main argument, assume (3) holds.[15]

(3) is commonly implemented statistically by the "market model"

(4) $(u_t+r_f) - r_d = a + b(R_m-r_d) + \varepsilon_t.$

where b is the OLS slope coefficient between the actual excess return on holding the foreign short-term assets $(u_t+r_f-r_d)$, and the excess return on the market (R_m-r_d), and ε_t a white noise that is orthogonal to R_m; estimation of (4) generally assumes stationarity of $u - (r_d-r_f)$, (R_m-r_d) and ε.[16] Thus, the CAPM, and its statistical implementation in (4), is simply an attempt to explain $u_t + r_f - r_d$ in terms of its covariation with $R_m - r_d$. The CAPM takes $\hat{b}$ as an estimate of the β in (3), and from (3) also predicts $\hat{a} = 0$. A standard CAPM test is whether $\hat{a}$ is significantly different from zero. Given the extensive results that have shown non-zero bs for various firms, a $\hat{b}$ for the exchange market that is not statistically significantly different from zero would not be taken as failure of the CAPM, but rather as evidence that foreign exchange positions bear no systematic risk. (3) has explanatory power, relative to simply using the mean $(\alpha-\alpha') = \hat{a}$ to forecast $u_t + (r_f-r_d)$, just in case $\hat{b}$ is significantly different from zero. Note that (4) implies (under stationarity) that the variance of $[u_t + (r_f-r_d)] = b^2\sigma^2_{R_m} + \sigma^2_\varepsilon$.

Consider the frequent assumption that $E(u) = r_d - r_f$, or that $\alpha_t = \alpha'_t$. This says that the expected excess return in putting funds in a safe asset abroad versus at home is zero, or

$[(Eu + r_f) - r_d] = 0$. Since $E(R_m - r_d) > 0$, the assumption $\alpha = \alpha'$ implies $\beta = 0$ in (3), or in other words that $\underline{u}$ is orthogonal to the return on a well-diversified portfolio, and hence there is no expected reward, beyond $\alpha + r_f = r_d$, to holding DMs.

Some analyses imply or assume a risk premium, $\alpha - \alpha' \neq 0$. This is perfectly consistent with the CAPM -- it merely says $Cov(u + r_f - r_d, R_m - r_d) \neq 0$, in order to give $\beta \neq 0$ and hence $\beta(ER_m - r_d) \neq 0$. Depending on the structure of the model surrounding the CAPM, the implied cov(·) may or may not equal zero.[17]

Filter Rule Profits. Suppose the filter rule beats buy-and-hold. Rather than compare the levels of dollar profits of the rule and buy-and-hold, a slightly different approach used above is to examine how the per period rate of return to buy-and-hold compares to the filter rule's per period rate of return;[18] normalize both rates by substracting r_d. The normalized rate for buy-and-hold is simply $u_t + (r_f - r_d)$. (Note that this is the same rate of return that the CAPM is used to explain, as discussed above.) For each period $\underline{t}$ in which the rule has the speculator in DMs, the rule's rate is also $u_t + (r_f - r_d)$; and for periods where the speculator is out of DMs, the normalized rate if $r_d - r_d = 0$. Write the sample per period rate of return to buy-and-hold as $\frac{1}{N}\sum_{i=1}^{N}[u_i + (r_f - r_d)]$, and the sample average rate of return to the filter rule as

$$\frac{1}{N}\sum_{j=1}^{N_{in}}[u_j + (r_f - r_d)] + \sum_{j=1}^{N_{out}}(r_d - r_d) = \frac{1}{N}\sum_{j}^{N_{in}}[u_j + (r_f - r_d)],$$

where N_{out} is the number of days "out" of the DM and N_{in} days "in". Thus, if the average rate of return to the filter exceeds buy-and-holds,

$$(5)\quad \frac{1}{N}\sum_{j}^{N_{in}}[u_j + (r_f-r_d)] - \frac{1}{N}\sum_{i}^{N}[u_i + (r_f-r_d) = -\frac{1}{N}\sum_{j}^{N_{out}}[u_j + (r_f-r_d)] > 0.$$

Thus, the filter rule on average has gotten the investor out of the DM in the periods when $u_j + (r_f-r_d)$ is negative (when $r_d > u_t + r_f$) -- an intuitively plausible result.

Of necessity, such a $\frac{1}{N}\sum_{i}^{N_{out}}(u_u + r_f - r_d)]$ is less than an OLS estimated version of (4) predicts for the average value of $(R_m - r_d)$. With $\frac{1}{N}\sum^{N}[u_i + (r_f-r_d)]$ as an estimate of $E[u + (r_f-r_d)]$, and $\frac{1}{N}\sum^{N}(R_m-r_d)$ as an estimate of $E(R_m - r_d)$, then $\hat{a}$, $\hat{b}$ are necessarily chosen by OLS to make

$$(6)\quad \frac{1}{N}\sum_{i}^{N}[u_i + (r_f-r_d)] = \hat{a} + \hat{b}\,\frac{1}{N}\sum_{i}^{N}(r_{m_i} - r_d).$$

Thus, given these $\hat{a}$, $\hat{b}$ it follows that on the average for the periods where the successful speculator is out of the DM,

$$(7)\quad \frac{1}{N}\sum_{j}^{N_{out}}[u_j + (r_f-r_d)] = \hat{a} + \hat{b}\,\frac{1}{N}\sum_{j}^{N_{out}}(R_{m_j}-r_d) + \sum_{j}^{N_{out}}\hat{\varepsilon}_j < 0$$

and hence over the sample of days out, the average of either or both of $(R_{m_t}-r_d)$ or $\hat{\varepsilon}_t$ over N_{out} must be negative. If the CAPM is a valid description of this market neither (R_m-r_d) nor $\hat{\varepsilon}$ can be forecast, and the excess filter profits in (7) must be attributed to chance. In other words, the CAPM cannot explain at all any excess filter returns as measured here.

Alternatively, if $(R_m - r_d)$ and/or ε can be forecast to allow filter profits, then the CAPM must be rejected. Thus, significant filter profits allow rejection of the hypothesis the CAPM holds, rather than the CAPM throwing light on the reasons for such profits.

Misuse of the CAPM to Explain Excess Filter Rule Profits.

Cornell and Dietrich[19] test whether estimated βs for various currencies relative to the dollar are non-zero, in hopes of explaining filter rule profits. If it is judged that $\hat{b}$ is statistically significantly different from zero, then this implies the average reward to buy-and-hold, $(\alpha - \alpha')$ is significant (assuming $\hat{a} = 0$ as the CAPM implies). Thus, estimating (4) cannot tell anything more about the risk premium than does examining $(\alpha - \alpha')$ and its sample variance, as seen from (5). Further, as shown below, $\hat{b}$ says nothing about why the excess profits to the filter rule occurred.

Table 3 shows how estimated β have sometimes been misued in explaining filter rule profits. Cornell and Dietrich argue that "...none of the rules led to annual profits of over 4% in the case of the British pound [£], Canadian dollar [C$], or Japanese yen [¥]...For the German mark [DM], Dutch guilder [Fl], and Swiss franc [SwFr]...the situation was quite different". This passage, however, indicates a failure to focus on the difference between the return to the filter rule versus buy-and-hold. The key issue is not how well the filter rule did, but how it did relative to buy-and-hold. However, column (3) shows the filter rules did an impressive job for the pound and yen vis-à-vis buy-and-hold, but not for the Swiss franc. Cornell and Dietrich go on to argue that "[o]ne explanation for the higher returns on the franc, mark and guilder, positions is that the high returns are compensation for risk. The three currencies showing the highest rates of return also had the largest variance in daily rates of return...[M]odern finance theory indicates that only undiversified risk must be compensated for via higher expected rates of return..." They then provide the estimated βs and t-statistics in columns (4) and (5).

Clearly, they are attempting to explain the filter rule profits in column (1) with the βs in column (4). However, column (4) is relevant to explain only the buy-and-hold results in column (2); column (4) cannot explain either the key results in column (3), or the column (1) results. The real question is, given column (2) (or column (4)), how can column (3) be explained? Are these results indicative of inefficiency, or could they arise merely by chance?

Beta analysis, then, can be used to explain the return to buy-and-hold, but not to filter rules. In one light, this leads to rejection of the CAPM. From another perspective, exchange markets offer opportunities for profitable investment/speculation. An appropriate way to evaluate these opportunities may be to use risk-adjusted discount rates based on the CAPM. If markets are not costlessly efficient, such a model bounds their deviations from efficiency.

5. Tests of Speculation Across the Spot and Forward Exchange Markets

The net return $u_t + (r_f - r_d)$ is also a good approximation to the per period rate of return to making contracts each period to buy DMs forward at the currently prevailing forward rate. In the Euro markets, the forward premium, on the DM is (almost always) equal to $(r_d - r_f)$ to a close approximation. Thus, if the percentage appreciation of the spot DM ($= u_t$) exceeds the premium, i.e., $u_t > r_d - r_f$, or $u_t + (r_f - r_d) > 0$, then profits are made. If $(\alpha - \alpha') \neq 0$, then average profits from this buy-every-period strategy are also expected to be non-zero; but as seen above, this is consistent with the CAPM.

Consider filter rule that sometimes has one make such transactions, other times not. Then, the average rate of return for periods when such transactions are made is

$\frac{1}{N_{in}} \sum^{N_{in}} u_j + (r_f - r_d)$. The average return over all periods is

$\frac{1-f}{N_{in}} \sum^{N_{in}} [u_j + (r_f - r_d)] = \frac{1}{N} \sum^{N_{in}} [u_j + (r_f - r_d)]$. The buy-every-period strategy plays the same role as buy-and-hold did above;

the rate of return from buy-every-period is $\frac{1}{N} \sum_i^N [u_i + (r_f - r_d)]$.

Clearly, a test of filter rule profits across these two markets can be formulated using the test statistic X in equation (4). This new filter test is just the same then as the spot market test using interest rates. Note, however, that in cases where X' in equation (5) is an adequate substitute for X, no more information is gained by considering the forward in addition to the spot exchange market.

In the empirical example developed above, testing the spot markets' efficiency using X' turns out to give as much information as including interest rates and using X. But since X is an appropriate statistic for testing the joint efficiency of the spot and forward exchange markets, it follows that it is adequate simply to look at the behavior of the spot market by using X. In principle, examining both markets gives a better test and could give results different from looking just at the spot market. But in practice for the case examined above, looking only at the spot market is sufficient. As noted above, this is because variations in X are so completely dominated by spot market fluctuations that it is an adequate approximation to treat α' as a constant, and if α' is constant then X and X' are identical. Casual observation suggests similar results will hold for all floating (but managed) spot rates.

6. Conclusions

This paper discussed two main issues: the first was which way or ways are appropriate for measuring filter rules profits, and the second was whether the filter rule profits some authors have found are perhaps explicable or "justified" due to the risk involved in speculation to learn these profits.

If one decides to judge filter rule profits on the basis of average daily rates of return versus buy-and-hold, it is theoretically sounder to use percentage exchange rate changes net of the interest rate differential, rather than just the percentage exchange rate changes themselves. However, there are instances when theoretically it doesn't matter which measure is used; tests are derived based on both measures, and the appropriateness of one or the other is discussed. In particular, if the interest differential is a constant, the two tests are identical. In the illustrative test performed above on 1289 daily observations on the dollar-DM exchange rate, and the federal funds rate and the overnight Frankfurt interbank loan rate, both tests give virtually identical results, that the filter profits are often substantial and statistically significantly better than buy-and-hold's returns. While the differential is not constant, its day-to-day variability is orders of magnitude is smaller than the percentage change in the exchange rate's. For practical purposes, then, the differential can be taken as constant and either test used. This seems likely to be the case in all of the major exchange markets under floating. This result is a great convenience, since it says filter tests need only look at exchange rates, and not also at the differentials which are more difficult to gather.

Some authors have argued that the filter profits found in exchange markets by a number of investigators are explicable in light of the speculative risk involved in earning them and may perhaps not be excessive or indicative in efficiency. Indeed, it is sometimes suggested that this issue should be looked at in a popular general equilibrium measure of risk and asset pricing, the Capital Asset Pricing Model (CAPM). As shown above, however, the CAPM explains returns to buy-and-hold, not to the filter. The CAPM implies that expected excess returns to the filter over buy-and-hold should equal zero, so the significant returns found above can be interpreted as rejecting the hypothesis that the CAPM describes exchange markets or that exchange markets are efficient in terms of the CAPM. On the other hand, if other markets are described by the CAPM, perhaps it remains a good way of estimating a discount rate to be used in evaluating whether the profits potentially earned from a filter strategy are high enough to justify the risk involved.

Table 1

Returns to Exchange Speculation, With and Without Adjustment
for Interest Rate Differentials -- the Dollar-DM Case

$(\Delta Ex/Ex)\cdot 100$

ACF lag	1	2	3	4	5	6	7	8	9	10	11	12	estimated standard error
estimated coefficient	.02	.00	.02	-.01	.02	.04	-.01	.08*	.02	.08*	-.01	-.02	.03

mean: .027 variance: .270 Q(12) 22.8

$(i_{DM}-i_{\$})/262$

ACF lag	1	2	3	4	5	6	7	8	9	10	11	12	estimated standard error
estimated coefficient	.95*	.95*	.90*	.88*	.87*	.86*	.85*	.84*	.82*	.81*	.80*	.79*	.03

mean: -.0113 variance: .0000875 Q(12) = 11,500

$\Delta[(i_{DM}-i_{\$})/262]$

ACF lag	1	2	3	4	5	6	7	8	9	10	11	12	estimated standard error
estimated coefficient	-.30*	.01	-.08	-.05	-.03	.01	.03	.00	-.02	.03	-.03	.03	.03

mean: $.45\text{x}10^{-5}$ variance: $.891\text{x}10^{-5}$ Q(12) = .26

$(\Delta Ex/Ex)\cdot 100 + (i_{DM}-i_{\$})/262$

ACF lag	1	2	3	4	5	6	7	8	9	10	11	12	estimated standard error
estimated coefficient	.02	.00	.02	-.01	.02	.04	-.01	.08*	.02	.08*	-.01	-.02	.03

mean: .016 variance: .271 Q(12) = 23.4

Table 2

Tests of Significance of Filter Rule Profits≠

Filter	a'_F	a'	f	X'	a_F	a	X
.5%	.029	.027	.446	.014* (.000, .028)	.024	.0156	.016*
1%	.034	.027	.388	.017* (.003, .031)	.028	.0156	.019*
2%	.028	.027	.422	.013 (-.001, .027)	.022	.0156	.013
3%	.021	.027	.423	.006 (-.008, .020)	.016	.0156	.007
4%	.026	.027	.250	.006 (-.007, .018)	.018	.0156	.007
5%	.024	.027	.265	.005 (-.008, .017)	.016	.0156	.005
10%	.009	.027	.396	-.007 (-.021, .007)	.003	.0156	-.006

Var[(Ex/Ex)·100] = .27041

Var[(Ex/Ex)·100 + $(i_{For}-i_{US})$/262] = .27063

* Significant at the 95% confidence level.

≠ Confidence bounds in parentheses

Table 3

Currency	(1) Annual Rate of Return From Filter Rule, Net of Transactions Costs	(2) Annual Rate of Return From Buy-and-Hold	(3) = (1-2)	(4) $\hat{\beta}$	(5) $t(\hat{\beta})$
£	1.9	-6.4	8.3	0.03	0.85
C$	1.4	-1.4	2.8	-0.003	0.22
Fl	13.0	4.8	8.2	0.12	2.18
DM	15.7	4.3	11.4	0.11	1.85
¥	2.5	-4.6	7.1	0.08	1.71
SwFr	10.2	8.3	1.9	0.05	0.72

Source: Based on Tables 3 and 5, Cornell and Dietrich (pp. 116-17). For (1) they report the <u>highest</u> rate. They do not compute (3).

Footnotes

[1]See Eugene F. Fama and Marshall Blume, "Filter Rules and Stock Market Trading," Journal of Business (January 1966), pp. 226-241.

[2]See Michael Dooley and Jeffrey Shafer, "Analysis of Short-Run Exchange Rate Behavior, March 1973 to September 1975," International Finance Discussion Paper No. 76, Federal Reserve Board, 1976; Dennis E. Logue, Richard James Sweeney and Thomas D. Willett, "Speculative Behavior of Exchange Rates Under the Current Float," Journal of Business Research, vol. 6 no. 2 (1978), pp. 157-174; and Bradford Cornell and Kimball Dietrich, "The Efficiency of the Market for Foreign Exchange Under Floating Exchange Rates," Review of Economics and Statistics (1977), pp. 111-20.

[3]See Bradford Cornell and Kimball Dietrich, op. cit.; Richard Levich, "Comment on Papers by Sweeney and Willett," in Jacob Dreyer, Gottfried Haberler and Thomas D. Willett, eds., The International Monetary System Under Stress (Washington, D.C.: American Enterprise Institute (forthcoming)); and the "Discussion" in Jacob Dreyer, Gottfried Haberler and Thomas D. Willett, op. cit.

[4]See Bradford Cornell and Kimball Dietrich, op. cit.

[5]See, for example, the discussion and references in Peter Sharp's paper in the volume, "Determinants of Forward Risk Premia in Efficient Markets".

[6] Harris and Douglas Purvis, "Diverse Information at the Market Efficiency in a Monetary Model of the Exchange Rate," Queen's University, mimeo, 1978.

[7]This is the general view taken towards serial correlation tests of weak-form efficiency in R.J. Sweeney, "Efficient Information Processing in Output Markets: Tests and Implications," Economic Inquiry (July 1978), pp. 313-331 and in R. J. Sweeney, "Efficient Information Processing by Markets: Seven Years of Evidence From Foreign Exchange Markets," in this volume.

[8]R. J. Sweeney, "A Statistical Filter Rule Test, With Application to the Dollar-DM Exchange Rate," Claremont Working Paper, Claremont Graduate School, Claremont, CA, 1981.

[9]This simply makes explicit the assumption of stationarity that lies behind virtually all statistical tests (including most non-parametric tests) that do not explicitly model non-stationarity in parameters.

[10]See R. J. Sweeney, "A Statistical Filer Rule Test, With Application to the Dollar-DM Exchange Rate," op. cit.

[11]See Bradford Cornell and Kimball Dietrich, "The Efficiency of the Market for Foreign Exchange Under Floating Exchange Rates," op. cit.

[12]See Richard Levich, "Comment on Papers by Sweeney and Willett," op. cit.

[13]Work over the past half dozen years has questioned the adequacy and indeed the logical foundations of the CAPM. See Richard Roll, "A Critique of the Asset Pricing Theory's Tests Part I: On Past and Potential Testability of the Theory," Journal of Financial Economics (March 1977), pp. 129-76; Richard J. Sweeney, "Testing the CAPM Under Stationarity," American Economic Review (forthcoming); Stephen Ross, "The Arbitrage Theory of Capital Asset Pricing," Journal of Economic Theory 13 (December 1976), pp. 341-360.

[14]See the discussion and references in Peter Sharp, "Determinants of Forward Risk Premia in Efficient Markets," op. cit.

[15]This is, for example, the assumption by Bradford Cornell and Kimball Dietrich, op. cit.

[16]See Eugene F. Fama and James D. McBeth, "Risk, Return and Equilibrium: Empirical Tests," Journal of Political Economy 71 (May/June 1973), pp. 607-36.

[17]See Bruno Solnik, "Equilibrium in an International Capital Market Under Uncertainty," Journal of Economic Theory 8 (1973), pp. 506-24; and Peter Sharp, "Determinants of Forward Risk Premia in Efficient Markets," op. cit.

[18] See Richard J. Sweeney, "A Statistical Filter Rule Test, With Application to the Dollar-DM Exchange Rate," op. cit.

[19] See Bradford Cornell and Kimball Dietrich, "The Efficiency of the Market for Foreign Exchange Under Floating Exchange Rates," op. cit.