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THE PROFITABILITY OF CURRENCY SPECULATION

John F. O. Bilson

David A. Hsieh

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ABSTRACT

This paper presents the results of a post-sample simulation of a speculative strategy using a portfolio of foreign currency forward contracts. The main new features of the speculative strategy are (a) the use of Kalman filters to update the forecasting equation, (b) the allowance for transactions, costs and margin requirements and (c) the endogenous determination of the leveraging of the portfolio. While the forecasting model tended to overestimate profit and underestimate risk, the strategy was still profitable over a three year period and it was possible to reject the hypothesis that the sum of profits was zero. Furthermore, the currency portfolio was found to have an extremely low market risk. Combinations of the speculative currency portfolio with traditional portfolios of U.S. equities resulted in considerable improvements in risk-adjusted returns on capital.

John F. O. Bilson and David A. Hsieh
University of Chicago
Graduate School of Business
1101 East 58th Street
Chicago, Illinois 60637
(312) 962-7128 and (312) 962-7418

THE PROFITABILITY OF CURRENCY SPECULATION*

INTRODUCTION

In an earlier study, Bilson (1981), a strategy for speculating in the foreign-exchange forward market was described. The strategy involved using econometric techniques to evaluate the forecasting efficiency of forward exchange rates, and financial techniques to estimate mean-variance optimal portfolios of forward contracts. The econometric analysis suggested that a composite forecast which included both the spot rate and the forward rate provided a statistically superior forecast of the future spot rate than did the forward rate by itself. In addition, it was not possible to reject the hypothesis that the weight given to the forward rate in a composite forecast should be zero, a result which implies that the spot exchange-rate evolves as a random walk. Since the difference between the forward rate and the spot rate at any point in time is directly related to the difference in nominal interest rates, the econometric analysis suggested a speculative strategy which involved borrowing in low-interest-rate currencies and lending in high-interest-rate currencies. Since movements in foreign-exchange rates are correlated, the mean variance portfolio technique was employed to determine the optimal positions in the set of nine currencies considered. The results demonstrated that a speculator who had employed the model would have realized an extremely high ratio of profit to risk.

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These results have recently been confirmed by a number of other studies. Hodrick and Srivastava (1983) consider an extended model in which the composite forecast includes the premiums or discounts on all of the currencies in the sample. Their estimates of the profitability of speculative trading in foreign currencies are slightly less favorable than those reported in the earlier paper, but they are nevertheless large and statistically significant. Fama (1983) and Korajcyzk (1983) also find that spot rates out-perform forward rates as forecasts of future spot rates. Furthermore, studies by Bilson (1983), Levich (1981), and Meese and Rogoff (1982) demonstrate that the spot rate forecasts are generally superior to forecasts generated by standard academic exchange rate models and by commercial foreign exchange forecasting serices. The consensus appears to be that exchange rates evolve as a random walk, and that nominal interest rate differentials do not reflect market expectations of changes in the exchange rate.

The apparent profitability of currency speculation may be interpreted in a number of ways. First, it could be the case that the results are specific to the particular sample and that the apparent profits would fail to be realized in post-sample speculations. Second, it could be the case that the actual risk of the activity has been understated, either because of the failure of a low probability outcome to occur in the sample, or because the measure of risk employed (the standard deviation of the profit on the portfolio) is not an accurate estimate of the 'market' risk of the activity. Finally, it could be the case that the market is 'inefficient.' Taken at face value, the results suggest a world in which interest rates are basically determined by domestic conditions, including the expected rate of inflation of domestic commodity prices and domestic monetary policies, and in which there is 'insufficient' uncovered interest arbitrage (McKinnon [1979], chapter 7). If it is true that

$$S(n,t+1) = \beta\, S(n,t) + (1-\beta)\, F(n,t) + u(n,t) \tag{1}$$

Notation: $S(n,t)$ = spot rate for currency 'n' at time 't'

$F(n,t)$ = forward rate for currency 'n' at time 't'

$u(n,t)$ = forecast error for currency 'n' at time 't'.

If the forward-parity model is correct, the regression coefficient 'β' should not be significantly different from zero. On the other hand, if the random walk model is correct, the estimate of 'β' should not be significantly different from unity. The purpose of the econometric analysis is to determine an appropriate estimate of the weights in the composite forecast. In addition, an estimate of the covariance matrix of the forecast errors is also required.

There are a number of issues that must be addressed in the estimation of the regression coefficients. First, in order to control for heteroscedasticity, we assume that the variance of the residuals is proportional to the square of the spot exchange rate. Hence we adjust the equation by dividing through by the spot exchange rate. Second, we take account of the correlation in the forecast errors through the use of the seemingly unrelated regression procedure developed by Zellner [1962]. Third, we take account of the colinearity between the spot and forward rates by imposing the constraint that the weights in the composite forecast sum to unity.

Other aspects of the estimation procedure have been dictated by the nature of the data. Since the variance of the residuals is large relative to the sample variation in the exogenous variables, it is extremely difficult to obtain precise estimates of the weights in the composite forecast. We increase the signal to noise ratio by imposing the constraint that the weights in the composite forecast are the same for all currencies. By combining low-interest-rate currencies like the Swiss franc with high-interest-rate currencies like exchange rates evolve as a random walk, then nominal interest rates on assets denominated in different currencies should be approximately the same. In a world in which speculators used the random walk model, it is more likely that both exchange rates and interest rates would be more stable (Bilson [1982]).

Our purpose in this paper is to investigate the above-mentioned issues. We consider the problem of sample specificity by examining the post-sample performance of the earlier model over a three-year period. We address one of the sources of excessive profitability by allowing for transactions costs in both the estimation of the optimal portfolios and in the statistical evaluation of the strategy. Finally, we examine both the absolute risk and the market risk of the strategy by examining the correlation between the return on the currency portfolio and the return on the S&P 500 index. Furthermore, we introduce an extended mean-variance portfolio algorithm that allows for the endogenous determination of the leverage on the portfolio.

I. ECONOMETRICS

Our forecasting equation may be considered as a synthesis of two popular characterizations of asset price-movements. The first is the forward parity model in which the best forecast of the spot price in any future period is the forward rate for that maturity. The second is the random walk model in which the best forecast of the spot price in any future period is the current spot price. In this study, we shall be concerned with forecasting spot exchange rates over a four week horizon. In order to do so, we create a composite forecast from the spot rate and the one-month forward rate.[1]

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[1]The use of a one month forward rate with a four-week horizon was dictated by our data source. Similar results have been obtained with other data. See, for example, Korajczyk [1983]; Hansen and Srivastava [1983].

the Italian lira, we increase the sample variation in the right hand-side variables and lower the variance of the estimated coefficient. Finally, we take account of the fact that extremely large values of the right hand-side variable occur on occasion. In the original sample of 666 observations (9 currencies by 74 time periods), there were 55 instances, or approximately 8 percent of the sample, in which the value of the regressor exceeded 10 percent per annum in absolute value. In order to avoid having the results biased by these extreme values, we allow for separate weights for values that exceed 10 percent in absolute value.

The data for the original study consisted of observations taken on the Friday of every fourth week on the spot rate and the one month forward rate. The data covered nine currencies--Canadian dollar, British pound, Belgian franc, French franc, Deutsche mark, Italian lira, Dutch guilder, Swiss franc, and Japanese yen--over the period from July 1974 to January 1980. Further details may be found in Bilson [1981]. For present purposes, all that we require are the final results.

$$\frac{S(n,t+1) - F(n,t)}{S(n,t)} = \underset{(0.150)}{0.741} \frac{[S(n,t) - F(n,t)]^S}{S(n,t)} + \underset{(0.120)}{1.280} \frac{[S(n,t) - F(n,t)]^L}{S(n,t)} \tag{2}$$

In this equation, the superscript 'S' refers to the values of $(S-F)/S$ that are less than 10 percent in absolute value while the superscript 'L' refers to values than exceed 10 percent.

These results offer strong support to the random-walk model of exchange-rate movements. For small values of the forward premium or discount, the optimal forecast of the future spot rate assigns 74 percent of the weight in the composite to the spot rate. The 26 percent weight assigned to the forward rate is not significantly different from zero at the 5 percent significance level. The results are even more extreme for the large values, where the weight on the forward rate is negative. For both large and small values, the forward-parity model is decisively rejected: the weight given to the forward rate in the composite forecast is significantly less than unity in both cases.

As was mentioned above, these results are not new. They were initially distributed as an NBER Working Paper in April 1980, and subsequently published in the Journal of Business in 1981. They consequently offer an opportunity for examining the post-sample performance of the forecasting equation. For our post-sample simulation, we update the estimates of the equation in each period using the Kalman filter technique.[2] The estimated values of the two coefficients are given in Appendix A. These coefficients appear to be quite stable. The end of sample estimates (.8892, 1.1707) are not greatly different from the original estimates. We also update the covariance matrix of the forecast errors. In each period, we compute a covariance matrix using the past 16 forecast errors. This adjustment is important since changing monetary arrangements, including the "snake," the "tunnel," and the European Monetary System, have a definite influence on the covariation between exchange rates. While the 16-period moving window is an extremely simple way of accounting for these changes, it is certainly superior to the alternative of no adjustment at all.

As a consequence of the updating procedure, we have an estimate of the bias in the forward rate in each period and an estimate of the covariance matrix of the forecast errors. We stress again that all of the information

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[2]In the Kalman filter program, we do not discount past observations. Hence the results are identical to a moving regression in which one observation is added each period.

required to form these estimates was available at the time, and that the techniques for constructing the estimates are standard. Using the information from the econometric analysis, we shall describe the techniques required to estimate the optimal mean variance portfolio in the next section. We shall subsequently examine the performance of the portfolios over the three year post-sample period.

II. THE SPECULATIVE STRATEGY

The econometric analysis yields forecasts of the spot exchange rate for four weeks hence for each of the nine currencies and of the covariance matrix of the forecast errors. In this section, we describe a technique which uses this information as an input and creates a vector of positions (long or short) in each currency. In our context, a position is a forward contract to buy or sell the currency. The speculator offsets the forward contract at its maturity by buying or selling an offsetting amount of currency in the spot market. Hence the gross profit on the transaction is equal to the difference between the forward rate at t, $F(n, t)$, and the subsequent spot rate, $S(n, t + 1)$, multiplied by the quantity of foreign currency purchased or sold. For ease of interpretation, we value all of the forward positions in U. S. dollars at the current spot rate, $S(n, t)$. Hence

$$\text{(3)} \qquad \text{Gross Profits} = \Big[\big(S(n, t + 1) - F(n,t)\big)/S(n,t)\Big] \; S(n,t)Q(n,t)$$

where $Q(n,t)$ represents the amount of foreign currency purchased or sold in the forward market. We simplify our notation by writing this definition as

$$\text{(4)} \qquad \text{Gross Profits} = r(n,t)q(n,t)$$

where $r(n,t) = \left(S(n, t+1) - F(n,t)\right)/S(n,t)$ and $q(n,t) = S(n,t)Q(n,t)$. The quantity, $q(n,t)$, represents the dollar value of the position and $r(n,t)$ represents the profit per dollar of position. It is also the endogenous variable in the econometric forecasting equation.

One important feature of the speculative model is that it takes account of transactions costs in assessing the optimal positions. The transactions costs are assumed to be 0.1 percent for the major currencies (CD, BP, DM, SF, DG, JY) and 0.2 percent for the less-traded currencies (BF, FF, IL). Thus we assume that it costs US$1000 to purchase one million dollars worth of British pounds, and US$2000 to purchase one million dollars worth of Italian lira. Allowance for transactions costs is of particular importance during periods in which two or more currencies are highly correlated because of monetary arrangements. Under these conditions, small differences in the premium or discount against the dollar would lead to extremely large spread positions if transactions costs were not accounted for.

The speculator is assumed to choose a vector of positions in order to maximize a utility function defined over expected profits, $E(\pi)$, and the variance of profits, $V(\pi)$. The specific utility function is defined in equation (5).

$$U\left[E(\pi), \quad V(\pi)\right] = E(\pi) - \left(\frac{1}{2\lambda}\right)V(\pi) \tag{5}$$

The 'λ' parameter represents the speculator's degree of risk aversion. The 'λ' may be interpreted in the following way. If the speculator is offered the opportunity to multiply the outcome of a drawing from a normal distribution with a mean and standard deviation of unity by a certain number of dollars, and if the speculator receives the product if positive or pays if the product is negative, then 'λ' represents the number of dollars by which that outcome will be multiplied.[3] In the following simulations, we assume a value for 'λ' of \$100. This assumption is inconseqential, since the positions and profits are all proportional to this parameter. The rate of return, and the ratio of profit to risk (standard deviation), are independent of the assumed degree of risk aversity.

The expected net dollar profit on the portfolio is defined as

$$E(\pi) = q'r - |q|'c \quad , \tag{6}$$

where 'q' is an $N \times 1$ vector whose typical value is the dollar value of the position taken in the n^{th} currency. The typical element of the $N \times 1$ vector 'r' is the expected bias in the forward rate, expressed as a fraction of the current spot rate, $r(n, t)$. The second term in equation (6), $|q|'c$, represents the allowance for transactions costs. The costs are assumed to be the product of the absolute value of the position and the transactions cost per dollar purchased or sold, 'c'.

The variance of profits is defined is equation (7)

$$V(\pi) = q'\Omega q \tag{7}$$

Ω represents the $N \times N$ covariance matrix of the forecast errors.

Substituting the definitions of expected profit and the variance of profit into the utility function allows for the level of utility to be expressed as a function of the vector of control variables, q. It is, however, difficult to maximize the function directly with respect to these variables because of the

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[3]Define k as a scale parameter. Then $U(\cdot,\cdot) = kE(\pi) - (\frac{1}{2\lambda})k^2V(\pi)$. Maximizing the function with k as the choice variable yields $k = \lambda E(\pi) \div V(\pi)$. For a N(1,1) distribution, $kE(\pi) = \lambda$. Hence λ equals the expected level of profits when the distribution is N(1,1). More generally, $kE(\pi) = s^2\lambda$, where $s = E(\pi)/\sqrt{V(\pi)}$. We refer to 's' as the safety ratio.

presence of the absolute value of q in the expression for the transactions costs. We circumvent this problem by approximating the transactions costs with a quadratic form, as described in equation (8).

(8)
$$|q|c' = (\frac{1}{2\lambda})q'Cq$$

C is a diagonal $N \times N$ matrix. The typical diagonal element of C is defined by

(9)
$$C(n, n) = (2\lambda c)/|q(n)|$$

Substituting (6), (7), and (8) into the objective function yields:

(10)
$$U[E(\pi), V(\pi)] = q'r - (\frac{1}{2\lambda})q'[\Omega + C]q$$

This formulation demonstrates that the effect of the transactions costs is to add a positive diagonal terms to the covariance matrix. Since the transactions costs reduce the apparent correlation between the returns, allowing for transactions costs will reduce spread positions and bias the estimated optimal positions towards zero.

Differentiating $U(\cdot)$ with respect to the vector q and setting the resulting first order conditions equal to zero, yields the following solution for the optimal portfolio.

(11)
$$q^* = [\Omega + C]^{-1}\lambda r$$

The only difficulty with the estimation of the positions from this equation is that the transactions cost matrix C depends upon the value of the positions. We solve this problem iteratively. In the first iteration, the elements of C are set equal to zero. We then use (11) to estimate q^* and we then use q^* to estimate the elements of C. This process continues until the position estimates stabilize.

In Table 1, we illustrate the optimization procedures by providing a detailed description of a particular portfolio. This portfolio is not representative, since it has both the highest expected and highest actual profit, but it offers a clear demonstration of the speculative strategy. The position was taken on May 22, 1981, and realized on June 19, 1981. At that time, French and Italian interest rates were high relative to Swiss, German and Dutch interest rates. Hence the optimal portfolio basically consisted of long positions in French francs and Italian lira offset by an equally valued short position in the Dutch guilder. It is noticeable that the program avoided a short position in the Japanese yen despite the large (13.62 percent per annum) premium on this currency, and that the net dollar position was small. Because of the higher correlation between the seven European currencies than between the dollar, yen and the Europeans, most of the positions taken by the program consist of spreads between the European currencies. This fact will become more important when the market risk of the speculative strategy is evaluated.

The illustrative portfolio can also be used to demonstrate the concept of the return on the portfolio that we shall use. Since the forward market positions do not require the placement of capital, it is often said that the return on forward contracts is either plus or minus infinity. However, even when a large corporation obtains a foreign-exchange guideline from a bank, the bank will typically require some deposits with the bank in order to ensure delivery. In addition, the transactions costs may be considered as an initial investment. We assume a margin requirement of 10 percent of the absolute value of the position, and we define the capital investment as being equal to the margin plus the transactions cost. In calculating the return on the investment, we

Table 1: A SAMPLE CURRENCY PORTFOLIO

Position Taken May 22, 1981

Position Realized June 19, 1981

Currency	Position (U.S.$)	Forward Premium (05/22) (% pa)	Forward Price (05/22) (U.S.$/*)	Spot Price (06/19) (U.S.$/*)	Gain (U.S.$)
FF	107285	-16.10	.1762	.1748	-811
IL	41121	- 3.12	.8669E-03	.8400E-03	-1296
SF	10877	10.53	.4874	.4814	-135
DM	- -5	6.91	.4330	.4188	0
JY	- 2352	13.62	.4529E-02	.4470E-02	33
BP	- 9652	8.25	2.0777	1.9642	531
BF	- 12948	2.54	.0265	.0256	434
DG	-141220	8.99	.3900	.3766	4876
NET	- 6894				3664
CD	25409	0.80	.8325	.8290	- 107
Net (U.S.$)	- 18515				3557

Summary:

	Trading Profits	$3557
	Transactions Costs	512
	Net Trading Profit	3045
	Margin ($35087)	
	T-Bill Rate (16.6 percent)	
	Interest on Margin	$ 485
	Total Profit	$ 3530
	Total Capital (Margin + Costs)	35599
	Return (% per month)	9.91

assume that the speculator earns the Treasury Bill rate on the margin. Hence the total profit is equal to the profit from the speculative activity plus the interest on the margin minus the transactions costs. Using this definition, our most successful portfolio earned a return of almost 10 percent over the four-week period.

In Table 2, summary statistics relating to the performance of the portfolio over the period from February 1980 to December 1982 are presented. The table offers an excellent example of the endogenous determination of the leveraging of the portfolio. The 'safety ratio,' defined as the ratio of expected profit to the expected standard deviation of profit, is the most important determinant of the degree of leveraging. The scale of the position in the market is proportional to the square of the safety ratio.[4] When the safety ratio is around unity, the expected gross profit is around $100; when the safety ratio is increases to around 5, the expected gross profit increases to around $2500. It is noticeable that a large part of the total actual profits were made in a few periods when the safety ratio was high.

The fact that the expected profits are proportional to the square of the safety ratio implies an important difference between the econometric and the financial analysis of speculative efficiency. In the econometric evaluation, concern is taken to ensure that the residuals in the regression are serially uncorrelated and homoscedastic. However, a speculator using the econometric results will weight the observations by the square of the safety ratio so that the unanticipated profit series will be strongly heteroscedastic. It is straightforward to demonstrate that the expected variance of profit is

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[4]See footnote 3.

Table 2: SUMMARY OF TRADING PERFORMANCE

Date	Expected Profit (U.S.$)	Actual Profit (U.S.$)	Safety Ratio	Transactions Costs (U.S.$)	Margin (U.S.$)
800201	66	173	.96	19	1195
800229	35	79	.76	13	850
800328	45	56	.78	11	1002
800425	76	14	.13	30	2103
800523	58	-25	1.06	28	1936
800620	62	12	.95	20	1337
800718	44	8	.82	15	989
800815	119	86	1.28	33	2206
800912	739	468	2.92	101	6605
801010	84	48	1.12	28	1899
801107	97	84	1.21	32	2228
801205	29	4	.67	10	743
810102	24	50	.61	8	606
810130	41	43	.78	13	947
810227	34	40	.72	11	792
810327	5	-42	.35	3	220
810424	6	10	.36	3	263
810522	19	73	.82	14	1014
810619	2411	3049	5.53	512	35087
810717	319	562	2.22	113	7845
810814	612	106	2.86	154	10948
810911	2374	1068	5.31	382	26340
811009	88	-476	1.20	34	2615
811106	51	-4	.91	19	1301
811204	15	-18	.52	6	554
811231	37	58	.81	16	1195
820129	26	41	.67	11	814
820226	18	12	.57	8	589
820326	19	20	.56	7	561
820423	350	322	2.03	54	3629
820521	48	99	.84	15	1068
820618	147	-400	1.35	28	1917
820716	11	19	.48	5	421
820812	29	92	.66	9	710
820910	19	21	.54	7	506
821008	27	17	.67	10	697
821105	13	-1	.50	6	412
821203	160	-243	1.49	45	2901
821231	89	107	1.10	24	1613
	8446	5632			

Notes: Date: year.month.day
Expected Profit: net of transactions costs
Actual Profit: net of transactions costs
Safety Ratio: Expected Profit/Expected Standard Deviation of Profit
Transactions Costs: 0.1 percent for CD, DM, BP, SF, JY, and DG
0.2 percent for IL, BF, and FF.

proportional to the expected profit, with the proportionality factor being equal to the risk aversion parameter λ .

$$V(\pi) = \lambda E(\pi) \tag{12}$$

Since the validity of equation (12) is an important component of both the evaluation of the speculative strategy and the econometric tests used in the evaluation, we begin by examining this relationship in the post sample simulation.

In order to test equation (12), we posit an extended model of the variance of profits which includes both the level and the square of expected profits. In the absence of other information, it appears reasonable to assume that the variance of profit would be proportional to the square of expected profits rather than the level. Hence this model constitutes a natural alternative to the relationship predicted by the speculative strategy. The alternative is tested against the maintained model by regressing the square of the error in forecasting profit, minus the value predicted by the maintained model, on the additional variables. The results of the estimation are presented below.

$$u_t^2 - \lambda E(\pi)_t = \underset{(35263)}{9580} + \underset{(241.02)}{96.37E(\pi)} + \underset{(.1012)}{.0979E(\pi)_t^2} + v_t \tag{13}$$

$$R^2 = 0.49 \quad F(2,36) = 19.38 \quad D.W = 1.44$$

Although the individual parameters in equation (13) are not stastistically significant, the F-statistic demonstrates that it is possible to reject the hypothesis that all of the coefficients are zero. Furthermore, since all of the parameters are positive, the variance predicted by the alternative model is greater than the variance predicted by the maintained model.

The underestimation of the variance of profits is quite significant. In order to illustrate the dimensions of the problem, we provide standard summary statistics for the standard deviations forecasted by the maintained and alternative models.

	Standard Deviation	
	Maintained	Alternative
Mean	104	207
Standard Deviation	106	206
Minimum	23	491
Maximum	491	1026

On average, the alternative estimate is twice that predicted by the maintained model. The extent of the downward bias appears to be greatest for the small values.

The underestimation of the risk of the speculative strategy has two major consequences for the evaluation. First, if the speculator had known the true risk of the strategy, the scale of the position would have been reduced. Using the maintained estimates, expected gross profits summed to $8,446 over the sample period. If the positions were re-estimated with the alternative risk estimates, expected profits would have summed to $2308.[5] Hence the major part of the profit realized from the positions taken was due to the fact that the

[5]In footnote 3, it was demonstrated that $kE(\pi) = S^2\lambda$. Since $S^2 = E(\pi)^2/V(\pi)$, the effect of the underestimation of the variance can be described by the relationship $kE(\pi) = S^2\frac{VE(\pi)}{VA(\pi)}\lambda$, where $VE(\pi)$ represents the maintained estimate of the variance and $VA(\pi)$ the alternative estimate. The average value of $VA(\pi)/VA(\pi)$ is approximately .5, hence the underestimation of risk caused the average scale of the position to be twice as large as the speculator would have taken with full information.

speculator underestimated the true risk of the strategy. Second, the underestimation of the risk implies that the maintained estimates should not be used in tests of the hypothesis that the actual profits realized are either significantly different from zero or from the expected value. In correcting for the heteroscedasticity in the profit series, we shall use the alternative estimates of the variances.

The first test of this type relates to the ability of the model to forecast situations in which currency speculation is profitable. We examine this issue by testing whether expected profits provide unbiased forecasts of actual profits. Our results are based on the estimates of the following regression equation.

$$A(\pi)_t = \underset{(20.9895)}{-7.4818} + \underset{(0.1910)}{0.6304}E(\pi)_{t-1} + u_t \tag{14}$$

$$R^2 = 0.21 \quad S.E. = 118.1 \quad F(1,37) = 10.89 \quad D.W. = 1.73$$

$A(\pi)_t =$ actual profits in period t; $E(\pi)_t$ = expected profits in period t - 1. Standard errors are presented in brackets beneath the coefficients. This equation was estimated using weighted least squares. The weights were the reciprocals of the alternative estimates of the standard deviations. We observe first that the coefficient on expected profits is significantly greater than zero at standard significance levels. The t-statistic for testing if the slope coefficient is unity is 1.935. With 37 degrees of freedom, we are unable to reject the hypothesis that the true slope coefficient is unity at the five percent level, but we are able to reject at the ten percent level. Furthermore, the constant term in the regression is negative. These considerations lead to the presumption that the model is tending to overestimate the profits from the trading strategy. If we use an F-test to test the joint hypothesis that the constant term is zero and the slope coefficient is unity, the value of the statistic turns out to be 3.74. The value is below the five percent critical value of the F-distribution with 1 and 37 degrees of freedom. We are consequently unable to reject the hypothesis that the model is providing unbiased forecasts of actual profits. It is, however, true that the most likely direction of bias is towards overly optimistic estimates of expected profits.

It was mentioned above that, had the speculator known of the overestimation of the variance, he or she would have reduced the total expected gross profits from $8,446 to $2,308, by reducing the scale of the position. The knowledge that the model tended to overestimate the expected profits would also induce a contraction in the scale of the position. Combining both the adjustment to the variance and the adjustment to expected profit, the total expected gross profit would have been reduced to $841.[6] The same point can be made from the point of view of the certainty equivalence value of the strategy. With the utility function that we have posited, the certainty equivalence value of the strategy is equal to one-half of the expected profit.[7] That is, given the degree of risk aversion, the speculator would be willing to pay up to one-half of the expected profit in order to partake in the speculative strategy. Given the maintained estimates of expected profit and the variance of profit, our speculator would be willing to pay up to $4223 to own the strategy. With the actual estimates, the maximum payment would be reduced to $420, and the scale of the position would have been reduced in proportion to the reduction in

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[6] Again, $kE(\pi) = S^2\left(\frac{EA(\pi)}{EM(\pi)}\right)^2\lambda$ where $EA(\pi)$ is the alternative estimate of profit and $EM(\pi)$ is the maintained estimate. Since the alternative estimate is always below the maintained estimate, the speculator would have reduced the scale of the position. Combining the two corrections, we have

$$kE(\pi) = S^2\left(\frac{EA(\pi)}{EM(\pi)}\right) \cdot \frac{VM(\pi)}{VA(\pi)}\lambda \ .$$

[7] $U(\pi) = E(\pi) - \left(\frac{1}{2\lambda}\right)V(\pi)$, and $V(\pi) = \lambda E(\pi)$, hence $U(\pi) = \frac{1}{2}E(\pi)$.

expected profits. In this sense, the post-sample performance of the strategy is disappointing.

While the profits from the strategy were less than predicted, and while the risk was greater than predicted, it is still the case that the strategy was profitable on average. Losses were realized on only eight of the 39 portfolios, and the largest loss, \$476, was considerably smaller than the largest gain of \$3049. We now examine the hypothesis that the sum of the actual profits is zero. In testing this hypothesis, the variance of the sum is assumed to be the sum of the variances predicted by the regression model presented in equation (13). Since these estimates are typically larger than the maintained estimates, their use lessens the probability of rejecting the null hypothesis. We test the hypothesis by computing the statistic

$$Z = \sum_{t=1}^{T} \pi_t \Big/ \sqrt{\sum_{t=1}^{T} \sigma_t^2} \tag{15}$$

Under the assumption that the true residuals are normally and independently distributed, this statistic follows a t-distribution with 38 degrees of freedom. The computed value of the test statistic is 3.298. This value exceeds the one percent critical value of the t-distribution with 38 degrees of freedom. We consequently reject the hypothesis that the true sum of profits is zero. This test is probably the most important test for purposes of testing the efficiency of the forward exchange market. In addition, we may wish to test if the sum of realized profits is significantly different from the sum predicted by the model. The test statistic for this hypothesis is -1.64. This statistic lies within the critical values of the t-distribution at the ten percent significance level. We are consequently unable to reject the hypothesis that the difference between actual and expected profits is due to sampling variation.

It is interesting to compare this test with the test used in Bilson [1981] and Hodrick and Srivastava [1983]. In their tests, the individual values of actual and expected profits are divided by the predicted standard deviation in order to create a series of standardized actual and expected profit. They then test if the mean of the distribution of actual standardized profits is significantly different from either zero or the average standardized expected profit. The average standardized actual profit is .2732, and the standard deviation of the average is .1622. The test statistic is computed to be 1.6841. Under the null hypothesis that the true average standardized profit is zero, this statistic falls within the acceptance region of the t-distribution with 38 degrees of freedom. We are consequently unable to reject the null hypothesis. We are also unable to reject the hypothesis that the true mean of the distribution is equal to the average standardized expected profit.

The difference between the two tests again relates to the timing element in the speculative strategy. The speculator is not as concerned with the average value of the standardized profit variable as with the ability of the standardized expected profit to predict the standardized actual profit. By scaling up the portfolio when the expected profit is high, the speculator changes the distribution of the outcomes. In the case that we have considered, most of the profits were made in two of the 38 periods. This is the reason why the total profits are significantly different from zero while the average standardized profits are not.[8]

In this section we have considered the speculative strategy as an isolated activity. We found that while the strategy did not perform as well as it was expected to do, the actual profits were still significantly different from zero. The main defect with the evaluation of the strategy as an isolated activity is that the risk is measured by the variance of profits. When considered as a part of a wider portfolio, the risk should be measured in terms of the contribution of the activity to the risk of the portfolio.

IV. THE MARKET RISK OF THE SPECULATIVE STRATEGY

In the previous section, the speculative strategy was evaluated as an isolated investment activity. In this section, we re-evaluate the strategy from the perspective of an investor whose wealth is initially held in a diversified equity portfolio. We represent the return on this portfolio by the capital appreciation of the S&P 500 index. While the index does not include dividends, the return on this portfolio should be representative of the risk/return tradeoff from conventional U.S. equity portfolios. We shall also assume that the expected capital appreciation of the S&P is equal to the Treasury risk-free return Bill rate. Over the period from 1970 to 1981, Ibbotson and Sinquefield (1982) report that the average capital appreciation of the S & P 500 index was 7.87 percent per annum. Over the same period, the average yield on U. S.

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[8]The statistic reported in equation (15) can be written as

$$Z = \frac{1}{N} \sum_t (\pi_t/\sigma_t)k_t$$

where N represents the degrees of freedom. The test used by Bilson and Hodrick and Srivastava sets k_t equal to unity. The test described in equation (15) sets k_t equal to $N\sigma_t/\sqrt{\Sigma\sigma_t^2}$. This weighting obviously gives a larger influence to observation with larger positions.

Treasury Bills was 7.43 percent. The main question that we will investigate is the following: given the opportunity to divide a fixed initial stock of capital between the S&P and the currency portfolio, what would be the optimal allocation between the two instruments? Furthermore, what is the effect on the risk and the return of the composite portfolio from the allocation of a part of the initial capital to currency speculation?

Since we are dealing with the allocation of capital between two investment activities, we begin by restating the role of capital investment in the currency portfolio. In order to implement the speculative strategy, the investor requires capital in order to cover margin requirements and transactions costs. Although forward contracts do not typically require explicit margins, a bank may require that the investor maintain a security deposit in order to ensure against default. We assume that the deposit amount to 10 percent of the absolute value of the position taken and that the interest earned on the deposit is equal to the Treasury Bill rate. Both of these assumptions are conservative. The largest loss incurred in the simulation was less than 2 percent of the absolute value of the position, and margins on foreign exchange futures are typically around 5 percent of the value of the position. Furthermore, the deposit would typically be held in the form of a certificate of deposit. The yield on a certificate of deposit typically exceeds the yield on U.S. Treasury Bills. We define the investment as the margin plus the transactions cost, and the revenue as the profit from the speculative activity, plus the interest on the margin, minus the transactions costs.

For an investor whose initial wealth is solely in equities, the derivative of the variance of end-of-period wealth with respect to a marginal allocation of wealth to the currency portfolio is determined by the 'beta' of the currency portfolio. Following standard practice, we first estimate the 'beta' by regressing the returns from the currency portfolio on the return on the S&P 500. After presenting these results, we shall discuss some problems that arise with this approach in the present instance and present some alternative formulations.

Estimation of the traditional market model led to the following results.

$$\text{(16)} \qquad RC - TBR = \underset{(.0122)}{.0235} + \underset{(.2350)}{.0390}\,[RP - TBR] + u$$

$$R^2 = .0007 \qquad S.E. = .0765 \qquad D.W. = 1.944$$

In equation (16), RC = the return on the currency portfolio, TBR = the Treasury Bill rate, RP = the return on the S&P 500, and u = the residual. Standard errors are presented in parentheses beneath the coefficient estimates. In interpreting these results, the first important point is that the slope coefficient, which measures the market risk of the currency level of market risk is small and not significantly different from zero. The low level of market risk is also evidenced by the low value of the R^2 statistic. In fact, the adjusted R^2 for the regression reported in equation (16) is negative. The low market risk of the currency portfolio is not surprising, since the most common activity consists of spreads between the European currencies. The second important point is the size and significance of the constant term. In annual percentage terms, the constant term implies a return of 28.2 percent per annum above the Treasury Bill rate. The estimate is 1.9 standard deviations from zero. While this value is not large enough to pass conventional statistical tests, the probability that the true constant term is zero is less than ten percent. The initial impression, then, is that the currency portfolio offers a substantial rate of return and an extremely low level of market risk.

There are, however, a number of problems with the regression reported in equation (16). The first is that the residuals in the regression are likely to be heteroscedastic. We have already seen that the series of speculative profits are very heteroscedastic because of the leveraging of the portfolio. While some of this heteroscedasticity may be eliminated by dividing the profits by the investment, there is no necessary connection between the size of the investment and the variance of profits. For example, if two currencies are highly correlated, a spread position may imply a large margin, and hence a large investment, but little risk. In order to account for this problem, we reestimate the market model by weighted least squares. The weights are equal to the ratio of the investment to the standard deviation of profits, and the standard deviations are computed from the alternative model of the variance of profits introduced in the previous section. The revised estimates are presented in equation (17).

$$\text{(17)} \qquad RC - TBR = \underset{(.01175)}{.03358} + \underset{(.26294)}{.08428}[RP - TBR] + u$$

While the estimate of the market risk is still small and insignificant, the new estimates result in an increase in the size and significance of the constant term. The risk-adjusted return is now over 3 percent per month, or 40 percent per annum, over the risk free rate, and it is possible to reject the hypothesis that this coefficient is zero using standard significance tests.

The second problem with the traditional market model analysis is that the expected rate of return is assumed to be constant throughout the sample period. The econometric analysis demonstrated that the risk and return on the currency portfolio is not constant, and it would be useful to take this finding into account in the assessment of the market risk of the activity. We do this by introducing the difference between the expected rate of return on the currency portfolio and the risk free rate as an additional right hand side variable.[9] In this formulation, the risk adjusted return is allowed to vary throughout the sample period. As in the previous estimation, weighted least squares is employed to account for the heteroscedasticity in the residuals. The results are reported in equation (18).

$$(18)\qquad RC - TBR = \underset{(.03285)}{-.03273} + \underset{(.5568)}{1.1957}[RE - TBR] + \underset{(.27036)}{.300187}[RP - TBR] + u$$

In this equation, RE = the expected return on the currency portfolio. This series is created using the same procedures as were used to compute the actual return. From this regression, we observe that the coefficient on the expected return is significantly different from zero, but not significantly different from unity. We consequently cannot reject the hypothesis that the model is providing unbiased forecasts of actual returns. When the expected returns are included in the regression, the estimate of the market risk of the activity is increased, but it is still small and not significantly different from zero.

These results suggest that the currency portfolio would be a valuable addition to a U.S. equity portfolio since the risk adjusted return is large and statistically significant and since the incremental risk of the activity appears to be small. We shall now explore this conjecture in greater detail by simulating the performance of a combined equity/currency portfolio. This simulation is subject to the following limitations. First, we do not allow the composition of the currency portfolio to be influenced by the fact that it will be combined with equities. In other words, our investor is envisaged to face the decision of dividing beginning of period wealth between an equities fund

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[9]Since we assume that the expected capital appreciation on the equity portfolio is equal to the Treasury Bill rate, there is no need for an additional term representing the difference between the expected equity return and the risk free rate.

and a currency fund. The fund managers do not take account of the activities of other funds in selecting their own positions. Second, the investor assumed that the returns on the two funds are uncorrelated. This assumption can be relaxed, but it is roughly consistent with the evidence, and it avoids problems associated with the use of ex post information. Although we shall use the sample data to estimate the variance of equity returns, all other information, including the expected return and the expected variance of the currency portfolio, were available at the time that the investment decisions would have been made. As was mentioned above, we approximate the expected capital appreciation on the S&P portfolio by the Treasury Bill rate.

We describe the investor's optimization process in the following terms. At the beginning of each period, the investor divides his capital between the two funds. At the end of the period, the returns are realized and the new stock of capital is re-allocated. The information set available to the investor includes the expected return and the variance of the return on the mean/variance utility function specified in (19).

$$U[E(R),\ V(R)] = E(R) - \big(1/(2\lambda)\big)V(R) \tag{19}$$

Since we are now dealing with the allocation of capital between two portfolios, this utility function is specified to be a function of the expected rate of return, $E(R)$, and the expected variance, $V(R)$, of the composite portfolio. The risk aversion parameter, λ, is set equal to .04 per month. This estimate is broadly consistent with the evidence on risk aversion by Friend and Blume [1975].[10]

The expected return and expected variance are defined in equations (20) and (21).

(20) $$E(R) = wE(R1) + (1 - w)E(R2)$$

(21) $$V(R) = w^2V(R1) + (1 - w)^2V(R2)$$

In these equations, R1 represents the return on the equity portfolio and R2 represents the return on the currency portfolio. The investor sets the share of equities in the portfolio, w, at the value that maximized expected utility. In equation (21), the covariance between the returns is assumed to be zero. The optimal value of the portfolio share is defined in equation (22).

(22) $$w = V(R2)/\big(V(R1) + V(R2)\big) + \lambda\big(E(R1) - E(R2)\big)/\big(V(R1) + V(R2)\big)$$

The first term in this equation is the minimum variance allocation between the two portfolios. The second term causes the actual share to deviate from the minimum variance value as the expected returns on the two portfolios diverge.

As in the previous simulation, we have attempted to restrict the information set available to the investor to information that was available at the time that the decision would have been made. In particular, the expected returns and the variance of the return on the currency portfolio are the prior values from the simulation analysis. We have already demonstrated that these

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[10] Friend and Blume use IRS data on asset holdings and conclude that the behavior of investors can be described by the utility function $U(W) = -W^{-1}$, where W represents wealth. Brown [1976] demonstrates that this function can be approximated by a negative exponential utility function, $U(R) = -\exp(-R/\lambda)$, with $\lambda = .0416$. Maximizing the utility function specified in equation (19) is equivalent to maximizing a negative exponential utility function. See Jorian [1983].

values tend to be overly optimistic relative to the ex post outcomes, and that this excessive optimism will lead to an underestimate of the weight of equities in the portfolio. On the other hand, it turns out that the Treasury Bill rate overestimated the capital appreciation on the S&P index during this sample period, so that the net bias is uncertain. The only ex post information that is used in the simulation is the estimate of the variance of the equity returns.

The results from the simulation are presented in Table 3. Over the sample period, the investor allocated between 100 percent to 22 percent of capital to the currency portfolio. On an annualized basis, the combined portfolio achieved an actual rate of return of 31.37 percent per annum. In comparison, the S&P portfolio achieved an annualized return of 8.73 percent and the currency portfolio achieved an annualized return of 47.67 percent. Furthermore, the standard deviation of the combined portfolio was not much greater than the standard deviation of the S&P return. Finally, we calculate the level of utility for the three portfolios.[11] All three turn out to be negative. In fact, our investor would prefer a certain loss of some six percent per month to an investment in the currency portfolio. For the combined portfolio, the certainly equivalent value of the strategy was minus 1.6 percent per month. These statistics need to be interpreted carefully. They are saying that if the investor had a chance to participate in an investment offering an expected return of 3.3 percent with a standard deviation of 7.6 percent, he or she would decide not to participate because of the high risk. These statistics represent the average return and the standard deviation of the return on the

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[11] The utility levels are calculated from $V(\cdot, \cdot) = A(\pi) - \left(\frac{1}{(2\lambda)}\right)V(\pi)$, where $A(\pi)$ is the ex post average actual return, and $V(\pi)$ is the ex post variance of the return.

Table 3: COMBINED EQUITY/CURRENCY PORTFOLIO

Date	S&P Actual Return	Currency Actual Return	Combined Actual Return	S&P Share
800201	.078	.153	.114	.52
800229	-.014	.103	.030	.62
800328	-.121	.067	-.033	.53
800425	.044	.017	.017	.36
800523	.051	-.007	.014	.36
800620	.031	.015	.022	.47
800718	.068	.015	.045	.57
800815	.030	.046	.041	.27
800912	-.001	.076	.076	.00
801010	.037	.034	.035	.34
801107	-.009	.048	.032	.28
801205	.037	.018	.030	.64
810102	.017	.093	.041	.69
810130	-.051	.057	-.005	.57
810227	.013	.061	.031	.63
810327	.025	-.177	.000	.88
810424	.004	.049	.011	.84
810522	-.029	.085	.012	.64
810619	.007	.098	.098	.00
810717	-.011	.082	.082	.00
810814	.013	.022	.022	.00
810911	-.086	.052	.052	.00
811009	-.001	-.169	-.132	.22
811106	.010	.007	.008	.48
811204	.029	-.024	.012	.69
811231	-.030	.057	.014	.50
820129	-.018	.060	.013	.61
820226	-.062	.030	-.034	.69
820326	-.010	.046	.006	.70
820423	.058	.097	.096	.03
820521	-.032	.101	.029	.54
820618	-.069	-.195	-.152	.34
820716	.035	.054	.039	.77
820812	-.067	.135	.004	.65
820910	.153	.048	.124	.72
821008	.080	.030	.064	.67
821105	.081	.004	.065	.79
821203	-.025	-.076	-.067	.18
821231	.014	.072	.049	.40
Mean	.007	.033	.023	.45
S.D.	.052	.076	.055	.27
Ratio	.140	.440	.420	1.66
Utility	-.038	-.062	-.016	

actual outcomes from the currency portfolio. These results do not imply, however, that the investor would never allocate capital to the currency portfolio because the expected ratio of return to risk is not constant.

We will illustrate this point by repeating the portfolio allocation decision for a choice between a risk free asset bearing the Treasury Bill rate and the currency portfolio. The simulation results are presented in Table 4. For most of the periods, the investor holds between 60 percent to 100 percent of capital in the form of Treasury Bills. However, there are five periods--associated with large differences in nominal interest rates--when 100 percent of capital is allocated to the currency portfolio and there are a number of other periods in which the currency share is substantial. These occasional allocations of capital to currency speculation substantially improved the return on the portfolio. On an annualized basis, the pure Treasury Bill portfolio had an average yield of 12.68 percent. The combined portfolio had an average yield of 25.35 percent per annum.

We conclude this section by examining the end of period wealth from the various strategies. We assume an initial capital of $1000 and allow for reinvestment of returns in each period.

	EOP Wealth	(% Increase)
Treasury Bills	$1466	46.6%
S&P 500	$1254	25.4%
Currencies	$3161	216.1%
Currencies and TB's	$2028	102.8%
Currencies and S&P	$2314	131.4%

These values demonstrate that the currency portfolio had the largest average rate of return over this sample period. An investor who had taken the positions suggested by the currency portfolio would have had an end-of-period wealth which would be more than twice that yielded by the traditional investment instruments. Furthermore, the low correlation between the currency portfolio returns and the return on U.S. equities implies that the addition of a currency portfolio to a U.S. equity portfolio will tend to diversify the risk of that portfolio. Over the sample period, an investor who had divided capital between the two portfolios in the way suggested by our analysis would have obtained a substantially higher average rate of return in exchange for a moderate increase in risk.

Table 4: COMBINED TREASURY BILL/CURRENCY PORTFOLIO

Date	T. Bill Actual Return	Currency Actual Return	Combined Actual Return	T.Bill Share
800201	.010	.153	.047	.74
800229	.012	.103	.026	.84
800328	.012	.067	.025	.78
800425	.010	.017	.017	.00
800523	.006	−007	.002	.70
800620	.006	.015	.008	.72
800718	.008	.015	.009	.80
800815	.007	.046	.026	.51
800912	.009	.076	.076	.00
801010	.010	.034	.019	.61
801107	.011	.048	.027	.55
801205	.013	.018	.014	.85
810102	.012	.093	.022	.88
810130	.012	.057	.021	.81
810227	.012	.061	.020	.84
810327	.011	−.177	.006	.97
810424	.011	.049	.013	.96
810522	.014	.085	.020	.91
810619	.013	.098	.098	.00
810717	.012	.082	.082	.00
810814	.013	.022	.022	.00
810911	.012	.052	.052	.00
811009	.010	−.169	−.077	.52
811106	.010	.007	.009	.76
811204	.008	−.024	.005	.91
811231	.009	.057	.019	.80
820129	.010	.060	.017	.86
820226	.010	.030	.012	.90
820326	.011	.046	.014	.90
820423	.010	.097	.092	.06
820521	.010	.101	.030	.78
820618	.010	−.195	−.086	.53
820716	.009	.054	.012	.94
820812	.008	.135	.026	.86
820910	.007	.048	.011	.90
821008	.006	.030	.009	.87
821105	.006	.004	.006	.93
821203	.007	−.076	−.046	.36
821231	.007	.072	.030	.64
Mean	.010	.033	.019	.64
S.D.	.002	.076	.035	.33
Ratio	4.420	.440	.540	1.93
Utility	.010	−.062	.004	

CONCLUSIONS

There are a number of conclusions that can be drawn from this study. First, there does appear to be a strong in-sample bias in tests of market efficiency in the foreign exchange market. In particular, we find that standard regression procedures tend to underestimate the variance and overestimate the mean of trading profits. As a consequence, speculators are likely to be disappointed if they follow the rules outlined in this and other papers on trading strategy.

On the other hand, the strategy was profitable despite the allowances made for transactions costs and margin requirements. Most of the profits were made in a small number of instances when interest rate differentials were large. Since these periods correspond to situations of unstable international monetary arrangements, the profits could be associated with central bank intervention (Taylor [1982]) or with a peso problem (Krasker [1980]) in which a small probability adverse outcome has not occured in the sample. It should be noticed, however, that the realization of the major part of profits in a small number of periods is a consequence of the trading strategy, rather than being a consequence of unanticipated outcomes.

In the final section of the paper, composite portfolios of equities and currencies, and equities and Treasury Bills, were considered. Although the share of currencies in the composite portfolio was typically small, it is probabily greater than existing investments by pension fund managers in forward contracts. Furthermore, there were a number of periods in which the allocation of capital to currency speculation was large, and these investments did substantially improve the risk/return characteristic of the portfolio. It is consequently unlikely that the failure of investment managers to engage in currency speculation is due to risk aversion.

Appendix A: Weights in Composite Forecast

DATE	Beta 1	Beta 2
800201	0.84	1.28
800229	0.91	1.28
800328	0.93	1.28
800425	0.98	1.26
800523	1.04	1.24
800620	1.01	1.24
800718	1.04	1.22
800815	1.03	1.21
800912	1.03	1.21
801010	1.02	1.20
801107	1.02	1.19
801205	1.01	1.19
810102	1.05	1.19
810130	1.01	1.19
810227	1.00	1.20
810327	0.97	1.23
810424	.96	1.21
810522	.93	1.22
810619	.92	1.21
810717	.95	1.22
810814	.98	1.24
810911	1.00	1.25
811009	.99	1.22
811106	.98	1.18
811204	.95	1.18
811231	.94	1.18
820129	.95	1.18
820226	.94	1.18
820326	.94	1.17
820423	.93	1.17
820521	.92	1.17
820618	.92	1.17
820716	.90	1.17
820812	.90	1.17
820910	.90	1.17
821008	.91	1.17
821105	.90	1.17
821203	.89	1.17
821231	.88	1.16

Appendix B: Summary of Positions Taken
(Values in U. S. Dollars)

DATE	CD	BP	BF	FF	DM	IL	DG	SF	JY
800201	-41	0	1	0	-5	7393	2	-4509	-4
800229	-12	0	0	0	-492	5335	0	-2461	-200
800328	-1171	945	170	880	0	716	1878	-4268	0
800425	-1	499	8067	0	-8736	1738	1	-1993	0
800523	58	259	9229	0	-1329	0	-5790	-2695	0
800620	-771	1	4	0	-3027	6770	0	-2256	509
800718	-0	0	1	0	2435	5209	-0	-1773	475
800815	-1475	0	0	0	-7055	11056	0	-1938	540
800912	-6056	-706	0	0	-27174	33348	-14	0	751
801010	-1908	0	0	0	-6452	9112	0	-1080	446
801107	-3731	3	0	0	-5961	10011	-0	-268	506
801205	-1090	550	1	0	0	2878	0	-224	32
810102	-14	-0	0	0	1	2787	-1873	-1369	-20
810130	-0	0	451	0	-1	3948	-3451	-1422	-206
810227	0	0	0	0	-9	3975	-1167	-2733	38
810327	0	0	0	0	2	1030	-317	-787	-65
810424	685	-0	0	0	0	830	-435	-508	-176
810522	1092	-36	2442	0	0	1721	-4853	-0	-2
810619	25409	-9653	-12949	107286	-5	41121	-141221	10877	-2352
810717	7351	-1519	0	16040	-6690	18719	-26770	0	-1363
810814	17107	0	141	17794	-2555	27392	-41021	-1339	-2136
810911	11273	-7808	36839	57439	-16397	24507	-90809	-14694	3635
811009	7199	-304	1	950	-4687	7503	-1825	-2050	-1637
811106	10	0	6246	0	-4325	0	-101	-921	-1407
811204	2144	297	0	0	-138	1094	0	-770	-1105
811231	2235	976	0	0	-309	4123	-2738	-29	-1540
820129	0	841	916	0	-1126	2369	-481	-708	-1701
820226	0	676	0	0	-42	2365	-1245	-277	-1293
820326	9	651	0	0	-212	2139	-391	-841	-1368
820423	-549	1310	-0	15043	0	2849	-13837	0	-2710
820521	8	1040	106	925	-15	3504	-1697	-1643	-1743
820618	0	544	0	9134	-367	3	-6362	-565	-2200
820716	359	115	41	4	-1091	1644	-5	-3	-948
820812	1487	210	0	0	0	2356	0	-1813	-1237
820910	1301	0	0	0	-5	1751	-0	-125	-773
821008	0	14	0	0	-1778	3767	-1	-531	-883
821105	0	35	0	0	-365	2191	-0	-883	-653
821203	0	2269	-288	-2029	-6291	13393	-1	-912	-3333
821231	-222	706	-81	0	-4164	8359	-502	-424	-1674

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