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Currency Hedging for International Portfolios

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ABSTRACT

This paper examines the benefits from currency hedging, both for speculative and risk minimization motives, in international bond and equity portfolios. The risk-return performances of globally diversified portfolios are compared with and without forward contracts. Over the period 1974 to 1990, inclusion of forward contracts results in statistically significant improvements in the performance of unconditional portfolios containing bonds. Conditional strategies are also implemented, both in sample and out of sample, and are shown to both significantly improve the risk-return tradeoff of global portfolios and to outperform unconditional hedging strategies.

WHETHER INTERNATIONAL PORTFOLIOS SHOULD be hedged against currency risks is the subject of an active debate. The theoretical side of the debate has been closely associated with two strands in the academic literature: international asset pricing and optimal hedging in the futures markets. In the international asset-pricing model (IAPM) of Solnik (1974), optimal portfolios contain positions in forward contracts, or equivalently foreign currency denominated bills. These positions, which can differ from the positions in foreign stocks, have since been termed "hedges." Black (1990) shows that, under additional assumptions, the hedge ratios should be identical for all investors regardless of their nationality (universality) and that investors should never fully hedge their foreign currency exposures. Similarly, theoretical models from the futures literature produce demands for hedging instruments that contain both speculative and hedging components. The empirical issue, unanswered so far, is whether adding forward contracts to international portfolios significantly improves the risk-return profile of global investments.

Empirical research has barely begun to respond to the challenges of theoretical models; there exists little empirical evidence on either the relevance of Black's universal hedge ratios, or the optimality of hedge ratios less than one. Instead, researchers have concentrated on the benefits of fully hedging exchange risk. For example, Eun and Resnick (1988) indicate that stock portfolios perform better when fully hedged, but offer no statistical tests

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to support their evidence.[1] More recently, Bekaert and Hodrick (1992) show that the addition of currencies improves the performance of stock portfolios; but again these authors do not offer tests of statistical significance, nor do they explore the relationship between the optimal hedge ratios and those predicted by theoretical models.

This paper considers both stocks and long-term bonds as risky assets; hedges are implemented using one-month forward contracts. We investigate the benefits from currency hedging from several perspectives, each successively more narrowly defined. First, we consider an unrestricted mean-variance optimization approach. This is in the spirit of the IAPM where hedging involves unconstrained positions where stocks, bonds, and forward positions are chosen simultaneously. We test whether adding currency hedges to the menu of assets improves the performance of diversified portfolios of stocks and bonds. We find that, over the sample period, hedging does significantly improve the performance of portfolios containing bonds.

Second, we investigate the use of forward contracts to "cross-hedge" a portfolio with predetermined positions, in this case a passive index invested in stocks and/or bonds. This corresponds to the optimal hedging approach from the futures market literature. These tests can also be viewed as tests of the mean-variance efficiency of a global index against the alternative that it should also contain bills in various currencies. Our tests do not reject the efficiency of the global index in this case, indicating either that cross-hedging is suboptimal, or that our efficiency tests have low power.

We also show that these approaches lead to portfolios that have extreme long and short positions which might not be implementable in practice. Moreover, such positions are at odds with views on hedging that consider leveraged positions in forward contracts as speculation. Therefore, we also investigate portfolios where no short sales are allowed for stocks and bonds, and where forward sales cannot exceed the amount of the underlying exposure. The tests show that constrained hedging still significantly improves portfolio performance.

Finally, evidence on the predictability of foreign exchange returns raises the issue of the optimality of unconditional hedging strategies. To address this issue, we simulate a conditional hedging strategy where the hedge positions depend on prior interest rate differentials. We find that this substantially improves portfolio performance. This raises further doubts about the importance of unitary and universal hedge ratios in particular, and in unconditional asset-pricing frameworks in general.

The paper is structured as follows. Section I reviews the frameworks employed in the paper and relates them to the theory of currency hedging. Optimal static hedging strategies are described in Section II, and statistical

[1] See for instance Jorion (1989) and Kaplanis and Schaefer (1991). Proponents of hedging argue that full currency hedging reduces the volatility of returns without a commensurate reduction in returns. This leads Pérold and Schulman (1988) to argue that currency hedging is a "free lunch."

tests of performance improvement are presented in Section III. Section IV extends the analysis to situations where short sales are not allowed for stocks and bonds, and where no leverage is permitted through forward contracts. Section V analyzes conditional currency hedging and Section VI offers concluding comments.

I. Currency Hedging

In Solnik's IAPM, investors are rational mean-variance optimizers that hold a combination of the domestic risk-free asset and a portfolio of all assets, including stocks and bills (or forward contracts).[2] This latter portfolio of risky assets is called "logarithmic" since it would be the sole investment of an investor with a logarithmic utility function. A result of this model is that all investors should hold the *same* portfolio of risky assets, which are optimally "hedged" against currency risk through the inclusion of forward contracts. Defining λ_i as the risk tolerance of investor i, and W_i as his wealth, this investor holds $(1 - \lambda_i)W_i$ in the domestic bill and $\lambda_i W_i$ in the Log portfolio. The composition of the Log portfolio is given by $\Sigma^{-1}\mu$, where Σ is the covariance of asset returns and μ is the vector of expected returns. Because the Log portfolio contains stocks and bills, one can define a hedge ratio as minus the ratio of the weight of the currency i bill to that of stock i in the Log portfolio: $h_i = -y_i/x_i$, where x_i is the weight of stock i and y_i is the weight of bill i in the portfolio.

Adding specific assumptions to the IAPM, Black (1990) suggests that there exists a "universal" hedge ratio that is optimal for all investors. Black's result comes from the aggregation of individual optimal portfolios across countries. Since the domestic bill is held by domestic investors, and assuming it is in zero net supply, it must enter the Log portfolio with a negative weight. In equilibrium, the hedge ratio is therefore proportional to $h_i = (1 - \lambda_i)W_i/M_i$, where M_i is the market capitalization of country i's stocks. By assuming that (1) all investors have the same risk tolerance, and (2) each national wealth is exactly equal to the value of each stock market, the optimal hedge ratio reduces to the "universal" value $h = (1 - \lambda)$. As discussed by Adler and Prasad (1992), the universality of the hedge ratio follows directly from the assumptions that impose homogeneity on world investors. Moreover, the assumptions require foreign investment to be in balance for all countries at all times. Whether universal or individual, the hedge ratio that arises from the IAPM encompasses both risk minimization and speculation motives. With low risk tolerance, the hedge ratio will be close to unity, which corresponds to pure risk minimization. The hedge ratio for a logarithmic investor is zero. For less risk-averse investors, the hedge ratio is even negative.

[2] The model assumes that consumption opportunity sets differ across countries, but that no barriers to international investments exist. The model assumes that inflation is nonstochastic. This model has been expanded by Sercu (1980), Stulz (1981), and Adler and Dumas (1983).

A second definition of hedging used in the literature refers to the practice of holding a portfolio of hedging assets to improve the risk-return characteristics of a predetermined portfolio. Anderson and Danthine (1981), for instance, find that the vector of optimal weights for the hedge instruments, z, is given by

$$z = \lambda \Sigma_{ff}^{-1} \mu_f - \Sigma_{ff}^{-1} \Sigma_{fx} x, \tag{1}$$

where x is the vector of underlying asset positions, Σ_{ff} is the covariance matrix of hedges, μ_f is the expected return on the hedges, and Σ_{fx} contains the covariances between the hedging instruments and the underlying positions. The optimal hedge ratio can be said to contain two components: a speculative component and a hedging component. The first one represents a gamble on expected returns from hedges, and reflects the investor's risk tolerance. If these expected returns are zero, then the optimal hedge position collapses to the coefficients obtained by a regression of asset returns on hedge instruments, the second term in the equation. Unitary hedging occurs when, in addition, local currency returns are uncorrelated with exchange rates, i.e. when $\Sigma_{ff} = \Sigma_{fx}$. Finally, the second term is zero when movements in underlying positions measured in the reference currency are uncorrelated with hedging instruments, i.e. when $\Sigma_{fx} = 0$. The vector of optimal hedges is then identical to that in an optimization that involves both underlying assets and hedges.

A shortcoming of the two theoretical models described so far is that they ignore the type of short-selling constraints that investors normally face. Extreme short positions are not possible in most markets; many institutional investors and banks limit leveraging through forward contracts. Our third approach considers portfolios with short-selling restrictions.

Considerable evidence now exists that expected returns in international markets exhibit variation through time, or that returns can be forecast. Our final approach to hedging incorporates a well-known forecasting variable, the forward premium, into the hedging decision. This results in a conditional hedging strategy where the hedge ratio varies through time. The approach used to calculate the optimal portfolio weights is again similar to that used with the IAPM approach.

Throughout all of these approaches, we assume rational expectations and use ex post data as measures of expectations. In contrast with the previous literature, however, we provide statistical tests of the performance improvement derived from adding currency hedges to portfolios of stocks and/or bonds.

II. Optimal Unconditional Hedging

We take the viewpoint of a U.S. investor who measures returns in dollars and views U.S. Treasury bills as riskless assets. Defining $S_{i,t}$ as the spot dollar price of foreign currency i at time t, and $P_{i,t}^*$ as the foreign currency asset value inclusive of reinvestments, returns in dollars are measured as

$$\tilde{R}_{i,t+1} = \frac{\tilde{P}^*_{i,t+1}\tilde{S}_{i,t+1}}{P^*_{i,t}S_{i,t}} - 1. \tag{2}$$

Forward contracts involve a commitment to buy or sell foreign currency and produce a random payoff, but require no initial investment. Therefore, a rate of return cannot be defined for forward contracts. It is possible, however, to compare the return on the portfolio with and without forward contracts. Without forwards, defining $x_{i,t}$ as the fraction of wealth invested in asset i, the portfolio return is given by

$$\tilde{R}_{t+1} = \sum_{i=1}^{N_1} x_{i,t}\tilde{R}_{i,t+1}. \tag{3}$$

Now defining $h_{i,t}x_{i,t}/S_{i,t}$ as the amount of foreign currency i sold forward at time t for delivery at time $t+1$, the return on a portfolio with forwards is equal to

$$\tilde{R}^h_{t+1} = \tilde{R}_{t+1} + \sum_{i=1}^{N} (-h_{i,t}x_{i,t})\tilde{f}_{i,t+1}, \tag{4}$$

where $\tilde{f}_{i,t+1} = (\tilde{S}_{i,t+1} - F_{i,t})/S_{i,t}$ is the normalized "payoff" on a long forward contract, with one-month forward price $F_{i,t}$. This notation permits any hedging strategy to be defined through the hedge ratio $h_{i,t}$. For example, when $h_{i,t} = 0$, assets denominated in currency i are left unhedged. Conversely, $h_{i,t} = 1$ implies a unitary hedge ratio, or a fully hedged strategy. In the remainder of this paper, we investigate the implications of various strategies for choosing $h_{i,t}$ on the performance of $\tilde{R}^h_{t+1}$.

The general approach we take is as follows. We investigate the composition of the portfolio of risky assets that maximizes the Sharpe ratio, the ratio of excess return to risk. This approach is consistent with the IAPM, and produces the same Sharpe ratio as the Log portfolio. We focus on the improvement in the Sharpe ratio that occurs when adding currency hedges to a portfolio of stocks and/or bonds.

This study considers five markets, the United States, Japan, Germany, Britain, and France.[3] The empirical analysis is based on monthly observations over January 1974 to December 1990. Returns are measured in U.S. dollars and expressed in excess of the one-month U.S. Treasury bill rate. Details on data sources are given in the Appendix.

Table I presents estimates of average returns and volatilities over the sample period. The first column reports statistics for long forward positions in the foreign currencies. The average return for these is between 0.87 and

[3] As of December 1990, the five stock markets selected account for 85 percent of the total market capitalization of all countries covered by the Capital International world stock index; the five currencies selected account for 89 percent of the total market capitalization of all countries covered by the Salomon Brothers world bond index.

Table I

Summary Statistics: January 1974 to December 1990

Statistics for forward positions, bonds, and stocks. A fully hedged foreign asset consists of the foreign asset plus a *short* position in a forward contract on the foreign currency. Returns are annualized percentages (% pa), in U.S. dollars and in excess of the one-month U.S. Treasury bill rate.

	Forward Positions	Bonds	Fully Hedged Bonds	Stocks	Fully Hedged Stocks
		Average Excess Return (% pa)			
United States		1.42		4.56	
Germany	0.87	4.89	4.02	9.42	8.55
Japan	2.41	5.44	3.02	11.16	8.75
United Kingdom	2.53	4.67	2.14	11.60	9.06
France	2.70	2.34	−0.36	9.49	6.78
World		2.87		5.81	
		Standard Deviation of Returns (% pa)			
United States		10.00		16.75	
Germany	11.99	15.14	6.14	22.17	18.91
Japan	12.32	16.23	7.06	23.03	17.96
United Kingdom	11.80	19.65	13.31	28.72	25.72
France	11.58	13.34	5.81	26.35	23.21
World		9.31		15.36	

2.70 percent per annum. As a result, unitary hedge ratios would have lowered returns, but they also would have lowered risk. Fully hedged foreign assets display substantially less volatility than unhedged foreign assets. The reduction is particularly striking for foreign bonds, where the volatility can be cut by more than one-half.[4]

In theory, however, the unitary hedge ratio is suboptimal since it ignores correlations between exchange rates and local returns as well as speculative motives for taking currency positions. To address the issue of currency hedging with more generality, two efficient sets can be compared. The first one includes stocks and bonds only, whereas the second also includes forward contracts. This second framework corresponds to a situation where an investor simultaneously optimizes over both the underlying assets and forward contracts, as in the IAPM.

The composition and risk-return characteristics of the optimal portfolios are reported in Table II. Adding currencies improves the portfolio performance. For example, consider a portfolio with standard deviation equal to

[4] The reduction in return from hedging, however, is unstable and period specific. We also investigate three subperiods. Over 1974 to 1978 and 1984 to 1990, full hedging generally reduces returns; in contrast, hedging improves returns from 1979 to 1983.

that of a corresponding U.S. asset. At the risk level of U.S. bonds, adding currencies would have improved the annual return of a bond portfolio by 4.7 percent.[5] At the risk level of U.S. stocks, the improvement amounts to 2.7 percent. Finally, for a portfolio consisting of stocks and bonds, the increase in annual return would have been 6.7 percent at the risk level of U.S. stocks.

Alternatively, the value of hedging can be analyzed in the context of cross-hedging a passive benchmark portfolio, chosen here as a global index of bonds, of stocks, and a balanced index of stocks and bonds. Table III reports the performance and allocations of passive benchmarks with and without optimal hedge positions in forward contracts. Maintaining the risk level equal to that of U.S. assets, as above, currencies would have increased returns by 2.7 percent for bonds, by 3.7 percent for stocks, and by 3.8 percent for a balanced stock/bond benchmark. Compared to Table II, the performance improvement from adding currencies to bond portfolios is much less than before, which reflects the superiority of optimizing over all assets rather than just over currencies. Because of high correlations between bonds and currencies, the optimal bond allocations reported in Table II are substantially altered when adding forward contracts. For example, the weight on the German bond market increases from 134 to 195 percent of the portfolio when forward contracts are added; this additional position is offset to some extent by a short position of 326 percent in deutsche mark one-month forward contracts. In Table III, on the other hand, the bond allocations are fixed to the market capitalization weights. As a result, the performance measures are lower than those reported in Table II and indicate that this cross-hedging approach would have been suboptimal over this time period, an issue investigated in more detail below.

III. Tests of Performance Improvement

The Sharpe performance measures presented in Tables II and III, while interesting, suffer from estimation error which precludes any direct comparison across samples. Since the optimization and the performance measurement are done over the same sample period, the performance of the optimized portfolios must by construction improve when assets are added. The main question, then, is whether the performance improvement is too large to be attributed to chance.

When short sales are allowed and a riskless asset exists, an appropriate test has been provided by Jobson and Korkie (1982), and extended by Kandel and Stambaugh (1989). Define T as the number of observations (months), N_1 as the number of base assets, and $N_2 (\geq N_1)$ as the number of total assets, with $N = N_2 - N_1$. Efficiency of the optimal portfolio of N_1 assets can be

[5] Using the historical volatility of 2.89 percent per month for U.S. bonds, the difference in the Sharpe ratios of the optimal bond portfolios with and without forwards translates into a difference in returns of $(0.262 - 0.125)2.89$ percent $= 0.40$ percent per month, or 4.7 percent per annum.

Table II

Optimal In-Sample Portfolios: Currencies with Bonds and Stocks

The statistics test the hypothesis of no performance improvement from adding forward contracts to an optimal portfolio of (1) unhedged assets, (2) fully hedged assets, and (3) assets hedged with a universal ratio. The F-test assumes that returns are normal i.i.d.; the Wald test is asymptotically consistent under heteroskedasticity. Returns are measured in U.S. dollars, in excess of the one-month U.S. Treasury bill rate, and are reported on a monthly basis in percentages (pm). Positions for bonds/stocks add to 100. Period is January 1974 to December 1990.

	Bonds Only	Bonds and Forwards	Stocks Only	Stocks and Forwards	Bonds and Stocks	Bonds, Stocks, Forwards
Mean (pm)	0.722	0.928	0.876	1.167	1.578	1.143
Standard deviation (pm)	5.771	3.542	5.269	5.473	8.560	3.819
Sharpe ratio	0.125	0.262	0.166	0.213	0.184	0.299
			Positions in Percentages			
Bonds						
United States	6.0	−18.7	—	—	−9.8	−24.3
Germany	134.3	195.0	—	—	135.1	174.8
Japan	79.4	30.4	—	—	27.4	19.3
United Kingdom	21.3	−5.2	—	—	−21.7	−12.9
France	−141.0	−101.6	—	—	−179.4	−103.8
Stocks						
United States	—	—	3.7	1.1	−3.5	2.9
Germany	—	—	31.7	53.0	26.4	15.1
Japan	—	—	45.9	52.9	61.2	24.0
United Kingdom	—	—	21.8	8.0	44.2	5.6
France	—	—	−3.0	−15.1	19.8	−0.7
Forwards						
Germany	—	−326.1	—	−247.2	—	−311.6
Japan	—	−13.8	—	−44.3	—	−31.3
United Kingdom	—	26.0	—	28.3	—	28.4
France	—	197.9	—	224.4	—	201.0

Table II—*Continued*

	Bonds Only	Bonds and Forwards	Stocks Only	Stocks and Forwards	Bonds and Stocks	Bonds, Stocks, Forwards
	Tests of Performance Improvement					
Optimal with forward vs.						
(1) Unhedged optimal						
F-Statistic (p-value)	2.542*	(0.041)	0.847	(0.497)	2.558*	(0.040)
Wald statistic (p-value)	10.685*	(0.030)	3.297	(0.509)	10.833*	(0.029)
(2) Fully hedged optimal						
F-Statistic (p-value)	0.843	(0.500)	0.752	(0.558)	0.716	(0.582)
Wald statistic (p-value)	3.456	(0.485)	3.139	(0.535)	2.862	(0.581)
(3) Universally hedged:						
F-Statistic (p-value)	0.580	(0.629)	0.633	(0.595)	0.574	(0.632)
Wald statistic (p-value)	2.452	(0.484)	2.601	(0.457)	2.288	(0.515)

* significant at the 5 percent level.

Table III

Optimal In-Sample Portfolios: Currencies with Passive Indices

The statistics test the hypothesis of no performance improvement from adding forward contracts to a passive portfolio of (1) unhedged assets, (2) fully hedged assets, and (3) assets hedged with a universal ratio. The F-test assumes that returns are normal i.i.d.; the Wald test is asymptotically consistent under heteroskedasticity. Returns are measured in U.S. dollars, in excess of the one-month U.S. Treasury bill rate, and are reported on a monthly basis in percentages (pm).

	Bond Index	Bond Index, Forwards	Stock Index	Stock Index, Forwards	Balanced Index	Balanced Index, Forwards
Mean (pm)	0.239	0.664	0.484	0.799	0.353	0.743
Standard deviation (pm)	2.687	3.978	4.434	4.643	3.414	4.402
Sharpe ratio	0.089	0.167	0.109	0.172	0.103	0.169
			Positions in Percentages			
Bond index	100.0	100.0	—	—	—	—
Stock index	—	—	100.0	100.0	—	—
Balanced index	—	—	—	—	100.0	100.0
Forwards						
Germany	—	−231.3	—	−423.1	—	−330.4
Japan	—	−7.5	—	11.3	—	3.1
United Kingdom	—	14.2	—	48.4	—	30.9
France	—	225.7	—	439.4	—	335.1
			Tests of Performance Improvement			
Optimal with forward vs.						
(1) Unhedged index						
F-Statistic (p-value)	0.615	(0.653)	0.621	(0.648)	0.605	(0.659)
Wald statistic (p-value)	2.386	(0.665)	2.438	(0.656)	2.330	(0.675)
(2) Fully hedged index						
F-Statistic (p-value)	0.683	(0.605)	0.733	(0.570)	0.676	(0.609)
Wald statistic (p-value)	2.719	(0.606)	2.957	(0.565)	2.670	(0.614)
(3) Universally hedged						
F-Statistic (p-value)	0.835	(0.476)	0.761	(0.517)	0.762	(0.516)
Wald statistic (p-value)	2.605	(0.457)	2.269	(0.518)	3.713	(0.294)

tested by the F-statistic that corresponds to the joint hypothesis of zero intercepts in a system of multivariate regressions of the additional N asset returns, $R^y_{i,t}$, on the original N_1 assets, $R^x_{i,t}$:

$$R^y_{i,t} = \alpha_i + \sum_{j=1}^{N_1} \beta_{ij} R^x_{j,t} + \epsilon_{i,t}, \qquad i = 1, \ldots, N, t = 1, \ldots, T. \tag{5}$$

As Gibbons, Ross, and Shanken (1989) have shown, this test can also be interpreted in terms of the maximal Sharpe ratios, $\hat{\theta}_1$ and $\hat{\theta}_2$ attainable in the sample with N_1 and N_2 assets, respectively. The statistic can also be written as

$$F = \frac{(T - N_2)}{N}\left(\hat{\theta}_2^2 - \hat{\theta}_1^2\right)/\left(1 + \hat{\theta}_1^2\right), \tag{6}$$

which has an F-distribution with $(T - N_2, N)$ degrees of freedom. Large values of F imply that portfolio performance is significantly improved by extending the menu of assets ($\hat{\theta}_2^2 \gg \hat{\theta}_1^2$), and that consequently, it is unlikely that the subset of assets is efficient.[6] The F-test assumes that returns are normal i.i.d.[7] Under less strict assumptions, a generalized method of moments (GMM)–based Wald test can be constructed as

$$W = (T - N - 1)\left(\hat{\alpha}'[D'S^{-1}D]^{-1}\hat{\alpha}\right) \tag{7}$$

where $[D'S^{-1}D]$ is the heteroskedasticity-consistent covariance matrix developed by White (1980).[8] Under the null, the Wald statistic has an asymptotic chi-square distribution with N degrees of freedom.

Tests of performance improvement to hedging are displayed at the bottom of Table II. The optimal portfolio with forward contracts is compared to three alternatives: an optimal portfolio of unhedged assets, of fully hedged assets, and of universally hedged assets. For bond portfolios, both the F- and Wald statistics reject the null hypothesis that currency forwards do not improve the risk-return tradeoffs of global unhedged bond portfolios at the usual 5 percent confidence level. For mixed stock and bond portfolios, Table II shows

[6] Actually, this statistic tests a necessary condition for efficiency. Abnormally large values of the statistic may also indicate a reduction in performance, unless the algebraic—as opposed to the absolute—value of the Sharpe ratio is also improved.

[7] Affleck-Graves and McDonald (1989) find the F-test to be robust to departures of the normality assumption. Amsler and Schmidt (1985) find that asymptotic statistics tend to reject too often in small samples, but that the F-test is generally well behaved.

[8] The pattern of return autocorrelations indicates that returns on stocks, bonds, and forward contracts are generally not autocorrelated over the sample period. Therefore no lags are allowed in the computation of S^{-1}. See MacKinlay and Richardson (1991) for further details on the GMM estimator.

that the performance improvement is also significant. For equity portfolios, in contrast, there is little evidence of improvement from adding currencies. The rejections when bonds are included in the portfolios appear related to two factors. First, the improvement in performance due to the addition of forward contracts is much greater when bonds are included in the portfolio than for the stock portfolio. And second, while the test statistics have low power to reject the null hypothesis, the reduction in portfolio volatility due to the introduction of bonds makes rejection easier.

For fully hedged assets, there is no statistical evidence that adding an optimal combination of forward contracts improves performance. This suggests that the risk reduction attained from full hedging is a major component of the performance improvement observed above. A similar conclusion holds for universally hedged assets. The universal hedge ratios, found by numerical optimization, are 1.59, 0.62, and 1.19, respectively, for bonds, stocks, and all assets. For bonds, for instance, the ratio of 1.59 can be compared with the optimal hedge ratios from the unrestricted optimization, which are 1.67 (mark), −0.45 (yen), −5.00 (sterling), and 1.95 (franc). Since the largest bond positions are for the mark and franc, imposing either a full or universal hedge ratio is apparently not statistically different from individual hedge ratios.

Statistical tests of performance improvement from currency management of passive indices are also presented at the bottom of Table III. In contrast with before, there is no evidence that currency hedges add value to any of the three portfolios, using either unhedged, fully hedged, or universally hedged benchmarks. Therefore, optimizing separately over bonds and currencies does not take full advantage of currency hedging. An important conclusion, therefore, is that the practice of delegating the management of currencies to overlay managers may be suboptimal because it does not fully exploit correlations between assets, especially bonds and exchange rates.

The rejections reported in Table II are rare in the literature. Most previous tests of international asset pricing have concentrated on the International Capital Asset-Pricing Model and efficiency of the market portfolio. Cumby and Glen (1990), for example, are unable to reject efficiency of the global stock market. Rejection of the efficiency of an optimal stock and bond portfolio, which by definition must outperform a market-weighted portfolio of stocks, can be traced to the risk reduction brought about by introducing bonds.

IV. Hedging with Short-selling Restrictions

A drawback of the classical approach to hedging and portfolio construction is that it yields portfolios involving very large positive and negative positions, often several times the size of the initial investment. If in practice some foreign markets cannot be sold short, or if investors are prohibited from taking such positions, the above results are irrelevant. In this section, we examine portfolios where short-selling restrictions are imposed on stocks and bonds; hedging is restricted to selling short no more than the exposure of the underlying market. Such hedging strategies have not been examined in the theories of hedging, but investors face similar restrictions in reality.

Table IV reports the composition of the optimal portfolios with short-sale restrictions. The optimal bond portfolio including currency forwards is invested in the German and Japanese bond markets, which are fully hedged against currency risk. The optimal stock portfolio is invested in three markets, Germany, Japan, and Britain; Germany is fully hedged, Japan is partially hedged, and Britain is left exposed. Similar patterns appear in the optimal mix of stocks, bonds, and forwards.

The Sharpe ratios in Table IV are substantially lower than those reported in Table II, reflecting the fact that the short-sales restrictions are binding. Still, currency hedging appears to improve total performance; at the risk level of the equivalent U.S. asset, currency forwards increase returns by 2.9 percent annually for a bond portfolio, by 0.8 percent annually for an equity portfolio, and by 3.8 percent annually for a mixed equity and bond portfolio. As before, the question is whether these increases reflect an actual performance improvement or are solely due to sampling variation.

When short selling is not allowed, the distribution of the statistic (6) is unknown and must be approximated by simulation. This is done as follows. First, expected returns, variances, and covariances are derived from historical data. Expected returns are then modified so that the null hypothesis—the mean-variance efficiency of the subset of assets—is satisfied.[9] Then T random samples of joint returns are drawn from a multivariate standard normal distribution with these parameters. From these simulated returns, a new set of means and a new variance-covariance matrix are estimated; the optimization is performed as before, and the value of the statistic is recorded. The empirical distribution of the statistic is tabulated under the null by repeating this process 1,000 times.[10]

The bottom of Table IV reports tests of performance improvement in portfolios where short sales are not allowed. The simulation p-values indicate that hedging results in a significant performance improvement for bond portfolios and portfolios containing both stocks and bonds. For the interna-

[9] This is achieved by first computing the portfolio of N_1 assets that maximizes the Sharpe ratio, allowing only positive weights. Expected returns on the remaining $N_2 - N_1$ assets are then forced to be proportional to their beta relative to this optimal portfolio. This ensures that the optimal portfolio is the same for the sample of N_1 and N_2 assets, which is the null under investigation.

[10] The simulations are also performed with time-varying second moments, by specifying a GARCH(1, 1) model for return variances. Throughout the table, the empirical significance levels obtained under the assumption of constant variances are very close to those found under the assumption of time-varying variances. The results are therefore robust to departures from homoskedasticity.

Table IV

Optimal In-Sample Portfolios with Short-Sales Restrictions

The statistics test the hypothesis of no performance improvement from adding forward contracts to a portfolio with short-selling restrictions. The optimal weights of bonds/stocks are restricted to be positive; short selling of currencies is only allowed up to the amount of the underlying position of bonds/stocks in the same currency. The empirical p-value is estimated by 1000 simulations, assuming constant (F-Statistic) and time-varying (GARCH) second moments. Returns are measured in U.S. dollars, in excess of the one-month U.S. Treasury bill rate, and are reported on a monthly basis in percentages (pm). Period is January 1974 to December 1990.

	Bonds Only	Bonds and Forwards	Stocks Only	Stocks and Forwards	Bonds and Stocks	Bonds, Stocks, Forwards
Mean (pm)	0.414	0.330	0.878	0.812	0.818	0.446
Standard deviation (pm)	3.860	1.718	5.283	4.545	4.905	1.922
Sharpe ratio	0.107	0.192	0.166	0.179	0.167	0.232
			Positions in Percentages			
Bonds						
United States	4.0	0.0	—	—	0.0	0.0
Germany	40.4	85.4	—	—	11.3	71.4
Japan	44.0	14.6	—	—	0.0	2.8
United Kingdom	11.6	0.0	—	—	0.0	0.0
France	0.0	0.0	—	—	0.0	0.0
Stocks						
United States	—	—	2.8	0.0	4.6	0.0
Germany	—	—	30.5	38.5	24.0	7.1
Japan	—	—	45.4	45.2	40.9	14.7
United Kingdom	—	—	21.2	16.2	19.1	4.0
France	—	—	0.0	0.0	0.0	0.0
Forwards						
Germany	—	−85.4	—	−38.5		−78.5
Japan	—	−11.2	—	−19.7		−15.9
United Kingdom	—	0.0	—	0.0		0.0
France	—	0.0	—	0.0		0.0

Table IV—*Continued*

	Bonds Only	Bonds and Forwards	Stocks Only	Stocks and Forwards	Bonds and Stocks	Bonds, Stocks, Forwards
			Tests of Performance Improvement			
Optimal with forward vs. unhedged F-Statistic (p-value, constant variance)	1.218*	(0.026)	0.205	(0.250)	0.587*	(0.032)
(p-value, GARCH variance)		(0.032)		(0.289)		(0.049)

* Significant at the 5 percent level.

tional equity portfolios, the simulation p-value is 0.250, which is lower than the p-value found without any restrictions, although still not statistically significant.

Overall, these results are very similar to those for unconstrained hedging, and suggest that static currency hedging improves the risk-return tradeoff, especially for portfolios including bonds, even when sampling variation is taken into account.

V. Optimal Conditional Hedging

In this section, we explore the possibility of improving performance even further by a conditional strategy that allows the hedging coefficient to vary over time. We present two approaches to evaluating conditional hedging strategies based on in-sample and out-of-sample performance.

Previous research on the efficiency of the foreign exchange market has identified the forward premium as a variable that predicts expected returns on forward contracts.[11] Since, by interest rate parity, the forward premium is also the interest rate differential, a simple forecasting equation for the return on forward contracts can be written as

$$\left(\tilde{S}_{t+1} - F_t\right)/S_t = a + b(i_t^* - i_t) + \tilde{\epsilon}_{t+1} \tag{8}$$

where $i_t(i_t^*)$ is the domestic (foreign) riskless interest rate, and $i^* - i$ is the forward discount. In such regressions, the slope coefficient is generally significantly positive, although the explanatory power is usually low. We use this regression to implement two conditional hedging strategies.

The first trading strategy sets the hedging coefficient equal to ± 1 depending on the sign of the forward discount. Intuitively, the strategy sells a foreign currency forward when it is at a premium and, conversely, initiates a purchase when it sells at a discount. This trading strategy is thus conditioned on prior information; the resulting time series of returns are then included in the in-sample tests of efficiency described above.

Table V presents the results of the conditional "forward premium hedge." Two sets of results are presented. The left-upper part of the table compares the performance of portfolios of bonds, stocks, and combined portfolios of bonds and stocks, with and without the forward premium hedge. In each case the efficiency of the unhedged portfolio is rejected. This is quite a strong result, especially in the case of the stock portfolio, whose efficiency is not rejected by the static hedging strategy.[12] The right-upper part of the table considers the same active hedging strategy, but combined with the passive

[11] See, for instance, Bilson (1981) and Giovannini and Jorion (1989). This research is surveyed by Hodrick (1987).

[12] Bekaert and Hodrick (1991) have independently examined similar trading rule strategies based on forward premia and also dividend yields, but report no statistical tests of performance improvement. It can be shown, however, that statistically significant improvement occurs only when adding the currency returns series scaled by the forward premium, which is similar to our trading rule strategy.

Table V

In-Sample Tests of Performance Improvement from Conditional Currency Hedging

The statistics present the performance improvement from adding a variable hedge strategy, where monthly long or short forward positions are taken according to whether the foreign currency sells at a forward discount or premium, respectively. In the upper panel, the original menu of assets consists of bonds, stocks, bonds and stocks, and global indices consisting of bonds, stocks, and a balanced portfolio of bonds and stocks. In the middle panel, (static) forward contracts are added to the previous assets. In the lower panel, bonds and stocks are fully and universally hedged. The F-test assumes that returns are normal i.i.d.; the Wald test is asymptotically consistent under heteroskedasticity. Period is January 1974 to December 1990.

	Variable Hedges with					
	Bonds	Stocks	Bonds, Stocks	Bond Index	Stock Index	Balanced Index
F-Statistic	7.064*	5.293*	7.098*	4.854*	4.860*	4.840*
(p-Value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald statistic	29.457*	20.366*	31.595*	18.823*	19.263*	19.044*
(p-Value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	Bonds, Forwards	Stocks, Forwards	Bonds, Stocks, Forwards	Bond Index, Forwards	Stock Index, Forwards	Balanced Index, Forwards
F-Statistic	5.613*	4.646*	5.604*	4.696*	4.721*	4.696*
(p-Value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald statistic	20.803*	17.393*	21.894*	16.553*	17.120*	16.890*
(p-Value)	(0.000)	(0.002)	(0.000)	(0.002)	(0.002)	(0.002)
	Fully Hedged			Universally Hedged		
	Bonds	Stocks	Bonds, Stocks	Bonds	Stocks	Bonds, Stocks
F-Statistic	6.458*	5.448*	6.101*	5.573*	5.551*	5.703*
(p-Value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald statistic	26.393*	21.227*	24.719*	22.038*	21.834*	22.446*
(p-Value)	(0.000)	(0.002)	(0.000)	(0.002)	(0.002)	(0.002)

* significant at the 5 percent level.

indices used previously. Rejections also occur in all cases. Note, however, that the values of the statistics are systematically lower than those in the left panel, even though the number of degrees of freedom are the same. As before, this indicates that efficiency gains could be obtained by not only actively hedging exchange rate risk, but also by changing the underlying asset positions to account for the currency hedges.

The middle section of Table V considers the question of whether the performance of portfolios with static forward contracts can be improved through the use of the forward-premium hedge. In all cases investigated, efficiency of the static currency hedge is rejected in favor of the forward premium hedge. Thus, over the sample period, investors are able to significantly improve the performance of their portfolios, even those containing forward contracts, by selectively buying and selling foreign currencies on the basis of the forward premium. The lower panel confirms that the forward-premium hedges also improve on fully hedged and universally hedged assets.

These results are quite dramatic in light of previous empirical research in this area. No other tests that we are aware of reject the efficiency of the global market-weighted stock portfolio. This highlights the role that hedging plays in improving portfolio performance, as well as the importance of considering conditional distributions. The results do not lend support to either of the unconditional models of asset pricing mentioned earlier. Finally, the time-varying nature of the hedges rejects the optimality of either universal or unitary hedge ratios.

The results in Table V suggest that, over this time period, it would have been possible to improve the portfolio performance by using forward contracts; unfortunately, the optimal weights are only revealed after the fact. Therefore, a remaining question is whether the performance gain also occurs when investment decisions are based only on prior information. Our second conditional strategy addresses this question as follows. Starting in December 1978, expected returns are constructed for forward contracts using equation (8) estimated over the previous 60 months; the variance-covariance matrix is also estimated over the same time period. These parameters are fed into a portfolio optimizer that determines the forward positions of the portfolio with the highest excess return-to-risk ratio. The performance of the optimal portfolio is recorded for the following month, after which the process is repeated, updating the input parameters over a moving window of 60 months. This is an "ex ante" strategy, as investment decisions are based only on prior information.

To focus on the benefits of conditional hedging, the analysis considers only passive benchmarks of bonds or stocks. Each month, the decision variables are the amounts to buy or sell forward. As before, short currency positions are allowed only up to the extent of the underlying market exposure.

Table VI reports the results from this second active hedging rule, implemented over the period January 1979 to December 1990, and compared to unhedged and fully hedged passive indices. Clearly, the active hedging rule adds substantial value to the bond portfolio. Holding the risk level equal to

Table VI

Out-of-Sample Tests of Performance Improvement from Conditional Currency Hedging

The statistics present the out-of-sample performance improvement from adding an active hedge strategy to a passive index. The tests measure the extent to which the variably hedged index outperforms either an unhedged or a fully hedged benchmark. Improvements are measured in U.S. dollars, in excess of the one-month U.S. Treasury bill rate, and are reported on a monthly basis in percentages (pm). The JK test statistic, derived by Jobson and Korkie (1981), has an asymptotic normal distribution. The test of equal R_t/σ_t measures the difference between returns, normalized by the anticipated standard deviation. Out-of-sample period is January 1979 to December 1990.

	World Bond Index			World Stock Index		
	Unhedged	Fully Hedged	Actively Hedged	Unhedged	Fully Hedged	Actively Hedged
Mean (pm)	0.179	0.174	0.480	0.622	0.619	0.919
Standard deviation (pm)	2.942	2.034	3.015	4.477	4.491	4.884
Sharpe ratio	0.061	0.086	0.159	0.139	0.138	0.188
	Tests of Performance Improvement					
Actively hedged vs. benchmark						
JK statistic (p-value)	−2.41*	−1.37		−1.88	−1.88	
Equal R_t/σ_t (p-value)	−2.13*	−1.74		−1.62	−1.64	

* significant at the 5 percent level.

that of the world bond portfolio, the excess return on an unhedged bond portfolio is increased by 3.5 percent through currency hedging. In the equity portfolio, active hedging increases returns by 2.7 percent. Similar gains are obtained over the fully hedged bond and stock portfolios.[13]

Table VI also reports tests of performance improvement, using the methodology developed by Jobson and Korkie (1981) for testing the equality of Sharpe ratios. This test is applicable to an out-of-sample analysis, whereas the previously used F- and Wald tests account for the biases due to in-sample optimization. In spite of the reported low power of these tests, Table VI shows that the performance improvement for the bond portfolio is not only economically, but also statistically significant against the unhedged passive index.[14] The tests are inconclusive for the stock and fully hedged bond portfolios.

VI. Conclusions

This paper examines the speculative and risk minimization motives for adding currency hedges to international portfolios. Even if currency hedging reduces the volatility of portfolio returns, hedging will be beneficial only if this risk reduction is not accompanied by an offsetting decrease in returns. In an IAPM framework, portfolio performance will be improved by currency hedging only if forward contracts are not fairly priced; hedging may be valuable to investors if exchange rate risk is not priced consistently with other risks.[15]

Four approaches to hedging are considered. In the first, the investor compares an optimal portfolio of stocks/bonds with an optimal portfolio also containing forward contracts. In the second, currency hedges are added to a predetermined stock/bond position. The third approach imposes short-selling restrictions on optimized portfolios; whereas, in the fourth approach, time variation in hedge ratios is introduced through the information contained in the forward premium.

Over the 1974 to 1990 time period, test statistics suggest that unconditional currency hedging significantly improves the performance of optimized portfolios containing unhedged bonds. Such hedging, however, does not sig-

[13] In addition, the results are consistent across two subperiods, covering periods of both strength (1979 to 1983) and weakness (1984 to 1990) for the U.S. dollar.

[14] One drawback of the Jobson-Korkie test is that it assumes constant moments, whereas the risk of the variably hedged portfolio changes through time due to changing portfolio weights. Therefore, a second statistic is presented, based on the portfolio excess returns, R_t, scaled by the anticipated standard deviation, σ_t. Under the null hypothesis of no additional value, the difference between the scaled returns on the benchmark and on the hedged portfolio should be zero. Table VI shows that, over the 1979 to 1990 period, this approach gives conclusions similar to the Jobson-Korkie tests.

[15] Recent research compares the risk-return tradeoffs in the foreign exchange and stock markets. Jorion (1991) finds that unconditional exposure to currency risk does not appear to be priced in the U.S. stock market, which is consistent with the findings that unconditional expected returns from forward market speculation are generally rather small. Korajczyk and Viallet (1992) report that international stock market factors cannot fully explain the time variation of foreign exchange returns.

nificantly outperform unitary or universal hedging strategies. With predetermined positions in either stocks or bonds, there is little evidence of improvement from adding currencies, which highlights the suboptimality of optimizing on currencies separately from bonds.

Finally, conditional hedging strategies significantly improve the performance of stock and bond portfolios, both in sample and out of sample, yielding substantially higher returns without additional risk. This conditional hedging strategy also outperforms both a unitary and universal hedging strategy. Currencies therefore appear to play an important role in optimized global portfolios, especially when used in conditional strategies.

Appendix: Data Sources

The stock index data are taken from Morgan Stanley Capital International, which provides national stock indices, measured in the local currency, where the individual stock performance is weighted by market value, starting in 1970. From this information, dollar returns are computed inclusive of dividends.

The bond data are taken from Salomon Brothers. The data source provides intermediate government bond indices that include all bonds with a remaining maturity of more than five years, weighted by par value, starting in 1978. The indices are computed in dollars inclusive of coupons, reinvested monthly. From 1974 to 1977, government bond indices are constructed from government bond yields provided by the International Monetary Fund. Returns are computed from the changes in yields, based on the reported maturities and assuming par coupons, and then translated into total dollar returns.

The passive benchmarks are taken to be the standard performance indices for international portfolios: the Salomon Brothers world bond index and the Morgan Stanley Capital International world stock index. In addition, a balanced stock/bond world index is constructed by weighting returns by the market capitalization of stocks and bonds, as reported at the end of each year.

Data Resources Incorporated (DRI) is the source of foreign exchange data up to December 1988, after which quotes are collected from the *Financial Times*. Spot and one-month forward rates are taken as the arithmetic average of bid and ask quotes against the U.S. dollar.

The U.S. risk-free rate is taken from Ibbotson and Sinquefield up to December 1988, and updated using the same methodology, using U.S. Treasury bill quotes from the *Wall Street Journal*. The risk-free rate is computed as the monthly return on the shortest Treasury bill with no less than one month to maturity.

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