OPTIMAL INTERNATIONAL PORTFOLIO STRATEGY

: FROM THE PERSPECTIVE OF KOREAN INVESTORS

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ABSTRACT

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The main purpose of this paper is to find out the best portfolio strategy among various optimal strategies in the international portfolio investment, from the perspective of Korean investors. I have attempted to evaluate the various ex ante and ex post strategies by the Sharpe reward-to-variability ratio for 33 out-of-sample overlapping holding periods over 1995.1 through 2001.6. The major findings of this paper are: First, exchange rate affects seriously in the total portfolio volatility. In a pre-crisis period, the exchange rate volatility accounts for 70% of the total portfolio volatility, while negative 40% in a post-crisis period. Second, the optimal portfolio strategy are the joint hedging strategy, in which the currencies themselves are treated as assets and the position in them are optimized over the whole sample periods, especially in a pre-crisis period. However, in a post-crisis, LCR unitary hedging strategy is better than the joint strategy which assumes that the Korean investor sells the expected foreign currency proceeds forward and then calculate the optimal portfolio parameter.

Dedicated To My Mother and My Wife

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I. INTRODUCTION

As the integration of international financial market has rapidly advanced, the international diversification of investment has received widespread attention at both the academic and practitioner level around the world for the last decade.

The Korean investors are more interested in the international portfolio investment than ever before, since the Korean government has actively introduced the new policies such as the international portfolio investment fund to promote international portfolio investment(1999) [1], and the first and second phases of the Foreign Exchange Liberalization(1999, 2001) [2]. Therefore, we may expect the

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1 Korea MOFE Foreign Exchange Regulation & External Debt Div., 8 Dec 1999, "Stabilization of Capital inflow and outflow through Foreign Capital Investment Fund" in Korean

2 Korea MOFE, Foreign Exchange Regulation & External Debt Div., Apr. 1999 & Dec. 2000. The Foreign Exchange Liberalization has been implemented to upgrade Korea's foreign exchange system to international standards, to facilitate the flow of foreign capital and to further promote overseas business activities of the private sector in the current open market environment. As its first phase, which began on 1 April 1999, restrictions on foreign exchange transactions of corporations and financial institutions regarding their overseas activities were eased. Beginning on 1 January 2001, the Foreign Exchange Liberalization entered its second phase, which further liberalized foreign exchange and capital account transactions for individuals and further streamlined remaining restrictions on corporations and financial institutions regarding their foreign exchange transactions. More details in http://www.mofe.go.kr/mofe/eng/e_econo_issues/e_int_finan/html/e_if2000122301.htm .

volume of the international diversification portfolio of Korean investors to increase rapidly in the near future.

Then, we can ask ourselves several questions as following. Should currencies play important roles in the international portfolio? Is there a convincing evidence of predictability that would support the use of optimal tactical currency allocation? Is the separate management of two asset classes, such as equities and currencies, desirable? What is the optimal portfolio strategy among the various hedged and unhedged strategies of the international investment?

For these kinds of questions, both the ex ante approach and the ex post approach have been developed. The ex ante portfolio selection studies such as Eun and Resnick(1988, 1994) [3], Larsen and Resnick(2000) show that exchange rate uncertainty is a largely non-diversifiable factor adversely affecting the performance of international portfolios and they developed ex ante methods to control parameter uncertainty and estimation risk. On the other hand, the latter studies such as Black(1989), Jorion (1985, 1994) on hedging exchange rate exposure in the portfolios of financial assets tried to find the optimal strategies by a mean/variance

3 They suggested that 3 alternative ex ante international portfolios such as the ex post minimum variance portfolio(MVP), the certainty equivalence tangency portfolio(CET), the Bayes-Stein(BST) strategy, both with and without forward exchange hedging to develop an effective strategy for controlling both estimation risk and exchange rate uncertainty

analysis of overlay currency estimated from historical data.[4]

In this paper, I have investigated the performance of 18 strategies, combined the ex post strategies with ex ante strategies, to find out the optimal portfolio method in the international portfolio investment from the perspective of a Korean investor.[5] Ex post methods include both unhedged investment strategies and the hedging investment strategies such as Jorion's 3 optimization portfolio methods — a joint, full-blown optimization, a partial optimization and a separate optimization —, and unitary hedging optimization, and Local currency return unitary hedging strategy. And also alternative ex ante portfolio strategies such as Minimum Variance Portfolio(MVP), Certainty Equivalence Tangency portfolio (CET), the Bayes-Stein(BST) strategy should be introduced to identify the ex ante optimal portfolio investment weight.

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4 Philippe Jorion(1994) considered three approaches to currency management in a mean/variance framework. In a joint optimization approach, positions in assets and currencies are determined simultaneously so as to the trade between risk and return for the portfolio as a whole. A partial optimization is conditioned on predetermined underlying asset positions. The asset weights are first determined without regard to the hedges. The currency weights are then determined. In a separated optimization, assets and hedge positions are determined independently.

5 Larsen and Resnick(2000) did not test a partial optimization test. But I will also examine this test as well as the other 5 methods they applied.

The structure of this paper is as following. Section II analyzes the effects of the fluctuating exchange rates in the international portfolio investment, and explains the various alternative portfolio strategies to apply for in the empirical test. Section III presents out-of-sample performance results including dominance analysis from the empirical test of those strategies. Finally, section IV offers a summary and concluding remark.

II. EXCHANGE RATE VOLATILITY AND HEDGING STRATEGIES

In this section, the effects of exchange rate volatility on the risk of foreign stock investment are examined by comparing the hedging strategy with the unhedged strategy. 8 major markets such as United States, United Kingdom, France, Germany, Japan, Hong Kong, Singapore, Korea are selected.[6] The primary data use in this study are the 'Datastream international' Monthly stock indexes for monthly return data and also the exchange rates for respective currency that span the time period 1990.1 through 2001.6.[7]

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6. These countries except Germany and France are selected in the criterion that the Korean investors including both the financial institutions and individual investors invested more than $20 million in the international stock and bond market in year 2001. In the European area, Luxemburg and Belgium invested in respective $163 M., $272 M. which belong to one of top 6, are excluded because of data unavailability, and Germany and France invested in less than the criterion are selected instead on assuming they are representative of European market.

7. The Recent data (2001.7~2002.6) are used only in calculating the forward risk rate, $f^{1}_{t,t+1} = \frac{(S_{i,t+1} - F_{i,t})}{S_{i,t}}$, over 2000.7 through 2001.6.

1. The Effect of Fluctuating Exchange Rates[8]

The Won rate of return, $R_{i₩}$, from the unhedged investments in the i^{th} foreign market over the holding period from time t to t+1 is given by

$$R_{i₩} = (1 + R_i)(1 + e_i) - 1, \qquad (1\text{ a})$$

$$= R_i + e_i + R_i e_i \qquad (1\text{ b})$$

where R_i is the local currency rate of return, $e_i = \frac{(S_{i,t+1} - S_{i,t})}{S_{i,t}}$ is the rate of appreciation of the local currency against Won, and $S_{i,t}$ is the spot exchange expressed in American terms of the currency(₩/\$, ₩/¥, ...). Since the cross product in equation (1b) is small in magnitute, we can approximate $R_{i₩}$ as follows,

$$R_{i₩} \fallingdotseq R_i + e_i \qquad (2)$$

Then the variance of the Won rate of return can be approximated as

$$Var(R_{i₩}) = Var(R_i) + Var(e_i) + 2\,cov(R_i, e_i) \qquad (3)$$

From the equation (3), the exchange rate change contributes to the variance of Won returns not only through its own variance but also through its covariance with the local stock market returns.

Table I shows the decomposition of volatility Won returns into different

8 Eun and Resnick, "Estimating the correlation structure of International share prices," *the Journal of Finance*, Vol. XXXIX, No.5, 1984, pp. 1311-1324
Eun and Resnick, "Exchange Rate Uncertainty, Forward Contracts, and International Portfolio Selection", *the Journal of Finance*, Vol. 9, 1988, pp. 199-204

components of each stock investment. During the sample period of 1990.1 through 2001.6, the Won exchange rates of U.S. dollar and U.K. pound were much more volatile than their respective stock markets. Their contribution ratio between stock market return and the exchange rate change turned out to be more than 7:3. But, in case of Hong Kong and Singapore, the covariance between stock market return and the exchange rate change represents both negative, so that the total volatility of direct and indirect effects of exchange rate change fully offset volatility of the stock market. And also their correlation coefficient between stock market returns and the exchange rate change is significantly different from zero at 1 % level, which different from other stock markets. Let's divide the total sample period into pre-crisis period(1990.1-1997.12) and post-crisis(1998.1-2001.6). Table 1 panel C shows that the results are quite different between those periods. In a pre-crisis, the direct effect of exchange rate change is much smaller than stock market volatility and is offset exactly by the negative indirect effect. Therefore, the total volatility of international portfolio is almost the amount of the stock market return movement. The correlation coefficients between stock market returns and the exchange rate change of all countries except Hang Seng stock market are significantly different from zero at 1 % level. However, in a post-crisis period, the results are quite different from those of pre-crisis period. The direct volatilities of

Won exchange rates of all currencies except Hong Kong dollar is larger than those of the respective stock markets because of the foreign currency crisis in Dec 1997. Only stock markets of 3 countries such as U.K., Hong Kong and Singapore showed stock market is significantly different from zero at 1 % level, but other countries' correlation coefficient are not statistically significant even in the 10% level.

Table 1. Decomposition of the Volatility of Stock Market Returns in Korean Won (1990.1- 2001.6) [1]

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(A) 90.1-01.6		$Var(R_i)$	$Var(e_i)$	$Cov(R_i, e_i)$	$Cor(R_i, e_i)$ [2]	Sum	(1)/(5)	(2)/(5)	2*(3)/(5)	(7)+(8)
	US	164.7	310.1	42.4	0.188 **	559.6	0.294	0.554	0.151	0.706
	Japan	413.3	239.9	-74.8	-0.238 ***	503.6	0.821	0.476	-0.297	0.179
	Germany	463.1	369.3	-4.6	-0.011	823.1	0.563	0.449	-0.011	0.437
	England	139.0	436.7	33.9	0.138	643.4	0.216	0.679	0.105	0.784
	France	397.6	380.0	-64.2	-0.165*	649.1	0.613	0.585	-0.198	0.387
	Singapore	1009.3	169.5	-213.3	-0.516 ***	752.2	1.342	0.225	-0.567	-0.342
	Hong Kong	884.7	310.8	-231.6	-0.442 ***	732.3	1.208	0.424	-0.633	-0.208
	Korea	2092.2	-	-		2092.2	1.000			0.000
(B)90.1-97.12	US	139.4	35.8	15.4	0.218 **	205.9	0.677	0.174	0.149	0.323
	Japan	403.2	114.5	-82.9	-0.386 ***	351.8	1.146	0.325	-0.471	-0.146
	Germany	405.6	125.1	-82.2	-0.365 ***	366.4	1.107	0.342	-0.449	-0.107
	England	122.7	168.4	-50.2	-0.349 ***	190.8	0.643	0.883	-0.526	0.357
	France	257.6	131.5	-78.1	-0.425 ***	232.7	1.107	0.565	-0.672	-0.107
	Singapore	348.2	28.4	-34.0	-0.342 ***	308.6	1.128	0.092	-0.220	-0.128
	Hong Kong	594.3	36.1	17.6	0.120	665.6	0.893	0.054	0.053	0.107
	Korea	463.3	-	-		463.3	1.000			0.000

Table 1 (continue) Decomposition of the Volatility of Stock Market Returns in Korean Won (1990.1- 2001.6) [1]

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		$Var(R_i)$	$Var(e_i)$	$Cov(R_i, e_i)$	$Cor(R_i, e_i)$ [2]	Sum	(1)/(5)	(2)/(5)	2*(3)/(5)	(7)+(8)
(C) 98.1-01.6	US	221.9	894.9	98.3	0.221	1313.4	0.169	0.681	0.150	0.831
	Japan	436.0	500.5	-59.9	-0.128	816.7	0.534	0.613	-0.147	0.466
	Germany	559.3	927.3	173.9	0.241	1834.4	0.305	0.505	0.190	0.695
	England	175.1	1038.0	229.4	0.538***	1671.9	0.105	0.621	0.274	0.895
	France	436.6	948.1	-30.2	-0.047	1324.3	0.330	0.716	-0.046	0.670
	Singapore	2518.9	487.0	-620.4	-0.560***	1765.2	1.427	0.276	-0.703	-0.427
	Hong Kong	1398.5	899.6	-724.7	-0.646***	848.8	1.648	1.060	-1.707	-0.648
	Korea	5661.8	-	-		5661.8	1.000			0.000

1) The variances and covariances of columns (1)~(3) , (5) are stated in terms of squared percentages

2) Correlation coefficient is significantly different from zero at the 1, 5, 10% levels, noted respectively ***, **, *

Generally under the bivariate normal distribution, the hypothesis test for correlation between variables is done by calculating

T-statistics $T = \sqrt{(n-2)} \; * \; \frac{r}{\sqrt{(1-r^2)}}$ where r is the sample correlation coefficient and n is the number of sample in sampling

Null hypothesis	alternative hypothesis	critical region at significant level α
$Ho: \rho = 0$	$H1: \rho \neq 0$	$\lvert T \rvert \geq t(n-2, \frac{\alpha}{2})$

The preceding analysis can be extended to the portfolio context. The variance of Won portfolio returns, $R_{i₩}$, can be written as follows. [9]

$$\mathrm{Var}(R_{i₩}) = \sum_i \sum_j X_i X_j \,\mathrm{cov}(R_i, R_j) + \sum_i \sum_j X_i X_j \,\mathrm{cov}(e_i, e_j) + 2 \sum_i \sum_j X_i X_j \,\mathrm{cov}(R_i, e_j) \quad (4)$$

where X_i represents the fraction of wealth invested in the i^{th} stock market. And the terms of the overall portfolio risk in equation (4) in a sequence mean the covariances among the local stock market returns, the covariances among the exchange rate changes, and the covariances among the local stock market returns and the exchange rates. The exchange rate change contribute to the portfolio risk via the second and third terms of the equation(4). If the exchange rates correlations and the stock/exchange market cross-correlations are largely positive(negative), then exchange rate changes will increase(decrease) the portfolio risk.

Table 2 provides the stock market correlation and the exchange rate market correlations and the cross correlation of the stock market and exchange market calculated using the monthly sample data period of 1990.1 through 2001.6. Stock markets such as S&P 500, Dax 30, FTSE 100, CAC 40 shows the high correlation among themselves, but they represents lower correlation in relation with the Asian stock markets including the Nikkei 225, Hang Seng, Singapore

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[9] Ibid.: p 200

stock market as well as Korea. Especially the stock market correlation between Singapore and other markets except Japan are around negative zero. And the cross correlation of the Singapore stock market and other exchange rate market except Japanese Yen are negative, which means when Singapore stock market advances in price the Korean won typically appreciates in value against other currencies and these low or negative pair wise correlations are sources of the gain from international portfolio investment. Correlations during the sample period of 1990.1 through 1997.12, and 1998.1 through 2001.6 are attached in appendix 1-1, 1-2.

Table 2 also shows that the correlations are much higher among the exchange rate changes than among the stock market returns. In fact, the average correlation is 0.831 for the exchange rate changes, compared with 0.324 for the local stock market returns. This implies that much of the exchange risk is non-diversifiable, while the local stock market risk can be diversified away to a large extent.[10]

The effects of exchange rate volatility can be clearly demonstrated by constructing an equally weighed portfolio. Table 3 shows that the $Var(R_{iW})$ of the portfolio is decomposed in according to equation(4), during the total sample period, a pre-crisis period and post-crisis period respectively.

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[10] Ibid.: p 202
Adler and Simon, "Exchange Risk surprises in International Portfolio,", *Journal of Portfolio Management,* 12 (Winter 1986), pp. 44-53

Table 2. Correlation matrices of 8 stock market returns and their respective exchange rate changes in 8 major countries (1990.1-2001.6)

	S&P 500	NIKKEI 225	DAX 30	FTSE 100	CAC 40	SINGA-PORE	HANG SENG	KOREA	WON	YEN/U$	DM/U$	U$/GBP	FRC/U$	SP$/U$	HK$/U$
S&P 500	1.00														
NIKKEI 225	0.35	1.00													
DAX 30	0.79	0.27	1.00												
FTSE 100	0.93	0.31	0.84	1.00											
CAC 40	0.81	0.30	0.92	0.82	1.00										
SINGAPORE	−0.04	0.58	−0.04	−0.02	−0.04	1.00									
HANG SENG	0.24	0.44	0.22	0.30	0.23	0.66	1.00								
KOREA	−0.29	0.45	−0.39	−0.34	−0.30	0.77	0.29	1.00							
WON	0.85	0.25	0.78	0.88	0.78	−0.16	0.16	−0.46	1.00						
YEN/U$	0.55	0.48	0.48	0.64	0.53	0.13	0.31	−0.05	0.72	1.00					
DM/U$	0.58	0.02	0.66	0.71	0.62	−0.23	−0.03	−0.49	0.81	0.65	1.00				
U$/GBP	0.74	0.12	0.78	0.89	0.75	−0.18	0.14	−0.47	0.90	0.65	0.87	1.00			
FRC/U$	0.59	0.02	0.67	0.72	0.64	−0.23	−0.01	−0.50	0.82	0.63	1.00	0.88	1.00		
SP$/U$	0.67	0.15	0.70	0.81	0.64	−0.12	0.20	−0.51	0.90	0.72	0.90	0.91	0.90	1.00	
HK$/U$	0.84	0.25	0.78	0.88	0.78	−0.16	0.17	−0.47	1.00	0.72	0.81	0.90	0.82	0.91	1.00

Table 3. Decomposition of variances with the equally weighted portfolios

Component	1990.1 ~ 2001.6	1990.1 ~ 1997.12	1998.1 ~ 2001.6
$\sum_i \sum_j X_i X_j \operatorname{cov}(R_i, R_j)$	18736.5 (72.0%)	6818.6 (29.2%)	43791.1 (142.3%)
$\sum_i \sum_j X_i X_j \operatorname{cov}(e_i, e_j)$	12668.2 (48.7%)	12759.8 (54.7%)	5317.3 (17.3%)
$2\sum_i \sum_j X_i X_j \operatorname{cov}(R_i, e_j)$	-5385.8 (-20.7%)	3737.4 (16.0%)	-18335 (-59.6%)
$Var(R_{iw})$	26019.1 (100.0%)	23315.7 (100.0%)	30773.5 (100.0%)

* The portfolio variances are computed, under the assumption of the equally weighted portfolio by using the monthly percentage returns. The relative contribution of the individual components to the total portfolio risk appears in parenthesis in respective sample periods .

The results of decomposition of variances of 3 respective periods are quite different. The fluctuating exchange accounts for positive 70% during the stable period before the crisis. Contrary to that, it contributed to negative 42.3% during the post crisis. During the whole sample period 1990.1 through 2001.6, the exchange rate change accounts for 48.7% through its own covariance, but negative 20.7% through its cross-covariance with stock market returns. Even though the total effect of exchange rate volatility is 28%, quite lower than the stock market returns, the exchange rate volatility influences quite strongly to the international portfolio returns.

2. Hedging Strategies[11]

As we see in the preceding analysis, the correlations among the exchange rate changes are so high, 0.831 among the currencies, but between stock returns, still room for diversification, during sample period 1990.1-2001.6. Therefore, it could not be much diversifiable to a large extent because of multi-collinearity and, as a result, substantially increases the overall risk of the portfolio. Therefore, we need to consider the use of exchange forward contracts for the risk hedging. In this paper, I will test 5 ex post hedging methods.[12]

A. Joint Portfolio Optimization

A joint portfolio optimization over the N stock markets and their respective N−1 currencies results in a $(2N-1) \times 1$ investment weight vector $\underline{X}$, where the elements X_i, i = 1, 2, ..., N, represents the optimal investment weights

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11 Eun and Resnick, "Exchange Rate Uncertainty, Forward Contracts, and International Portfolio Selection", *the Journal of Finance,* Vol. 9, 1988, pp. 199-204

____________, "International Diversification of Investment Portfolios," *Management Science,* Vol. 40, No. 1, January 1994, pp.146-147

Larsen and Resnick, "The Optimal Construction of Equity Portfolios," *European Financial Management,* Vol. 6, No. 4, 2000, pp. 483-484

12 Larsen and Resnick, "The Optimal Construction of Equity Portfolios," *European Financial Management,* Vol. 6, No. 4, 2000, pp. 483-485

Phillippe Jorion, "Mean/Variance Analysis of Currency Overlays," *Financial Anaysts Journal,* May-June 1994, pp 48-56 for the N stock markets(i = N denotes the Korean stock market) and the elements X_{N+i}, i = 1, 2, ..., N−1, are the optimal currency investment weights for the N−1 forward FX currency positions. The joint portfolio optimization is a quadratic programming problem that can be stated as:

$$\text{Maximize} \quad \frac{\underline{X}^T \underline{\mu}}{\underline{X}^T V \underline{X}} \qquad (5)$$

$$\text{Subject to : } \quad \Sigma X_i = 1, \quad \text{and} \quad X_i \geq 0, \qquad \text{for } i = 1, 2, \ldots, N$$

$$\text{and} \quad -X_i \leq X_{N+i}, \qquad \text{for } i = 1, 2, \ldots, N-1$$

where a bar under a variable symbol denotes a vector and $\underline{\mu}$ is (2N−1) × 1 vector of expected excess returns on the N stock markets, each defined by equation :

$$E(R_{i₩,t+1}) - R_{f,₩} \qquad (6)$$

And the N−1 forward foreign exchange contracts, each stated as $E(f^1_{i,t+1}) - R_{f,₩}$. V is the (2N−1) (2N−1) variance and covariance matrix of returns of the 2N−1 assets. Also, let's assume that the optimization problem realistically allows a short position in a currency only up to the amount of long position in their respective corresponding stock market. Long positions in foreign exchange contracts are also allowed.

B. Partial Portfolio Optimization

Under partial portfolio optimization, an optimal portfolio of stocks is predetermined without regard to hedges, and an optimal portfolio of forward foreign exchange contracts are then determined under the condition on predetermined underlying asset position. Each optimization is structured as a quadratic programming problem. This two-stage optimization can be represented as:

$$\text{Maximize} \quad \frac{\underline{X}^T{}_s \, \underline{\mu}_s}{\underline{X}^T{}_s \, V_{ss} \, \underline{X}_s} \tag{7}$$

Subject to : $\Sigma X_i = 1$, and $X_i \geq 0$, for $i = 1, 2, \ldots, N$

$$\text{And} \quad \text{Maximize} \quad \frac{\underline{X}^T{}_f \, \underline{\mu}_f}{\underline{X}^T{}_f \, V_{ff} \, \underline{X}_f} \tag{8}$$

Subject to : $\underline{X}_f = \text{argmax} \dfrac{\underline{X}^T{}_f \, \underline{\mu}_f}{\underline{X}^T{}_f \, V_{ff} \, \underline{X}_f}$, given predetermined X_s

C. Separate Portfolio Optimization

Under separate portfolio optimization, an optimal portfolio of stocks and an optimal portfolio of forward foreign exchange contracts are separately created. Each optimization is structured as a quadratic programming problem. This two-stage optimization can be represented as:

$$\text{Maximize} \quad \frac{\underline{X}^T_s \; \underline{\mu}_s}{\underline{X}^T_s \; V_{ss} \; \underline{X}_s} \tag{9}$$

Subject to : $\Sigma X_i = 1$, and $X_i \geq 0$, for $i = 1, 2, \ldots, N$

$$\text{And} \quad \text{Maximize} \quad \frac{\underline{X}^T_f \; \underline{\mu}_f}{\underline{X}^T_f \; V_{ff} \; \underline{X}_f} \tag{10}$$

Subject to : $-X_i \leq X_{N+i}$, for $i = 1, 2, \ldots, N-1$

Where Xs is a subset of $\underline{X}$ containing the optimal investment weights for the N stock markets and $\underline{X}_f$ is a subset of $\underline{X}$ containing the optimal currency investment weights for the N – 1 forward foreign exchange contracts. The vector $\underline{\mu}_s$ is a sub set of $\underline{\mu}$ containing the expected excess returns on the N stock markets, each defined by equation(6), $\underline{\mu}_f$ is a subset of containing the N-1 expected excess currency returns, each stated as $E(f^1_{i,t+1}) - R_{f,W}$, V_{ss} is the variance-covariance matrix of stock market returns, and V_{ff} is the (N-1)$\times$(N-1) variance-covariance matrix of forward FX returns. Note that the correlation structure among the stock markets and the forward contracts does not enter into determining the solution set under separate portfolio optimization.

D. Unitary Hedging Strategy

Unitary hedging is a special case of quadratic programming problem (9). Under standard unitary hedging, each of the N-1 forward FX contracts is arbitrarily sold short in the amount of the optimal long positions in the foreign stock market. Thus, $X_{N+i} = -X_i$ for i = 1, 2, ..., N−1. The optimal investment weights for the N stocks will be the same as under separate portfolio optimization

E. Unhedged Investment Strategy

Unhedged investment can also be presented as a special case of quadratic programming problem (9, 10). When it is arbitrarily decided not to hedge the exchange rate risk from investing in foreign sock markets, $X_{n+i} = 0$ for i=1,...,N-1. The optimal investment weight vector for the stock markets will again be the same as under separate portfolio optimization.

F. Local Currency Return Unitary Hedging Strategy (LCR)

The hedged return for a Won investor investing in the i^{th} foreign market as :

$$R^H_{iW,t+1} = R_{iW,t+1} - h f^1_{i,t+1}, \tag{11}$$

where the hedge ratio $h_i = -\dfrac{X_{N+i}}{X_{i,t}}$, the return on a long position in a forward contract written on currency i with price $F_{i,t}$ at time t , $f^1_{i,t+1} = \dfrac{(S_{i,t+1} - F_{i,t})}{S_{i,t}}$

Substituting equation(1) into equation (11) when h_i=1 results in

$$R^H_{iW,t+1} = R_{i,t+1} + e_{i,t+1} + R_{i,t+1}\, e_{i,t+1} - f^1_{i,t+1}, \tag{12a}$$

$$R^H_{iW,t+1} = R_{i,t+1} + R_{i,t+1}\, e_{i,t+1} + f^2_{i,t+1} \tag{12b}$$

where $f^{2}_{i,t+1} = \frac{(F_{i,t} - S_{i,t})}{S_{i,t}}$ is the forward exchange premium. Because the second term in equation (12b) will be small in magnitude, the following approximation results for the expected hedged return in excess of the risk-free rate:

$$E(R^{H}_{i₩,t+1}) - R_{f,s} \doteqdot E(R_{i,t+1}) + f^{2}_{i,t+1} - R_{f,s} \qquad (13)$$

Equation(13) is the basis of the unitary hedging strategy developed by Eun and Resnick (1988, 1994). Note, that equation (13) implicitly incorporates into the expected excess hedged return for the stock market with a hedge ratio of unity. In Eun and Resnick(1988, 1994), the value in equation(13) is not an expectation but rather the market-determined forward premium. They recommend the following quadratic programming problem for identifying the optimal investment weight vector for the N stock markets:

$$\text{Maximize} \quad \frac{\underline{X}^{T}_{s}\ \underline{\mu}_{s}^{H}}{\underline{X}^{T}_{s}\ V_{ss}\ \underline{X}_{s}} \qquad (14)$$

Subject to : $\Sigma\ X_i = 1$, and $X_i \geq 0$, for $i = 1, 2, \ldots, N$

where $\underline{\mu_s}^{H}$ is the (N×1) vector containing the expected hedged excess returns defined by the RHS of equation(13). As will be noted in the next section, Vss in programming problem (14) is calculated from local currency returns. Hence, we call this method the local currency (LCR) unitary hedging strategy.

There is an important difference between constructing hedged portfolios using the LCR unitary hedging strategy and the standard unitary hedging strategy. Under the unitary hedging strategy, the ex ante optimal stock investment weights are first weights are first estimated using $\underline{\mu_S}$ and then currency weights are set equal to their negative, i.e. , $X_{N+i} = -X_i$ for i = 1, 2, ..., N–1. On the other hand, LCR unitary hedging strategy implicitly incorporates the hedge ratio into the stock market expected return vector. That is, it is recognized in advance that the hedge ratio will be unity. Thus, the ex ante optimal stock investment weight vector is estimated using the expected excess return vector $\underline{\mu_S}^H$.

3. Alternative Ex Ante Portfolio Strategies[13]

The ex ante international portfolio strategy generally means the efficient international portfolio strategy that is capable of capturing the potential gains available from international diversification as much as possible by controlling both estimation risk and exchange rate uncertainty in the portfolio selection.

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13 Eun and Resnick, "Exchange Rate Uncertainty, Forward Contracts, and International Portfolio Selection", *the Journal of Finance,* Vol. 9, 1988, pp. 202-210

____________, "International Diversification of Investment Portfolios," *Management Science,* Vol. 40, No. 1, January 1994, pp.147-148

Larsen and Resnick, "The Optimal Construction of Equity Portfolios," *European Financial Management,* Vol. 6, No. 4, 2000, pp. 484-487

The ex ante international portfolio strategies both with and without forward exchange hedging are developed by Jobson and Korkie (1980, 1981), Jorion(1985, 1986) and extended by Eun and Resnick (1988, 1994).

Let us examine the unhedged strategies first, using the expected return equation

$$\underline{\mu_s} = (1-w)\,\underline{Y} + w\,\underline{1}\,Y_o - R_{f,w}\,\underline{1} \qquad (15)$$

where $\underline{Y}$ is the $N \times 1$ ex post (historical) sample mean-return vector of N assets, $\underline{1}$ is a vector of ones, Y_o denotes the mean return from the ex post minimum-variance portfolio, and w represents the estimated shrinkage factor for shrinking the elements of $\underline{Y}$ toward Y_o.

Equation (15) is a Bayes-Stein expression derived by Jorion for estimating the ex ante expected-return vector to use in solving the portfolio problem. It is, however, general enough to encompass other models. If $w = 0$, the resulting vector of estimated expected returns is the ex post classical sample means. This method implicitly assumes no estimation risk in the classical sample estimates and is labeled the certainty-equivalence-tangency (CET) portfolio strategy. A second strategy is arbitrarily set with $w = 1$. This strategy identifies the optimal ex ante investment weights as those of the ex post minimum-variance portfolio (MVP). The MVP strategy implicitly assumes that there is no useful asset-specific information in $\underline{Y}$ because it is not required as input to solve the portfolio problem.

A third method is the Bayes-Stein strategy developed by Jorion, which uniquely estimates the shrinkage factor according to the equation:

$$w = \frac{(N+2)(T-1)}{(N+2)(T-1) + (Y - Y_0 \underline{1})' T V^{-1}_{ss} (T - N - 2) \ (Y - Y_0 \underline{1})} \qquad (16)$$

where 'T' represents the length of the time series of the sample observations and V_{ss} is as defined before. Using Jorion's w in equation (15), the Bayes-Stein (BST) optimal ex ante tangency portfolio can be determined. Equation (15) can potentially result in a uniform improvement on the ex post classical sample mean $\underline{Y}$ or Y_o as estimates of the expected return because it relies on a more general model that includes them as special cases. Whether using the Bayes-Stein estimates in the portfolio problem results in a more efficient ex ante optimal portfolio or not is an empirical question.

If the investor selects an unhedged strategy, realized returns are defined by Equation (1b). To implement either the CET, MVP or the BST strategy requires obtaining a historical time series sample of 'Won' returns, $R_{iW,\,t+1}$ (i = 1, 2, ..., N) to calculate the Y, Y_o, V_{ss}, and w needed for Equation 15 and 16.

If the investor selects a hedged (H) strategy such as the joint optimization strategy, the separate optimization strategy, partial optimization strategy, or the standard unitary strategy, realized returns are defined by the equation (11). The expected excess vector returns, $\underline{\mu}_s$ is estimated the same as for unhedged investment by equation (15), and $\underline{\mu}_f$ is estimated analogously.

If, however, the LCR unitary strategy is used, the ex ante expected excess return vector is estimated as :

$$\underline{\mu}_s^H = R + f^2 - R_{f,w}\underline{1} \tag{17}$$

$$\underline{\mu}_s^H = (1-w)\,\underline{Y} + w\,\underline{1}\,Y_o + f^2 - R_{f,w}\underline{1} \tag{17a}$$

where $\underline{Y}$, Y_o, V_{ss}, and w, and thus $\underline{R}$, are calculated from a historical time series of local currency returns R_i (i=1,….,N) The vector f^2 is not estimated from historical data but rather contains as elements the current market-determined forward exchange premiums. When the LCR unitary hedging strategy is used, realized returns are defined by Equation (12b).

III. EMPIRICAL RESULTS

1. Data and Test Structure

In this paper, I use monthly stock indexes of 8 major markets such as United States, United Kingdom, France, Germany, Japan, Hong Kong, Singapore, Korea for asset return data, and its respective currency spot and 1 year forward exchange rates for the exchange rate. The data series for stock indices and exchange rates are provided for the period from January 1990 through June 2001. The tests are examined from the perspective of the Korea Won investors.

I assume a 12-month investment holding and hedging period to evaluate the performance of strategies. The historical time series of the forward risk rate, $f^1_{t,\,t+1}$, using 12-month forward contracts are calculated as of the inception date of the holding period from spot and 12-month forward exchanges obtained from Datastream International. Similarly, 12-month forward contracts are also used to calculate the forward risk premiums, $f^2_{t,\,t+1}$. [14]

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14. (A) Data series of won-dollar Forward exchange rate are available only after 1997 and therefore, the pre-1997 forward rate data are estimated by using the interest rate parity method.

$$\text{Forward premium} \quad f_i = \frac{(1+r_w)}{(1+r_i)} - 1$$

The performance results for each strategy are examined for 33 out-of-sample overlapping holding periods. For each test, 60 corresponding monthly returns for each of the 8 stock indices and 7 forward exchange rates are used to estimate the input parameters to solve the ex ante optimal investment weights for each investment strategy. For example, to evaluate the first holding period covering months 61 through 72, the estimation period covers 1 through 60. For the second holding period covering months 63 through 74, the estimation period covers 3 through 62. Each subsequent pair of estimation and holding period is shifted forward in time by 2 months. The performance of each strategy over the holding periods is measured by the Sharpe reward-to-variability ratio, $\frac{E(R_p) - R_f}{\sigma_p}$. And the dominance analysis is also performed, which shows the number of times out of the 33 out-of-sample holding periods that one strategy has a larger shape ratio than each other strategy.

$$\text{Forward rate } F_i = (1+f_i)\, S_i = \frac{(1+r_w)}{(1+r_i)} * \text{Won/\$}$$

The data sources as follows.

o 1990.1 – 1996 : Theoretical forward rate calculated by the interest rate parity

o 1997.1 – 1998.12 : Prebon Yamane(Hong Kong)

o 1999.1 – 2001.6 : Bloomberg

(B) The DM and the France Franc forward rate are not available after January 1999 by establishing the European Union, either. So the post 1999 data are estimated by using their spot rates and Euro 1-year forward rate.

2. Test Results

A. the Average Performance Results

Table 4 panel A presents the average performance results from the 33 out-of sample holding periods, composed of 18 pre-crisis periods and 15 post-crisis periods, by using the various ex ante investment strategies stated before in chapter II-3. For each strategy, the table shows the average portfolio mean return and standard deviation in percent per 1 year and the Sharpe reward-to-variability ratio. In conducting the Sharpe tests, the risk free rate is assumed to be zero (Larsen and Resnick, 2000).[15]

For comparison purposes, Table 5 presents the investment in the only Korean stock market yielded an average return rate of 5.16%, an average standard deviation of return 65.1% per year, and the average of Sharpe reward-to-variability ratio 0.08 over the 33 out-of-sample tests. The corresponding numbers for the pre-crisis period are –23.12%, 33.8%, and –0.68. For the post-crisis period, they are 39.09%, 89.1%, and 0.44. Korean Monetary Stability Bond for 1 year,

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15 The risk free rate is assumed to be zero in calculating the ex ante optimal investment weights for each strategy and the resulting Sharpe ratio in this paper. Because a positive risk-free rate locates the tangency portfolio higher up on the efficient frontier, where fewer assets are likely to make up the optimal portfolio. Using an assumed zero rate leads to a conservative measure of the effects of estimation risk on all assets. Eun and Resnick (1988, 1994), Larsen and Resnick(2000) also assumed a zero risk free rate.

Table 4 Average Performance Results of the Various Ex Ante Investment Strategy[1)]

A. Sample Period : The whole Sample periods (1995.1 – 2000.6)

		Unhedged	Separate	Partial	Joint	Unitary	LCU
MVP	Mean	28.50	28.50	29.31	20.17	22.98	22.86
	S.D.	9.15	9.15	8.20	4.42	14.91	7.15
	SHP	4.10	4.10	4.54	7.00	1.79	3.39
CET	Mean	28.03	29.81	30.32	28.21	27.71	23.02
	S.D.	10.42	10.44	11.49	7.16	18.43	7.69
	SHP	3.76	4.01	4.16	4.80	2.15	3.23
BST	Mean	28.25	29.78	30.84	28.51	27.54	22.97
	S.D.	10.28	10.71	11.50	7.12	18.17	7.66
	SHP	3.82	3.99	4.19	5.02	2.15	3.24

B. Sample Period : Pre crisis period (1995.1 – 1997.12)

		Unhedged	Separate	Partial	Joint	Unitary	LCU
MVP	Mean	30.92	30.92	31.97	27.73	21.27	23.68
	S.D.	6.14	6.14	5.74	2.74	8.67	6.94
	SHP	5.22	5.22	5.79	11.13	2.09	3.38
CET	Mean	34.58	37.84	38.84	40.79	37.07	24.73
	S.D.	6.72	6.76	7.26	5.61	9.27	7.21
	SHP	5.50	5.95	6.30	7.02	3.41	3.42
BST	Mean	34.63	37.20	39.39	41.65	36.33	24.56
	S.D.	6.60	6.70	7.44	5.78	9.24	7.18
	SHP	5.55	5.86	6.30	7.31	3.37	3.40

C. Sample Period : Post crisis period (1998.1 – 2000.6)

		Unhedged	Separate	Partial	Joint	Unitary	LCU
MVP	Mean	30.96	30.96	31.54	13.85	30.06	27.12
	S.D.	11.84	11.84	10.38	6.19	20.98	7.35
	SHP	3.26	3.26	3.61	2.48	1.68	4.16
CET	Mean	23.74	23.74	23.37	16.02	20.54	25.96
	S.D.	14.16	14.16	15.70	8.46	29.26	8.26
	SHP	1.96	1.96	1.84	2.53	0.79	3.69
BST	Mean	24.22	24.45	23.93	15.60	21.14	26.05
	S.D.	13.97	14.71	15.48	8.13	28.66	8.24
	SHP	2.05	2.03	1.92	2.68	0.83	3.72

1. Each cell is the average of 33 out-of-sample test periods. SHP means Sharpe ratio.

Table 5. Average Performance Results in Korean Markets

Evaluation period	Mean	S.D.	Sharpe Ratio	Risk [1] Free rate
Total period	5.16	65.1	0.08	10.14
Pre-crisis [2]	-23.12	33.8	-0.68	12.50
Post-crisis [2]	39.09	89.1	0.44	7.31

1. 1-year base Korean Monetary stability bond
2. Periods are separated by investment timing criterion.
   The last investment point in the pre crisis periods is 1997.11

I select it as risk free financial product, yields respectively average return rate of 9.38%, 12.50%, and 7.31% for the same corresponding evaluation periods. Examination of Table 4 and Table 5 shows that every international portfolio strategy provides superior performance to investment only in Korean stock market, regardless of hedging or time periods, in terms of average Sharpe ratio

First, consider the performance of the unhedged strategies. The 3 ex ante strategies that controls the estimation risk such as CET(3.76), MVP(4.10), BST(3.82) outperform 40-50 times more than the only Korean stock market portfolio strategy(0.08). However, in the post crisis period, the gap between them is largely decreased, but the unhedged strategies(CET 1.96, MVP 3.26, BST 2.05) still outperform more than 4 times than Korean stock market(0.44).

Second, when the unhedged strategies and hedging strategies which are designed to control exchange risk as well as estimation risk, are compared, some hedging strategies such as separate strategy, partial strategy, joint strategy outperform the unhedged strategies, while unitary hedging strategy and local currency return unitary hedging strategy are beated by the unhedged strategies during the evaluation sample period. Especially the joint strategies(CET 4.80, MVP 7.00, BST 5.02) yield superior average performance to all other hedged and unhedged strategies.

However, Table 4 panel B and C show that the results are inconsistent across two sub-periods of pre crisis(1995.1-1997.12) and post crisis period(1998.1-2000.6). In a pre-crisis period under the stable exchange rate, the joint strategies(CET 7.02, MVP 11.13, BST 7.31) are the best optimal portfolio of all strategies including LCR unitary hedging strategy. These results are quite different from those of Larsen and Resnick(2000), where LCR unitary hedging strategy yields superior average performance to other hedged and unhedged strategies. In contrast to pre- crisis period, the results of a post-crisis period under the fluctuating exchange rate show that LCR strategies (CET 3.69, MVP 4.16, BST 3.72) are the best strategies of all the strategies. And the Joint strategy is also good strategy, second best here. These results mean that the best strategy is joint hedging strategy during exchange rate stable periods, while LCR strategies during the high exchange volatility period from the perspective of Korean investors.

B. Dominance Analysis

The average performance results presented in Table 4 indicate that the joint hedging strategy is the best strategy of all the strategy from the perspective of the Korean investors over 1995.1-2000.6 investment holding periods. When periods are divided into pre crisis and post crisis period, and it shows that joint strategy is superior in a pre 1997 while the LCR unitary hedging strategy is more beneficial in a post 1997.

However, the above average performance results do not show clear discrimination among the various strategies. So, a dominance analysis will clearly show discrimination among them. Table 6 presents a dominance analysis comparing all investment strategies under each parameter estimation technique versus unhedged strategies. The each number in Table 6 denotes the number of times out of the 33 out-of-sample holding periods that the row strategy has a larger Sharpe reward-to-variability ratio than the strategy at the top of the table.

Also it shows the Jobson and Korkie's Z-test for performance whether the Sharpe performance measure is a statistically significantly different from that of another portfolio strategy. Unfortunately this test is not powerful the test is not powerful because only 12-monthly observations are small samples used here.

Table 6. Dominance analysis of the out of-sample performance of the ex ante investment strategies versus unhedged investments

		MVP	CET	BST
Joint	MVP	20(12/7)	20(14/6)	20(13/6)
	CET	21(12/7)	21(15/2)	20(14/3)
	BST	21(11/6)	24(14/2)	22(14/2)
LCR	MVP	18(9/12)	17(13/11)	17(12/11)
	CET	16(7/10)	16(12/9)	16(12/9)
	BST	16(7/9)	16(12/9)	16(12/9)
Partial	MVP	23(11/6)	24(20/9)	24(19/9)
	CET	15(8/7)	17(10/6)	16(10/8)
	BST	16(8/7)	19(10/5)	17(10/6)
Separate	MVP	14(0/0)	14(11/5)	13(9/6)
	CET	18(8/8)	16(5/2)	17(5/2)
	BST	16(9/9)	22(8/4)	17(7/4)
Unhedged	MVP	0(0/0)	14(11/5)	13(9/6)
	CET	19(5/11)	0(0/0)	17(0/13)
	BST	20(6/9)	16(13/0)	0(0/0)
Unitary	MVP	6(3/25)	3(2/20)	3(2/20)
	CET	9(3/12)	8(2/15)	8(2/15)
	BST	9(3/12)	8(2/15)	7(2/15)

Note : A number in the table represents the number of times, out of 33 ex ante test periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 17 out of the 33 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

Table 6 indicates that all the joint hedging strategies and LCR-MVP, partial-MVP strategies only dominates the unhedged strategies no matter how the parameter inputs are estimated. I also find the similar results in the Jobson and Korkie's Z-test at the two-tailed 5% significance level, in case of the joint hedging strategies and LCR-MVP, Partial-MVP.[16] But simple unitary hedging method is dominated by the unhedged strategy no matter what the input parameter is, and especially Unitary-MVP is significantly statistically dominated by the unhedged international portfolio investment.

Appendices 2-1, 2-2 indicate that the results are quite different between pre-crisis period and post-crisis period. In a pre-crisis period, all the Joint hedging strategies and Partial-MVP, BST, Separate CET & BST dominate the unhedged strategies, but others are similar or inferior to the unhedged strategy no matter

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16 Jobson and Korkie(1981) derive a Z-statistic $Z = \frac{Sh}{\sqrt{\theta}}$ for statistically comparing the Sharpe performance measures of two portfolios i and n, where

$Sh = \sigma_n r_i - r_n \sigma_i$ (the transformed difference for Sharpe measure)

$$\theta = \frac{(\sigma_i^2 * \sigma_n^2)}{T} \left[2(1-\rho_{in}) + 0.5\left\{\frac{r_i^2}{\sigma_i^2} + \frac{r_n^2}{\sigma_n^2} - \frac{r_i r_n}{\sigma_i \sigma_n}(1+\rho_{in}^2)\right\}\right]$$

r = sample portfolio mean return,

σ = sample portfolio standard deviation of returns,

ρ_{in} = sample correlation coefficient of returns between portfolios i and n,

T = length of sample time series of returns.

what input parameter are. Especially Joint-CET, BST and Partial-MVP dominate the unhedged strategies in the Jobson and Korkie's Z-test at the two-tailed 5% significance level. But in a post 1997, all the LCR unitary hedging strategies and Partial-MVP, Separate MVP dominate the unhedged strategies, but the Joint strategies are similar or inferior to the unhedged strategy no matter what input parameter are estimated. Especially all the LCR and Partial-MVP, Separate-MVP strategies except relating to the unhedged-MVP strategy also dominate the unhedged strategies in the Jobson and Korkie's Z-test at the two-tailed 5% significance level.

The main reason seems originated from the correlation between asset return and exchange rate change in the portfolio. Table 3 as seen before indicates that in a post-crisis period the covariance between asset return and exchange rate change accounts for negative 60% which is 3 times larger than the variance of exchange rate(positive 17%), while in a pre-crisis period, positive 16% of total portfolio.

Table 7 presents a dominance analysis with comparing joint hedging strategies versus all investment strategies under each parameter estimation technique, out of the 33 out-of-sample holding periods. It indicates clearly that the joint hedging strategies dominate all other strategies no matter how the parameter inputs are estimated. It also shows that the joint hedging strategies are also superior to the other strategies in the Jobson and Korkie's Z-test at the two-tailed 5% significance level, even though the Z-statistic has lower power in small samples. Appendices 2-3, 2-4 show that there is a great difference between pre-crisis period results and post-crisis period results. In a pre-crisis period, all the joint hedging strategies dominate all other strategies including LCR unitary hedging. But in a post-crisis, all the joint strategies are dominated by LCR unitary hedging strategies, and also Joint-MVP is inferior to other strategies excluding simple unitary hedging strategy.

Table 7. Dominance analysis of the out of-sample ex ante performance of the Joint hedging strategies versus the other hedging strategies. [a]

		Joint			LCU			Partial			Separate			Unhedged			Unitary		
		MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST
Joint Strategy	MVP	0	14	14	22	20	20	18	18	18	20	19	18	20	20	20	24	25	25
			(7/3)	(7/4)	(16/8)	(16/8)	(16/8)	(10/8)	(14/6)	(14/6)	(12/7)	(14/6)	(13/6)	(12/7)	(14/6)	(13/6)	(19/3)	(16/3)	(16/3)
	CET	19	0	15	20	21	21	23	23	24	21	21	21	21	21	20	27	26	26
		(3/7)		(0/4)	(10/9)	(11/6)	(11/6)	(8/5)	(12/4)	(12/4)	(12/7)	(12/4)	(12/4)	(12/7)	(15/2)	(14/3)	(23/1)	(24/1)	(24/1)
	BST	19	18	0	20	21	21	23	23	24	21	24	23	21	24	22	28	26	26
		(4/7)	(4/0)		(10/9)	(11/5)	(11/5)	(8/4)	(13/3)	(12/4)	(11/6)	(12/3)	(12/3)	(11/6)	(14/2)	(14/2)	(23/1)	(24/1)	(24/1)

A number in the table represents the number of times, out of 33 ex ante test periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 17 out of the 33 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

IV. CONCLUSION

The main purpose of this paper is to develop ex ante international portfolio selection strategy that can effectively control the exchange rate risk and parameter estimating risk under the fluctuating exchange rate system and capture the gains as much as possible, from the perspective of a Korean investor. The main findings of this paper are as follows.

Firstly, the exchange rate change makes the international investment more risky and aggravates estimation as well, thereby diminishing the gains from the international diversification. In a pre-crisis period, 1990.1 through 1997.12, the exchange rate volatility explains 70% of the total portfolio variances while in a post-crisis, 1998.1-2001.6 it contributed to negative 42.3%. In this sense, the exchange forward contracts should be used for the exchange rate risk hedging in the international portfolio investment.

Secondly, performance results of the alternative hedging and Unhedged strategies in the 33 out-of-sample holding periods during the 1995.1 through 2001.6 indicate that the Korean investors can actually obtain more substantial gains from international portfolio than the only domestic market, in terms of Sharpe ratio if the estimation risk is controlled by any ex ante methods, i.e., MVP, CET, BST.

Thirdly, among all strategies, the joint strategies yield superior average performance to all other hedging or unhedged strategies over the whole sample periods(1995.1-2001.6), especially the pre-crisis holding periods, which is quite different from the results of Larsen and Resnick(2000), where LCR yields superior average performance to other hedging and unhedged strategies. However, LCR unitary hedging strategies are the best strategies of all the strategies instead of the joint strategies in the post-crisis periods. Even though the joint hedging strategy accounts for the correlations between assets and the currencies, when the exchange rate change dramatically increases or decreases, the LCR unitary hedging strategies are the best strategies because it eliminates the great part of exchange rate volatility in prior to selection of optimal portfolio weight.

In conclusion, from the perspective of a Korean investor, first he or she has to recognize and predict the degree of exchange rate volatility, then find out the best portfolio strategies. The Joint-MVP strategy is the best strategy during stable exchange rate periods, while LCR-MVP strategies during the high exchange volatility period.

APPENDICES

Appendix 1-1 : Correlation matrices of 8 stock market returns and their respective exchange rate changes in 8 major countries

(Monthly data : 1990.1 through 1997.12)

	S&P 500	NIKKEI 225	DAX 30	FTSE 100	CAC 40	SINGA-PORE	HANG SENG	KOREA	WON	YEN/U$	DM/U$	U$/GBP	FRC/U$	SP$/U$	HK$/U$
S&P 500	1.00														
NIKKEI 225	-0.02	1.00													
DAX 30	0.44	-0.11	1.00												
FTSE 100	0.74	-0.14	0.62	1.00											
CAC 40	0.55	-0.14	0.87	0.72	1.00										
SINGAPORE	-0.12	0.55	0.30	-0.02	0.23	1.00									
HANG SENG	0.23	0.19	0.25	0.36	0.39	0.58	1.00								
KOREA	-0.44	0.63	-0.22	-0.48	-0.39	0.55	0.12	1.00							
WON	0.60	-0.13	0.49	0.70	0.66	-0.05	0.33	-0.51	1.00						
YEN/U$	-0.36	0.16	-0.30	-0.12	-0.18	0.13	0.22	0.24	0.07	1.00					
DM/U$	-0.31	-0.48	0.20	0.02	0.26	-0.23	-0.17	-0.44	0.13	0.18	1.00				
U$/GBP	0.20	-0.43	0.47	0.66	0.53	-0.25	0.11	-0.60	0.60	0.06	0.59	1.00			
FRC/U$	-0.26	-0.48	0.24	0.06	0.30	-0.23	-0.14	-0.46	0.18	0.11	0.99	0.63	1.00		
SP$/U$	-0.07	-0.37	0.27	0.35	0.44	-0.06	0.20	-0.50	0.58	0.32	0.71	0.79	0.72	1.00	
HK$/U$	0.58	-0.14	0.48	0.69	0.66	-0.05	0.35	-0.51	1.00	0.08	0.14	0.61	0.20	0.60	1.00

Appendix 1-2: Correlation matrices of 8 stock market returns and their respective exchange rate changes in 8 major countries

(Monthly data : 1998.1 through 2001.6)

	S&P 500	NIKKEI 225	DAX 30	FTSE 100	CAC 40	SINGAPO	HANG SENG	KOREA	WON	YEN/U$	DM/U$	U$/GBP	FRC/U$	SP$/U$	HK$/U$
S&P 500	1.00														
NIKKEI 225	0.56	1.00													
DAX 30	0.92	0.51	1.00												
FTSE 100	0.99	0.55	0.92	1.00											
CAC 40	0.92	0.53	0.98	0.91	1.00										
SINGAPORE	-0.01	0.63	-0.19	-0.02	-0.14	1.00									
HANG SENG	0.33	0.84	0.26	0.33	0.25	0.81	1.00								
KOREA	-0.31	0.40	-0.49	-0.33	-0.41	0.87	0.51	1.00							
WON	0.92	0.37	0.88	0.94	0.83	-0.18	0.20	-0.53	1.00						
YEN/U$	0.92	0.69	0.84	0.93	0.82	0.13	0.49	-0.20	0.89	1.00					
DM/U$	0.89	0.30	0.84	0.91	0.82	-0.24	0.07	-0.52	0.97	0.86	1.00				
U$/GBP	0.94	0.43	0.90	0.96	0.87	-0.15	0.22	-0.48	0.99	0.91	0.97	1.00			
FRC/U$	0.89	0.30	0.85	0.91	0.82	-0.24	0.08	-0.52	0.97	0.86	1.00	0.98	1.00		
SP$/U$	0.89	0.39	0.86	0.92	0.81	-0.14	0.24	-0.51	0.99	0.90	0.96	0.98	0.96	1.00	
HK$/U$	0.92	0.37	0.88	0.94	0.83	-0.18	0.20	-0.53	1.00	0.89	0.97	0.99	0.97	0.99	1.00

Appendix 2-1 Dominance analysis of the pre-crisis period performance of the ex ante investment strategies versus unhedged investment

		Unhedged		
		MVP	CET	BST
Joint	MVP	14(8/3)	13(8/3)	13(8/3)
	CET	13(10/2)	13(10/2)	12(10/2)
	BST	13(10/2)	13(10/2)	12(10/2)
LCU	MVP	6(3/10)	5(3/8)	5(2/8)
	CET	7(1/7)	5(2/7)	5(2/7)
	BST	7(1/7)	5(2/7)	5(2/7)
Partial	MVP	13(10/5)	13(11/5)	13(10/5)
	CET	9(4/1)	9(6/4)	9(6/4)
	BST	10(4/1)	10(6/4)	9(6/4)
Separate	MVP	7(0/0)	4(2/1)	3(0/2)
	CET	13(5/0)	10(5/2)	10(5/2)
	BST	11(6/2)	12(8/4)	11(7/4)
Unhedged	MVP	0(0/0)	4(2/1)	3(0/2)
	CET	14(1/2)	0(0/0)	10(0/6)
	BST	15(2/0)	8(6/0)	0(0/0)
Unitary	MVP	1(1/17)	1(1/17)	1(1/17)
	CET	3(1/5)	4(1/8)	4(1/8)
	BST	3(1/5)	4(1/8)	3(1/8)

Note : A number in the table represents the number of times, out of 18 ex ante test pre crisis periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 10 out of the 18 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

Appendix 2-2. Dominance analysis of the post-crisis period performance of the ex ante investment strategies versus unhedged investment

		Unhedged		
위기후		MVP	CET	BST
Joint	MVP	6(4/4)	7(6/3)	7(5/3)
	CET	8(2/5)	8(5/0)	8(4/1)
	BST	8(1/4)	11(4/0)	10(4/0)
LCR	MVP	12(6/2)	12(10/3)	12(10/3)
	CET	9(6/3)	11(10/2)	11(10/2)
	BST	9(6/2)	11(10/2)	11(10/2)
Partial	MVP	10(1/1)	11(9/4)	11(9/4)
	CET	6(4/6)	8(4/2)	7(4/4)
	BST	6(4/6)	9(4/1)	8(4/2)
Separate	MVP	7(0/0)	10(9/4)	10(9/4)
	CET	5(3/8)	6(0/0)	7(0/0)
	BST	5(3/7)	10(0/0)	6(0/0)
Unhedged	MVP	0(0/0)	10(9/4)	10(9/4)
	CET	5(4/9)	0(0/0)	7(0/7)
	BST	5(4/9)	8(7/0)	0(0/0)
Unitary	MVP	5(2/8)	2(1/3)	2(1/3)
	CET	6(2/7)	4(1/7)	4(1/7)
	BST	6(2/7)	4(1/7)	4(1/7)

Note : A number in the table represents the number of times, out of 15 ex ante test post crisis periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 8 out of the 15 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

Appendix 2-3. Dominance analysis of the pre 1997 period, 18 out of-sample ex ante performance of the Joint hedging strategies versus the other hedging strategies. [a]

		Joint			LCU			Partial			Separate			Unhedged			Unitary		
		MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST
Joint Strategy	MVP	0	8	8	15	15	15	11	10	10	14	12	11	14	13	13	15	14	14
			(7/3)	(7/3)	(13/3)	(13/3)	(13/3)	(8/4)	(10/3)	(10/3)	(9/3)	(8/3)	(9/2)	(9/3)	(8/3)	(8/3)	(14/2)	(8/0)	(8/0)
	CET	10	0	9	14	14	14	15	13	14	13	13	13	13	13	12	18	15	15
		(3/7)		0	(11/3)	(9/4)	(9/4)	(6/0)	(6/2)	(6/2)	(11/2)	(8/3)	(8/3)	(11/2)	(11/2)	(11/2)	(17/0)	(14/0)	(14/0)
	BST	10	9	18	14	14	14	15	13	14	13	13	13	13	13	12	18	15	15
		(3/7)	(0/0)		(11/3)	(9/4)	(9/4)	(5/0)	(6/2)	(6/2)	(11/2)	(7/3)	(7/3)	(11/2)	(11/2)	(11/2)	(17/0)	(14/0)	(14/0)

[a] A number in the table represents the number of times, out of 18 ex ante test periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 10 out of the 18 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

Appendix 2-4. Dominance analysis of the post 1997 period, 15 out of-sample ex ante performance of the Joint hedging strategies versus the other hedging strategies. [a]

Joint Strategy	Joint			LCU			Partial			Separate			Unhedged			Unitary		
	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST	MVP	CET	BST
MVP	0	6 (1/0)	6 (1/1)	7 (3/5)	5 (3/6)	5 (3/6)	7 (2/5)	8 (6/3)	8 (6/3)	6 (4/4)	7 (6/3)	7 (5/3)	6 (4/4)	7 (6/3)	7 (6/3)	9 (5/1)	11 (9/2)	11 (8/1)
CET	9 (0/1)	0	6 (1/4)	6 (3/5)	7 (2/5)	7 (2/5)	8 (3/5)	10 (6/3)	10 (6/3)	8 (3/5)	8 (6/1)	8 (5/2)	8 (4/4)	8 (5/1)	8 (5/1)	9 (6/1)	11 (10/1)	11 (10/1)
BST	9 (1/1)	9 (4/1)	0	6 (2/5)	7 (2/4)	7 (2/4)	8 (3/4)	10 (7/2)	10 (6/2)	8 (3/4)	11 (6/0)	10 (5/2)	8 (3/4)	11 (5/1)	10 (4/0)	10 (6/1)	11 (10/1)	11 (10/1)

[a] A number in the table represents the number of times, out of 15 ex ante test periods, that the left-hand-side strategy had a larger out-of-sample reward-to-variability ratio than the strategy at the top. A left-hand-side strategy is said to dominate the strategy at the top if it has a larger Sharpe value in at least 8 out of the 15 out-of-sample holding periods. The first number (x of x/y) in a pair of parentheses denotes the number of times that the left-hand side strategy had a statistically significantly larger reward-to-variability ratio than did the strategy at the top at the two-tailed 5% significance level and the second number (y of x/y) denotes the number of times that the left-hand side strategy had a statistically significantly smaller reward-to-variability ratio than did the strategy at the top.

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