Measuring Time-varying Market and Currency Risks with Stochastic Dominance: Evidence from Country Level Stock Returns

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Abstract

In this paper, time-varying market and currency risks among a selected set of developed and emerging economies are compared in terms of stochastic dominance. For this purpose, time-varying exchange rate exposure and market betas are obtained through a multivariate model that explicitly allows for time-varying second moments. Two betas are not assumed to be orthogonal and we explicitly allow for non-orthogonality. The cumulative distribution functions of time-varying betas in the sample indicate that stock returns in emerging economies are more exposed to currency risk, though their exposure to market risk is moderate. On the contrary, the stock returns in developed economies are more exposed to market risk while their exposure to currency risk is remarkably low. There is also evidence to establish the notion that, during the post-currency crisis period, currency risk in Korea is fading out over time.

1. Introduction

The validity of the International Capital Asset Pricing Model (CAPM) has been the subject matter for many research publications during the last few decades. A number of extensions of the CAPM itself have been developed in order to overcome some of its limitations. The International CAPM (ICAPM), one such alternative, suggests that the investments that cross the national borders are not properly explained by the CAPM which does not explicitly take the currency risk into account. With due respect to the fact that there are many versions of the ICAPM, one can outline the ICAPM as a model that explains the return on a certain asset in terms of the covariance between returns and the returns on market portfolio and the covariance between the returns and exchange rate changes[2]. This version of ICAPM with time-varying coefficients is represented by the following equation:

$$E_{t-1}\left(r_{i,t}\right) = \beta_{m,t-1} E_{t-1}\left(r_{m,t}\right) + \beta_{x,t-1} E_{t-1}\left(r_{x,t}\right) \qquad (1)$$

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[2]This version of ICAPM is developed by Adler and Dumas (1983). In extending the CAPM to accommodate cross border investments, Adler and Dumas (1983) use the correlation between inflation in a certain country and the returns on the asset in question. However, if the inflation is assumed to be non-stochastic, then the price difference between two countries mostly stem from the exchange rate differences. This simplification was introduced by Dumas and Solnik (1995). De Santis and Gerard (1998) test the validity of ICAPM using this assumption of non-stochastic inflation.

where $\beta_{m,t-1}$ and $\beta_{x,t-1}$ are market beta and the exchange rate exposure beta, respectively. $\beta_{m,t-1}$ measures the asset's exposure to market risk while $\beta_{x,t-1}$ measures its exposure to currency risk. The intuition is that, while the expected returns on an asset is proportional to market returns and exchange rate changes, depending on the conditioning information that is publicly available at time *t*-1, the proportionality factors (market and exchange rate exposure betas) themselves are also time-varying. In other words, the investors are sensitive to "the new information that periodically becomes available to [them], who then use it to adjust their investment strategies" (Harvey, 1998).

The mean values of time-varying betas are often used to evaluate the market and currency risks of the relevant assets. However, the mean values of time-varying betas are based on only one aspect of the relevant distribution (more specifically, the magnitude of betas). A measure that is based on several aspects of the distribution of time-varying betas would be a more reliable and instructive measure of exposure. Empirical cumulative distribution functions (CDF) of the time-varying market and exchange rate exposure betas are extremely important in this sense. In addition to the magnitudes of betas in a distribution, it also takes into account the probability with which each beta in the distribution would occur. The criterion of stochastic dominance uses CDF as its main analytical tool. In this paper, we compare exposure to currency and market risks among a sample of countries using the stochastic dominance criterion.

The rest of the paper is organized as follows. Section 2 elaborates on how the concept of stochastic dominance should be viewed in an attempt of evaluating the risk of an asset. Section 3 briefs the econometric methodology used to derive time-varying market and exchange rate exposure betas. Section 4 describes the information related to data. Empirical findings of the analysis are reported in Section 5. In addition to the market and currency risk among various economies, currency risk in the same economy in different time periods are also compared. Section 6 includes concluding remarks.

2. The Concept of Stochastic Dominance in Explaining Market and Currency Risk

The concepts of first and second order stochastic dominance criterion can be defined as follows. Let $F_z(r)$ and $G_y(r)$ be the CDFs of the return structures on the two assets z and y, respectively. z is said to first order stochastic dominate y, if two CDFs do not cross each other and $F_z(r) \leq G_y(r)$ for all r. Graphically, $F_z(r)$ lies below and to the right of $G_y(r)$ when this happens. In second order stochastic dominance, wherein two CDFs do cross each other, z is said to dominate y, if $\int_{-\infty}^{r} (F_z(r) - G_y(r))dr \leq 0$ for all r with at least one strict inequality. When used to compare the return structure of two assets, this means that the dominant asset assigns higher probabilities to higher returns than the dominated asset does so.

Gonzales-Rivera (1996) initiated the use of the stochastic dominance concept to compare the risk associated with the market betas of firms. Brooks et al (2000) employed the concept to carry out a detailed analysis of the impact of regulatory changes on the risk and returns of the US banking industry. In this context, the dominance of one coefficient on the other means that it represents less exposure to risk than the exposure represented by the other. When it comes to the sensitivity of the returns of an asset to a certain risk factor, the usual stochastic dominance inequalities must be reversed. Let $F_z(\beta_t)$ and $G_y(\beta_t)$ be the CDFs of the time-varying exposure betas of two assets z and y, respectively. β_t in both CDFs represents an exposure beta. Asset z 's exposure beta first order stochastic dominates asset y 's exposure beta, if two CDFs do not cross and the following requirement is met for all β_t with at least one strict inequality:

$$F_z(\beta_t) \geq G_y(\beta_t) \tag{2}$$

Graphically, $F_z(\beta_t)$ lies above and to the left of $G_y(\beta_t)$. Asset z 's exposure beta is said to second order stochastic dominate asset y 's exposure beta, if the following requirement is met for all β_t with at least one strict inequality:

$$\int_{-\infty}^{\beta_{x,t}} (F_z(\beta_t) - G_y(\beta_t))d\beta_t \geq 0 \tag{3}$$

3. Deriving Time-Varying Exchange Rate Exposure Coefficients

Following Jayasinghe and Tsui (2008) whose analysis is based on the version of ICAPM suggested by Adler and Dumas (1983), we employ the following mean structure to derive time-varying exchange rate coefficients[3].

$$\begin{aligned}
r_{i,t} &= \lambda_{0,i} + \lambda_X h_{ix,t} + \lambda_M h_{im,t} + \theta_i \varepsilon_{i,t-1} + \varepsilon_{i,t} \\
r_{x,t} &= \lambda_{0,x} + \lambda_X h_{x,t} + \lambda_M h_{xm,t} + \theta_x \varepsilon_{x,t-1} + \varepsilon_{x,t} \\
r_{m,t} &= \lambda_{0,m} + \lambda_X h_{xm,t} + \lambda_M h_{m,t} + \theta_m \varepsilon_{m,t-1} + \varepsilon_{m,t}
\end{aligned} \tag{4}$$

$$(\varepsilon_{i,t}\varepsilon_{m,t}\varepsilon_{x,t})' \mid I_{t-1} \sim N(0, H_t)$$

$$\varepsilon_t = z_t H_t^{1/2}$$

[3] The reasons for selecting this particular model specification are not discussed here. See Jayasinghe and Tsui (2008) for details.

Assuming off-diagonal elements in parameter matrixes are zero, the following BEKK multivariate GARCH structure is used to construct the time-varying second moments:

$$H_t = \begin{bmatrix} h_{i,t} & h_{ix,t} & h_{im,t} \\ h_{xi,t} & h_{x,t} & h_{xm,t} \\ h_{mi,t} & h_{mx,t} & h_{m,t} \end{bmatrix} = \begin{bmatrix} c_i & 0 & 0 \\ c_{xi} & c_x & 0 \\ c_{mi} & c_{mx} & c_m \end{bmatrix} \begin{bmatrix} c_i & c_{ix} & c_{im} \\ 0 & c_x & c_{xm} \\ 0 & 0 & c_m \end{bmatrix}$$
$$+ \begin{bmatrix} b_i & 0 & 0 \\ 0 & b_x & 0 \\ 0 & 0 & b_m \end{bmatrix} \begin{bmatrix} h_{i,t-1} & h_{ix,t-1} & h_{im,t-1} \\ h_{ix,t-1} & h_{x,t-1} & h_{xm,t-1} \\ h_{im,t-1} & h_{xm,t-1} & h_{m,t-1} \end{bmatrix} \begin{bmatrix} b_i & 0 & 0 \\ 0 & b_x & 0 \\ 0 & 0 & b_m \end{bmatrix}$$
$$+ \begin{bmatrix} a_i & 0 & 0 \\ 0 & a_x & 0 \\ 0 & 0 & a_m \end{bmatrix} \begin{bmatrix} \varepsilon_{i,t-1} \\ \varepsilon_{x,t-1} \\ \varepsilon_{m,t-1} \end{bmatrix} \begin{bmatrix} \varepsilon_{i,t-1} & \varepsilon_{x,t-1} & \varepsilon_{m,t-1} \end{bmatrix} \begin{bmatrix} a_i & 0 & 0 \\ 0 & a_x & 0 \\ 0 & 0 & a_m \end{bmatrix} \qquad (5)$$

where $r_{i,t}$ is return on country index; $r_{m,t}$ is return on world market portfolio; $r_{x,t}$ is exchange rate changes expressed as US dollar price of foreign currency. $h_{j,t}$ for $j = i, m, x, im, ix, xm$ denotes the variance and covariance terms of the three variables involved. $(\varepsilon_{i,t}\varepsilon_{m,t}\varepsilon_{x,t})'$ is conditional on complete information set I_{t-1} and normally distributed with zero mean and a conditional variance-covariance matrix H_t. z_t represents the vector of standardized residuals.

An intercept and a MA(1) term is included in each of the three mean equations in order to capture any remaining risk or market inefficiencies. Following Hamao et al (1990), one can justify the inclusion of MA(1) term in the first equation as that will capture the inefficiencies associated with the non-synchronous closure of the various stock markets in the world.

Following Lim (2005), in deriving market and exchange rate exposure betas, we allow for non-orthogonality between the two variables. As such, market and exchange rate exposure betas are computed as follows:

$$\beta_{m,t-1} = \frac{h_{x,t}h_{im,t} - h_{xm,t}h_{ix,t}}{h_{x,t}h_{m,t} - [h_{xm,t}]^2} \qquad (6)$$

$$\beta_{x,t-1} = \frac{h_{m,t}h_{ix,t} - h_{xm,t}h_{im,t}}{h_{x,t}h_{m,t} - [h_{xm,t}]^2}. \qquad (7)$$

Assuming that the standardized residuals of the suggested trivariate GARCH model are conditionally normally distributed, the conditional log-likelihood of residual vector ε_t at time *t* can be defined as follows:

$$\ell(\varphi)_t = -\frac{1}{2}\ln(2\pi) - \frac{1}{2}\ln|H_t| - \frac{1}{2}\varepsilon_t' H_t^{-1}\varepsilon_t \tag{8}$$

The log-likelihood function of the sample is obtained as $L(\varphi) = \sum_{t=1}^{T} \ell(\varphi)_t$, where T is the number of observations. The parameter vector φ of the trivariate BEKK-GARCH-M model is estimated by maximizing L with respect to φ. In order to accommodate the non-normal features reflected in the basic statistics of country returns and the exchange rate changes, all estimates of the parameters are obtained through the quasi-maximum likelihood (QML) estimation method proposed by Bollerslev and Wooldridge (1992). Under certain regularity conditions, the QML estimate is assumed to be consistent and asymptotically normal. Therefore, statistical inference can be drawn due to robust standard errors. Required computer programs are coded in GAUSS and use BHHH algorithm to compute QML estimates.

4. Data

We use a sample of nine countries: the US, UK, Canada, Japan, Australia, Korea, Singapore, Taiwan and Thailand. The sample is assumed to represent a balanced combination of developed and emerging markets. We use daily closing stock prices for the period from 5th Jan 1999 to 30th Dec 2005[4]. The resultant sample period provides us with 1824 observations. Except for the exchange rate used for the US, all data series are from Morgan Stanley Capital International (MSCI) and extracted from Datastream. Country level portfolios are represented by MSCI country indexes measured in relevant local currency. World market portfolio is represented by the MSCI world market index MSWRLDL. It is a value-weighted world market index which is not converted into a common/reference currency and, therefore, free from exchange rate fluctuations (Giannopoulos, 1995; MSCI, 1998). Exchange rates used for non-US countries are MSCI bilateral rates that show the units of the relevant currency per one US dollar. The rates are inverted to express the exchange rates as the US dollar price of the foreign currency. A trade-weighted exchange rate compiled by the Bank of England is used to measure the exposure of the US assets.

Continuously compounded daily returns and exchange rate changes are calculated as follows:

[4]The currency crisis period is excluded from the sample in order to avoid the impact of unusual currency moments.

$$r_{j,t} = \ln\left(R_{j,t} \big/ R_{j,t-1} \right) * 100 \qquad j = i, m, x$$

where $R_{j,t}$ and $R_{j,t-1}$ are the closing values of stock prices/exchange rates for the trading days t and (t-1) respectively.

Table 1 shows the summary statistics of return on country indexes. Standard deviation of the return series ranges from the lowest 0.76 (Australia) to the highest 2.16 (Korea). Return in Taiwan, Thailand and the US which are slightly positively skewed whereas the return on the other country indexes are slightly negatively skewed. Highest absolute value is found for Australia (0.45) and the lowest is found for Taiwan (0.07). All return series show excess kurtosis which ranges from the lowest 1.773 for Japan to the highest 7.06 for Thailand. Jarque-Bera statistic is extremely high in all cases. These features justify the use of QML method of estimation. ADF statistics reveal that, although the country indexes are not stationary, continuously compounded returns on all country indexes are stationary and free of unit roots. Q statistic for 20 lags reveal that Canada, Korea, Taiwan, Thailand, UK and World market are not free from linear dependencies. As the Q^2 statistic for 20 lags displays, a great deal of non-linear dependencies is there to be captured by the model of estimation. This provides an enormous empirical support for the use of GARCH-type models to derive time-varying exchange rate exposure betas.

Table 1: **Preliminary statistics of return on country stock indexes**

Coefficient	Australia	Canada	Japan	Korea	Singapore	Taiwan	Thailand	UK	US
Mean	0.0279	0.03406	0.0210	0.0585	0.0283	0.0030	0.0426	-0.0018	-0007
Maximum	3.6701	5.0813	6.2730	8.4841	5.5240	9.1716	15.8604	5.5885	5.6104
Minimum	-5.3721	-9.2605	-6.5115	-13.0968	-9.0950	-10.3091	-8.0731	-6.0113	-6.1609
S D	0.7673	1.1386	1.2204	2.1646	1.2024	1.7723	1.8158	1.1426	1.1700
Skewness	-0.4540	-0.3984	-0.2093	-0.1909	-0.3494	0.0746	0.7199	-0.2147	0.0933
Kurtosis	6.4580	8.5220	4.7732	5.6680	7.6216	5.2707	10.0663	5.9358	5.2435
J-B stat	971.42	2365.69	252.26	552.07	1660.39	393.54	3952.48	669.05	385.18
$Q(20)$	22.37	32.30	17.00	36.44	27.68	35.23	69.01	73.33	29.23
$Q^2(20)$	231.66	343.6	180.79	186.38	218.40	432.91	266.59	1885.60	782.87
ADF (index)[a]	0.65	-1.07	-0.27	-0.47	-1.51	-1.73	-0.69	-1.54	-1.59
ADF (returns)[b]	-43.52	-41.83	-41.11	-41.71	-39.73	-41.75	-36.95	-27.98	-43.63

$Q(20)$ and $Q^2(20)$ are Ljung-Box statistics of returns and squared returns for 20 lags. They follow a χ^2 distribution and the critical value at the 5% level of significance with 20 degrees of freedom is 31.41; [a] and [b] - Augmented Dikey-Fuller statistic for stock index (level) and returns (first difference), respectively.
Source: Author constructed

5. Empirical Results

In this Section, time-varying market and currency risks are analyzed in terms of the stochastic dominance concept. Time-varying exchange rate exposure and market betas are obtained using the multivariate GARCH-M model outlined by Equations 4 and 5 in Section 3. In order to provide a common platform to compare the currency risk among various countries, bilateral exchange rates between the US dollar and the relevant currencies are used. For this reason, the analysis in what follows is carried out from a US citizen's standpoint. In Sub-section 5.1, market and currency risks between countries within the sample are compared. Sub-section 5.2 attempts to compare the currency risk in the same country (namely Korea) during three consecutive time periods.

5.1 Comparison of Time-Varying Currency and Market Risks between Countries

The stochastic dominance criterion can be used to compare the risk structures associated with the exchange rate exposure betas of various assets. The analysis of the exchange rate exposure betas in terms of CDFs is slightly different from that of the market betas. Suppose that an US investor wants to find out the *level* of exchange rate exposure associated with the assets in the sample. Both negative and positive values of time-varying exposure betas are likely outcomes for a certain country. In some cases, it may even be negative throughout the sample period. Unlike in market betas, a positive value, though it is algebraically higher, does not necessarily imply a higher risk than a negative value. A large exchange rate exposure coefficient, whether it is negative or positive, represents a higher risk. One can get round this issue by viewing exposure coefficients as a kind of elasticity measure. What matters in this sense is the absolute value of exposure betas, but not their algebraic values. As such, to fulfill the aforementioned investor's requirement, the analysis must be carried out using the CDFs of the distributions of the absolute values of exposure betas.

Figure 1 displays the empirical CDFs of the absolute values of exchange rate exposure beta distributions. Apparently, the CDFs of the three emerging markets, Taiwan, Korea and Thailand lie below and to the right of the CDFs of the other countries, suggesting that exposure of the stocks in these countries to currency risk (associated with dollar exchange rate) is higher. Taiwan emerges as the country with the highest currency exposure during the sample period considered. Though Singapore is less exposed to currency risk than Taiwan, Korea and Thailand, it is more exposed than the cases like Australia, Canada, Japan, UK and the US. Though it is not that easy to rank the cases without using second order stochastic dominance, Australia and Canada seem to be less exposed than the other three cases. Based on these results, we can divide the nine countries in the sample into two sub-groups: (a) countries that are relatively less exposed to currency risk (Australia, Japan and Canada, Singapore, UK and the US); and (b) countries that are relatively more exposed to currency risk (Korea, Taiwan and Thailand).

More importantly, this result, obtained through the CDFs of time-varying exposure betas, is not fully reflected in the mean values of time-varying exposure betas. For instance, in terms of the mean values of time-varying exposure betas, Thailand is more exposed to exchange rate changes than Korea (mean values for the two countries are -0.9114 and -0.8660, respectively). However, as Figure 1 shows, Korea seems to be second order stochastically dominated by Thailand, suggesting that Korea is more exposed to exchange rate changes than Thailand. Singapore, UK and the US provide another example. Though UK and the US are more exposed than Singapore in terms of the mean value of time-varying betas, CDF of Singapore lies well down and to right of the CDFs of UK and the US, thus suggesting that the opposite is true. In a way, this is not a surprising result when the volatility measures of relevant betas are also taken into account. Except for the year 2005, in all the other one-year sub-periods, unconditional volatility of exposure beta series for Korea is clearly greater than that of Thailand. The

Unconditional volatility of Singapore is also higher than those measures of UK and the US for all seven one-year sub-periods[1].

Now suppose that the investor in question is a US importer (or a person who has a large number of essential imported goods in his consumption basket) who is looking for means of hedging against currency risk through investment in foreign assets. The above analysis which is based on the absolute values of exposure betas may not help him much in choosing the proper destination for his funds. As such, Figure 2 depicts the empirical CDFs of all distributions of *algebraic* values of exposure betas. Though the results are much similar to that in Figure 1 in this particular example, it may not be the case for a different sample. It is more likely that the investor will be able to fulfill his hedging requirement by investing in assets in emerging markets such as Korea, Thailand and Taiwan, which are highly positively exposed to the depreciation of the US dollar. By the same token, assets in a country like UK would be the appropriate choice for an exporter who seeks means of hedging against currency risk.

We also compare the exposure to market risk among countries using the same tool. The market beta distributions of the countries reveal that, for some countries in the sample, the multivariate GARCH model has computed a few negative market beta values. Unlike a negative value of exchange rate exposure beta, a negative value of market beta implies a less risky status. Therefore, in plotting CDFs of market betas, we did not take the absolute values, but let the negative betas exist.

Figure 3 compares the exposure to market risk among countries in terms of the CDFs of time-varying market betas. Similar to the case of currency risk, one can identify three sub-groups in terms of the market risk. Apparently, the US emerges as the country with the highest exposure to market risk. UK and Canada are the other countries whose stocks are highly exposed to market risk. Australia, Taiwan, Thailand and Singapore can be identified as the countries with relatively low exposure to market risk. Japan and Korea can be situated between these two groups of relatively high and relatively low market risk.

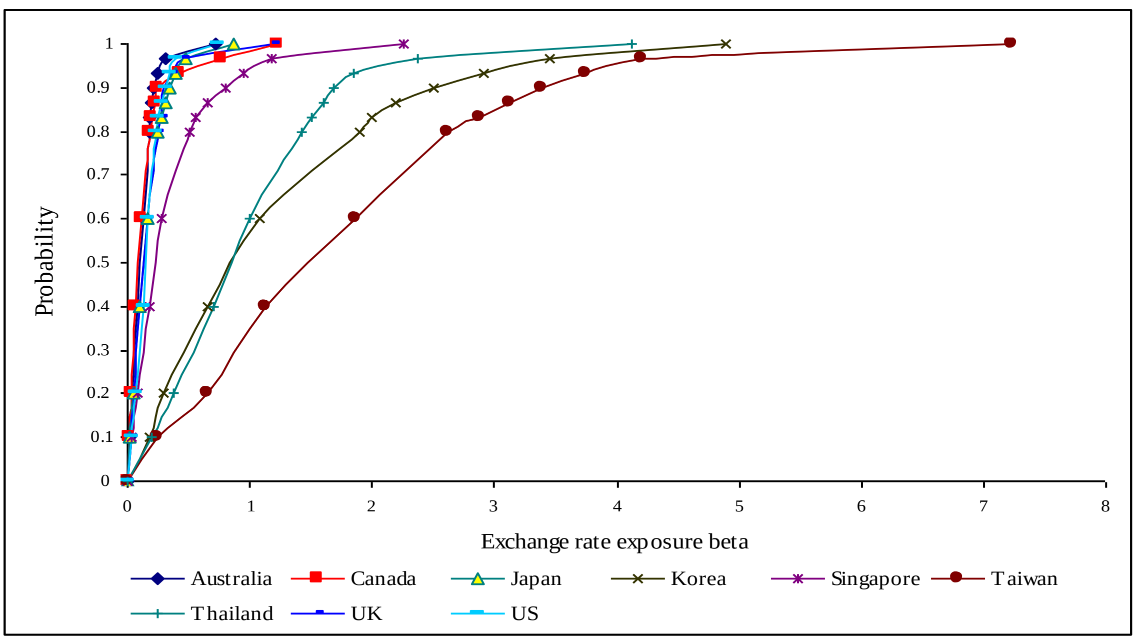

Figure 1: **Cumulative distribution functions of time-varying exchange rate exposure betas (absolute values)**
Source: Author constructed

[1] Results are not reported in order to conserve space.

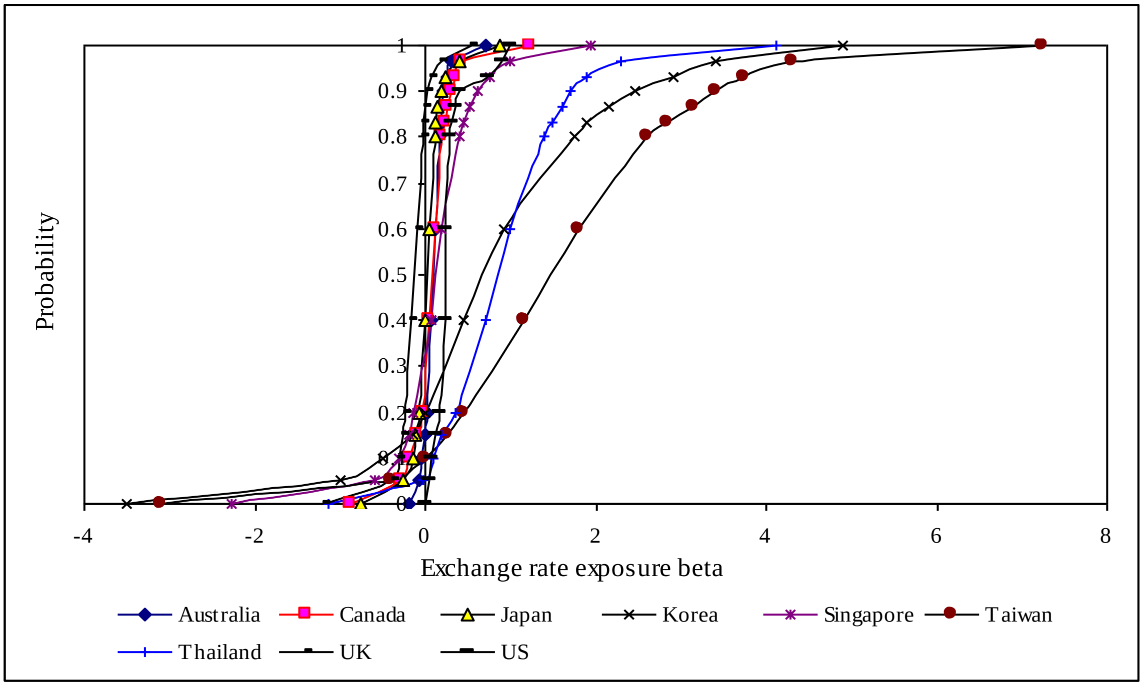

Figure 2: **Cumulative distribution functions of time-varying exchange rate exposure betas (algebraic values)**
Source: Author constructed

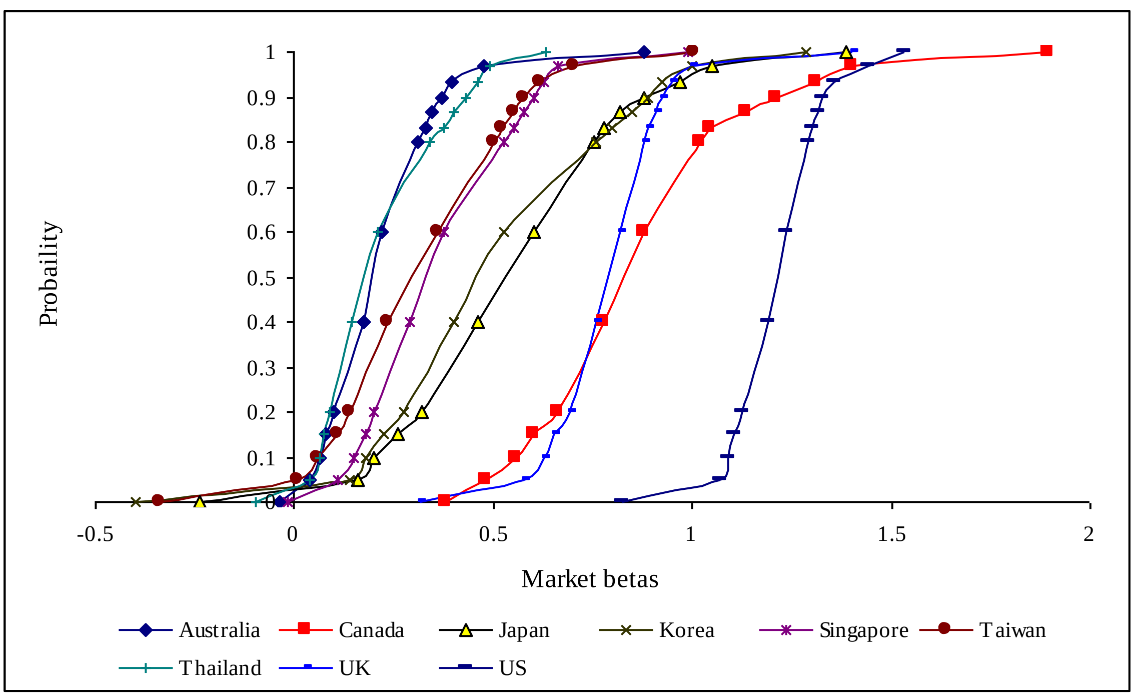

Figure 3: **Cumulative distribution functions of time-varying market betas**
Source: Author constructed

Based on the Figures 1, 2 and 3, we identify a few important patterns within the sample of nine countries. There are a set of countries whose exposure to currency risk is high, though the exposure to market risk is relatively low (Taiwan, Thailand and Korea). There is another set of countries whose exposure to market risk is high, but the exposure to currency risk is relatively low (Canada, UK and US). Interestingly, the former group consists of emerging markets while the latter consists of Developed markets. There exists a third group of countries with relatively low exposure to both currency and market risk (Australia, Singapore and Japan). This group consists of both emerging and developed markets. Although these patterns of observations are by no means generalizations, they may be extremely useful for the investors in international financial markets. For instance, the information included in Table 2 is good enough to be considered in a pre-investment study of any investor who is seeking locations for his/her funds.

Table 2: **Comparison of the exposure to market and currency risk among countries**

Country	Exposure to market risk	Exposure to currency risk (associated with dollar exchange rate)
Group 1		
Canada	High	Low
UK	High	Low
US	High	Low
Group 2		
Korea	Low	High
Taiwan	Low	High
Thailand	Low	High
Group 3		
Australia	Low	Low
Japan	Low	Low
Singapore	Low	Low

Sample period for which these patterns are identified: 1/5/1999 - 31/12/2005; Exposure to currency risk is measured in terms of a bilateral exchange rate between the US dollar and the relevant currency; A trade weighted exchange rate is used for the case of the US.
Source: Author constructed

5.2 Comparison of Exposure within the Same Country in Different Time Periods: The Case of Korea

Again we can view the issue from a US citizen's point of view. Assume that a US investor wants to invest in Korean assets. However, may be due to the unpleasant memories of the currency crisis, he wants to examine how the dollar/won exchange rate exposure of Korean assets changed over the few years after the crisis. More importantly, the stochastic dominance criterion can be used in making such a decision. First, Table 3 reports the means and standard deviations of the time varying-exposure betas during three post-crisis periods of equal length (this division is completely arbitrary and is not based on any relevant structural feature). The mean values suggest that exposure during the first period is clearly higher than that in the other two periods. However, there is not much difference between the mean values in second and third periods. Strictly speaking, the exposure during the third period is slightly higher than that in the second period.

Table 3: **Mean and volatility of time-varying exposure beta for Korea during three sub sample periods**

Period	No of observations	Mean of $\beta_{x,t}$	Std deviation of $\beta_{x,t}$
(1) 8/1/1999-7/5/2001	607	1.6590	1.3768
(2) 8/5/2001-3/9/2003	607	0.4660	1.0593
(3) 4/9/2003-30/12/2005	607	0.4696	0.7056

Source: Author constructed

Figure 4 depicts the CDF associated with each time period. It is evident that the period 1 is clearly first order stochastically dominated by the periods 2 and 3. Also, period 3 first order stochastically dominates period 2 and this is not well reflected in the mean values of time-varying exchange rate exposure betas. As a relevant fact, Table 3 indicates that, though the mean value for period 2 is slightly less than the mean value for the period 3, standard deviation of the exposure betas during period 2 is higher than the standard deviation of exposure betas during period 3. These results help us establish the notion that bad memories of the currency crisis in Korea are in the process of fading out over time.

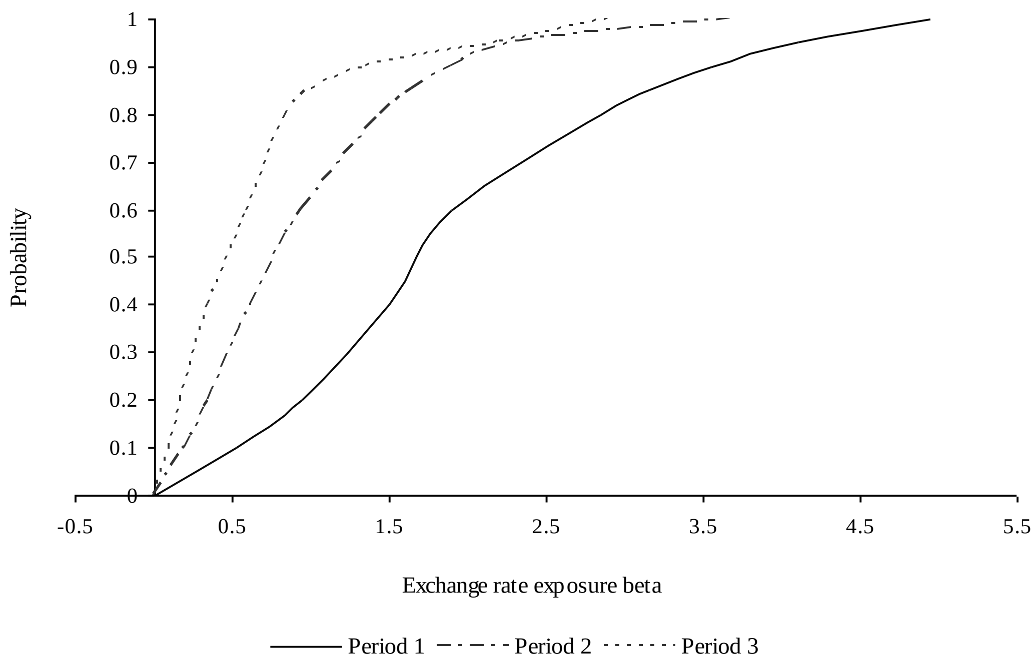

Figure 4: **Cumulative distribution functions of time-varying exposure beta during three sub-sample periods: the case of Korea**
Source: Author constructed

Diagnostic test results reported in Table 4 show the validity of the multivariate GARCH-M model used to obtain time-varying betas for the analysis. Ljung Box test statistic of standardized and squared standardized residuals (Q and Q^2, respectively) are not only less than those of country level stock returns, but also less than the critical χ^2 value[2]. This implies that the model used to derive time-varying market and currency betas is correctly specified and is able to capture linear and non-linear dependencies.

[2] It is worth making a special comment on the case which does not satisfy this requirement: Thailand. Q^2 statistic for standardized residuals of Thailandis below the critical value up to 11 lags ($Q^2(11)$ = 13.71).

Table 4: **Diagnostics: Return on country stock indexes**

Coefficient	Australia	Canada	Japan	Korea	Singapore	Taiwan	Thailand	UK	US
Mean	-0.0265	-0.0314	-0.0161	-0.0279	-0.0339	-0.0231	-0.0169	-0.0549	-0.0536
Maximum	3.9285	4.1928	4.8650	3.9242	4.2083	5.1874	7.3946	3.0403	3.5236
Minimum	-6.1078	-5.5514	-4.7516	-7.5811	-7.9686	-5.0443	-4.7672	-5.1153	-5.3602
S D	0.9901	0.9964	0.9852	0.9999	0.9992	0.9953	1.0041	0.9979	1.0045
Skewness	-0.3933	-0.3076	-0.1846	-0.3357	-0.3358	0.0028	0.3999	-0.3553	-0.2431
Kurtosis	4.8198	4.5228	4.3655	5.5817	6.6696	4.4066	6.3975	3.6614	4.0960
J-B Stat	295.64	204.79	151.90	540.22	1056.55	150.21	924.84	71.55	109.07
$Q(20)$	13.87	27.79	11.30	19.54	18.70	17.19	21.19	26.26	57.26
$Q^2(20)$	26.76	17.63	24.51	10.73	8.28	24.05	70.07	23.14	15.73

$Q(20)$ and $Q^2(20)$ are Ljung-Box statistics of residuals and squared residuals for 20 lags. They follow a χ^2 distribution and the critical value at the 5% level of significance with 20 degrees of freedom is 31.41.
Source: Author constructed

6. Concluding Remarks

Though the mean value of time-varying betas is often used as a measure of the market and currency risks, CDFs of beta distributions provide a better measure as it accommodates the magnitude of betas as well as the probability with which each observation of betas would occur. In this paper, we used the concept of stochastic dominance which took CDFs as its main tool to compare time-varying market and currency risks among a set of developed and emerging economies. A multivariate GARCH-M model was used to derive time-varying market and exposure betas. Two betas were not assumed to be orthogonal and, in computing time-varying beta series, the non-orthogonality was explicitly taken into account.

Empirical results show a few patterns. Stock returns in a set of emerging economies are more exposed to currency risk, though their exposure to market risk is moderate. On the contrary, the stock returns in a set of developed economies are more exposed to market risk while their exposure to currency risk is remarkably low. There exists another set of developed and emerging economies whose stock returns are less exposed to both market and currency risk. Stochastic dominance is also used to compare the currency risk in the same economy among different time periods. This provides evidence to establish the notion that the bad memories of the currency crisis in Korea is fading out over time.

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