INTERNATIONAL JOURNAL OF BUSINESS, 12(3), 2007 ISSN: 1083–4346

Global Stocks and Contemporaneous Market Risk

Leyuan You[a], Chun-Hao Chang[b], Ali M. Parhizgari[c] and Arun J. Prakash[d]

[a] *Department of Business, University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK, 99508, afly@uaa.alaska.edu*

[b] *Department of Finance, Florida International University,11200 SW 8th Street, Miami, FL 33199, changch@fiu.edu*

c Department of Finance, Florida International University, 1200 SW 8th Street, Miami, FL 33199, parhiz@fiu.edu

[d] *Department of Finance, Florida International University, 1200 SW 8th Street, Miami, FL 33199, prakasha@fiu.edu*

ABSTRACT

This paper provides a comprehensive set of contemporaneous estimates of the market risk for globally listed stocks on 59 world equity markets. The results reveal that the estimates of the systematic risk of a stock are distinct from market to market, and from the stock's corresponding estimate of its global beta. The limitations of these estimates and, in particular, the constraints under which they are computed are pointed out. The results also indicate the need to first refine upon the single-market country estimate of the beta in the original capital asset pricing model (CAPM) before extending and or analyzing such estimates in determining the corresponding global beta.

JEL Classification: *G15*

Keywords: *Global beta; Market risk; International equity markets*

I. INTRODUCTION

There is a consensus that in estimating the relative systematic risk of a firm's stock the use of the standard market model is inappropriate, if the stock is listed in multiple markets (see, among others, Stulz (1981), Harvey (1991), and Bernard and Bruno (1995)). This consensus arises from the specification of the standard market model wherein the market index is bounded to represent the stocks in a single country only. Though it is possible that the indices of the country equity exchanges where the stock is traded on may be highly correlated with one another, yet whether this correlation will be identically equal to one is highly improbable. Hence, using the market index from only one country may not include the available information set that is contained (or conveyed) by the indices of other countries.

In a seminal paper, Roll (1977) contends that, irrespective of how an index is structured econometrically, it is impossible to construct a market index that will include all the assets in the universe. Thus, it is not possible to have a "global" market index. In fact, Roll argues, even if one is able to construct the global market index, it may not be possible to correctly measure the global rate of return of an individual stock if it is traded in multiple markets.

Roll's position is revisited by Prakash, Reside and Smyser (1993) who suggest a procedure to obtain the BLUE estimator of a global beta under the usual wide-sense stationarity assumptions of the linear regression models. Later on, Ghai, de Boyrie, Hamid and Prakash (2001) provide a detailed procedure to obtain such estimators when the wide-sense stationarity assumptions are violated.

Under both of the above extensions of Roll's work, an attempt is made to employ all the relevant available information in the global market, thereby resolving the measurement problems to some extent. Notwithstanding these extensions, Prakash et al. and Ghai et al., do not provide any empirical evidence as to whether there is any statistically robust significant difference between the estimates of beta obtained using the standard procedures (as suggested by Markowitz (1959) and Sharpe (1963)) vis-à-vis the procedures suggested by them.

The purpose of this paper is to estimate and statistically compare the betas of multiple-listed firms using the Markowitz and Sharpe procedures as well as the one forwarded by Prakash, Reside and Smyser (1993). The paper is organized as follows. In section II we note briefly the Markowitz-Sharpe as well as the Prakash et al., procedures. In section III, we present the data selection procedure. The empirical findings and the concluding remarks are in sections IV and V, respectively.

II. METHODOLOGY

A. Markowitz's Procedure[1]

The testable *ex-post* version of the market model is expressed as:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}; \quad t = 1, \dots, T \tag{1}$$

where ε_{it} is the random error term for the i^{th} security, or the residual portion of R_{it} which is unexplained by the regression of the i^{th} stock during the t^{th} time period. The random error term ε_{it} is assumed to follow the wide-sense stationarity assumptions[2].

B. Prakash et al.'s Procedure[3]

For simplicity of exposition, we will consider only two markets. The extension to more than two markets is considered next. Assume a stock is being listed in markets K and J. Let: R_{kt} = rate of return of the underlying security in market K during time t (t = 1,2, , m); R_{Kt} = rate of return of the K^{th} market index during time t (t = 1,2, …, m); R_{jt} = rate of return of the underlying security in market J during time t (t = 1,2, …, n); R_{Jt} = rate of return of the J^{th} market index during time t (t = 1, 2, ..., n).

Let β be the global measure of the systematic risk. Since this measure of beta will be the same in the two markets, the underlying return generating process for the security in each of two markets is given by:

$$R_{kt} = \alpha + \beta R_{Kt} + \varepsilon_{kt} \qquad (t = 1,2, \ldots, m) \tag{2}$$
$$R_{jt} = \alpha + \beta R_{Jt} + \varepsilon_{jt} \qquad (t = 1,2, \ldots, n) \tag{3}$$

The number of bivariate observations (R_k, R_K) and (R_j, R_J) available in markets K and J, that is, m and n, respectively, may or may not be the same as long as, by assumption, β remains the same in the two markets. Econometrically, if there is reason to believe that, intertemporally, beta might change if $m \neq n$, then m should be taken equal to n and observations must be chosen contemporaneously in each market. The properties of the estimators obtained below, however, are unaffected by whether or not m = n.

Econometrically, there is no loss of generality if the returns are measured from their respective means. Thus, the return generating process reduces to:

$$r_{kt} = \beta r_{Kt} + \varepsilon_{kt} \qquad (t = 1,2, \ldots, m) \tag{4a}$$
$$r_{jt} = \beta r_{Jt} + \varepsilon_{jt} \qquad (t = 1,2, \ldots, n) \tag{4b}$$

where $r_{kt} = R_{kt} - \overline{R}_k$, etc.

Our purpose is to obtain, in the Gauss-Markov sense, the best estimator for β. Prakash et al. provide the BLUE estimator for β, i.e. $\hat{\beta}$, as:

$$\hat{\beta} = \frac{\sum_{t=1}^{m} r_{kt} r_{Kt} + \sum_{t=1}^{n} r_{jt} r_{Jt}}{\sum_{t=1}^{m} r_{Kt}^2 + \sum_{t=1}^{n} r_{Jt}^2} \tag{5}$$

A variant of relationship (5) could be derived based on the covariance and variance of each security with the market index. For example, for a security traded in the kth market, the covariance and variance are defined as:

$$\mathrm{Cov}(r_k, r_K) = \frac{1}{m}\sum_{t=1}^{m} r_{kt} r_{Kt},$$

and

$$\mathrm{Var}(r_K) = \frac{1}{m}\sum_{t=1}^{m} r_{Kt}^2,$$

Relationship (5) could then be cast into:

$$\hat{\beta} = \frac{m\,\mathrm{Cov}(r_k, r_K) + n\,\mathrm{Cov}(r_j, r_J)}{m\,\mathrm{Var}(r_K) + n\,\mathrm{Var}(r_J)}. \quad (6)$$

The estimator in relationship (6) can be easily extended to multi (more than two) markets case. Specifically, if there are p markets with $n_1, n_2, \ldots, n_p$ observations on the stock, then the multi-market BLUE estimator of beta will be:

$$\hat{\beta} = \frac{\sum_{i=1}^{p} n_i \mathrm{Cov}(r_i, r_{mi})}{\sum_{i=1}^{p} n_i \mathrm{Var}(r_{mi})}. \quad (7)$$

where r_i and r_{mi} are, respectively, the rates of return measured from the means on the stock, and the market index in market i, i = 1, 2, … , p; and n_i is the number of observations in market i.

C. Our Step-by-Step Procedures

To sum up the methodology and our step-by-step procedures, for each group of the securities we first estimate the betas for each security in each market using the market model described in equation (1). Then, using relationship (7), the global beta for each security is estimated. Next, for each security, the estimates of its betas that are separately obtained in each market are compared and tested for equality using the W-test statistic (Welch, 1953)[4]. To confirm the appropriateness of our estimates, we also test one of the underlying wide-sense stationarity assumptions that are the subject of the Prakash et al., extensions, i.e., that the error variances of the market model are the same (homoskedasticity). We use the Bartlett's M-test for this purpose. This test as well as the Welch's W-test, as they are cast within the framework of our analysis, are described below.

a. Welch's W-test

Suppose a stock is traded in k exchanges (markets). Also assume that $\hat{\beta}_i$ is the computed estimate of beta in the i^{th} market with standard error of the estimate s_i. Under the null hypothesis that all β_i's (i = 1, 2, …., k) are same, Welch (1951) test requires the computation of the W-statistic given by:

$$W = \frac{\sum_{i=1}^{k} \frac{\left(\hat{\beta}_i - \hat{\beta}^*\right)}{s_i^2} \Big/ (k-1)}{1 + \frac{(2k-2)}{(k^2-1)} \sum_{i=1}^{k} \frac{1}{(n_i - 1)} \left(1 - \frac{1/s_i^2}{\sum_{i=1}^{k} 1/s_i^2}\right)^2} \tag{8}$$

where n_i is the number of observations in the i^{th} market (which may be non-overlapping with the other markets), s_i is the standard error of $\hat{\beta}$, and

$$\hat{\beta}^* = \left(\sum_{i=1}^{k} \frac{\hat{\beta}_i^2}{s_i^2}\right) \Big/ \left(\sum_{i=1}^{k} \frac{1}{s_i^2}\right) \tag{9}$$

Under the null hypothesis: H_0: $\beta_1 = \beta_2 = \ldots = \beta_k$, the W-statistic will follow Snedecor's F distribution with (M-1) and

$$\left[\frac{3}{(k^2-1)} \sum_{i=1}^{k} \frac{1}{(n_i - 1)} \left(1 - \frac{1/s_i^2}{\sum_{i=1}^{k} 1/s_i^2}\right)^2\right]^{-1} \tag{10}$$

degrees of freedom, where M is the number of regression coefficients in the market model. Therefore, M-1 will equal to one, in our case.

b. Bartlett Test for Homogeneity of Variances

An assumption underlying our methodology, as well as those of Prakash et al.'s, is the homogeneity of the variances of each security across the k-markets wherein it is cross-listed. To examine this assumption, Bartlett's test statistic (Snedecor and Cochran, 1983) is used to check if the k-market samples have equal variances. For each security, letting σ_i^2 be the variance of the error terms of the market model in the equity exchange i, the Bartlett's statistic is defined as:

$$B = \frac{(n-k)\ln s_q^2 - \sum_{i=1}^{k} (n_i - 1)\ln s_i^2}{1 + \frac{1}{3(k-1)} \cdot \left(\left(\sum_{i=1}^{k} \frac{1}{(n_i - 1)}\right) - \frac{1}{(n-k)}\right)} \tag{11}$$

where s_i^2 is the variance of the i^{th} group, n is the total sample size ($n = \sum_i^k n_i$), N_i is the sample size of the i^{th} group, and s_q^2 is the pooled variance defined as:

$$s_q^2 = \sum_{i=1}^{k} \frac{(n_i - 1)s_i^2}{(n_i - k)} . \tag{12}$$

We want to test the null hypothesis:

$$H_0: \ \sigma_1^2 = \sigma_2^2 = \sigma_3^2 = \cdots = \sigma_k^2 \text{ , againe the alternative} \tag{13}$$
$$H_a: \ \sigma_i^2 \neq \sigma_j^2 \text{ for at least one pair (i, j).}$$

If the null hypothesis is true, then the B-statistics will be distributed as a chi-square distribution with (k-1) degrees of freedom.

III. DATA

Scanning for cross listed stocks in 59 world wide stock exchanges, seven hundred and four company stocks are identified to have multiple listing on two or more equity exchanges. Weekly price series for these stocks[2] are compiled from DataStream for the period of June 1998 to June 2003. Table 1 summarizes the data set. Among the multiple-listed stocks, 636 companies have their stocks listed in two equity exchanges, 55 companies are listed in three exchanges, 13 companies are listed in four exchanges, 2 companies are listed in seven different international markets, and one company, Bayer AG, is listed in eight different exchanges.

Since a "market portfolio" is required to compute the beta for each security, we also obtain the corresponding weekly index series for the 59 equity exchanges from DataStream. Table 2 contains the names of the 59 international stock exchanges and their respective market indices. If more than one index is available for an equity exchange in a country, an effort is being made to select the most comprehensive index in that country. In the rare cases wherein data is deficient for the market index of a particular country, we select the Morgan Stanley Composite index for that country.

Table 1
Number of securities cross-listed in two or more equity markets

Number of Securities Listed In	Number of Securities
Group1: 2 markets	636
Group 2: 3 Markets	47
Group 3: 4 Markets	13
Group 4: 5 Markets	5
Group 5: 6 Markets	0
Group 6: 7 Markets	2
Group 7: 8 Markets	1
Total	**704**

Note: The name of the companies and the equity exchanges wherein their securities are cross-listed are available upon request from the first author.

Table 2
Major international equity exchanges that host multiple listing of stocks and their respective indices (Total number of exchanges = 59)

Exchange	Index
AMERICAN	AMXIXAX
AMSTERDAM (AEX)	NLALSHR
AMSTERDAM (AEX)	NLALSHR
BERLIN	DAXINDX
BOMBAY	IBOMBSE
BOMBAY	IBOMBSE
BRUSSELS	BRUSIDX
COLOMBO	SRALLSH
COPENHAGEN	CHAGENZ
DUBLIN	ISEQUIT
FRANKFURT	DAXINDX
HAMBURG	DAXINDX
HELSINKI	HEXINDX
HONG KONG	HNGKNGI
ISTANBUL	TRKISTB
JASDAQ	JASDAQI
JOHANNESBURG	JSEOVER
KARACHI	PKSE100
KOREA	KORCOMP
KUALA LUMPUR	KLPCOMP
LILLE	FSBF120
LIMA	PEGENRL
LISBON	POPSI20
LONDON	FTALLSH
LUXEMBOURG	LXLUXXI
LYON	FSBF120
MADRID-SIBE	MADRIDI
MANILA	MANCOMP
MILAN	MILANBC
MILAN	MILANBC
MUNICH	DAXINDX
NASDAQ EUROPE	BGBEL20
NASDAQ NM	NASCOMP
NASDAQ SMALLCAP	NASCOMP
NATIONAL INDIA	IBOMBSE
NATIONAL INDIA	IBOMBSE
NEW YORK	NYSE
NEW ZEALAND	NZ40CAP
OSLO	OSLOASH
OTC BULL.BD.NASD	NASCOMP
OTHER OTC NASDAQ	NASCOMP
PARIS-SBF	FSBF250
PRAGUE	CZPX50I
SANTIAGO	IGPAGEN
SHANGHAI	CHSCOMP
SHENZEN	DJSHENZ

Table 2 (continued)

SINGAPORE	SNGPORI
STOCKHOLM	AFFGENL
STUTTGART	BDSTUTT
TAIWAN	TACOMPT
TEL AVIV	ISTGNRL
THAILAND	TOTMKTH
TOKYO	TOKYOSE
TORONTO	TTOCOMP
VIENNA	WBKINDX
VIRT-X	SWISSMI
XETRA	DAXINDX
ZIMBABWE	ZIMINDS
ZURICH	SWISSMI

IV. EMPIRICAL RESULTS

Table 3 provides a summary of the various estimates of the betas. The firm's stock is cited in column 1 and the estimate of its global beta is included in column 5. The second column of this Table includes the number of equity markets wherein each stock is traded on. To manage space and to provide a concise summary of the values of the various betas in the seven group cross-listed markets (see Table 1), we have included in this Table a limited number (the first ten) of stocks, and have provided only the range of their beta estimates (columns 3 and 4)[3]. A cursory examination of the estimates of the global betas and the single country betas reveals substantial differences between them. This statement, as is stated, is ad hoc at this point and needs to be statistically scrutinized via the application of the W-test that is reported below.

Table 4 summarizes the results of the W-test statistics for the multiple-listed stocks in the seven group cross-listed markets. For Group 1, i.e. wherein each security is listed on two stock exchanges, the null hypotheses for 289 out of 636 stocks are rejected, i.e., these stocks show different beta values in different stock exchanges at the10 percent or below significance (33+60+196=289). The null hypothesis for the remaining 347 stocks in this group cannot be rejected, thus leaving us to conclude that each of these stocks possesses similar betas in the two different exchanges it is cross-listed. In Groups 2 through 7, wherein each security is listed in three through eight stock exchanges, the W-test statistics for each group indicate that most of the betas in each of the exchanges are statistically significantly different. There are only two securities in Group 3 (cross-listing in 4 markets) and one security in Group 4 (cross-listing in 5 markets) that exhibit similar betas.

The above results indicate that for multiple-listed stocks, the estimates of beta computed from the market index in one exchange is significantly different from the beta computed using the market index from another exchange. This provides ample evidence not to rely on the betas computed from local market indices in decisions involving international investments. A global beta for a cross-listed stock, as specified in relationship (7), is more suitable under a global investment setting.

Table 3
Estimates of each stock's "exchange-" and "global-" betas[1]

Name	# of Exchanges	Range of Betas		Global Beta
		Low	High	
1-800 CONTACTS	2	0.3273	0.5034	0.4342
24/7 MEDIA (FRA)	2	0.6959	1.9390	1.4505
3COM	2	0.8166	0.9412	0.8656
8X8	2	0.8483	1.4540	1.2160
A B WATLEY GP.	2	-0.1305	0.5645	0.2914
A D A M	2	-0.0646	0.8773	0.5072
AAON	2	-0.6872	0.2502	-0.1181
AASTROM BIOSCIENCES	2	0.7139	0.9335	0.8472
AB SOFT	2	-0.7664	0.1303	-0.2586
ABAXIS	2	-0.0846	0.5930	0.3267
ABBOTT LABS.	3	0.0068	0.5873	0.0085
ABER DIAMOND	3	0.0108	0.4589	0.1890
ABN AMRO HOLDING	3	1.0313	1.3716	1.1630
AFLAC	3	0.0007	0.5219	0.0027
AGNICO-EAGLE MNS.	3	-0.1135	-0.0779	-0.1014
AGRIUM	3	0.0028	0.1944	0.0034
AJINOMOTO	3	-0.0051	0.6418	0.2418
ALCAN	3	0.0009	0.9812	0.0035
ALCOA	3	0.0009	0.9006	0.0049
ALLEGHENY EN.	3	0.0090	0.9545	0.0120
AEGON (FRA)	4	0.2697	1.7952	1.1629
ALLIANZ	4	0.3710	1.5738	1.1509
AT & T (FL) (AMS)	4	0.2590	1.0693	0.7773
BELLSOUTH	4	-0.1336	0.5770	0.0019
BHP BILLITON	4	0.5250	1.4259	1.0210
BOEING	4	-0.1199	0.7103	0.0052
CATERPILLAR	4	-0.0003	0.6743	0.0035
CLARIANT	4	0.5589	1.3182	0.7878
COMMERZBANK	4	0.3084	1.2665	0.9533
COREL	4	0.2623	1.2534	0.7753
AKZO NOBEL	5	-0.0130	0.6754	0.5230
ALTRIA GP.	5	-0.0022	0.6572	0.0008
AMER.INTL.GP.	5	-0.3094	0.9535	0.0009
BARRICK GOLD	5	-0.0524	-0.0003	-0.0001
SANTANDER CTL.HISP.(FRA)	5	0.3070	1.0354	0.8546
DAIMLERCHRYSLER	7	0.0019	0.9406	0.0133
DEUTSCHE BANK	7	0.6603	1.6223	1.1727
BAYER	8	0.3150	1.3128	0.8399

[1] To manage space and to provide a concise summary of the values of the various betas in the seven group cross-listed markets (se Table 1), we have provided in this Table only the range of such estimates (columns 3 and 4), and only a limited (the first ten) number of stocks.

Table 4
Summary of W-statistics for multiple-listed stocks

	Number of Multiple-Listed Stocks with Different Betas at Significance Level			**Not Significant (= Same Betas)**	**Total**
	$0.05<\alpha\leq 0.10$	$0.01<\alpha\leq 0.05$	$\alpha\leq 0.01$		
Group 1: 2 Markets	33	60	196	347	636
Group 2: 3 Markets	1	5	27	14	47
Group 3: 4 Markets		3	8	2	13
Group 4: 5 Markets		1	3	1	5
Group 6: 7 Markets		1	1	0	2
Group 7: 8 Markets			1	0	1
Total	34	70	236	364	**704**

Note: No stocks were cross-listed in Group 5, i.e., in 6 markets.

Table 5
Summary of Bartlett test statistics
on the equality of the error variances of the cross-listed stocks

	Number of Stocks Significant at the Levels of			**Not Significant**	**Total**
	$0.05<\alpha\leq 0.10$	$0.01<\alpha\leq 0.05$	$\alpha\leq 0.01$		
Group 1: 2 Markets	30	43	193	370	636
Group 2: 3 Markets	1	3	18	25	47
Group 3: 4 Markets	1	1	7	4	13
Group 4: 5 Markets			3	2	5
Group 6: 7 Markets			2	0	2
Group 7: 8 Markets			1	0	1
Total	32	47	224	401	**704**

Table 5 provides a summary of the Bartlett test statistics for the homogeneity of the error variances for all the securities that are cross-listed in the various group markets. Note that K varies across the groups, i.e., K= 2, 3, ….., 8. The total number of company betas that show homoskedasticity of variance in all markets is 401. Thus, the results reported in Table 4 are subject to the caveat that they are based on estimates that may not be BLUE. Hence, we conclude that employment of Ghai et al. (2001) approach that adjusts for some of these caveats is more appropriate.

To further elaborate on the above Bartlett test results, it should be pointed out that a measure of the information content of a market is often provided by the inverse of its variance. Hence, our use of the Bartlett tests above provides us a venue, in addition to our prime purpose to check on the homogeneity of the error variances, to examine the similarity of the information contents of the markets in each cross-listed group. In other words, the results of the Bartlett tests are indicative as to whether the markets in each group reveal the same information. Thus, an interpretation of the null hypothesis in relationship (13) is that the markets in each group reveal the same information, against the alternative hypothesis that at least one market in the group has different information from the rest of the markets in the group. For example, in the two markets case, if a security is traded in markets i and j, and another security is traded in markets i and k, we have tested, respectively, the null hypotheses that $\sigma_i^2 = \sigma_j^2$ and $\sigma_i^2 = \sigma_k^2$. The results in Table 5 could thus be viewed in the context of the diversity in the information contents of the markets.

Since the majority of the multiple-listed stocks show strong statistical evidence of heteroskedasticity, we opted to check, as an aside, the equality of the variances of the equity markets that appear in each “group” of the markets. More specifically, we tested the equality of the variances on the market indices that appear in each of the groups. These groupings are exactly the same as the trading locations (exchanges) of the cross-listed stocks. For example, if stock j is traded in New York (NYSE) and London (FTALLSH), then the bi-variate observation (NYSE, FTALLSH) will constitute a member of the group 1 markets.

Table 6 presents the results of the heteroskedasticity of the various groups. In the case of the two-market groupings, the Bartlett test statistics for 70 out of 86 groups are statistically significant at the 10 percent level or below, i.e., rejecting the null of the equality of the market index variances. The majority of these test statistics, i.e., 60 of them, are statistically significant at the one percent level or below. Similarly, in the remaining groups of three to eight market groupings, the test statistics for only four out of 51 groups are found to be insignificant, i.e., their respective equity exchanges exhibit similar variances.

As was mentioned above, in uni-variate analysis the inverse of the variance is a measure of the information content of the data population that underlies the variance. Thus, the above strong evidence of heteroskedasticity in the various market groupings suggests that the information provided by the various markets is asymmetric. That is, one market disseminates more (or less) information in comparison to another market.

Table 6
Summary of Bartlett test statistics on the equality of the variances
of the market indices that appear in various groups

	Number of Stocks Significant at Levels of			**Not Significant**	**Total**
	$0.05<\alpha \leq 0.10$	$0.01<\alpha \leq 0.05$	$\alpha \leq 0.01$		
Group 1: 2 Markets	2	8	60	16	86
Group 2: 3 Markets		1	27	3	31
Group 3: 4 Markets		1	11	0	12
Group 4: 5 Markets			5	0	5
Group 6: 7 Markets			2	0	2
Group 7: 8 Markets			0	1	1
Total	2	10	105	20	137

Note: No stocks were cross-listed in Group 5, i.e., in 6 markets.

V. CONCLUDING REMARKS

In this paper we provided a comprehensive set of contemporaneous estimates of the market risk for globally listed stocks across various world equity markets. We nearly exhausted a sample of 704 globally listed stocks in 59 international exchanges that were available in Datastream. Our results reveal that the estimates of the systematic risk of a stock are distinct from market to market, and from the stock's corresponding estimate of the global beta that are computed using Prakash et al.'s procedure.

Using Welch's W-test and Bartlett's B-test statistics, we pointed out the limitations of our estimates and, in particular, we examined the constraints under which such estimates were computed. The refined procedure provided by Ghai et al., that addresses some of these limitations, i.e., the assumption of the homogeneity of the error variances across various markets, is expected to provide better estimates of global beta.

Irrespective of the value of the estimates rendered by either Prakash et al.'s or Ghai et al.'s procedures, we would like to conclude that it is imperative to first refine upon the single-market country estimate of the beta in the original capital asset pricing model (CAPM) before extending and or analyzing such estimates in determining the corresponding global beta. The extent of such refinements is purely empirical and is dictated by the level of the accuracy desired. At minimum, the standard application of a few simple econometric techniques, e.g., adjustments for multicollinearity and heteroskedasticity, will substantially improve the resultant estimates of the global beta.

ENDNOTES

1. For a general discussion of the historical development of the market model see Prakash et al. (1999).
2. The wide-sense stationarity assumptions are (see Reinmuth and Wittink, 1974): $E(\varepsilon_{it})=0$ (zero mean), $var(\varepsilon_{it})=\sigma_{\varepsilon}^2$ (homoskedasticity), $cov(\varepsilon_{it}, \varepsilon_{it+k})=0$ for all $k\neq 0$, and $cov(\varepsilon_{it}, R_{mt})=0$.
3. This section draws upon Prakash, Reside and Smyser (1993).
4. The list of these stocks is available upon request from the first author.
5. The estimate of each single stock beta is available upon request from the first author.

REFERENCES

Bernard, D., and Solnik Bruno, 1995, "The World Price of Foreign Exchange Risk," *Journal of Finance* 2, 445-479.

Ghai, G.L., M.E. de Boyrie, S. Hamid, and A.J. Prakash, 2001, "Estimation of Global Systematic Risk for Securities Listed in Multiple Markets," *European Journal of Finance* 7 (2, June), 117-130.

Harvey, C., 1991, "The World Price of Covariance Risk," *Journal of Finance* 46 (1), 111-158.

James, G.S., 1951, "The Comparison of Several Groups of Observations when the Ratios of the Population Variances Are Unknown," *Biometrika* 38, 324-329.

Markowitz, H., 1959, *Portfolio Selection: Efficient Diversification of Investments,* New Haven: Yale University Press.

Prakash, A.J., M.A. Reside, and M.W. Smyser, 1993, "A Suggested Simple Procedure to Obtain Blue Estimator of Global Beta," *Journal of Business Finance and Accounting* 20 (5), 755-760.

Prakash, A.J., R. Bear, K. Dandapani, G. Ghai, T.E. Pactuwa, and A.M. Parhizgari, 1999, *The Return Generating Models in Global Finance*, Oxford, UK: Pergamon, Elsevier Science Ltd.

Press, S.J., 1972, *Applied Multivariate Analysis,* New York: Holt, Rinehard and Winston.

Reinmuth, J.E., and D.R. Wittink, 1974, "Recursive Models for Forecasting Seasonal Processes," *Journal of Financial and Quantitative Analysis* 9 (4), 659-684.

Roll, R., 1977, "A Critique of the Asset Pricing Theory's Tests. Part I: On Past and Potential Testability of Theory," *Journal of Financial Economics* 4 (2), 129-176.

Scheffe, H., 1959, *The Analysis of Variance*, New York, John Wiley & Sons.

Sharpe, W.F., 1963, "A Simplified Model for Portfolio Analysis," *Management Science* 9 (Jan.), 277-293.

Snedecor, G.W., and C. William, 1989, *Statistical Methods,* Eighth Edition, Iowa State University Press.

Stulz, R.M., 1981, "A model of International Asset Pricing," *Journal of Financial Economics* 9, 383-406.

Welch, B.C., 1953, "On the Comparison of Several Mean Values: An Alternative Approach," *Biometrika* 40, 330-336.