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A Measure of Stock Market Integration for Developed and Emerging Markets

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A wide array of official capital controls across countries makes it difficult to perform cross-sectional analysis of the effects of market segmentation. This article constructs a measure of deviations from capital market integration that can be consistently applied across countries. It measures the deviations of asset returns from an equilibrium model of returns constructed assuming market integration. Applying the measure to stock returns from twenty-four national markets indicates that market segmentation tends to be much larger for emerging markets than for developed markets, and that the measure tends to decrease over time. Along several dimensions, the proposed measure yields results that are consistent with reasonable priors about the relations between effective integration and explicit capital controls, capital market development, and economic growth.

In financially integrated markets, capital should flow across borders in order to ensure that the price of risk—the compensation investors receive for bearing risk—is equalized across assets. Conversely, if capital controls or other forces prevent free movement of capital across borders, then it is likely that different economies will demand different levels of compensation for risk. In some markets, direct measures of the severity of capital controls are available. For example, some countries have dual classes of common equity. Restricted equity can be held only by domestic residents, but unrestricted equity can be held by both domestic and foreign investors. The price differential between restricted and unrestricted shares that have identical payoffs is a direct measure of the effects of capital controls (Hietala 1989; Bailey and Jagtiani 1994). Similarly, differences between official and black market exchange rates, between official and offshore interest rates, or between the market price and the net asset value of closed-end country mutual funds can be used to measure the effects of capital controls (Bonser-Neal and others 1990).

A difficulty arises when attempting intercountry comparisons of the severity of capital controls because different countries may have different mechanisms

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for restricting capital movements. For example, a country that prohibits all foreign investment does not have unrestricted shares whose prices can be compared to restricted shares. In addition, countries without any formal restrictions against foreign investment will not have restricted shares trading. Although the former case is ostensibly one of segmented markets and the latter case is one of integrated markets, there may be methods by which investors circumvent the restrictions in the former case, and there may be informal barriers that lead to actual segmentation in the latter case (such as less stringent accounting standards or insider trading regulations).

Given the difficulty of directly comparing the effects of the wide array of official capital controls across countries, a measure of deviations from capital market integration that can be consistently applied across countries is important for cross-sectional analyses of the effects of market segmentation. The approach taken here is to measure deviations from integration by measuring the deviations of asset returns from an equilibrium model of returns constructed assuming market integration.

Testing the law of one price (LOP) in financial markets requires a model that identifies the type of risk that is important to investors. The model used here is the International Arbitrage Pricing Theory (IAPT). An advantage of an approach that relies on asset prices or returns is that effective barriers to capital flows, regardless of their source, should lead to actual deviations from LOP. Statutory barriers to capital flows that are ineffective should not lead to pricing deviations. Ostensibly free markets with large nonstatutory barriers (such as large differentials in information costs) should exhibit pricing deviations.

A disadvantage of the IAPT approach is that it relies on a particular specification of the asset pricing model. If the asset pricing model is incorrect, then pricing errors will be observed even when markets are integrated. Also, regime shifts, such as those that would occur when an economy moves from being segmented to integrated, will lead to changes in the asset pricing relation and to large short-term measured deviations from LOP.

The next section contains a brief description of the asset pricing model. Section II relates pricing errors to the existence of deviations from the law of one price induced by market segmentation. Section III discusses estimation of pricing errors. Section IV addresses the effects of regime shifts. Section V describes the data. The techniques used to construct factor-mimicking portfolios are described in section VI. The empirical measures of deviations from the law of one price are described in section VII. Section VIII presents conclusions and suggestions for future work.

I. The Multifactor Asset Pricing Model

The logic behind the Arbitrage Pricing Theory (APT; Ross 1976) and international extensions (Ross and Walsh 1983; Solnik 1983; Levine 1989; and Clyman, Edelson, and Hiller 1991) is that there are a small number of risks that are common to most assets, for which investors command risk premiums. Risk that is specific to one asset (or a small set of assets) is diversifiable and, therefore, investors do not demand compensation for this risk.

The Case without Diversifiable Risk

The arbitrage argument can be most easily illustrated in the case where there is no diversifiable, or idiosyncratic, risk. Assume that the realized returns on securities are given by the following linear factor model:

$$r_{j,t} = \mu_{j,t} + b_{j,1}\delta_{1,t} + \ldots + b_{j,k}\delta_{k,t} \tag{1}$$

where $r_{j,t}$ denotes realized returns on asset j at time t, $b_{j,i}$ is the sensitivity of asset j to the ith common source of risk, $\delta_{i,t}$ is the realization of risk factor i in period t, and $\mu_{j,t} = E_{t-1}(r_{j,t})$ is the expected return on asset j. In this case where there is no asset-specific risk, there could be a riskless, costless arbitrage opportunity unless:[1]

$$\mu_{j,t} = \lambda_{0,t} + b_{j,1}\lambda_{1,t} + \ldots + b_{j,k}\lambda_{k,t} \tag{2}$$

where $\lambda_{0,t}$ is the return on a riskless asset and $\lambda_{i,t}$ is the risk premium on the ith source of risk. More generally, expected returns could be expressed as

$$\mu_{j,t} = \alpha_j + \lambda_{0,t} + b_{j,1}\lambda_{1,t} + \ldots + b_{j,k}\lambda_{k,t} \tag{3}$$

where α_j represents the pricing error, or deviation of expected returns from the predictions of the multifactor asset pricing model.

In this case, α_j must equal zero for all j so that no arbitrage opportunities are possible. Let $\mu' = (\mu_{1,t}, \mu_{2,t}, \ldots \mu_{n,t})$, $\boldsymbol{\alpha}' = (\alpha_1, \alpha_2, \ldots, \alpha_n)$, $\boldsymbol{\lambda}' = (\lambda_0, \lambda_1, \ldots, \lambda_k)$, and $B = (\iota, b)$ where ι is an n-vector of ones and b is an $n \times k$ matrix whose (j, i) element is $b_{j,i}$. In matrix notation, equation 3 can be expressed as:

$$\boldsymbol{\mu} = \boldsymbol{\alpha} + B\boldsymbol{\lambda}.$$

The value of $\boldsymbol{\lambda}$ that minimizes the pricing error (in terms of minimizing the sum of squared pricing errors) is $\boldsymbol{\lambda} = (B'B)^{-1}B'\mu$ and $\boldsymbol{\alpha} = [I - B(B'B)^{-1}B']\mu$, where I is an $n \times n$ identity matrix. Note that $\boldsymbol{\alpha}'B = 0$, so that a portfolio formed by choosing the portfolio weight on asset i to be $\boldsymbol{\alpha}_i$ is costless (since $\boldsymbol{\alpha}'\iota = 0$) and riskless (since $\boldsymbol{\alpha}'b = 0$, which implies that the portfolio has no exposure to the risk factors). The expected return on the portfolio is

$$\boldsymbol{\alpha}'\boldsymbol{\mu} = \boldsymbol{\alpha}'\boldsymbol{\alpha} + \boldsymbol{\alpha}'B\boldsymbol{\lambda} = \boldsymbol{\alpha}'\boldsymbol{\alpha} + 0 > 0.$$

1. This requires the assumptions that there are more assets than sources of risk ($n > k$) and that the $n \times k$ matrix of sensitivities, b—where the (j,i) element of b is $b_{j,i}$—has rank k.

Thus, this portfolio is riskless and costless and has a strictly positive return. This is an arbitrage opportunity that will be exploited. In order to avoid arbitrage opportunities, the pricing relation given by equation 2 must hold. That is, $\alpha_j = 0$ for all j in equation 3.

The Case with Diversifiable Risk

The expression for asset returns in equation 1 assumes that there are only k worldwide factors that influence all asset returns. To generalize this specification to include uncertainty that is asset specific, or diversifiable, returns will be expressed as:

$$r_{j,t} = \mu_{j,t} + b_{j,1}\delta_{1,t} + \ldots + b_{j,k}\delta_{k,t} + \varepsilon_{j,t} \tag{4}$$

where $\varepsilon_{j,t}$ is the uncertainty in asset j's returns that is not explained by the worldwide factors. Ross (1976) assumes that there are an infinite number of assets and that the asset-specific risks are uncorrelated across assets, that is, $\text{corr}(\varepsilon_{j,t}, \varepsilon_{m,t}) = 0$ for $j \neq m$. Ross notes that weaker conditions also imply that the risk embodied in the term $\varepsilon_{j,t}$ is diversifiable (Chamberlain and Rothschild 1983; Connor and Korajczyk 1993).

Because each asset has its own unique, or asset-specific, risk, it will not be possible to form riskless portfolios from a finite set of risky assets. However, an asymptotic arbitrage opportunity can be defined as one in which it is possible to construct a sequence of portfolios whose expected returns approach infinity and whose variance approaches zero as the number of assets, n, approaches infinity. The absence of such arbitrage opportunities implies that the sum of squared pricing deviations $(\alpha_1^2 + \alpha_2^2 + \ldots + \alpha_n^2)$ must remain finite as n approaches infinity (Ross 1976; Huberman 1982).

The fact that the sum of squared pricing deviations must remain finite implies (in an economy with an infinite number of assets) that most of the pricing errors must be small and that equation 2 holds as an approximation for most assets:

$$\mu_{j,t} \approx \lambda_{0,t} + b_{j,1}\lambda_{1,t} + \ldots + b_{j,k}\lambda_{k,t}. \tag{5}$$

Further restrictions can be placed on the economy to get the pricing model to hold as an equality (Connor 1984; Constantinides 1989). I will assume that, under the null hypothesis of financial market integration, either such restrictions hold or the approximation is good enough to ignore the approximation error in equation 5.

II. Market Segmentation and Pricing Errors

Although the method of estimating the risk factors is described more fully later, it is useful at this juncture to point out that capital market segmentation prevents cross-market arbitrage and, therefore, prevents the prices of risk (vector $\boldsymbol{\lambda}$) from being equated across markets. Capital market segmentation will lead to pricing errors relative to risk factors constructed assuming capital market integration. This is illustrated by a hypothetical world consisting of two markets (a and b) that are influenced by the same single-world factor. That is, assets in each economy satisfy a one-factor pricing model. However, because the markets are segmented, the parameters of the asset pricing model are different across markets. The expected returns on asset j in the two markets are given by

$$\mu^a_{j,t} = \lambda^a_0 + b^a_{j,1}\lambda^a_1$$

$$\mu^b_{j,t} = \lambda^b_0 + b^b_{j,1}\lambda^b_1$$

with $\lambda^a_0 \neq \lambda^b_0$ and $\lambda^a_1 \neq \lambda^b_1$. However, the implied riskless return and world factor risk premium estimated by pooling the two markets together and assuming (incorrectly) that they are integrated will be (assuming the markets are of equivalent size and have the same distribution of sensitivities) $\bar{\lambda}_0 = (\lambda^a_0 + \lambda^b_0)/2$ and $\bar{\lambda}_1 = (\lambda^a_1 + \lambda^b_1)/2$. That is, estimating an integrated model when the null is incorrect will lead to estimated risk premiums that are weighted averages of the true segmented risk premiums. This implies that for economy a, the measured pricing deviation (relative to a model estimated assuming integration) of asset j is

$$\alpha^a_j = (\lambda^a_0 - \bar{\lambda}_0) + b^a_{j,1}(\lambda^a_1 - \bar{\lambda}_1) \tag{6}$$

and for economy b, the measured pricing deviation of asset j is

$$\alpha^b_j = (\lambda^b_0 - \bar{\lambda}_0) + b^b_{j,1}(\lambda^b_1 - \bar{\lambda}_1). \tag{7}$$

Thus, the mispricing parameters, α, provide a direct measure of deviations from the LOP.

Although the example assumes a single common factor, the results extend to any number of common factors, under the assumption that the IAPT would be the appropriate pricing model in an integrated world. That is, different prices of risk for common factors will lead to nonzero alphas relative to the IAPT.

Under certain conditions, the pricing errors relative to a factor model might actually miss market segmentation. This could occur if there are local factors in one or more countries that are priced locally (because of segmentation) but not priced in other countries. In addition, market segmentation could be missed if (1) the local factors are unrelated to asset returns in the other countries (that is, the factors are not common in that the sensitivities of nonlocal assets to the local factors are zero) and (2) the local factors are included in the asset pricing model. To illustrate this situation, consider a hypothetical world consisting of two markets (a and b) that are influenced by the same single-world factor. Country b's assets are sensitive to a local factor that is priced in b but not in a. That is, assets in each economy satisfy the factor pricing models

$$\mu_j^a = \lambda_0^a + b_{j,W}^a \lambda_W$$

$$\mu_j^b = \lambda_0^b + b_{j,W}^b \lambda_W + b_{j,L}^b \lambda_L^b$$

where W and L stand for world and local factors. Here I have assumed that the two economies have the same price of risk for the world factor but different prices for the local factor. Applying a two-factor model to these economies using the world and local factors will not reveal a pricing deviation even though the nonzero price of the local factor in country b is due to market segmentation. The pricing deviation will be undetected because assets in economy a have zero sensitivity to the local factor.

Failure to reject integration in this case hinges on including the local factor in the model. If only the world factor, and not the local factor, is included in the model, then the pricing errors for country b's assets will be nonzero and should lead to a rejection of the market integration hypothesis.

An alternative approach to testing the law of one price is to estimate the price of risk for different subsets of securities and test the hypothesis that the price of risk is equal across subsets. This is done within a single country in Roll and Ross (1980), who test for the equality of the zero-beta return, λ_0, across subsets, and in Brown and Weinstein (1983), who test for the equality of all risk premiums. In an international setting, subsetting by country allows an estimate of country-specific prices of risk. This is done by Cho, Eun, and Senbet (1986); Gultekin, Gultekin, and Penati (1989); and Harvey (1991).

III. Estimation of Pricing Errors

The pricing deviations discussed in sections I and II were expressed as discrepancies between an asset's true expected return and the expected return implied by the asset pricing model. However, the ex post return on the asset is observed, not the true expected returns on the asset. From equation 4, the asset's ex post return deviates from its expected return because of shocks from the common factors and asset-specific shocks.

Let T be the number of time periods for observed asset returns; n the number of securities; r^n the $n \times T$ matrix of excess returns on the assets; F the $k \times T$ matrix of realized factors plus risk premiums $F_{i,t} = \delta_{i,t} + \lambda_{i,t}$, where $F_{i,t}$ is the excess return on the portfolio that mimics factor i in period t; b^n the $n \times k$ matrix of sensitivities, or factor loadings; and ε^n the $n \times k$ matrix of idiosyncratic (asset specific) returns. Equations 2 and 4 imply that

$$r^n = b^n F + \varepsilon^n \tag{8}$$

with $E(F\varepsilon^{n\prime}) = 0$, $E(\varepsilon^n) = 0$, and $E(\varepsilon^n \varepsilon^{n\prime}/T) = V^n$.

The assumption of a factor structure and the asset pricing theory (equations 2 and 4) imply that there is a restriction on a multivariate regression of asset returns on a constant and the excess returns on factor-mimicking portfolios, which is embodied in equation 8. The restriction is that the intercepts are jointly equal to zero. That is, in the multivariate regression

$$r^n = \alpha^n + b^n F + \varepsilon^n \tag{9}$$

the vector of intercept terms, α^n, contains the pricing deviations. If markets are integrated and the multifactor asset pricing model describes asset expected returns, α^n should be equal to zero. However, if risks are priced differently across economies, these pricing differences will lead to nonzero values of α^n. Thus, one measure of financial integration is the size of the intercept terms in the multivariate regression (equation 9).

IV. Asset Pricing Dynamics and Regime Shifts

The theoretical pricing errors in equations 6 and 7 are derived assuming that each economy is in a steady-state segmented equilibrium each period. However, the recent trend in most markets is movement from segmented markets toward integrated markets. This trend implies that the asset pricing regimes will shift from segmented to integrated regimes and that the parameters in equation 9 are likely to change through time. In the long run, increasing integration should lead to smaller pricing errors (zero pricing errors in the limit approaching complete integration). However, in the short run, measured pricing errors might be larger as asset prices change because of the changes in asset pricing regimes. Since the movement from a completely segmented market to a completely integrated market is rarely smooth, the asset pricing dynamics during the transition phase are difficult to characterize. In particular, if market participants anticipate the liberalization from a segmented to integrated market, asset expected returns in the transition period are not likely to be set according to models that assume complete segmentation or complete integration.

The appendix contains a simple numerical example of an unanticipated regime shift. Although the numerical results are clearly dependent on the numbers picked for the example, the fact still remains that shifts across pricing regimes are likely to cause changes in the parameters (α and b) and cause large measures of mispricing in the short run. Also, these shifts in pricing should occur as shifts in regimes become anticipated. Thus, the effects of regime shifts could be spread over a longer period as the market updates its assessment of changes in capital controls. The unconditional approach in equation 9 ignores shifts in the parameters and the transition dynamics. Clearly, if the nature of pricing errors was constant through time, the full time-series sample should be used to estimate α. Given the importance of regime shifts, I investigate the behavior of estimated mispricing over a sequence of different time periods. This is an admittedly crude method of accommodating nonstationarities such as regime shifts. However, it is a first step toward measuring levels of integration.

Most empirical studies of market integration assume that the level of segmentation is constant over the estimation period. A notable exception is Bekaert and Harvey (1995). They propose a regime switching model in which markets stochastically move between segmented and integrated regimes. In addition, the probability of a regime shift is allowed to change as a function of predetermined instrumental variables. Within a regime, the model assumes that assets are priced as though agents expect to be in that regime forever. Although this does not admit an investigation of the pricing effects of anticipated regime shifts, it takes seriously the fact that regime shifts happen and that the transition probabilities vary through time.

V. Data Sources and Summary Statistics

Historical monthly data on equity returns for individual stocks trading in twenty emerging markets are from the Emerging Markets Data Base provided by the International Finance Corporation (IFC). The economies covered by the data base are Argentina, Brazil, Chile, Colombia, Greece, India, Indonesia, Jordan, the Republic of Korea, Malaysia, Mexico, Nigeria, Pakistan, the Philippines, Portugal, Taiwan (China), Thailand, Turkey, Venezuela, and Zimbabwe. The set of emerging markets is geographically diverse as well as diverse in the severity of capital controls.

The sample of developed equity markets includes stocks from Australia, Japan, the United Kingdom, and the United States. Equity data sources for the developed markets are the Centre for Research in Finance at the Australian Graduate School of Management for Australia, the Japan Securities Research Institute for Japan, the London Share Price Data Base from the London Business School for the United Kingdom, and the Center for Research in Security Prices at the University of Chicago for the United States. The sample includes all assets traded on the Australian Stock Exchange, the New York and American Stock Exchanges, the first section of the Tokyo Stock Exchange, the London Stock Exchange, and the unlisted securities market in the United Kingdom.

Monthly returns, adjusted for dividends and stock splits, are transformed into U.S. dollar returns using end-of-month exchange rates. The emerging markets exchange rates are from the IFC's Emerging Markets Data Base, and the developed markets exchange rates are from IMF (various issues). To compute excess returns, I use the U.S. Treasury Bill returns from Ibbotson Associates (1993).

Data on equity returns and shares outstanding from the IFC's Emerging Markets Data Base were screened for unusual values. Confirmations or corrections of these values were obtained from the IFC. When there is more than one exchange rate system in place within a country, the IFC attempts to obtain a free market rate either from newspapers or from IFC correspondents in each market (see IFC 1993). There are a few instances, earlier in the sample, when the exchange rates seem too stable to be free market rates, given that black market rates seem to be varying over the same period. This does not appear to be an issue later in the sample.

Construction of the Emerging Markets Data Base began in 1981. Firms were chosen at that time on the basis of 1980 data (Errunza and Losq 1985: 562). Although such a choice poses no particular problems for returns after 1980, there may be a survivorship bias induced for the returns before 1981. That is, firms that disappeared between 1975 and 1980, for example, would not be included in the data base. An actual portfolio strategy might have included those assets in the sample. As shown in table 1, eleven of the twenty emerging markets have data prior to 1981. Errunza and Losq (1985) investigate the issue of survivorship bias in a sample of eight of these emerging markets. They apply the selection criteria to assets as of the beginning of the sample, December 1975. They find that the overlap between this sample and the actual sample in the data base is between 53 and 85 percent. Seven companies that would have been included when applying the selection criteria in 1975 were not trading on the exchanges in 1980. Errunza and Losq argue that the survivorship bias is small in the sample. Although the reported statistics about the overlap of the samples and delistings are suggestive, the extent of the survivorship bias is difficult to estimate without recreating each market's sample with a nonanticipatory inclusion rule over the period from 1975 to 1980. Even if this were done, there is another potential survivorship bias in that the initial set of emerging markets was chosen on the basis of information available in 1980. There may have been markets that would have been included in 1975 that performed poorly between 1975 and 1980 (that is, failed to emerge) and were thus not included in the sample.

Random errors in the individual stock data will clearly induce noise into the estimated mispricing parameters. More systematic errors—such as errors in the exchange rate, which influence the calculated return on all assets in a given economy, or survival biases—will tend to cause false rejection of market integration by inducing nonzero pricing errors in the factor model.

Tables 1 and 2 provide some summary statistics on the emerging markets in the sample. The IFC's Emerging Markets Data Base does not include all of the stocks traded in the emerging markets. Rather, the data base consists of a sample of stocks from each market. The stocks are chosen on the basis of trading activity, capitalization, and diversity across market sectors (see IFC 1993). On average, the stocks in the IFC sample represent 57 percent of the total capitalization of the respective markets.

As illustrated in table 1, the average number of firms ranges from 11 (Zimbabwe) to 66 (Indonesia). The capitalization (as of December 1992) of the stocks included in the data base ranges from $268 million (Zimbabwe) to $66 billion (Mexico and Korea).[2] Average monthly turnover (volume for month t divided by

2. One billion is equal to 1,000 million.

Table 1. *Summary Statistics for Emerging Markets*

Market	*Beginning of sample period*[a]	*Average number of firms*	*Capitalization as of December 1992 (millions of U.S. dollars)*	*Trading volume as of December 1992 (millions of U.S. dollars)*	*Average turnover (monthly percentage)*
Emerging market composite[b]	1984	590	401,998	16,535	8.79
Europe and Middle East					
Greece	1975	15	5,377	112	1.05
Jordan	1978	15	1,988	70	1.18
Portugal	1985	20	4,868	52	1.07
Turkey	1975	19	3,872	158	2.54
Latin America					
Latin America composite[b]	1984	176	135,638	3,936	3.24
Argentina	1975	23	14,293	1,112	3.41
Brazil	1975	33	23,200	803	3.40
Chile	1975	25	21,933	96	0.76
Colombia	1984	21	5,107	23	0.49
Mexico	1975	32	66,108	1,806	5.31
Venezuela	1984	14	4,997	96	2.00
Asia					
Asia composite[b]	1984	325	249,191	12,204	10.99
India	1975	36	25,365	364	6.42
Indonesia	1989	66	8,661	260	3.85
Korea, Rep. of	1975	37	66,461	6,007	8.20
Malaysia	1984	52	47,941	773	1.11
Pakistan	1984	52	3,774	33	0.86
Philippines	1984	22	8,167	84	2.13
Taiwan (China)	1984	50	60,454	3,172	23.66
Thailand	1975	17	28,368	1,877	5.38
Africa					
Nigeria	1984	18	797	1	0.05
Zimbabwe	1975	11	268	1	0.35

a. The sample begins at the end of December of the year indicated.
b. Composites are value-weighted portfolios formed from the national market indices.
Source: IFC's Emerging Markets Data Base.

the capitalization of the market in month $t - 1$) for the sample period is lowest for Nigeria at 0.05 percent and highest for Taiwan (China) at 23.66 percent.

Table 2 reports some statistics for the return distributions of the IFC emerging market indexes. The average monthly rate of return in U.S. dollars is lowest for Indonesia (−1.02 percent) and highest for Argentina (5.66 percent). The variability of the index returns (standard deviation in table 2) is also quite high. Jordan has the smallest monthly standard deviation, 5.17

Table 2. *Monthly Return and Pricing Error Statistics for Emerging Markets*

	Monthly return (percent)			
Market	*Mean*	*Standard deviation*	*Autocorrelation coefficient, ρ_1*[a]	*Average pricing errors, $\hat{\theta}$*[b]
Emerging market composite[c]	1.50	6.98	0.16 (1.53)	
Europe and Middle East				
Greece	0.62	10.46	0.13 (1.89)	0.85
Jordan	0.90	5.17	0.00 (0.00)	2.42
Portugal	2.88	14.50	0.29 (2.61)	−10.43
Turkey	3.15	21.44	0.23 (1.97)	−4.43
Latin America				
Latin America composite[c]	2.60	11.21	0.24 (2.40)	
Argentina	5.66	30.00	0.05 (0.77)	−2.73
Brazil	1.84	17.39	0.03 (0.41)	−31.29
Chile	3.06	11.42	0.17 (2.41)	48.99
Colombia	3.64	9.28	0.49 (4.79)	11.01
Mexico	2.53	12.86	0.25 (3.53)	10.97
Venezuela	2.68	13.66	0.27 (2.62)	2.43
Asia				
Asia composite[c]	1.50	7.42	0.01 (0.13)	
India	1.68	7.86	0.08 (1.13)	−2.05
Indonesia	−1.02	9.40	0.28 (1.71)	−0.01
Korea, Rep. of	1.77	9.34	0.00 (−0.02)	3.15
Malaysia	1.15	7.61	0.05 (0.51)	2.50
Pakistan	1.79	6.70	0.25 (2.45)	0.22
Philippines	3.78	11.02	0.34 (3.32)	6.62
Taiwan (China)	2.84	15.27	0.07 (0.72)	1.84
Thailand	1.86	7.44	0.11 (1.63)	5.33
Africa				
Nigeria	0.22	10.54	0.08 (0.83)	2.04
Zimbabwe	0.65	9.86	0.14 (1.97)	21.70

a. First-order autocorrelation coefficient of market index returns. t-statistics are in parentheses.
b. Time-series average of bias-adjusted average squared pricing errors.
c. Composites are value-weighted portfolios formed from the national market indices.
Source: IFC's Emerging Markets Data Base.

percent, while Argentina has the largest monthly standard deviation, 30 percent. By contrast, the S&P 500 portfolio has a monthly standard deviation of 4.46 percent for the period from January 1976 to December 1992 (Ibbotson Associates 1993).

VI. Construction of Factor-Mimicking Portfolios

In order to estimate the level of mispricing, $\boldsymbol{\alpha}^n$ in equation 9, we need to have the matrix F. F contains the time series of excess returns on k portfolios whose innovations are perfectly correlated with the k sources of factor risk. In practice, these excess return portfolios need to be estimated.

To estimate the excess returns on the factor-mimicking portfolios, I use the asymptotic principal components technique of Connor and Korajczyk (1986, 1988). The asymptotic principal components procedure can easily accommodate the large number of stocks in the sample. The procedure assumes that the factor structure is as in equation 4; that the exact multifactor pricing relationship, equation 2, holds; that the conditional factor loadings, $b_{j,t}$, are constant through time for most assets; and that the cross-sectional average asset-specific variance is constant through time. Let Ω^n be the $T \times T$ matrix defined by $\Omega^n = r^{n\prime} r^n / n$ and $\hat{F}^n$ the $k \times T$ matrix of the first k eigenvectors of Ω^n (where $\hat{F}^n$ is an estimate of F, and where r^n and F are as defined in equation 8). Under the assumption that asset returns follow a k-factor model as in equation 4, Connor and Korajczyk (1986) show that $\hat{F}^n$ converges in probability to a nonsingular linear transformation of F as n goes to infinity. Because the sample of equity returns is large, I ignore the estimation error in $\hat{F}^n$. In order to use all available data in the sample, I employ an extension of the principal components technique from Connor and Korajczyk (1988), which does not require that asset returns exhibit continuous time series of returns. This method is designed to avoid a common source of survivorship bias. Although these types of factor portfolios do not fully explain the pricing of international equities, they perform well relative to common alternative models (Korajczyk and Viallet 1989).

I use the returns on all stocks from the twenty-four national stock markets to estimate the factor-mimicking portfolios. For an average month in the period from January 1976 to December 1992, 6,851 firms from the twenty-four markets have available returns.

An alternative approach to implementing international multiple factor models is to specify, ex ante, the identity of the factors. This is the approach taken in Harvey (1995a, 1995b). The factors used in those papers include the return on the proxy for the world market portfolio, the return on a portfolio of currencies, and proxies for changes in commodity and agricultural prices (Harvey 1995a) plus proxies for oil price movements, inflation, and world business cycles (Harvey 1995b). Harvey (1995a) investigates conditional as well as unconditional factor models.

VII. Empirical Measures of Deviations from the Law of One Price

As discussed in section III, the estimated IAPT pricing errors (that is, the intercepts, $\boldsymbol{\alpha}$, in a regression of asset returns (in excess of a riskless asset) on the excess returns of a factor-mimicking portfolio) are a measure of segmentation. The estimation treats the pricing errors as constant over the sample period even though there have been significant liberalizations of capital controls in many economies. Therefore, I estimate pricing errors over a sequence of time periods and attempt to characterize the time-series behavior of the mispricing parameters. Although it is somewhat schizophrenic to assume $\boldsymbol{\alpha}$ is fixed for estimation but then to look at the time series of $\boldsymbol{\alpha}$ over different sample periods, the exercise should provide some information about the behavior of pricing errors (see Foster and Nelson 1991 for an analysis of such "rolling regressions").

My approach is as follows:

1. Estimate factor-mimicking portfolios using the asymptotic principal components procedure. The asymptotic principal components procedure uses data on all of the equities traded in the twenty-four markets studied here to estimate factor-mimicking portfolios for the entire sample period.
2. For each national market, estimate equation 9 for all stocks individually over rolling eighteen-month sample periods. This estimation will yield vectors of mispricing estimates, $\hat{\alpha}_t^n$, where the time subscript denotes the sample period over which the parameters are estimated.
3. Calculate a summary measure of the mispricing for each national market.

In focusing on deviations (both positive and negative) of $\boldsymbol{\alpha}$ from zero, a natural measure of mispricing across the assets is the average squared mispricing coefficient, $\boldsymbol{\alpha}^{n\prime}\boldsymbol{\alpha}^n/n$. However, the regressions provide only an estimate of $\boldsymbol{\alpha}^n$, $\hat{\boldsymbol{\alpha}}^n$, not the true value. The average squared values of the estimates, $\hat{\boldsymbol{\alpha}}^{n\prime}\hat{\boldsymbol{\alpha}}^n/n$, will converge to $\boldsymbol{\alpha}^{n\prime}\boldsymbol{\alpha}^n/n$ plus the average squared value of the estimation error. Thus, $\hat{\boldsymbol{\alpha}}^{n\prime}\hat{\boldsymbol{\alpha}}^n/n$ will yield an upwardly biased estimate of $\boldsymbol{\alpha}^{n\prime}\boldsymbol{\alpha}^n/n$. However, the bias for asset i, $E[\hat{\alpha}_i^2 - \alpha_i^2]$, has an expected value equal to the variance of the intercept coefficient. Let v_i denote the estimated variance of the regression intercept for asset i and let the n-vector of these variances for n assets be v^n. Given v^n, an adjusted average squared pricing error can be calculated as $\hat{\theta} = \hat{\alpha}^{n\prime}\hat{\alpha}^n/n - v^{n\prime}\boldsymbol{\iota}/n$, where $\boldsymbol{\iota}$ is an n-vector of ones. The quantity $\hat{\theta}$ will be called the *average adjusted mispricing* for the n assets. In the empirical analysis, I use estimates, v_i, which are corrected for conditional heteroskedasticity, as in White (1980).

Under the null hypothesis that $\boldsymbol{\alpha}^n = 0$, the expected value of $\hat{\theta}$ is zero. Thus, if capital markets are integrated and share the same set of pervasive risks, the average adjusted mispricing should be close to zero. This measure of mispricing should tend to be larger the more severe the barriers to free capital flows. In addition, the periods of transition from segmented to integrated markets should be associated with large average adjusted mispricing, as asset prices adjust to a different equilibrium level.

Rather than emphasize formal statistical tests, I wish to characterize the cross-sectional and time-series characteristics of the estimated mispricing and relate the behavior of the measures to changes in capital controls in the various markets. This characterization of the empirical properties of the mispricing, or market segmentation, measures should provide some sense of the forces causing the measured deviations from LOP. Average adjusted mispricing is estimated for each of the twenty-four national markets. Since the severity of capital controls is likely to vary through time, I estimate a time series of $\hat{\theta}$'s, rather than estimate each economy's adjusted mispricing for the entire sample period. The time series of $\hat{\theta}$'s is constructed by estimating $\hat{\theta}$ for each (overlapping) eighteen-month period in the sample. That is, data from January 1976 to June 1977 are used to estimate $\hat{\theta}_{6/77} = \hat{\alpha}^{n\prime}_{6/77}\hat{\alpha}^{n}_{6/77}/n - v^{n\prime}_{6/77}\iota/n$, data from February 1976 to July 1977 are used to estimate $\hat{\theta}_{7/77}$, and so on. The final period is July 1991 through December 1992. All firms are included in the sample as long as they have at least fifteen monthly observations in the subperiod.

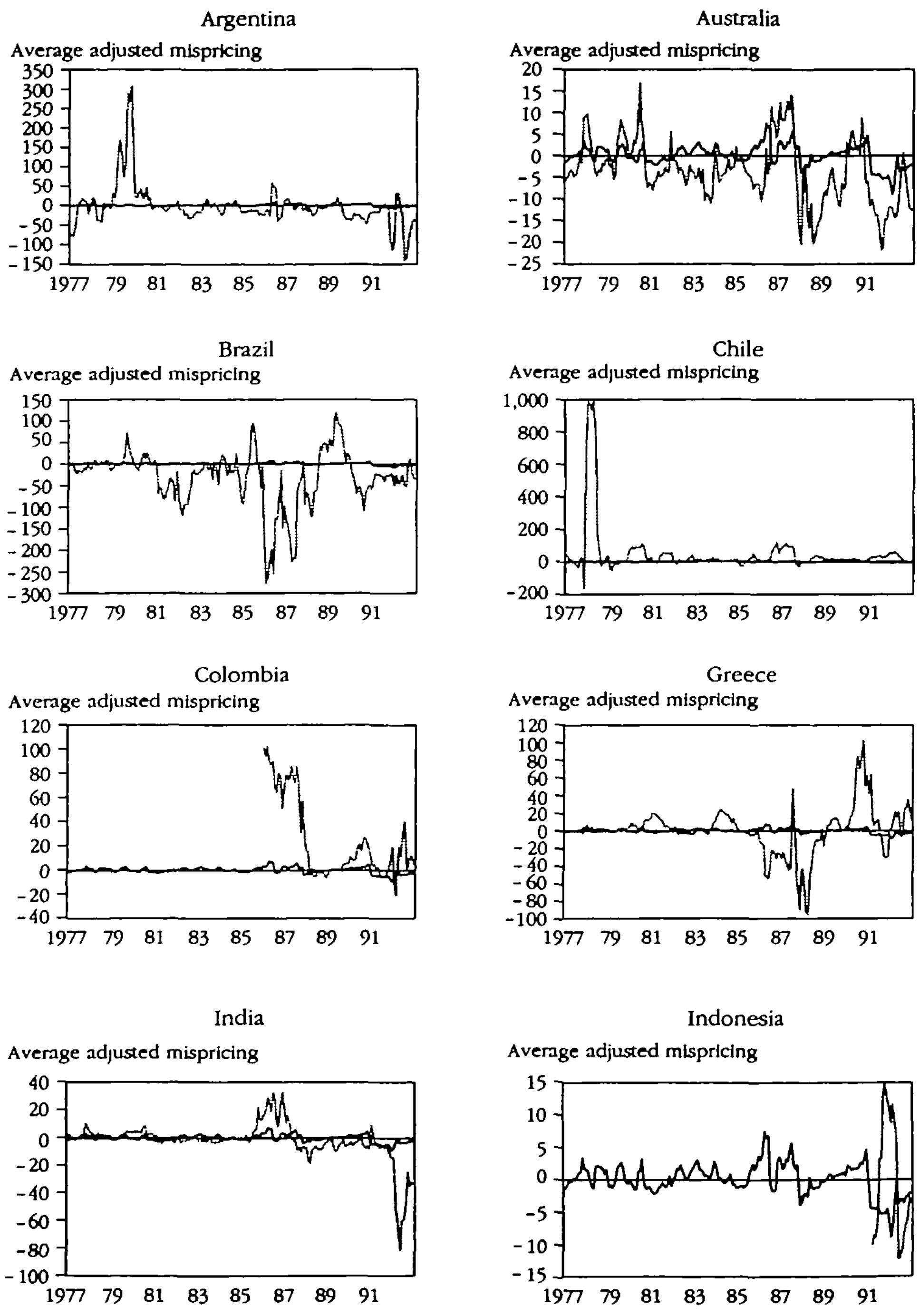
The time-series averages of the values of $\hat{\theta}_t$ are reported in table 2. The average adjusted mispricing, $\hat{\theta}_t$, is plotted for each national market in figure 1. Each graph also plots $\hat{\theta}_t$ for the United States as a reference point. The values of $\hat{\theta}_t$ for Australia, Japan, and the United Kingdom are generally small. The largest deviations from the value of zero occur for Australia, with values around –20 that occur around the 1987 stock market crash.

Argentina begins in the late 1970s with very high values of $\hat{\theta}_t$ (around 300), that decline rapidly. There is a sharp rise in $\hat{\theta}_t$ in 1986, followed by a sharp decline. The period from 1986 through 1987 coincides with increased investment by foreign institutional investors. Beginning in the autumn of 1989, there is a period in which $\hat{\theta}_t$ takes on large negative values. This latter period coincides with the beginning of a series of economic reforms in Argentina.[3] The reforms include the State Reform Law (in September 1989), which announced—among other things—various privatizations, and the New Foreign Investment Regime (in November 1989), which essentially opened the Argentine capital markets to foreign investors by eliminating restrictions on both foreign ownership (except in selected sectors) and the repatriation of capital.

The values of $\hat{\theta}_t$ for Brazil are particularly large in the period from 1985 through 1989. The largest deviations occur in 1986. This corresponds to a period in which the government announced the Cruzado Plan, which instituted strict price controls on goods, wages, and official exchange rates. There is a short-lived boom in the stock market in which the IFC index of stocks doubles (in U.S. dollar terms) in the span of two months (from February to April). The boom is followed by a decline in the IFC index of stocks to their February levels by the end of the year. Large negative values of adjusted mispricing seem to accompany liberalizations in March 1987 (approval of

3. Sources of information on economic and political developments as well as extant capital controls in emerging markets are Chuppe and Atkin (1992), IFC (1993), Park and Van Agtmael (1993), Levine and Zervos (1994), and Bekaert (1995).

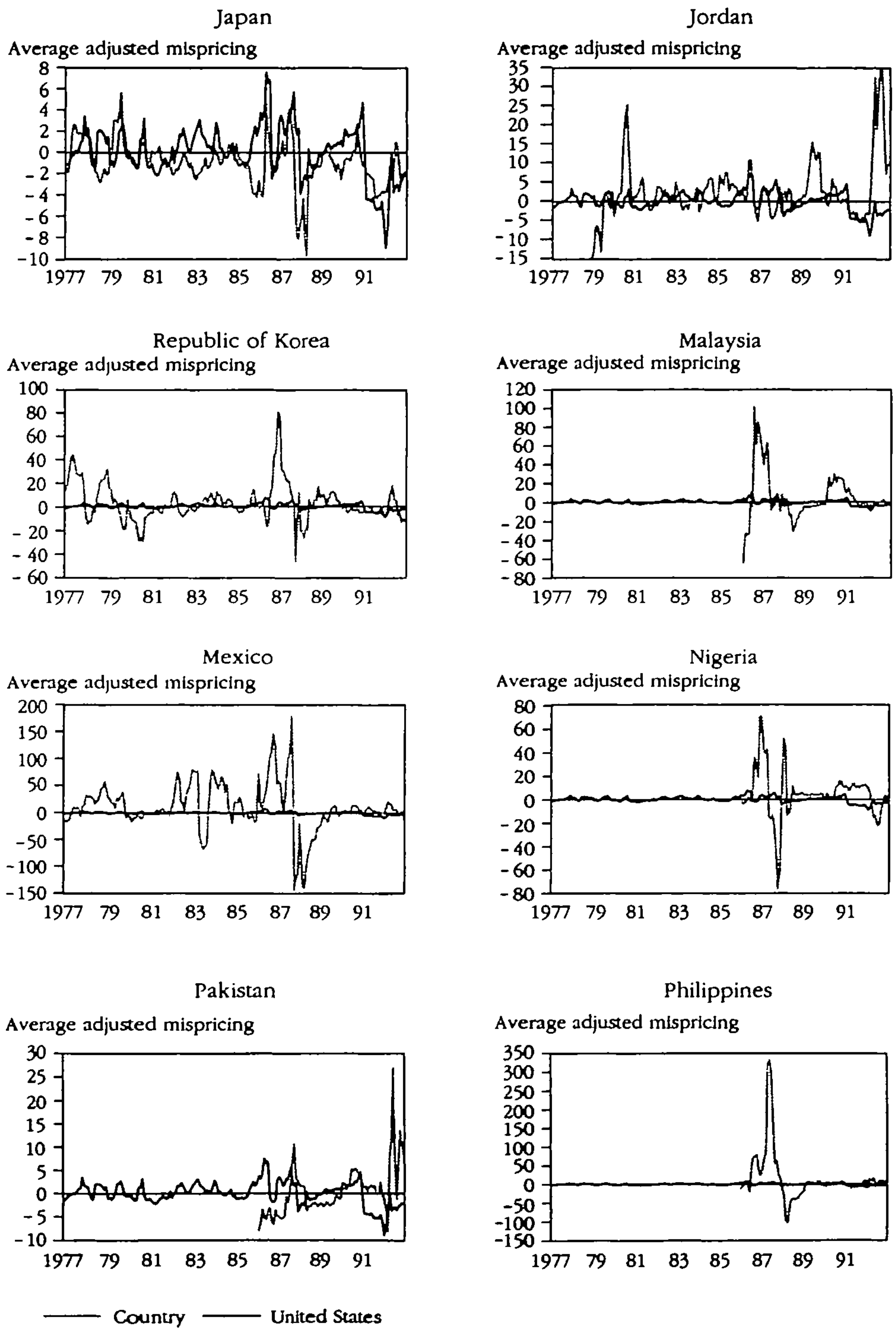
Figure 1. *Average Adjusted Mispricing, Selected Markets, June 1977 to December 1992*

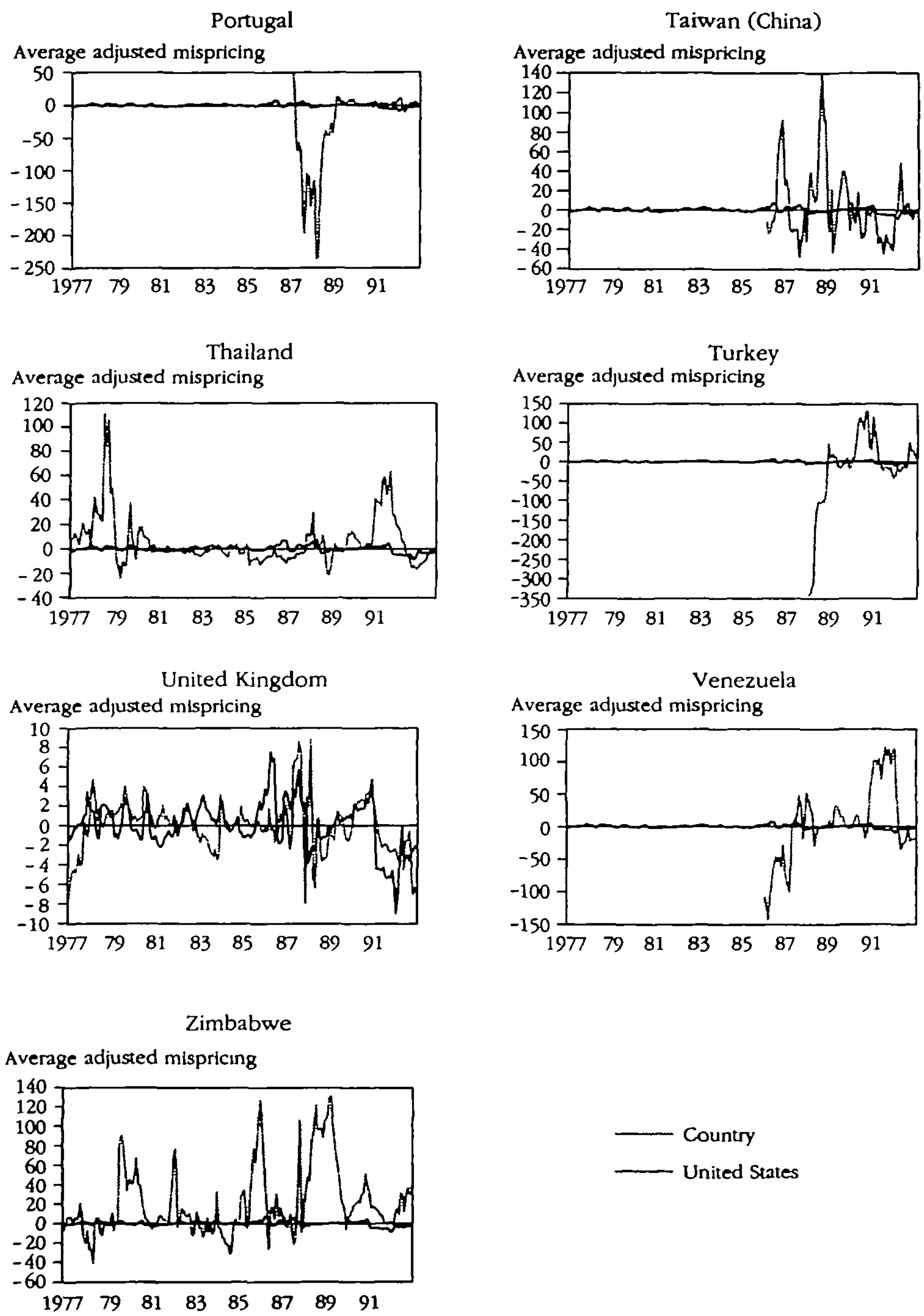


—— Country —— United States

(Figure continues on the following page.)

Figure 1. *(continued)*





Source: IFC's Emerging Markets Data Base.

foreign investment trusts) and 1990 (when an interbank foreign exchange market is allowed).

Chile has extremely large values of adjusted mispricing in 1977–78. There are smaller (but still large) values of mispricing in 1981 and 1987.

Colombia shows a steady decline in $\hat{\theta}_t$ for the periods ending March 1986 through March 1988. After that, $\hat{\theta}_t$ stays relatively close to zero until late 1990. The large values of $\hat{\theta}_t$ in late 1990 and early 1991 may be associated with a move toward making the market 100 percent investable in February 1991.

The values of $\hat{\theta}_t$ are relatively close to zero for Greece until the mid-1980s. There is a large increase in mispricing in 1990. After several years of a socialist government (from 1981 to 1989) and a year in which two elections failed to produce a clear winning party, the conservative party was elected to power in April 1990. There is a 59 percent return to holding the portfolio of stocks in the IFC index in April 1990, followed by a 44 percent return in June 1990. Prices subsequently decline in late 1990.

The average adjusted mispricing values for India are generally small except from 1985 to 1987 and in 1991–92. This later period includes a balance of payments crisis in mid-1991, followed by a series of reforms phasing in full convertibility of the rupee. Restrictions on institutional investment in Indian equities were loosened in 1992. In April 1992 it was disclosed that a number of banks were illegally investing funds in the Indian equity market. The disclosure led to a sharp decline (approximately 40 percent) in the equity market.

The time-series sample for Indonesia is rather short. Because of this, it is difficult to detect particular patterns in the average adjusted mispricing.

Jordan exhibits some of the smallest absolute levels of average adjusted mispricing among the emerging markets. It also exhibits the lowest volatility and one of the lowest mean returns among the emerging markets (table 2). The largest values of adjusted mispricing occur in 1991–92.

The Korean stock market exhibits relatively small values of adjusted mispricing except in the late 1970s and the mid-1980s, in spite of the fact that there were severe restrictions on foreign investment in Korean equities. In 1981 the first of a series of funds was offered through which foreign investors could invest in Korean securities (see Chuppe and Atkin 1992). From 1985 through 1987 additional liberalization occurred. Additional Korean mutual funds were offered to international investors. In 1985, companies on the Korean stock exchange were granted authorization to raise capital in international bond markets and, as a result, gained access to equity capital through convertible bond issues. An over-the-counter market for unlisted stocks was opened in 1987. A government fund to stabilize stock prices was created in 1989 after the 1989 crash.

The Malaysian stock market shows very large levels of mispricing in 1986 and early 1987. The period through late 1986 involved extensive liberalization of restrictions on capital inflows. The large values of adjusted mispricing might be due to large capital inflows at that time, although it is difficult to infer much from the short time series.

For the Mexican stock market, the average adjusted mispricing is relatively large until 1989. From 1989 through 1992 the average pricing errors are relatively low. Before 1989, restricted shares—which could be owned by foreigners—were typically restricted to below 50 percent of a firm's equity capital. In 1989, foreigners were allowed to hold up to 100 percent of a firm's equity in most industrial sectors. A trust fund was also established in 1989 to allow foreign investors to buy (through the trust) previously restricted shares.

The Nigerian stock market was essentially closed to foreign investment throughout the sample period. The average adjusted mispricing is large and volatile in the mid-1980s. The value of $\hat{\theta}_t$ declines to approximately 0 in the late 1980s with a jump to the 7–10 range in 1991.

Pakistan has relatively small average mispricing throughout the sample period. There is a small jump in mispricing in 1991, which coincides with the lifting of restrictions on foreign investment.

The Philippines shows large values of average mispricing from 1986 to 1989. This may reflect the price effects of inflows of capital following the ouster of President Marcos. After 1989 the average mispricing is generally small.

The Portuguese stock market shows large values (first positive, then negative) of average mispricing from 1987 through 1989. This may have been caused by pricing effects of the Portuguese entry into the European Union (and the associated elimination of barriers to foreign investments) followed by the October 1987 crash. After 1989 the estimated average adjusted mispricing is relatively small.

The Taiwan (China) stock market shows generally large levels of estimated mispricing with no discernible trend, even though the period is one in which barriers to foreign investments were generally being lifted. Indirect investment was allowed through investment trust funds in 1982, with direct investment by foreign institutions following in 1991 (with a temporary halt in 1992).

Average mispricing on the Thailand stock market is generally small in the 1980s. Larger average mispricing occurs in the late 1970s and early 1990s.

The Istanbul Stock Exchange opened in 1986. The short time series of mispricing for Turkey does not show any pronounced trend, except the initial increase from very negative values.

The Zimbabwe stock market shows generally high levels of adjusted mispricing. This is consistent with the fact that the market was closed to foreign investment throughout the sample period.

VIII. Conclusions and Suggestions for Future Work

In this article I suggest a measure of the deviations from the law of one price across potentially segmented capital markets. This measure is applied to stock returns from twenty-four national markets (four developed markets and twenty emerging markets). The measure of market segmentation tends to be much larger for emerging markets than for the developed markets, a result consistent with larger barriers to capital flows into or out of the emerging markets. The measure often tends to decrease through time, a result that is consistent with growing levels of integration. Large values of adjusted mispricing also occur around periods of economic turbulence and periods in which capital controls change significantly. Thus, the adjusted mispricing estimates measure not only the level of deviations from the LOP but also the revaluations inherent in moving from one regime to another.

Relating the proposed measure of market integration to alternative measures of integration (as in Bekaert 1995), to measures of capital market development, or to ex post measures of economic growth would be useful for highlighting the advantages and disadvantages of this measure.

Bekaert and Harvey (1995, figure 2) plot the estimated probability of being in the integrated regime. There are some interesting similarities and differences in the conclusions that could be drawn from their measure of integration and the adjusted mispricing plotted in figure 1. For example, Bekaert and Harvey (1995) show dramatic declines in the probability of India's stock market's being integrated in 1985 and 1992, corresponding to the periods in which there are large values of the adjusted mispricing parameter for India in figure 1. An example of a case in which the measures of integration seem to differ is Mexico. Bekaert and Harvey's estimate of the probability of integration is quite low in the post-1989 period. This is the period in which the adjusted mispricing estimate is the closest to zero for Mexico (figure 1). Thus, these alternative measures of market integration seem to be highlighting different aspects of the mechanism generating expected returns.

Demirgüç-Kunt and Levine (1996) investigate the cross-sectional relation between mispricing and other indicators of capital market development. They find that mispricing (without the bias adjustment) is significantly negatively correlated with the size (market capitalization) and trading volume of the respective markets and is significantly positively related to market volatility and concentration. Levine and Zervos (1994, 1995) find that the mispricing measure proposed here is negatively correlated with economic growth and that the levels of adjusted mispricing decline after liberalization of restrictions on capital flows. Thus, along several dimensions, the proposed measure of integration yields results that are consistent with reasonable priors about the relations between effective integration and explicit capital controls, capital market development, and economic growth.

Appendix. Unanticipated Asset Pricing Regime Shifts

To illustrate the short-term effects of regime shifts, I will consider the somewhat artificial but tractable example of a market that changes unexpectedly from being completely segmented from world markets to being completely integrated. Assume that under complete segmentation the economy's assets are priced by a domestic representative consumer with time-additive utility,

$$U_t = \sum_{s=1}^{\infty} \rho^s u(c_{t+s})$$

where ρ reflects the consumer's rate of time preference, c_{t+s} is the consumer's consumption in period $t + s$, and $u(\cdot)$ is the per period utility of consumption. The pricing of assets in this multiperiod, multifactor world depends crucially on the comovements of the risk factors with the marginal utility of consumption (see Connor and Korajczyk 1989 for details). Consider the following special case: the covariances between the representative consumer's marginal utility of consumption and the risk factors are constant $E_t[\delta_{i,t+s}u'(c_{t+s})/u'(c_t)] = \gamma_i$, and assets are expected to pay one unit of consumption each period, but their actual payoff depends on the risk factors. Then asset j will have a price equal to

$$P_{j,t} = \left(\frac{\rho}{1-\rho}\right)(1 + b_{j,1}\gamma_1 + \ldots + b_{j,k}\gamma_k).$$

To make the example concrete, assume that for the closed-economy (segmented market) case there are two risk factors (a world factor and a domestic factor) that are correlated with the marginal utility of consumption; the domestic representative investor has a time-preference parameter of 0.98 ($\rho = 0.98$); and the covariances between the representative consumer's marginal utility of consumption and the two risk factors—$E_t[\delta_{1,t+s}u'(c_{t+s})/u'(c_t)]$ and $E_t[\delta_{2,t+s}u'(c_{t+s})/u'(c_t)]$—are -0.10 and -0.20, respectively. Asset j will have a price equal to:

$$P_{j,t} = \left(\frac{\rho}{1-\rho}\right)[1 + b_{j,1}(-0.1) + b_{j,2}(-0.20)].$$

Thus, if asset j has $b_{j,1} = 1.0$ and $b_{j,2} = 0.5$, then $P_{j,t} = 39.20$. Now assume that the market is opened to global investors and asset prices are determined by the preferences of a globally diversified representative consumer. The new parameters are $\rho = 0.98$, $E_t[\delta_{1,t+s}u'(c_{t+s})/u'(c_t)] = -0.10$, and $E_t[\delta_{2,t+s}u'(c_{t+s})/u'(c_t)] = 0.0$. For example, the covariance between the domestic factor and the global representative investor's marginal utility might be zero because the small economy's domestic factor risk is diversifiable across economies. The unexpected shift from a segmented to an integrated economy leads to a change in price from \$39.20 to \$44.10, an immediate return of 12.5 percent. If the parameter ρ were to simultaneously change from 0.98 to 0.99, the price of asset j would jump to \$89.10, an immediate return of 127 percent.

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