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A Measure of Stock Market Integration for Developed and Emerging Markets

Robert A. Korajczyk

Along several dimensions, a measure of the financial integration of equity markets yields results consistent with prior assumptions about the relationship between effective integration, explicit capital controls, capital market development, and economic growth.

Summary findings

If equity markets are financially integrated, the price of risk should be the same across markets. If the markets are not financially integrated — possibly because of barriers to capital flows across markets — the price of risk may differ across markets.

Korajczyk investigates one measure of financial integration between equity markets. He uses a multifactor equilibrium Arbitrage Pricing Theory to define risk and to measure deviations from the "law of one price." He applies the integration measure to equities traded in 24 countries (four developed, and 20 emerging).

The measure of market segmentation tends to be much larger for emerging markets than for developed markets, which is consistent with larger barriers to capital flows into or out of the emerging markets.

The measure tends to decrease over time, which is consistent with growing levels of integration.

Large values of adjusted mispricing occur around periods of economic turbulence and periods in which capital controls change significantly. So, the adjusted mispricing estimates measure not only the level of deviation from the law of one price, but also the revaluations inherent in moving from one regime to another.

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Robert A. Korajczyk
Northwestern University

In financially integrated markets, capital should flow across borders in order to insure that the price of risk (i.e., 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 only be held by domestic residents while 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 [e.g., Hietala (1989) and Bailey and Jagtiani (1994)]. Similarly, differences in official and black market exchange rates, between official and off-shore interest rates, or between the market price and the net asset value of closed-end country mutual funds [e.g., Bonser-Neal, Brauer, Neal, and Wheatley (1990)] can be used to measure the effects of capital controls.

A difficulty arises when attempting inter-country comparisons of the severity of capital controls because different countries may have different mechanisms for restricting capital movements. For example, a country which prohibits all foreign investment does not have unrestricted shares whose prices can be compared to restricted shares. Also, countries without any formal restrictions against foreign investment will not have restricted shares trading. While 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 which lead to *de facto* 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. Alternative approaches to measuring the integration of developed and emerging markets are developed in Bekaert (1995) and Bekaert and Harvey (1995).

When testing the law of one price (LOP) in financial markets we first need a model of which type of risk 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. Conversely, ostensibly free markets with large non-statutory barriers (such as large differentials in information costs) should exhibit pricing deviations.

A disadvantage of the approach is that it relies on a particular asset pricing model and the assumption that the equilibrium asset pricing relation is stable. Regime shifts, such as those one would expect 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. Bekaert and Harvey (1995) propose a model in which markets can move between segmented and integrated regimes. Within a regime, assets are priced as though assets are not demanded as hedges against regime shifts.

The next section of the paper contains a brief description of the asset pricing model. In Section 2 pricing errors are related to the existence of deviations from the law of one price induced by market segmentation. In Section 3 the issue of the effects of regime shifts is addressed. I describe the data in Section 4. The techniques used to estimate the pervasive factors

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are described in Section 5. The empirical measures of deviations from the law of one price are described in section 6.

1. Multi-factor Asset Pricing

The logic behind the Arbitrage Pricing Theory [Ross (1976)] and international extensions of the APT [Ross and Walsh (1983), Solnik (1983), Levine (1989), and Clyman, Edelson, and Hiller (1991)] is that there are a small number of risks which are common to most assets, for which investors command risk premia. 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.

A. The Arbitrage Approach to Asset Pricing Without Asset-Specific 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:

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

where $b_{j,i}$ 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 i. In this case where there is no asset specific risk, we could create a riskless, costless arbitrage opportunity unless[1]:

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

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[1] We need to assume that there are more assets than sources of risk (n > k) and that the n x k matrix of sensitivities, b (where the (j,i) element of b is $b_{j,i}$), has rank k.

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, we could express expected returns as

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

where α_j represents the pricing error, or deviation of expected returns from the predictions of the multi-factor asset pricing model. The appendix contains a proof that α_j must equal zero for all i in order for there to be no arbitrage opportunities. However a simple example will suffice to convey the intuition of the result.

Assume that there is only one risk factor (k = 1) and three assets with the following risk parameters, $b_{1,1} = 1.0$, $b_{2,1} = 0.5$, $b_{3,1} = 0.75$, and expected return of $\mu_1 = 11.5\%$, $\mu_2 = 7.5\%$, and $\mu_3 = 11.0\%$. With $\lambda_0 = 4\%$ and $\lambda_1 = 8\%$ the model's pricing errors (deviations of $\mu_{j,t}$ from $\lambda_0 + b_{j,1}\lambda_1$) are $\alpha_1 = -0.5\%$, $\alpha_2 = -0.5\%$, and $\alpha_3 = 1.0\%$. We will form a portfolio that invests $1 in asset three and takes a short position of $0.50 in each of assets 1 and 2. The cost of the portfolio is zero and from (1) and (3) the return on the portfolio is:

$$r_{3,t} - 0.5r_{1,t} - 0.5r_{2,t} =$$
$$(\alpha_3 - 0.5\alpha_1 - 0.5\alpha_2) + (\lambda_0 - 0.5\lambda_0 - 0.5\lambda_0) + (b_{3,1} - 0.5b_{1,1} - 0.5b_{2,1})(\lambda_1 + \delta_{1,t}) =$$
$$1.5\% + 0 \times \lambda_0 + 0 \times (\lambda_1 + \delta_{1,t}) = 2.0\%.$$

Thus, the portfolio provides a costless and riskless return of 2.0%.

B.   The Arbitrage Approach to Asset Pricing with Diversifiable Asset-Specific Risk

The expression for asset returns in (1) assumes that there are only k world-wide factors

that influence all asset returns. We can 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 world-wide factors. Ross (1976) assumes that there are an infinite number of assets and that the asset-specific risks are uncorrelated across assets (i.e., $\mathrm{corr}(\varepsilon_{j,t}, \varepsilon_{m,t}) = 0$ for $j \neq m$). Ross notes that weaker conditions also imply that the risk embodied in the term $\varepsilon_{j,t}$ is diversifiable [see Chamberlain and Rothschild (1983), Connor and Korajczyk (1993)].

Since 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, we can define an asymptotic arbitrage opportunity as one in which we can 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) and 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 (2) holds as an approximation for most assets:

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

Further restrictions can be placed on the economy to get the pricing model to hold as an equality [e.g., see Connor (1984) and 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 (5).

2. Segmentation Leads to Pricing Errors (α's) Relative to International Risk Factors

While the method of estimating the risk factors is described more fully below, it is useful at this juncture to point out that capital market segmentation prevents cross-market arbitrage and, therefore, prevents the prices of risk (the vector λ) from being equated across markets. This will lead to pricing errors relative to risk factors constructed assuming capital market integration. To illustrate this, consider 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, since the markets are segmented the parameters of the asset pricing model are different across markets.

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

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

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 that they are integrated will be (assuming the markets are of equivalent size) $\bar{\lambda}_0 = (\lambda^a_0 + \lambda^b_0)/2$ and $\bar{\lambda}_1 = (\lambda^a_1 + \lambda^b_1)/2$. This implies that for assets in economy a, the measured pricing deviation (relative to a model estimated assuming integration) of asset j is

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$$\alpha_j^a = (\lambda_0^a - \bar{\lambda}_0) + b_{j,1}(\lambda_1^a - \bar{\lambda}_1) \tag{6}$$

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

$$\alpha_j^b = (\lambda_0^b - \bar{\lambda}_0) + b_{j,1}(\lambda_1^b - \bar{\lambda}_1). \tag{7}$$

Thus, the mispricing parameters, α, provide a direct measure of deviations from the law of one price.

3. Regime Shifts

The pricing errors in (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 implies that the asset pricing regimes will shift from segmented to integrated regimes. In the long run, this should lead to smaller pricing errors (zero pricing errors in the limit as we approach complete integration). However, in the short run we will see larger measured pricing errors as asset prices change due to 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 assuming complete segmentation or complete integration.

To illustrate the short-term effects of regime shifts I will consider the somewhat artificial but tractable example of a market which changes unexpectedly from being completely segmented

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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 multi-period, multi-factor 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:

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

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:

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

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Thus if asset j has $b_{j,1} = 1.0$ and $b_{j,2} = 0.5$, then $P_{j,t} = 39.20$. Now let's 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 since 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%. 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%.

While 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 large measures of mispricing in the short run.

4. Data Sources and Summary Statistics

Historical monthly equity returns data for individual stocks trading in twenty emerging markets are from the *Emerging Markets Database* provided by the International Finance Corporation. The countries covered by the database are Argentina, Brazil, Chile, Colombia, Greece, Indonesia, India, Jordan, Korea, Malaysia, Mexico, Nigeria, Pakistan, Philippines, Portugal, Taiwan, Thailand, Turkey, Venezuela, and Zimbabwe. The set of emerging markets are 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. A summary of the developed markets equity data sources is presented in Table 1. 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 U.K. unlisted securities market.

Monthly returns adjusted for dividends and stock splits, are transformed into US dollar returns using end-of-month exchange rates. The emerging markets exchange rates are from the *Emerging Markets Database* while the developed markets exchange rates are from

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nternational Financial Statistics which is published by the International Monetary Fund. To compute excess returns I use the US Treasury Bill returns from Ibbotson Associates (1993).

Tables 2 and 3 provide some summary statistics on the emerging markets in the sample. The *Emerging Markets Database* does not include all of the stocks traded in the emerging markets. Rather, the database 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 International Finance Corporation (1993)]. On average, the stocks in the IFC sample represent 57% of the total capitalization of the respective markets.

Construction of the *Emerging Markets Database* began in 1981. Firms were chosen at that time on the basis of 1980 data [Errunza and Losq (1985, p. 562)]. While this poses no particular problems for returns after 1980, there may be a survivorship bias induced for the returns before 1981. That is, firms which disappeared between, say, 1975 and 1980 would not be included in the database. An actual portfolio strategy might have included those assets in the sample. As we can see from Table 2, eleven of the twenty emerging markets have data prior to 1981. Errunza and Losq (1985) investigate the issue of survivorship biases in a sample of eight of these emerging markets. They apply the selection criteria to assets as of the beginning of the

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sample, December 1975. They find that the overlap between this sample and the actual sample in the database is between 53% and 85%. Seven companies that would have been included when applying the selection criteria in 1975, were not trading on the exchanges in 1980. They argue that the survivorship bias is small in the sample. While 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 non-anticipatory inclusion rule over the 1975-1980 period. Even if this were done there is another potential survivorship bias in that the initial set of emerging markets were chosen on the basis of information available in 1980. There may have been markets that would have been included in 1975 which performed poorly between 1975 and 1980 (i.e., failed to emerge) and were thus not included in the sample.

As illustrated in Table 2, the average number of firms ranges from 11 (Zimbabwe) to 66 (Indonesia). The capitalization (as of December 1992) of the stocks included in the database ranges from $268 million (Zimbabwe) to $66 billion (Mexico). Average monthly turnover (volume for month t divided by the capitalization of the market in month t-1) for the sample period is the lowest for Nigeria at 0.05% and is the highest for Taiwan at 23.66%.

Table 3 reports some statistics for the return distributions of the IFC emerging market indices. The average monthly rate of return, in $US, (column 2) is the lowest for Indonesia (-1.02%) and the highest for Argentina (5.66%). The variability of the index returns is also quite high. Jordan has the smallest monthly standard deviation of 5.17% while Argentina has the largest monthly standard deviation of 30%. The S&P 500 portfolio, by contrast, has a monthly standard deviation (over the January 1976 - December 1992 period) of 4.46%.

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5.   Construction of Factor-Mimicking Portfolios

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 our sample. The

procedure assumes the factor structure in (4); that the exact multifactor pricing relationship, (2),

holds; that the conditional factor loadings, $b_{j,i}$, are constant through time for most assets; and that

the cross-sectional average asset specific variance is constant through time. Let T be the number

of time periods over which we observe asset returns; n the number of securities; r^n the n x T

matrix of excess returns on the assets; F the k x T matrix of realized factors plus risk premia ($F_{i,t}$

$= \delta_{i,t} + \lambda_{i,t})^2$, b^n the n x k matrix of factor loadings, and ε^n the n x k matrix of idiosyncratic (asset

specific) returns. Equations (2) and (4) imply that:

$$r^n = b^n F + \varepsilon^n \qquad (8)$$

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

Let Ω^n be the T x T matrix defined by $\Omega^n = r^{n\prime} r^n/n$ and $\hat{F}^n$ the k x T matrix of the first k

eigenvectors of Ω^n. Under the assumption that asset returns follow a k-factor model as in (4),

Connor and Korajczyk (1986) show that $\hat{F}^n$ converges in probability to a non-singular linear

transformation of F as n goes to infinity. Because of our large sample of equity returns, I ignore

the estimation error in $\hat{F}^n$. In order to use all available data in our 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. While these types of factor portfolios do not fully explain

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[2] F_{it} is the excess return on the portfolio which mimics factor i in period t.

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 January 1976 to December 1992 there are 6851 firms with available returns from the twenty-four markets.

6.   Measuring Deviations from the Law of One Price

The pricing deviations discussed in Section 1 and 2 were expressed as discrepancies between an asset's true expected return and the expected return implied by the asset pricing model. However, we do not observe the true expected returns on the asset, we observe the *ex post* return on the asset. From (4), we see that the asset's *ex post* return deviates from its expected return due to (i) shocks from the common factors and (ii) asset specific shocks.

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

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

α^n, the vector of intercept terms, are 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 non-zero values of α^n. Thus, one measure of financial integration is the size of the intercept

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terms in the multivariate regression (9). The approach that I take is as follows:

1) Estimate factor-mimicking portfolios for using the asymptotic principal components procedure.

2) For each national market estimate (9) for all stocks individually in that market. This estimation will yield vectors of mispricing estimates, $\hat{\alpha}^n$.

3) Calculate a summary measure of the mispricing for each national market.

Since we are concerned about deviations (both positive and negative) of α from zero, a natural measure of mispricing across the assets is the average squared mispricing coefficient, $\alpha^{n'}\alpha^n/n$. However, the regressions provide only an estimate of α^n, $\hat{\alpha}^n$, not the true value. This implies that average squared values of the estimates, $\hat{\alpha}^{n'}\hat{\alpha}^n/n$, will converge to $\alpha^{n'}\alpha^n/n$ *plus* the average squared value of the estimation error. Thus, $\hat{\alpha}^{n'}\hat{\alpha}^n/n$ will yield an upwardly biased estimate of $\alpha^{n'}\alpha^n/n$. However, the bias for asset i, $\hat{\alpha}_i^2 - \alpha_i^2$ 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 $\hat{\theta} = \hat{\alpha}^{n'}\hat{\alpha}^n/n - v^{n'}\iota/n$, where ι 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 we use estimates, v_i, which are corrected for conditional heteroskedasticity, as in White (1980).

Under the null hypothesis that $\alpha^n = 0$, 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. One would expect that this measure of mispricing will tend to be larger

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the more severe the barriers to free capital flows. One would also expect the periods of transition from segmented to integrated markets would 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. Through this characterization of the empirical properties of the mispricing, or market segmentation, measures we should get some sense of the forces causing the measured deviations from LOP. Average adjusted mispricing is estimated for each of the twenty-four national markets (twenty emerging markets and four developed 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 country's adjusted mispricing for the entire sample period. The time series of θ is constructed by estimating θ for each (overlapping) eighteen-month period in the sample. That is, data from January 1976 to June 1977 are used to estimate $\hat{\theta}_{6/77}$ then data from February 1976 to July 1977 are used to estimate $\hat{\theta}_{7/77}$, etcetera. 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 average adjusted mispricing, $\hat{\theta}_t$, is plotted for each national market in Figures 1 through 23. Each figure also plots $\hat{\theta}_t$ for the United States as a reference point. Figures 1 through 3 plot $\hat{\theta}_t$ for the three other developed countries. The values of $\hat{\theta}_t$ for the developed countries are generally small. The largest deviations from the value of zero occur for Australia with values around -20, which occur around the 1987 stock market crash.

Argentina (Figure 4) begins with very high values of $\hat{\theta}_t$ (around 300) in the late 1970's which decline rapidly. There is a sharp rise in $\hat{\theta}_t$ in 1986 followed by a sharp decline in $\hat{\theta}_t$. The period 1986-1987 coincides with increased investment by foreign institutional investors.

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Beginning with the autumn of 1989, there is 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 foreign ownership (except in selected sectors) and by eliminating restrictions on the repatriation of capital.

The values of $\hat{\theta}_t$ for Brazil (Figure 5) are particularly large in the period from 1985 to 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 was a short-lived boom in the stock market in which the IFC index of stocks doubled (in $US terms) in the span of two months (from February to April). The boom was followed by a decline in the IFC index stocks to their February levels by the end of the year.

Chile (Figure 6) has extremely large values of adjusted mispricing in the 1977-1978 period. There are smaller (but still large) values of mispricing in 1981 and 1987.

Colombia (figure 7) shows a steady decline in $\hat{\theta}_t$ for the periods ending March 1986 through March 1988. After that period $\hat{\theta}_t$ stays relatively close to zero until 1992.

The values of $\hat{\theta}_t$ are relatively close to zero for Greece (Figure 8) until the mid-1980's. There is also a large increase in mispricing in 1990. After several years of a socialist government (1981-1989) and a year in which two elections failed to produce a clear winning party, the

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

conservative party was elected to power in April 1990. There was a 59% return to holding the portfolio of stocks in the IFC index in April 1990 followed, two months later, by a 44% return in June 1990. There was a subsequent decline in prices in late 1990.

The average adjusted mispricing values for India are generally small except in the 1985-1987 period and the 1991-1992 period. 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 lead to a sharp decline (approximately 40%) in the equity market.

The time-series sample for Indonesia (Figure 10) is rather short. Because of this, it is difficult to detect particular patterns in the average adjusted mispricing.

Jordan (Figure 11) exhibits some of the smallest absolute levels of average adjusted pricing amongst the emerging markets. It also exhibits the lowest volatility and one of the lowest mean returns amongst the emerging markets (Table 3). The largest values of adjusted mispricing occur in the 1991-1992 period.

The Korean stock market (Figure 12) exhibits relatively small values of adjusted mispricing except in the late 1970's and the mid-1980's, in spite of the fact that there were severe restriction on foreign investment in Korean equities. In 1981 the first of a series of funds were offered through which foreign investors could invest in Korean securities [see Chuppe and Atkin (1992)]. The 1985-1987 period is one in which 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, thus giving companies access to equity capital through convertible bond issues. An over-the-counter

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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 (Figure 13) 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 (Figure 14) the average adjusted mispricing is relatively large until 1989. In the 1989-1992 period the average pricing errors are relatively low. Prior to 1989 restricted shares, which could be owned by foreigners, had been typically restricted to below 50% of a firm's equity capital. In 1989 foreigners were allowed to hold up to 100% 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 (Figure 15) has been essentially closed to foreign investment throughout the sample period. The average adjusted mispricing is large and volatile in the mid-1980's. The value of $\hat{\theta}_t$ decline to approximately zero in the late 1980's with a jump to the 7-10 range in 1991.

Pakistan (Figure 16) has had 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 (Figure 17) shows large values of average mispricing in the period 1986-1989. 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 (Figure 18) shows large values (first positive then negative)

of average mispricing in the period from 1987 to 1989. This may be due to pricing effects from the Portuguese entry into the EC (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 stock market (Figure 19) shows generally large levels of estimated mispricing with no discernable 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 (Figure 20) is generally small in the 1980's. Larger average mispricing occurred in the late 1970's and early 1990's.

The Istanbul Stock Exchange opened in 1986. The short time series of mispricing (Figure 21) does not show any pronounced trend except the initial increase from very negative values.

The Zimbabwe stock market (Figure 23) shows generally high levels of adjusted mispricing. This is consistent with the fact that the market has been closed to foreign investment throughout the sample period.

7.   Conclusions and Suggestions for Future Work

In this paper 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 24 national markets (four developed markets and 20 emerging markets). The measure of market segmentation tends to be much larger for emerging markets than the developed markets which is consistent with larger barriers to capital flows into or out of the emerging markets. The measure often tends to

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decrease through time which 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 law of one price, but also measure the revaluations inherent in moving from one regime to another.

Relating the proposed measure of market integration to alternative measures of integration, to measures of capital market development, or to *ex post* measures of economic growth would be useful in highlighting its advantages and disadvantages.

Bekaert and Harvey (1995) plot the estimated probability of being in the integrated regime (their Figure 2). There are some interesting similarities and differences in the conclusions that one might draw from their measure of integration and the adjusted mispricing plotted in Figures 1-23. For example, Bekaert and Harvey (1995) show dramatic declines in the probability of India's stock market being integrated in 1985 and 1992. This corresponds to the periods in which there are large values of the adjusted mispricing parameter in Figure 9. An example of a case where our measures of integration seem to differ is Mexico. Their 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 (Figure 14). Thus, these alternative measures of market integration seem to be highlighting different aspects of the mechanism generating expected returns.

Demirgüç-Kunt and Levine (1995) investigate the cross-sectional relation between adjusted mispricing and other indicators of capital market development. They find that mispricing 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.

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Levine and Zervos (1994, 1995) find that the adjusted 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 relation between effective integration, explicit capital controls, capital market development and economic growth.

Appendix

Let us assume that the pricing model in (2) does not hold. Then in the case where there is no asset specific risk [as in (1)], we can create a riskless, costless portfolio that has a strictly positive return, which is an arbitrage opportunity. If (2) does not hold then there is a deviation between the expected return predicted by the model and the true expected return. Call asset j's deviation, or pricing error, α_j. Thus, expected returns are given as in equation (3).

Let $\mu' = (\mu_1, \mu_2, ..., \mu_n)$, $\alpha' = (\alpha_1, \alpha_2, ..., \alpha_n)$, $\lambda' = (\lambda_0, \lambda_1, ..., \lambda_k)$, and $B = (\iota, b)$ where ι is an n-vector of ones and b is an n x k matrix whose (j, i) element is $b_{j,i}$. In matrix notation (3) can be expressed as:

$$\mu = \alpha + B\lambda .\qquad\qquad (A1)$$

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

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

Thus, we have formed a riskless, costless portfolio with a strictly positive return. This is an arbitrage opportunity that will be exploited. Thus, in order to avoid arbitrage opportunities, the pricing relation (2) must hold. That is, we must have that $\alpha_j = 0$ for all j in (3).

References

Bailey, Warren and Julapa Jagtiani, 1994, Foreign ownership restrictions and Stock Prices in the Thai capital market, *Journal of Financial Economics* **36**, 57-87.

Bekaert, Geert, 1995, Market integration and investment barriers in emerging equity markets, *World Bank Economic Review* **9**, 75-107.

Bekaert, Geert and Campbell R. Harvey, 1995, Time-varying world market integration, *Journal of Finance* **50**, forthcoming.

Bonser-Neal, C., G. Brauer, R. Neal, and S. Wheatley, 1990, International investment restrictions and closed-end country fund prices, *Journal of Finance* **45**, 523-547.

Chamberlain, Gary and Michael Rothschild, 1983, Arbitrage and mean variance analysis on large asset markets, *Econometrica* **51**, 1281-1304.

Chuppe, Terry M. and Michael Atkin, 1992, Regulation of securities markets: Some recent trends and their implications for emerging markets, Policy Research Working paper 829, International Finance Corporation.

Claessens, Stijn, Susmita Dasgupta, and Jack Glen, 1994, The cross-section of stock returns: Evidence from the emerging markets, Working paper, The World Bank.

Clyman, Dana R., Michael E. Edelson, and Randall S. Hiller, 1991, International arbitrage pricing, risk premia and exchange rate drift, Working paper 92-019, Harvard Business School.

Connor, Gregory, 1984, A unified beta pricing theory, *Journal of Economic Theory* **34**, 13-31.

Connor, Gregory and Robert A. Korajczyk, 1986, Performance measurement with the arbitrage pricing theory: a new framework for analysis, *Journal of Financial Economics* **15**, 373-394.

Connor, Gregory and Robert A. Korajczyk, 1988, Estimating pervasive economic factors with missing observations, Working paper #34 (Department of Finance, Northwestern University, Evanston, IL).

Connor, Gregory and Robert A. Korajczyk, 1989, An intertemporal equilibrium beta pricing model, *Review of Financial Studies* **2**, 373-392.

Connor, Gregory and Robert A. Korajczyk, 1993, A test for the number of factors in an approximate factor model, *Journal of Finance* **48**, 1263-1291.

Constantinides, George M., 1989, Theory of valuation: overview and recent developments, in: S. Bhattacharya and G. M. Constantinides, eds., *Theory of Valuation: Frontiers of Modern Financial Theory*, Vol. 1, (Rowman & Littlefield, Totowa NJ).

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Cumby, Robert E., 1990, Consumption risk and international equity returns: some empirical evidence, *Journal of International Money and Finance* 9, 182-192.

Demirgüç-Kunt, Ash and Ross Levine, 1995, Stock markets and financial intermediaries: Stylized facts, Working paper, The World Bank, January.

Errunza, Vihang R. and Etienne Losq, 1985, The behavior of stock prices on LDC markets, *Journal of Banking and Finance* 9, 561-575.

Errunza, Vihang, Etienne Losq, and Prasad Padmanabhan, 1985, Tests of integration, mild segmentation and segmentation hypotheses, *Journal of Banking and Finance* 16, 949-972.

Hansen, Lars P., and Robert J. Hodrick, 1983, Risk averse speculation in the forward exchange market: an econometric analysis of linear models, in: J. A. Frenkel, ed., *Exchange Rates and International Macroeconomics*, (University of Chicago Press, Chicago).

Harvey, Campbell R., 1994, Predictable risk and returns in emerging markets, Working paper, Duke University, January.

Hietala, Pekka T., 1989, Asset pricing in partially segmented markets: Evidence from the Finnish market, *Journal of Finance* 44, 697-718.

Huberman, Gur, 1982, A simple approach to arbitrage pricing, *Journal of Economic Theory* 28, 183-191.

Ibbotson Associates, *Stocks, Bonds, Bills, and Inflation*, 1993 yearbook.

International Finance Corporation, 1993, *IFC Index Methodology*, (International Finance Corporation, Washington).

Korajczyk, Robert A., and Claude J. Viallet, 1989, An empirical investigation of international asset pricing, *Review of Financial Studies* 2, 553-585.

Levine, Ross, 1989, An international arbitrage pricing model with PPP deviations, *Economic Inquiry* 27, 587-599.

Levine, Ross, and Sara Zervos, 1994, International capital flow liberalization and stock market development: A cross-country event study, Working paper, The World Bank, December.

Levine, Ross, and Sara Zervos, 1995, Stock markets and banks: Revving the engines of growth, Working paper, January.

Park, Keith K. H. and Antoine W. Van Agtmael (eds.) *The Worlds Emerging Stock Markets: Structure, Developments, Regulations & Opportunities*. Chicago: Probus Publishing, 1993.

Ross, Stephen A., 1976, The arbitrage theory of capital asset pricing, *Journal of Economic Theory* **13**, 341-360.

Ross, Stephen A., and Michael M. Walsh, 1983, A simple approach to the pricing of risky assets with uncertain exchange rates, *Research in International Business and Finance* **3**, 39-54.

Solnik, Bruno, 1983, International arbitrage pricing theory, *Journal of Finance* **38**, 449-457.

White, Halbert, 1980, A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica* **48**, 817-838.

Table 1. Developed Equity Markets Data: sources.

Country (Exchange)	Source of Data
Australia (Australian Stock Exchange)	Centre for Research in Finance Australian Graduate School of Management
Japan (Tokyo Stock Exchange - First Section)	Japan Securities Research Institute
United Kingdom (London Stock Exchange and Unlisted Securities Market)	London Share Price Data Base London Business School
United States (NYSE, ASE)	Center for Research in Security Prices University of Chicago

Table 2. Summary statistics for emerging markets.

Market	Beginning of Sample Period (End = 12/1992)	Average Number of Firms	Capitalization December 1992 ($US millions)	Trading Volume December 1992 ($US millions)	Average Turnover (%/month)
Emerging Market Composite	December 1984	590	401,998	16,535	8.79
Europe and Middle East					
Greece	December 1975	15	5,377	112	1.05
Jordan	December 1978	15	1,988	70	1.18
Portugal	December 1985	20	4,868	52	1.07
Turkey	December 1975	19	3,872	158	2.54
Latin America					
Latin America	December 1984	176	135,638	3,936	3.24
Argentina	December 1975	23	14,293	1,112	3.41
Brazil	December 1975	33	23,200	803	3.40
Chile	December 1975	25	21,933	96	0.76
Colombia	December 1984	21	5,107	23	0.49
Mexico	December 1975	32	66,108	1,806	5.31
Venezuela	December 1984	14	4,997	96	2.00

		Asia			
Asia	December 1984	325	249,191	12,204	10.99
India	December 1975	36	25,365	364[a]	6.42
Indonesia	December 1989	66	8,661	260	3.85
Korea	December 1975	37	66,461	6007	8.20
Malaysia	December 1984	52	47,941	773	1.11
Pakistan	December 1984	52	3,774	33	0.86
Philippines	December 1984	22	8,167	84	2.13
Taiwan	December 1984	50	60,454	3,172	23.66
Thailand	December 1975	17	28,368	1,877	5.38
		Africa			
Nigeria	December 1984	18	797	1	0.05
Zimbabwe	December 1975	11	268	1	0.35

Table 3. Summary statistics for emerging markets.				
Market	Mean return (%/month)	Standard Deviation (%/month)	ρ_1	t-stat ρ_1
Emerging Market Composite	1.50	6.98	0.16	1.53
Europe and Middle East				
Greece	0.62	10.46	0.13	1.89
Jordan	0.90	5.17	0.00	0.00
Portugal	2.88	14.50	0.29	2.61
Turkey	3.15	21.44	0.23	1.97
Latin America				
Latin America	2.60	11.21	0.24	2.40
Argentina	5.66	30.00	0.05	0.77
Brazil	1.84	17.39	0.03	0.41
Chile	3.06	11.42	0.17	2.41
Colombia	3.64	9.28	0.49	4.79
Mexico	2.53	12.86	0.25	3.53
Venezuela	2.68	13.66	0.27	2.62
Asia				
Asia	1.50	7.42	0.01	0.13
India	1.68	7.86	0.08	1.13
Indonesia	-1.02	9.40	0.28	1.71
Korea	1.77	9.34	0.00	-0.02
Malaysia	1.15	7.61	0.05	0.51
Pakistan	1.79	6.70	0.25	2.45
Philippines	3.78	11.02	0.34	3.32
Taiwan	2.84	15.27	0.07	0.72
Thailand	1.86	7.44	0.11	1.63
Africa				
Nigeria	0.22	10.54	0.08	0.83
Zimbabwe	0.65	9.86	0.14	1.97

Figure 1: Average Adjusted Mispricing for the United Kingdom
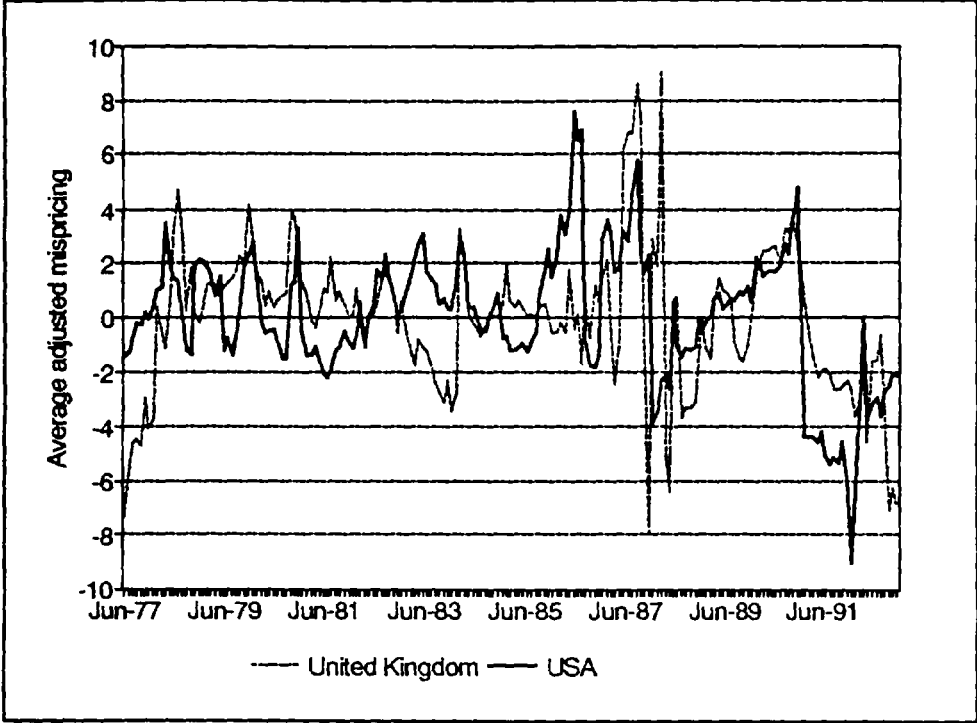
Figure 2: Average Adjusted Mispricing for Japan
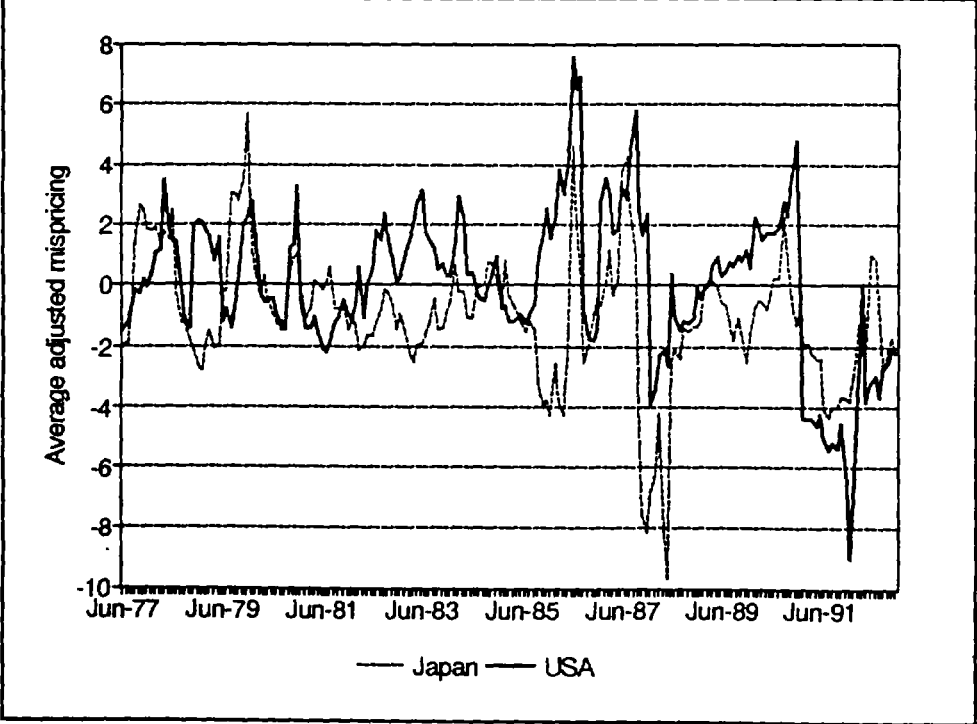
Figure 3:   Average Adjusted Mispricing for Australia
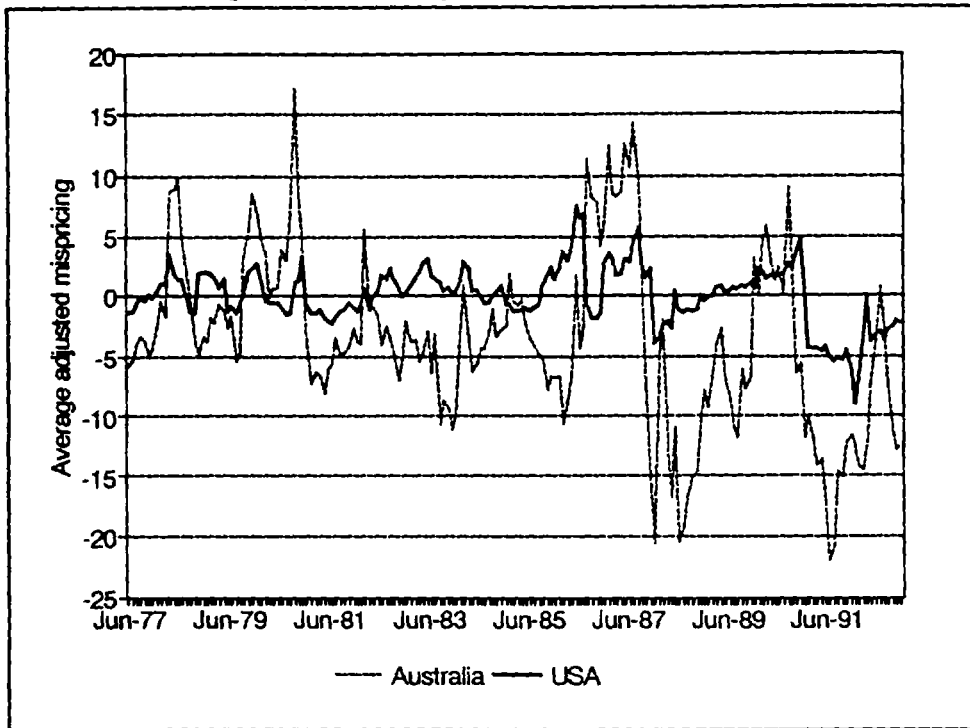
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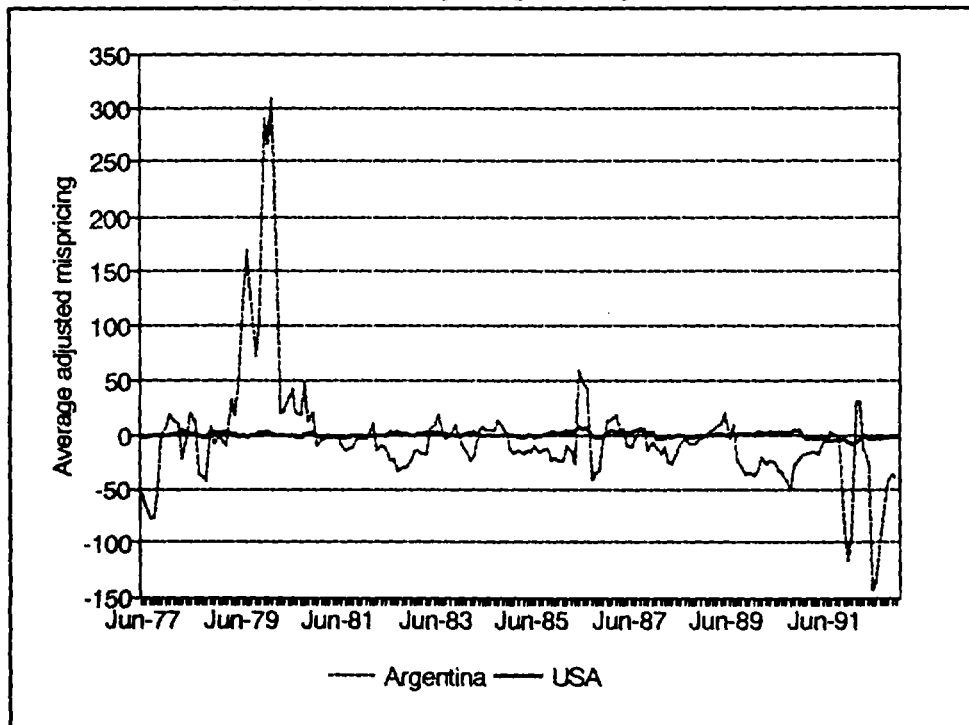
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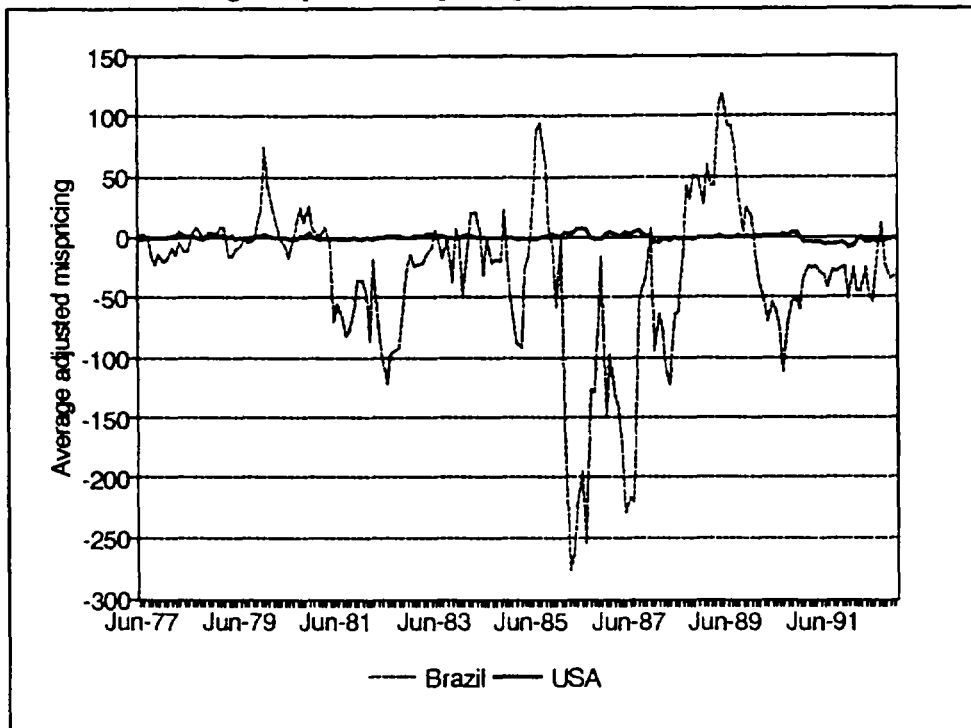
Figure 6:   Average Adjusted Mispricing for Chile
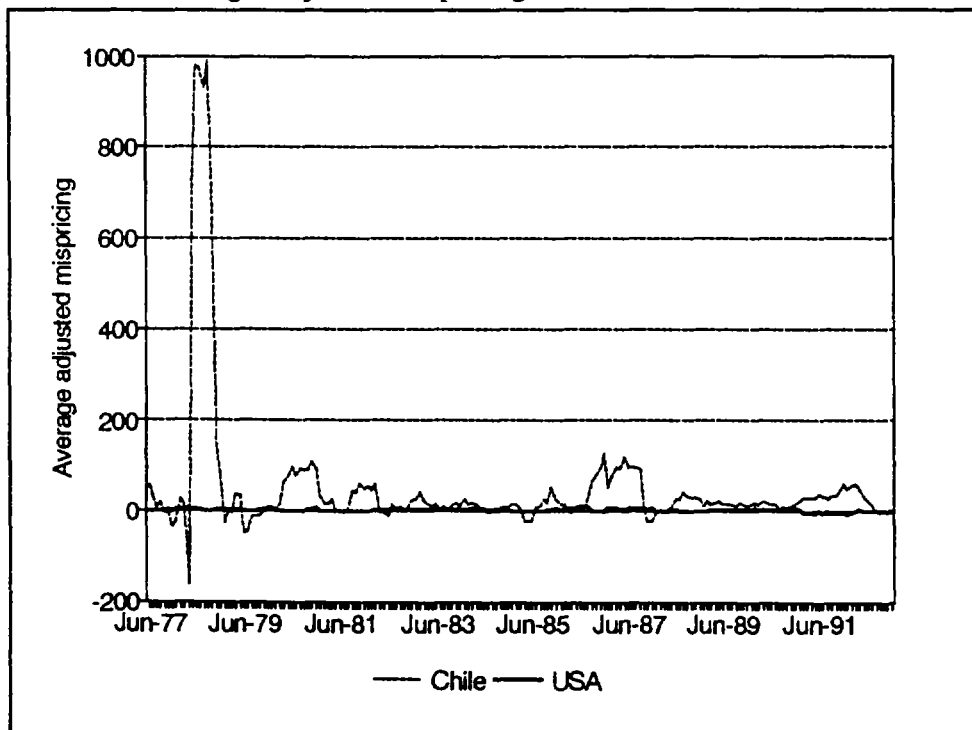
Figure 7: Average Adjusted Mispricing for Colombia
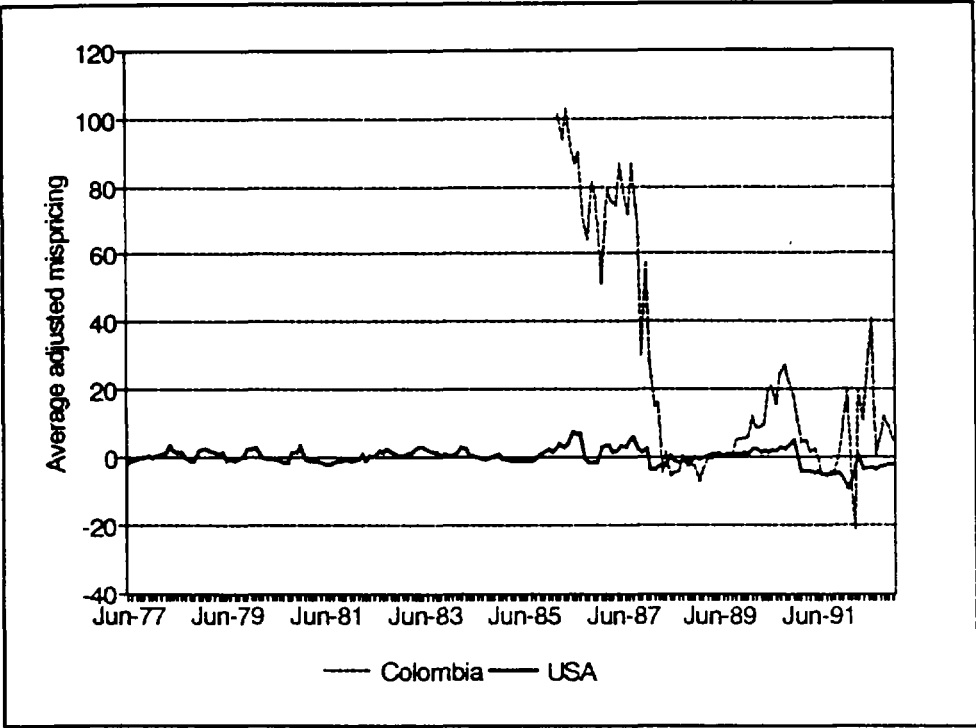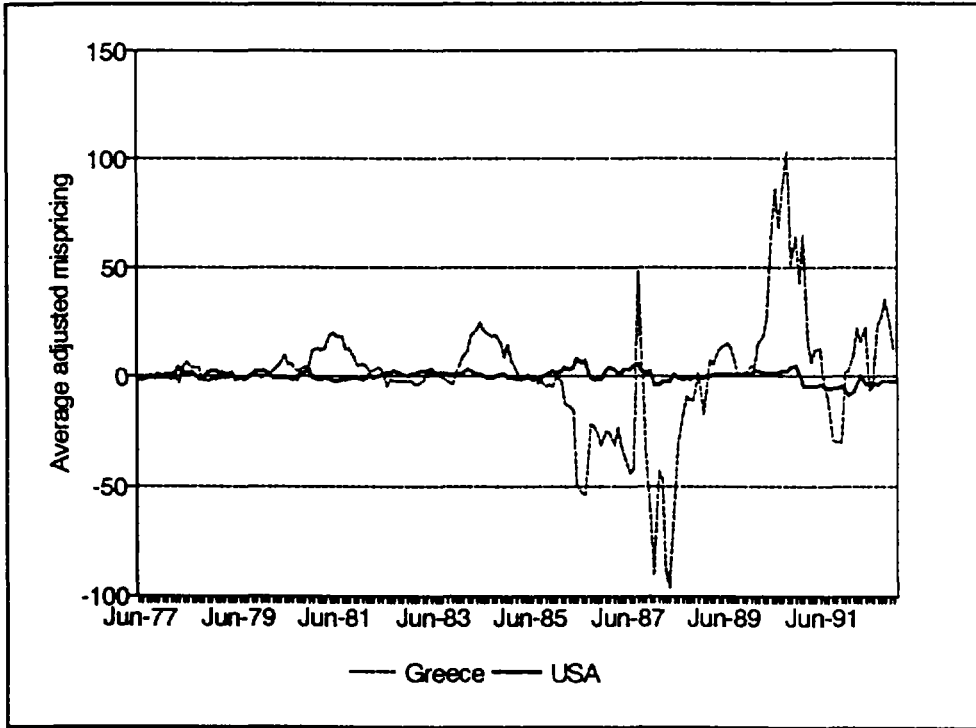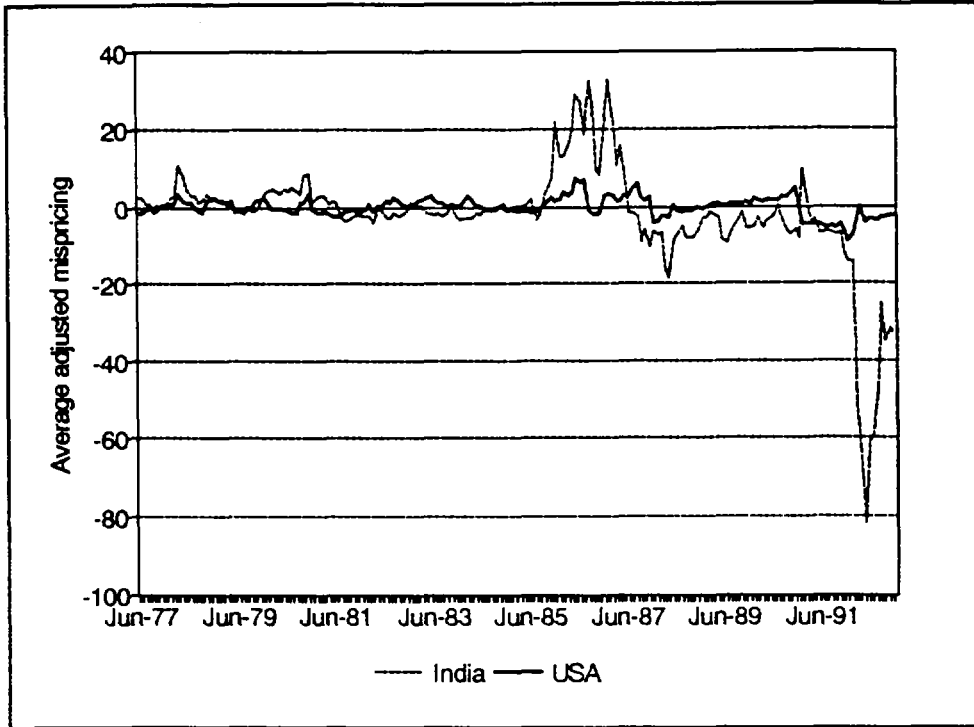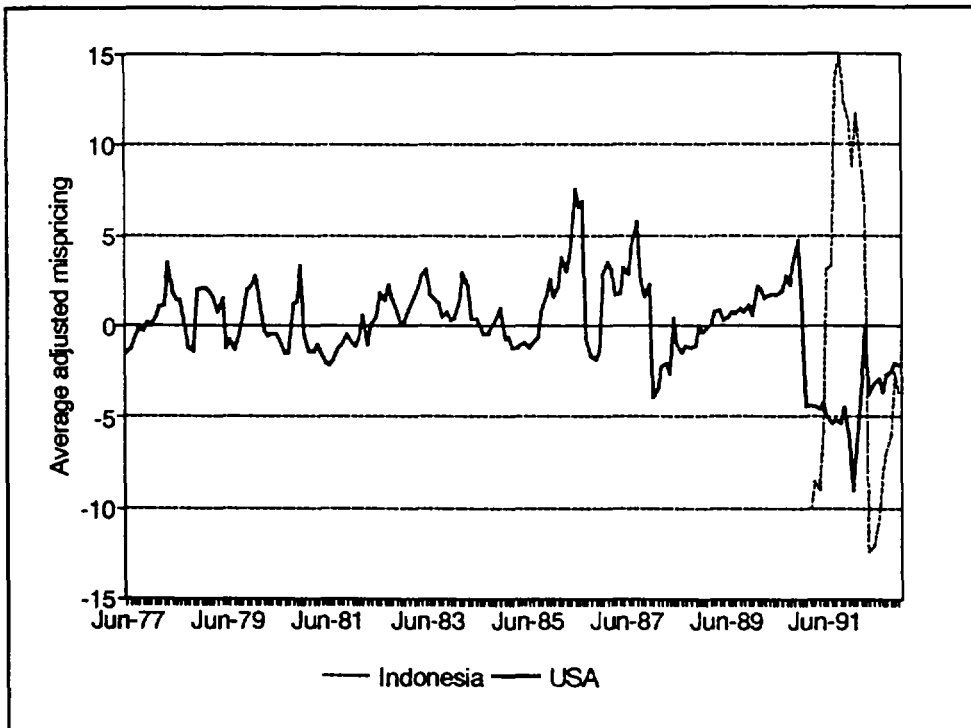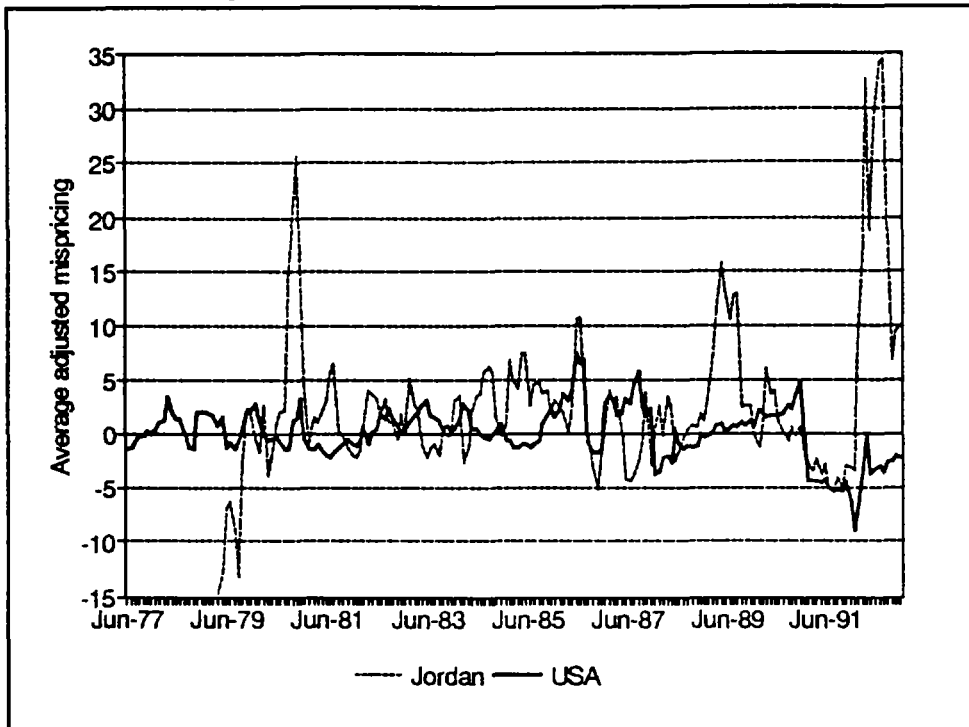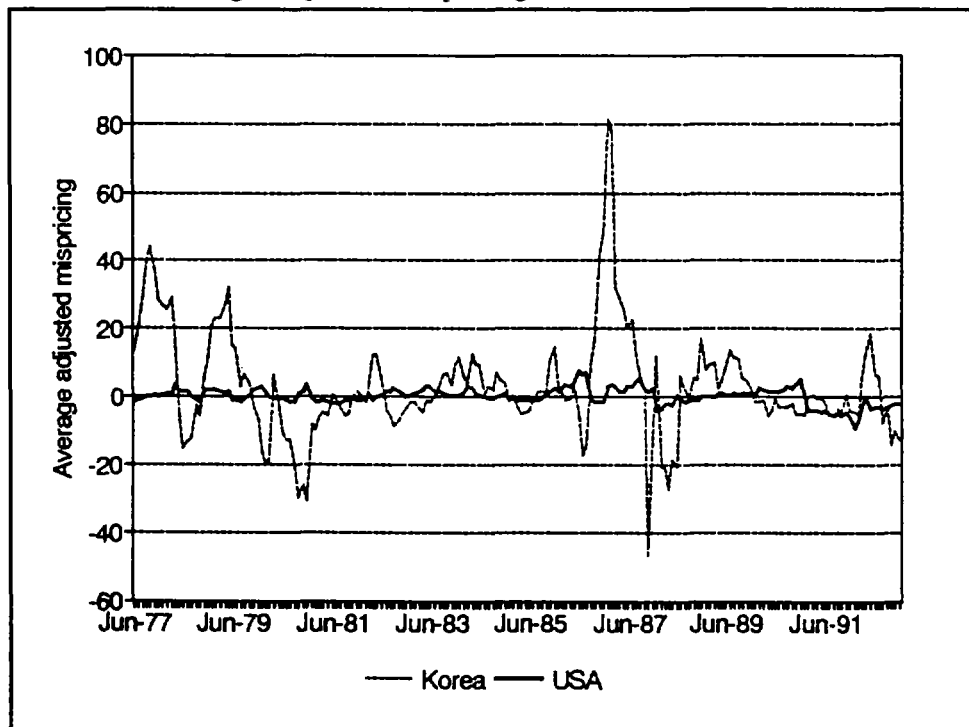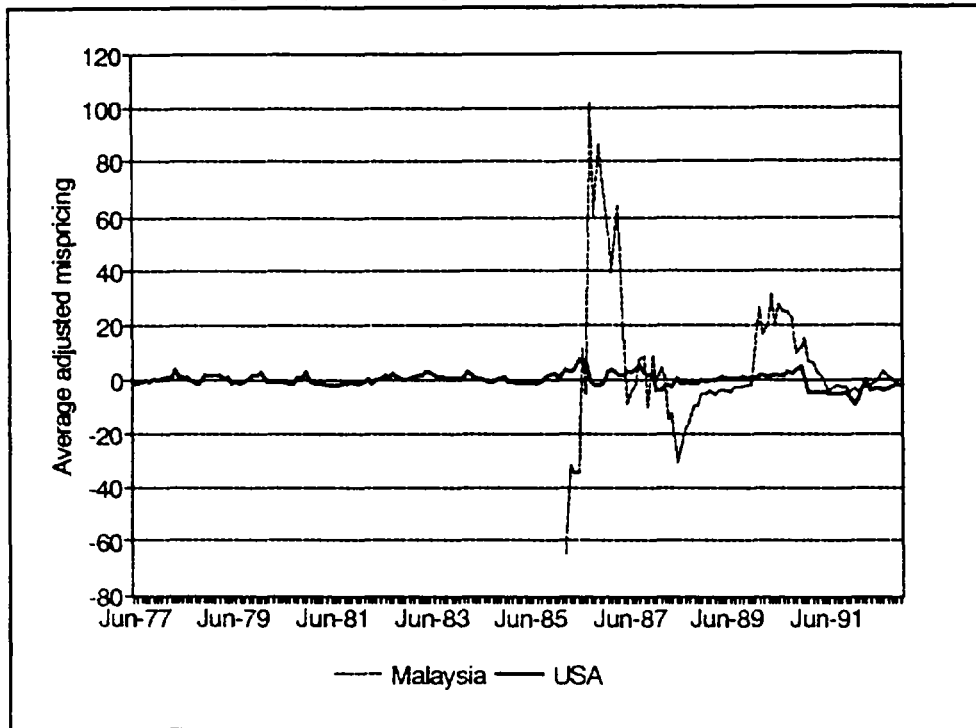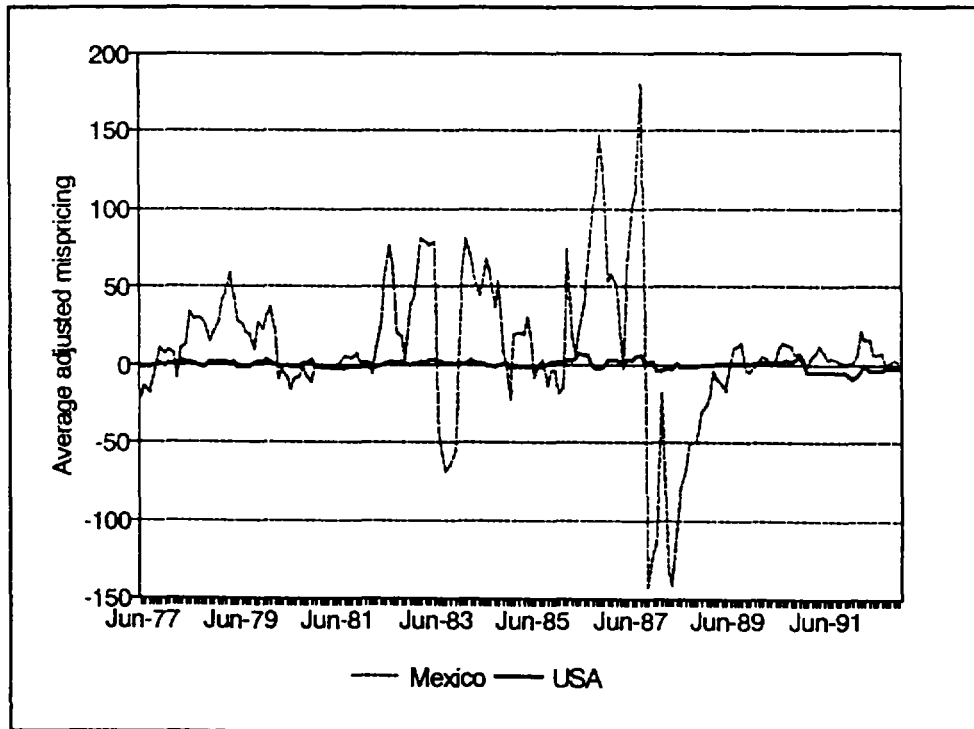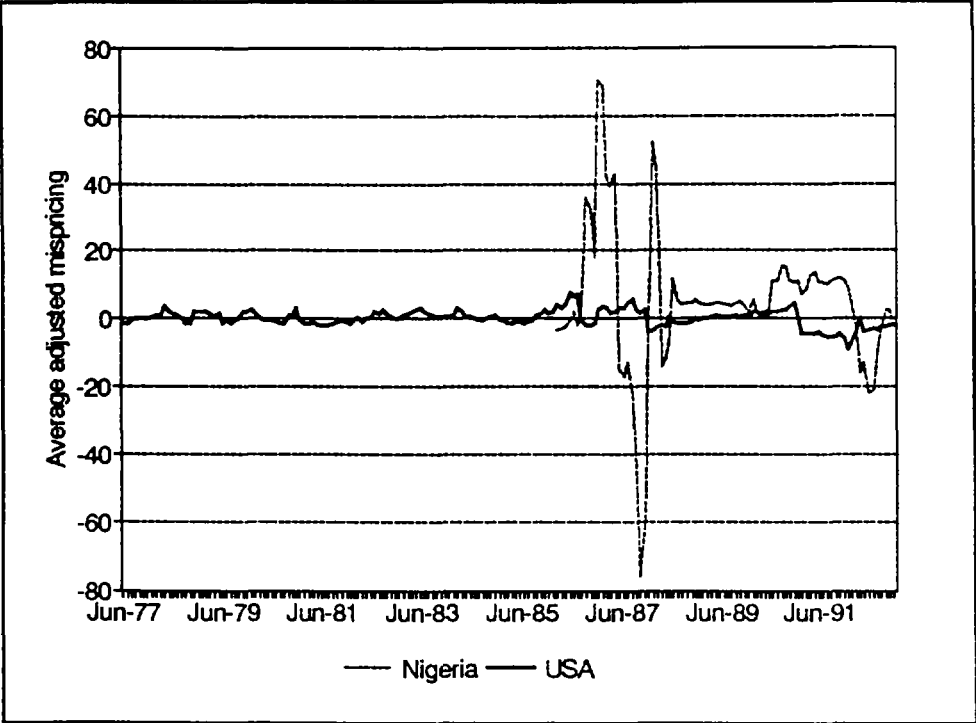

Figure 8: Average Adjusted Mispricing for Greece

Figure 9: Average Adjusted Mispricing for India

Figure 10: Average Adjusted Mispricing for Indonesia

Figure 11:   Average Adjusted Mispricing for Jordan

Figure 12:   Average Adjusted Mispricing for Korea

Figure 13: Average Adjusted Mispricing for Malaysia

Figure 14: Average Adjusted Mispricing for Mexico

Figure 15: Average Adjusted Mispricing for Nigeria
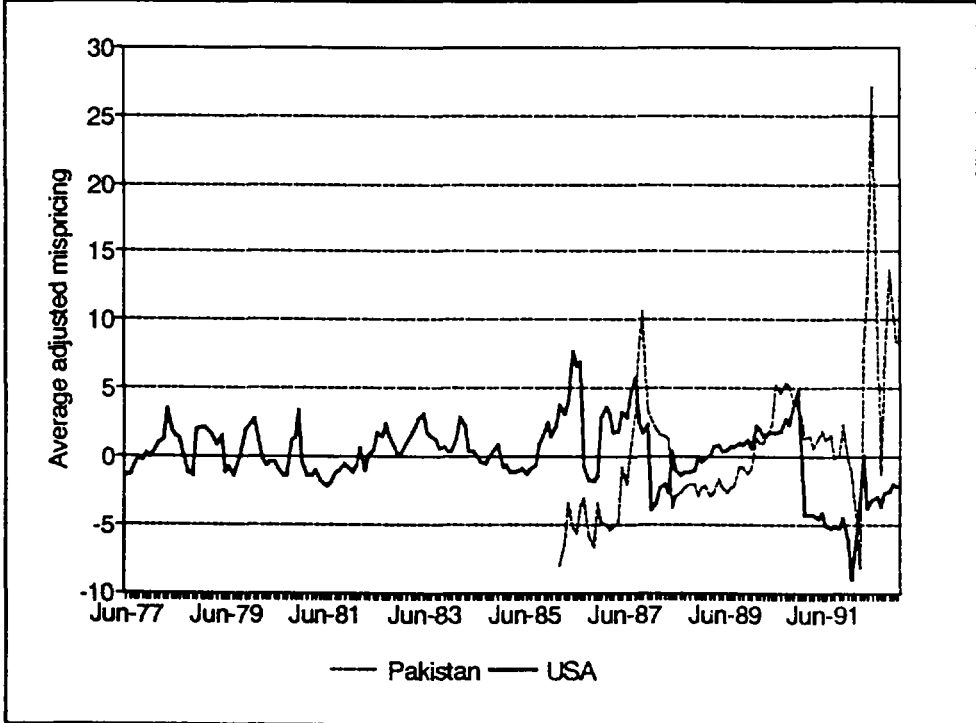

Figure 15: Average Adjusted Mispricing for Nigeria

Figure 16: Average Adjusted Mispricing for Pakistan
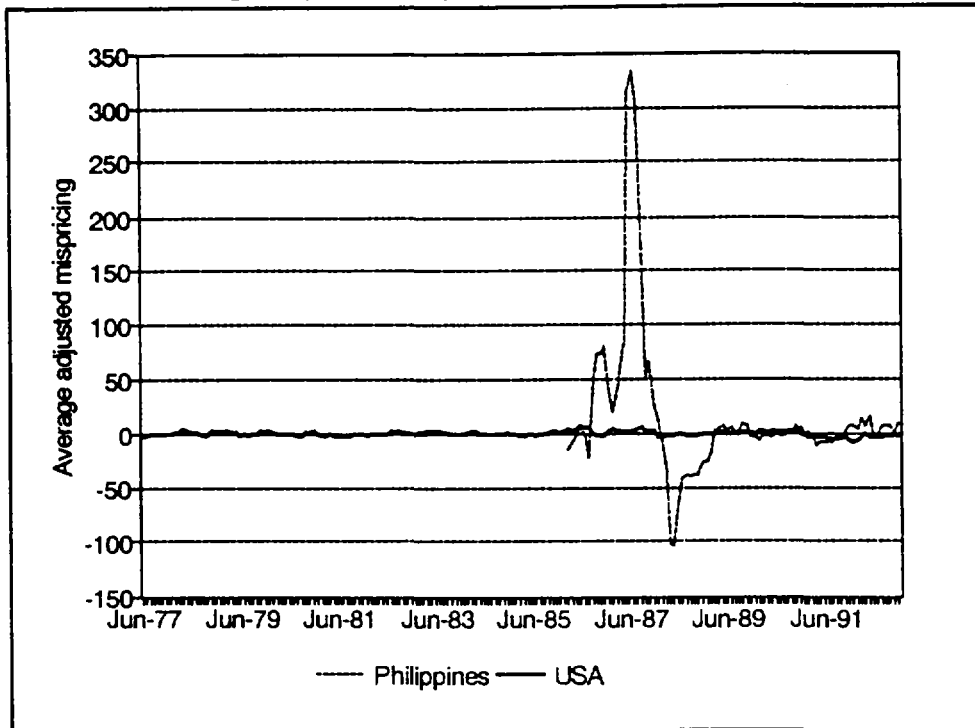

Figure 16: Average Adjusted Mispricing for Pakistan

Figure 17: Average Adjusted Mispricing for Philippines
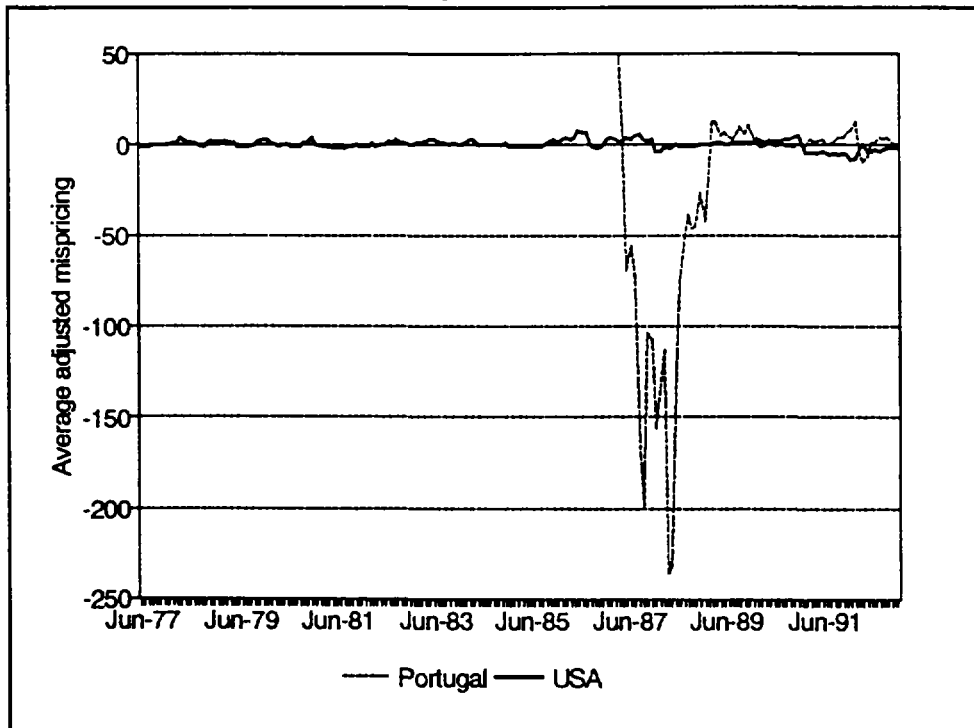

Figure 17 chart: Average adjusted mispricing (y-axis, 350 to -150) vs time (x-axis, Jun-77 to Jun-91). Legend: Philippines, USA.

Figure 18: Average Adjusted Mispricing for Portugal

Figure 18 chart: Average adjusted mispricing (y-axis, 50 to -250) vs time (x-axis, Jun-77 to Jun-91). Legend: Portugal, USA.

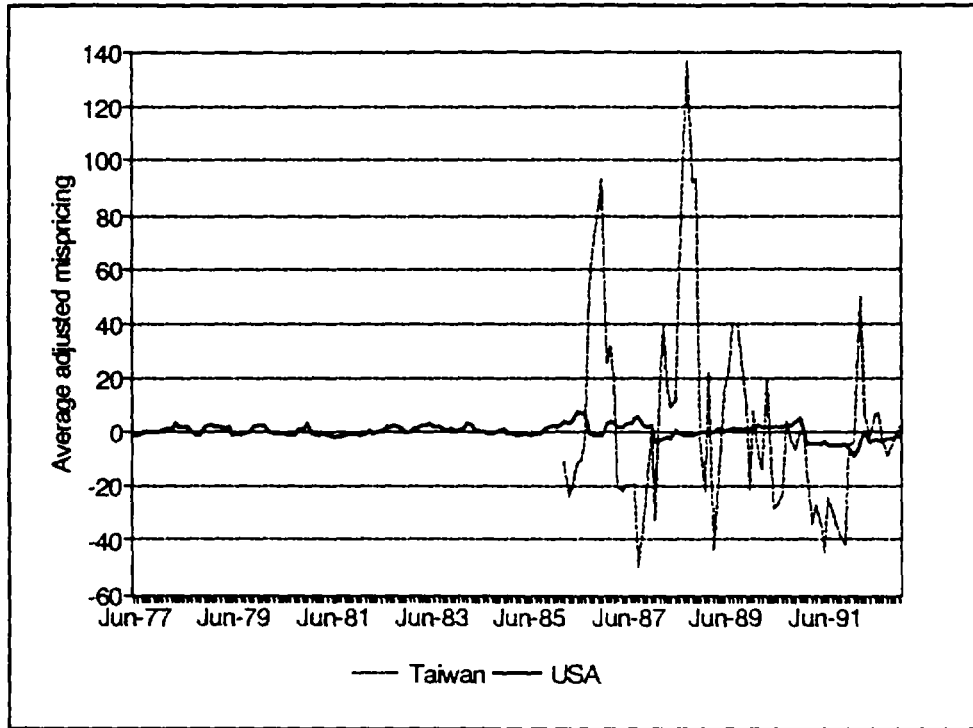**Figure 19:** Average Adjusted Mispricing for Taiwan

Figure 20: Average Adjusted Mispricing for Thailand
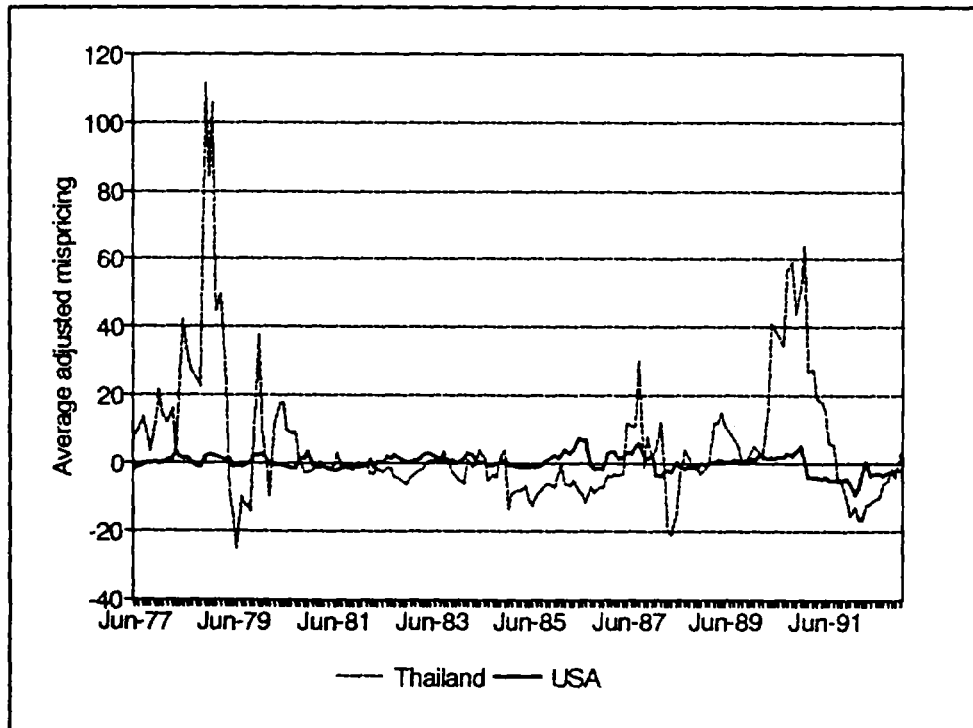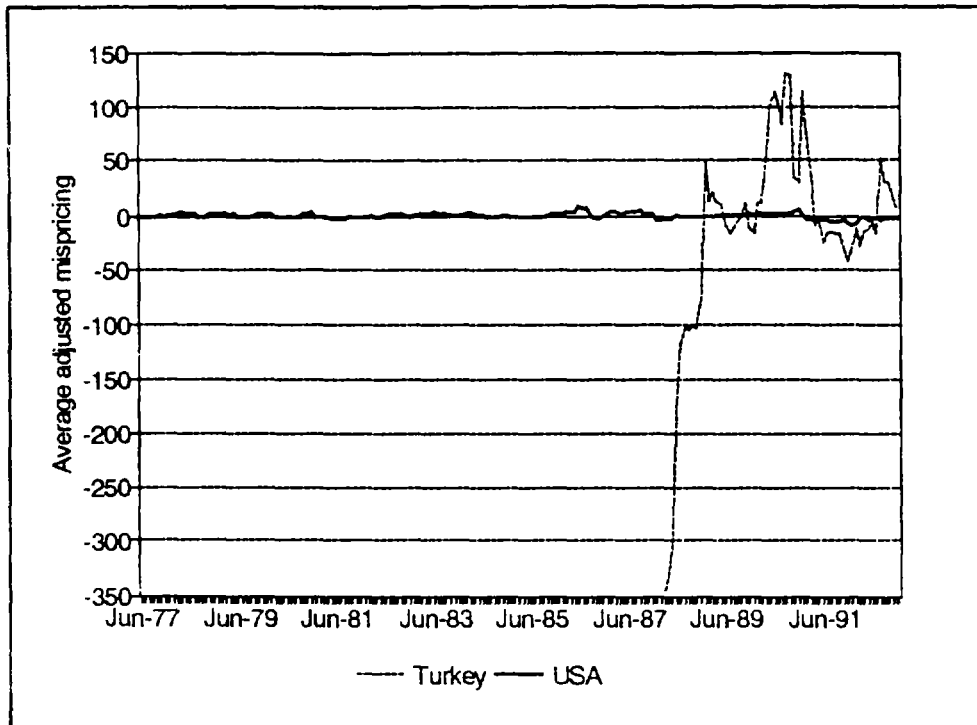
Figure 21:   Average Adjusted Mispricing for Turkey

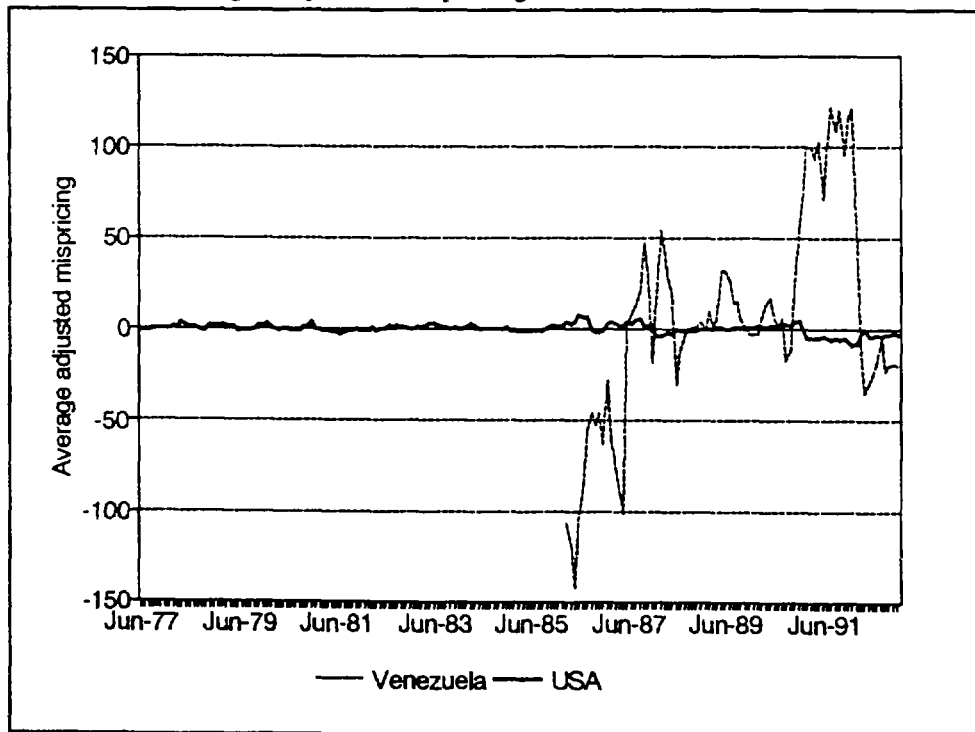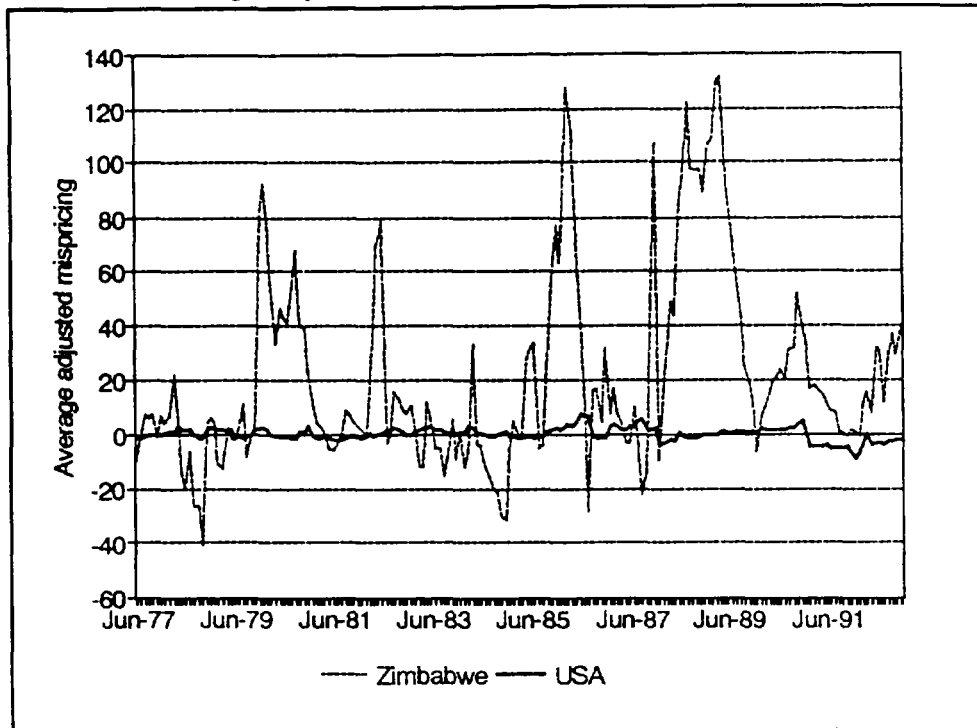**Figure 22:**   Average Adjusted Mispricing for Venezuela

Figure 23: Average Adjusted Mispricing for Zimbabwe

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