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International asset pricing under segmentation and PPP deviations ☆

Ines Chaieb[a,*], Vihang Errunza[b]

[a] *University of Amsterdam, 11 Roetersstraat, Amsterdam 1018 WB, The Netherlands*
[b] *McGill University, 1001 Sherbrooke Street West, Montreal, Qc, Canada H3A 1G5*

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Abstract

We analyze the impact of both purchasing power parity (PPP) deviations and market segmentation on asset pricing and investor's portfolio holdings. The freely traded securities command a world market risk premium and an inflation risk premium. The securities that can be held by only a subset of investors command two additional premiums: a conditional market risk premium and a segflation risk premium. Our model is empirically supported with important implications for tests of international asset pricing.

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*Corresponding author. Tel.: +31 20 525 5573; fax: +31 20 525 5285.
E-mail address: i.chaieb@uva.nl (I. Chaieb).

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1. Introduction

Exposure to purchasing power risk or barriers to free flow of portfolio capital or both does not allow application of the capital asset pricing model (CAPM) to an international setting. Hence, the well-known international asset pricing models (IAPMs) consider either deviations from purchasing power parity (PPP) in perfect markets (e.g., Solnik, 1974a; Stulz, 1981a; Adler and Dumas, 1983, henceforth A-D) or the impact of barriers to international investment when PPP holds (e.g., Stulz, 1981b; Errunza and Losq, 1985, henceforth E-L). However, a more realistic model should incorporate both deviations from PPP and barriers to international investment. Furthermore, past empirical international asset pricing papers either test for the pricing of purchasing power risk under full integration or study world market structure under PPP.[1] Our paper develops a theoretical model with new insights when markets are not fully integrated and PPP is violated, which seems to be the case for the majority of national markets, and provides a theoretical framework to conduct joint tests of important issues such as, pricing of foreign exchange risk and world market structure.

To derive a valuation model, we postulate a two-country world, the domestic country and the foreign country. There are two sets of securities, the eligible and the ineligible securities. The eligible securities are investable for all investors, whereas the ineligible securities are investable for only a subset of investors. For the sake of simplicity, in most of the paper we assume that all domestic securities are eligible and all foreign securities are ineligible. That is, domestic investors can invest only in domestic stocks, while foreign investors can invest in foreign ineligible stocks as well as domestic stocks, i.e., the mild segmentation model. We show that the pricing of eligible securities command the world market premium and inflation risk premium. The ineligible securities command two additional premiums. First, barriers to portfolio flows limit diversification benefits because of incomplete risk sharing. In equilibrium, foreign investors have to hold all foreign ineligible securities, which they alone can hold. They can reduce this risk exposure by short selling the diversification portfolio, which is the portfolio of eligible securities that is most highly correlated with the market portfolio of ineligible securities. Domestic investors are willing to take a long position in the diversification portfolio as a best substitute for the market portfolio of ineligible securities. Unless the diversification portfolio is a perfect substitute for the market portfolio of ineligible securities, foreign investors are exposed to residual risk and hence require an extra premium, the conditional market premium. Second, barriers to portfolio flows also limit inflation-hedging benefits because of incomplete risk sharing. Hence the expected return on ineligible securities commands an additional premium, the segflation risk premium.

We also analyze a general setup, partial segmentation, that is characterized by the existence of both eligible and ineligible securities in each market. Our mild segmentation results extend to this case with an additional risk premium, the conditional cross-market premium, for the ineligible securities. This additional premium depends on the correlation

[1]Most empirical tests substitute currency risk for purchasing power risk under the assumption of no inflation or nonstochastic inflation. As Stulz (1981a, p. 383) states: "Asset markets are said to be fully integrated internationally if two assets (existing or hypothetical) which have perfectly correlated returns in a given currency but belong to different countries have identical expected returns in that currency. Markets are said to be segmented if this condition does not hold".

structure of the asset's return with the returns on the ineligible securities in the other market.

To test the validity of the model as well as the statistical and economic relevance of the different premiums, we estimate a conditional version of the model using a multivariate generalized autoregressive conditional heteroscedasticity in mean (GARCH-M) methodology similar to De Santis and Gerard (1998). Over the period between January 1976 and December 2003, we examine eight emerging markets (EMs). We find that the world market, inflation, and the conditional market risks are significantly priced. Further, the segflation risk premium is statistically and economically significant. Thus, our model is supported with important implications for tests of international asset pricing.

The rest of the paper is organized as follows. Section 2 briefly reviews the literature. Section 3 presents the model. Section 4 contains the main theoretical results including analytical derivations of the equilibrium asset pricing relationships. Section 5 examines the case of partial segmentation. Section 6 presents empirical methodology and data. The empirical findings are reported in Section 7. Conclusions follow in Section 8.

2. Literature review

A number of authors have extended the Sharpe (1964) and Lintner (1965) CAPM to the international market through simplifying assumptions. For example, if we assume that PPP holds exactly at every point in time and that the world market is fully integrated, then the CAPM would apply to the international setting (see Grauer, Litzenberger, and Stehle, 1976; Stulz, 1984, 1995). However, empirical evidence suggests significant violations of the PPP.[2] The main contributions on the impact of PPP deviations in an integrated market on asset valuation come from Solnik (1974a), Sercu (1980), Stulz (1981a), and A-D. Their IAPMs contain market risk premium and risk premia based on the covariances of assets with state variables (Stulz, 1981a), inflation (A-D), and exchange rates (Solnik, 1974a; Sercu, 1980). Traditional unconditional tests do not support the Solnik-Sercu model (see, for example, Solnik, 1974b; Korajczyk and Viallet, 1989), while conditional tests do (see, for example, Dumas and Solnik, 1995; De Santis and Gerard, 1998).

Another strand of literature focuses on the impact of barriers to free cross-border portfolio flows under PPP (see, for example, Black, 1974; Stulz, 1981b; Errunza and Losq, 1985, 1989; Eun and Janakiramanan, 1986; Cooper and Kaplanis, 2000; De Jong and De Roon, 2005). Early tests of world market structure (see, for example, Stehle, 1977, Cho, Eun, and Senbet, 1986; Jorion and Schwartz, 1986; Wheatley, 1988) investigate the polar cases of full integration or complete segmentation or both. More recent tests (see, for example, Errunza, Losq, and Padmanabhan, 1992; Bekaert and Harvey, 1995; Carrieri, Errunza and Hogan, forthcoming, henceforth CEH; Karolyi, 2003a; Baele, 2005) study the evolution of market structure over time. The consensus is that the world markets are gradually becoming more integrated.

Thus, the available theoretical international asset pricing models include assumptions on the consumption opportunity set or the investment opportunity set. Correspondingly, the

[2]Deviations from PPP could result from a departure from the commodity price parity (CPP), different tastes, or the existence of nontraded goods.

empirical studies either test whether purchasing power risk is priced under full integration or examine the evolution of market structure under PPP. However, a more realistic model should incorporate both deviations from PPP and barriers to international investment. Such a model would also provide a theoretical framework to conduct tests of important issues in international finance.

3. The model

We assume that there are two countries: the domestic country D and the foreign country F. In the domestic market, all securities can be freely traded by any investor and are called eligible securities, while securities of the foreign market can be held only locally and are termed the ineligible securities. This is the market structure of E-L termed mild segmentation.[3]

We can think of the domestic country as the US and the foreign country as an emerging market. Thus, US investors do not have access to the securities traded in the EM, while the investors of the EM have access to both US and EM securities. Although most EM governments restrict portfolio capital outflows, they do not appear to be binding when one considers the participation of large (privileged) EM investors in global markets. Further, not withstanding market liberlizations, significant barriers to free flow of portfolio capital are in place.[4] Finally, the mild segmentation characterization is empirically supported by CEH. Nonetheless, in Section 5, we consider a more general market structure termed partial segmentation characterized by two sets of securities, eligible securities and ineligible securities that could exist in the same country. Though this market structure, in which both countries face some segmentation, is more attractive, we start with the mild segmentation case as it makes understanding the forces at work easier. In Section 5, we show that the results extend to the more general market structure with the addition of another premium at equilibrium.

Thus, our model constrains some investors from trading in a subset of securities. The countries are also distinguished by deviations from PPP that cause national investors to perceive real returns from the same security differently. In addition, we assume the international fixed income market to be integrated, i.e., the short-term bonds are part of the eligible set.[5]

Summing up, the investment opportunity set for each type of investor can be described as follows: Investors of the foreign market have free access to all stocks and to the short-term bonds of each country. Domestic investors have access only to their domestic stocks and to the short-term bonds of each country.

[3]Although a characterization that imposes a tax on investor's holdings of foreign risky assets in the vein of Stulz (1981b) would be more general, the analytics are difficult to track and we cannot obtain a closed form solution for expected returns for all assets.

[4]Investment barriers that give rise to ineligible segments could be explicit or implicit. Some examples of explicit barriers are legal restrictions on cross-border securities trade, foreign exchange regulation, and repatriation limits. Examples of implicit barriers include risk perception based on ignorance, expectations of expropriation by the government or majority shareholder, and less developed markets or institutions. See Stulz (2005) for an excellent discussion of the impact of agency problems on financial globalization.

[5]Stulz (1981b) and Basak (1996) use a similar assumption regarding the integration of the international bond market, while E-L assume the existence of a universal risk-free rate.

3.1. Assumptions

A1 : We consider the domestic currency as the reference currency.

A2 : The national capital markets are perfect and frictionless.

A3 : We measure nominal returns in terms of the domestic currency. Hence, the nominal rate of return of a foreign security in domestic currency is equal to its foreign currency rate of return multiplied by the ratio of the end of period to the beginning of period exchange rate, expressed in domestic currency per unit of foreign currency. The instantaneous returns are assumed to follow a stationary diffusion process implying that the nominal asset prices are lognormally distributed. The dynamics of the asset prices, expressed in terms of the domestic currency, are given by the geometric Brownian motion

$$\frac{\mathrm{d}S_j}{S_j} = \mu_j \,\mathrm{d}t + \sigma_j \,\mathrm{d}z_j, \quad j = 1 \ldots N, \tag{1}$$

where S_j is the market value of security j, μ_j is the instantaneous expected nominal rate of return on security j, σ_j is the instantaneous standard deviation of the nominal rate of return on security j, z_j is a standard Wiener process, and $\rho_{jk}\,\mathrm{d}t = \mathrm{d}z_j\,\mathrm{d}z_k$, where ρ_{jk} is the instantaneous correlation coefficient between the Wiener processes $\mathrm{d}z_j$ and $\mathrm{d}z_k$.

A4 : We assume that investors within a country face the same commodity prices and that their preferences are homothetic. The price index P^l, expressed in the domestic currency, of an investor of type $l \in \{D, F\}$ follows the geometric Brownian motion

$$\frac{\mathrm{d}P^l}{P^l} = \pi^l \,\mathrm{d}t + \sigma_\pi^l \,\mathrm{d}z_\pi^l, \quad l \in \{D, F\}, \tag{2}$$

where π^l is the instantaneous expected rate of inflation for investor l, σ_π^l is the instantaneous standard deviation of the rate of inflation, z_π^l is a standard Wiener process, and $\rho_{j,\pi}^l\,\mathrm{d}t = \mathrm{d}z_j\,\mathrm{d}z_\pi^l$, where $\rho_{j,\pi}^l$ is the instantaneous correlation coefficient between the Wiener processes $\mathrm{d}z_\pi^l$ and $\mathrm{d}z_j$.[6]

Eq. (2) illustrates that the rates of inflation in the two countries, expressed in the domestic currency, are unequal and their difference $(\mathrm{d}P^F/P^F - \mathrm{d}P^D/P^D)$ is random.

A5 : The exchange rate, e, follows a similar process as nominal returns and price indices

$$\frac{\mathrm{d}e}{e} = \phi \,\mathrm{d}t + \sigma_e \,\mathrm{d}z_e, \tag{3}$$

where ϕ is the instantaneous mean and σ_e is the instantaneous standard deviation of the percentage rate of change of the exchange rate.

A6 : All investors, foreign and domestic, can borrow and lend at the nominally risk-free rate denoted r and denominated in domestic currency. Both domestic and foreign bonds are nominally riskless for the respective local investors when denominated in terms of their local currency. Nonetheless, because of inflation risk, the two bonds are

[6]We follow A-D and restrict ourselves to stationary Brownian motions. For a detailed discussion of the stock price endogeneity problem, nonstationarity, and commodity price endogeneity, see A-D, pp. 940–941 and references therein. We specify dynamics for price indices instead of individual commodity prices (Stulz, 1981a). For the conditions of the existence of price indices, please refer to A-D, p. 975, and references therein.

risky in real terms. Because the domestic and foreign bond returns are measured in terms of the domestic currency, the domestic bond is nominally riskless for both domestic and foreign investors, while the foreign bond is the nominally risky bond and its return depends on the change in exchange rate.

A7 : There are no restrictions on short sales in either country.

Although we measure all returns in terms of the domestic currency, all the results that follow hold independently of the choice of the measurement currency.[7]

3.2. Notations

The subscripts e, and i are used as generic indexes to represent, respectively, the eligible risky assets (i.e., the domestic eligible risky securities and the foreign bond) and the foreign ineligible securities. The tilde denotes randomness; the inferior bar, a vector. The prime stands for the transposition operator.

There are N nominally risky assets partitioned as follows: The first N_e assets are eligible risky assets that include domestic eligible risky securities and the foreign short-term nominally risky bond, and the second N_i assets are the foreign ineligible securities. The $N+1$th security is the nominally risk-free domestic bond. We also define V as the $N \times N$ matrix of instantaneous covariances of the nominal rates of return on the various securities ($\sigma_{jk} = \rho_{jk}\sigma_j\sigma_k$), and it can be partitioned as

$$V \equiv \begin{pmatrix} V_{ee} & V_{ei} \\ V'_{ei} & V_{ii} \end{pmatrix}, \tag{4}$$

where V_{ee} is the variance–covariance matrix of eligible assets, V_{ii} is the variance–covariance matrix of ineligible securities, and V_{ei} is the covariance matrix between eligible and ineligible securities.

The vector of instantaneous expected returns $\underline{\mu}$, the vector of aggregate market values $\underline{S}$, and the vector of covariances of the N risky asset returns with investor l's rate of inflation $\underline{\omega}^l$ are partitioned in the same way

$$\underline{\mu} \equiv \begin{pmatrix} \underline{\mu}_e \\ \underline{\mu}_i \end{pmatrix}, \quad \underline{S} \equiv \begin{pmatrix} \underline{S}_e \\ \underline{S}_i \end{pmatrix}, \quad \underline{\omega}^l \equiv \begin{pmatrix} \underline{\omega}^l_e \\ \underline{\omega}^l_i \end{pmatrix}, \tag{5}$$

where $\underline{\omega}^l_x$ is the $N_x \times 1$ vector of covariances $\sigma^l_{j,\pi} = \rho^l_{j,\pi}\sigma_j\sigma_\pi$ of the N_x risky assets returns with investor l's rate of inflation, with $x \in \{e, i\}$.

We also denote by $\underline{0}_{N_x}$ ($\underline{\iota}_{N_x}$) the $N_x \times 1$ vector of zeros (ones), with $x \in \{e, i\}$; W^l the investable wealth of investor l at time 0, $l \in \{D, F\}$; $\widetilde{W}^l$ the random end-of-period wealth of investor l, $l \in \{D, F\}$; and W^m the total wealth of all investors, i.e. $W^m \equiv \sum_{l\in\{D,F\}} W^l$.

3.3. Asset demands

We adopt the Merton (1971, 1973) continuous time methodology as in Solnik (1974a), Stulz (1981a), and A-D. Each investor is assumed to maximize the expected value at each

[7]Proof is available upon request and is similar to Sercu (1980).

instant in time of a time-additive and state independent Von Neumann-Morgenstern utility function of consumption given his current wealth. It is further assumed that the direct utility function is homothetic. Hence, the maximization problem can be stated in terms of the indirect utility function of the consumption expenditure. The assumption of homothetic direct utility function implies the existence of a single price level (See, Breeden, 1979; Stulz, 1981a, for the case of nonhomothetic utility function).

A domestic investor can invest in the nominally riskless bond of the domestic market and the N_e eligible assets. He solves the optimization problem stated below, where the wealth denoted by W is the state variable and the control variables are the consumption flow, C, and $\underline{\alpha} \equiv \{\alpha_j\}_{j=1\ldots N_e+1}$, which indicates the proportion of wealth invested by the investor in the various assets,

$$\underset{\underline{\alpha}^l, C^l}{\text{Max}}\ \mathrm{E}\left[\int_t^T U^l(C^l, P^l, s)\,\mathrm{d}s\right], \quad l \in D, \tag{6}$$

where C^l is the instant consumption expenditure, P^l is the price level index, and $U^l(\bullet)$ is the indirect utility function, which is homogenous of degree zero in C^l and P^l. Denote by $W^l(t)$ the nominal wealth of the domestic investor l at time t. The wealth dynamics are given by

$$\mathrm{d}W^l = \left[\sum_{j=1}^{N_e} \alpha_j^l(\mu_j - r) + r\right] W^l\,\mathrm{d}t - C^l\,\mathrm{d}t + W^l \sum_{j=1}^{N_e} \alpha_j^l \sigma_j\,\mathrm{d}z_j. \tag{7}$$

Let $J^l(W^l, P^l, t)$ be the maximum value of Eq. (6) subject to Eq. (7). J^l satisfies the Hamilton-Jacobi-Bellman equation

$$0 \equiv \underset{\{C^l, \underline{\alpha}^l\}}{\text{Max}} \begin{pmatrix} U^l(C^l, P^l, t) + J_t^l + J_W^l \left\{ \left[\sum_{j=1}^{N_e} \alpha_j^l(\mu_j - r) + r\right] W^l - C^l \right\} \\ + J_P^l P^l \pi^l + \frac{1}{2} J_{WW}^l \sum_{j=1}^{N_e} \sum_{k=1}^{N_e} \alpha_j^l \alpha_k^l \sigma_{j,k} (W^l)^2 \\ + \frac{1}{2} J_{P,P}^l \sigma_{\pi^l}^2 (P^l)^2 + J_{W,P}^l \sum_{j=1}^{N_e} \alpha_j^l \sigma_{j,\pi}^l W^l P^l \end{pmatrix}, \tag{8}$$

where subscripts of the $J^l(\bullet)$ function represent partial derivatives with respect to wealth and price index.

The homogeneity of degree 0 of the function $U^l(C^l, P^l, t)$ implies that $J^l(W^l, P^l, t)$ and $C^l(W^l, P^l, t)$ which satisfy Eq. (8) must be homogenous of degree 0 in W and P. By Euler's theorem

$$J_P = -(W/P) J_W. \tag{9}$$

(This procedure has also been used by Fischer, 1975; A-D, among others.)

Differentiating Eq. (9) with respect to W and then with respect to P, we obtain

$$J_{P,W} = -(1/P) J_W - (W/P) J_{W,W} \quad \text{and} \tag{10}$$

$$J_{P,P} = 2(W/P^2) J_W + (W/P)^2 J_{W,W}. \tag{11}$$

Substituting into Eq. (8) gives

$$0 \equiv \underset{\{C^l,\underline{\alpha}^l\}}{\text{Max}} \left(\begin{array}{l} U^l(C^l,P^l,t) + J^l_t \\ \quad + J^l_W \left\{ \left[\sum_{j=1}^{N_e} \alpha^l_j(\mu_j - r) + r - \pi^l + (\sigma^l_\pi)^2 - \sum_{j=1}^{N_e} \alpha^l_j \sigma^l_{j,\pi} \right] W^l - C^l \right\} \\ \quad + \frac{1}{2} J^l_{WW} \left\{ \sum_{j=1}^{N_e} \sum_{k=1}^{N_e} \alpha^l_j \alpha^l_k \sigma_{j,k} - 2 \sum_{j=1}^{N_e} \alpha^l_j \sigma^l_{j,\pi} + (\sigma^l_\pi)^2 \right\} (W^l)^2 \end{array} \right). \tag{12}$$

The $N_e + 1$ first-order conditions derived from Eq. (12) are

$$0 = U^l_C(C^l,P^l,t) - J^l_W(C^l,P^l,t) \quad \text{and} \tag{13}$$

$$0 = J^l_W(\mu_j - r - \sigma^l_{j,\pi}) + J^l_{WW} \left(\sum_{k=1}^{N_e} \alpha^l_k \sigma_{j,k} - \sigma^l_{j,\pi} \right) W^l, \quad j = 1 \ldots N_e. \tag{14}$$

Eq. (13) is the standard envelope condition and states that the marginal utility of consumption is equal to the marginal utility of nominal wealth. Eq. (14) is the usual portfolio equation. Defining $A^l \equiv -J^l_{WW}/J^l_W$ as the investor l's absolute risk aversion coefficient, we can rewrite Eq. (14) as

$$\mu_j = r + (1 - A^l W^l)\sigma^l_{j,\pi} + A^l W^l \sum_{k=1}^{N_e} \alpha^l_k \sigma_{j,k}, \quad j = 1 \ldots N_e, \ \ l \in D. \tag{15}$$

(Stulz, 1981a; Breeden, 1979, use the Arrow-Pratt definition of relative risk aversion. The two definitions differ to the extent that the wealth elasticity of consumption is different from one.)

Solving for the asset demands in vector notation, we get

$$\underline{d}^l = \frac{1}{A^l} \begin{pmatrix} V^{-1}_{ee}(\underline{\mu}_e - r\underline{\iota}_{N_e}) \\ 1 - \underline{\iota}' V^{-1}_{ee}(\underline{\mu}_e - r\underline{\iota}_{N_e}) \end{pmatrix} + \left(W^l - \frac{1}{A^l} \right) \begin{pmatrix} V^{-1}_{ee}\underline{\omega}^l_e \\ 1 - \underline{\iota}' V^{-1}_{ee}\underline{\omega}^l_e \end{pmatrix}, \quad l \in D, \tag{16}$$

where $\underline{d}^l$ is the $N_e \times 1$ vector of demand by the domestic investor l, i.e., $\underline{d}^l \equiv W^l \underline{\alpha}^l, \ l \in D$.

Eq. (16) implies that the ratio of the demands for risky assets is a function of preferences. Hence we cannot obtain the standard separation theorem.[8] However, it can easily be shown that all domestic investors are indifferent between choosing portfolios from the original risky assets or from two funds provided that all investors within the domestic country face the same commodity prices implying that $\underline{\omega}^l_e = \underline{\omega}^{l'}_e \forall \ l, \ l' \in D$ (assumption A4). A possible choice for those funds is the logarithmic portfolio, i.e., the portfolio held by an investor with unit relative risk aversion, and the portfolio that constitutes the best hedge against purchasing power risk, i.e., the portfolio the most highly correlated with the domestic inflation rate. (The separation result we have here is similar to the generalized separation result of Merton (1973). Proof is provided in Appendix A.)

[8]The standard separation result states that there exists a unique pair of efficient portfolios (one containing only the riskless asset and the other only risky assets), such that, independent of preferences, all investors are indifferent between choosing portfolios from among the original assets or from these two funds (see, e.g., Merton, 1973). As explained by Merton, the uniqueness of the two funds is ensured by the requirement that one fund hold only the riskless asset and the other only risky assets, and that both funds be efficient.

As a result of the unequal access, the components of the optimal portfolio of domestic investors includes only the eligible assets. Hence, both the logarithmic portfolio and the portfolio to hedge purchasing power risk are country specific unlike in A-D, where the logarithmic portfolio is universal.

A foreign investor solves a similar problem, but he faces a different investment opportunity set. A foreign investor can invest in all assets traded in the two markets, i.e., the eligible and ineligible securities. The assets' demand of a foreign investor $l \in F$ is

$$\underline{d}^l = \frac{1}{A^l}\begin{pmatrix} V^{-1}(\underline{\mu} - r\underline{\iota}_N) \\ 1 - \underline{\iota}' V^{-1}(\underline{\mu} - r\underline{\iota}_N) \end{pmatrix} + \left(W^l - \frac{1}{A^l}\right)\begin{pmatrix} V^{-1}\underline{\omega}^l \\ 1 - \underline{\iota}' V^{-1}\underline{\omega}^l \end{pmatrix}, \quad l \in F, \tag{17}$$

where A^l and $\underline{d}^l$ are, respectively, the absolute risk aversion coefficient and the demand vector of a foreign investor $l \in F$. [9]

Similar to the domestic investors, all foreign investors' optimal portfolios of risky assets can be represented as a linear combination of two mutual funds. However, the two funds are formed from all risky assets in the economy because foreign investors do not face any barriers to international investment.

After solving for the investors' demand for each asset, the demands are aggregated and set equal to the supply of assets. The equities are in net positive supply equal to their market capitalization and the bonds are in zero net supply. Following such a procedure, we obtain the equilibrium asset pricing relationships.

4. Equilibrium risk and return under PPP deviations and mild segmentation

In this section, we present the main theoretical results including the equilibrium asset pricing relationships in a mildly segmented market when PPP is violated.

4.1. Eligible set

The eligible securities are priced as if the market is fully integrated but PPP does not hold, i.e., the barriers do not affect the pricing of securities that can be held by all investors. For an eligible asset, the expected return is

$$\mu_e = r + AM\ \sigma_{e,m} + (1 - AM)\frac{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)\sigma^l_{e,\pi}}{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)}, \quad e = 1 \ldots N_e, \tag{18}$$

where A is the aggregate absolute risk aversion coefficient defined by $1/A \equiv \sum_{l\in\{D,F\}} 1/A^l$, M is the market value of the world market portfolio (WMP), $\sigma_{e,m} = \sum_{j=1}^{N} \alpha_j^m \sigma_{e,j}$, and $\alpha_j^m = (\sum_{l\in\{D,F\}} W^l \alpha_j^l)/W^m$. (The representative vector of WMP is given by $\underline{WMP} = \underline{S}$.)

Thus, the expected return on an eligible asset, denominated in the domestic currency, is linearly related to the covariance with the world market and the covariances with inflation

[9] It might be more intuitive to first derive the asset demand for a foreign investor in terms of his own currency. The means and covariances would be measured in the foreign currency. Also, the risky assets would be made up of the domestic and foreign stocks as well as the domestic bond. In terms of the foreign currency, the foreign bond is nominally riskless, while the domestic bond is nominally risky. The asset demand for foreign investors would then be expressed in terms of the domestic currency as given in Eq. (17).

rates. Hence, the eligible securities command a world market risk premium and an inflation risk premium, which is a weighted sum of covariances between the security's rate of return and inflation rates.

4.2. Ineligible set

To derive the equilibrium asset pricing relationship for the ineligible securities, we introduce the diversification portfolio and the hedge portfolio. The projection of the market portfolio of ineligible securities (MPIS) return on the space of eligible securities returns is defined as the return on the diversification portfolio, DP, which is the portfolio of eligible assets that is most highly correlated with the market portfolio of ineligible securities. DP can be represented by $\underline{DP} \equiv \begin{bmatrix} V_{ee}^{-1} V_{ei} \underline{S}_i \\ \underline{0}_{N_i} \end{bmatrix}$. The residual vector is orthogonal to the plane defined by the eligible securities returns and is the return on the hedge portfolio, HP. Thus, the hedge portfolio consists of a long position in the MPIS and a short position in DP; i.e., $\underline{HP} \equiv \underline{MPIS} - \underline{DP}$, where $\underline{MPIS}$ is defined as $\underline{MPIS} = \begin{pmatrix} \underline{0}_{N_e} \\ \underline{S}_i \end{pmatrix}$.

The foreign ineligible securities command four risk premiums: the world market risk premium; the inflation premium, which is a weighted sum of covariances between the diversification portfolio and inflation rates; the conditional market risk premium of E-L; and the segflation risk premium, which is what investors can expect from bearing purchasing power risk in the presence of barriers. The segflation premium is measured by the covariance between the foreign inflation rate and the rate of return of the hedge portfolio. The asset-pricing model is given by

$$\begin{aligned} \mu_i = {} & r + AM\ \sigma_{i,m} + (1 - AM) \frac{\sum_{l \in \{D,F\}} \left(W^l - \frac{1}{A^l} \right) \sigma^l_{DP_i,\pi}}{\sum_{l \in \{D,F\}} \left(W^l - \frac{1}{A^l} \right)} \\ & + (A^F - A) M_I\ \sigma_{i,I\ |e} + (1 - A^F W^F) \sigma^F_{HP_i,\pi}, \\ & i = 1 \ldots N_i, \end{aligned} \tag{19}$$

where A^F is the aggregate absolute risk aversion coefficient of foreign investors defined by $1/A^F \equiv \sum_{l \in F} 1/A^l$, M_I is the market value of the market portfolio of ineligible securities, $\sigma_{i,m}$ is the instantaneous covariance between the return on the foreign ineligible security i and the return on the world market portfolio, $\sigma^l_{DP_i,\pi}$ is the covariance between the return on the diversification portfolio of security i and the inflation rate for investor l, $l \in \{D, F\}$, $\sigma_{i,I|e}$ is the conditional market risk of the foreign ineligible security i defined as the conditional covariance between the return on security i and the return on MPIS given the return on all eligible assets, and $\sigma^F_{HP_i,\pi}$ is the segflation risk of the foreign ineligible security i, i.e., the covariance between the return on the hedge portfolio of security i and the foreign inflation rate.[10]

[10]Proof is available from authors upon request. $\sigma_{i,I|e}$ is the element of $(V_{i|e}\underline{S}_i)$, where $V_{i|e}$ is the covariance matrix of ineligible securities conditional on the return on all eligible assets, i.e., $V_{i|e} \equiv V_{ii} - V'_{ei} V_{ee}^{-1} V_{ei}$. $V_{i|e}$ can also be written as $V_{i|e} = V_{ii} - \gamma'_i V_{ee} \gamma_i$, where $\gamma'_i \equiv V'_{ei} V_{ee}^{-1}$ is the $N_i \times N_e$ matrix, each row containing the N_e slope coefficients in the regression of the foreign ineligible security's return on all eligible assets. Hence $V_{i|e}$ is the covariance matrix of residuals of the N_i regressions.

By aggregating Eq. (19) over the ineligible set of securities, we obtain

$$\mu_I = r + AM\ \sigma_{I,m} + (1 - AM)\frac{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)\sigma^l_{DP,\pi}}{\sum\limits_{\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)} + (A^F - A)M_I\sigma^2_{I|e} + (1 - A^F W^F)\ \sigma^F_{HP,\pi}. \tag{20}$$

The ineligible securities command the world market premium and the inflation premium as in A-D. However, unlike A-D, where inflation premium is proportional to the covariance between the security's return and inflation rates, in our model the inflation premium is proportional to the covariance between the return on the diversification portfolio and the inflation rates. The diversification portfolio is by construction a portfolio of eligible securities and hence can be held by all investors. Thus, the expected return on the ineligible security depends on the ability of the diversification portfolio to hedge purchasing power risk for domestic and foreign investors. Further, the ineligible securities can be held only by foreign investors. Although the risk exposure of foreign investors from ineligible securities can be reduced by short selling the diversification portfolio, they remain exposed to the residual risk embedded in the hedge portfolio. To entice foreign investors to bear this residual risk, they receive a premium, the E-L conditional market premium. This premium is positive at the aggregate level because the exposure to conditional market risk, $\sigma^2_{I|e}$, and the price of risk, $(A^F - A)M_I$, are both positive. Finally, barriers to portfolio flows limit inflation hedging benefits as a result of incomplete risk sharing. Hence the expected return on the ineligible security commands an additional premium: the segflation risk premium that depends on the ability of the hedge portfolio to hedge purchasing power risk for foreign investors.[11] Both the conditional market risk premium and the segflation premium vanish when the ineligible security has a perfect substitute in the set of eligible assets.

Thus, as shown by Eq. (19) and earlier demonstrated by Merton (1973), each source of risk toward consumption and investment opportunities commands its own risk premium. In our model, the conditional market risk premium is the result of the mildly segmented market structure. Deviations from PPP leads to the inflation risk premium, which is proportional to the weighted sum of covariances between inflation rates and the diversification portfolio. Bearing purchasing power risk in the presence of barriers leads to the segflation risk premium, which is proportional to the covariance between inflation and the hedge portfolio.[12]

5. Partial segmentation

In Section 3, we specified two types of securities traded in two different countries. We now consider two sets of securities, eligible securities and ineligible securities, that could exist in the same country. That is, in each country, some securities can be freely traded by all investors and are called eligible securities, while the other securities can be held only

[11]The segflation premium is a reward to systematic risk that arises in a world market characterized by barriers and PPP deviations. This systematic risk is the risk exposure of the hedge portfolio to purchasing power risk.

[12]Changing currency unit preserves the equilibrium international asset pricing Eqs. (18) and (19). Proof is available from authors upon request.

locally and are termed ineligible securities. We call this specification partial segmentation. Thus, each investor has free access to all eligible stocks, to the local ineligible stocks, and to the short-term bonds of each country.

Because there is a subset of ineligible securities in each country, we introduce the local diversification portfolio and the local hedge portfolio. The local diversification portfolio is the portfolio of eligible assets that is most highly correlated with the local portfolio of ineligible securities. The local hedge portfolio is the portfolio that consists of a long position in the portfolio of local ineligible securities and a short position in the local diversification portfolio.

We further define the conditional cross-market risk of a domestic (foreign) security as the conditional covariance between its return and the return on the portfolio of the foreign (domestic) ineligible securities given the return on all eligible assets.

With this characterization of the world capital market structure, all eligible securities (domestic and foreign) are priced as though the markets are fully integrated and PPP does not hold; They command a world market premium and inflation premium. However, each set of the ineligible securities command five risk premiums: (1) the world market risk premium, (2) the inflation premium, (3) the conditional market risk premium, (4) the segflation risk premium, and (5) the conditional cross-market risk premium. The asset-pricing equations for domestic ineligible securities are given by

$$\begin{aligned}\mu_y &= r + AM\ \sigma_{y,m} + (1-AM)\frac{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)\sigma^l_{DP_y,\pi}}{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)} \\ &\quad + (A^D - A)M_Y\ \sigma_{y,Y|e} + (1 - A^D W^D)\sigma^D_{HP_y,\pi} - AM_I\sigma_{y,I|e} \quad \text{and} \\ y &= 1\ldots N_y, \end{aligned} \tag{21}$$

where A^D is the aggregate absolute risk aversion coefficient of domestic investors defined by $1/A^D \equiv \sum_{l\in D} 1/A^l$, μ_y is the instantaneous expected return on the domestic ineligible security y, M_Y is the market value of the portfolio of domestic ineligible securities, M_I is the market value of the portfolio of foreign ineligible securities, $\sigma_{y,m}$ is the instantaneous covariance between the return on the domestic ineligible security y and the return on the world market portfolio, $\sigma^l_{DP_y,\pi}$ is the covariance between the return on the diversification portfolio of security y and the inflation rate for investor l, $l \in \{D, F\}$, $\sigma_{y,Y|e}$ is the conditional market risk of the domestic ineligible security y, $\sigma^D_{HP_y,\pi}$ is the segflation risk of the domestic ineligible security y, and $\sigma_{y,I|e}$ is the conditional cross-market risk of the domestic ineligible security y.[13]

[13]Proof is available from authors upon request. $\sigma_{y,I|e}$ is the element of $(V_{yi|e}\underline{S}_i)$, where $V_{yi|e}$ is the covariance matrix between the return on domestic ineligible securities and foreign ineligible securities conditional on the return on all eligible assets, i.e., $V_{yi|e} \equiv V_{yi} - V'_{ey}V^{-1}_{ee}V_{ei}$, where V_{yi} is the covariance matrix between domestic ineligible securities and foreign ineligible securities and $V_{ey}(V_{ei})$ is the covariance matrix between eligible assets and domestic (foreign) ineligible securities. $V_{yi|e}$ can also be written as $V_{yi|e} = V_{yi} - \gamma'_y V_{ee}\gamma_i$, where $\gamma'_y \equiv V'_{ey}V^{-1}_{ee}$ is the $N_y \times N_e$ matrix, each row containing the N_e slope coefficients in the regression of the domestic ineligible security's return on all eligible assets. $(V_{yi|e}\underline{S}_i)$ is proportional to the covariance between the return on the domestic ineligible security y and the return on the foreign hedge portfolio. Because of the absence of correlation between the eligible securities and the hedge portfolios, $(V_{yi|e}\underline{S}_i)$ is also proportional to the covariance between the return on the hedge portfolio of the security y and the portfolio of foreign ineligible securities.

The asset pricing equations for foreign ineligible securities are given by

$$\mu_i = r + AM\ \sigma_{i,m} + (1 - AM)\frac{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)\sigma^l_{DP_i,\pi}}{\sum_{l\in\{D,F\}}\left(W^l - \frac{1}{A^l}\right)} + (A^F - A)M_I\ \sigma_{i,I|e} + (1 - A^F W^F)\ \sigma^F_{HP_i,\pi} - AM_Y\ \sigma_{i,Y|e} \quad \text{and} \quad i = 1\ldots N_i, \tag{22}$$

where $\sigma_{i,m}$ is the instantaneous covariance between the return on the foreign ineligible security i and the return on the world market portfolio, $\sigma^l_{DP_i,\pi}$ is the covariance between the return on the diversification portfolio of security i and the inflation rate for investor l, $l \in \{D, F\}$, $\sigma_{i,I|e}$ is the conditional market risk of the foreign ineligible security i, $\sigma^F_{HP_i,\pi}$ is the segflation risk of the foreign ineligible security i, and $\sigma_{i,Y|e}$ is the conditional cross-market risk of the foreign ineligible security i.

Hence, all of the premiums that obtain in the mild segmentation case discussed in Section 4.2 also appear in this case. The only new term is the conditional cross-market risk premium. The interpretation of this extra premium for the expected return on the portfolio of domestic ineligible securities is as follows: If the domestic hedge portfolio is a partial substitute for the foreign hedge portfolio, it would provide some diversification benefits that are otherwise unattainable. Hence, the domestic investors are willing to accept a lower premium equal to the conditional cross-market premium, which would be negative if the domestic hedge portfolio covaries positively with the foreign hedge portfolio.

While the conditional market risk premium is proportional to the differential risk aversion, the conditional cross-market risk premium is proportional to the aggregate risk aversion. Hence, as domestic investors become much more risk-tolerant than the foreign investors, the conditional market risk premium associated with the domestic ineligible securities tends to disappear. However, the conditional cross-market risk premium holds. The former is a premium that induces the domestic investors to hold their local ineligible securities. The less risk averse they are, the lower this premium would be. The conditional cross-market risk premium is the result of the hedging value of the local ineligible securities, assuming the return on those securities is positively correlated with the foreign hedge portfolio.

Notwithstanding the significance of the conditional cross-market risk premium as suggested by Eqs. (21) and (22), this premium vanishes when we consider the pricing of any market in a global context; i.e., when we consider a market set-up that consists of the fully accessible global market and any other market. The conditional cross-market premium plays a role only where the two market segments are both not fully investable. The above theoretical set up would allow consideration of such a case.

6. Empirical methods

We test whether exposure to different risk factors is priced and assess the statistical significance and relative magnitude of the different premia. We first present the system of equations in a conditional setting and then detail the econometric approach. Next, we describe the data and discuss construction of the diversification portfolios, followed by estimation. We measure all returns in US dollars.

6.1. Estimation

The empirical set-up consists of a global market that can be considered fully accessible to all investors and an emerging market that is accessible only to local investors. We test the model using Eq. (20) for the ineligible set and Eq. (18) for the eligible set. These equations are derived under the assumption of a constant investment opportunity set, i.e., the returns are assumed to be independent and identically distributed and all the moments are unconditional moments. However, many recent studies show that it is necessary to allow the prices of risk to vary over time (see, among others, Dumas and Solnik, 1995; De Santis and Gerard, 1997, 1998). This result stems from a more general argument that the rejection of the unconditional CAPM does not imply a rejection of the conditional CAPM.[14] Thus, we estimate a conditional version of our model where we allow prices and quantities of risk to change through time. Testing a conditional version of the model would require additional risk premia for hedging the stochastic changes in investment opportunities. To do so we would need to derive a formal intertemporal model with PPP deviations and segmentation. We leave this for future work. However, the conditional model is internally inconsistent as argued by Dumas and Solnik (1995). Also, to keep the dimensionality of the model reasonable, we test the model using one country at a time, which implies that power is lost in the testing procedure because the cross-sectional restriction that the global (world market and inflation) prices of risk is common to all countries cannot be exploited.[15] The conditional version of the model can be written as

$$\begin{aligned} \mathrm{E}_{t-1}[r_{It}] = {} & \delta_{W,t-1} cov_{t-1}[r_{It}, r_{Wt}] + \sum_j \delta_{j,t-1} cov_{t-1}[r_{DP,t}, \pi_{jt}^{\$}] \\ & + \lambda_{I,t-1} var_{t-1}[r_{It} | r_{DP,t}] + \lambda_{e,t-1} cov_{t-1}[r_{HP,t}, \pi_{It}^{\$}], \end{aligned} \tag{23}$$

where r_{It} is the excess return on the country's market index; r_{Wt} is the excess return on the world index; $r_{DP,t}$ is the excess return on the country's diversification portfolio; $r_{HP,t}$ is the excess return on the country's hedge portfolio; $\pi_j^{\$}$ is the rate of inflation of country j expressed in the reference currency (the US dollar); $\delta_{W,t-1}$ and $\lambda_{I,t-1}$ are time-varying prices of world market risk and conditional market risk respectively; $\delta_{j,t-1}$ are time-varying prices of inflation risk; and $\lambda_{e,t-1}$ is the time-varying price of segflation risk. Because we test the model for the EMs that experience high inflation rates, the assumption that the local inflation rate is nonstochastic as assumed by Dumas and Solnik (1995) and De Santis and Gerard (1998) is not appropriate in our case. Hence, we follow Carrieri, Errunza, and Majerbi (2006a,b) and replace the term $\pi_j^{\$}$ by the change in real exchange rate of currency j vis-à-vis the US dollar denoted by e_j^r. The rate of inflation of country j expressed in the US dollar is given by $\pi_j^{\$} = \pi_j + \phi$, where π_j is the inflation rate in country j measured in terms of the country j's currency and ϕ is the change in the nominal exchange rate ($\$/j$). By definition, the change in real exchange rate is equal to $e_j^r = \phi + \pi_j - \pi^{\$}$, where $\pi^{\$}$ is the

[14]Also Ferson and Harvey (1991, 1993) point out the importance of incorporating time-varying risk and returns. Harvey (1991) was the first to apply the conditional framework to international asset pricing. Harvey (1995) also used the conditional world asset-pricing model to emerging equity markets.

[15]Another alternative would be to estimate the model in two stages. In the first stage, the global prices of risk would be estimated. The second stage estimates the model country by country, conditioning on the estimates from the first stage. A similar approach was adopted by Bekaert and Harvey (1995, 1997). Though such an approach would impose the equality of global prices of risk, it would yield consistent but not efficient estimates. Further, the two-step procedure would not allow us to analyse the contribution of each premium to the total premium.

inflation rate in the US. Hence we can write the dollar value of the country j's inflation rate as $\pi_j^{\$} = e_j^r + \pi^{\$}$. Assuming nonstochastic inflation in the US, which is a reasonable assumption, we can proxy $cov_{t-1}[r_{DP,t}, \pi_{jt}^{\$}]$ by $cov_{t-1}[r_{DP,t}, e_j^r]$. Eq. (23) can then be expressed as

$$\begin{aligned} \mathrm{E}_{t-1}[r_{It}] &= \delta_{W,t-1} cov_{t-1}[r_{It}, r_{Wt}] + \sum_j \delta_{j,t-1} cov_{t-1}[r_{DP,t}, e_{jt}^r] \\ &\quad + \lambda_{I,t-1} var_{t-1}[r_{It}|r_{DP,t}] + \lambda_{e,t-1} cov_{t-1}[r_{HP,t}, e_{It}^r]. \end{aligned} \tag{24}$$

To further simplify the estimation, we aggregate the global real exchange rate factor. (See, Ferson and Harvey, 1993; Harvey, 1995; Carrieri, Errunza, and Majerbi, 2006a,b.) We use the change in two Federal Reserve currency indices: the major currency index and the Other Important Trading Partner currency index (OITP, termed the EM index). The major currency index includes 16 currencies until the introduction of the euro in January 1999. After that, the index becomes a seven-currency index. The OITP includes mainly emerging market currencies. The trade weights are used as an aggregation method and are allowed to vary over time. We take the inverse of the real index so that higher index values represent an appreciation of the foreign currency.

The following system of equations has to hold at any time:

$$\begin{aligned} \mathrm{E}_{t-1}[r_{It}] &= \delta_{W,t-1} cov_{t-1}[r_{It}, r_{Wt}] + \sum_{j=mj,em} \delta_{j,t-1} cov_{t-1}[r_{DP,t}, e_{jt}^r] \\ &\quad + \lambda_{I,t-1} var_{t-1}[r_{It}|r_{DP,t}] + \lambda_{e,t-1} cov_{t-1}[r_{HP,t}, e_{It}^r], \\ \mathrm{E}_{t-1}[r_{DP,t}] &= \delta_{W,t-1} cov_{t-1}[r_{DP,t}, r_{Wt}] + \sum_{j=mj,em} \delta_{j,t-1} cov_{t-1}[r_{DP,t}, e_{jt}^r], \\ \mathrm{E}_{t-1}[r_{Wt}] &= \delta_{W,t-1} var_{t-1}[r_{Wt}] + \sum_{j=mj,em} \delta_{j,t-1} cov_{t-1}[r_{Wt}, e_{jt}^r], \text{ and} \\ \mathrm{E}_{t-1}[e_{kt}^r] &= \delta_{W,t-1} cov_{t-1}[e_{kt}^r, r_{Wt}] + \sum_{j=mj,em} \delta_{j,t-1} cov_{t-1}[e_{kt}^r, e_{jt}^r], \quad k = mj, em, I, \end{aligned} \tag{25}$$

where $\delta_{mj,t-1}$ and $\delta_{em,t-1}$ are time-varying prices of, respectively, major real currency risk and EM real currency risk.

The first equation in the system is the pricing equation for the emerging market index return, where global and local factors are priced. The global factors include the world market and real exchange covariance risk and the local factors are made up of the conditional market risk and segflation risk. The other equations in the system price the diversification portfolio, the world index portfolio, the currency indices and bilateral exchange rates with just the world market and currency premia. By further expressing $var_t[r_{It}|r_{DP,t}] = var_t(r_{It})(1 - \rho_{I,DP,t}^2)$, where $\rho_{I,DP,t}$ is the correlation coefficient between the diversification portfolio and the EM index return, we write the previous system for estimation as

$$\begin{aligned} r_{It} &= \delta_{W,t-1} h_{I,W,t} + \delta_{mj,t-1} h_{DP,mj,t} + \delta_{em,t-1} h_{DP,em,t} \\ &\quad + \lambda_{I,t-1} h_{I,t} \left(1 - \frac{h_{I,DP,t}^2}{h_{It} h_{DP_t}}\right) + \lambda_{e,t-1} h_{HP,e_I,t} + \varepsilon_{I,t}, \end{aligned}$$

$$r_{DP,t} = \delta_{W,t-1} h_{DP,W,t} + \delta_{mj,t-1} h_{DP,mj,t} + \delta_{em,t-1} h_{DP,em,t} + \varepsilon_{DP,t},$$
$$r_{Wt} = \delta_{W,t-1} h_{W,t} + \delta_{mj,t-1} h_{W,mj,t} + \delta_{em,t-1} h_{W,em,t} + \varepsilon_{W,t}, \text{ and}$$
$$e^r_{kt} = \delta_{W,t-1} h_{k,W,t} + \delta_{mj,t-1} h_{k,mj,t} + \delta_{em,t-1} h_{k,em,t} + \varepsilon_{k,t}, k = mj, em, I, \tag{26}$$

where $h_{j,t}$ are the elements of H_t, the 6×6 conditional covariance matrix of the assets in the system. In particular, $var_t[r_{It}|r_{DP,t}]$ is parameterized as $var_t(r_{It})(1 - \rho^2_{I,DP,t}) = h_{It}(1 - \frac{h^2_{I,DP,t}}{h_{It} h_{DP_t}})$ with $h_{I,DP,t}$, the time-varying covariance, and h_{It} and $h_{DP,t}$, the time-varying variances.

To be able to determine the magnitude of the time-varying risk premiums, we follow the fully parametric approach of De Santis and Gerard (1998) and parameterize the prices of risk factors. Given that the model implies that the prices of world market and conditional market risks must be positive, we use an exponential function to model their dynamics as

$$\delta_{W,t-1} = \exp(k'_W Z_{G,t-1}) \quad \text{and} \tag{27}$$
$$\lambda_{I,t-1} = \exp(k'_I Z_{I,t-1}), \tag{28}$$

where Z_G is the set of global information variables and Z_I is the set of local information variables for country I.

As the model does not restrict the prices of currency risk to be positive, we let the prices of global currency risk to be linear functions of a set of global information variables and the price of segflation risk to be linear function of a set of local instrumental variables:

$$\delta_{j,t-1} = k'_j Z_{G,t-1}, \quad j = mj, em \quad \text{and} \tag{29}$$
$$\lambda_{e,t-1} = k'_e Z_{I,t-1}. \tag{30}$$

Following De Santis and Gerard (1998), we specify the dynamics of H_t as

$$H_t = H_0 * (\iota\iota' - aa' - bb') + aa' * \varepsilon_{t-1}\varepsilon'_{t-1} + bb' * H_{t-1}, \tag{31}$$

where $*$ denotes the Hadamard product, H_0 is a (6×6) unconditional covariance matrix of residuals, a and b are (6×1) parameter vectors.[16] This implies that the variances in H_t depend only on past squared residuals and an autoregressive component, while the covariances depend on past cross-products of residuals and an autoregressive component.

Assuming a normal conditional density, the log likelihood function is written as

$$\ln L(\theta) = -\frac{T}{2}\ln 2\pi - \frac{1}{2}\sum_{t=1}^{T}[\ln|H_t(\theta)| + \varepsilon_t(\theta)' H_t(\theta)^{-1}\varepsilon_t(\theta)], \tag{32}$$

where θ is the vector of unknown parameters in the model. The estimation is performed using Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm. (See, e.g., Shanno, 1985). Because the assumption of conditional normality is too restrictive, the quasi-maximum likelihood estimate (QMLE) is used. QMLE of the parameters are generally consistent and

[16]Under partial segmentation, one would ideally want to use a full matrix to account for the effect of off-diagonal elements. However, as formulated, the system has 30 parameters to estimate, which would increase to 111 with a full matrix. Also, by setting the off-diagonal coefficients to zero except for those corresponding to the world column similarly to Bekaert and Wu (2000), the system remained too large with 61 parameters to estimate and the model failed to converge. Thus unless we assume a diagonal GARCH process, the system becomes econometrically untractable as the addition of parameters to render the volatility process more flexible is limited by the number of degrees of freedom and the finite-sample properties.

asymptotically normally distributed provided that the conditional mean and variance are correctly specified (see White, 1982; Bollerslev and Wooldridge, 1992).

6.2. Data and summary statistics

The analysis requires three groups of data. First, data on the eligible securities traded abroad to construct the diversification portfolios. Second, returns data on the IFC Global (IFCG) indices, the world market index, changes in real bilateral exchange rates, and the changes in MJ and EM real currency indices. Third, the instrumental variables including global and local variables.

6.2.1. Eligible set to construct diversification portfolios

To replicate the ineligible emerging market returns (R_I), we specify the set of eligible securities ($\underline{R}_e$) available to international investors. Because our analysis is conducted from the perspective of global investors, we include Morgan Stanley Capital International (MSCI) World index, 35 global industries, 17 US and seven UK-traded emerging market closed-end funds (CFs), 95 American Depository Receipts (ADRs) programs, and 16 non-US foreign listings that include direct placements and Global Depository Receipts (GDRs).[17] All US country funds trade on the New York Stock Exchange (NYSE) and all UK country funds trade on the London Stock Exchange (LSE). Data on CFs that trade on other exchanges are not available in Datastream. The monthly returns (adjusted for dividends) for US funds are obtained from the Center for Research in Security Prices (CRSP) database. The end-of-month closing prices are from Datastream for UK country funds. (By contrast to US funds, UK funds retain capital gains for reinvestment.) In addition, return data on ADRs are collected from CRSP, while return data on GDRs are compiled from Datastream.[18] A complete list of the set of eligible securities is posted on the Journal of Financial Economics site, http://jfe.rochester.eduunder "Unpublished Erratum and Appendices".

6.2.2. Returns data

Data on monthly returns on IFCG indices are obtained from the Standard and Poors (S&P)/IFC database. The MSCI value-weighted world index is from Morgan Stanley Capital International. Among the set of all emerging markets, we select eight major emerging markets: Argentina, Brazil, Chile, India, Korea, Malaysia, Mexico, and Thailand. These markets have also been studied by other authors and hence facilitate comparison with previous results. The IFCG indices are market value weighted and expressed in US dollar terms. We compute total returns. The sample period is from January 1976 to December 2003, except for Malaysia, which begins in January 1985. For the conditionally risk-free asset, we use the return on the one-month Eurodollar deposit. We compute the monthly excess returns by subtracting the Eurodollar rate from the

[17]Data on the end of month total return on the 35 global industries are collected from Datastream, which uses the financial times stock exchange (FTSE) industry classification. For a detailed description, see "FTSE Global Classification System" available at http://www.ftse.com.

[18]Following Karolyi (2003a,b), listing information was obtained from the Bank of New York and the Citibank and was supplemented and cross-checked with data obtained from the NYSE, Nasdaq, Amex, and Over-the-counter Bulletin Board (OTCBB). We thank Sergei Sarkissian for kindly providing the list of overseas listings as of 1998. These data were updated using world stock exchanges and Datastream.

monthly return on each security. Real bilateral exchange rates with respect to the dollar are computed on a price-adjusted basis using consumer price indices available from the International Finance Statistics (IFS) database. Data on the real exchange rate indices that include the major index and the EM index are from the Federal Reserve Board. Some summary statistics for the emerging market returns and changes in bilateral real exchange rates (ΔRXR) are presented respectively in Panels A and B of Table 1. Panel A shows that the IFC global indices exhibit high returns, high volatility, and substantial deviation from normality as previously shown (see, for example, Bekaert and Harvey 1995,1997).

Table 1
Summary statistics for assets returns

In Panel A, emerging market (EM) country equity indices are IFC Global and the world equity index is the Morgan Stanley Capital International (MSCI) value-weighted total return. Returns are monthly percentage, denominated in US dollars and in excess of the one-month Euro-dollar deposit rate. The period is from January 1976 to December 2003 for all countries except for Malaysia, which starts in January 1985. Statistics for change in real exchange rates are presented in Panel B. The period is from January 1976 to December 2003 for all countries except for Brazil, where it starts later in January 1980 and for Malaysia in January 1985. The test for the kurtosis coefficient has been normalized to zero, B-J is the Bera-Jarque test for normality based on excess skewness and kurtosis, and Q is the Ljung-Box test for autocorrelation of order 12 for the returns and for the returns squared. EN-AN and EN-AP are the Engle–Ng test statistics for negative and positive asymmetry, respectively. * and ** indicate significance at the 5% and 1%, respectively. Statistics for global instruments are in Panel D. The global instruments include a constant, the world dividend yield in excess of the one-month Euro-dollar interest rate (XWDY), the change in US term premium (ΔUSTP), and the US default premium (USDP). All variables are in percent per month, lagged one month. In Panel E, the local instruments include a constant, the lagged emerging market excess returns (LagRet), the change in local inflation rate (ΔLCinf). All variables are in percent per month, lagged one month.

Panel A. Distributional statistics of excess returns on emerging equity indices, world market index, and of changes in real currency indices

	Mean	Standard deviation	Skewness	Kurtosis	B-J	$Q(z)_{12}$	$Q(z^2)_{12}$	EN-AN	EN-AP
Argentina	0.746	21.603	0.080	5.46**	409.77**	10.428	55.74**	0.954	5.17**
Brazil	0.154	15.642	−0.466	2.87**	124.83**	9.552	49.92**	−1.006	0.555
Chile	1.167	9.643	0.28**	1.98**	57.73**	51.06**	49.48**	1.108	1.510
India	0.411	7.896	0.142	0.81**	9.75**	15.203	56.05**	−0.411	3.27**
Korea	0.277	10.670	0.37**	2.73**	109.36**	9.427	145.64**	−8.54**	−0.360
Malaysia	−0.121	9.729	−0.209	3.59**	120.29**	34.37**	126.38**	−4.98**	−1.779
Mexico	0.481	12.769	−2.052	10.41**	1728.70**	32.43**	36.70**	−5.49**	0.217
Thailand	0.264	10.352	−0.443	2.90**	125.55**	45.77**	189.37**	−1.376	2.50**
MSCI World index	0.344	4.187	−0.673	1.68**	63.36**	12.435	8.350	−1.566	−1.70*
Major currency index	0.026	1.743	0.20*	0.230	2.870	50.20**	9.652	0.465	0.497
EM currency index	−0.091	1.139	−1.283	5.04**	440.96**	34.44**	59.13**	−6.81**	−0.299

Panel B. Distributional statistics of changes in real exchange rates (ARXR)

	Mean	Standard deviation	Skewness	Kurtosis	B-J	$Q(z)_{12}$	$Q(z^2)_{12}$	EN-AN	EN-AP
Argentina	−0.066	13.841	−3.00	34.89**	17320.42**	38.29**	87.21**	−3.76**	2.31**
Brazil	−0.148	5.551	−2.39	25.35**	7864.39**	10.85	5.44	−0.46	0.60
Chile	−0.113	3.856	−7.13	94.98**	127560.57**	18.89	1.95	0.06	0.21

Table 1 (*continued*)

Panel B. Distributional statistics of changes in real exchange rates (ARXR)

	Mean	Standard deviation	Skewness	Kurtosis	B-J	$Q(z)_{12}$	$Q(z^2)_{12}$	EN-AN	EN-AP
India	−0.223	2.211	−2.86	20.59**	6310.43**	9.13	0.55	0.31	0.52
Korea	−0.048	3.109	−4.63	54.87**	42811.71**	27.80**	62.94**	−10.25*	0.36
Malaysia	−0.196	2.314	1.69**	38.35**	20487.85**	12.31	109.53**	−16.66*	−0.57
Mexico	−0.423	9.358	−9.35	113.69**	183612.93**	20.31	3.80	0.06	5.28**
Thailand	−0.149	2.874	−0.62	33.75**	15757.73**	25.07**	123.42**	−6.65**	1.36

Panel C. Pairwise correlations for assets returns

	Argentina	Brazil	Chile	India	Korea	Malaysia	Mexico	Thailand	Average
Country index and world	0.090	0.256	0.199	0.111	0.352	0.413	0.344	0.355	0.265
Country index and diversification portfolio	0.367	0.651	0.524	0.613	0.783	0.734	0.793	0.830	0.662
Diversification portfolio and world	0.343	0.521	0.500	0.335	0.477	0.586	0.457	0.480	0.462

Panel D. Global information variables

	Mean	Standard deviation	Pairwise correlations		
XWDY	−0.365	0.256	1.000	0.098	−0.445
ΔUSTP	0.002	0.456		1.000	0.119
USDP	1.097	0.441			1.000

Panel E. Local information variables

Country	ΔLCinf		
	Mean	Standard deviation	Correlations with LagRet
Argentina	−0.026	12.492	−0.131
Bazil	−0.022	5.479	−0.104
Chile	−0.025	2.027	−0.014
India	0.002	0.927	−0.077
Korea	−0.001	0.762	0.019
Malaysia	0.003	0.539	0.000
Mexico	0.000	5.676	0.023
Thailand	−0.002	0.763	0.000

The Bera-Jarque test of normality rejects the hypothesis of normality in all the countries at the 95% confidence level. Furthermore, the Ljung-box test statistic, $Q_{12}(z)$, for 12th-order serial correlations in the squares strongly suggests the presence of time-varying volatility. Similar to the market return series, the exchange rate series display a high level of kurtosis and a significant departure from normality as depicted in Panel B of Table 1. To explore the time-varying volatility in the data series, we conduct the diagnostic test statistics proposed by Engle and Ng (1993) also reported in Panels A and B for the return and ΔRXR series. The Engle–Ng test statistic indicates the presence of negative asymmetry in

three emerging markets and four real exchange rate series, while the returns of three EMs and two ΔRXR series suggest positive asymmetry.

6.2.3. Instrumental variables

We select global and local instrumental variables, to model the dynamics of the prices of risk. (See Ferson and Harvey, 1993; Bekaert and Harvey, 1995, 1997; Dumas and Solnik, 1995; De Santis and Gerard, 1998; Carrieri, Errunza, and Majerbi, 2006a,b.) The world information set includes the world dividend yield in excess of the risk-free rate; the change in the US term premium, measured by the yield difference between the ten-year T-bond and the three-month T-bill; and the US default premium measured by the yield difference between Moody's Baa- and Aaa-rated bonds. The local information variables include the local equity return in excess of the risk-free rate and the change in local inflation rates. (We exclude the local dividend yield as data are not available over the whole sample period.) All the information variables are lagged. Because these instrumental variables have been widely used in other studies, we omit a detailed description of their properties. Panels D and E of Table 1 show some basic statistics as well as the pairwise correlations among the instruments.

6.3. The diversification portfolios

To obtain the diversification portfolio for a given EM, we follow CEH and proceed in two steps. In the first step, we regress the return of the emerging market, $R_{I,t}$, on the returns of 35 global industries along with MSCI World index. Using a stepwise regression procedure with a forward and backward threshold criteria, we obtain the global portfolio (R_G). In the second step, we include US and globally traded CFs and depository receipts and allow the weights assigned to the previous securities to vary upon the availability of new country funds and overseas listings as in CEH.[19] The inclusion of the subsequent CFs is motivated by the recent empirical findings by Patro (2005), who shows that listing of new country funds results in a statistically and economically significant decrease in the country fund premiums because of the ability of new country funds to span old country funds. Hence, listing of new country funds could further integrate emerging markets with the world market. (See Appendix B for detailed description of the methodology.)

Panel C of Table 1 reports the pairwise correlations for assets returns. Our results suggest that the growth of the country funds and international cross-listings has enhanced the ability of global investors to span ineligible emerging markets confirming the earlier results of Errunza, Hogan, and Hung (1999). The correlation between the return on a diversification portfolio constructed from globally traded assets and the emerging market index return is on average 0.67, and the average correlation coefficient between the EM return and the world market index is 0.27.[20] The inclusion of UK country funds and GDRs

[19]Some of the country funds such as the Argentina Fund, the Emerging Mexico Fund, and the Korea Investment Fund are open-ended or liquidated during our sample period. However, to avoid the survivorship bias we include all CFs.

[20]Our results on the diversification portfolio composition should be interpreted with caution because many of the CFs listed outside the US and the UK, as well as the international cross-country listings in Luxembourg, are not included for lack of data. Their inclusion might further enhance the spanning of the foreign index by globally traded assets as far as the omitted funds or other listings are not subsumed by the included CFs, ADRs, or GDRs. This might be the case in particular for India, which had 42 listings in Luxembourg in 1998 as illustrated in

Table 2
Composition of diversification portfolios for the emerging markets

Columns 1 and 2 report the composition of portfolio R_G obtained by stepwise regression procedure over the world market index return (R_m) and the 35 global industry portolios returns. Columns 3–5 report the composition of the diversification portfolio (DP) in addition to R_G obtained by stepwise regression over R_G, all Closed-end Funds (CFs), and overseas listings for which data are available from the Center for Research Securtity Prices and Datastream. The numbers in each column correspond to the identification in Table 1, Panels A–C of Appendix B posted on the Journal of Financial Economics site, http://jfe.rochester.edu under "Unpublished Erratum and Appendices". ADRs = American Depository Receipts; GDRs = Global Depository Receipts.

Country	Rm[a] (1)	Global industry portfolios (2)	CFs (3)	ADRs (4)	GDRs (5)
Argentina	No	I11, I19, I22	1	A2	n/a
Brazil	Yes	I3, I6, I11, I20, I22, I23, I26, I35	1, 3	No	n/a
Chile	Yes	I7, I10, I11, I13, I22	No	A1, A8	n/a
India	Yes	I3, I4, I7, I14, I18, I28, I30, I32	1, 2	n/a[b]	G4
Korea	Yes	I6, I8, I9, I12, I13, I16, I19, I21, I25, I26, I27, I32, I34, I35	1, 2, 6	No	No
Malaysia	No	I1, I4, I7, I17, I24, I26, I34	1	n/a	G3
Mexico	No	I1, I2, I11, I13, I19, I22, I27, I32	1	A1, A2, A5	n/a
Thailand	Yes	I6, I7, I10, I11, I16, I18, I19, I21, I22, I24, I25, I26, I31, I32, I35	1, 2, 3	n/a	G1

[a]Yes (no) means that the asset is (not) included by the stepwise procedure.
[b]n/a means that there are no such securities for a given country.

has significantly increased the correlation between the diversification portfolios and the Asian index returns compared with what was previously reported in CEH.

Table 2 reports the resulting composition of DP for each EM from the stepwise regressions. With the exception of Chile, the portfolio weight associated with the first country fund is statistically significant. However, in five cases, we observe that the subsequent CFs enhance spanning of the EM index. For instance, in the case of India, both of the portfolio weights associated with the Indian Growth fund, which is the first CF listed in the US on August 1988, and the India Fund, which was listed in the US on February 1994, are statistically significant. In the case of Malaysia, some of the Malaysian companies have been traded in the UK throughout our sample period. The portfolio weights associated with the Malaysian fund listed in the US in June 1987 and the Kula Lumpur Kepong Berhad direct listing in the UK since October 1973 are statistically significant. For Chile and Mexico, which witnessed a noticeable increase of the ADR programs during the 1990s, multiple ADRs are included in the DP. Except for Chile, only up to the five first ADRs are included in the DP portfolio composition. This result is in line with the recent findings of Sarkissian and Schill (2004) that first listings are associated with the largest decrease in post-listing returns, while subsequent listings lead to additional but insignificant declines.

7. Results

Table 3 reports country-by-country estimation results of system Eq. (26). Panel A of Table 3 contains point estimates and robust T-statistics of the parameters for the mean

(*footnote continued*)
Sarkissian and Schill (2004), whereas, for the Latin American emerging markets, most of the CFs trade in the US and most of the listings are made in the US.

Table 3
Hypothesis testing of the model

The estimated model is

$r_{I,t} = \delta_{W,t-1} cov(r_{It}, r_{Wt}) + \lambda_{It-1} var(r_{It}|r_{DPt}) + \delta_{mj,t-1} cov(r_{DP,t}, e^r_{mj,t}) + \delta_{em,t-1} cov(r_{DP,t}, e^r_{em,t}) + \lambda_{et-1} cov(r_{HP,t}, e^r_{I,t}) + \varepsilon_{It},$

$r_{DP,t} = \delta_{W,t-1} cov(r_{DP,t}, r_{Wt}) + \delta_{mj,t-1} cov(r_{DP,t}, e^r_{mj,t}) + \delta_{em,t-1} cov(r_{DP,t}, e^r_{em,t}) + \varepsilon_{DP,t},$

$r_{W,t} = \delta_{W,t-1} var(r_{W,t}) + \delta_{mj,t-1} cov(r_{W,t}, e^r_{mj,t}) + \delta_{em,t-1} cov(r_{W,t}, e^r_{em,t}) + \varepsilon_{W,t},$

$e^r_{j,t} = \delta_{W,t-1} cov(e^r_{j,t}, r_{Wt}) + \delta_{mj,t-1} cov(e^r_{j,t}, e^r_{mj,t}) + \delta_{em,t-1} cov(e^r_{j,t}, e^r_{em,t}) + \varepsilon_{j,t},$ and $j = mj,\ em,\ I,$

where $r_{I,t}$ is the country index excess return, $r_{DP,t}$ is the diversification portfolio excess return, $r_{HP,t}$ is the hedge portfolio excess return, $r_{W,t}$ is the world index excess return, δ_W is the price of world covariance risk, λ_I is the price of conditional market risk, δ_{mj}, δ_{em} are, respectively, the prices of major and emerging market (EM) real currency risks, λ_e is the price of segflation risk and $\varepsilon_t|\vartheta_{t-1} \sim N(0, H_t)$. Price of risk specifications are given by

$\delta_{W,t-1} = \exp(\kappa'_W \mathbf{Z}_{G,t-1}),$

$\delta_{j,t-1} = \kappa'_j \mathbf{Z}_{G,t-1},$ and $j = mj,\ em,$

where $\mathbf{Z}_G$ is a set of global information variables, which includes a constant (Const), the US default spread (USDP), the US term structure spread (ΔUSTP), and the world dividend yield in excess of the risk free rate (XWDY),

$\lambda_{I,t-1} = \exp(\kappa'_I \mathbf{Z}_{I,t-1})$ and

$\lambda_{e,t-1} = k'_e \mathbf{Z}_{I,t-1},$

where $\mathbf{Z}_I$ is a set of local information variables, which includes a constant, the change in the local inflation rate (ΔLCinf), and the local market index excess return (LagRet).

H_t is the time-varying conditional covariance parameterized as

$H_t = H^*_0(ii' - \boldsymbol{aa}' - \boldsymbol{bb}') + \boldsymbol{aa}'^* \Sigma_{t-1} + \boldsymbol{bb}'^* H_{t-1},$

where * denotes the Hadamard product, $\boldsymbol{a}$ and $\boldsymbol{b}$ are (6×1) vector of constants, i is (6×1) unit vector, and Σ_{t-1} is the matrix of cross error terms, $\varepsilon_{t-1}\varepsilon'_{t-1}$. Country equity indices are from Standard & Poor's /IFC and the world equity index is from Morgan Stanley Capital International. The risk-free rate is the one-month Euro-dollar rate from Datastream. All returns are denominated in US dollars. The model is estimated by Quasi-Maximum Likelihood (QML). For each country, Panel A reports point estimates, QML standard errors, and p-values of the parameters k_W,k_{mj}, k_{em} used to model the dynamics of the global prices of risk, and of the parameters k_I, k_e used to model the dynamics of the local prices of risk. We do not include XWDY when estimating the price of world market risk of India as the estimation becomes instable. Panel B reports under each country p-values for robust Wald tests on the set of coefficients used to model the dynamics of the prices of risk. The period is from January 1976 to December 2003 for all countries except for Brazil, where it starts in January 1980 and for Malaysia in January 1985. In Panel C, B-J is the Bera-Jarque test for normality based on excess skewness and kurtosis, Q is the Ljung-Box test for autocorrelation of order 12 for the residuals and the residuals squared, and EN-AN and EN-AP are, respectively, the Engle–Ng negative size bias and positive size bias test on the squared residuals. RMSE is the root mean square error. R^2 is pseudo R-squared. * and ** indicate significance at the 5% and 1%, respectively.

Panel A. Parameter estimates
Global prices of risk

	k_W			k_{mj}			k_{em}		
	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value
Argentina									
Const	−3.498	1.624	0.031	−0.068	0.054	0.205	0.179	0.113	0.113
XWDY	0.105	1.017	0.918	1.084	0.031	0.000	0.390	0.161	0.015
ΔUSTP	−0.674	0.380	0.076	0.087	0.039	0.027	0.368	0.059	0.000
USDP	0.411	1.653	0.804	0.268	0.029	0.000	−0.173	0.065	0.008
Brazil									
Const	−4.334	1.514	0.004	−0.031	0.069	0.649	0.225	0.083	0.007
XWDY	1.457	0.874	0.096	0.542	0.144	0.000	−0.202	0.322	0.531
ΔUSTP	−0.833	1.260	0.509	−0.122	0.065	0.062	0.243	0.077	0.002
USDP	0.966	0.809	0.233	0.210	0.066	0.002	−0.300	0.038	0.000
Chile									
Const	−4.390	1.680	0.009	−0.005	0.018	0.771	0.264	0.097	0.006
XWDY	1.062	0.818	0.194	0.584	0.147	0.000	0.016	0.156	0.917
ΔUSTP	−0.644	0.769	0.402	−0.141	0.079	0.073	0.224	0.087	0.010
USDP	0.924	0.797	0.246	0.202	0.045	0.000	−0.287	0.079	0.000
India									
Const	−3.901	0.661	0.000	−0.001	0.071	0.987	0.236	0.087	0.007
XWDY				0.608	0.141	0.000	0.057	0.246	0.817
ΔUSTP	−0.355	0.251	0.158	−0.135	0.073	0.066	0.215	0.088	0.015
USDP	0.846	0.267	0.002	0.218	0.068	0.001	−0.221	0.071	0.002
Korea									
Const	−4.372	1.211	0.000	−0.011	0.074	0.880	0.282	0.065	0.000
XWDY	1.158	0.753	0.124	0.641	0.142	0.000	−0.092	0.227	0.685
ΔUSTP	−0.544	0.665	0.413	−0.124	0.076	0.101	0.181	0.085	0.033
USDP	1.096	0.516	0.034	0.219	0.072	0.002	−0.320	0.054	0.000
Malaysia									
Const	−5.830	2.605	0.025	−0.237	0.114	0.038	0.218	0.161	0.174
XWDY	−1.796	2.915	0.538	0.323	0.215	0.134	−0.087	0.285	0.761
ΔUSTP	−3.044	1.335	0.023	−0.418	0.129	0.001	0.262	0.261	0.316
USDP	1.501	1.216	0.217	0.405	0.113	0.000	−0.309	0.139	0.026

Table 3 (*continued*)

Panel A. Parameter estimates

Global prices of risk

	k_W			k_{mj}			k_{em}		
	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value
Mexico									
Const	17.802	2.400	0.000	0.025	0.074	0.736	0.013	0.123	0.917
XWDY	84.371	37.361	0.024	0.674	0.135	0.000	−0.493	0.236	0.037
ΔUSTP	−4.802	2.196	0.029	−0.122	0.070	0.082	0.183	0.076	0.017
USDP	−25.760	3.806	0.000	0.225	0.071	0.002	−0.263	0.057	0.000
Thailand									
Const	−5.269	2.171	0.015	0.042	0.076	0.583	0.190	0.101	0.060
XWDY	1.656	0.987	0.094	0.581	0.143	0.000	−0.031	0.256	0.903
ΔUSTP	−0.785	0.750	0.295	−0.141	0.073	0.052	0.289	0.076	0.000
USDP	1.538	0.750	0.040	0.164	0.073	0.024	−0.208	0.093	0.025

Local prices of risk

	k_I			k_e		
	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value
Argentina						
Const	−21.3298	6.1055	0.0005	0.0010	0.0063	0.8796
LagRet	0.0023	0.0250	0.9270	0.0002	0.0001	0.0596
ΔLCinf	0.2282	0.0413	0.0000	−0.0033	0.0001	0.0000
Brazil						
Const	−9.8667	2.6013	0.0001	−0.0126	0.0746	0.8658
LagRet	0.1709	0.0073	0.0000	−0.0064	0.0009	0.0000
ΔLCinf	0.0998	0.0330	0.0025	−0.1568	0.0328	0.0000
Chile						
Const	−17.3862	562.7201	0.9754	0.0085	0.0394	0.8284
LagRet	−0.0557	3.3924	0.9869	0.0060	0.0028	0.0323
ΔLCinf	0.5792	1.1905	0.6266	−0.0222	0.0103	0.0313

India						
Const	−11.4155	6.0371	0.0586	0.0377	0.1267	0.7662
LagRet	0.3555	0.0593	0.0000	0.0055	0.0093	0.5559
ΔLCinf	2.1257	1.7841	0.2335	−0.2545	0.1114	0.0224
Korea						
Const	−39.1314	0.1202	0.0000	0.0340	0.0785	0.6653
LagRet	−1.0168	0.0008	0.0000	−0.0269	0.0006	0.0000
ΔLCinf	−4.6364	1.8647	0.0129	−0.1262	0.1033	0.2217
Malaysia						
Const	−20.9923	64.4428	0.7446	−0.0247	0.0236	0.2944
LagRet	−0.3574	0.0297	0.0000	0.0001	0.0003	0.6900
ΔLCinf	−7.1327	7.3337	0.3308	0.0388	0.0398	0.3302
Mexico						
Const	−5.3892	2.0680	0.0092	−0.0237	0.0094	0.0115
LagRet	0.0344	0.0376	0.3609	0.0002	0.0004	0.6276
ΔLCinf	0.0589	0.0030	0.0000	0.0008	0.0003	0.0026
Thailand						
Const	−21.5018	6.1639	0.0005	−0.0532	0.1135	0.6394
LagRet	0.5126	0.0134	0.0000	−0.0019	0.0028	0.4871
ΔLCinf	5.2618	3.0883	0.0884	−0.2160	0.1231	0.0793

Panel B. Specification tests

Null hypothesis	Argentina	Brazil	Chile	India	Korea	Malaysia	Mexico	Thailand
For time-varying market risk								
$k_{W,j} = 0$, for $j > 1$	0.0468	0.0155	0.1286	0.0082	0.0165	0.0530	0.1512	0.0440
For time-varying conditional market risk								
$k_{i,j} = 0$, for $j > 1$	0.0006	0.0269	0.7151	0.2843	0.0000	0.5922	0.1124	0.0005
For significant major real currency risk								
$k_{mj,j} = 0$, for $j > 0$	0.0000	0.0105	0.0050	0.0009	0.0014	0.0007	0.0000	0.0039
For time-varying major real currency risk								
$k_{mj,j} = 0$, for $j > 1$	0.0000	0.0105	0.0050	0.0011	0.0014	0.0008	0.0001	0.0044
For significant EM real currency risk								
$k_{em,j} = 0$, for $j > 0$	0.0000	0.0000	0.0082	0.0028	0.0002	0.1356	0.0006	0.0117
For time-varying EM real currency risk								
$k_{em,j} = 0$, for $j > 1$	0.0000	0.0000	0.0044	0.0010	0.0001	0.1931	0.0017	0.0048

Table 3 (*continued*)

Panel B. Specification tests

Null hypothesis	Argentina	Brazil	Chile	India	Korea	Malaysia	Mexico	Thailand
For significant global real currency risk								
$k_{mj,j} = 0$ and $k_{em,j} = 0$ for $j > 0$	0.0000	0.0000	0.0005	0.0055	0.0000	0.0015	0.0000	0.0003
For significant segflation risk								
$k_{e,j} = 0$, for $j > 0$	0.0000	0.0001	0.2519	0.1831	0.0001	0.3239	0.0063	0.7076
For time-varying segflation risk								
$k_{e,j} = 0$, for $j > 1$	0.0000	0.0000	0.1517	0.0948	0.0000	0.2660	0.0975	0.5438
For time-varying local risk								
$k_{e,j} = 0$ and $k_{I,j} = 0$ for $j > 1$	0.0000	0.0000	0.4146	0.0682	0.0000	0.5139	0.1813	0.0014
Likelihood function	−5758.7	−4685.9	−4925.7	−4748.5	−4875.1	−3215.5	−5353.8	−4837.7

Panel C. Diagnostics for the residuals

	Argentina	Brazil	Chile	India	Korea	Malaysia	Mexico	Thailand
B-J	88.05**	16.78**	5.01	24.26**	52.06**	10.17**	441.72**	100.44**
$Q(z)_{12}$	6.79	6.96	22.03*	6.22	11.73	10.40	20.22	32.11**
$Q(z^2)_{12}$	8.34	12.41	7.16	21.67*	3.68	40.30**	9.17	5.69
EN-AN	1.44	−0.37	1.24	−0.42	−1.57	−1.31	−3.39**	1.52
EN-AP	2.00*	−0.48	1.09	1.81*	−0.52	−1.36	−1.25	2.20*
RMSE	10.24	15.89	9.38	7.80	10.41	9.63	12.84	10.24
R^2	10.54%	6.49%	4.64%	1.98%	3.58%	1.93%	−1.16%	2.10%

equations. We do not report the parameter estimates (a and b) for the conditional covariance processes, but these are significant in all cases, of the usual size, and satisfy the stationarity condition, i.e., $a_i a_j + b_i b_j < 1$, $\forall i, j$. This value is also close to one in most instances, suggesting that the variance and covariance processes in H_t are highly persistent. Panel A indicates that the estimates on several k coefficients used to parameterize the prices of risk are statistically significant. However, to test the various hypotheses namely, the significance and time variation in the prices of world market risk, major and EM real currency risks, conditional market risk and segflation risk requires the use of joint tests. The results for those tests are reported in Panel B of Table 3. Specifically, Panel B contains, for each country, p-values for the robust Wald test statistics for the different hypothesis.[21]

We find that the price of world market risk is significantly time-varying in all countries except for Mexico and Chile, where it is only marginally significant at around the 10% level. Though it is surprising to find that Mexico, the largest emerging market in terms of capitalization, shows little evidence of time-varying price of world market risk, this result is consistent with previous work (see, for example, CEH). Bekaert and Harvey (1995) also report Mexico as segmented. In addition, the major currency risk is significantly priced and is time-varying in all instances, and the EM currency risk is priced and is time-varying in all cases except for Malaysia. (The nonsignificance of the EM currency risk for Malaysia might stem from the lack of power to detect some relevant priced factors as a result of small sample size.) Further, the null hypothesis that the prices of global currency risk factors are jointly equal to zero is rejected at the 1% level in all cases. Hence, there is strong evidence that the world market and currency risks are priced for our emerging markets sample.

We also find that the price of conditional market risk is time-varying in four cases and marginally time-varying for Mexico. The hypothesis that the price of segflation risk is not significant is rejected in four cases. Further, the price of segflation risk is time-varying in five cases. Finally, the joint test on the time-variability of local (i.e., conditional market and segflation) risk factors is rejected in all cases except for Chile, Malaysia, and Mexico. Hence there is substantial evidence that local risk factors are important in explaining market returns for a majority of our sample EMs.

The mean price of world market risk is significantly different from zero in all cases, and it amounts to 3.0 on average across countries. Furthermore, the sample means for the prices of major and EM real currency risks are negative and are, respectively, equal to -1.39 and -5.85 on average across countries. With the exception of Argentina, India, and Malaysia, the mean price of major real currency risk is not significant, while the mean price of EM real currency risk is significant and negative in all instances. The mean price of conditional market risk is significantly different from zero in three out of eight cases. The price of segflation risk fluctuates through time and across countries both in terms of sign and size. In addition, its mean price is significantly different from zero in five out of eight cases. Percentage of the time that the price of segflation risk is negative ranges from 40% for Chile to over 99% in the case of Mexico. The negative episodes mean that this risk factor contributes to the investors' attempt to hedge against PPP deviations.

[21]An important concern in the estimation procedure is the likely strong correlation between the different prices of risk factors because global (local) factors are projected on the same global (local) instruments. We thank Bruno Solnik for bringing this to our attention. We verified that the correlation between the different prices of risk factors and, in particular, among the local factors is small, ranging from -0.4 to 0.2, except for Mexico where it reaches 0.6.

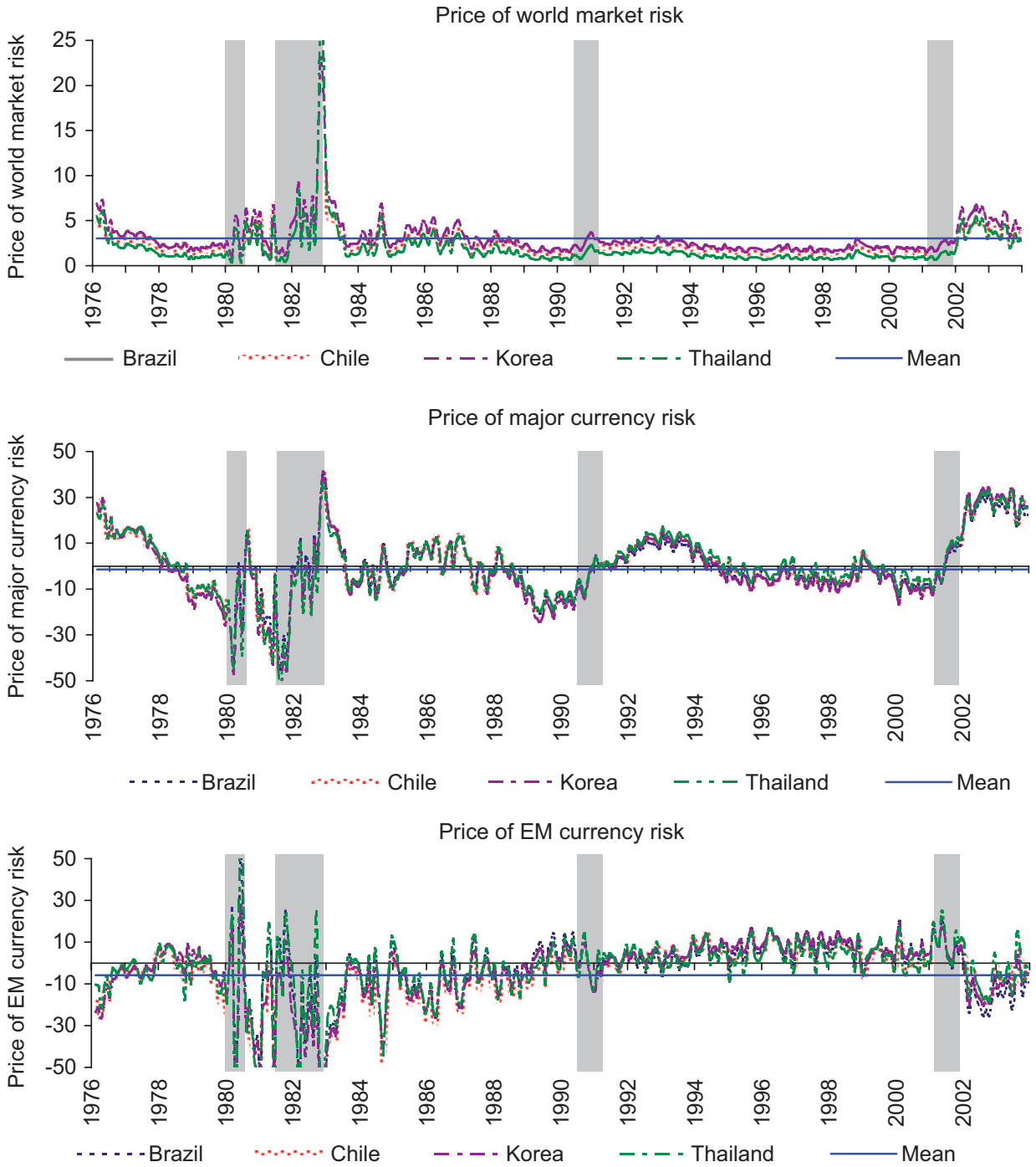

Fig. 1. Estimated prices of global risk. The figure plots the time series of estimated prices of World market risk, major currency risk, and emerging market (EM) currency risk from January 1976 to December 2003. Shaded area indicates periods of US recessions from National Bureau of Economic Research.

The model implies a common price of world market risk and global currency risks across all assets. However, because we perform a country-by-country estimation, we obtain as many price estimates as countries in the sample. To compare the point estimates of the prices of global risk factors, we plot in Fig. 1 the time series of the prices of global risk factors. The dynamics of the prices of world market risk and global currency risks exhibit

the same pattern from the different estimations.[22] Moreover, we observe that the price of world market risk increases during economic contractions, which are represented by the shaded areas in the figures, and peaks near business cycle troughs. (The period of contraction is measured from peak to trough as determined by the National Bureau of Economic Research, NBER.) Also, the price of major currency risk depicts a pattern consistent with the NBER predictions of business cycle. The price tends to increase from negative to positive values during economic recessions. However, the price of EM currency risk does not show a clear pattern.

To assess the economic importance of each premium, we decompose the total premium into four risk premiums: world market, conditional market, global currency (major and EM), and segflation risk premium. In many cases, the average value of the total premium is close to the average value of the world market premium whereas the average global currency premium is small, often negative, and not statistically or economically significant except for Argentina and Mexico. The average segflation premium is significant in five out of eight cases and ranges from −0.6 (with standard error of 0.07) for Mexico to 0.4 (with standard error of 0.33) for Argentina. The average conditional market premium is economically significant in three out of eight cases.[23]

Given the important variation in the risk premiums through time and across countries, the statistics on the mean values of the risk premiums could be misleading and are not sufficient. Hence, in Fig. 2, we plot the time series of the total premium along with the global premium (sum of the world market and the global currency premiums) and the segflation premium. For most of the countries, global risk premium represents a large proportion of the total premium. For instance, in Malaysia, the global premium determines most of the total premium over the entire sample period except during the period of the Asian crisis. In addition, the contribution of the global premium to the total premium has increased recently for most of the EMs of our sample. These results suggest that global factors play an important role in pricing emerging markets. As for the segflation risk premium, its contribution to the total premium varies considerably through time and across countries and fluctuates widely between positive and negative values. In some periods, it accounts for most of the total premium. This is particularly the case around financial and currency crises. Hence, this premium is statistically and also economically significant.

Panel C of Table 3 reports diagnostics tests on the estimated residuals. The results support our use of the De Santis and Gerard (1998) multivariate GARCH process. There is no more serial correlation in the squared standardized residuals, and the non-normality in the data is reduced although not eliminated. We also report the Engle–Ng tests for asymmetry. The Engle–Ng tests indicate that, with the exception of Mexico, there is no evidence of negative asymmetry in the residuals. Also, marginal evidence on the presence of positive asymmetry exists in three cases. Hence there is no consistent

[22]For sake of clarity, we include estimations from only four countries. Estimates obtained from Argentina and India exhibit similar patterns though the estimated prices of world market risk are consistently higher. Also we do not report estimates from Malaysia because the sample starts in January 1985. The only country estimation that results in different estimates for the global market and currency factors is Mexico.

[23]Detailed results on average premiums are available from authors upon request.

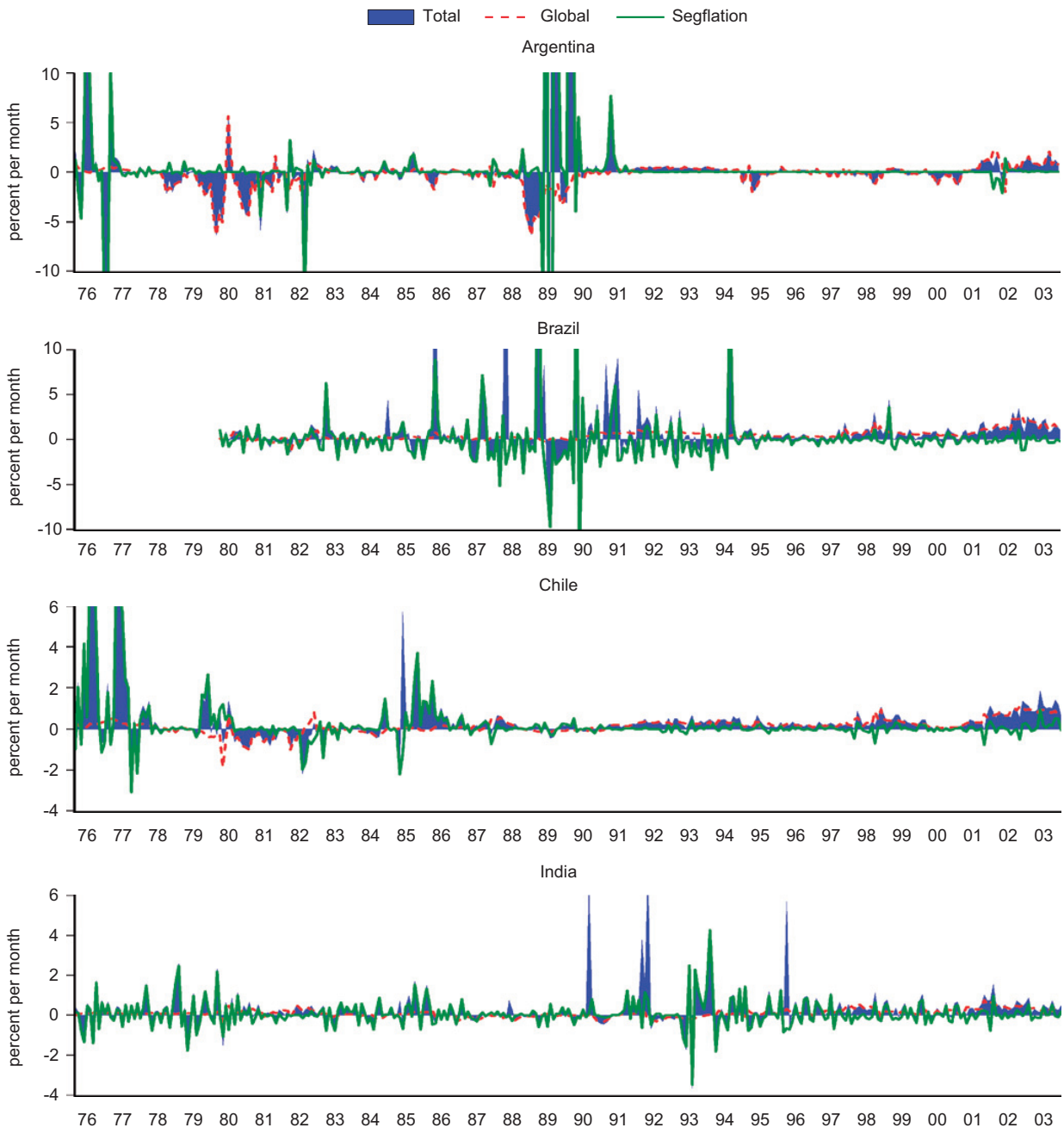

Fig. 2. Estimated risk premiums. For each emerging market (EM) index return, the area labeled "total" represent the sum of the estimated world market, conditional market, global currency (major and EM), and segflation premiums. The line labeled "global" represents the portion of the total premium associated with world market and global currency exposure. The line labeled "segflation" represents the portion of the total premium associated with segflation risk exposure.

evidence of asymmetric response of the conditional second moments to past innovations. We also report the pseudo R-squared and root mean squared error computed from our model.[24]

[24]For each asset, the pseudo R-squared is the ratio between the explained sum of squares and the total sum of squares. Because of the cross-equation restrictions, there is no guarantee that the pseudo R-squared is positive for all assets.

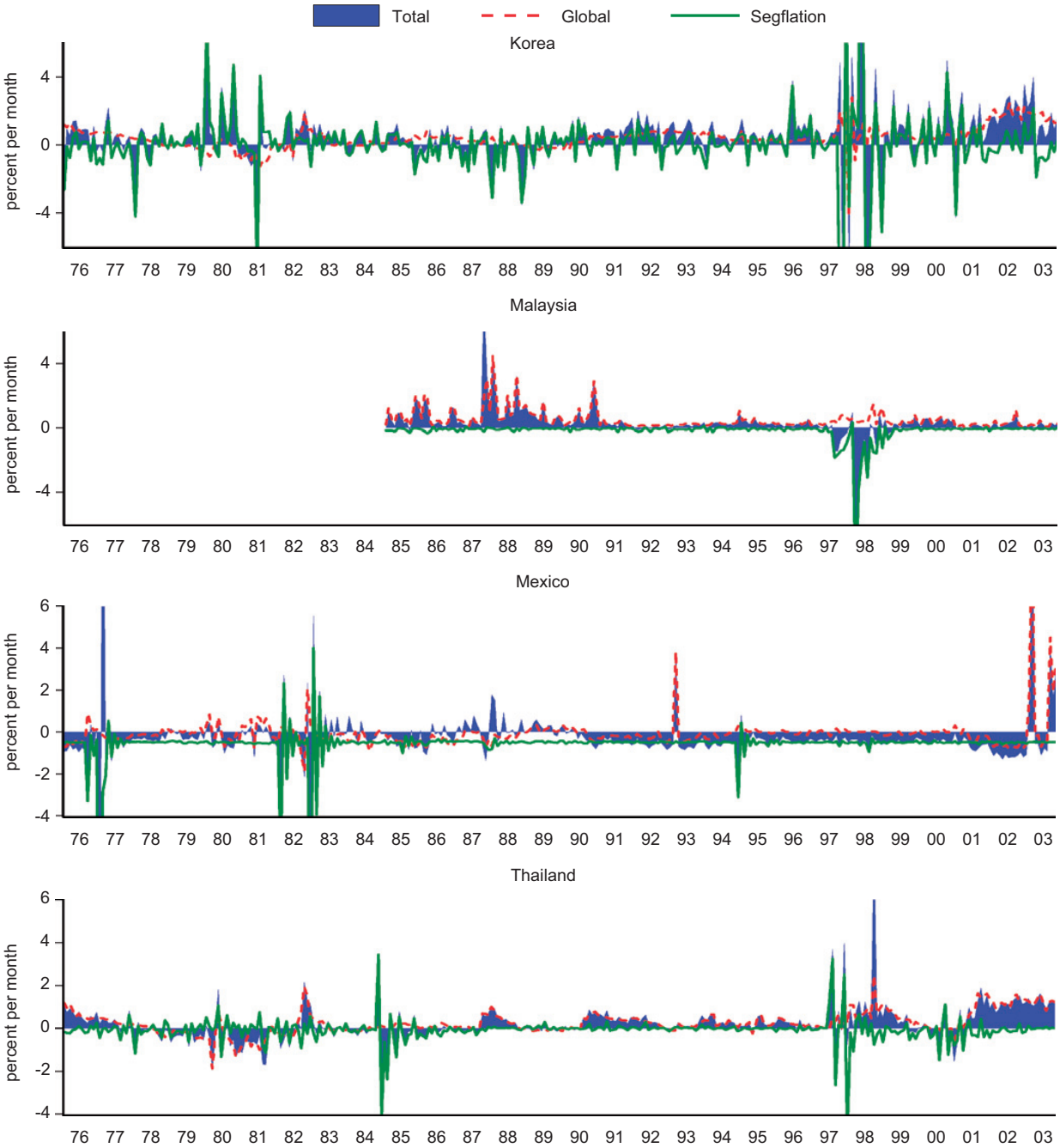

Fig. 2. (*Continued*)

8. Conclusions

In this paper, we derive an international asset pricing model in a mildly segmented market when PPP is violated. We postulate a two-country world and two sets of securities: eligible securities traded in the domestic market and ineligible securities traded in the foreign market. Domestic investors can invest only in domestic eligible stocks, while foreign investors can invest in their local ineligible stocks as well as domestic stocks. All investors can invest in the short-term bonds of each country. The eligible securities that can be freely held by all investors are priced as if the market were fully integrated. They command a world market and an inflation risk premium. The ineligible securities that can

be held only by foreign investors command two extra premiums: the conditional market risk premium and the segflation risk premium. Further, the inflation risk premium for the ineligible securities is a weighted sum of covariances between inflation rates and the diversification portfolio. This result is not surprising, as investors of the domestic market cannot hold foreign ineligible securities; Instead, they are supplied with the diversification portfolio by the foreign investors.

We also derive the IAPM under PPP deviations in a more general market structure, termed partial segmentation and characterized by eligible and ineligible securities that exist in each market. This market set-up results in an additional premium, the conditional cross-market premium, for the ineligible securities. This premium plays a role when the two market segments are both not fully investable.

In summary, our model provides new insights when markets are not fully integrated and PPP is violated, which seems to be the case for the majority of national markets and thus provides a theoretical framework for joint tests of important issues, such as pricing of foreign exchange risk and world market structure. We estimate the model using the multivariate GARCH-M methodology for eight emerging markets over the period 1976–2003. Our results suggest that, in addition to global factors, conditional market and segflation risks are priced. Thus, our results support theoretical predictions and provide new evidence that local factors still matter for the emerging markets.

Our paper suggests many potential avenues for further research. Because our model nests several existing IAPMs, it provides a framework to distinguish empirically between competing models. We can also investigate the dynamics of market integration while explicitly accounting for currency risk factors. Finally, a generalization of the model to an intertemporal framework would allow a better specification of the model because investment opportunities are stochastic. In terms of policy implications, the model can shed further light on the issues related to liberalization of emerging markets; for example, the impact on the cost of capital. This is important because the available evidence suggests a small reduction in the cost of capital on market liberalization. Further, after almost two decades of liberalizations, we find that the emerging markets are not fully integrated with the global market. These issues have important implications for financial management as well as policy decisions. Our model can be useful to study welfare implications of liberalization policies.

Appendix A. Proof of the separation theorem

The purpose of this appendix is to prove that domestic investors' optimal portfolios of risky assets can be represented as a linear combination of two mutual funds provided that all investors within the domestic country face the same commodity prices, implying that $\underline{\omega}_e^l = \underline{\omega}_e^{l'}\ \forall l,\ l' \in D$ (Assumption A4). The proof is similar to Merton (1973).

Let the first fund be the logarithmic portfolio. The proportion of the first fund's assets, δ_{1k}, invested in the kth asset is $\delta_{1k} = \sum_{j=1}^{N_e} v_{kj}(\mu_j - r)/\sum_{k=1}^{N_e}\sum_{j=1}^{N_e} v_{kj}(\mu_j - r)$, for $k = 1 \ldots N_e$, where v_{kj} are the elements of V_{ee}^{-1}. Let the second fund be the portfolio that constitutes the best hedge against purchasing power risk. The proportion of the second fund's assets, δ_{2k}, invested in the kth asset is $\delta_{2k} = \sum_{j=1}^{N_e} v_{kj}\sigma_{j,\pi}^{l}$, for $k = 1 \ldots N_e$, and $l \in D$. From assumption $A4$, $\sigma_{j,\pi}^{l} = \sigma_{j,\pi}^{l'}\ l, l' \in D$. Therefore, the composition of the second

fund is independent of investors preferences the same as is the composition of the first fund. Let λ_i^l be the fraction of the lth investor's wealth invested in the ith fund, $i = 1, 2$. To prove the theorem, we need to show that there exists an allocation $(\lambda_1^l, \lambda_2^l)$ that replicates the demand function Eq. (16), i.e.,

$$\lambda_1^l \delta_{1k} + \lambda_2^l \delta_{2k} = \frac{1}{A^l} \sum_{j=1}^{N_e} v_{kj}(\mu_j - r) + \left(W^l - \frac{1}{A^l} \right) \sum_{j=1}^{N_e} v_{kj} \sigma_{j,\pi}^l, \quad k = 1 \ldots N_e, \ l \in D. \tag{A.1}$$

It can easily be seen that the allocation $\lambda_1^l = \frac{1}{A^l} \sum_{k=1}^{N_e} \sum_{j=1}^{N_e} v_{kj}(\mu_j - r)$ and $\lambda_2^l = (W^l - \frac{1}{A^l})$ satisfy Eq. (A.1). This demonstrates the theorem.

The mutual funds result also applies to foreign investors. However, the two funds are constructed from all the risky securities in the economy because the foreign investors face no barriers.

Appendix B. Construction of the diversification portfolios

To construct the diversification portfolio for a given EM, we proceed in two steps. In the first step, we regress the return of the emerging market, $R_{I,t}$, on the returns of 35 global industries along with MSCI World index. Using a stepwise regression procedure with a forward and backward threshold criteria, we obtain the global portfolio (R_G).

In the second step, we include globally traded CFs and DRs in addition to those listed on US markets as well as subsequent country funds, ADRs, or GDRs allowing the weights assigned to the previous securities to vary upon the availability of new country, funds and overseas listings as in CEH. (CEH include only US traded CFs and ADRs. Specifically, in the second step, they consider the first five ADRs along with the first country fund.) We examine which of the multiple CFs and cross-listings are statistically significant to span the EM returns using the stepwise procedure. We construct an augmented diversification portfolio by running the following regression:

$$R_{I,t} = \varphi_{1,t} R_{G,t} + \underline{\varphi}_{2,t} \underline{R}_{CF,t} + \underline{\varphi}_{3,t} \underline{R}_{DR,t} + \varepsilon_t, \tag{B.1}$$

where

$$\varphi_{1,t} R_{G,t} = \alpha_0 R_{G,t} + \sum_{i=1}^{N_{CF,I}} \alpha_{1i} D_{CF_i,t} R_{G,t} + \sum_{j=1}^{N_{DR,I}} \alpha_{2j} D_{DR_j,t} R_{G,t}, \tag{B.2}$$

$$\underline{\varphi}_{2,t} \underline{R}_{CF,t} = \sum_{i=1}^{N_{CF,I}-1} \sum_{x=i+1}^{N_{CF,I}} \beta_{1ix} D_{CFix,t} R_{CFix,t} + \sum_{j=1}^{N_{DR,I}} \beta_{2j} D_{DR_j,t} R_{CF,t} \quad \text{and} \tag{B.3}$$

$$\underline{\varphi}_{3,t} \underline{R}_{DR,t} = \sum_{j=1}^{N_{DR,I}-1} \sum_{y=j+1}^{N_{DR,I}} \gamma_{yj} D_{DR_{jy},t} R_{DR_{jy},t}. \tag{B.4}$$

For each market I, we use as regressors the return of the previously estimated portfolio ($R_{G,t}$), the vector of returns on the CFs ($\underline{R}_{CF,t}$), and the vector of returns from DRs ($\underline{R}_{DR,t}$). The fitted value of this regression is what we call $R_{DP,t}$, the diversification portfolio. The set of eligible CFs and overseas listings varies for each of the countries in our dataset. We denote by $N_{CF,I}$ ($N_{DR,I}$) the number of country funds (DRs) in the Ith market. To preserve

degrees of freedom, we use stepwise regressions to select only those CFs and foreign listings that enhance home-made diversification in a statistically significant way.[25] For the period prior to the country fund or depository receipt inception, the returns are set to zero. We also add dummy variables, D_*, set to one at the introduction of the securities (country funds, ADRs, and GDRs) on market exchanges. (Because we include the CFs that has been delisted or suspended during our sample period, we allow the dummy variables to take value one at the inception of the CF and zero at the delisting, liquidation, or suspension of the CF.) The dummy variables allow for subsequent CFs and overseas listings to impact the weights assigned to the portfolio of global securities and the preceding funds and depository receipts. The dummy variable $D_{CF,t}$ ($D_{DR,t}$) proxy for the spanning of the old funds (DRs) using new funds (DRs).

Appendix C. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jfineco.2006.06.008.

Appendix B

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[25]We estimated alternative diversification portfolios by excluding the country funds that were not listed during the entire sample period, and including in the eligible set only the first five ADRs as in CEH, in addition to the country funds. These portfolios exhibit correlations with the country index similar to those obtained with our benchmark methodology. We also conducted the regression with only the world market index along with the CFs and overseas listings (excluding the global industry portfolios). The diversification portfolios are highly correlated with our benchmark portfolios.

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