THE JOURNAL OF FINANCE • VOL. LXI, NO. 2 • APRIL 2006

How Do Crises Spread? Evidence from Accessible and Inaccessible Stock Indices

BRIAN H. BOYER, TOMOMI KUMAGAI, and KATHY YUAN*

ABSTRACT

We provide empirical evidence that stock market crises are spread globally through asset holdings of international investors. By separating emerging market stocks into two categories, namely, those that are eligible for purchase by foreigners (accessible) and those that are not (inaccessible), we estimate and compare the degree to which accessible and inaccessible stock index returns co-move with crisis country index returns. Our results show greater co-movement during high volatility periods, especially for accessible stock index returns, suggesting that crises spread through the asset holdings of international investors rather than through changes in fundamentals.

THE PAST DECADE WAS MARKED BY SEVERAL stock market crises in developing economies; in particular, the Mexican peso collapse in 1994, the Asian crisis in 1997, and the Russian default in 1998. One striking feature common to these crises is how an initially country-specific event seemed to transmit rapidly to markets around the globe. These events have prompted a surge of empirical and theoretical interest in "contagion" and the determinants of a country's vulnerability to crises that originate elsewhere.[1]

In the empirical literature, Karolyi and Stulz (1996) and Connolly and Wang (2003) find that macroeconomic announcements and other public information do not affect co-movements of Japanese and American stock markets. King, Sentana, and Wadhani (1994) find that observable economic variables explain only a small fraction of international stock market co-movements. Forbes (2002) finds evidence that international trade linkages allow country-specific crises to spread to stock markets elsewhere in the world. However, these trade linkages

*Brian H. Boyer is at Brigham Young University, Tomomi Kumagai is at Wayne State University, and Kathy Yuan is at the Stephen M. Ross School of Business at the University of Michigan. Earlier versions of this paper circulated with the title "Are Investors Responsible for Stock Market Contagion?" The authors wish to thank Mark Aguiar, Christopher Couch, Campbell Harvey, Jerry Hausman, Guido Kuersteiner, Xiangming Li, Grant McQueen, Matt Pritsker, Ruy Ribeiro, Linda Tesar, Frank Warnock, and seminar participants at the University of Michigan, the University of Utah, the University of Wisconsin-Madison, Wayne State University, the UCLA Brainstorming Conference on International Capital Flows, and the American Finance Association Winter 2003 meetings in Washington, DC for helpful comments. We also thank Rob Stambaugh (the editor), an associate editor, and an anonymous referee for comments that substantially improved the original paper. Kumagai gratefully acknowledges the financial support from a University Research Grant from Wayne State University.

[1] We define contagion in this paper as a significant increase in cross-market linkages during periods of high volatility, similar to other work in this literature (e.g., Forbes and Rigobon (2002)).

only partially explain the reaction of stock markets to crises that originate in other countries. In addition, correlations among market returns computed by Longin and Solnik (2001), Connolly and Wang (1998), Ang and Bekaert (2002), and Ang and Chen (2002) are especially large during market downturns, suggesting that contagion may be "asymmetric," that is, stronger during market downturns.

Motivated by the lack of evidence that macroeconomic fundamentals serve as the determinants of contagion, researchers have sought alternative explanations. In particular, models have been developed in which limits to arbitrage allow crises to spread through the asset holdings of international investors. Kodres and Pritsker (2002) develop a theoretical model of financial contagion through cross-market portfolio rebalancing. One implication of their model is that market co-movements should be symmetric in both market upturns and downturns. Kyle and Xiong (2001), Calvo (1999), and Yuan (2005) predict that crises spread to stock markets by their wealth-constrained investors, and that correlations among markets are greater during market downturns. Kyle and Xiong (2001) argue that when investors suffer a large loss in investment in the crisis country, they may have to liquidate their positions in other countries and thus cause equity prices to depreciate in these other countries. Moreover, Calvo (1999) and Yuan (2005) find that wealth effects persist even when only a small fraction of investors are wealth constrained, as long as they are relatively more informed. These latter authors argue that uninformed rational investors are not able to distinguish between selling based on liquidity shocks and selling based on fundamental shocks. In the presence of margin-constrained informed investors, it is possible for contagion to result from confused uninformed investors. Although theoretically convincing, there is little empirical evidence for the investor-induced contagion hypothesis.

This paper uses a distinct attribute of emerging stock markets to determine whether cross-market correlation dynamics are driven by investor asset holdings or by fundamental linkages. In emerging market countries, not all publicly listed stocks are eligible for purchase by foreigners. By differentiating between those stocks that are readily accessible to foreign investors (accessible) and those that are accessible primarily to local investors (inaccessible), we form testable implications that allow us to distinguish between the investor-induced contagion hypothesis and the fundamental-based contagion hypothesis. In order to illustrate the testable implications of the paper, we offer a simple thought experiment.[2]

Consider an economy with two emerging markets (A and B) that have independent economic fundamentals. Both accessible and inaccessible stocks exist for each country, and these stocks are traded by three types of investors: international investors, local A investors, and local B investors. International investors can only invest in the accessible stocks of countries A and B. For concreteness, one might interpret these investors as institutional investors from developed

[2] This simple thought experiment can be considered a reduced form of the models in Kyle and Xiong (2001), Calvo (1999), and Yuan (2005).

countries. Local A investors, those in emerging market country A, and local B investors, those in emerging market country B, can only invest in their respective home country stocks (accessible and inaccessible). This assumption can be reasonably motivated by the potentially large transaction costs investors face when trading assets issued outside their home country or by the "home bias" phenomenon.[3] We further assume that all investors face trading constraints such as borrowing constraints (i.e., investors have to deposit collateral in margin accounts), motivated by the findings on international mutual funds.[4] When country A is struck by a country-specific crisis, international investors suffer losses in country A's accessible stock investment and must liquidate their holdings in country B's accessible stocks to meet margin calls. This selling of country B's accessible stocks by international investors is unrelated to country B's economic fundamentals but, nevertheless, leads to a price decline in country B's accessible stocks. If the price decline in country B's accessible stocks is sufficiently severe, local B investors may also be forced to liquidate their holdings in country B's stocks (accessible and inaccessible) to meet margin requirements. Hence, the idiosyncratic shock in country A, if severe enough, may eventually spread to country B's inaccessible stocks.

We draw the following testable implications from the above thought experiment. First, if contagion is investor induced, either through portfolio rebalancing or wealth constraints, the co-movement of accessible stock returns with the crisis country stocks should increase more than the co-movement of inaccessible stock returns with the crisis country stocks during the period of turmoil. Alternatively, if contagion is fundamental based, the increase in co-movement should be similar for accessible and inaccessible stocks. Second, the investor-induced contagion hypothesis also predicts that within a country, movements of accessible stock returns should lead movements of inaccessible stock returns through the wealth constraints of local investors during the turmoil period. Third, if crises spread through wealth constraints, correlations should be asymmetrically higher in market downturns than in market upturns. In addition, we examine the correlation dynamics between government bonds and stock index returns to investigate how crises spread within a country. If international investors withdraw capital from both equity and bond markets and wealth-constrained local investors are unable to arbitrage away the price impact of foreign trades, the correlation between accessible stock and government bond returns should increase during crises. On the other hand, if investors rebalance their portfolio toward safe assets such as government bonds in a flight to quality during crises, the correlation between stock and government bond returns during crises should decrease.

[3] Transaction costs include institutional constraints, information asymmetries, capital outflow restrictions, and language barriers. The home bias has been found to be pervasive in developed and emerging equity markets as well as bond markets (see French and Poterba (1991), Bertaut and Kole (2004), Tesar and Werner (1995), Burger and Warnock (2003)).

[4] In their study of net monthly flows of East Asian equity funds during the Asian crisis, Kallberg, Liu, and Pasquariello (2005) find that information spillover and investor constraints, rather than common information shocks, represent the major channels for the transmission of the crisis across countries.

To formally test these implications, we estimate and compare the correlation dynamics of accessible and inaccessible stock returns with the stock index returns of the crisis country. Once we establish that accessible stocks and inaccessible stocks demonstrate no differences in cash flow fundamentals, we can attribute differences in correlation dynamics to differences in investor activity, with accessible stocks being more susceptible to outside shocks through portfolio rebalancing or wealth constraints. The outside shocks that can affect the asset holdings of investors include changes in both exchange rates and stock prices. To assess the relative importance of each component, we decompose co-movements to separate out the effects of exchange rate movements.[5]

Although seemingly straightforward to implement, calculating return correlations during crisis periods is not a trivial statistical exercise. Some misleading results have been reported in the past that ignore the relationship between correlation and volatility. Stambaugh (1995), Boyer, Gibson, and Loretan (1999), and Forbes and Rigobon (2002) note that calculating correlations conditional on high (low) returns, or on high (low) volatility, induces a conditional bias in the correlation estimate. To correct for the conditional bias, Forbes and Rigobon (2002) propose a bias correction methodology based on the assumption of independent and identically distributed (i.i.d.) returns. However, Corsetti, Pericoli, and Sbracia (2002) show that if the returns are not i.i.d. (e.g., if variances increase during crisis periods), the bias correction errs in the direction of not finding contagion. We use two different methodologies to calculate correlations. First, we estimate a regime-switching model, in which return variances are allowed to change across regimes. Second, we estimate correlations of tail observations using extreme value theory, which is robust under any distributional assumption over returns.[6]

The regime-switching model is a dynamic model of stock returns that allows for endogenous structural breaks and thus allows the data to determine the beginning and end of each crisis. In our estimation, the unobserved state variable follows a two-state Markov process. Regime-switching models have been found to successfully exhibit important features of the correlation dynamics of financial times series (Ang and Chen (2002), Ang and Bekaert (2002), and Gibson and Boyer (1997)). We find that (1) a significant number of the accessible index returns of the emerging markets in our sample have higher correlations with the crisis country during the volatile regime, (2) the correlation increase during the period of crisis is more pronounced for the accessible returns than for the

[5] Pavlova and Rigobon (2003) find that the foreign exchange market acts as a channel through which shocks are propagated across stock markets even though dividend processes are independent. In their setup, the wealth effect is implicitly modeled with logarithmic utility preference. Although their model's transmission mechanism of shocks is similar to our own, our focus is different. We compare the reactions of accessible and inaccessible stocks to external shocks, excluding the currency component that is common to both types of stocks from the same country. We thank an anonymous referee for pointing out the importance of separating out the currency component of the co-movements.

[6] Earlier versions of this paper include another measure of correlation, following the bias correction suggested by Forbes and Rigobon (2002). The results are similar, and therefore are omitted for clarity of exposition.

inaccessible returns, and (3) our results are not driven by correlated exchange rates. These findings support the investor-induced contagion hypothesis.

We also consider the time dimension in the transmission of crises among countries. As a preliminary measure, we test the lead and lag relationship by comparing sizes of cross-autocorrelations between accessible and inaccessible stock index returns for each country. Our analysis shows that accessible stock returns lead inaccessible stock returns during the crisis period, which is consistent with the predictions from our thought experiment.

After finding empirical evidence in support of the investor-induced contagion hypothesis, we conduct further tests to determine how crises spread through the asset holdings of investors. We test whether market co-movements are symmetric during extreme market upturns and downturns by estimating exceedance correlation, as in Ledford and Tawn (1997) and Longin and Solnik (2001). A test of symmetry of correlations at extreme tails helps distinguish between two hypotheses: Symmetric tails are consistent with the hypothesis that portfolio rebalancing influences correlation dynamics, while asymmetric tails are consistent with the hypothesis that correlation dynamics are driven by wealth constraints. We find that in emerging markets, correlations in negative tails are higher than correlations in positive tails, and that this effect is more pronounced for accessible returns than inaccessible returns. We do not find, however, evidence for asymmetry in exceedance correlation in developed countries. These results suggest that crises spread to emerging markets through asymmetric market frictions such as wealth constraints. In contrast, for developed markets, portfolio rebalancing could act as a channel for crises to spread. These hypotheses are supported by our analysis of correlations between stock and government bond returns within the same country: We observe higher return correlations for emerging market accessible stock indices during the crisis period, but not for emerging market inaccessible stock and developed country stock indices.

The remainder of the paper is organized as follows. Section I discusses the related literature. Section II presents the hypotheses we consider and the methodologies we use to conduct our tests. Section III describes the data and empirical evidence for two crucial assumptions underlying our tests. The first assumption is that foreign investor trades can move the market. The second assumption is that accessible stocks share similar cash flow fundamentals with inaccessible stocks, differing only in investor ownership. Section IV discusses test results for the hypotheses laid out in Section II. Section V concludes.

I. Related Literature

Our paper is closely related to the literature on limits to arbitrage (DeLong et al. (1990) and Shleifer and Vishny (1997)), which emphasizes that market frictions or noise trader risks break the link between asset price movements and economic fundamentals. This is in contrast to the traditional asset pricing theory, according to which co-movement in prices reflects co-movement in fundamentals in an economy with rational investors. For example,

Barberis, Shleifer, and Wurgler (2005) and Boyer (2004) find evidence for investor-induced co-movements by showing that some co-movements of stock returns can be attributed to asset reclassification. Our paper complements this literature because it provides cross-country evidence for a nonfundamental-based and investor-induced theory of co-movements.

Our paper is also related to the literature on measuring contagion across markets. Several approaches have been adopted to model the linkage between economic fundamentals and asset market co-movements. Bae, Karolyi, and Stulz (2003) analyze the joint occurrences of extreme events using a multinomial logistic model. Bekaert, Harvey, and Ng (2005) apply a two-factor model with time-varying betas and measure contagion as correlation among model residuals. Tang (2001) uses a similar approach but restricts the factor model to a world capital asset pricing model (CAPM). In our analysis, by demonstrating that accessible and inaccessible stocks share similar economic fundamentals, any difference in correlation dynamics between the two asset classes cannot be attributed to differences in fundamentals. As such, any increase in correlation during periods of high volatility among the accessible stocks that is not common to the inaccessible stocks can be classified as excess correlation over and above what one would expect given economic fundamentals. Hence, we circumvent the need to specify a factor model.[7]

Finally, our paper is closely related to the literature on international mutual fund holdings. Similar to our findings, this literature shows that investor asset holdings are a mechanism through which crisis shocks propagate. Kaminsky, Lyons, and Schmukler (2001) demonstrate that the Mexican, Asian, and Russian crises triggered withdrawals by mutual funds from other countries. Kaminsky, Lyons, and Schmukler (2004) find that mutual funds contributed to the contagion in Latin America by withdrawing money from other Latin American countries, following the initial crisis shock in Mexico in 1994. Kaminsky and Reinhart (2000) mention anecdotal evidence, which shows countries with negligible representations in the portfolios of mutual funds are hardly affected by regional crises (e.g., Colombia and Venezuela during the Mexican crisis). Broner, Gelos, and Reinhart (2003) find some evidence that stock markets are correlated through mutual fund asset holdings, especially during crises.

II. Methodology

To gauge the cross-market transmission mechanism of financial crises, we employ two different methodologies to estimate correlations. The first is based on estimated correlations from a regime-switching model. The second is based on extreme value theory. The estimated correlations are used to test three hypotheses on the transmission mechanism of crises.

[7] The theoretical literature on international asset pricing under mild segmentation (e.g., unequal access to certain asset markets) predicts that restricted securities command a "super risk premium" over unrestricted securities (Errunza and Losq (1985, 1989)). The super risk premium in these papers does not vary with the returns on accessible stocks and is constant across stable and unstable regimes. Our results are therefore not explained by these models.

A. Test Hypotheses and Statistics

Our first test is a test for the existence of contagion. For each emerging market, we estimate the correlation (ρ) of the crisis country's total market index returns with the return on the index of accessible stocks (indexed by A) and the return on the index of inaccessible stocks (indexed by IA) during stable and crisis periods. We then compare the difference in correlations between stable and crisis periods. If contagion exists, no matter whether the transmission mechanism is investor induced or fundamental based, accessible stock index returns should have a greater co-movement with the crisis country market index returns during the turmoil period. Therefore, the relevant test statistic for the existence of contagion is the difference in correlations of the accessible index returns of a market with the crisis country's total market index returns across periods. We first perform this test using index returns denominated in U.S. dollars. We then decompose the co-movement to separate out effects driven by correlated exchange rates.

TEST 1 (Existence of Stock Market Contagion): *If stock market contagion exists, co-movement is higher during the turmoil period for accessible index returns (A), that is,*

$$\begin{cases} H_0 : \rho_{A,\text{turmoil}} - \rho_{A,\text{stable}} \leq 0 \\ H_1 : \rho_{A,\text{turmoil}} - \rho_{A,\text{stable}} > 0. \end{cases}$$

To aggregate the results across countries, we use the nonparametric sign test. Under the null hypothesis that co-movement does not significantly change across periods, we should expect the number of countries with a higher estimated correlation during the turmoil period to be approximately equal to the number of countries with a lower correlation during the turmoil period. In other words, the median difference should be zero across countries. The nonparametric sign test therefore assesses the likelihood of observing the number of estimated positive differences, given that each country's estimated difference is positive with probability 0.5.

Our second set of tests seeks to determine how crises spread—through changes in country fundamentals or through market frictions (e.g., portfolio rebalancing and wealth constraints). We first compare the correlation dynamics of accessible and inaccessible index returns during crises. By the argument from the simple thought experiment described earlier, if crises spread through correlated fundamentals, the effect of crisis shocks on accessible index returns should be the same as that on inaccessible index returns. A finding that the change in co-movement of accessible index returns with the crisis country during the turmoil period is significantly greater than the change in co-movement for inaccessible index returns would reject the fundamental-based hypothesis and support the investor-induced hypothesis. Similar to the first test, we also perform this test after separating out exchange rate effects.

TEST 2A (Fundamental-Based vs. Investor-Induced Hypothesis): *If stock market crises spread due to market frictions rather than fundamentals, the correlation*

increase during the turmoil period is more pronounced for accessible index returns than for inaccessible index returns, that is,

$$\begin{cases} H_0 : (\rho_{A,\text{turmoil}} - \rho_{A,\text{stable}}) - (\rho_{IA,\text{turmoil}} - \rho_{IA,\text{stable}}) \leq 0 \\ H_1 : (\rho_{A,\text{turmoil}} - \rho_{A,\text{stable}}) - (\rho_{IA,\text{turmoil}} - \rho_{IA,\text{stable}}) > 0. \end{cases}$$

Furthermore, the investor-induced contagion hypothesis also predicts that within a country, movements of accessible index returns should lead movements of inaccessible index returns through constraints of local investors (either due to portfolio rebalancing needs or wealth constraints) during market crises. In order to test this lead-lag relationship, we compare the cross-autocorrelation between accessible and inaccessible index returns as in Campbell, Lo, and MacKinlay (1997). A higher correlation between inaccessible index returns and lagged accessible index returns (ρ_{A_{t-1},IA_t}) than between accessible index returns and lagged inaccessible index returns ($\rho_{A_t,IA_{t-1}}$) would suggest that accessible index returns lead inaccessible index returns.

TEST 2B (Fundamental-Based vs. Investor-Induced Hypothesis: Lead-Lag): *If stock market crises spread due to investor constraints rather than fundamentals, the effect first appears in the accessible stock index, followed by the inaccessible stock index, that is,*

$$\begin{cases} H_0 : \rho_{A_{t-1},IA_t} - \rho_{A_t,IA_{t-1}} \leq 0 \\ H_1 : \rho_{A_{t-1},IA_t} - \rho_{A_t,IA_{t-1}} > 0. \end{cases}$$

Our third set of tests provides evidence on whether crises spread due to portfolio rebalancing or wealth constraints. If crises are transmitted due to investors' portfolio rebalancing needs, market co-movements should be symmetric in extreme market upturns and downturns. On the other hand, if crises are transmitted due to investor wealth constraints, market co-movements should be greater in extreme market downturns than extreme market upturns. A test of whether market co-movements are symmetric at extreme tails allows us to distinguish between these two hypotheses. More specifically, we estimate and compare co-movements at two extreme tails: jointly positive, denoted by (+), and jointly negative, denoted by (−). If the cross-market linkage is through investor stock ownership, the relevant test statistic is the co-movement difference for accessible index returns. Despite the similarity of this set to Test 1, there is one important difference: Instead of comparing co-movement between the turmoil period and the stable period, we compare correlations at the extreme tails.

TEST 3A (Portfolio Rebalancing vs. Wealth Constraints): *If stock market crises are spread by constraints such as investor wealth constraints rather than the need for portfolio rebalancing, co-movement is higher during extreme market downturns than upturns, especially for accessible index returns, that is,*

$$\begin{cases} H_0 : \rho_{A,(-)} - \rho_{A,(+)} \leq 0 \\ H_1 : \rho_{A,(-)} - \rho_{A,(+)} > 0. \end{cases}$$

Additionally, by computing the co-movement between stock and government bond index returns during crisis and noncrisis periods, we analyze how a crisis spreads between risky and safe assets within a country. Analyzing how a crisis shock is transmitted within a country sheds light on how the shock spreads across countries during crises. If international investors withdraw capital from both equity and bond markets and wealth-constrained local investors are unable to arbitrage away the price impact of foreign trades, the correlation between accessible stock and government bond returns should increase during crisis periods. On the other hand, if there is no capital flight from the country and/or investors reallocate their investments to safer assets in response to the crisis shock, correlations between safe and risky assets should decrease. This portfolio rebalancing activity is commonly known as "flight to quality." Hence, this is a further test of how crises spread. Increases in correlation would suggest wealth constraints are binding while decreases in correlation would suggest active portfolio rebalancing within the country. Specifically, we estimate co-movement measures (ρ) between each country's stock market index returns (either accessible or inaccessible) and the local government bond market index returns (indexed by B) in the stable and crisis regimes, and compare differences in co-movement across regimes.

TEST 3B (Portfolio Rebalancing vs. Wealth Constraints: Government Bonds): *If stock market crises are spread by constraints such as investor wealth constraints rather than the need for portfolio rebalancing, co-movements between equity and government bond returns within a country are higher during crises, that is,*

$$\begin{cases} H_0 : \rho_{B,\text{turmoil}} - \rho_{B,\text{stable}} \leq 0 \\ H_1 : \rho_{B,\text{turmoil}} - \rho_{B,\text{stable}} > 0. \end{cases}$$

The rest of this section describes in detail the methodologies we employ to estimate the co-movement (ρ).

B. A Dynamic Model of Correlation: Regime-Switching Model

Our first method of estimating the correlation among asset returns is to specify and estimate the coefficients of a dynamic model that allows for the possibility of endogenous structural breaks (Hamilton (1989, 1990)).

The unobserved state variable in our model, s_t, is allowed to take on one of two values, $s_t \in \{1, 2\}$, which we term "volatile" and "stable" regimes. Let ψ_t represent all information through time t. The state variable s_t is assumed to follow a two-state Markov process,

$$P(s_t = b \mid \psi_{t-1}) = P(s_t = b \mid s_{t-1} = a) = p_{ab}, \tag{1}$$

resulting in a 2×2 transition matrix.

Conditional on being in state s, returns are assumed to be normally distributed,

$$(\mathbf{r}_t \mid s_t = s) \sim N(\alpha_s, \Sigma_s), \tag{2}$$

where $\mathbf{r}_t$ is an $n \times 1$ vector of index returns realized at time t, with t ranging from 0 to T, α_s is a vector of conditional expected returns, and Σ_s is an $n \times n$ conditional covariance matrix. For any two indices, let $\sigma_{ij,s}$ (an element in Σ_s) be the conditional covariance between index i and index j given $s_t = s$. The conditional correlation estimate, $\rho_{ij,s}$, between r_{it} and r_{jt} given state $s_t = s$ is

$$\rho_{ij,s} = \frac{\sigma_{ij,s}}{\sqrt{\sigma_{ii,s}\sigma_{jj,s}}}. \tag{3}$$

In our model, α_s and Σ_s can be constant across regimes. We therefore avoid pitfalls in estimating conditional correlations by splitting the data according to realized values (Boyer et al. (1999), Forbes and Rigobon (2002)).

Maximum likelihood estimates of the model parameters, including the elements of the transition matrix, are obtained using the expectation maximization (EM) algorithm (Hamilton (1990)). To obtain maximum likelihood estimates it is necessary to create inferences about the value of s_t based on data obtained through date T, $P(s_t = s \mid \mathbf{r}_1, \ldots, \mathbf{r}_T)$. These "smoothed inferences" are generated using an algorithm developed by Kim (1994).

We use the above approach to estimate correlations of the crisis country stock index return with emerging market stock index returns (accessible and inaccessible), correlations of the crisis country index return with developed market index returns, cross-autocorrelations between accessible and inaccessible index returns of the same country, and correlations among government bond and stock index returns of the same country. We separately estimate correlations across countries. To make the results of these separate estimations comparable, we define turmoil and stable regimes using only the information contained in the returns of the crisis country and the world index. The crisis country index helps to associate the regimes with a particular financial crisis, while the world index helps to define the high volatility regime as a regime of high global volatility rather than country-specific volatility. Individual country returns are assumed to contain no information about s_t beyond that contained in the returns of the crisis country and the world index.

Since the number of observations varies for each country, a two-step procedure is used to ensure that regime probabilities are identical across countries. In the first step, we estimate the parameters of a bivariate regime model using the crisis country and world index returns. These first-step parameters are then held constant in estimating correlations in multivariate regime models. The estimation procedure therefore takes the form of two-step maximum likelihood, and the asymptotic covariance matrix is estimated using the method of Murphy and Topel (1985) (see Appendix A for further details).

C. Exceedance Correlation

Alternative estimates of correlations among returns are obtained from the extreme tails of the joint distribution, as in Longin and Solnik (2001). This method is attractive in that we do not need to specify a joint distribution function nor define a crisis period. Instead, we rely strictly on the tail distribution that converges to a generalized Pareto distribution regardless of the data generating process. Thus, the results are robust to nonnormal and non-i.i.d. returns. We use this methodology to distinguish between the differences in correlation during market upturns and downturns.

For the univariate random variable (X), the tail distribution conditional on the observation being in the tail is fully characterized by the two parameters of the generalized Pareto distribution,[8]

$$F^*(x) = 1 - \left(1 + \frac{\xi(x-\theta)}{\sigma}\right)_+^{-1/\xi}. \tag{4}$$

The tail index, ξ, describes the thickness of the tail, while the dispersion parameter, σ, describes the width of the distribution.

For the bivariate (or more generally, multivariate) case, the resulting multivariate distribution of extreme returns is a function of univariate generalized Pareto distributions, which do not depend on the underlying true distribution. Let $(X_1, X_2, \ldots X_q)'$ be a q-dimensional vector of random variables and $(\theta_1, \theta_2, \ldots \theta_q)'$ denote the vector of the threshold level. Following Ledford and Tawn (1997) and Tawn (1988), the joint tail distribution is as follows:

$$F^*(x_1, x_2 \ldots x_q) = \exp\left[-D\left(\frac{-1}{\log F_1^m(x_1)}, \frac{-1}{\log F_2^m(x_2)}, \cdots \frac{-1}{\log F_q^m(x_q)}\right)\right], \tag{5}$$

where $D(\,)$ is a specific dependence function and $F_j^m(\,)$ is the marginal distribution of the jth variable. The marginal distribution

$$F^m(x_j) = (1 - \lambda_j) + \lambda_j \left(1 + \frac{\xi_j(x_j - \theta_j)}{\sigma_j}\right)_+^{-1/\xi_j} \tag{6}$$

contains two parts: probability $1 - \lambda_j$ that the observation is not in the tail and probability λ_j that the observation is in the tail as represented by the Pareto distribution. In the multivariate case, although the limiting marginal distributions are known, the dependence function is not known and must be specified.

We proceed with the most widely used dependence function, the equally weighted logistic function,

$$D(z_1, z_2 \ldots z_q) = \left(z_1^{-1/\alpha} + z_2^{-1/\alpha} + \cdots + z_q^{-1/\alpha}\right)^{\alpha}, \tag{7}$$

[8] The plus-sign notation is defined as $s_+ = \max(s, 0)$.

where the dependence parameter is α, with $0 < \alpha \leq 1$.[9] With only one parameter to estimate, this dependence function is simple and tractable. Furthermore, for the bivariate model $q = 2$, the measure of exceedance correlation is $1 - \alpha^2$, which is simple to compute. The seven parameters (two tail probabilities, two tail indices, two dispersion parameters, and one parameter from the dependence function, α) are estimated using maximum likelihood assuming independent observations.[10]

We estimate this limiting distribution to characterize the correlations of the crisis country stock index return with emerging market stock index returns for the two tails of the joint distribution function, namely the positive tail (for jointly positive returns or bull market) and the negative tail (for jointly negative returns or bear market). We follow Ang and Chen (2002) in setting the positive tail and negative tail threshold values, θ_U and θ_L respectively, to be multiples of sample deviations away from the sample mean. We use asymptotic properties of the maximum likelihood estimator to obtain our parameter estimates and the covariance matrix, and we derive inferences based on asymptotic normality.[11]

III. Data

Our analysis uses two types of stock index returns for each country when available: returns for accessible stocks and returns for inaccessible stocks. In developed financial markets such as the United States, practically all stocks are accessible to both foreign and local investors and thus the entire market is accessible. However, in many emerging markets, some stocks are only accessible to local investors. Section A describes the accessible and inaccessible stock indices, and Section B compares characteristics of firms, which are designated accessible and inaccessible. Section C explains the bond data we use in conducting further analyses.

Before discussing the data used in our statistical tests, we first discuss the magnitude of foreign equity holdings. Data of U.S. holdings of foreign equity are collected by the Treasury International Capital System (TIC) through periodic benchmark surveys of U.S.-resident custodians (typically banks and broker-dealers) and institutional investors. Table I reports the market value of U.S. holdings of foreign equity by country at year-end 1997 as reported by TIC. We also report the total market capitalization of these countries at year-end 1997 as reported in both the International Finance Corporation's (IFC) Emerging Markets Data Base (EMDB) and Datastream. From Table I, it is clear that U.S. holdings of emerging market equity are large relative to the size of the emerging markets. For example, U.S. holdings of Korean equity at year-end

[9] The models of the dependence function can be either nonparametric or parametric. In the class of parametric functions, Tawn (1988) describes two distinct models, mixed and logistic.

[10] The details on the construction of the likelihood function can be found in Prescott and Walden (1980), Ledford and Tawn (1997), and Longin and Solnik (2001).

[11] We note that a trade-off exists in selecting the threshold values. The sample distribution converges toward the true extreme tail distribution as the threshold increases, but the precisions of the estimates suffer from a smaller number of observations satisfying the tail criteria.

Table I

Market Capitalization and U.S. Equity Ownership

This table reports year-end 1997 values of the total stock market capitalization, U.S. equity ownership, and percentages of market capitalization that are accessible and inaccessible to foreign investors for each country. Stock market capitalization values are from International Finance Corporation's global index (IFCG) in the emerging market database (EMDB) for emerging markets and from Datastream for developed markets. U.S. equity ownership values are from Table 1 of http://www.ustreas.gov/tic/flts.html. The accessible and inaccessible percentages of market capitalization are computed based on IFCG and IFCI indices from International Finance Corporation (IFC).

Region	Country	Total Market Capitalization (million dollars)	U.S. Equity Ownership (million dollars)	Accessible Percentage (%)	Inaccessible Percentage (%)
Emerging Markets					
Latin	Argentina	35,142	12,892	99.6	0.4
America	Brazil	102,965	31,338	86.8	13.2
	Chile	44,498	4,555	98.9	1.1
	Colombia	11,452	704	79.5	20.5
	Mexico	108,941	34,965	94.8	5.2
	Peru	9,657	2,341	93.6	6.4
	Venezuela	9,138	1,975	91.2	8.8
Asia-Pacific	China	49,981	2,256	10.2	89.8
South Asia	India	50,856	6,176	28.9	71.1
	Indonesia	13,553	2,488	97.7	2.3
	Korea	25,157	4,428	54.5	45.5
	Malaysia	45,911	4,713	93.6	6.4
	Pakistan	5,979	1,180	88.7	11.3
	Philippines	18,650	2,848	48.3	51.7
	Sri Lanka	1,293	133	33.6	66.4
	Taiwan, China	153,176	4,939	39.5	60.5
	Thailand	10,921	2,158	47.0	53.0
Emerging	Czech Republic	4,847	763	37.7	62.3
Europe	Greece	16,255	1,513	99.8	0.2
	Hungary	11,175	3,483	99.5	0.5
	Poland	6,234	1,618	100.0	0.0
	Portugal	24,745	6,993	89.9	10.1
	Russia	54,744	8,457	63.3	36.7
	Slovakia	1,320	87	86.2	13.8
Others	Egypt	8,141	763	79.1	20.9
	Israel	18,812	7,036	99.4	0.6
	Jordan	3,261	40	34.3	65.7
	Morocco	7,562	217	85.9	14.1
	South Africa	90,297	9,937	99.5	0.5
	Turkey	33,732	6,005	100.0	0.0
	Zimbabwe	1,123	133	40.4	59.6
Developed Markets					
Asia-Pacific	Australia	548,380	31,120		
	Hong Kong	205,200	28,102		
	Japan	2,690,000	136,404		
	Singapore	141,100	10,185		

(*continued*)

Table I—*Continued*

Region	Country	Total Market Capitalization (million dollars)	U.S. Equity Ownership (million dollars)	Accessible Percentage (%)	Inaccessible Percentage (%)
Europe	Belgium	787,920	6,099		
	France	1,320,150	85,019		
	Germany	608,510	64,965		
	Italy	1,871,040	41,547		
	Netherlands	1,055,560	106,984		
	Spain	302,010	25,223		
	Sweden	181,110	38,783		
	Switzerland				
	United Kingdom	5,407,200	217,525		
North America	Canada	461,120	70,798		
	United States	13,292,800	952,900		

1997 were about $4.4 billion, while the total market capitalization of the Korean stock market was only about $25 billion. We note that the first two columns in Table I may not be exactly comparable since the U.S. holding measures are likely to include holdings of equity that are not traded on an exchange, while the market capitalization measures are limited to exchange-traded firms in the IFC global index, which is not comprehensive. However, the numbers are approximately comparable. For example, Choe, Kho, and Stulz (2003) find that foreign investors held about 14.7% of the total market capitalization of the Korean equity market in 1997. Table I thus offers one idea of the magnitude of U.S. holdings of foreign equity relative to the size of the local market. Given the evidence of Table I, specifically, that foreign holdings of emerging markets are large relative to the size of these markets, it is reasonable to conclude that trades by foreigners can have important price effects.[12]

A. Accessible and Inaccessible Stock Index Returns

For emerging markets, IFC provides two stock market index series for each emerging market: IFC Global (IFCG), representing the total market, and IFC Investable (IFCI), consisting of firms that are designated to be accessible to foreigners. Both IFC index series are dividend inclusive and available in U.S. dollars or in local currency. For the IFCG index, the IFC selects stocks by reviewing trading activities and targets a market coverage of 60–75% of total market capitalization.[13] For the IFCI index, the stocks included are a subset

[12] In addition, the empirical findings of Clark and Berko (1996) indicate that foreign trades impact crises. They find that unexpected foreign capital inflows of 1% of the market capitalization drove prices up by 13% in Mexico during the late 1980s through the crisis in 1993.

[13] The IFC trading criteria are as follows: Any share selected must be among the most actively traded shares in terms of value traded, must have traded frequently during the annual review period, and must have reasonable prospects for a continued trading presence in the stock exchange without imminent danger of being suspended or delisted.

of firms that are in IFCG, and selection for this subset is a two-step process. First, the IFC determines which securities may be legally held by foreigners.[14] Next, the IFC screens stocks according to size and liquidity.[15] Thus, the IFCI index is designed to measure the composite stock market index of what foreign investors might receive from investing in emerging market securities that are legally and practically available to them (IFC (1999)).

We construct weekly log returns using index levels reported on Fridays. Weekly data are used to avoid market microstructure complications that appear in daily level data. Since IFC does not provide an explicit series for inaccessible stocks, we construct the inaccessible index return as

$$R_{IA,t} = \frac{M_{G,t-1} \times R_{G,t} - M_{A,t-1} \times R_{A,t}}{(M_{G,t-1} - M_{A,t-1})}, \tag{8}$$

where R is the index return, M is the index market capitalization, G, A, and IA refer to the global, accessible, and inaccessible index, respectively, and t denotes period t.[16]

Note that the degree of investor accessibility may not be a good proxy for the degree of actual foreign ownership—a stock that is designated as investable may or may not be owned by foreign investors. If the measure of accessibility overstates foreign ownership, then our results are biased in favor of the null hypothesis that foreign ownership does not affect co-movement.

For the developed countries, we treat all stocks as accessible. We use the country index levels from Datastream (Datastream Total Market Index) to construct log weekly returns. We also calculate weekly returns using index levels for the Datastream World Market Index.

The sample period of our data (from both EMDB and Datastream) is from January 1989 to December 2002. In Table I, we report the percentage of total market capitalization of the IFCG index that is accessible and inaccessible by country for the year 1997. The percentage of total market capitalization attributed to inaccessible firms varies greatly across countries. The cross-country market-weighted average is 27%. We also compute the sample correlation between the accessible and inaccessible returns of each country over the entire

[14] The first legal test of a stock's accessibility is to determine whether the market is open to foreign institutions. IFC determines the extent to which foreign institutions can (1) buy and sell shares on local exchanges and (2) repatriate capital, capital gains, and dividend income without undue constraint. The second legal test is to determine whether there are any corporate by-law, corporate charter, or industry limitations on foreign ownership of the stock.

[15] The size requirement is a minimum market capitalization of $50 million or more over the 12 months prior to a stock's addition to an IFCI index. The liquidity requirement is a minimum trading volume of $20 million over the year prior to inclusion, with trades occurring on at least half the local exchange's trading days.

[16] Inaccessible index returns are calculated and used in our analysis only if the inaccessible portion of the total market capitalization remains above 0.01% for several years during and around 1997, the year of the Asian crisis. This prevents the use of inaccessible index returns for Poland, South Africa, and Turkey.

sample period.[17] For any statistical comparison of the two indices to be meaningful, accessible and inaccessible returns should be different and not highly correlated. The sample average correlation is found to be 0.651 with a cross-sectional standard deviation of 0.25. Hence, there appear to be economically relevant differences across the two indices within each country. In the next section we investigate firm-level characteristics to compare cash flow fundamentals of firms that comprise the two indices.

B. Characteristics of Accessible and Inaccessible Firms

In order to compare the impact of crises on the emerging market's accessible index and inaccessible index, it is necessary to understand any differences in the sets of firms that comprise the indices. Our test of the investor-induced contagion hypothesis against the correlated country fundamentals hypothesis requires the assumption that accessible firms share similar cash flow fundamentals with inaccessible firms. That is, accessible and inaccessible firms differ primarily in investor holdings. To explore structural differences that may affect our results, we examine characteristics of accessible and inaccessible firms. IFC characterizes how accessible a firm is to foreign investors by a variable called "degree of open factor" that ranges from zero to one. When this degree of open factor equals one, the stock of the firm is completely accessible to foreigners; at zero, the stock of the firm is completely inaccessible to foreigners. In our comparisons between accessible and inaccessible firms, accessible firms are those with a degree of open factor equal to one, while inaccessible firms are those with a degree of open factor equal to zero.[18]

A possible cause for observing differences in co-movement across accessible and inaccessible firms is that inaccessible firms are in different industries from accessible firms. In particular, cash flows of tradable sectors are more vulnerable to exogenous shocks that originate elsewhere in the world. In Figure 1 we compare the sector distribution of accessible and inaccessible firms at the beginning of 1994 (the year of the Mexican crisis), 1997 (the year of the Asian crisis), and 1998 (the year of the Russian crisis) using firm-level data for January of each year.[19] We find that the distributions are similar across years. The figure also shows that both indices are mainly comprised of firms in the manufacturing sector, a predominantly tradable sector. At the beginning of 1994, 1997, and 1998, the percentage of completely accessible firms in the manufacturing sector is 39.1%, 39.6%, and 41.2% while the percentage of completely inaccessible firms in the manufacturing sector is 51.0%, 48.7%, and 49.4%,

[17] All statistics that are discussed but not reported may be obtained from the authors upon request.

[18] To give one idea of how many firms are within each accessibility group at the end of 1994, we have data on 1,505 stocks across all emerging market countries, with 480 completely accessible, 534 completely inaccessible, and 491 in between. At the end of 1997, there are 2,005 stocks, with 535 completely accessible, 581 completely inaccessible, and 889 in between.

[19] Other years are not shown but the figures are similar for all years and for the entire sample, 1989–2002.

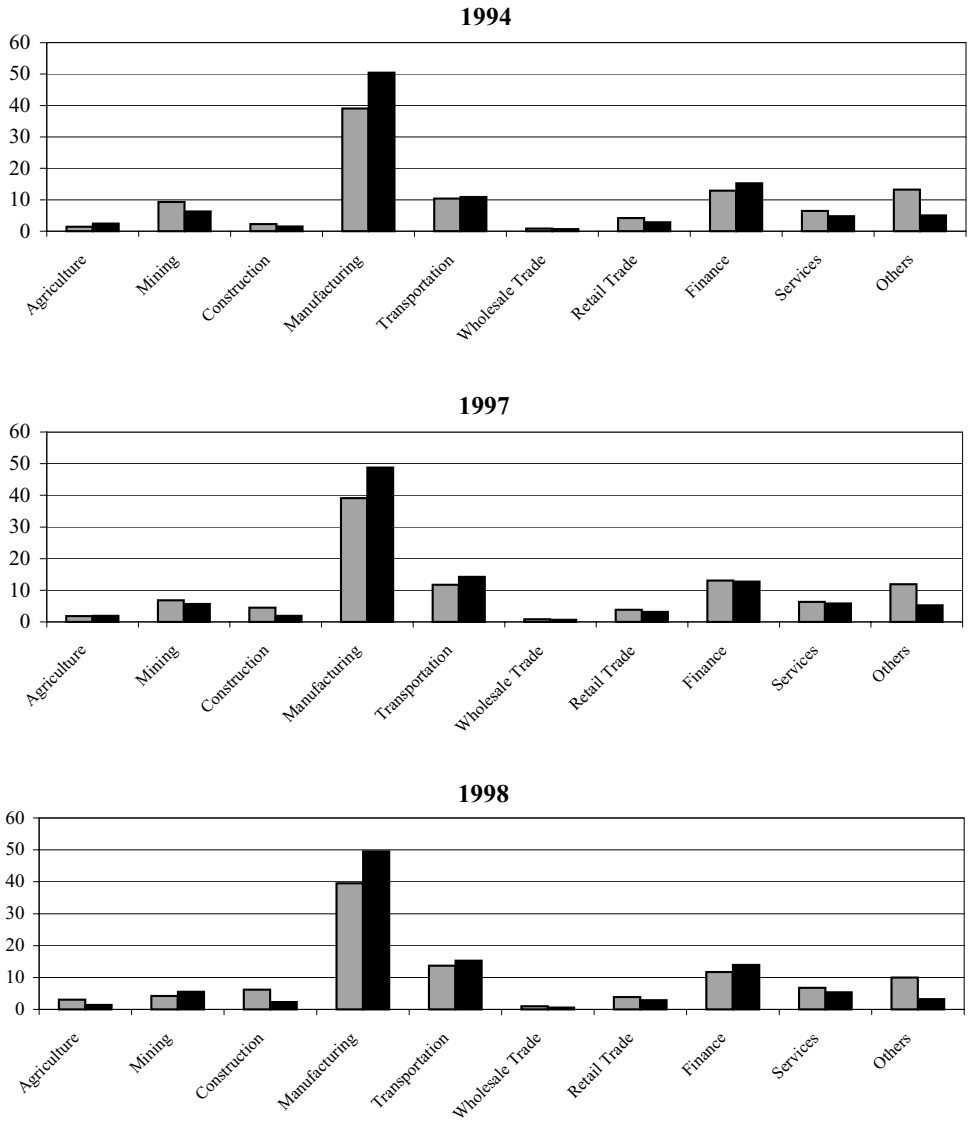

Figure 1. Distribution of accessible and inaccessible firms by industry. This graph displays percentage distributions of accessible firms (light color bars) and inaccessible firms (dark color bars) by industry, based on market capitalization in January of each year. SIC codes for each industry are as follows, in parentheses: Agriculture (1, 2, 7, 8, 9), Mining (10, 12, 13, 14), Construction (15–17), Manufacturing (20–36), Transportation (38–49), Wholesale Trade (50, 52), Retail Trade (53, 54, 55, 58, 59), Finance (51, 60, 61, 62, 63, 65), Services (67, 70, 73, 75, 78, 79, 89), and Others (99).

respectively. Since a slightly larger portion of completely inaccessible firms is in this tradable sector, our results may be biased against the investor-induced hypothesis. Overall, however, there appears to be no meaningful difference between the distribution of accessible firms and inaccessible firms across sectors. Bae, Chan, and Ng (2004) also find no pronounced variation in accessibility across industries. Therefore, any differences we find in correlations cannot be attributed to sector differences between accessible and inaccessible firms.

To check for other differences between accessible and inaccessible firms, we compare two market microstructure characteristics of firms in the two indices, size (market capitalization) and liquidity (ratio of value traded to market capitalization). Cash flows of firms that are very large or very small may be particularly vulnerable to global shocks. Further, stock prices of firms that are very liquid may be more sensitive to fundamental news about future earnings prospects. We therefore report in Table II the one-sided test of means for each country to determine whether average liquidity is significantly higher, and the two-sided test of means to determine whether the average size is significantly different for completely accessible firms than completely inaccessible firms for the crisis years 1994, 1997, and 1998. In 1994, out of 14 countries for which comparison is possible, we find that average liquidity for accessible firms is significantly greater only in 2 countries and average size is significantly different in 6 countries. In 1997, out of 16 countries, average liquidity for accessible firms is significantly greater in 5 countries and average size is significantly different in 5 countries. In 1998, out of 19 countries, average liquidity for accessible firms is significantly greater only in Mexico and average size is significantly different in 6 countries.

Our liquidity results are similar to those of Bae et al. (2004) who find that the average liquidity of accessible stocks is not significantly greater than that of inaccessible stocks. We also find that in 1994, 1997, and 1998, the average size of accessible stocks is not significantly different from that of inaccessible stocks for more than half the countries for which the comparison is possible.[20] This is a conservative comparison of liquidity and size across accessible and inaccessible indices because it involves firms with only extreme values of degree of open factors, zero and one. Firms with interim values are in both indices and hence make the difference in size and liquidity across accessible and inaccessible indices less pronounced. Although there is some evidence that accessible and inaccessible firms differ somewhat in size based on the analysis of the stock-level data, the stock-level data from EMDB include more firms than are used to construct the EMDB indices. Since IFC screens firms based on size before including them in the indices, the difference in size of firms that are actually in

[20] Bae et al. (2004) conduct the analysis using the whole EMDB data sample (1994–2001), and we conduct the analysis using each January of crisis years 1994 (Mexico), 1997 (Asia), and 1998 (Russia). Chari and Henry (2004) use data before stock market liberalization dates and find higher liquidity for accessible stocks but no difference in size between accessible and inaccessible stocks.

Table II

Firm-Level Comparison of Accessible and Inaccessible Firms

This table compares accessible firms and inaccessible firms for each country by comparing the averages of two measures of firm characteristics: (1) liquidity, which equals the turnover rate of stock holdings as represented by the ratio of value traded to total market capitalization, and (2) size, the ratio of the firm market capitalization to total stock market capitalization. A firm is defined to be accessible if the "degree of open factor" value reported in the emerging market database (EMDB) is one and inaccessible if the value is zero. All observations with interim values are deleted from this analysis. The test of comparison is a one-sided t-test to verify whether liquidity is significantly larger for accessible firms than inaccessible firms and a two-sided t-test to verify whether size is significantly different for accessible firms from inaccessible firms, at the 5% significance level. All values are taken from January of each year.

	1994				1997				1998			
Emerging	Observations		Higher	Different	Observations		Higher	Different	Observations		Higher	Different
Markets	Accessible	Inaccessible	Liquidity?	Size?	Accessible	Inaccessible	Liquidity?	Size?	Accessible	Inaccessible	Liquidity?	Size?
Argentina	25	6	N	N	24	4	N	N	25	3	N	N
Brazil	44	26	N	N	32	18	Y	N	25	12	N	N
Chile	0	16	–	–	29	2	N	N	35	3	N	N
Colombia	11	14	N	Y	3	13	N	Y	5	12	N	Y
Mexico	66	14	Y	N	59	12	Y	N	56	13	Y	N
Peru	11	24	N	Y	14	17	N	N	16	13	N	N
Venezuela	11	6	Y	N	5	9	Y	Y	10	7	N	N
China	18	99	N	N	27	153	N	N	43	152	N	Y
India	0	43	–	–	0	52	–	–	0	61	–	–
Indonesia	0	9	–	–	0	1	–	–	45	1	–	–
Korea	0	6	–	–	0	6	–	–	0	11	–	–
Malaysia	100	0	–	–	94	0	–	–	88	0	–	–
Pakistan	15	56	N	Y	21	36	Y	Y	10	31	N	Y
Phillipines	15	23	N	N	9	10	Y	N	3	10	N	N
Sri Lanka	4	27	N	Y	4	42	N	Y	4	45	N	Y
Taiwan	0	2	–	–	0	0	–	–	5	0	–	–
Thailand	0	6	–	–	0	1	–	–	0	9	–	–
Czech Republic	5	55	N	Y	3	67	N	N	3	35	N	N
Greece	25	11	N	Y	43	4	N	N	43	2	N	N
Hungary	5	8	N	N	8	6	N	Y	8	2	N	N
Portugal	19	7	N	N	19	4	N	N	10	0	–	–
Russia	–	–	–	–	0	25	–	–	11	7	N	N
Slovakia	–	–	–	–	0	20	–	–	3	15	N	Y
Egypt	–	–	–	–	0	32	–	–	11	26	N	Y
Israel	–	–	–	–	12	2	N	N	10	3	N	N
Jordan	0	32	–	–	0	44	–	–	1	38	–	–
Morocco	–	–	–	–	0	13	–	–	5	6	N	N
Zimbabwe	0	19	–	–	0	17	–	–	0	12	–	–

the indices is smaller than in the stock-level data.[21] In summary, we conclude that there are no significant differences in cash flow fundamentals across firms in accessible and inaccessible indices.

C. Government Bond Index Returns

Besides using equity index returns, we also use government bond index returns. Ideally, to test for "flight to quality" we need returns on the safest asset in a country, which in most cases is the government bond with the shortest maturity. Bond index data for emerging market countries are notoriously difficult to obtain, however. For 21 of our emerging market countries, we are able to obtain weekly bond index returns from the Emerging Market Bond Index (EMBI) database maintained by JPMorgan-Chase. Each EMBI index, however, is constructed to have a 5-year duration. To maintain consistency across developed and emerging market countries, we use 5-year maturity government bond indices for the 13 developed countries. The source for developed country bond data is Datastream.

IV. Contagion in the 1997 Asian Crisis

We consider the 1997 Asian crisis to investigate the transmission mechanisms of crises. As stated in Forbes and Rigobon (2002), multiple events constituted the Asian financial crisis, beginning with the Thailand stock market crash in June, the Indonesian market crash in August, and then the Hong Kong market crash in mid-October. As a benchmark case, we first adopt Forbes and Rigobon's definition of the Asian crisis, using the Hong Kong equity market as the source of contagion. For comparison, we then consider Thailand as the source of crisis.

A. Test 1: Existence of Stock Market Contagion

To test for the existence of stock market contagion, we examine whether correlations between the crisis country index returns and the index returns of other countries increase during the crisis period (Test 1). If the cross-market linkage is through investor holdings, correlation changes between the crisis country returns and accessible returns are the most relevant, though we measure correlation changes for both accessible and inaccessible returns.

To obtain measures of correlation, for each country we estimate coefficients of a regime-switching model that characterizes the joint data generating process of the crisis country index, the world index, the U.S. index, the accessible index, and, when available, the inaccessible index. In our estimation, the crisis regime is defined as the state with higher volatility in the crisis country index returns. We report estimation results for emerging market economies in Tables III (where Hong Kong is the crisis source country) and IV (where

[21] In fact, our strongest results against the fundamental-based hypothesis for contagion during the Asian crisis in Table VII are for countries in which firm size does not differ significantly across accessible and inaccessible indices in 1997, the year of the Asian crisis.

Table III

Test 1: Existence of Contagion with Hong Kong as the Crisis Country (Regime-Switching Model).

This table reports differences in estimated moments across two regimes, separately for accessible and inaccessible returns: volatility (columns 2 and 8), correlation with the crisis country index return (columns 4 and 10), and correlations with the world index return (columns 6 and 12). The *t*-test statistics reported are of tests of equivalent volatility (columns 3 and 9), of equivalent correlation with the crisis country (columns 5 and 11), and of equivalent correlation with the world index return (columns 7 and 13), between the turmoil and stable regimes. The rejection of the null against the one-sided alternative that the turmoil regime volatility or correlation is greater, at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. *N* is the number of observations used in estimation. In the row below the differences are the numbers of countries with higher values during the turmoil period (positive differences) and the sign test *p*-value, for the test of the null hypothesis that the turmoil periods' values are not higher.

		Panel A: Accessible Returns						Panel B: Inaccessible Returns					
		Volatility		Corr C		Corr W		Volatility		Corr C		Corr W	
Emerging Markets	*N* (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)	Diff (8)	*t*-Stat (9)	Diff (10)	*t*-Stat (11)	Diff (12)	*t*-Stat (13)
Argentina	730	0.078	1.677**	0.119	1.098	0.094	0.680	0.016	0.381	−0.037	−0.240	−0.013	−0.079
Brazil	730	0.201	3.708***	0.080	0.570	0.209	2.151**	0.083	1.641*	0.121	0.806	0.168	1.613*
Chile	730	0.049	2.985***	0.113	1.222	0.137	1.334*	0.028	1.911**	0.079	0.919	0.033	0.288
Colombia	560	−0.011	−0.407	−0.051	−0.287	0.150	0.812	−0.006	−0.218	−0.056	−0.226	0.023	0.063
Mexico	730	0.114	4.152***	0.176	1.753**	0.319	4.426***	0.060	3.336***	−0.027	−0.214	0.003	0.030
Peru	521	0.022	0.661	0.207	1.378*	0.189	0.982	0.008	0.428	0.072	0.433	0.080	0.538
Venezuela	616	0.020	0.367	0.121	0.706	−0.006	−0.039	−0.007	−0.213	−0.021	−0.139	−0.055	−0.335
China	521	0.219	5.339***	0.220	3.953***	0.135	1.199	−0.135	−3.649	−0.092	−0.460	−0.036	−0.139
India	529	0.064	2.090**	0.205	1.750**	0.197	1.332*	0.061	2.045**	0.225	1.885**	0.216	1.448*
Indonesia	639	0.429	7.665***	0.283	1.207	0.171	0.264	0.410	7.972***	0.250	0.758	0.194	0.676
Korea	573	0.266	6.544***	0.089	0.740	0.107	0.743	0.270	7.052***	0.095	0.772	0.135	0.949
Malaysia	730	0.249	11.537***	0.211	2.525***	0.167	1.568*	0.250	10.815***	0.237	3.006***	0.167	1.510*
Pakistan	552	0.071	1.913**	−0.095	−0.626	−0.126	−0.632	0.071	2.877***	−0.082	−0.525	−0.099	−0.548
Philippines	730	0.135	5.663***	0.273	3.533***	0.215	1.981**	0.167	7.474***	0.312	3.717***	0.268	2.810***
Sri Lanka	460	0.055	2.828***	0.022	0.094	0.111	0.474	0.028	1.652**	0.037	0.155	0.165	0.707
Taiwan	625	0.081	0.751	0.206	1.060	0.116	0.692	0.079	0.746	0.209	1.060	0.122	0.725
Thailand	730	0.229	6.940***	0.253	3.080***	0.206	2.146**	0.257	7.328***	0.261	3.172***	0.219	2.283**

(*continued*)

Table III—*Continued*

		Panel A: Accessible Returns						Panel B: Inaccessible Returns					
		Volatility		Corr C		Corr W		Volatility		Corr C		Corr W	
Emerging Markets	*N* (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)	Diff (8)	*t*-Stat (9)	Diff (10)	*t*-Stat (11)	Diff (12)	*t*-Stat (13)
Czech Republic	469	0.092	0.123	0.144	0.086	0.301	0.055	0.020	0.014	0.081	0.060	0.226	0.034
Greece	565	0.125	3.897***	0.021	0.189	0.218	2.166**	0.061	2.347***	−0.020	−0.126	0.134	0.695
Hungary	520	0.159	4.160***	0.102	0.761	0.238	1.642*	0.065	2.557***	0.076	0.418	0.145	0.831
Poland	455	0.000	0.001	0.128	0.566	0.222	1.309*	–	–	–	–	–	–
Portugal	534	0.104	4.215***	0.217	1.842**	0.289	3.230***	0.116	3.484***	0.193	1.566*	0.276	2.544***
Russia	307	0.272	2.564***	0.087	0.462	0.141	1.003	0.321	4.661***	−0.120	−0.487	−0.029	−0.131
Slovakia	247	−0.007	−0.135	0.042	0.174	0.132	0.595	−0.042	−0.642	−0.078	−0.324	0.068	0.237
Egypt	308	0.053	1.861**	0.021	0.095	0.099	0.680	−0.008	−0.325	−0.021	−0.093	0.095	0.415
Israel	312	0.098	2.533***	−0.032	−0.169	0.018	0.129	0.102	1.510*	0.072	0.333	0.094	0.523
Jordan	669	0.029	3.406***	0.196	1.556*	0.237	1.735**	0.029	3.526***	0.209	1.517*	0.293	2.216**
Morocco	307	−0.033	−1.358	0.169	0.822	0.134	0.683	−0.039	−1.837	0.052	0.265	0.134	0.763
South Africa	243	0.169	3.618***	0.325	1.986**	0.409	2.176**	–	–	–	–	–	–
Turkey	395	0.289	2.814***	−0.011	−0.048	0.063	0.282	–	–	–	–	–	–
Zimbabwe	434	0.168	4.474***	−0.076	−0.460	−0.007	−0.038	−0.263	−2.609	−0.091	−0.319	0.007	0.018
Number of Positive Differences		28		26		28		21		17		23	
Sign Test (*p*-value)		0.000		0.000		0.000		0.002		0.092		0.000	

Thailand is the crisis source country) and for developed economies in Table V. Since we are interested in the change in volatilities and correlations across regimes, we report only differences in these estimated moments and do not report levels. Changes in volatility are annualized by multiplying by $\sqrt{52}$.

When using Hong Kong as the crisis source country, we find a clear definition of two regimes (crisis and stable) during the sample estimation period. During the crisis regime, 28 of 31 emerging market countries have higher volatilities in accessible returns (column 2 in Table III), and 21 of 28 countries have higher volatilities in inaccessible returns (column 8 in Table III). Many of the volatility increases are significant at the 5% level. We also observe higher return volatilities for every developed country (column 2 in Table V), and all the volatility increases are significant at the 1% level.

The results in Table III show strong evidence for contagion. For example, correlations between accessible returns and crisis country returns increase significantly during the volatile regime for many countries. In addition, the sign test rejects the null that the accessible return correlation with the Hong Kong index does not increase during the crisis period at the 1% significance level for both emerging markets and developed countries. More specifically, for emerging markets, 26 of 31 countries show increases in correlation of accessible returns with the Hong Kong index during the crisis regime (column 4 in Table III). Of these increases, eight are significant at the 5% level and two others are significant at the 10% level (column 5 in Table III). For developed economies, 12 of 14 countries show an increase in correlation with the Hong Kong index during the crisis regime and two are significant at the 1% level (columns 4 and 5 in Table V).

Furthermore, the corresponding results for inaccessible returns are weaker. During the crisis regime, only 17 of 28 emerging market inaccessible indices show increases in correlation with the Hong Kong index, and of these increases, four are significant at the 5% level while two others are significant at the 10% level (columns 10 and 11 in Table III). Moreover, the sign test can reject the null that the correlation does not increase during crises only at the 10% level. Stronger evidence for increasing correlations among accessible returns than for inaccessible returns is indicative of the investor-induced contagion hypothesis.

We also analyze correlation estimates with the world index (columns 6 and 12 in Table III). Compared to correlations with the Hong Kong index (columns 4 and 10 in Table III), more countries show an increase in correlation with the world index than with the Hong Kong index in both accessible and inaccessible returns. Further, in most cases, more countries show a *statistically significant* increase in correlation with the world index than with the Hong Kong index. For example, all but one of the developed countries show a significant increase in correlation with the world index at the 1% level, compared with only two developed countries that show a significant increase in correlation with the stock index in the crisis country, Hong Kong, at the 1% level. The stronger evidence for increases in correlation with the world index, as compared with the Hong Kong index, suggests that increases in correlation with the

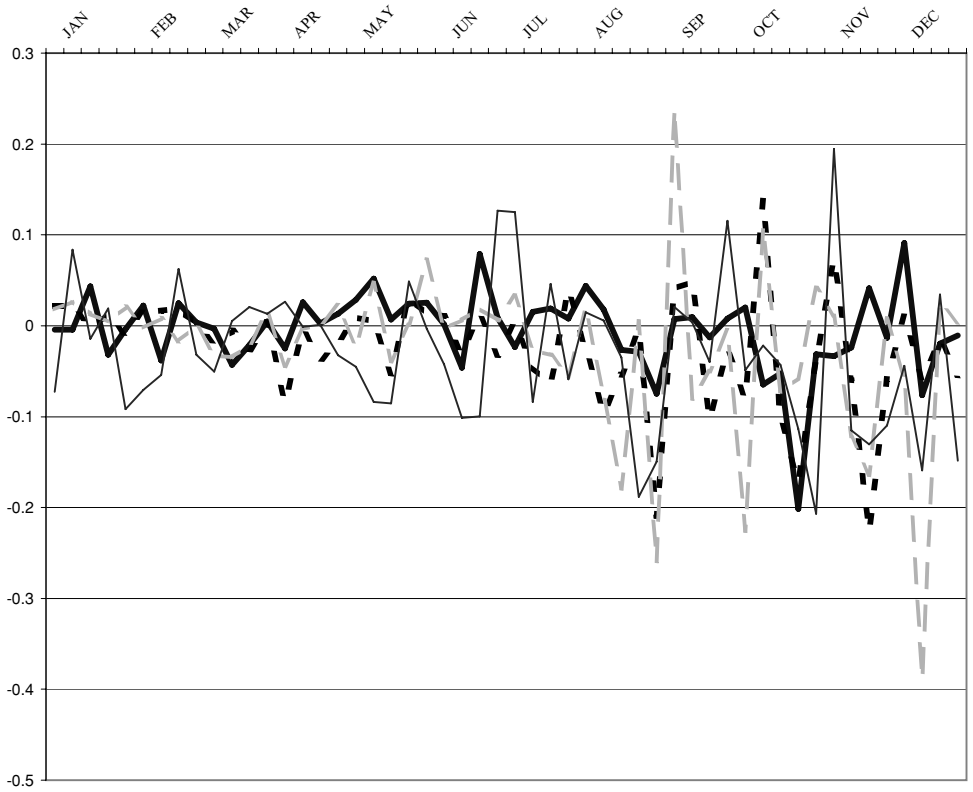

Figure 2. Weekly total index returns (1997). This graph plots weekly total index returns for Hong Kong (thick solid line), Thailand (dark dashed line), Indonesia (light dashed line), and Malaysia (thin solid line) from January to December 1997. Weekly total index returns are from Datastream.

Hong Kong index are caused by general global stock market linkages, rather than direct linkages to Hong Kong itself.[22]

This finding is also supported by the graph in Figure 2, in which we plot the time series of the stock index returns for some Asian countries from January 1997 to December 1997. The figure shows that the volatile period started much earlier than October 1997, the month in which the Hong Kong stock market crashed. According to Nouriel Roubini's account of the Asian Crisis and its global contagion,

> July 2—The Bank of Thailand announces a managed float of the Baht and calls on the International Monetary Fund for "technical assistance." The

[22] We also analyze the increases in correlations with the U.S. index during the turmoil period, which are similar to the increases in correlations with the world index. This finding is indicative of the size and centrality of the U.S. equity market.

> announcement effectively devalues the Baht by about 15–20%. It ends at a record low of 28.80 to the dollar. This is a trigger for the Asian crisis.[23]

Radelet and Sachs (1998) also report that "... the Thai Baht devaluation triggered the capital outflows from the rest of East Asia." Given the agreement that the trigger event of the Asian crisis is somehow associated with events that happened in Thailand, we reestimate the regime-switching model using Thailand as the crisis country.

The two regimes are also clearly defined using Thailand as the crisis country in estimating the regime-switching model. During the crisis regime, 23 of 30 emerging market countries have a higher accessible index volatility (column 2 in Table IV), and 19 of 27 emerging market countries have a higher inaccessible index volatility (column 8 in Table IV). Many of the volatility increases in emerging markets are significant at the 5% level. In addition, every developed country again shows higher volatility during the crisis regime, and all volatility increases are significant at the 1% level (column 8 in Table V).

As for Test 1, we find even stronger evidence for the existence of contagion using Thailand as the crisis source country. During the crisis regime, among 30 emerging market economies, 28 show increases in correlation with the Thailand index returns in accessible returns (column 4 in Table IV). Of these increases, 17 are significant at the 5% level and one other is significant at the 10% level. Among developed countries, all 15 show increases in correlation with the Thailand index returns (column 10 in Table V) and all 15 are significant at the 1% level. Furthermore, we observe that the increase in correlation is less pronounced for inaccessible returns than for accessible returns using Thailand as the crisis source country (columns 10 and 11 in Table IV).

Additionally, we find the following differences in results using Thailand as the crisis country: (1) Regimes are more persistent; (2) regime probabilities are smoother and the crisis period is more clearly defined; and (3) more countries have increased co-movement with the crisis country than with the world index during crisis periods. We now discuss each of these points in more detail.

First, estimated regimes are more persistent using Thailand as the crisis country. The probability that a week in the crisis regime will be followed by another week in the crisis regime is 0.685 using Hong Kong as the crisis country and 0.924 using Thailand as the crisis country. These results indicate that the crisis regime lasts on average about 3 weeks using Hong Kong as the crisis country and about 13 weeks using Thailand as the crisis country. Moreover, the probability that a week in the stable regime will be followed by another week in the stable regime is 0.923 using Hong Kong as the crisis country and 0.969 using Thailand as the crisis country. These results indicate that the stable regime lasts on average about 13 weeks using Hong Kong as the crisis country and about 32 weeks using Thailand as the crisis country. All four probability estimates are significant at the 1% level.

Second, regime probabilities obtained using Thailand as the crisis country (Panel B of Figure 3) are much smoother than those obtained using Hong Kong

[23] http://www.stern.nyu.edu/nroubini./asia/AsiaChronology1.html.

Table IV

Test 1: Existence of Contagion with Thailand as the Crisis Country (Regime-Switching Model).

This table reports differences in estimated moments across two regimes, separately for accessible and inaccessible returns: volatility (columns 2 and 8), correlation with the crisis country index return (columns 4 and 10), and correlations with the world index return (columns 6 and 12). The *t*-test statistics reported are of tests of equivalent volatility (columns 3 and 9), of equivalent correlation with the crisis country (columns 5 and 11), and of equivalent correlation with the world index return (columns 7 and 13), between the turmoil and stable regimes. The rejection of the null against the one-sided alternative that the turmoil regime volatility or correlation is greater, at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. *N* is the number of observations used in estimation. In the row below the differences are the numbers of countries with higher values during the turmoil period (positive differences) and the sign test *p*-value, for the test of the null hypothesis that the turmoil periods' values are not higher.

		Panel A: Accessible Returns						Panel B: Inaccessible Returns					
		Volatility		Corr C		Corr W		Volatility		Corr C		Corr W	
Emerging Markets	*N* (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)	Diff (8)	*t*-Stat (9)	Diff (10)	*t*-Stat (11)	Diff (12)	*t*-Stat (13)
Argentina	730	−0.210	−7.515	0.286	3.206***	0.236	2.984***	0.087	2.619***	0.047	0.375	0.007	0.056
Brazil	730	−0.054	−1.496	0.341	3.370***	0.258	3.531***	−0.019	−0.631	0.283	3.025***	0.176	2.124**
Chile	730	0.044	3.181***	0.235	2.897***	0.304	3.656***	0.009	0.733	0.113	1.292*	0.117	1.279
Colombia	560	0.010	0.463	0.096	0.137	0.198	0.256	−0.067	−1.648	−0.003	−0.021	0.114	0.730
Mexico	730	0.065	2.927***	0.262	3.038***	0.365	5.440***	0.034	3.156***	0.130	1.269	0.097	1.070
Peru	521	−0.032	−2.013	0.143	1.378*	0.206	1.459*	0.000	0.028	−0.007	−0.063	−0.032	−0.245
Venezuela	616	−0.057	−1.684	0.258	2.553***	0.016	0.147	0.028	1.059	0.025	0.220	−0.069	−0.537
China	521	0.172	6.307***	0.089	1.038	0.108	1.016	−0.226	−10.037	−0.117	−0.893	−0.025	−0.153
India	529	0.042	2.044**	0.230	2.387***	0.191	1.716**	0.039	1.940**	0.239	2.428***	0.207	1.855**
Indonesia	639	0.534	4.438***	0.244	0.117	0.246	1.417*	0.669	2.878***	0.137	0.056	0.160	0.229
Korea	573	0.347	9.966***	0.307	3.908***	0.085	0.706	0.332	11.743***	0.337	3.886***	0.092	0.734
Malaysia	730	0.287	16.185***	0.214	2.895***	0.078	0.884	0.289	15.265***	0.256	3.335***	0.086	0.980
Pakistan	552	0.098	3.766***	0.030	0.307	−0.025	−0.183	0.079	4.015***	0.039	0.373	−0.057	−0.407
Philippines	730	0.162	8.102***	0.315	4.588***	0.300	3.130***	0.201	10.045***	0.439	6.292***	0.321	3.615***
Sri Lanka	460	0.039	1.931**	0.219	1.737**	0.172	1.196	−0.014	−1.015	0.161	1.255	0.228	1.418*
Taiwan	625	0.040	0.926	0.258	2.727***	0.174	1.154	0.039	0.943	0.240	2.542***	0.169	1.108

(*continued*)

Table IV—*Continued*

		Panel A: Accessible Returns						Panel B: Inaccessible Returns					
		Volatility		Corr C		Corr W		Volatility		Corr C		Corr W	
Emerging Markets	*N* (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)	Diff (8)	*t*-Stat (9)	Diff (10)	*t*-Stat (11)	Diff (12)	*t*-Stat (13)
Czech Republic	469	0.042	1.656**	0.254	1.734**	0.302	1.706**	0.147	4.704***	0.125	0.636	0.049	0.221
Greece	565	0.122	4.623***	0.341	3.721***	0.367	4.115***	0.215	8.503***	0.165	1.357*	0.028	0.190
Hungary	520	0.133	5.936***	0.211	2.059**	0.325	2.940***	0.139	6.977***	−0.045	−0.327	−0.002	−0.011
Poland	455	−0.109	−4.030	0.286	2.373***	0.266	2.025**	–	–	–	–	–	–
Portugal	534	0.118	6.153***	0.347	3.968***	0.384	4.976***	0.123	5.588***	0.392	4.024***	0.360	4.189***
Russia	307	0.284	4.637***	0.155	0.907	0.120	0.822	0.343	2.756***	0.067	0.315	0.016	0.085
Slovakia	247	−0.030	−0.550	−0.076	−0.248	0.039	0.218	−0.034	−0.902	−0.086	−0.419	0.054	0.228
Egypt	308	0.011	0.537	0.064	0.364	0.079	0.468	−0.020	−0.847	0.031	0.144	0.066	0.336
Israel	312	0.062	2.391***	0.035	0.298	−0.026	−0.225	0.074	1.882**	0.066	0.430	0.077	0.505
Jordan	669	0.003	0.549	0.110	0.931	0.181	1.375*	0.006	1.230	0.123	1.044	0.243	1.946**
Morocco	307	−0.032	−1.832	−0.030	−0.188	0.083	0.449	−0.031	−1.496	−0.107	−0.593	0.083	0.490
South Africa	243	0.183	4.249***	0.432	4.168***	0.352	2.427***	–	–	–	–	–	–
Turkey	395	0.231	1.821**	0.244	1.053	0.157	0.960	–	–	–	–	–	–
Zimbabwe	434	0.166	6.702***	0.039	0.287	0.027	0.163	−0.331	−3.248	0.119	0.309	0.026	0.061
Number of Positive Differences		23		28		28		19		21		22	
Sign Test (*p*-value)		0.000		0.000		0.000		0.010		0.001		0.000	

Table V

Test 1: Existence of Contagion (Regime-Switching Model). Developed Markets

This table reports differences in estimated moments across two regimes separately for the model with Hong Kong as crisis country (Panel A) and Thailand as the crisis country (Panel B): volatility (columns 2 and 8), correlation with the crisis country index return (columns 4 and 10), and correlation with the world index return (columns 6 and 12). The *t*-test statistics reported are of tests of equivalent volatility (columns 3 and 9), of equivalent correlation with the crisis country index return (columns 5 and 11), and of equivalent correlation with the world index return (columns 7 and 13) between the turmoil and stable regimes. The rejection of the null against the one-sided alternative that the turmoil regime volatility or correlation is greater, at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. *N* is the number of observations used in the estimation. In the row below the differences are the numbers of countries with higher values during the turmoil period (positive differences) and the sign test *p*-value, for the test of the null hypothesis that the turmoil periods' values are not higher.

		Panel A: Hong Kong as the Crisis Country						Panel B: Thailand as the Crisis Country					
		Volatility		Corr C		Corr W		Volatility		Corr C		Corr W	
Developed Markets	*N* (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)	Diff (8)	*t*-Stat (9)	Diff (10)	*t*-Stat (11)	Diff (12)	*t*-Stat (13)
Australia	730	0.048	3.525***	0.092	1.101	0.212	2.958***	0.043	4.113***	0.301	4.032***	0.215	3.139***
Hong Kong	730	–	–	–	–	–	–	0.116	7.171***	0.265	3.863***	0.269	3.870***
Japan	730	0.099	4.847***	0.075	0.716	0.023	0.476	0.079	5.089***	0.359	4.426***	−0.097	−1.948
Singapore	730	0.172	8.614***	0.240	3.697***	0.173	2.122**	0.176	11.427***	0.347	5.771***	0.237	3.387***
Belgium	730	0.082	6.055***	0.126	1.190	0.220	3.480***	0.073	6.813***	0.217	2.431***	0.193	3.352***
France	730	0.092	5.687***	0.088	0.826	0.153	3.654***	0.082	6.603***	0.298	3.590***	0.182	5.273***
Germany	730	0.112	6.238***	0.051	0.530	0.161	3.579***	0.097	7.561***	0.245	2.923***	0.228	5.708***
Italy	730	0.105	6.496***	0.213	2.355***	0.272	4.206***	0.075	5.957***	0.212	2.623***	0.358	6.316***
Netherlands	730	0.106	7.978***	0.049	0.451	0.131	2.730***	0.100	9.977***	0.230	2.584***	0.115	2.708***
Spain	730	0.090	5.239***	0.087	0.885	0.213	3.670***	0.084	6.091***	0.297	3.569***	0.240	4.543***
Sweden	730	0.147	7.532***	0.018	0.180	0.206	4.007***	0.127	8.341***	0.236	2.609***	0.251	5.368***
Switzerland	730	0.103	6.658***	0.035	0.356	0.126	2.222**	0.075	6.978***	0.203	2.345***	0.144	3.002***
United Kingdom	730	0.079	6.285***	0.023	0.234	0.138	3.274***	0.054	5.864***	0.258	3.124***	0.171	4.301***
Canada	730	0.090	6.820***	−0.030	−0.294	0.109	2.305**	0.099	9.329***	0.219	2.592***	0.172	3.867***
United States	730	0.102	7.463***	−0.011	−0.096	0.110	3.642***	0.103	9.690***	0.222	2.527***	0.157	6.474***
Number of Positive Differences		14		12		14		15		15		14	
Sign Test (*p*-value)		0.000		0.001		0.000		0.000		0.000		0.000	

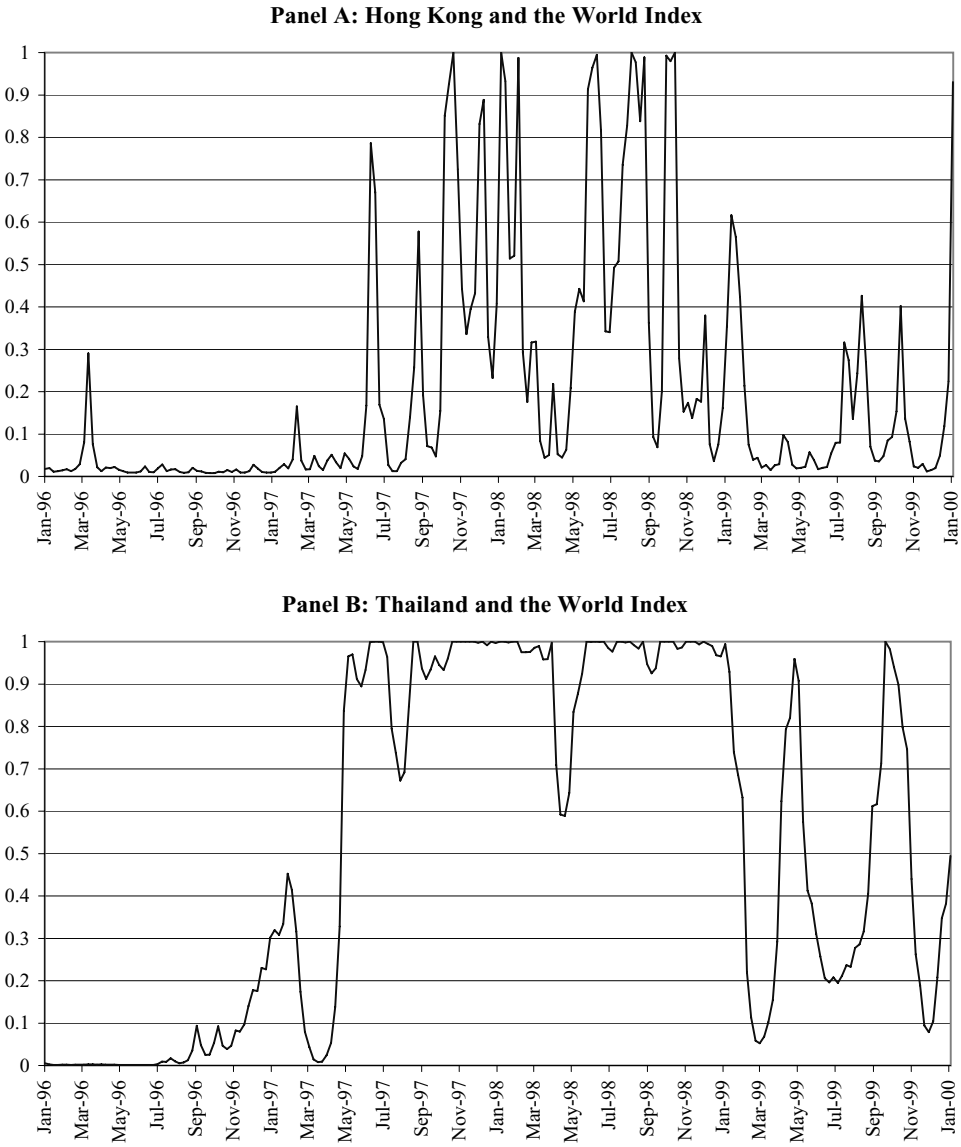

Figure 3. Regime probabilities (January 1996–January 2000). The graph in Panel A plots probabilities of the volatile regime for the period January 1996–January 2000 from the regime-switching model estimated using the Hong Kong stock index and the world index. The graph in Panel B plots probabilities of the volatile regime for the period January 1996–January 2000 from the regime-switching model estimated using the Thailand stock index and the world index.

as the crisis country (Panel A of Figure 3). These are estimates of smoothed inferences (Kim (1994)) for a subsample period from January 1996 though January 2000. Panel A of Figure 3 shows that when we estimate the regime-switching model using Hong Kong as the crisis country, the probability of being in the crisis regime frequently reaches unity between June 1997 and January 1999, and is also quite volatile, often fluctuating from as low as 10% to near unity during this period. The longest duration of the crisis regime occurs during the period from October 1997 to February 1998, during which the probability of being in the crisis regime is between 70% and 100%. Panel B of Figure 3 shows that when Thailand is used as the crisis source country, the probability of being in the crisis regime jumps dramatically from near zero to near unity in May 1997, and then stays near unity for much of the time until March 1999, only dipping down to 69% in August 1997 and to 59% in April 1998.

Third, more countries show a significant increase in correlation with the crisis country than with the world index in both accessible and inaccessible returns when using Thailand as the crisis country. For example, for emerging market accessible returns, 12 of 30 countries show a significant increase in correlation with the world index at the 5% level (column 6 in Table IV), compared with 17 of the same group that show a significant increase in correlation with the Thailand index at the 5% level (column 4 in Table IV). Similar patterns exist for inaccessible returns (columns 10 and 12 in Table IV) and index returns for developed countries (columns 10 and 12 in Table V). This observation substantiates our earlier finding that increases in correlation with the Hong Kong index in the crisis regime are likely to be caused by general global stock market linkages, while increases in correlation with the Thailand index during the crisis are more likely to be caused by direct linkages to Thailand itself, rather than global shocks originating elsewhere.

The first two findings described above indicate the two regimes are more clearly defined using Thailand as the crisis country than Hong Kong. The third finding suggests the Asian crisis originated in Thailand. On another note, our results indicate the Asian crisis could have started much earlier and lasted much longer than the 1-month period (from October 17 to November 16, 1997) defined by Forbes and Rigobon (2002). These results point out the difficulties in correctly specifying regimes with exogenously defined periods. We therefore focus the discussion of our results with endogenously defined regimes, using Thailand rather than Hong Kong as the crisis country.

To differentiate between changes in correlation caused by stock market and exchange rate shocks, we decompose the contemporaneous correlation of returns denominated in U.S. dollars to separate out the correlation component not influenced by exchange rate movements. This component is a weighted correlation calculated from returns denominated in local currencies (see Appendix B for details). We therefore refer to this component of correlation as the "LC component."

Results excluding the effects of exchange rates mirror the findings using returns denominated in U.S. dollars. First, returns denominated in local currencies exhibit a clear definition of two regimes (volatile and stable): 23 of 30

accessible return series and 20 of 28 inaccessible return series in emerging markets (columns 1 and 5 in Table VI, Panel A), as well as all 15 developed country indices (column 1 in Table VI, Panel B) show an increase in volatility during the crisis regime. Second, there is evidence that the LC component of the correlation of accessible returns with the crisis country increases for several countries during the crisis regime: 25 of 30 emerging market accessible return series show an increase in the LC component of correlation with the crisis country during the crisis regime, eight of which are significant at the 5% level and four others of which are significant at the 10% level (columns 3 and 4 in Table VI, Panel A). In addition, all 15 developed country stock index series show an increase in the LC component of correlation with the crisis country, all of which are significant at the 1% level (columns 3 and 4 in Table VI, Panel B). The sign tests reject the null hypothesis that the LC components of correlation do not increase during crises at the 1% level for accessible returns and developed countries, which lends support to the conjecture that stock market contagion is unrelated to exchange rate shocks.

Test results for the LC component of correlation also reflect one important difference from the findings using correlations calculated from returns denominated in U.S. dollars. The sign test cannot reject the null that the LC component of correlation does not increase during crises for inaccessible stock returns (column 7 in Table VI, Panel A). Only 15 of 27 inaccessible return series show an increase in the LC component of correlation with the crisis country, three of which are significant at the 5% level and one other of which is significant at the 10% level (column 8 in Table VI, Panel A). Since inaccessible stocks are restricted to local investors only, the fact that we find no evidence for increasing co-movement of inaccessible returns with the crisis country during the crisis regime, but do find clear evidence that accessible returns increase in co-movement with the crisis country during the crisis regime, supports the investor-induced contagion hypothesis. Additionally, this finding highlights another insight brought forward by decomposing currency effects: External shocks appear to have a more pronounced effect on accessible returns and exchange rates than on inaccessible returns.[24]

We also conduct several robustness checks of our results. Specifically, to control for the extent of accessibility changes over time, first we construct value-weighted constant accessibility/inaccessibility indices for each country using a subsample of firms whose IFC-designated accessibility measure, degree of open factor, varies at most 0.25 for the period from January 1994 to December 2002 and reestimate our model using these constant accessibility indices; second, we reestimate our model for the subsample period January 1, 1996–December 31, 2002. In both cases, we obtain slightly stronger results.

In summary, when we compare co-movements of accessible and inaccessible returns with the crisis country returns, we find that (1) many emerging market

[24] We find that, in most cases, volatility and correlation estimates excluding the currency effect are slightly smaller than those obtained using U.S. dollar returns. This finding indicates that exchange rates are often positively correlated with the local stock market, and that exchange rate fluctuations are small relative to fluctuations in the stock market.

Table VI

Test 1: Existence of Contagion (Regime-Switching Model with Currency Decomposition)

This table reports difference in estimated moments between the stable and turmoil regimes for emerging markets' accessible and inaccessible returns (Panel A) and developed markets (Panel B) excluding exchange rate effects. Differences in volatility are reported in columns 1 and 5. Differences in correlation with the crisis country index return are reported in columns 3 and 7. The *t*-test statistics reported are of tests of equivalent volatility (columns 2 and 6) and of equivalent correlation with the crisis country index return (columns 4 and 8) between the turmoil and stable regimes. The rejection of the null against the one-sided alternative that the turmoil regime volatility or correlation is greater, at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. In the row below the differences are the numbers of countries with higher values during the turmoil period (positive differences) and the sign test *p*-value for the test of the null hypothesis that the turmoil periods' values are not higher.

	Accessible Returns				Inaccessible Returns			
	Volatility		Corr with Crisis		Volatility		Corr with Crisis	
	Diff (1)	*t*-Stat (2)	Diff (3)	*t*-Stat (4)	Diff (5)	*t*-Stat (6)	Diff (7)	*t*-Stat (8)
Panel A: Emerging Markets								
Argentina	−0.175	−2.816	0.180	0.907	0.081	2.081**	−0.005	−0.041
Brazil	−1.783	−53.250	−0.021	−0.006	−1.783	−53.062	−0.120	−0.030
Chile	0.038	5.389***	0.139	1.943**	0.007	0.856	0.025	0.306
Colombia	−0.006	−0.239	0.092	1.105	−0.072	−2.785	−0.020	−0.126
Mexico	0.074	6.479***	0.169	2.517***	0.064	5.517***	0.067	0.788
Peru	−0.032	−2.522	0.089	0.941	0.007	0.623	−0.006	−0.054
Venezuela	0.011	0.501	0.229	2.599***	0.127	5.719***	−0.002	−0.023
China	0.161	6.907***	−0.055	−0.492	−0.224	−6.384	−0.110	−0.683
India	0.040	12.454***	0.133	1.322*	0.037	10.968***	0.141	1.388*
Indonesia	0.267	0.300	0.018	0.005	0.398	0.482	−0.034	−0.008
Korea	0.205	9.237***	0.135	1.945**	0.190	8.184***	0.153	2.062**
Malaysia	0.192	14.067***	0.005	0.093	0.190	13.881***	0.045	0.748
Pakistan	0.096	8.394***	0.000	−0.003	0.076	5.020***	0.016	0.151
Philippines	0.091	13.975***	0.113	2.035**	0.129	18.823***	0.225	4.141***
Sri Lanka	0.036	4.130***	0.212	1.628*	−0.018	−1.527	0.109	0.820
Taiwan	0.025	9.561***	0.100	0.811	0.023	8.821***	0.090	0.757
Czech Republic	0.014	0.695	0.126	1.010	0.148	7.616***	0.044	0.206
Greece	0.140	5.120***	0.280	2.474***	0.212	9.173***	0.087	0.605
Hungary	0.126	6.502***	0.152	1.359*	0.142	7.115***	−0.071	−0.582
Poland	−0.145	−5.013	0.159	1.575*	–	–	–	–
Portugal	0.153	7.407***	0.340	3.048***	0.157	8.202***	0.389	3.008***
Russia	0.258	4.077***	0.053	0.394	0.316	5.257***	−0.014	−0.105
Slovakia	−0.021	−0.507	−0.084	−0.282	−0.030	−0.793	−0.097	−0.393
Egypt	0.006	0.234	0.063	0.328	−0.019	−0.509	0.088	0.404
Israel	0.044	1.626*	−0.031	−0.238	0.045	3.158***	−0.021	−0.121
Jordan	0.015	4.045***	0.093	0.923	0.020	4.794***	0.099	1.007
Morocco	−0.026	−1.880	−0.062	−0.377	−0.030	−2.249	−0.114	−0.637
South Africa	0.182	4.157***	0.332	2.151**	–	–	–	–
Turkey	0.077	0.473	0.190	0.572	–	–	–	–
Zimbabwe	0.073	0.505	0.013	0.018	0.098	0.574	0.033	0.045
Number of Positive Differences	23		25		20		15	
Sign Test (*p*-value)	0.001		0.000		0.003		0.221	

(*continued*)

Table VI—*Continued*

	Accessible Returns			
	Volatility		Corr with Crisis	
	Diff (1)	*t*-Stat (2)	Diff (3)	*t*-Stat (4)
Panel B: Developed Markets				
Australia	0.027	3.156***	0.129	2.094**
Hong Kong	0.117	7.540***	0.133	1.844**
Japan	0.055	4.143***	0.202	3.225***
Singapore	0.139	9.637***	0.125	2.365***
Belgium	0.085	9.300***	0.140	1.772**
France	0.090	6.895***	0.215	2.635***
Germany	0.112	8.806***	0.165	2.142**
Italy	0.094	7.665***	0.169	2.311**
Netherlands	0.112	11.279***	0.152	1.809**
Spain	0.093	7.371***	0.229	2.938***
Sweden	0.111	7.533***	0.145	1.824**
Switzerland	0.110	11.944***	0.157	2.042**
United Kingdom	0.065	5.913***	0.177	2.032**
Canada	0.087	9.203***	0.149	2.025**
United States	0.103	13.007***	0.222	4.233***
Number of Positive Differences	15		15	
Sign Test (*p*-value)	0.000		0.000	

countries have a significant increase in correlation with the crisis country market returns during the turmoil period (or the volatile regime) and this pattern is more pronounced for accessible returns than for inaccessible returns; (2) the correlation results and estimates of smoothed inferences suggest that the crisis originated in Thailand rather than in Hong Kong; and (3) our findings are robust to alternative currency denominations, accessible/inaccessible definitions, and subsample estimations. These results provide supporting evidence for the existence of stock market contagion during the 1997 Asian crisis period and support the investor-induced contagion hypothesis.

B. Test 2: Fundamental Based or Investor Induced?

Having established that correlations increase during crises, we now turn to Test 2 and investigate why we observe such patterns in the data. We first examine whether the difference in co-movement across crisis and stable regimes is more pronounced for accessible stocks than for inaccessible stocks (Test 2A), the results of which are presented in Table VII. We then investigate whether accessible stocks lead inaccessible stocks (Test 2B), the results of which are reported in Table VIII.

Table VII shows the more pronounced impact of the crisis shock on accessible stocks than inaccessible stocks. The difference-in-difference statistic, that is, the difference in the change in correlation with the crisis country (crisis minus stable) across stock indices (accessible minus inaccessible) described in Test 2A,

Table VII

Test 2: Fundamental-Based versus Investor-Induced Contagion with Thailand as the Crisis Country (Regime-Switching Model).

This table reports the difference-in-difference statistics specified in Test 2 to compare the correlation dynamics of accessible and inaccessible returns with the crisis country during the turmoil regime. The rejection of the null, against the one-sided alternative that correlations between accessible and crisis country returns increase more than correlations between inaccessible and crisis country returns during the turmoil regime at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. Panel A reports estimation results using U.S. dollar-denominated returns. Panel B reports estimation results excluding exchange rate effects, indicated by LC. In the row below the differences are the numbers of countries with higher values for the accessible returns (positive differences) and the sign test p-value for the test of the null hypothesis that the accessible return differences are not higher.

	Panel A: U.S. Dollars		Panel B: LC	
Emerging Markets	Diff-in-Diff (1)	t-Stat (2)	Diff-in-Diff (3)	t-Stat (4)
Argentina	0.239	1.822**	0.185	1.017
Brazil	0.057	1.106	0.100	0.236
Chile	0.122	1.554*	0.114	1.605*
Colombia	0.099	0.157	0.113	0.766
Mexico	0.132	1.240	0.102	1.019
Peru	0.150	1.342*	0.095	0.906
Venezuela	0.233	2.588***	0.231	2.496***
China	0.205	1.405*	0.055	0.292
India	−0.009	−0.533	−0.008	−0.396
Indonesia	0.107	0.305	0.052	0.098
Korea	−0.029	−0.535	−0.018	−0.350
Malaysia	−0.043	−1.069	−0.040	−1.101
Pakistan	−0.009	−0.121	−0.016	−0.203
Philippines	−0.124	−2.661	−0.112	−2.656
Sri Lanka	0.058	0.741	0.103	1.172
Taiwan	0.018	1.398*	0.009	0.791
Czech Republic	0.129	0.544	0.082	0.346
Greece	0.176	1.393*	0.194	1.472*
Hungary	0.255	1.913**	0.223	1.651**
Portugal	−0.045	−0.698	−0.048	−0.661
Russia	0.088	0.290	0.067	0.573
Slovakia	0.011	0.040	0.013	0.046
Egypt	0.033	0.159	−0.026	−0.124
Israel	−0.032	−0.219	−0.010	−0.064
Jordan	−0.013	−0.391	−0.006	−0.195
Morocco	0.077	0.548	0.052	0.364
Zimbabwe	−0.079	−0.209	−0.019	−0.062
Number of Positive Differences	18		17	
Sign Test (p-value)	0.026		0.061	

Table VIII

Test 2: Fundamental-Based versus Investor-Induced Contagion (Lead-Lag Relationship). Crisis Country: Thailand

This table exhibits contemporaneous correlations and 1-week lag correlations between accessible and inaccessible returns during the crisis period. The crisis period is defined by the regime-switching model using Thailand as the crisis country. Results using returns denominated in U.S. dollars are reported in Panel A. Results excluding exchange rate effects are reported in Panel B. Contemporaneous correlations between accessible and inaccessible stock index returns are reported in columns 1 and 6. Correlations between inaccessible returns and 1-week lagged accessible returns are presented in columns 2 and 7. Correlations between accessible returns and 1-week lagged inaccessible returns are presented in columns 3 and 8. In the row below the differences are the numbers of countries with higher values during the turmoil period (positive difference) and the sign test p-value for the test of null hypothesis that accessible stocks do not lead inaccessible stocks during crises.

	Panel A: U.S. Dollars					Panel B: LC				
Emerging Markets	Contemporaneous Correlation (1)	Lag Accessible (2)	Lag Inaccessible (3)	Difference (2)–(3) (4)	t-Stat (5)	Contemporaneous Correlation (6)	Lag Accessible (7)	Lag Inaccessible (8)	Difference (7)–(8) (9)	t-Stat (10)
Argentina	0.261	0.092	−0.011	0.103	0.655	0.350	0.098	0.004	0.094	0.221
Brazil	0.890	0.159	0.046	0.113	1.549*	20.659	−0.593	−0.628	0.036	0.014
Chile	0.567	0.207	0.174	0.033	0.327	0.427	0.218	0.143	0.075	0.756
Colombia	0.542	0.115	0.216	−0.101	−0.619	0.390	0.114	0.179	−0.065	−0.379
Mexico	0.488	0.284	0.028	0.256	2.542***	0.261	0.202	−0.018	0.220	2.602***
Peru	0.436	0.040	0.159	−0.119	−0.884	0.397	0.048	0.153	−0.105	−0.736
Venezuela	0.477	0.142	0.106	0.037	0.316	0.449	0.153	0.122	0.031	0.339
China	0.130	0.102	−0.028	0.130	0.872	0.131	0.100	−0.029	0.129	0.939
India	0.991	0.125	0.104	0.021	0.938	0.918	0.113	0.092	0.021	0.959
Indonesia	0.825	−0.096	−0.190	0.094	1.510*	0.257	−0.001	−0.080	0.079	1.757**
Korea	0.933	−0.134	−0.153	0.019	0.423	0.503	−0.045	−0.067	0.022	0.633
Malaysia	0.953	−0.073	−0.047	−0.027	−0.646	0.587	−0.025	0.005	−0.029	−0.846
Pakistan	0.787	0.305	0.188	0.116	1.557*	0.768	0.291	0.160	0.131	1.715**
Philippines	0.899	0.094	−0.018	0.112	2.416***	0.575	0.103	0.006	0.097	2.617***
Sri Lanka	0.828	0.168	0.191	−0.023	−0.245	0.801	0.168	0.207	−0.039	−0.409
Taiwan	0.989	−0.011	−0.002	−0.009	−0.440	0.852	−0.022	−0.014	−0.009	−0.484

(*continued*)

Table VIII—*Continued*

	Panel A: U.S. Dollars					Panel B: LC				
Emerging Markets	Contemporaneous Correlation (1)	Lag Accessible (2)	Lag Inaccessible (3)	Difference (2)–(3) (4)	*t*-Stat (5)	Contemporaneous Correlation (6)	Lag Accessible (7)	Lag Inaccessible (8)	Difference (7)–(8) (9)	*t*-Stat (10)
Czech Republic	0.347	0.031	0.023	0.007	0.031	0.235	0.053	0.017	0.036	0.185
Greece	0.463	0.101	−0.177	0.278	2.892***	0.425	0.135	−0.119	0.254	2.310**
Hungary	0.314	0.050	0.042	0.007	0.044	0.303	0.047	0.052	−0.006	−0.033
Poland	–	–	–	–	–	0.355	0.015	−0.040	0.055	0.354
Portugal	0.878	0.112	−0.047	0.159	1.983**	0.888	0.202	0.020	0.182	2.147**
Russia	0.646	0.110	0.198	−0.087	−1.039	0.553	0.071	0.061	0.010	0.067
Slovakia	0.207	0.129	0.113	0.016	0.068	0.128	0.114	0.086	0.027	0.117
Egypt	0.550	−0.034	0.159	−0.193	−0.998	0.514	0.004	0.149	−0.145	−0.805
Israel	0.668	−0.098	−0.083	−0.015	−0.105	0.521	−0.049	−0.077	0.028	0.238
Jordan	0.932	0.073	0.059	0.014	0.298	0.944	0.086	0.074	0.012	0.305
Morocco	0.613	0.165	0.103	0.062	0.348	0.479	0.131	0.124	0.008	0.037
South Africa	–	–	–	–	–	0.395	0.302	0.172	0.130	0.967
Turkey	–	–	–	–	–	−0.052	0.011	0.032	−0.021	−0.006
Zimbabwe	0.954	0.077	0.058	0.018	0.481	0.554	−0.010	−0.019	0.009	0.240
Number of Positive Differences				19					22	
Sign Test (*p*-value)				0.010					0.000	

is positive for most countries. Of the 27 emerging market countries, 18 show a more pronounced increase in correlation in accessible U.S. dollar-denominated returns than the corresponding inaccessible returns during crises (column 1 in Table VII). Three are significant at the 5% level and six others are significant at the 10% level. The sign test rejects the null hypothesis of zero difference-in-difference across all countries at the 5% level. Results for the LC component of correlations are similar albeit slightly weaker. Of the 27 countries in the sample, 17 show a more pronounced increase in correlation in accessible returns than inaccessible returns during the crisis regime, nearly the same number as in Panel A (column 3 in Table VII). Of these difference-in-difference measures, two are significant at the 5% level and two others are significant at the 10% level. The sign test rejects the null hypothesis of zero difference-in-difference across all countries at the 10% level. These findings strongly support the investor-induced contagion hypothesis.

It is also interesting to note that the difference-in-difference measures are particularly large and positive for countries outside Asia. For returns denominated in U.S. dollars, the average difference-in-difference measure for countries outside Asia is 0.091 and for countries within Asia is 0.019. Similar results are obtained for the correlation component that excludes the currency effect. This indicates the Thailand crisis shock was quick to spread to inaccessible returns in Asia but slow to spread to inaccessible returns in countries outside Asia. Overall, these findings suggest that foreign investor holdings were especially instrumental in spreading the Asian crisis to countries outside Asia.

Next, we turn to Test 2B and examine the relative magnitude of cross-autocorrelations during crises between (1) accessible returns and lagged inaccessible returns and (2) inaccessible returns and lagged accessible returns. To obtain these cross-autocorrelations, we estimate the coefficients of a regime-switching model for each country that characterizes the joint data generating process of accessible returns, inaccessible returns, 1-week lagged accessible returns, 1-week lagged inaccessible returns, the world index, and the crisis country index. We report the results for the returns denominated in U.S. dollars in Panel A of Table VIII and the results for the LC components of cross-autocorrelation in Panel B of Table VIII.

The results in Table VIII indicate that accessible returns lead inaccessible returns during the crisis regime and that the effect is slightly stronger for the LC components of cross-autocorrelation. For returns denominated in U.S. dollars, of the 27 emerging market economies, 19 show higher cross-autocorrelations between inaccessible and lagged accessible returns than between accessible and lagged inaccessible returns (column 4 in Table VIII). For four countries, the differences in cross-autocorrelation are significant at the 5% level and for three others the differences are significant at the 10% level. The sign test rejects the null hypothesis that the accessible stocks do not lead inaccessible stocks during the crisis period at the 1% level. For the LC components, of the 27 countries, 22 show higher cross-autocorrelations between inaccessible and lagged accessible returns than between accessible and lagged inaccessible returns (column 9 in Table VIII). For six countries, the differences are significant at the 5% level.

Again, the sign test rejects the null hypothesis that accessible stocks do not lead inaccessible stocks during crises at the 1% level.

To summarize, we find statistical evidence that during the turmoil period, increases in co-movement with the crisis country are more pronounced for accessible than inaccessible returns, and accessible returns lead inaccessible returns during crises. These findings indicate that accessible returns act as a larger channel for crisis transmission and provide supporting evidence for the investor-induced contagion hypothesis.

C. Test 3: Portfolio Rebalancing or Wealth Constraint?

Having found supportive evidence of the investor-induced contagion hypothesis, we now turn to Test 3 and further investigate the mechanism by which crises spread through investor holdings. We first examine whether the increase in correlation with the crisis country is more pronounced in the negative tail (Test 3A). We then investigate correlation dynamics between government bond and local stock index returns within each country (Test 3B).

In Table IX we report the exceedance correlation results at a threshold level of 1.5 standard deviations away from the mean.[25] We find evidence that negative tail correlations are larger than positive tail correlations for emerging markets (Panel A, Table IX). For accessible returns, 24 countries have larger correlations in the negative tails. Of these 25 positive differences, 6 are significant at the 5% level, and 3 others are significant at the 10% level. For inaccessible returns, 20 countries have larger correlations in the negative tails. Of these 20 positive differences, 4 are significant at the 5% significance level, and 2 others are significant at the 10% level. The results for inaccessible returns are slightly weaker than the results for accessible returns, but in both cases the sign test rejects the null hypothesis that correlations are equal in both tails. Therefore, the null hypothesis of Test 3 is rejected for emerging market countries: Higher correlations in the negative tail suggest that portfolio rebalancing is unlikely to be the channel through which crises spread among emerging markets.

In contrast, for developed countries, the null hypothesis of Test 3A cannot be rejected (Panel B, Table IX). Of the 15 countries, 9 have larger correlations in the negative tails, and only one of these increases is significant at the 10% level. This finding suggests portfolio rebalancing can be a mechanism through which crises spread to developed countries.

Turning to Test 3B, to obtain measures of correlation between stock and government bond indices, for each country we estimate coefficients of a regime-switching model that characterizes the joint data generating process of the crisis country index, the world index, government bond index, accessible index, and, when available, inaccessible index. We report estimates of the change in

[25] We also estimate exceedance correlations at one and two deviations away from the mean and confirm that results are similar. In addition, we find evidence of asymmetry similar to Longin and Solnick (2001) in that correlations are decreasing in the threshold for the positive tail, but nondecreasing in the threshold for the negative tail.

Table IX

Test 3: Portfolio Balancing versus Wealth Constraint with Thailand as the Crisis Country (Exceedance Correlation).

This table reports exceedance correlation estimates and the difference between negative and positive tails (negative minus positive), at 1.5 standard deviations away from the mean, for emerging markets in Panel A and for developed markets in Panel B. The rejection of the null, against the one-sided alternative that the negative tail correlation is greater, at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. In the row below the differences are the numbers of countries with higher correlations in the negative tail (positive differences) and the sign test *p*-value, for the test of null hypothesis that the negative tail correlations are not higher.

	Accessible Returns				Inaccessible Returns			
	Correlation		Difference		Correlation		Difference	
	Positive	Negative	Neg. – Pos.	*t*-Stat	Positive	Negative	Neg. – Pos.	*t*-Stat
Panel A: Emerging Markets								
Argentina	0.000	0.102	0.102	1.450*	0.000	0.000	0.000	1.080
Brazil	0.002	0.191	0.189	2.400***	0.009	0.128	0.119	1.700**
Chile	0.086	0.153	0.066	0.661	0.033	0.146	0.113	1.260
Colombia	0.011	0.006	−0.005	−0.051	0.000	0.000	0.000	−0.029
Mexico	0.033	0.282	0.250	2.230**	0.030	0.110	0.080	0.791
Peru	0.056	0.225	0.170	1.430*	0.001	0.094	0.094	1.140
Venezuela	0.073	0.085	0.011	0.102	0.002	0.170	0.168	1.940**
China	0.088	0.406	0.318	2.120**	0.001	0.000	−0.001	−3.790
India	0.060	0.292	0.232	1.840**	0.066	0.282	0.216	1.720**
Indonesia	0.615	0.413	−0.202	−1.410	0.547	0.381	−0.166	−1.070
Korea	0.404	0.490	0.086	0.606	0.371	0.541	0.170	1.220
Malaysia	0.394	0.521	0.127	0.986	0.394	0.439	0.046	0.341
Pakistan	0.028	0.203	0.175	1.610*	0.000	0.184	0.184	2.120**
Philippines	0.284	0.390	0.106	0.835	0.381	0.516	0.135	1.120
Sri Lanka	0.071	0.085	0.014	0.113	0.054	0.060	0.006	0.047
Taiwan	0.185	0.320	0.135	1.080	0.148	0.292	0.144	1.150
Czech Republic	0.078	0.190	0.112	0.841	0.263	0.059	−0.204	−1.610
Greece	0.141	0.284	0.143	1.180	0.018	0.207	0.189	1.640*
Hungary	0.124	0.358	0.235	1.680**	0.001	0.153	0.152	1.460*
Poland	0.000	0.110	0.110	1.280	0.009	0.032	0.023	0.298
Portugal	0.326	0.268	−0.058	−0.392	0.223	0.316	0.093	0.629
Russia	0.286	0.325	0.039	0.241	0.280	0.304	0.025	0.140
Slovakia	0.002	0.066	0.064	0.521	0.002	0.000	−0.002	−1.870
Egypt	0.002	0.000	−0.001	−0.278	0.012	0.000	−0.012	−0.034
Israel	0.360	0.197	−0.164	−0.621	0.009	0.068	0.059	0.637
Jordan	0.024	0.036	0.012	0.163	0.035	0.025	−0.009	−0.126
Morocco	0.001	0.000	0.000	−0.683	0.000	0.000	0.000	−0.712
South Africa	0.310	0.398	0.089	0.637	0.175	0.192	0.018	0.083
Turkey	0.000	0.211	0.211	2.510***	0.011	0.009	−0.002	–
Zimbabwe	0.012	0.233	0.221	0.520	0.005	0.370	0.365	–
Number of Positive Differences			25				20	
Sign Test (*p*-value)			0.000				0.006	

(*continued*)

Table IX—*Continued*

	Accessible Returns			
	Correlation		Difference	
	Positive	Negative	Neg. − Pos.	*t*-Stat
Panel B: Developed Markets				
Australia	0.213	0.312	0.098	0.859
Japan	0.307	0.471	0.164	1.380*
Hong Kong	0.164	0.292	0.128	1.100
Singapore	0.493	0.629	0.135	1.160
Belgium	0.161	0.165	0.003	0.029
France	0.282	0.190	−0.092	−0.792
Germany	0.204	0.198	−0.007	−0.056
Italy	0.200	0.223	0.023	0.193
Netherlands	0.201	0.234	0.033	0.280
Spain	0.287	0.218	−0.069	−0.597
Sweden	0.233	0.134	−0.099	−0.887
Switzerland	0.198	0.223	0.024	0.203
UK	0.194	0.084	−0.110	−1.040
Canada	0.220	0.271	0.051	0.421
US	0.196	0.166	−0.031	−0.272
Number of Positive Differences			9	
Sign Test (*p*-value)			0.151	

government bond return volatility and the change in government bond return correlation with the stock returns in the same country in Table X.

The change in government bond return volatility from the stable to the crisis regime is quite different for emerging market and developed countries. Of 20 emerging markets, 14 countries show an increase in government bond return volatility during the crisis regime, with 10 countries statistically significant at the 1% level (column 2 in Table X, Panel A). The sign tests indicate that government bond return volatility in emerging markets is increasing during the crisis regime. In contrast, of the 13 developed countries, only Switzerland shows a small increase in volatility and the remaining 12 countries show decreases in volatility during the crisis regime (column 2 in Table X, Panel B). The sign test cannot reject the null hypothesis that government bond volatility does not increase during the crisis regime, which is consistent with the phenomenon of a flight to quality in the time of crisis in developed countries.

We observe similar contrasting patterns between emerging market and developed countries when examining the change in government bond return correlation with the stock returns in the same country. During the crisis regime, 14 of the 20 emerging market countries show an increase in government bond return correlation with the accessible returns in the same country (column 5 in Table X, Panel A). Of these increases, three are significant at the 5% level and four others are significant at the 10% level. For inaccessible returns, 10 of the 17 countries show an increase in government bond return correlation, 2 of

which are significant at the 5% level (column 7 in Table X, Panel A). The sign test rejects the null hypothesis that the return correlations between stocks and government bonds do not increase during the turmoil regime at the 5% level for accessible returns but not for inaccessible returns. In contrast, no developed countries show an increase in correlation between government bonds and stock

Table X

Correlationb between Stock and Government Bond Returns with Thailand as the Crisis Country.

This table reports differences (turmoil minus stable) in bond volatility and differences in correlations between government bond and stock (separately for accessible and inaccessible) index returns, for emerging markets in Panel A and for developed markets in Panel B. The *t*-test statistics reported are tests of equivalent bond volatility (3), of equivalent correlations between government bond and stock index returns (accessible returns (5), inaccessible returns (7)). The rejection of the null against the one-sided alternative at the 10%, 5%, and 1% significance levels, is denoted by *, **, and ***, respectively. *N* is the number of observations used in the estimation. In the row below the differences are the number of countries with higher volatility or correlations in the turmoil period (positive differences) and sign test *p*-values for the test of null hypothesis that the turmoil periods' values are not higher.

				Corr Bond			
	Bond Volatility			Accessible Returns		Inaccessible Returns	
	N (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)	Diff (6)	*t*-Stat (7)
Panel A: Emerging Markets							
Argentina	469	−0.071	0.000	0.147	0.000	0.044	0.000
Brazil	469	0.058	3.193***	0.153	1.465*	0.069	0.647
Chile	187	0.000	0.025	0.034	0.102	0.047	0.115
Colombia	243	0.068	4.680***	0.072	0.350	−0.006	−0.025
Mexico	469	−0.011	−1.007	−0.034	−0.335	−0.063	−0.693
Peru	469	−0.037	−2.794	0.173	1.523*	−0.016	−0.117
Venezuela	408	0.064	5.283***	0.444	2.752***	0.101	0.649
Korea	469	0.073	17.296***	0.345	3.468***	0.337	3.613***
Malaysia	468	0.031	9.556***	0.248	1.585*	0.201	1.357
Thailand	291	0.130	14.871***	0.340	2.008**	0.356	2.074**
Czech Republic	139	0.000	0.012	−0.163	−0.546	−0.050	−0.048
Hungary	204	0.002	0.506	−0.218	−0.989	0.031	0.116
Poland	407	−0.087	−8.364	0.256	1.315*	–	–
Portugal	323	−0.017	−5.470	−0.226	−1.395	−0.113	−0.706
Russia	307	0.326	8.884***	0.081	0.584	0.130	0.376
Slovakia	247	−0.053	−1.404	0.010	0.004	0.007	0.002
Egypt	73	0.129	2.475***	−0.066	−0.091	−0.012	−0.028
Morocco	307	0.123	12.223***	−0.115	−0.615	−0.034	−0.195
South Africa	139	0.154	7.864***	0.224	0.901	–	–
Turkey	165	0.012	0.068	0.110	0.238	–	–
Number of Positive Differences		14		14		10	
Sign Test (*p*-value)		0.021		0.021		0.166	

(*continued*)

Table X—*Continued*

		Bond Volatility		Corr Bond Accessible Returns	
	N (1)	Diff (2)	*t*-Stat (3)	Diff (4)	*t*-Stat (5)
Panel B: Developed Markets					
Australia	520	−0.002	−0.488	−0.146	−1.168
Japan	520	−0.008	−4.222	−0.063	−0.456
Belgium	520	−0.009	−3.726	−0.176	−1.502
France	520	−0.004	−1.955	−0.302	−2.556
Germany	520	−0.002	−0.687	−0.220	−1.967
Italy	520	−0.020	−7.910	−0.392	−3.315
Netherlands	520	−0.003	−1.385	−0.239	−2.003
Spain	520	−0.018	−7.591	−0.360	−2.786
Sweden	520	−0.017	−6.807	−0.193	−1.607
Switzerland	520	0.000	0.283	−0.172	−1.308
UK	520	−0.002	−1.013	−0.275	−2.345
Canada	520	−0.010	−3.640	−0.319	−3.688
US	520	−0.002	−0.704	−0.235	−2.025
Number of Positive Differences		1		0	
Sign Test (*p*-value)		0.998		1.000	

returns of the same country during the crisis regime (column 5 in Table X, Panel B).

The increase in correlation between government bond and accessible stock returns in emerging markets during the crisis regime suggests that wealth constraints are binding in these countries. One plausible explanation for the increase in co-movement between risky and safe assets within a country during a crisis is that international investors withdraw capital from both equity and bond markets and wealth-constrained local investors are unable to arbitrage away the price impact of foreign trades. Our results are not consistent with the alternative view that local investors, constrained to invest locally, rebalance their portfolios in a flight to quality, since we do not observe any change in correlation between government bond and inaccessible returns. In developed markets, however, there is strong evidence for active portfolio rebalancing activities during crises since we observe decreases in correlations between government bond and equity returns for all countries.

To summarize, both Test 3A with exceedance correlations and Test 3B with government bond and stock correlations show that the null hypothesis that stock markets are spread through the need for portfolio rebalancing can be rejected for emerging markets, but not for developed markets. These results further support the hypothesis that asymmetric market frictions, such as wealth constraints, spread the Asian crisis across emerging market countries, and that symmetric market frictions, such as portfolio rebalancing, propagated the crisis shock to developed countries.

V. Conclusion

In this paper we find evidence supporting the hypothesis that crises spread through the asset holdings of investors. We estimate and compare the degree to which accessible and inaccessible returns co-move with the crisis country returns in the case of the 1997 Asian crisis. Our analysis using Thailand as the crisis country reveals that correlations with the crisis country do increase during the turmoil period, and that the increase is especially prevalent for accessible returns, indicating that the crisis was transmitted through accessible stocks. We also estimate and compare co-movement of accessible and inaccessible returns with the crisis country after separating out the effects of exchange rate shocks. We find that our results are not driven by correlated exchange rates. Furthermore, we find evidence that accessible stocks are not fundamentally different from inaccessible stocks in terms of industry distributions, implying that differences in cash flow fundamentals cannot explain the increase in correlations.

We use three alternative measures to investigate the transmission mechanism of the crisis through investor holdings. First, we estimate and compare cross-autocorrelations between accessible and inaccessible returns for each country during the turmoil period. We find evidence that accessible stocks lead inaccessible stocks, further suggesting that crises spread first to accessible stocks through the asset holdings of investors. Second, in estimating exceedence correlations for market upturns and downturns, we find evidence of asymmetry in correlation for emerging markets but not for developed countries. These results suggest that the Asian crisis spread to emerging markets through asymmetric market frictions such as wealth constraints. In contrast, for developed markets the results suggest that portfolio rebalancing acts as a channel through which crises spread. Finally, we analyze the correlation dynamics between the stock and government bond indices in each country. We find that during crisis regimes, return correlations between accessible stock and government bond indices increase for emerging markets, but not for inaccessible stock indices in emerging markets or stock indices in developed countries. Again, this result further supports the hypothesis that asymmetric market frictions, such as wealth constraints, spread the Asian crisis across emerging market countries, and that symmetric market frictions, such as portfolio rebalancing, may have propagated the crisis shock to developed countries. Therefore, our findings shed light on the transmission mechanism of crisis shocks across countries and suggest that market frictions have an important effect on asset valuations.

Appendix A: Second-Step Covariance Matrix

In order to calculate the test statistics for our regime-switching model estimates, we need the entire covariance matrix of first-step (θ_1) and second-step (θ_2) parameter estimates. We define the asymptotic covariance matrix as

$$\mathrm{Var}(\theta_1, \theta_2) = \begin{bmatrix} \Sigma_1 & \Sigma_{1,2} \\ \Sigma_{1,2}' & \Sigma_2 \end{bmatrix}, \tag{A1}$$

where Σ_1 is the covariance matrix for θ_1, Σ_2 is the covariance matrix for θ_2, and $\Sigma_{1,2}$ is the covariance between θ_1 and θ_2. Each component is as follows:

$$\Sigma_1 = n^{-1}R_1^{-1}, \tag{A2}$$

$$\Sigma_2 = n^{-1}\{R_2^{-1} + R_2^{-1}[R_3'R_1^{-1}R_3 - R_4'R_1^{-1}R_3 - R_3'R_1^{-1}R_4]R_2^{-1}\}, \tag{A3}$$

and

$$\Sigma_{12} = n^{-1}\{R_1^{-1}R_4R_2^{-1} - R_1^{-1}R_3R_2^{-1}\}, \tag{A4}$$

where n is the number of observations used in estimation and

$$R_1 = E\left[\frac{\partial L_1}{\partial \theta_1}\left(\frac{\partial L_1}{\partial \theta_1}\right)'\right], \quad R_2 = E\left[\frac{\partial L_2}{\partial \theta_2}, \left(\frac{\partial L_2}{\partial \theta_2}\right)'\right],$$

$$R_3 = E\left[\frac{\partial L_2}{\partial \theta_1}\left(\frac{\partial L_2}{\partial \theta_2}\right)'\right], \quad \text{and} \quad R_4 = E\left[\frac{\partial L_1}{\partial \theta_1}\left(\frac{\partial L_2}{\partial \theta_2}\right)'\right], \tag{A5}$$

following Murphy and Topel (1985).

The first-step parameters are estimated via maximum likelihood (with the EM algorithm), and the measure of covariance matrix is obtained from the sample analog of the inverse of the outer product of the gradient. The second-step parameters are conditional on first-step parameters and are estimated via conditional maximum likelihood (also with the EM algorithm).

With a complete set of asymptotic variance and covariance of all parameters, test statistics can be computed as functions of these parameters. Volatilities, correlations, differences in volatilities, differences in correlations, and differences in differences are all functions of the estimated parameters, and thus standard errors of these functions are calculated using the delta method.

Appendix B: Currency Decomposition

In this section we first decompose co-movement of index returns denominated in U.S. dollars into several components, one of which represents the portion of co-movement that excludes effects from local currency fluctuations, denoted as the "LC" component. We then conduct a similar currency decomposition on cross-autocorrelations of returns denominated in U.S. dollars.

For any two countries, denoted by A and B, the logarithmic U.S. dollar return can be written as

$$r_A = r_A^* - \Delta q_A, \quad r_B = r_B^* - \Delta q_B, \tag{B1}$$

where r is the logarithmic return denominated in U.S. dollars, r^* is the logarithmic return denominated in a foreign currency, q is the logarithmic exchange value of U.S. dollars in terms of the foreign currency, and Δ denotes a first difference. The covariance between r_A and r_B is

$$\mathrm{Cov}[r_A, r_B] = \mathrm{Cov}[r_A^*, r_B^*] + \mathrm{Cov}[q_A, q_B] - \mathrm{Cov}[r_A^*, q_B] - \mathrm{Cov}[r_B^*, q_A]. \tag{B2}$$

Therefore, correlations of returns denominated in dollars can be decomposed into the following four components:

$$\rho[r_A, r_B] = \frac{\mathrm{Cov}[r_A^*, r_B^*]}{\sigma_A \sigma_B} + \frac{\mathrm{Cov}[q_A, q_B]}{\sigma_A \sigma_B} - \frac{\mathrm{Cov}[r_A^*, q_B]}{\sigma_A \sigma_B} - \frac{\mathrm{Cov}[r_B^*, q_A]}{\sigma_A \sigma_B}$$

$$= \underbrace{\rho[r_A^*, r_B^*] \frac{\sigma_A^* \sigma_B^*}{\sigma_A \sigma_B}}_{\text{Stock Market Shocks}}$$

$$+ \underbrace{\left(\rho[q_A, q_B] \frac{\sigma_{q_A} \sigma_{q_B}}{\sigma_A \sigma_B} - \rho[r_A^*, q_B] \frac{\sigma_A^* \sigma_{q_B}}{\sigma_A \sigma_B} - \rho[r_B^*, q_A] \frac{\sigma_B^* \sigma_{q_A}}{\sigma_A \sigma_B} \right)}_{\text{Exchange Rate Shocks}}, \quad \text{(B3)}$$

where the first term represents the effect on the correlation due to stock market shocks and the remaining terms represent the effect on the co-movement due to exchange rate shocks. To determine the extent to which the dollar-denominated correlations among the international indices studied in this paper are driven by correlations in exchange rates, we measure the LC component of the co-movement as the first term in equation (B3), since this is the only term in equation (B3) that is not influenced by exchange rates.

We next conduct a currency decomposition for cross-autocorrelations. For any two stocks in the same country, denoted by i and j, the logarithmic U.S. dollar return can be written as

$$r_i = r_i^* - \Delta q, \quad r_j = r_j^* - \Delta q. \quad \text{(B4)}$$

The cross-autocovariance between r_i and r_j is

$$\mathrm{Cov}[r_{i,t-1}, r_{j,t}] = \mathrm{Cov}[r_{i,t-1}^*, r_{j,t}^*] + \mathrm{Cov}[q_{t-1}, q_t] - \mathrm{Cov}[r_{i,t-1}^*, q_t] - \mathrm{Cov}[r_{j,t}^*, q_{t-1}]. \quad \text{(B5)}$$

Therefore, correlations of returns denominated in dollars can be decomposed into the following four components:

$$\rho[r_{i,t-1}, r_{j,t}] = \frac{\mathrm{Cov}[r_{i,t-1}^*, r_{j,t}^*]}{\sigma_i \sigma_j} + \frac{\mathrm{Cov}[q_{t-1}, q_t]}{\sigma_i \sigma_j} - \frac{\mathrm{Cov}[r_{i,t-1}^*, q_t]}{\sigma_i \sigma_j} - \frac{\mathrm{Cov}[r_{j,t}^*, q_{t-1}]}{\sigma_i \sigma_j}$$

$$= \underbrace{\rho[r_{i,t-1}^*, r_{j,t}^*] \frac{\sigma_i^* \sigma_j^*}{\sigma_i \sigma_j}}_{\text{Stock Market Shocks}}$$

$$+ \underbrace{\left(\rho[q_{t-1}, q_t] \frac{\sigma_q^2}{\sigma_i \sigma_j} - \rho[r_{i,t-1}^*, q_t] \frac{\sigma_i^* \sigma_q}{\sigma_i \sigma_j} - \rho[r_{j,t}^*, q_{t-1}] \frac{\sigma_j^* \sigma_q}{\sigma_i \sigma_j} \right)}_{\text{Exchange Rate Shocks}}. \quad \text{(B6)}$$

We report changes in both $\rho[r_{i,t-1}, r_{j,t}]$ and the first term in equation (B6), the LC component ($\rho[r_{i,t-1}^*, r_{j,t}^*] \frac{\sigma_i^* \sigma_j^*}{\sigma_i \sigma_j}$), in our analysis of the lead-lag relationship between accessible and inaccessible index returns.

REFERENCES

Ang, Andrew, and Geert Bekaert, 2002, International asset allocation with regime shifts, *Review of Financial Studies* 15, 1137–1187.

Ang, Andrew, and Joseph Chen, 2002, Asymmetric correlations of equity portfolios, *Journal of Financial Economics* 63, 443–494.

Bae, Kee-Hong, Kalok Chan, and Angela Ng, 2004, Investibility and return volatility in emerging equity markets, *Journal of Financial Economics* 71, 239–263.

Bae, Kee-Hong, Andrew Karolyi, and Rene Stulz, 2003, A new approach to measuring financial market contagion, *Review of Financial Studies* 16, 717–764.

Barberis, Nicholas, Andrei Shleifer, and Jeffrey Wurgler, 2005, Comovement, *Journal of Financial Economics* 75, 283–317.

Bekaert, Geert, Campbell R. Harvey, and Angela Ng, 2003, Market integration and contagion, *Journal of Business* 78, 1–31.

Bertaut, Carol C., and Linda S. Kole, 2004, What makes investors over or underweight? Explaining international appetites for foreign equities, Working paper, Federal Reserve Board.

Boyer, Brian H., 2004, Style investing and comovement among stocks with similar book-to-market ratios, Working paper, University of Michigan.

Boyer, Brian H., Michael S. Gibson, and Mico Loretan, 1999, Pitfalls in tests for changes in correlations, International Finance Discussion paper 597, Board of Governors of the Federal Reserve.

Broner, Fernando A., R. Gaston Gelos, and Carmen M. Reinhart, 2003, When in peril, retrench: International investors and crises, *Journal of International Economics,* forthcoming.

Burger, John D., and Francis E. Warnock, 2003, Diversification, original sin, and international bond portfolios, Working paper 755, Board of Governors of Federal Reserve.

Calvo, Guilermo A., 1999, Contagion in emerging markets: When Wall Street is a carrier, Working paper, University of Maryland.

Campbell, John Y., Andrew W. Lo, and A. Craig MacKinlay, 1997, *The Econometrics of Financial Markets* (Princeton University Press: New Jersey).

Chari, Anusha, and Peter Blair Henry, 2004, Risk sharing and asset prices: Evidence from a natural experiment, *Journal of Finance* 59, 1295–1324.

Choe, Hyuk, Bong-Chan Kho, and Rene M. Stulz, 2003, Do foreign investors destabilize stock markets? The Korean experience in 1997, *Journal of Financial Economics* 54, 227–264.

Clark, John, and Elizabeth Berko, 1996, Foreign investment fluctuations and emerging market stock returns: The case of Mexico, Working paper 9635, Federal Reserve Bank of New York.

Connolly, Robert, and Albert Wang, 1998, On stock market return co-movements: Macroeconomic news, dispersion of beliefs, and contagion, Working paper, University of North Carolina-Chapel Hill.

Connolly, Robert, and Albert Wang, 2003, International equity market co-movements: Economic fundamentals or contagion? *Pacific-Basin Finance Journal* 11, 23–43.

Corsetti, Giancarlo, Marcello Pericoli, and Massimo Sbracia, 2002, Some contagion, some interdependence: More pitfalls in tests of financial contagion, Discussion Paper 3310, Centre for Economic Policy Research (CEPR).

DeLong, J. Bradford, Andrei Shleifer, Lawrence Summers, and Robert Waldmann, 1990, Noise trader risk in financial markets, *The Journal of Political Economy* 98, 703–738.

Errunza, Vihang, and Etienne Losq, 1985, International asset pricing under mild segmentation: Theory and test, *Journal of Finance* 40, 105–124.

Errunza, Vihang, and Etienne Losq, 1989, Capital flow controls, international asset pricing, and investor's welfare: A multi-country framework, *Journal of Finance* 44, 1025–1037.

Forbes, Kristin J., 2002, Are trade linkages important determinants of country vulnerability to crises? in Sebastian Edwards and Jeffrey Frankel, eds.: *Preventing Currency Crises in Emerging Markets* (University of Chicago Press).

Forbes, Kristin J., and Roberto Rigobon, 2002, No contagion, only interdependence: Measuring stock market co-movements, *Journal of Finance* 56, 2223–2261.

French, Kenneth R., and James Poterba, 1991, Investor diversification and international equity markets, *American Economic Review* 81, 222–226.

Gibson, Michael S., and Brian. H. Boyer, 1997, Evaluating forecasts of correlation using option pricing, *Journal of Derivatives* 6, 18–38.

Hamilton, James D., 1989, A new approach to the economic analysis of nonstationary time series and the business cycle, *Econometrica* 57, 357–384.

Hamilton, James D., 1990, Analysis of time series subject to changes in regime, *Journal of Econometrics* 45, 39–70.

IFC, 1999, The IFC indexes: Methodology, definitions, and practices, User guide.

Kallberg, Jarl G., K. Crocker Liu, and Paolo Pasquariello, 2005, An examination of the Asian crisis: Regime shifts in currency and equity markets, *Journal of Business* 78, 169–211.

Kaminsky, Graciela, Richard K. Lyons, and Sergio Schmukler, 2001, Mutual fund investment in emerging markets: An overview, *World Bank Economic Review* 15, 315–340.

Kaminsky, Graciela, Richard K. Lyons, and Sergio Schmukler, 2004, Managers, investors, and crises: Mutual fund strategies in emerging markets, *Journal of International Economics* 64, 113–134.

Kaminsky, Graciela, and Carmen M. Reinhart, 2000, On crisis, contagion, and confusion, *Journal of International Economics* 51, 145–168.

Karolyi, Andrew, and Rene Stulz, 1996, Why do markets move together? An investigation of U.S.-Japan stock return co-movements, *Journal of Finance* 51, 951–986.

Kim, Chang-Jin, 1994, Dynamic linear models with Markov-switching, *Journal of Econometrics* 60, 1–22.

King, Mervyn, Enrique Sentana, and Sushil Wadhwani, 1994, Volatility and links between national stock markets, *Econometrica* 62, 901–933.

Kodres, Laura E., and Matthew Pritsker, 2002, A rational expectations model of financial contagion, *Journal of Finance* 57, 769–799.

Kyle, Albert S., and Wei Xiong, 2001, Contagion as a wealth effect, *Journal of Finance* 56, 1410–1440.

Ledford, Anthony R., and Jonathan A. Tawn, 1997, Statistics for near independence in multivariate extreme values, *Biometrika*, 169–187.

Longin, François, and Bruno Solnik, 2001, Extreme correlation of international equity markets, *Journal of Finance* 56, 649–676.

Murphy, Kevin M., and Robert H. Topel, 1985, Estimation and inference in two-step econometric models, *Journal of Business and Economic Statistics* 3, 370–379.

Pavlova, Anna, and Roberto Rigobon, 2003, Asset prices and exchange rates, Working paper, MIT.

Prescott, P., and A. T. Walden, 1980, Maximum likelihood estimation of the parameters of the generalized extreme-value distribution, *Biometrika* 67, 723–724.

Radelet, Steven, and Jeffrey Sachs, 1998, The onset of Asian crisis, Working Paper 6680, NBER.

Shleifer, Andrew, and Robert W. Vishny, 1997, The limit of arbitrage, *Journal of Finance* 52, 35–55.

Stambaugh, Robert F., 1995, Unpublished discussion of Karolyi and Stulz (1996), National Bureau of Economic Research Universities Research Conference on Risk Management.

Tang, Jon Wongswan, 2001, Contagion: An empirical test, Working Paper, Duke University.

Tawn, Jonathan, 1988, Bivariate extreme value theory: Models and estimation, *Biometrika* 75, 397–415.

Tesar, Linda, and Ingrid Werner, 1995, Home bias and high turnover, *Journal of International Money and Finance* 14, 467–493.

Yuan, Kathy, 2005, Asymmetric price movements and borrowing constraints: A rational expectations equilibrium model of crisis, contagion, and confusion, *Journal of Finance* 60, 379–411.