Equity Market Comovement and Contagion: A Sectoral Perspective

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This paper takes an asset pricing perspective to investigate the equity market comovement and contagion at the sector level during the period 1990-2004 across the regions of Europe, Asia, and Latin America. It examines whether unexpected shocks from a particular market, or group of markets, are propagated to the sectors in other countries. The results confirm the sector heterogeneity of contagion. This implies that there are sectors that can still provide a channel for achieving the benefits of international diversification during crises despite the prevailing contagion at the market level. In addition, the results lend support to the importance of financial links in the propagation of contagion.

Researchers have shown a long-time interest in the study of financial market comovement. Various studies have found that market comovement is currently higher.[1] This increased comovement can be attributed to the increasing market integration in relation to the close economic and financial links. However, market integration may not fully explain this comovement, and contagion may, in part, contribute to the process. In the last decade or so, financial markets were hit by a series of crises: 1) the 1992 ERM attacks, 2) the 1994 Mexican peso collapse, 3) the 1997 East Asian crisis, 4) the 1998 Russian collapse, 5) the 1998 LTCM crisis, 6) the 1999 Brazilian devaluation, and 7) the 2000 technological crisis. A striking feature during those crises is that markets tend to move more closely together as compared to tranquil times. Such strong comovement is frequently referred to as contagion. Evaluating if contagion occurs and understanding its origin is important for policy makers and fund managers aiming to diversify risks. If contagion prevails in times of crises, the benefits of international diversification will be hampered when they are needed most.

Many papers have studied the contagion effect on equity markets (e.g., King and Wadhwani, 1990; Forbes and Rigobon, 2001, 2002; and Bekaert, Harvey, and Ng, 2005). All of them focus on the empirical evidence at the market level and examine whether contagion exists across markets. The question they try to answer is whether idiosyncratic shocks from one particular market or group of markets are transmitted to the other markets during financial crises. In this paper, we take a different perspective and explore the equity market contagion at the disaggregated sector level, an issue that has not yet been examined in the literature. The question we endeavor to answer

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[1] See Freimann (1998) and Goetzmann, Li, and Rouwenhorst (2005).

is whether unexpected shocks from a particular market, or group of markets, are propagated to the sectors in other countries.

Studying the contagion effect at sector level is important for several reasons. First, studying the contagion at the market level may mask the heterogeneous performances of various sectors. Sector contagion may be asymmetric, in the sense that some sectors are more severely affected by external shocks than others within a market. Forbes (2002) demonstrates that trade linkages are an important determinant of a country's vulnerability to crises that originate from elsewhere in the world. If this is so, sectors with extensive international trade (e.g., traded goods sectors) would tend to be more prone to external shocks than sectors with less international trade (e.g., nontraded goods sectors). Some sectors (e.g., banking) may even constitute a major channel in transmitting the shocks across markets during crises (Kaminsky and Reinhart, 1999; Tai, 2004). From the point view of portfolio management, the sector heterogeneity of contagion implies that there are sectors that can still provide a channel for attaining the benefits of international diversification during crises despite the prevailing contagion at the market level. Second, there is evidence indicating that in recent years, global industry factors are becoming more important than country-specific factors in driving the variation of international equity returns (Baca, Garbe, and Weiss, 2000; Cavaglia, Brightman, and Aked, 2000; Phylaktis and Xia, 2006a).[2] Industries have overcome the cross-border restrictions and have become increasingly correlated worldwide. This trend increases the likelihood of industries' role in propagating global shocks and provides a channel for transmitting the contagion effect. Third, the industrial composition varies across global markets. A large, mature market (e.g., the US and the UK) comprises more diversified industries whereas a small, less mature market (e.g., Switzerland) is usually concentrated on a few industries. Therefore, it would be interesting to determine whether markets with similar industrial structures will comove more closely with each other and be more prone to contagion during crises as compared to markets with different industrial structures.

The literature on contagion has shown no consensus as to the exact definition of contagion. In this paper, we define contagion as excess correlation, that is, correlation over and above what one would expect from economic fundamentals.[3] Our paper takes an asset pricing perspective and contagion is defined by the correlation of the model residuals. Our asset pricing model follows the methodology of Bekaert, Harvey, and Ng (2005) and examines two sources of risk: 1) one from the US equity market (proxy for the world market) and 2) the other from the regional market. This structure nests a world capital asset pricing model (CAPM) with the US equity return as the benchmark and a regional CAPM with a regional portfolio as the benchmark. We test the asset pricing specifications by adding local factors. Essentially, the test of integration or segmentation constitutes a critical step in our analysis. If a sector is globally integrated for most of the sample period, but suddenly experiences a strong integration at the regional level during a regional crisis, our test will reject the null hypothesis of no contagion. Conversely, if the sector is initially integrated at the regional level, an increase of regional integration during the regional crisis may not indicate a contagion, but may simply be the consequence of increased interdependence.

Therefore, our main contribution to the literature is the examination of contagion effect at the sector level. As it has been argued above, sector-level contagion is an important issue, which

[2]In other studies, such as Baele and Inghelbrecht (2006), evidence indicates that in recent years, the geographical and industry diversification yield about the same diversification benefits. A detailed literature review can be found in Phylaktis and Xia (2006a, 2006b).

[3]The detailed definitions of contagion are shown on the World Bank's website: http://www1.worldbank.org/economicpolicy/managing%20volatility/contagion

has not yet been examined. Our sectoral analysis will also allow us to explore the importance of financial links in the propagation of crises, an issue widely discussed in the literature. We focus on the sectors of small equity markets across three regions: 1) Europe, 2) Asia, and 3) Latin America. At the same time, our model tests whether the sectors are more integrated at the global or regional level; thus, nesting the empirical work on equity market integration at the industry level. This subject is covered in papers such as Carrieri, Errunza, and Sarkissian (2004), Berben and Jansen (2005), and Kaltenhauser (2002, 2003). However, the novelty of our analysis in this area is our focus on the sector returns in 29 smaller markets in Europe, Asia, and Latin America, whereas previous papers concentrate mainly on sectors in the euro zone or in a few major markets such as the US, UK, Japan, or G-7 countries. This constitutes our paper's second major contribution to the literature.

The remainder of our paper is organized as follows: after reviewing the relevant literature in Section I, we describe our estimation and modeling framework in Section II. Section III presents the data and the empirical results, while the final section summarizes and concludes the paper.

I. Related Literature

As mentioned above, our paper draws from two strands of literature: 1) equity market contagion and 2) equity market integration.

A. Equity Market Contagion

The primary focus of our paper is to examine the contagion effect at sector level in equity markets and test whether contagion exists in sectors during periods of financial crises such as the Mexican crisis in 1994 and the Asian crisis in 1997. The previous literature focused on cross-market evidence. The early studies make use of correlation analysis. The central idea is to assess whether the correlation coefficient between two equity markets changes across tranquil and volatile periods. If the correlation increases significantly, it suggests that the transmission between the two markets amplifies after the shock and that contagion occurs. Papers following this methodology examine the contagion immediately after the US equity market crash of 1987. The seminal reference is King and Wadhwani (1990), which uses hourly equity market data for the period September 1987-November 1987 and finds that cross-market correlations between the United States, United Kingdom, and Japan increased significantly after the US crash.

Bertero and Mayer (1990) extend this analysis to a sample of 23 industrialized and developing countries and also find that the correlation coefficients increased appreciably following the equity market crash in the United States. Lee and Kim (1993) find further evidence of contagion when applying the same approach to 12 major markets. The average weekly cross-market correlations went from 0.23 before the 1987 crash up to 0.39 afterward. Calvo and Reinhart (1996) focus on emerging markets and find that the correlations in equity prices and Brady bonds between Asian and Latin American emerging markets increased significantly during the 1994 Mexican peso crisis. Baig and Goldfajn (1999) present the most thorough analysis using this framework and test for contagion in equity indices, currency prices, interest rates, and sovereign spreads in emerging markets during the 1997-1998 Asian crisis. They document a surge of cross-market correlations during the crisis for many of the countries.

However, later studies have recognized that focusing on correlations can be misleading. For example, Forbes and Rigobon (2001, 2002) demonstrate that looking at unadjusted correlation coefficients is not appropriate, as the calculated correlation coefficient is an increasing function of the variance of the underlying asset return. When coefficients between a tranquil period and a crisis period are compared, the coefficient in the crisis period is biased upward as volatility rises substantially. After correcting for this bias, they find no contagion during the 1997 Asian crisis, the 1994 Mexican peso collapse, and the 1987 US equity market crash. Instead, a high level of market comovement is found during these crises periods, reflecting a continuation of strong cross-market linkages present globally. Their conclusion is "there is no contagion, only interdependence." On the other hand, a contrary argument is developed in Corsetti, Pericoli, and Sbracia (2005), who suggest that the results of Forbes and Rigobon (2001, 2002) are highly dependent on their specification of idiosyncratic shocks. When these shocks are accounted for, the results show contagion was present during the Asian crisis.

Bekaert, Harvey, and Ng (2005) avoid the above correlation analysis and develop a two-factor (global and regional) asset pricing model to examine the equity market contagion in the regions of Europe, Southeast Asia, and Latin America during both the Mexican and Asian crises of the 1990s. By defining contagion as correlation among the model residuals after controlling for the local and foreign shocks, the authors demonstrate that there is no evidence of additional contagion caused by the Mexican crisis. However, economically meaningful increases in the residual correlation are found, especially in Asia, during the Asian crisis, a result confirmed by Dungey, Fry, and Martin (2003) and others who have studied the contagion in Asian equity markets.

B. Industry-Level Integration

Equity market integration has been extensively studied, while integration at the industry level has been of recent interest (Kaltenhauser, 2002, 2003; Carrieri, Errunza, and Sarkissian, 2004; Berben and Jansen, 2005). Our paper is closely related to this literature and examines whether sectors are integrated at the global or regional level. However, our focus is on the evidence in smaller countries in Europe, Asia, and Latin America, while the aforementioned papers concentrate on either the euro zone or large, developed countries such as the United States, United Kingdom, Japan, or the G-7 countries.

Carrieri, Errunza, and Sarkissian (2004) apply a conditional asset pricing framework to a sample of 458 weekly returns from 18 industries across the G-7 countries during the period 1991-1999. They find that global industry risk is priced for some industries and that the time variation in the prices of global industry risks has recently increased. Their evidence further illustrates that market-level integration does not preclude industry level segmentation. Even if a market is integrated with world markets, some of its industries may still be segmented. Similarly, some industries may be integrated even though a market is segmented from the rest of the world.

Berben and Jansen (2005) develop a novel bivariate GARCH model with smooth time-varying correlation to test for an increase in comovements between equity returns at the market and industry level. They find that in the period 1980-2000, conditional correlations among Germany, UK, and US equity markets have doubled. This correlation behavior is broadly reflected at the industry level as well.

Kaltenhauser (2002) estimates the time-varying spillover effects from European and US equity return innovations to 10 industry sectors within the euro area, the United States, and the United Kingdom for the period 1988-2002. Over time, sectors have become more heterogeneous and the response to aggregate shocks has increasingly varied across sectors. This provides evidence that sector-specific effects have gained in importance. They also indicate that information technology and noncyclical services, which are most affected by the aggregate European and US shocks, are the most integrated sectors worldwide. On the other hand, basic industries, noncyclical consumer goods, resources, and utilities are less affected by aggregate shocks.

In another paper, Kaltenhauser (2003) distinguishes among three types of linkages (cross-country linkages, cross-sector linkages within a given country, and the linkages among equivalent sectors across countries) and explores the spillover effects between equity returns of 10 sectors in the euro area, the United States, and Japan during the period 1986-2002. The results indicate that the price innovations in European equities, stemming from both aggregate and sector returns, have doubled or tripled their impacts on other equity markets. At the same time, the response to aggregate shocks in the countries examined has increasingly varied across sectors. Overall, the equity markets in the euro area and the United States have become more integrated with each other during the late 1990s, and this higher integration is especially pronounced for sectors as compared to the aggregate markets.

II. Framework of Analysis

A. The Models

We examine the sector returns using the two-factor asset pricing model developed in Bekaert, Harvey, and Ng (2005), where the two factors are defined as the US market (proxy for the global source of risk) and a particular regional market (proxy for the regional source of risk). We also allow for local factors to be priced. Our model has the following specification

$$r_{i,j,t} = \delta_{i,j} X_{i,j,t-1} + \beta^{us}_{i,j,t-1}\mu_{us,t-1} + \beta^{reg}_{i,j,t-1}\mu_{reg,t-1} + \beta^{us}_{i,j,t-1}e_{us,t} + \beta^{reg}_{i,j,t-1}e_{reg,t} + e_{i,j,t}, \tag{1}$$

$$e_{i,j,t} \mid \Omega_{t-1} \sim N\left(0, \sigma^2_{i,j,t}\right), \tag{2}$$

$$\sigma^2_{i,j,t} = a_{i,j} + b_{i,j}\sigma^2_{i,j,t-1} + c_{i,j}e^2_{i,j,t-1} + d_{i,j}\eta^2_{i,j,t-1}, \tag{3}$$

where $r_{i,j,t}$ is the weekly excess return of sector i in country j. $\mu_{us,t-1}$ and $\mu_{reg,t-1}$ are the conditional expected excess returns on the US and a regional market, respectively, based on information available at time $t-1$. $e_{us,t}$ and $e_{reg,t}$ are the respective residuals of the US and regional market excess returns. All the excess returns are calculated in excess of the weekly US one-month Treasury bill rate and expressed in US dollars. $e_{i,j,t}$ is the idiosyncratic shock of sector i in country j, and Ω_{t-1} includes all the information available at time $t-1$. The variance of the idiosyncratic return shock of sector i follows a GARCH process as specified in Model (3) with asymmetric effects in conditional variance. $\eta_{i,j,t}$ is the negative return shock of sector i in country j, (i.e. $\eta_{i,j,t} = \min\{0, e_{i,j,t}\}$). The vector $X_{i,j,t-1}$ contains a set of local economic fundamentals, which help estimate the expected return of sector i. In our analysis, the fundamentals are proxied by a constant, the dividend yield of sector i and the market dividend yield of country j which sector i belongs to.

The parameter $\beta^{us}_{i,j,t-1}$ measures the sensitivities of sector i to the US news factors derived from two components: 1) the conditional expected returns ($\mu_{us,t-1}$) and 2) the residuals ($e_{us,t}$). An analogy applies to the parameter $\beta^{reg}_{i,j,t-1}$, which measures the sensitivities of sector i to the regional news factors. Those conditional betas, $\beta^{us}_{i,j,t-1}$ and $\beta^{reg}_{i,j,t-1}$, are the cornerstone of our tests of integration and contagion. We begin with an examination of Models (1)-(3) assuming the betas to be constant in order to obtain the benchmark case, and then allow those betas to change over time in order to capture their time-varying nature. The time-varying parameters of $\beta^{us}_{i,j,t-1}$ and $\beta^{reg}_{i,j,t-1}$ are obtained through a one-year window rolling estimation. Specifically, we take a 12-month regression window, starting from the beginning of our data sample and moving this 12-month window forward by one month at a time. We use this method to study the time-varying integration of our sectors.[4]

The US and regional market models are the special cases of Models (1)-(3). For the US market, $r_{i,j,t} = r_{us,t}$, $\beta^{us}_{us,t-1} = \beta^{reg}_{us,t-1} = 0$, and $X_{i,j,t-1} = X_{us,t-1}$ where the latter comprises a set of world information variables, including a constant, the world market dividend yield, the spread between the 90-day Eurodollar rate and the three-month Treasury bill yield, the difference between the US 10-year Treasury bond yield and the three-month bill yield, the change in the 90-day Treasury bill yield, and the US money supply (M3). These variables are often used in the literature to capture the movement of international equity market returns. For the regional market model, $r_{i,j,t} = r_{reg,t}$, $\beta^{reg}_{reg,t-1} = 0$ and $X_{i,j,t-1} = X_{reg,t-1}$, which includes a constant and the regional market dividend yield.

Apart from examining the beta parameters, we also calculate the variance ratios for each sector i. As shown in Model (1), the return of sector i is composed of expected (i.e., the expected excess return) and unexpected parts. The expected excess return of sector i, $\mu_{i,j,t}$, is a linear function of some local information variables as well as the expected excess return on the US and regional markets

$$\mu_{i,j,t} = E[r_{i,j,t} \mid \Omega_{t-1}] = \delta_{i,j} X_{i,j,t-1} + \beta^{us}_{i,j,t-1}\mu_{us,t-1} + \beta^{reg}_{i,j,t-1}\mu_{reg,t-1}. \tag{4}$$

Similarly, the unexpected part of the sector return ($\varepsilon_{i,j,t}$) is driven not only by its own idiosyncratic shocks, but also by the shocks from the United States and regional markets

$$\varepsilon_{i,j,t} = \beta^{us}_{i,j,t-1} e_{us,t} + \beta^{reg}_{i,j,t-1} e_{reg,t} + e_{i,j,t}. \tag{5}$$

To complete the model, we assume that the idiosyncratic shocks from the United States, the region, and the sector i are orthogonal with each other, and, therefore, the conditional variance of sector i is in the following form

$$h_{i,j,t} = E\left[\varepsilon^2_{i,j,t} \mid \Omega_{t-1}\right] = \left(\beta^{us}_{i,j,t-1}\right)^2 \sigma^2_{us,t} + \left(\beta^{reg}_{i,j,t-1}\right)^2 \sigma^2_{reg,t} + \sigma^2_{i,j,t}. \tag{6}$$

Equation (6) allows us to derive two variance ratios to explore how much of the local sector return variance is explained by the respective US and regional factors ($VR^{us}_{i,j,t}$ and $VR^{reg}_{i,j,t}$)

$$VR^{us}_{i,j,t} = \frac{\left(\beta^{us}_{i,j,t-1}\right)^2 \sigma^2_{us,t}}{h_{i,j,t}}, \tag{7}$$

[4]It should be noted, however, that it is only the betas that are reestimated, while the remaining parameters are fixed at their full sample value. See Fratzscher (2002) and Kaltenhauser (2002, 2003) for a similar approach to time-varying integration. This approach does not distinguish between structural changes and temporary fluctuations in betas as in Baele and Inghelbrecht (2006). However, their specification focuses on volatility spillover effects and does not attempt to appropriately specify the expected market, industry, and country returns in order to explore issues of market integration.

$$VR^{reg}_{i,j,t} = \frac{\left(\beta^{reg}_{i,j,t-1}\right)^2 \sigma^2_{reg,t}}{h_{i,j,t}}. \tag{8}$$

B. Tests of Integration and Contagion at Sector Level

In examination of the two-factor model of Models (1)-(3), we assume first that the conditional betas are time invariant to obtain a benchmark case, and then relax this assumption and allow the betas to change over time. Models (1)-(3) with time-invariant betas can test several integration hypotheses. On the one hand, if the model holds (if the two foreign risk factors are sufficient in explaining the expected returns of sectors within a particular country), the local instruments should have no explanatory power on those sector returns, and, thus, $\delta_{i,j} = 0$. We interpret this test as a test of integration, where the integration can be either global or regional. On the other hand, the model nests the one-factor CAPM model as a special case. If $\beta^{reg}_{i,j,t-1} = 0$ together with $\delta_{i,j} = 0$, the model reduces to the traditional CAPM with the United States being the benchmark market and sector i priced with the US market. In this case, the model implies that sector i is fully integrated with the world market. Similarly, if $\beta^{us}_{i,j,t-1} = 0$ together with $\delta_{i,j} = 0$, the model becomes a one-factor model with the region serving as the benchmark market. We interpret this as a full integration of sector i at the regional level.

Models (1)-(3) with time variant betas are examined via the rolling estimation method with a one-year regression window. We use this method to study the time varying integration at sector level. After the time variant betas have been accounted for, we employ the model residuals to examine the sector-level contagion effect. Contagion is measured by the correlation of the model's idiosyncratic shocks. Any significant correlations among those shocks would indicate that sector residuals are correlated beyond what is captured in our model, suggesting evidence of contagion.

For each sector i, three correlations are considered: 1) with the global shocks from the US market, 2) with the regional shocks from a geographic region, and 3) with intrasector shocks from the equivalent sectors in other countries within a region. Our model is in the following form

$$\hat{e}_{i,j,t} = \nu_{i,j} + \phi_{i,j,t}\hat{e}_{g,t} + \xi_{i,j,t}, \tag{9}$$

$$\phi_{i,j,t} = m + nD_{i,t}, \tag{10}$$

where $\hat{e}_{i,j,t}$, $\hat{e}_{g,t}$ are the estimated idiosyncratic return shocks of sector i and a country-group, respectively, after the time varying betas have been accounted for. Three country-groups are employed: 1) the return shocks from the United States, $\hat{e}_{g,t} = \hat{e}_{us,t}$; 2) the return shocks from a geographic region, $\hat{e}_{g,t} = \hat{e}_{reg,t}$; and 3) the intrasector shocks (i.e., the sum of equivalent sector shocks within a particular region excluding that sector in country j to be considered), $\hat{e}_{g,t} = \sum_{\substack{k \neq j \\ k \subset G}} \hat{e}_{i,k,t}$, where G denotes a particular region country k belongs to.

The regression of Model (9) across time yields the time varying coefficient, $\phi_{i,j,t}$, for each sector i. The time varying coefficients, $\phi_{i,j,t}$, of equivalent sectors are pooled into cross-sectional time-series data and examined separately in Model (10) for each of the three regions: Europe, Asia, and Latin America.[5] $D_{i,t}$ is a dummy variable that represents two sample periods: 1) the Mexican crisis period from November 1994 to December 1995 and 2) the Asian crisis period from April 1997 to October 1998. We are concentrating on those crises, which have been the most

[5]The estimation of Model (10) for each region corrects for the serial correlation and group-wise heteroskedasticity.

severe and widely examined in the literature. In estimation of the above regression, we establish a baseline level of contagion by examining the shock correlations over the full sample period, whether the coefficients of m and n are zero (overall contagion for the whole sample period), and test for additional contagion during crisis periods by examining the significant increase of shock correlations during a particular crisis period; whether n is significantly different from zero (contribution of a particular crisis period to contagion).

The sectoral analysis of contagion allows us also to examine the importance of financial links in the propagation of crises. As previously mentioned, the literature on contagion has highlighted two main channels of transmission of disturbances: 1) trade links and 2) financial links. The latter can occur as mutual fund portfolio managers sell assets held in the portfolio in emerging markets other than the country of the original disturbance in anticipation of future redemptions (Kaminsky, Lyons, and Schmukler, 2001). It may also occur through bank lenders in financial centers that need to rebalance the overall risk of their asset portfolio due to a crisis in an emerging market leading to a marked reversal in commercial bank lending across markets where the bank has exposure (Kaminsky and Reinhart, 2000, 2001). Thus, a test of the hypothesis that $n \neq 0$ with respect to $e_{us,t}$ for the financial sector (TOTFL) relates to whether the shock was transmitted through the financial sector of the two countries.[6]

C. Model Estimation and Specification Test

Sector returns, together with the United States and regional market returns, can be treated as a joint multivariate likelihood function. We estimate this joint function in three stages. In the first stage, the model for the US market is estimated, and then based on the US estimates, we examine the regional market model. In the final stage, a univariate model in Models (1)-(3) is estimated sector by sector, based upon the US and regional market estimates.[7]

By using the generalized method of moments, we conduct a series of specification tests on the estimated standardized idiosyncratic shocks, $\hat{z}_{i,j,t} = \hat{e}_{i,j,t}/\hat{\sigma}_{i,j,t}$ for sector i (including the US and regional markets). Under the null hypothesis that the model is correctly specified,

$$E[\hat{z}_{i,j,t}] = 0, \tag{11a}$$

$$E[\hat{z}_{i,j,t}\hat{z}_{i,j,t-s}] = 0, \quad \text{for } s = 1, \ldots \tau, \tag{11b}$$

$$E\left[\hat{z}^2_{i,j,t} - 1\right] = 0, \tag{11c}$$

$$E\left[\left(\hat{z}^2_{i,j,t} - 1\right)\left(\hat{z}^2_{i,j,t-s} - 1\right)\right] = 0, \quad \text{for } s = 1, \ldots \tau, \tag{11d}$$

$$E\left[\hat{z}^3_{i,j,t}\right] = 0, \tag{11e}$$

$$E\left[\hat{z}^4_{i,j,t} - 3\right] = 0. \tag{11f}$$

[6]It is not possible to discuss the transmission through trade links as our industrial classification is not disaggregated sufficiently between traded and nontraded industries.

[7]This methodology has also been employed in, for example, Bekaert and Harvey (1997).

Equations (11b) and (11d) are a sequence of the correct specifications for the conditional mean and variance. We test these two conditions by Ljung-Box Q-statistics. The unconditional moments in the other four constraints are jointly tested by a χ^2 statistics with four degrees of freedom.

III. Empirical Results

A. Data

The empirical analysis is conducted on the sector returns for a set of 29 countries that are grouped into three geographical regions: Europe, Asia, and Latin America. All the sector indices, as well as the US and regional market indices, are compiled by and extracted from Datastream International. We follow the broad distinction of 10 economic sectors according to the Financial Times Actuaries, which Datastream uses: 1) basic industries, 2) cyclical consumer goods, 3) cyclical services, 4) financials, 5) general industries, 6) information technology, 7) noncyclical consumer goods, 8) noncyclical services, 9) resources, and 10) utilities (see Appendices A and B for a more detailed description of sector classifications and a list of our sample countries).

Our Wednesday-to-Wednesday sample covers the period from January 3, 1990 to June 30, 2004 for most countries and a somewhat shorter time period for a few countries where some of the time series started later. All weekly returns are calculated in excess of the weekly US one-month Treasury bill rate and expressed in US dollars. The other data, including dividend yields, 90-day Eurodollar rate, three-month Treasury bill yield, US 10-year Treasury bond yield, and the US money supply (M3) are also downloaded from Datastream.

B. US and Regional Models

Table I details the US and regional market estimation. Looking at the US market first (first row in the table), the asymmetric GARCH model is selected as the hypothesis of no asymmetry in the conditional variances is strongly rejected. All three specification tests fail to reject the US model specification. The Wald test on the information variables indicates that the explanatory power of those variables is significant.

The rest of Table I presents the regional market estimation. Like the US market, both Asia and Latin America exhibit asymmetric volatility. However, we find little evidence of asymmetry in the region of Europe. The three specification tests fail to provide evidence against our model specification for all three regions.[8] The local instruments have significant explanatory power in Asia, but not in Latin America or Europe.

The conditional betas with respect to the US market are significant for all three regions, with Europe being the highest (0.593), followed by Latin America (0.576), and Asia (0.431). In terms of variance ratios, more than 30% of the conditional return variance in Europe can be attributed to the US shocks; whereas, the ratios are 15.68% and 12.25% for Latin America and Asia, respectively.

C. Sector-Level Integration

In this subsection, we estimate the GARCH Models (1)-(3) for sectors with constant coefficients (i.e., with coefficients that are assumed to be time invariant). Our framework tests the sector-level

[8]Similar model specification tests were run for sectors. Over 95% of the sectors passed all the specification tests.

Table I. United States and Regional Market Return Model

The following GARCH model is examined:

$$r_{i,t} = \delta_i X_{i,t-1} + \beta^{us}_{i,t-1}\, \mu_{us,t-1} + \beta^{us}_{i,t-1}\, e_{us,t} + e_{i,t},$$
$$e_{i,t}\, |\Omega_{t-1} \sim N(0, \sigma^2_{i,t}),$$
$$\sigma^2_{i,t} = a_i + b_i\sigma^2_{i,t-1} + c_i e^2_{i,t-1} + d_i \eta^2_{i,t-1},$$
$$\eta^2_{i,t-1} = \min\{0, e_{i,t}\},$$

where $r_{i,t}$ is the excess return and $X_{i,t-1}$ represents local information variables available at time $t-1$. $\mu_{us,t-1}$ and $e_{us,t}$ are the conditional expected excess return and residual of the US market. For the US market ($i = us$), $\beta^{us}_{i,t-1}$ is zero, and $X_{i,t-1}$ represents a set of US or world information variables, which includes a constant, the world market dividend yield, the spread between the 90-day eurodollar rate and the three-month T-bill yield, the difference between the US 10-year Treasury bond yield and the three-month Treasury bill yield, the change in the 90-day Treasury bill yield, and the US money supply (M3). All the information variables are lagged by one period. For the regional market ($i = reg$), $X_{i,t-1}$ represents a set of regional variables, which includes a constant and the regional market dividend yield. To test for model specification, Q(20) and $Q^2(20)$ are the 20th order Ljung-Box statistics for the autocovariances of the scaled residuals (10b) and the autocovariances of the squared scaled residuals (10d); the moments are based on joint test of four moments (10a, c, e, f). The Wald test is the test of the significance of the local information in the mean (i.e., $\delta_i = 0$). The *p*-value is shown in parentheses. Latin Am. = Latin America.

Market	Model	Specification Test			Wald Test $\delta_i = 0$	$\hat{\beta}^{us}_{i,t-1}$	$\widehat{VR}^{us}_{i,t-1}$ (%)
		Q(20)	$Q^2(20)$	Moments			
US	Asymmetric	20.250	16.067	6.412	34.757		
		[0.442]	[0.712]	[0.170]	[0.000]		
Europe	Symmetric	18.598	16.037	0.797	0.896	0.593	31.79
		[0.233]	[0.714]	[0.939]	[0.826]		
Asia	Asymmetric	21.268	17.748	0.326	15.646	0.431	12.25
		[0.381]	[0.604]	[0.988]	[0.001]		
Latin Am.	Asymmetric	33.789	12.647	0.186	3.844	0.576	15.68
		[0.289]	[0.892]	[0.996]	[0.146]		

integration and nests at least two distinct models: 1) an asset pricing model with a single US factor and 2) an asset pricing model with a single regional factor. Detailed sector-by-sector tests are available upon request. Here, we summarize the main results.

In total, a number of sector returns to be tested are 130 in Europe, 76 in Asia, and 61 in Latin America. We first test whether lagged local information enters the mean equation (test of $\delta_{i,j} = 0$). If the asset pricing model is properly specified, those local instruments should not enter the model. This test can be thought of as a test of whether the conditional alpha (or pricing error) is zero and, under the null hypothesis of the regional or world CAPM, as a test of market integration. In Europe, 34 out of a total of 130 sector returns represented in 14 countries reject the hypothesis that local information is unrelated to the pricing errors. In Asia, 24 out of a total of 76 sector returns presented in eight countries demonstrate the significant explanatory power of local information. Whereas, in Latin America, local information is important in explaining the pricing errors in 21 sector returns from a total of 61 presented in seven countries.

Tests of whether betas are significantly different from zero indicate that the beta with respect to the United States ($\beta^{us}_{i,j,t-1}$) is significant in 110 sector returns in Europe, 68 in Asia, and 41 in Latin America. A number of sector returns with significant beta with respect to the regional factor ($\beta^{reg}_{i,j,t-1}$) are 121, 73, and 53, respectively, for Europe, Asia, and Latin America.

We also test restrictions on two sets of parameters. If $\beta^{reg}_{i,j,t-1} = 0$ and $\delta_{i,j} = 0$, the model reduces to the traditional world CAPM with the United States as the benchmark. This model is rejected at the 5% level for 116 sector returns in Europe, 75 in Asia, and 48 in Latin America. If $\beta^{us}_{i,j,t-1} = 0$ and $\delta_{i,j} = 0$, the model becomes a one-factor model with the region as the benchmark. This model is rejected at the 5% level for 126 sector returns in Europe, 75 in Asia, and 55 in Latin America.

Generally, our Wald tests reveal that most sectors in the three regions are priced at both regional and global levels, with local information having little explanatory power in the return process. However, one single factor CAPM (special case of our two-factor model) is usually rejected, indicating that it is not a good description of the data by itself. Nevertheless, the covariance with one factor benchmark is a significant determinant of expected returns for most sectors.

The conditional betas and variance ratios are our primary focus on the sector-level integration analysis. Table II reports the average betas and variance ratios with respect to the United States and regional markets across the sectors in Europe, Asia, and Latin America.[9] In Europe, out of the 10 sectors examined, information technology has the highest average betas (0.7105 on the United States vs. 0.6368 on the region), whereas utilities has the lowest betas (0.1255 vs. 0.3635). This is consistent with our prior expectations as the Information technology sector is considered more international in nature, while the utilities sector is subject to local country-specific factors. Generally, sectors have a greater beta related to their regional market than to the US market. This suggests that the European sectors are more responsive to shocks from their own regional market than to shocks from the US market. As such, they are more integrated at the regional level. The only exception is the information technology sector, which responds more strongly to US market innovations (as indicated by a higher beta with respect to the United States rather than to the region). Not surprisingly, the variance ratios follow the same pattern, and the fraction of the return shock variance explained by the region is larger than that demonstrated by the United States (except for information technology).

In Asia, as in Europe, the sector with the highest betas is information technology (0.694 on the United States vs. 0.5659 on the region) and the sector with lowest betas is utilities (0.2055 vs. 0.2352). However, for most sectors, the betas related to the US market are larger than those related to the regional market, suggesting the dominance of the US market in the region. The pattern of US market dominance is about the same in terms of the variance ratios.

In Latin America, the noncyclical services sector tops the rest with the highest betas (0.5834 for the United States vs. 0.6885 for the region) and the smallest betas are found in the sector of cyclical consumer goods (0.1397 vs. 0.2667). Nevertheless, the sectors in the region display a pattern closer to what we see for the region of Europe, with the betas of the regional market higher than those of the US market. Clearly, the regional integration, relative to the global one, is stronger in Latin America. A similar result can be made from the comparison of the variance ratios.

In summary, we find that the performance of sectors vary across regions. While sectors are dominated by the regional market and, as such, more strongly integrated at the regional level in Europe and Latin America, those in Asia are more heavily influenced by the US market and more integrated at the global level. One point to note is the distinct deviation of the information technology sector, which is more responsive to global shocks. This global nature is ubiquitous across different regions.

[9]There are only nine sectors in Latin America and information technology is unclassified in the data set.

Table II. GARCH Summary for Sector-Level Integration

The following asymmetric GARCH model is examined:

$$r_{i,j,t} = \delta_{i,j} X_{i,j,t-1} + \beta^{us}_{i,j,t-1}\,\mu_{us,t-1} + \beta^{reg}_{i,j,t-1}\,\mu_{reg,t-1} + \beta^{us}_{i,j,t-1}\,e_{us,t} + \beta^{reg}_{i,j,t-1}\,e_{reg,t} + e_{i,j,t},$$
$$e_{i,j,t}\,|\Omega_{t-1} \sim N(0, \sigma^2_{i,j,t}),$$
$$\sigma^2_{i,j,t} = a_{i,j} + b_{i,j}\sigma^2_{i,j,t-1} + c_{i,j}e^2_{i,j,t-1} + d_{i,j}\eta^2_{i,j,t-1},$$
$$\eta_{i,j,t} = \min\{0, e_{i,j,t}\},$$

where $r_{i,j,t}$ is the excess return, $\mu_{us,t-1}$ and $e_{us,t}$ ($\mu_{reg,t-1}$ and $e_{reg,t}$) are the conditional expected excess return and residual on the US (regional) market. $e_{i,j,t}$ is the idiosyncratic shock of any sector i in country j, and $X_{i,j,t-1}$ represents local information variables available at time $t - 1$. The table reports the sample average across all countries within the region of beta parameters ($\hat{\beta}^{us}_{i,j}$ and $\hat{\beta}^{reg}_{i,j}$) and variance ratios accounted for by the United States and the corresponding region ($V\hat{R}^{us}_{i,j}$ and $V\hat{R}^{reg}_{i,j}$) for sector i. Standard deviations are given in parentheses. Std. Dev. = standard deviation; BASIC = basic industries; CYCGD = cyclical consumer goods; CYSER = cyclical services; GENIN = general industries; ITECH = information technology; NCYCG = noncyclical consumer goods; NCYSR = noncyclical services; RESOR = resources; TOTLF = financials; and UTILS = utilities.

Sector	$\hat{\beta}^{us}_{i,j}$ Mean (Std. Dev.)		$\hat{\beta}^{reg}_{i,j}$ Mean (Std. Dev.)		$\widehat{VR}^{us}_{i,j}$ (%) Mean (Std. Dev.)		$\widehat{VR}^{reg}_{i,j}$ (%) Mean (Std. Dev.)	
				Europe				
BASIC	0.3299	(0.148)	0.4858	(0.075)	5.9794	(4.745)	9.0025	(5.059)
CYCGD	0.3569	(0.199)	0.4479	(0.212)	3.6816	(4.397)	3.5554	(2.192)
CYSER	0.3922	(0.177)	0.5107	(0.127)	6.9211	(5.738)	9.1897	(5.629)
GENIN	0.4019	(0.295)	0.5286	(0.114)	8.0265	(8.238)	8.4258	(4.975)
ITECH	0.7105	(0.364)	0.6368	(0.207)	7.2742	(7.147)	4.4303	(2.766)
NCYCG	0.2694	(0.117)	0.4392	(0.072)	3.9709	(3.779)	6.8267	(3.594)
NCYSR	0.3967	(0.229)	0.4886	(0.260)	5.5331	(4.667)	6.5537	(4.280)
RESOR	0.1841	(0.198)	0.4119	(0.158)	2.5906	(3.544)	4.1710	(3.536)
TOTFL	0.4395	(0.222)	0.5543	(0.096)	8.6642	(7.371)	10.8427	(5.628)
UTILS	0.1255	(0.192)	0.3635	(0.114)	1.5847	(2.173)	4.9105	(4.124)
				Asia				
BASIC	0.3359	(0.123)	0.3196	(0.099)	2.1120	(1.277)	2.4681	(1.759)
CYCGD	0.3912	(0.138)	0.2731	(0.215)	2.6236	(2.444)	2.2119	(1.840)
CYSER	0.3722	(0.139)	0.3374	(0.069)	4.4800	(4.460)	3.6968	(2.158)
GENIN	0.4735	(0.203)	0.3413	(0.081)	5.5982	(5.212)	3.6256	(3.198)
ITECH	0.6940	(0.289)	0.5659	(0.338)	5.2074	(3.119)	4.5234	(2.604)
NCYCG	0.2786	(0.087)	0.2622	(0.065)	2.0027	(1.796)	2.2676	(1.751)
NCYSR	0.3888	(0.196)	0.3251	(0.058)	3.2120	(3.061)	2.7145	(1.197)
RESOR	0.2966	(0.148)	0.3289	(0.078)	1.3433	(1.077)	1.6345	(0.765)
TOTLF	0.4426	(0.142)	0.3345	(0.063)	4.7466	(4.539)	3.1358	(2.046)
UTILS	0.2055	(0.081)	0.2352	(0.098)	0.7535	(0.394)	1.4007	(0.918)
				Latin America				
BASIC	0.3409	(0.199)	0.4528	(0.260)	3.9528	(3.939)	12.1821	(13.353)
CYCGD	0.1397	(0.126)	0.2667	(0.238)	0.5203	(0.613)	2.6004	(2.919)
CYSER	0.2185	(0.284)	0.3972	(0.346)	2.9667	(4.160)	7.8290	(8.813)
GENIN	0.2657	(0.335)	0.4344	(0.297)	3.0495	(3.683)	8.2466	(9.224)
ITECH	–	–	–	–	–	–	–	–
NCYCG	0.3086	(0.182)	0.4365	(0.236)	3.1929	(2.883)	10.5641	(10.009)
NYCSR	0.5834	(0.350)	0.6885	(0.384)	6.9520	(7.799)	15.3412	(16.930)
RESOR	0.2552	(0.312)	0.4008	(0.360)	2.8214	(2.746)	9.2245	(13.216)
TOTLF	0.3185	(0.233)	0.4676	(0.290)	3.2746	(2.890)	10.8926	(10.141)
UTILS	0.2980	(0.221)	0.4095	(0.416)	2.4305	(2.620)	9.5409	(14.915)

Our finding of regional dominance in Europe is consistent with the market integration analysis in Fratzscher (2002). Fratzscher demonstrates that the European regional market has gained considerably in importance in world financial markets and has surpassed the United States as the dominant market in Europe. Similarly, Hardouvelis, Malliaropoulos, and Priestley (2006) have also found that expected returns became increasingly determined by EU-wide market risk and less by local risk implying stock market integration across the euro zone countries. This regional dominance can be attributed to, in large part, to the drive toward EMU and in particular, the elimination of exchange rate volatility and uncertainty in the process of monetary unification after the introduction of the euro.

The dominance by the regional market in Latin America is also reported in other literature. For example, Heaney, Hooper, and Jagietis (2002) find that the equity markets in Latin America are becoming regionally integrated at a faster rate than globally, reflecting the growing cooperation between Latin American countries since liberalization in the early 1990s. On the other hand, the stronger connection to the US market found in Asia is documented by Masih and Masih (1997), Siklos and Ng (2001), and Bekaert, Harvey, and Ng (2005) in their investigation of market interdependence in Asian countries.

D. Time-Varying Integration

To capture the time-varying nature of sector-level integration, we relax the assumption of constant betas and allow them to change over time. Our GARCH Model (1)-(3) is reexamined via a one-year window rolling estimation to obtain the time variant betas. As noted earlier, only the betas are reestimated, while the remaining parameters are fixed at their full sample value. Figure 1 details the intertemporal movement of sector average betas in Europe, Asia, and Latin America. Indeed, those betas vary substantially with several peaks and valleys along the time horizon, yet distinct features across regions can be observed. For sectors in Europe, regional betas dominated the US betas for most of the sample period (except for information technology, which had a higher US beta than a regional beta). The variability of betas is also confirmed when estimating the model for the full sample period and the crisis periods separately, and comparing the two betas, United States and regional, between each crisis period and the full sample period (see Appendix C).[10] One can see that during the Mexican crisis, the US beta was lower, while the regional beta was higher for all the sectors except for information technology. The difference between the two betas widened implying an increase in regional integration during the crisis. In the case of the Asian crisis, although both betas increased for most sectors, their difference also increased suggesting, once again, an increase in regional integration.

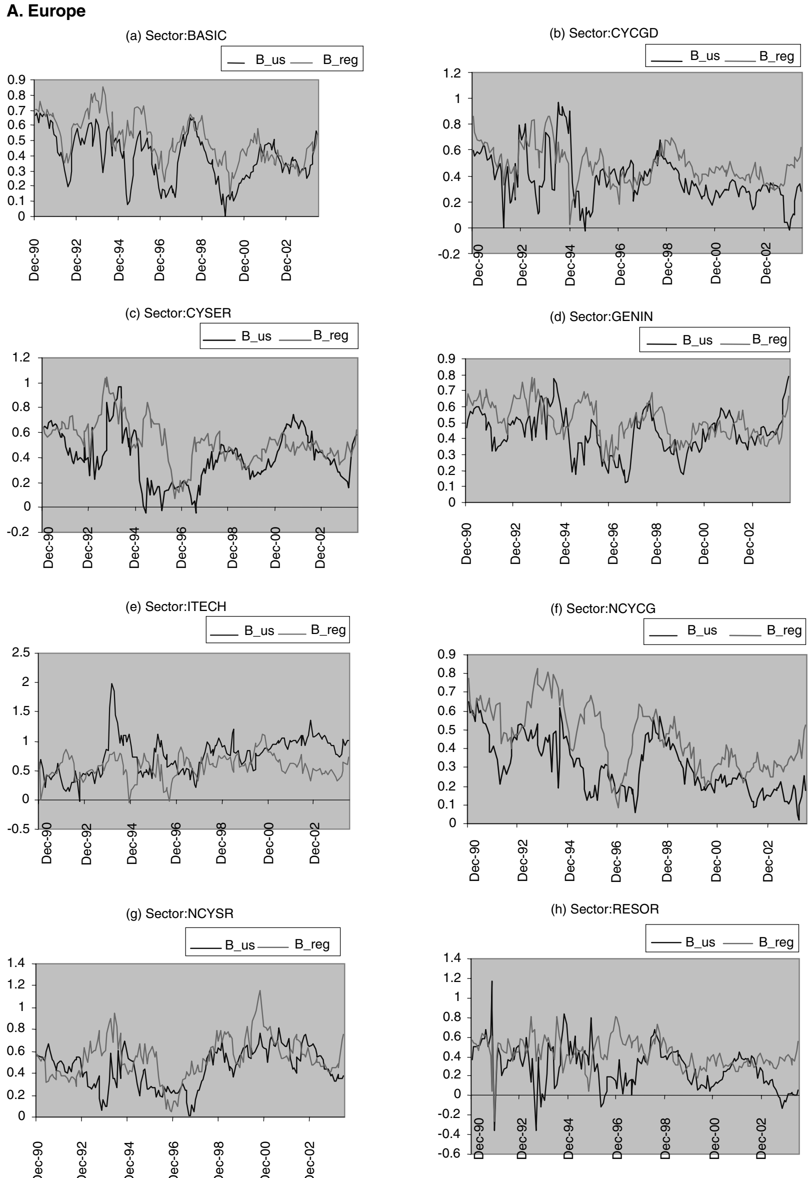
The sector betas in Asia present a different scenario. When compared to other regions, the beta dominance in Asia was more unstable and fluctuated from time to time. The US betas were at their lowest from 1992 to 1994. Immediately after this period, they rose abruptly and began to dominate the regional betas from 1994 to 1996, indicating the increasingly strong impact of the US market in Asian countries. Another period of high US betas was from 1997 to 1999 during the Asian crisis period. But the regional betas during this period were even higher and dominated the US betas. These patterns are also confirmed by the comparison of the betas between the two

[10]In Appendix C, Panel A, we report betas for each sector in each region on the basis of pool data. That means that for each sector in a region, there is one US beta and one regional beta, instead of one US beta and one regional beta for each sector in each country. Had we chosen to examine betas for each sector by country as we did in Table II, we would have had many betas for each sector in a region (due to the number of countries in the region) making it difficult to estimate the significance and do the comparison. Thus, the results in Table II obtained by estimating each sector for each country and then calculating the mean, are slightly different.

Figure 1. Summary of Time-Varying Sector-Level Integration: GARCH 12-Month Rolling Estimates

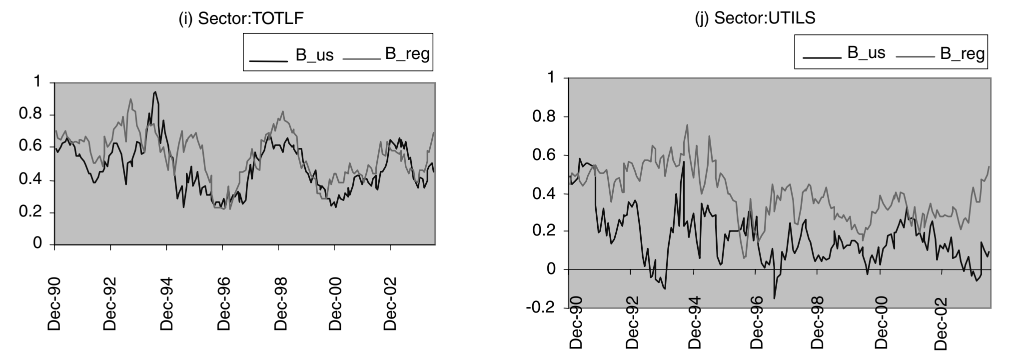
The model description is identical to that in Table II. The result is the 12-month regression window rolling estimation moved month by month. The coefficients of $\hat{\beta}_i^{us}$ and $\hat{\beta}_i^{reg}$ are the averages across all the countries within a region examined. B_us = $\hat{\beta}_i^{us}$; B_reg = $\hat{\beta}_i^{reg}$; BASIC = basic industries; CYCGD = cyclical consumer goods; CYSER = cyclical services; GENIN = general industries; ITECH = information technology; NCYCG = noncyclical consumer goods; NCYSR = noncyclical services; RESOR = resources; TOTLF = financials; and UTILS = utilities.

A. Europe

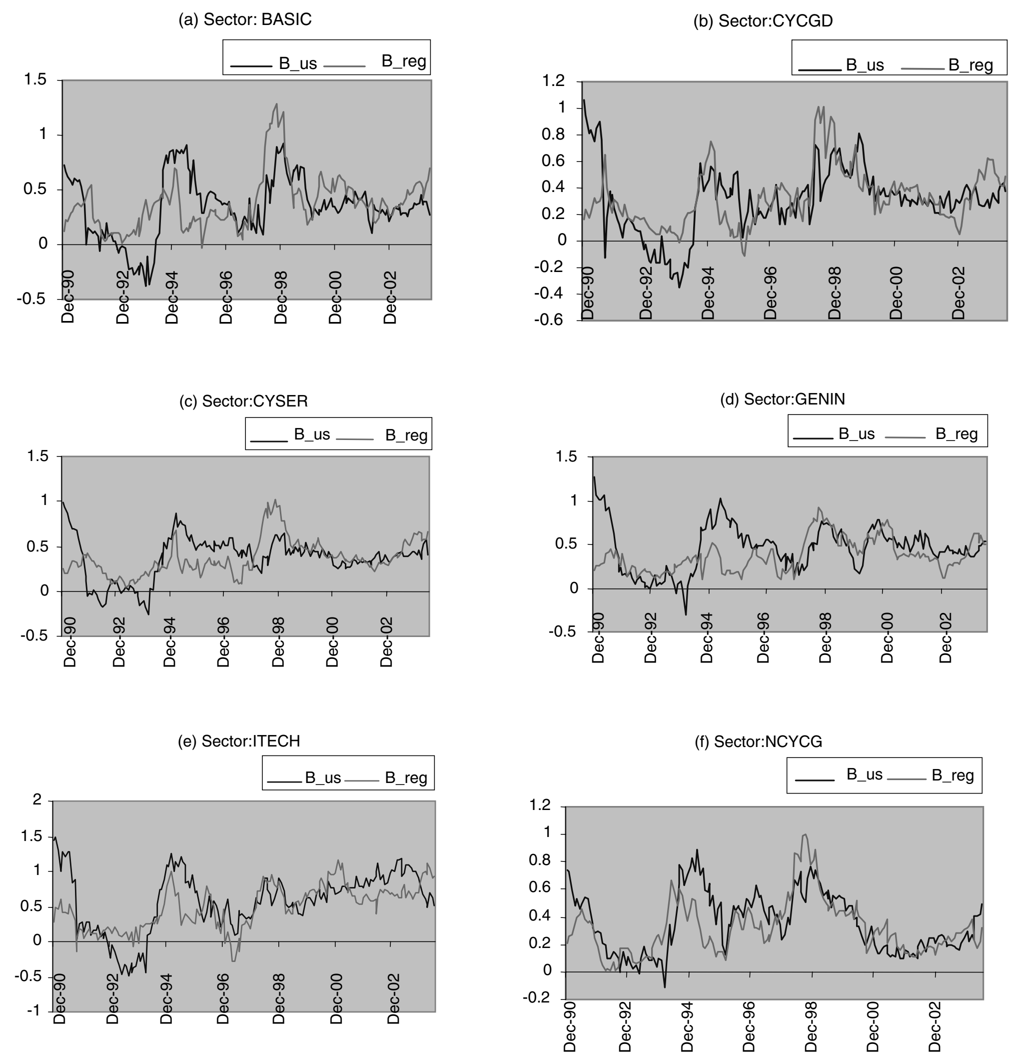


(*Continued*)

Figure 1. Summary of Time-Varying Sector-Level Integration: GARCH 12-Month Rolling Estimates (*Continued*)



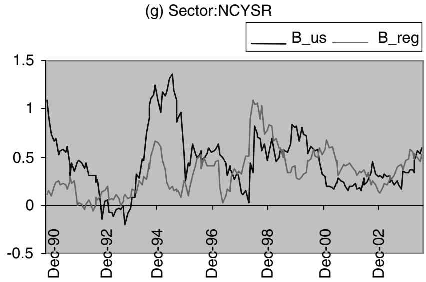
B. Asia



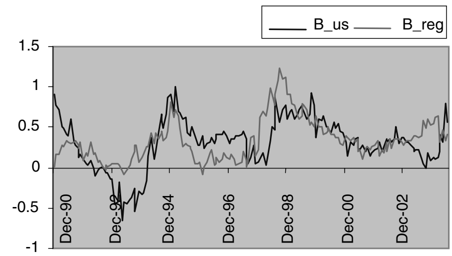
(*Continued*)

Figure 1. Summary of Time-Varying Sector-Level Integration: GARCH 12-Month Rolling Estimates (*Continued*)

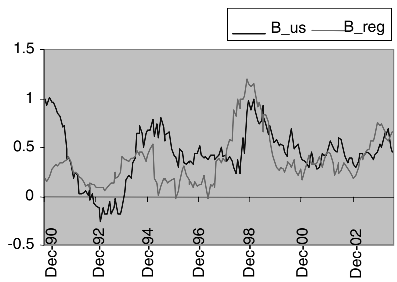
(g) Sector:NCYSR



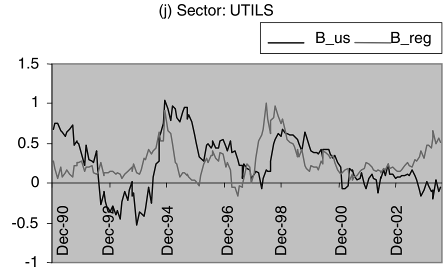
(h) Sector:RESOR



(i) Sector:TOTLF

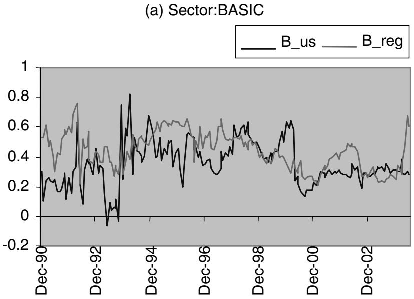


(j) Sector: UTILS

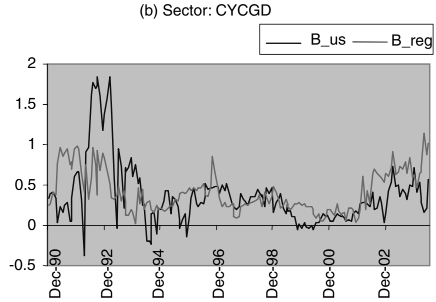


C. Latin America

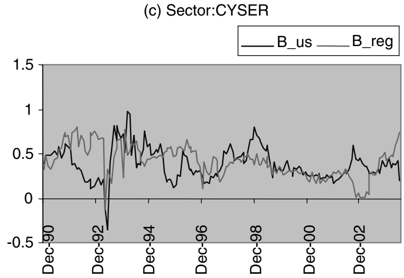
(a) Sector:BASIC



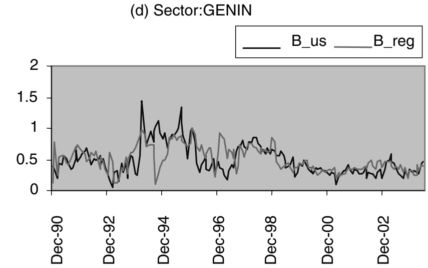
(b) Sector: CYCGD



(c) Sector:CYSER

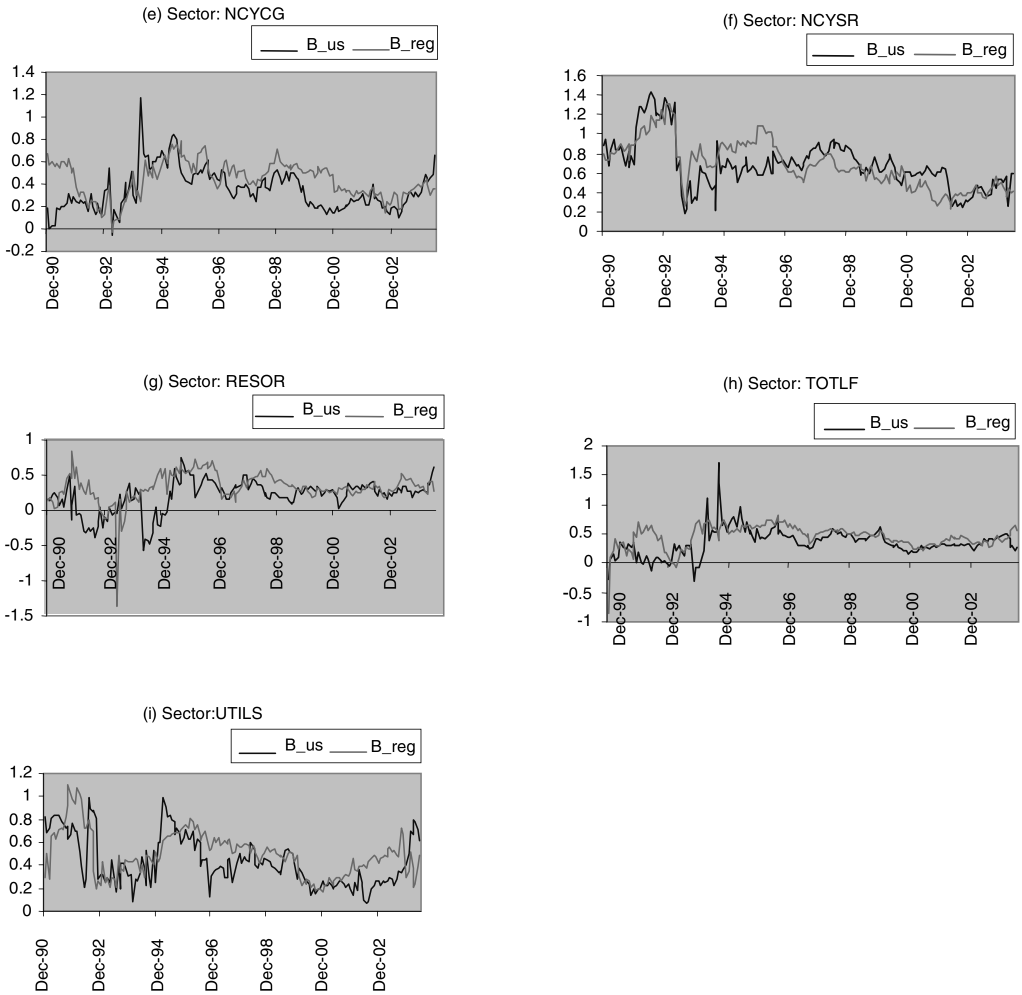


(d) Sector:GENIN



(*Continued*)

Figure 1. Summary of Time-Varying Sector-Level Integration: GARCH 12-Month Rolling Estimates (*Continued*)



crises and the whole period (see Appendix C, Panel A). As a rule, both betas fell during the Mexican crisis. Yet in half of the sectors, the drop in the US beta was less suggesting a relative increase in US integration. During the Asian crisis, there is a marked increase in the regional beta as compared to the US beta in all of the sectors indicating a substantial increase in regional integration. Phylaktis and Ravazzolo (2002) find a similar result when examining real and financial links for the Asian countries during the period 1980-1998. In their study, they analyzed the covariances of excess returns on national stock markets and used the comovement of innovations in future expected stock returns as an indicator of financial integration and the comovement of dividend news between two countries as an indicator of economic integration.

In Latin America, the movement of betas was the least volatile of the three regions. All the sectors display a stronger regional-level integration for most of the sample period. There were periodic switches of beta dominance over time and those switches were also related to the financial crisis periods. A similar conclusion is derived by comparing the betas during the two crises and over the whole period. Regional integration increases during the Mexican crisis as the US betas become statistically insignificant and the regional betas increase for all sectors. During the Asian crisis, not only did the US betas increase substantially for all sectors, but their difference with regional betas also increases, implying an increase in US integration.

In general, sector betas in the three regions had a great deal of variation and the beta dominance was unstable over time. We find that in Asia, there was an increase in regional integration during the Asian crisis for all sectors. Since Asia was more integrated at the global level previously, the switch to regional integration during the crisis indicates the possibility of contagion. In contrast, in Latin America we find an increase in regional integration for all sectors during the Mexican crisis. However, since Latin America was already much more integrated at the regional level, the increase in regional integration during the crisis may not indicate contagion, but simply be the consequence of an increase in interdependence. In the next section, we will explore whether there was sector-level contagion.

E. Sector-Level Contagion

As previously explained, our framework decomposes the correlations of sector returns into two components: 1) the part the asset pricing model explains and 2) the part the model does not explain. The explained portion provides potential insights regarding sector-level integration through the movements in the conditional betas. The unexplained portion allows us to examine the correlations of model residuals, which we define as the contagion effects at the sector level.

We examine Models (9) and (10) to detect the overall contagion for the whole sample as well as the additional contagion during particular crisis periods. Two crises are considered: 1) the Mexican crisis during 1994-1995 and 2) the Asian crisis during 1997-1998 (see Table III). Panel A in Table III reports the estimation for the Mexican crisis. Looking first at the overall contagion through the joint test of $m = n = 0$, we reject the null of no contagion against all the country-group benchmarks at the 5% level for the majority of sectors in the three regions. However, the channels and magnitude of contagion vary across regions. In Europe and Asia, the overall contagion comes from all three channels, each of which is significant: 1) the global shocks, 2) regional shocks, and 3) the shocks of regional equivalent sectors. In Latin America, it is mainly transmitted via global and regional shocks channels, but the link with regional equivalent sector shocks is not as widely spread as that in Europe or Asia. On the other hand, when comparing the m coefficients against the three benchmarks within each region, we find that sectors in Europe and Latin America had the greatest correlation with regional residuals. In Asia, however, the correlation with the sum of equivalent sector residuals was the greatest. In other words, the highest magnitude of contagion is driven by regional shocks for sectors in Europe and Latin America, but by the equivalent sector shocks for sectors in Asia. The importance of regional equivalent shocks for overall contagion highlights the increasing role of sector-specific components as compared to country-specific components of stock returns noted in another strand of literature, which adopted a more micro-based approach to explaining stock returns.[11] For example, Phylaktis and Xia (2006a) find a ratio of country to industry effects to be 5.25:1, 3.57:1, and 1.49:1 for Latin America, Asia, and Europe, respectively. Furthermore, they find these ratios to be decreasing over time for all of these regions.

[11] See Baca, Garbe, and Weiss (2000) and Cavaglia, Brightman, and Aked (2000).

Table III. Cross-Sectional Analysis of Sector Residuals

The following models are estimated:

$$\hat{e}_{i,j,t} = \nu_{i,j} + \phi_{i,j,t}\hat{e}_{g,t} + \xi_{i,j,t},$$
$$\phi_{i,j,t} = m + nD_{i,t},$$

where $\hat{e}_{i,j,t}$, $\hat{e}_{g,t}$ are the estimated idiosyncratic return shocks of sector i and a country-group, respectively in examination of Model (1)-(3) with time-variant betas. Three country-groups are considered: 1) the return shocks from the United States, $\hat{e}_{g,t} = \hat{e}_{us,t}$; 2) the return shocks from a geographic region, $\hat{e}_{g,t} = \hat{e}_{reg,t}$; and 3) the return shocks from the sum of residuals of sector i in a region excluding the country to be considered, $\hat{e}_{g,t} = \sum_{\substack{k\neq j \\ k\subset G}} \hat{e}_{k,t}$, where G denotes a particular region country k belongs to. The former equation involves the time series regression and $\phi_{i,j,t}$ is the time varying coefficient of each sector i. The time varying coefficients $\phi_{i,j,t}$ of equivalent sectors in each region (Europe, Asia, and Latin America) are pooled together and the latter equation involves the panel data regression. The estimation corrects for individual serial correlations by adding the cross-sectional AR(1) term in equation and group-wise heteroskedasticity by employing the seemingly unrelated regression (SUR) method. $D_{i,t}$ is a dummy variable that represents two sample periods: 1) the Mexican crisis period from November 1994 to December 1995 and 2) the Asian crisis period from April 1997 to October 1998. The parameter estimates of m and n are reported, with standard errors in parentheses, while p-values are given in brackets. Wald t = Wald test; BASIC = basic industries; CYCGD = cyclical consumer goods; CYSER = cyclical services; GENIN = general industries; ITECH = information technology; NCYCG = noncyclical consumer goods; NCYSR = noncyclical services; RESOR = resources; TOTLF = financials; and UTILS = utilities.

Sector	US Residuals $e_{us,t}$			Regional Residuals $e_{reg,t}$			Sum of Residuals $\sum_{\substack{k\neq j \\ k\subset G}} e_{kt}$		
	m	n	Wald t $m=n=0$	m	n	Wald t $m=n=0$	m	n	Wald t $m=n=0$
Panel A. Mexican Crisis Dummy									
Europe									
BASIC	0.11	0.018	127.68	0.203	−0.01	148.17	0.033	−0.003	114.54
	(0.01)	(0.028)	[0.000]	(0.017)	(0.038)	[0.000]	(0.003)	(0.004)	[0.000]
CYCGD	0.111	0.174	100.01	0.179	−0.039	89.07	0.025	0.008	56.49
	(0.013)	(0.045)	[0.000]	(0.019)	(0.048)	[0.000]	(0.003)	(0.005)	[0.000]
CYSER	0.129	0.058	134.99	0.224	0.076	168.14	0.029	−0.000	161.26
	(0.012)	(0.031)	[0.000]	(0.018)	(0.042)	[0.000]	(0.002)	(0.003)	[0.000]
GENIN	0.099	0.048	103.53	0.188	−0.009	111.68	0.034	0.001	198.39
	(0.011)	(0.029)	[0.000]	(0.018)	(0.04)	[0.000]	(0.002)	(0.003)	[0.000]
ITECH	0.181	0.242	120.67	0.295	0.049	130.78	0.035	0.004	36.1
	(0.021)	(0.056)	[0.000]	(0.027)	(0.064)	[0.000]	(0.006)	(0.005)	[0.000]
NCYCG	0.086	0.054	91.04	0.2	0.086	139.33	0.037	0.004	166.06
	(0.01)	(0.026)	[0.000]	(0.018)	(0.038)	[0.000]	(0.003)	(0.003)	[0.000]
NCYSR	0.098	0.06	66.52	0.389	−0.024	163.88	0.051	−0.002	94.93
	(0.013)	(0.034)	[0.000]	(0.031)	(0.058)	[0.000]	(0.005)	(0.005)	[0.000]
RESOR	0.099	0.145	82.38	0.132	0.146	54.34	0.03	0.005	29.13
	(0.014)	(0.038)	[0.000]	(0.02)	(0.054)	[0.000]	(0.006)	(0.006)	[0.000]
TOTLF	0.071	0.052	47.07	0.208	0.066	120.58	0.047	0.001	189.75
	(0.012)	(0.029)	[0.000]	(0.02)	(0.044)	[0.000]	(0.003)	(0.003)	[0.000]
UTILS	0.079	0.107	75.54	0.178	0.074	96.25	0.036	0.001	78.94
	(0.011)	(0.032)	[0.000]	(0.019)	(0.043)	[0.000]	(0.004)	(0.004)	[0.000]

(*Continued*)

Table III. Cross-Sectional Analysis of Sector Residuals (*Continued*)

Sector	US Residuals $e_{us,t}$			Regional Residuals $e_{reg,t}$			Sum of Residuals $\sum_{\substack{k\neq j\\ k\subset G}} e_{kt}$		
	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$
				Panel A. Mexican Crisis Dummy					
				Asia					
BASIC	0.051	0.097	9.112	0.08	0.02	25.99	0.075	0.012	90.35
	(0.024)	(0.06)	[0.011]	(0.017)	(0.045)	[0.000]	(0.008)	(0.007)	[0.000]
CYCGD	0.048	0.139	12.103	0.073	0.006	12.16	0.075	0.031	96.82
	(0.023)	(0.061)	[0.002]	(0.022)	(0.057)	[0.002]	(0.008)	(0.01)	[0.000]
CYSER	0.032	0.08	9.476	0.063	0.05	29.49	0.063	0.008	94.79
	(0.016)	(0.045)	[0.009]	(0.013)	(0.036)	[0.000]	(0.007)	(0.007)	[0.000]
GENIN	0.026	0.105	9.55	0.085	−0.095	21.84	0.086	0.009	166.47
	(0.017)	(0.046)	[0.008]	(0.019)	(0.046)	[0.000]	(0.007)	(0.008)	[0.000]
ITECH	−0.003	0.394	25.63	0.062	−0.043	6.189	0.085	0.048	42.86
	(0.019)	(0.079)	[0.000]	(0.025)	(0.079)	[0.045]	(0.014)	(0.02)	[0.000]
NCYCG	0.016	0.152	21.1	0.022	0.05	6.923	0.05	0.044	95.96
	(0.012)	(0.038)	[0.000]	(0.013)	(0.033)	[0.031]	(0.006)	(0.009)	[0.000]
NCYSR	0.012	0.133	12.43	0.038	−0.008	9.321	0.064	0.003	41.25
	(0.015)	(0.043)	[0.002]	(0.013)	(0.038)	[0.009]	(0.01)	(0.01)	[0.000]
RESOR	0.059	0.009	5.505	0.037	0.037	4.184	0.042	−0.002	34.11
	(0.026)	(0.068)	[0.064]	(0.022)	(0.052)	[0.123]	(0.007)	(0.011)	[0.000]
TOTLF	0.019	0.018	1.699	0.054	−0.008	10.27	0.063	0.007	96.29
	(0.017)	(0.046)	[0.427]	(0.017)	(0.046)	[0.006]	(0.006)	(0.006)	[0.000]
UTILS	0.027	0.135	3.617	0.034	−0.124	3.809	0.04	0.043	8.63
	(0.03)	(0.09)	[0.164]	(0.028)	(0.071)	[0.149]	(0.019)	(0.024)	[0.013]
				Latin America					
BASIC	0.026	0.212	35.05	0.127	0.006	14.51	0.012	0.024	11.35
	(0.016)	(0.041)	[0.000]	(0.017)	(0.034)	[0.000]	(0.006)	(0.009)	[0.000]
CYCGD	0.027	−0.097	1.649	0.008	−0.011	0.017	0.002	0.001	0.132
	(0.023)	(0.057)	[0.199]	(0.014)	(0.025)	[0.897]	(0.008)	(0.007)	[0.716]
CYSER	0.045	0.109	18.95	0.163	−0.003	8.94	−0.021	0.017	0.019
	(0.011)	(0.037)	[0.000]	(0.024)	(0.054)	[0.003]	(0.014)	(0.027)	[0.891]
GENIN	0.092	0.108	11.22	0.088	0.046	10.31	0.003	0.009	1.057
	(0.023)	(0.061)	[0.0001]	(0.016)	(0.043)	[0.001]	(0.007)	(0.011)	[0.304]
ITECH	–	–	–	–	–	–	–	–	–
NCYCG	0.042	0.021	4.08	0.129	−0.000	16.48	0.024	0.023	5.647
	(0.011)	(0.032)	[0.043]	(0.012)	(0.033)	[0.000]	(0.013)	(0.016)	[0.017]
NCYSR	0.069	0.002	1.411	0.074	−0.015	0.834	0.015	−0.022	0.085
	(0.022)	(0.061)	[0.235]	(0.029)	(0.063)	[0.361]	(0.014)	(0.024)	[0.771]
RESOR	0.015	0.07	3.09	0.091	0.007	6.634	0.012	−0.003	0.36
	(0.018)	(0.049)	[0.079]	(0.017)	(0.038)	[0.01]	(0.009)	(0.014)	[0.548]
TOTLF	0.03	0.079	7.842	0.047	0.031	6.482	0.021	0.005	8.087
	(0.015)	(0.04)	[0.005]	(0.012)	(0.031)	[0.011]	(0.004)	(0.009)	[0.004]
UTILS	0.039	0.128	11.69	0.051	−0.000	1.479	0.018	0.065	4.457
	(0.016)	(0.049)	[0.000]	(0.014)	(0.041)	[0.224]	(0.014)	(0.039)	[0.035]

(*Continued*)

Table III. Cross-Sectional Analysis of Sector Residuals (*Continued*)

Sector	US Residuals $e_{us,t}$			Regional Residuals $e_{reg,t}$			Sum of Residuals $\sum_{k \subset G}^{k \neq j} e_{kt}$		
	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$
Panel B. Asia Crisis Dummy									
Europe									
BASIC	0.112	−0.009	17.98	0.199	0.031	150.93	0.033	−0.000	112.54
	(0.01)	(0.025)	[0.000]	(0.017)	(0.036)	[0.000]	(0.003)	(0.003)	[0.000]
CYCGD	0.112	0.047	30.86	0.167	0.067	95.96	0.025	0.004	54.35
	(0.014)	(0.03)	[0.000]	(0.019)	(0.041)	[0.000]	(0.004)	(0.004)	[0.000]
CYSER	0.129	0.039	36.9	0.227	0.009	160.03	0.03	0.000	160.88
	(0.012)	(0.029)	[0.000]	(0.019)	(0.039)	[0.000]	(0.002)	(0.003)	[0.000]
GENIN	0.107	−0.042	6.478	0.185	0.048	111.05	0.034	0.002	203.02
	(0.011)	(0.026)	[0.011]	(0.019)	(0.039)	[0.000]	(0.002)	(0.003)	[0.000]
ITECH	0.211	−0.013	14.68	0.296	0.064	129.63	0.035	0.003	36.96
	(0.021)	(0.053)	[0.000]	(0.027)	(0.06)	[0.000]	(0.006)	(0.005)	[0.000]
NCYCG	0.094	−0.024	8.886	0.205	0.086	149.44	0.037	−0.002	166.94
	(0.01)	(0.024)	[0.003]	(0.018)	(0.036)	[0.000]	(0.003)	(0.003)	[0.000]
NCYSR	0.102	0.029	15.08	0.387	−0.01	162.12	0.051	0.004	99.73
	(0.014)	(0.035)	[0.000]	(0.031)	(0.054)	[0.000]	(0.005)	(0.005)	[0.000]
RESOR	0.111	−0.019	7.381	0.133	−0.032	42.59	0.031	0.001	29.14
	(0.015)	(0.034)	[0.007]	(0.02)	(0.048)	[0.000]	(0.006)	(0.006)	[0.000]
TOTLF	0.075	0.001	8.336	0.206	0.05	119.16	0.047	0.000	188.58
	(0.012)	(0.027)	[0.004]	(0.02)	(0.041)	[0.000]	(0.003)	(0.003)	[0.000]
UTILS	0.086	−0.033	3.589	0.184	0.016	89.43	0.037	−0.007	85.07
	(0.011)	(0.029)	[0.058]	(0.02)	(0.04)	[0.000]	(0.004)	(0.004)	[0.000]
Asia									
BASIC	0.032	0.209	24.21	0.072	0.064	27.52	0.076	−0.003	84.32
	(0.022)	(0.052)	[0.000]	(0.017)	(0.041)	[0.000]	(0.008)	(0.007)	[0.000]
CYCGD	0.035	0.154	14.89	0.063	0.094	15.88	0.071	−0.003	49.52
	(0.022)	(0.054)	[0.000]	(0.022)	(0.052)	[0.000]	(0.01)	(0.01)	[0.000]
CYSER	0.025	0.08	8.997	0.059	0.07	30.02	0.066	−0.01	86.84
	(0.016)	(0.04)	[0.011]	(0.014)	(0.034)	[0.000]	(0.007)	(0.007)	[0.000]
GENIN	0.025	0.044	4.321	0.073	0.068	23.89	0.086	0.006	158.18
	(0.017)	(0.043)	[0.115]	(0.018)	(0.043)	[0.000]	(0.007)	(0.008)	[0.000]
ITECH	0.009	0.068	2.715	0.051	0.08	8.133	0.09	−0.001	41.85
	(0.021)	(0.051)	[0.257]	(0.025)	(0.059)	[0.017]	(0.014)	(0.011)	[0.000]
NCYCG	0.035	−0.1	11.48	0.023	0.037	6.125	0.051	0.005	48.22
	(0.013)	(0.036)	[0.003]	(0.013)	(0.031)	[0.047]	(0.008)	(0.009)	[0.000]
NCYSR	0.025	−0.019	2.684	0.029	0.098	18.87	0.065	0.001	40.9
	(0.015)	(0.041)	[0.261]	(0.012)	(0.034)	[0.000]	(0.01)	(0.01)	[0.000]
RESOR	0.042	0.159	13.94	0.019	0.163	16.53	0.04	0.001	38.33
	(0.025)	(0.059)	[0.000]	(0.02)	(0.046)	[0.000]	(0.007)	(0.01)	[0.000]
TOTLF	0.013	0.087	6.206	0.047	0.052	11.97	0.065	−0.014	94.01
	(0.017)	(0.043)	[0.044]	(0.017)	(0.042)	[0.003]	(0.007)	(0.006)	[0.000]
UTILS	0.039	−0.041	1.745	−0.004	0.214	16.1	0.045	0.006	5.98
	(0.03)	(0.064)	[0.418]	(0.026)	(0.055)	[0.000]	(0.019)	(0.022)	[0.05]

(*Continued*)

Table III. Cross-Sectional Analysis of Sector Residuals (*Continued*)

Sector	US Residuals $e_{us,t}$			Regional Residuals $e_{reg,t}$			Sum of Residuals $\sum_{\substack{k \neq j \\ k \subset G}} e_{kt}$		
	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$	m	n	Wald t $m = n = 0$
Panel B. Asia Crisis Dummy									
Latin America									
BASIC	0.03	0.046	5.804	0.126	0.011	60.51	0.014	0.009	5.867
	(0.018)	(0.042)	[0.055]	(0.017)	(0.033)	[0.000]	(0.007)	(0.01)	[0.053]
CYCGD	0.007	0.044	1.083	−0.007	0.051	4.137	0.006	−0.008	1.106
	(0.024)	(0.054)	[0.582]	(0.014)	(0.026)	[0.126]	(0.008)	(0.008)	[0.575]
CYSER	0.053	0.01	19.597	0.174	−0.041	54.49	−0.024	0.043	4.926
	(0.013)	(0.036)	[0.000]	(0.024)	(0.052)	[0.000]	(0.014)	(0.026)	[0.085]
GENIN	0.097	0.057	22.49	0.094	−0.024	33.51	0.002	0.005	0.334
	(0.024)	(0.056)	[0.000]	(0.016)	(0.039)	[0.000]	(0.008)	(0.011)	[0.846]
ITECH	–	–	–	–	–	–	–	–	–
NCYCG	0.041	0.023	18.37	0.124	0.028	130.61	0.022	0.018	4.867
	(0.011)	(0.028)	[0.000]	(0.012)	(0.03)	[0.000]	(0.013)	(0.016)	[0.088]
NCYSR	0.066	0.028	11.06	0.058	0.061	6.673	0.01	0.02	1.743
	(0.022)	(0.055)	[0.004]	(0.028)	(0.057)	[0.036]	(0.014)	(0.021)	[0.418]
RESOR	0.013	0.034	1.601	0.092	0.002	29.66	0.011	0.006	1.838
	(0.018)	(0.044)	[0.449]	(0.018)	(0.035)	[0.000]	(0.009)	(0.014)	[0.399]
TOTLF	0.035	0.01	5.789	0.045	0.039	19.19	0.023	−0.014	27.67
	(0.016)	(0.037)	[0.055]	(0.013)	(0.029)	[0.000]	(0.004)	(0.009)	[0.000]
UTILS	0.034	0.074	11.52	0.051	−0.005	12.79	0.019	0.014	4.023
	(0.017)	(0.037)	[0.003]	(0.015)	(0.034)	[0.002]	(0.014)	(0.013)	[0.134]

However, our main interest is the additional correlation during crises, which is captured through the n coefficient. We look first at the Mexican crisis and note that only some sectors display a positive and statistically significant coefficient and those are largely related to the US residuals (see Panel A of Table III). In particular, there are five sectors in Europe and Asia and four in Latin America. Clearly, the Mexican crisis caused contagion and this was primarily driven by global shocks (shocks from the US market). Looking at the sectors that have been affected, we note that the financial sector (TOTLF) did not show significant additional correlation in the case of Europe and Asia, but it did in the case of Latin America.

The results for contagion during the Asian crisis are presented in Panel B of Table III. Five (4) sectors in Asia had a positive significant n coefficient with respect to the United States (region); whereas, the number of significant n coefficients in Europe and Latin America was negligible. This finding indicates that the Asian crisis worsened contagion for many sectors in Asia but had no effect elsewhere. What is also interesting is that the financial sector displayed additional correlation with respect to US residuals.

Overall, our analysis reveals that sector residuals are correlated beyond what is captured in our model, suggesting evidence of contagion. An overall contagion at sector level over our entire sample period is found, but varies across regions. In terms of possible channels, contagion across the three regions is transmitted via global and regional shocks. But in Europe and Asia, an additional channel is identified, which is the shocks from equivalent sectors within the region. This confirms our prior expectation that contagion occurs at the sector level and sectors provide channels in propagating unexpected shocks. In terms of the magnitude of contagion, Europe and

Latin America experienced the most severe contagion from regional shocks, whereas in Asia, it is mainly driven by the shocks from equivalent sectors within the region.

Our analysis of contagion during crisis periods revealed the following. First, contagion is transmitted in some sectors and not in others. This explains the mixed results found in studies of contagion at the market level. Second, the results also point out that even though contagion might be prevalent at the market level, there are still some sectors that are immune from the contagion effect during a crisis. This has implications for international portfolio diversification, which are discussed in the next section.

Third, the type of sectors affected provides insight concerning the transmission channels of contagion. A test of the hypothesis that $n \neq 0$ with respect to $e_{us,t}$ for the financial sector (TOTFL) relates to whether the shock was transmitted through the financial sector of two regions. In our analysis of the Mexican crisis, we found that the financial sector did not exhibit additional correlation with respect to the United States in Europe and Asia, but it did in Latin America. In addition, correlations with similar sectors in the region were found to be statistically insignificant. This demonstrates that financial links with the United States might have transmitted the Mexican crisis in the region. This result is supported by Frankel and Schmuckler (1998), who examined the behavior of mutual funds in international equity markets. They found that the Mexican crisis spread to other equity markets in Latin America through New York rather than directly. In Europe and Asia, trade links might have been the transmission mechanism of the crisis.

In the case of the Asian crisis, the scenario is different. Our analysis indicates that contagion can only be observed in Asia. In addition, the financial sector is among the sectors that displayed additional correlation with respect to the United States. This again confirms the financial links through the United States for the propagation of the crisis. This result is supported by Van Rijckeghem and Weder (2001, 2002), who examined shifts in portfolios of European, North American, and Japanese banks during the Asian crisis. They found that North American banks shifted their lending amid emerging markets from Asia to Latin America and Europe explaining our findings as to why the last two regions were unaffected. In conclusion, our analysis lends support to the importance of financial links through a financial center, such as the United States, in propagating a crisis, at least within the region of the initial disturbance.

IV. Conclusion

The last decade or so witnessed a series of financial crises, and one common observation during those crises is that financial markets tend to comove more closely than during tranquil times. Such strong comovement across markets is often referred to as contagion. The purpose of this paper is to examine equity market comovement and contagion at the sector level across the regions of Europe, Asia, and Latin America, an issue not yet studied in the literature. A by-product of our analysis is the investigation of industry/sector-level integration on equity markets, which has been studied on a limited basis of the euro zone, the United States, the United Kingdom, and G-7 countries.

In this paper, we define contagion as excess correlation (i.e., correlation over and above what one expects from economic fundamentals). As no consensus has agreed upon what the fundamentals are, our paper follows the two-factor international asset pricing model framework of Bekaert, Harvey, and Ng (2005) to study the sector-level integration and contagion. Our analysis focuses on the 10 broad sectors in 29 smaller markets in Europe, Asia, and Latin America during the period of January 1990-June 2004. The key results are summarized as follows. First, the sector-level integration displays a distinct pattern across regions. Sectors in Europe and Latin America have higher betas with respect to the regional market than with the US market, suggesting stronger integration at the regional level. Conversely, sectors in Asia are more responsive to the US market than to the regional market and thus more integrated at the global level. Information technology stands out as a sector, as it is more globally integrated regardless of its geographic location.

Second, the pattern of sector integration changes over time, especially during crisis periods. Across the three regions, we find many sectors showing a sudden change from regional beta dominance to the US beta dominance or vice versa during crisis periods. This beta shift indicates that contagion may possibly be sustained at the sector level.

Third, our analysis reveals that sector residuals are correlated beyond what is captured by our asset pricing model suggesting evidence of contagion. An overall contagion over our entire sample period is found for the majority of sectors in Europe, Asia, and Latin America. However, there are differences in the transmission channels and in the magnitude of contagion across regions.

Finally, in examining whether the Mexican and Asian crises provide additional contagion effects, we find that nearly half of the sectors in the three regions were affected via global shocks during the Mexican crisis. During the Asian crisis, no additional contagion is found in Europe or Latin America, but a worsened contagion transmitted via global and regional shocks is found for most sectors in Asia. In reviewing the affected sectors, we note that the financial sector exhibited additional correlation with respect to the United States in Latin America during the Mexican crisis and in Asia during the Asian crisis supporting the importance of financial links through a financial center in propagating a crisis.

In conclusion, our results confirm the sector heterogeneity of contagion and this has implications for portfolio managers aiming to diversify risks. On the one hand, industries/sectors are found to have crossed national boundaries and become integrated with the rest of the world. This means that domestic risk factors now matter less and nondomestic factors matter more. Diversification across countries may be losing merit and diversification across industries is preferable. However, the divergence of integration across regions points to the fact that industries/sectors are not as globally correlated as we expect and regional effects still play a role. Therefore, selecting portfolios across regions rather than within regions would be more efficient. However, international investors and portfolio managers are concerned with diversification in volatile times, especially during crisis periods when it is most needed. Our evidence indicates that some sectors are plagued with contagion during crises, so investors and portfolio managers should avoid choosing individual securities from those contagious sectors. However, our evidence also demonstrates that there are sectors that are immune from external shocks or contagion during financial crises. Those sectors can provide a tool to diversify risks during crisis periods and achieving the benefits of diversification. ■

Appendix A. FTSE Actuaries (Sector and Industry Classification)

Sector	Industries Included
Basic industries	Chemicals
	Construction & building materials
	Forestry & paper
	Steel & other metals
	Chemicals, construction, & building
	Materials, forestry, & paper
	Steel & other metals
Cyclical consumer goods	Automobiles & parts
	Household goods & textiles
Cyclical services	General retailers
	Leisure entertainment & hotels
	Media & photography
	Support services
	Transport
General industries	Aerospace & defense
	Electronic & electrical equipment
	Engineering & machinery
Information technology	Information technology hardware
	Software & computer services
Noncyclical consumer goods	Beverages
	Food producers & processors
	Health
	Personal care & household products
	Pharmaceuticals & biotechnology
	Tobacco
Noncyclical services	Food & drug retailers
	Telecommunication services
Resources	Mining
	Oil & gas
Financials	Banks
	Insurance
	Life assurance
	Investment companies
	Real estate
	Specialty & other finance
Utilities	Electricity
	Gas distribution
	Water

Appendix B. Sample Countries Included in the Analysis

Region	Countries Included
Europe	Belgium, Denmark, Spain, Finland, Greece, Ireland, Luxemburg, Netherlands, Norway, Austria, Portugal, Sweden, Switzerland, Turkey
Asia	Hong Kong, Malaysia, Korea, Indonesia, Singapore, Thailand, Taiwan, Philippines
Latin America	Argentine, Brazil, Columbia, Chile, Mexico, Peru, Venezuela

Appendix C. Contagion: Panel Data Estimation

The following asymmetric GARCH model is examined

$$r_{i,j,t} = \delta_{i,j} X_{i,j,t-1} + \beta^{us}_{i,j,t-1} \mu_{us,t-1} + \beta^{reg}_{i,j,t-1} \mu_{reg,t-1} + \beta^{us}_{i,j,t-1} e_{us,t} + \beta^{reg}_{i,j,t-1} e_{reg,t} + e_{i,j,t},$$
$$e_{i,j,t}|\Omega_{t-1} \sim N(0, \sigma^2_{i,j,t}),$$
$$\sigma^2_{i,j,t} = a_{i,j} + b_{i,j}\sigma^2_{i,j,t-1} + c_{i,j}e^2_{i,j,t-1} + d_{i,j}\eta^2_{i,j,t-1},$$
$$\eta_{i,j,t} = \min\{0, e_{i,j,t}),$$

where $r_{i,j,t}$ is the excess return, $\mu_{us,t-1}$ and $e_{us,t}$ ($\mu_{reg,t-1}$ and $e_{reg,t}$) are the conditional expected excess return and residual on the US (regional) market. $e_{i,j,t}$ is the idiosyncratic shock of any sector i in country j, and $X_{i,j,t-1}$ represents local information variables available at time $t-1$. The table reports betas for each sector in each region on the basis of pool data. That means that for each sector in a region there is one US beta ($\hat{\beta}^{us}_{i,j}$) and one regional beta ($\hat{\beta}^{reg}_{i,j}$), instead of one US beta and one regional beta for each sector in each country. The p-values are given in parentheses. Std dev. = standard deviation; Latin Am. = Latin America; BASIC = basic industries; CYCGD = cyclical consumer goods; CYSER = cyclical services; GENIN = general industries; ITECH = information technology; NCYCG = noncyclical consumer goods; NCYSR = noncyclical services; RESOR = resources; TOTLF = financials; and UTILS = utilities.

	Whole Sample		Mexican Crisis		Asian Crisis	
Sector	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$
			Panel A. Europe			
BASIC	0.357	0.508	0.187	0.938	0.472	0.648
	(0.000)	(0.000)	(0.136)	(0.000)	(0.000)	(0.000)
CYCGD	0.359	0.474	−0.013	0.770	0.464	0.649
	(0.000)	(0.000)	(0.935)	(0.000)	(0.000)	(0.000)
CYSER	0.431	0.539	−0.265	0.617	0.370	0.502
	(0.000)	(0.000)	(0.049)	(0.000)	(0.000)	(0.000)
GENIN	0.422	0.542	0.096	0.760	0.422	0.665
	(0.000)	(0.000)	(0.369)	(0.000)	(0.000)	(0.000)
ITECH	0.822	0.712	0.120	0.693	0.857	0.490
	(0.000)	(0.000)	(0.759)	(0.031)	(0.000)	(0.000)
NCYCG	0.293	0.440	−0.070	0.799	0.373	0.579
	(0.000)	(0.000)	(0.484)	(0.000)	(0.000)	(0.000)
NCYSR	0.503	0.608	−0.079	0.720	0.434	0.780
	(0.000)	(0.000)	(0.559)	(0.000)	(0.000)	(0.000)
RESOR	0.249	0.443	−0.030	0.719	0.332	0.680
	(0.000)	(0.000)	(0.905)	(0.000)	(0.000)	(0.000)
TOTLF	0.471	0.581	0.122	0.840	0.588	0.768
	(0.000)	(0.000)	(0.178)	(0.000)	(0.000)	(0.000)
UTILS	0.146	0.365	−0.182	0.612	0.061	0.316
	(0.000)	(0.000)	(0.341)	(0.000)	(0.000)	(0.000)

(*Continued*)

Appendix C. Contagion: Panel Data Estimation (*Continued*)

Sector	Whole Sample		Mexican Crisis		Asian Crisis	
	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$	$\hat{\beta}^{us}_{i,j}$	$\hat{\beta}^{reg}_{i,j}$
Panel B. Asia						
BASIC	0.433	0.450	0.335	0.266	0.708	1.128
	(0.000)	(0.000)	(0.027)	(0.000)	(0.000)	(0.000)
CYCGD	0.423	0.429	0.020	0.171	0.565	0.790
	(0.000)	(0.000)	(0.919)	(0.067)	(0.000)	(0.000)
CYSER	0.437	0.431	0.278	0.306	0.565	0.938
	(0.000)	(0.000)	(0.047)	(0.000)	(0.000)	(0.000)
GENIN	0.561	0.450	0.485	0.225	0.561	0.808
	(0.000)	(0.000)	(0.008)	(0.009)	(0.000)	(0.000)
ITECH	0.738	0.606	0.658	0.337	0.682	0.841
	(0.000)	(0.000)	(0.137)	(0.099)	(0.000)	(0.000)
NCYCG	0.350	0.347	0.398	0.206	0.502	0.854
	(0.000)	(0.000)	(0.005)	(0.002)	(0.000)	(0.000)
NCYSR	0.479	0.418	0.327	0.241	0.498	0.869
	(0.000)	(0.000)	(0.042)	(0.001)	(0.000)	(0.000)
RESOR	0.405	0.421	0.217	0.176	0.617	1.046
	(0.000)	(0.000)	(0.336)	(0.095)	(0.000)	(0.000)
TOTLF	0.524	0.445	0.457	0.204	0.702	1.106
	(0.000)	(0.000)	(0.003)	(0.005)	(0.000)	(0.000)
UTILS	0.310	0.353	0.365	0.153	0.397	0.859
	(0.000)	(0.000)	(0.103)	(0.143)	(0.000)	(0.000)
Panel C. Latin America						
BASIC	0.356	0.496	−0.214	0.667	0.572	0.433
	(0.000)	(0.000)	(0.433)	(0.000)	(0.000)	(0.000)
CYCGD	0.183	0.332	−0.384	0.372	0.341	0.339
	(0.000)	(0.000)	(0.255)	(0.000)	(0.000)	(0.000)
CYSER	0.316	0.399	−0.091	0.612	0.619	0.387
	(0.000)	(0.000)	(0.759)	(0.000)	(0.000)	(0.000)
GENIN	0.347	0.517	−0.127	0.633	0.928	0.746
	(0.000)	(0.000)	(0.515)	(0.000)	(0.000)	(0.000)
ITECH	–	–	–	–	–	–
NCYCG	0.314	0.487	−0.177	0.664	0.531	0.434
	(0.000)	(0.000)	(0.430)	(0.000)	(0.000)	(0.000)
NCYSR	0.586	0.680	−0.142	1.011	0.863	0.659
	(0.000)	(0.000)	(0.682)	(0.000)	(0.000)	(0.000)
RESOR	0.291	0.451	0.231	0.656	0.391	0.434
	(0.000)	(0.000)	(0.468)	(0.000)	(0.000)	(0.000)
TOTLF	0.372	0.525	−0.127	0.633	0.466	0.466
	(0.000)	(0.000)	(0.664)	(0.000)	(0.000)	(0.000)
UTILS	0.356	0.474	−0.050	0.797	0.553	0.464
	(0.000)	(0.000)	(0.828)	(0.000)	(0.000)	(0.000)

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