Louis Gagnon[*]
G. Andrew Karolyi[**]

Price and Volatility Transmission across Borders

Abstract

Over the past forty years, financial markets throughout the world have steadily become more open to foreign investors. With open markets, asset prices are determined globally. A vast literature on portfolio choice and asset pricing has evolved to study the importance of global factors as well as local factors as determinants of portfolio choice and of expected returns on risky assets. There is growing evidence that risk premia are increasingly determined globally. An important outcome of this force of globalization is increased comovement in asset prices across markets. This survey study examines the literature on the dynamics of comovements in asset prices and volatility across markets around the world. The literature began in the 1970s in conjunction with early theoretical developments on international asset pricing models, but it blossomed in the late 1980s and early 1990s with the availability of comprehensive international stock market databases and the development of econometric methodology to model these dynamics.

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[*] School of Business, Queen's University.
[**] Fisher College of Business, Ohio State University.
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1. Introduction

The international finance literature has come full circle. Early papers focused on diversification benefits accruing to internationally diversified investors. These benefits stemmed from the less-than-perfect correlations among returns on national markets. At the time, this research generated significant interest not only among finance academics but also among institutional investors, such as mutual funds, pension funds, and hedge funds, and sophisticated retail investors. This public interest, in turn, paved the way for the creation of a myriad of institutional and retail investment products catering to an increasingly internationally-minded market place.

The surge in international portfolio investment activity spawned by international asset allocation strategies translated into strong financial linkages between otherwise seemingly unrelated economies and intensified the interdependency of other countries which already enjoyed significant real linkages created by trade and foreign direct investments. Figure 1 shows the growth in U.S. gross purchases from and sales to foreign investors of U.S. and foreign assets from 1977 to 2005. Total gross capital flows have grown from less than $100 billion (which corresponded to less than 1% of U.S. Gross Domestic Product) to well over $3.5 trillion (or, around 30% of U.S. GDP). U.S. purchases have outpaced the sales, and the focus of this net purchase activity has been on foreign assets, especially foreign equities. As of December 2005, according to the U.S. Federal Reserve, U.S. investors now hold over $2.8 trillion of foreign equities.

A potentially important by-product of this rapid growth in international investment capital flows was whether it changed how global asset returns move together. With freer flows, markets could become more closely connected. Investors who think that one market will have higher expected returns can move their investors to that market and this connection implies that markets move together more than they would if they were segmented from each other by foreign investment barriers. Research and public interest on these issues were heightened during stressful market events, such as the International Crash of October 1987, European Currency Crisis in 1992, the Asian flu in 1997 or the Russian

Government's default and the collapse of LTCM in 1998, when stock markets around the world experienced abrupt, though short-lived, downfalls (See Figure 2). These events raised concerns about the "safety-net" of international diversification and the risk that vacillations in private capital flows reflected the irrational behavior of global investors. Indeed, a number of prominent economists called for greater regulation of capital flows (Stiglitz, 1998; Krugman, 1998; Bhagwati, 1998). How could stock markets fall simultaneously when the underlying economies were not synchronized? Are national markets not supposed to be driven by domestic fundamentals rather than by international panics? Are benefits from international diversification real or illusory?

These questions have generated an immense literature focusing on return and volatility spillovers across markets. Some studies attempted, with limited success, to link these spillovers to economic fundamentals. Others have theorized that "errors" drive these spillovers and propagate across markets and yet a more recent strand of literature examines the forces giving rise to financial contagion during periods of market turbulence. None of these efforts has produced a definitive answer to the questions raised by the Crash of 1987 or subsequent financial crises during the 1990s.

One general conclusion that emerges from this literature is that although we do not understand the forces giving rise to international diversification benefits, the capital flows accompanying the drive to exploit these benefits intensifies financial linkages between countries. These linkages, in turn, engender a systemic vulnerability to liquidity gaps and market shocks whose impact was once contained within national boundaries. Shocks experienced in one market transmit to other countries and, thus, forces of what seem to be contagion arise as inevitable by-products of financial market integration whose ultimate effect is to destroy the very benefits that international diversification offers in the first place.

This paper is organized as follows. In the first section, we discuss the early literature on the benefits of international diversification. Next, we proceed with a survey of studies examining lead-lag relationships in international stock market returns. This strand of literature leads us to the section where we cover more methodologically rigorous attempts to uncover both return and volatility spillover

effects across national markets. This section is followed by a survey of studies attempting to link the return and the volatility transmission process to fundamental economic factors. Then, we explore the market contagion literature and, in the final section, we summarize the contributions of these various literature strands to our understanding of return and volatility transmission across markets and ultimately suggest future research opportunities in this literature.

2. The Early Days

The early papers in the international market comovements can be categorized into three main groups. The first group includes studies investigating the potential benefits associated with international diversification from the mean-variance perspective developed by Markowitz (1952). The second group of studies takes a descriptive slant to uncover the presence of structural patterns in international market comovements, while the third group of studies lead the way to a new line of investigation focusing on lead-lag relationships between international markets to which Section 3 will be devoted.

The key contributions in the first group are from Grubel (1968), Levy and Sarnat (1970), and Solnik (1974). The main premise behind these studies is that if diversification opportunities were present within any given country, then surely further diversification benefits could be achieved by expanding the opportunity set to include stocks from other countries. Using monthly returns data on common stock market averages for 11 major industrial countries between January 1959 and December 1966, Grubel (1968) demonstrated that U.S. investors would have been able to achieve a higher rate of return or lower variance by diversifying their portfolios across these countries than they could by purchasing a portfolio consisting of Moody's industrial average of common stocks.[1] More specifically, his results indicate that international diversification would have allowed a U.S. investor to boost the total return of her portfolio from 7.5% per year to 12.6% per year. In a similar experiment involving 28 high income and developing countries over the period 1951-1967, Levy and Sarnat (1970) reported that although an American investor should never restrict her portfolio to developing countries alone, the

[1] The countries included in this early study were the U.S., Canada, United Kingdom, West Germany, France, Italy, Belgium, Netherlands, Japan, Australia, and South Africa.

inclusion of those countries in her opportunity set materially improved her risk-return position. Indeed, Levy and Sarnat (1970) observed that mean-variance optimal portfolios were much more heavily weighted towards developing countries than towards high income countries like Western Europe (or Canada which had zero weighting) thanks to the stabilizing effect that emerging market stocks had on a U.S. investor's portfolio. The fundamental insights delivered by these papers are that the traditional rule to international investments based on return comparisons between countries understated the true benefits of such investments and that efficient international diversification implied a shift in investment policy favoring countries exhibiting the lowest possible correlation with the home country, as opposed to countries possessing strong economic ties with the home country.[2]

While the first group of studies was interested in measuring benefits to international diversification, the second strand of literature examined the structural features of international market comovements.[3] Using a cluster analytic perspective, Panton, Lessig, and Joy (1976) examined weekly index returns over the ten-year period starting in 1963 and ending in 1972 for a sample consisting of the world's 12 largest international stock markets at the time of their study. Their analysis revealed the existence of an important cluster containing the U.S., Canada, the Netherlands, Switzerland, West Germany and to a lesser extent Belgium, i.e. well-developed countries that are open to capital flows, as well as somewhat less-important clusters such as France and Belgium, Germany and the Netherlands, and England and Australia. Ripley (1972), using factor analysis on monthly index returns data for 19 developed countries between 1960 and 1970, tentatively identified three prevalent factors underpinning comovement of stock prices across nations: 1) strength of financial ties, 2) free movement of capital flows, and 3) trade linkages. Close to 80% of the common movement between stock prices was attributed to these three identifiable factors. In Ripley's sample, the four countries exhibiting the highest

[2] Other studies in this line of investigation include Robichek, Cohn, and Pringle (1972) who examine the mean-variance benefits associated with the inclusion of Japanase and Australian stocks in a U.S. portfolio consisting of equities, debt, and commodities. Lessard (1973) also demonstrated benefits to diversification across the four Latin American countries of Columbia, Chile, Argentina, and Brazil.

[3] Although Grubel and Fadner (1971) had conjectured that these benefits were driven by asynchronous business cycles, differences in industrial structure, government policies, and exchange rate risk, the literature had not yet addressed the structure underpinning comovements explicitly.

level of comovement were the U.S., Canada, Switzerland, and the Netherlands, while those possessing the lowest levels of comovement were Finland, South-Africa, and Denmark.

The third strand of literature, lead by Agmon (1972), Granger and Morgenstern (1970) and Hilliard (1979), focuses on lead-lag relationships between international markets. Using monthly data for the U.S., the U.K., Germany, and Japan for the period 1961-1966, Agmon (1972) finds a strong contemporaneous relationship between U.S. market returns and returns in the three other markets and interprets his findings in the context of the 'one-efficient-market' hypothesis and suggests his evidence supports the notion of a single world market risk factor. Using spectral analysis on weekly data for eight countries, Granger and Morgenstern (1970) conclude that "contrary to widespread beliefs, there is little or no interrelationship between different stock market exchanges around the world". Notwithstanding this strong statement, the authors do uncover linkages between New York and Amsterdam as well as between Frankfurt and Amsterdam and suggest that markets would not likely be independent in a period of world-wide financial crisis or in times of war.[4] Hilliard (1979) chose the period July 7, 1973 to April 30, 1974 to examine the impact of the October 18, 1973 Oil embargo on the comovement structure of ten world exchanges (London, Paris, Amsterdam, Frankfurt, Zurich, Milan, New York, Toronto, Sydney and Tokyo). Given the daily sampling frequency of Hilliard's data, spectral methods revealed the existence of close relationships among the countries that were not apparent in Granger and Morgenstern (1970) weekly data but Hilliard was unable to find any evidence of the presence of a world-wide financial market factor. Furthermore, Hilliard (1979) found that most intra-continental prices moved simultaneously and that inter-continental prices were unrelated, with the exception, perhaps, of New York and Amsterdam.[5]

The key insight from the early contributions in this literature is that international diversification delivers benefits because correlation in stock prices is much less pronounced across national boundaries than within countries.

[4] Section 6 will be devoted to the analysis of market comovements in periods of market crisis.
[5] Hilliard (1979) conjectured this close inter-continental relationship between New York and Amsterdam was likely due to the fact that close to 50% of Amsterdam's turnover was accounted for by large international companies, i.e. Royal Dutch Shell, Unilever, Phillips, Hoogovens, and AKZO.

3. Lead-Lag Effects In International Returns

As the 1970's drew to a close, there seemed to be little if any evidence for the existence of significant lead-lag relationships between international markets. However, advances in econometries and the availability of high frequency data presented an opportunity to re-visit this issue. Eun and Shim (1989) rose to the occasion and estimated a nine-market vector-autoregression (VAR) system using daily rates of return on the stock market indices from the period January 1980 through December 1985.[6] This methodology, along with the data sampling frequency, were chosen in order to shed insights as to 1) the magnitude of the U.S. market influence on other markets, 2) how much movements in one stock market could be explained by innovations in other markets and, 3) how rapidly price movements in one market transmitted to other markets. The findings of Eun and Shim (1989) can be summarized as follows: 1) The U.S. stock market is by far the most influential one in the world, perhaps reflecting the dominant position of the U.S. in the world economy, 2) No single market's innovations explains its variance. An average of 26% of a country's error variance is explained by collective innovations in foreign markets. The U.S. is the most exogenous market with about 89% of its variance explained by its own innovations and Canada is one of the least exogenous countries with 48% of its variance explained by its own innovations. 3) Patterns of impulse responses emerging from the VAR analysis indicate that markets around the world respond to U.S. innovations very quickly. Canadian stocks respond most strongly to U.S. innovations on day 0 when the U.S. shock occurs and most of the adjustments are completed by day 1. For European and Asian countries, the most dramatic adjustment occurs on day 1 and most of the adjustment to U.S. shocks is completed by day 2. Eun and Shim (1989) conclude that their evidence supports the notion of informationally efficient markets.[7]

[6] The nine markets included in the Eun and Shim (1989) study are Australia, Canada, France, Germany, Hong-Kong, Japan, Switzerland, the United Kingdom, and the United States.

[7] Using the persistence profile technique proposed by Pesaran and Shin (1996), Yang, Hsiao, Li, and Wang (2005) extend Eun and Shim's (1989) investigation of international linkages to Eastern European markets around the

If anything, the notion that national stock markets were poorly correlated even during such troubled periods as the 1973 oil embargo was shaken to its foundation during the international Crash of October 1987. The dramatic market decline experienced in New York on October 19 that translated into a 508 point drop in the Dow Jones Industrial Average (a 19% drop in the index) and reverberated throughout the world exchanges almost instantaneously took everyone by surprise. Roll (1988, 1989) described the event in great detail. Figure I and Table II are from Roll (1988) and capture the extent of the comovements between the world's largest markets during this very stressful market event. This proved to be a catalyst for academic research on linkages across national stock markets not only because it came as a surprise to market participants and market observers alike but also because it revealed a substantial degree of interdependence among national stock markets that differed in fundamental ways – in terms of business cycles, market influences, market structure, institutional characteristics, market liquidity, etc.

In the aftermath of the Crash of 1987, a re-examination of international stock market movements seemed justified. Von Furstenberg and Jeon (1989) conducted a principal component analysis on daily stock index returns data for New York, Tokyo, London, and Frankfurt during the January 6, 1986-November 24, 1988 period and noted an increase in the post-crash interdependence between markets. The explanatory power of the first principal component in the post-crash period rose from 34 to 55%. This increase and the associated decline in the importance of country-specific shocks after the crash was accompanied by changes in patterns of leadership around world exchanges. Indeed, impulse response analysis from a four-country VAR system revealed that sustained innovations in the British market had a substantially longer lasting effect on other markets after the crash than before the crash. However, this result could also be attributed to the expansion and internationalization of the London market (the Big Bang) during the year preceding the crash. This analysis also revealed an increase in Tokyo's influence on other markets in the post-crash period, but the impulses from this market did not appear to have the sustained effect of those emanating from London. Von Furstenberg

1998 Russian crisis. Their results show that short-run dynamic linkages among these markets and the U.S. were strengthened after the crisis.

and Jeon (1989) attempted to link the post-crash rise in international comovements to broad economic fundamentals (exhange rates, interest rate differentials, oil and gold prices) but the evidence for such links was weak at best. They also attempted to find a connection between industry effects and the shift in comovements, without success.

In an attempt to shed more light on the dynamic interrelationships across national stock markets, Koch and Koch (1991) model the daily returns for eight countries for the year 1972, 1980, and 1987 using a block-recursive simultaneous equations model. Their sample includes countries from the Pacific Basin (Japan, Australia, Hong Kong, Singapore) as well as a European/U.S. block (Switzerland, West Germany, the U.K, and the U.S.). The authors report an increase in the number of 'same-day coefficients' from the 1972 and 1980 to 1987, indicating a rise in the contemporaneous correlations between markets. The authors attribute this result to greater integration of global capital markets enabled by advances in communication technology and capital mobility, to the growing number of cross-listings around the world, and to the recent growth in financial innovations. The interdependence across markets is concentrated within time zones blocks where trading takes place concurrently or for part of the day. This is an important finding which suggests that geographic proximity does not matter as much as time zone for comovements. Evidence also shows that between 1972 and 1987, the U.S. market's influence on other markets has waned and that the U.S. market started responding to three different markets. The exact opposite result was observed for Japan, suggesting that Japan has grown to be more of a market leader over time.

Becker, Finnerty, and Gupta (1990) employ opening and closing prices for market averages in the U.S. and Japan from 1985 to 1988 in order to study the synchronization of price movements between the two markets. The use of intra-day data (close-to-open and open-to-close returns on the S&P 500 index and the Nikkei 225 average) marked a significant departure from earlier studies that relied on close-to-close returns. Since there is no overlap in trading hours in the two markets, the authors were able to perform direct tests of market efficiency using simulated trading strategies in which a trader in Japan (the U.S.) buys or sells at the opening price depending on the performance of

the U.S. (Japanese) market on the previous day. Their empirical strategy also allowed them to examine the influence of daily returns in one market on overnight returns of the other market. The authors found that the U.S. market had a large impact on the Japanese market, but the impact of the Japanese market on the U.S. market was very small. Indeed, returns on the S&P 500 index in the previous day explained between 7 and 25% of the variation in the Nikkei index open-to-close returns the next day and between 11 and 18% of the fluctuations on the index' overnight returns. Contrastingly, daytime returns on the Nikkei index could only explain 1% of the variation in open-to-close returns on the S&P 500 index, demonstrating the much smaller (though statistically significant) influence of the Japanese market on the U.S. market. Trading strategies were simulated using 0.5%, 1%, 1.5%, and 2% filters and round-trip transactions costs of 0%, 0.5%, and 1%. Although the filters rules did a remarkable job in predicting up and down movements in Japan (the up triggers predicted profitable trades 72 to 81% of the time and down triggers predicted profitable trades 59% to 75%), profits from these strategies were eliminated once round-trip transactions costs and taxes faced by institutions were factored in.

4. Return and volatility spillovers across national market

In spite of the large number of reports and commentaries generated by the Crash of October 1987, the question as to why markets around the world fell simultaneously and with such uniformity in spite of differences in economic fundamentals, market mechanisms, and degree of 'mispricing', remained unanswered. In their path-breaking paper, King and Wadhwani (1990) developed a non-fully revealing equilibrium rational expectations model in which price changes in one market depend on price changes in other markets through structural contagion effect, thus coining the term 'market contagion', to explain this phenomenon. In a fully-revealing equilibrium model where agents act rationally, mistakes or idiosyncratic price changes in one market would have no impact on prices in the other market. However, in the non-fully revealing setting developed by the authors, mistakes or idiosyncratic price changes in one market transmit to the other country, thereby causing an increase in volatility in that country. The non-fully revealing nature of the equilibrium postulated by the authors is

a natural feature of international markets where trading hours are non-overlapping. This contagious (or 'spillover') effect in turn induces an increase in the correlation between the two markets even if the covariance between the two markets remains constant. Investors in the second market have no way of establishing whether the 'news' reflected in price changes from the first market is driven by fundamentals or by idiosyncratic forces. Hence, King and Wadhwani (1990) offer an alternative explanation to stories suggesting that 'news' gave rise to the contemporaneous fall in all major stock exchanges around the world in October 1987 and predict the significant increase in the correlations observed among world exchanges during that period.[8] The authors conduct empirical tests of their model using high-frequency (hourly) data from FTSE index in London, the Dow-Jones index for New York, and the Nikkei-Dow index for Tokyo for the eight-month period starting in July 1987 and ending in February 1988. Their evidence, based on OLS and instrumental variables estimation, suggest a statistically significant association between London and New York before and one that increases in mid-October and then declines after the end of November 1987. Furthermore, the estimates for the contagion coefficients measuring the effect of New York on London increased from 0.2, before the crash, to about 0.4 after the crash. As for the contagion effects from London to New York, the authors report a rise in the contagion estimates from 0.2 before the crash to unity immediately after the crash. Similar evidence of contagion effects between Tokyo and both London and New York strengthens the case for the market contagion hypothesis.[9] Finally, King and Wadhwani (1990) observe "The pattern of correlations between markets that is revealed by the data seems easier to reconcile with the contagion model than with a fully revealing or purely `fundamental' model" (p. 24).[10]

[8] See previous discussion of Roll (1988), Von Furstenberg and Jeon (1989), Koch and Koch (1991), among others.

[9] Further evidence for this hypothesis is included in the sharp reduction in variance observed in London during the second half of 1968 when U.S. stock markets were closed on Wednesdays in order to clear the settlement backlog. See French and Roll (1986) for an examination of this period.

[10] Notwithstanding the strong evidence presented by King and Wadhwani (1990) supporting the contagion hypothesis, Roll (1989) observes: "Indeed, in deciphering the global sequencing of declines in the context of the contagion model, one would be obliged to conclude that the crash was caused by investor "mistakes' in Hong Kong, Malaysia, and Singapore! This seems a bit far-fetched" (p. 128).

Hamao, Masulis, and Ng (1990) explore the issue of volatility spillover effects around the Crash of October 1987 by modeling the short-run interdependence of price and price volatility across markets with a GARCH-in-means representation.[11] Their sample consists of returns on the FTSE index for London, S&P 500 index for New York, and the NIKKEI index for Tokyo during the period April 1, 1985 - March 31, 1988. In order to isolate the spillover effects, they divide the close-to-close return into its close-to-open and open-to-close components. First, they examine spillover effects in open-to-close returns for a given market by estimating two separate models. In the first one, they append the volatility surprise from the most-recently open foreign market to the domestic market's conditional variance specification. This foreign market volatility surprise corresponds to the squared-residuals derived from an MA(1)-GARCH(1,1)-M model applied to the open-to-close return of the previously open foreign market. In the second model, they append the volatility surprise for both foreign markets that complete their trading cycles while the domestic market is still closed, thus enabling an examination of separate volatility spillover effects from both foreign markets. These models are estimated using data for the full sample period as well as for the pre-crash sub-period April 1, 1985 to September 30, 1987. For the full sample, the authors find significant volatility spillover effects from the U.S. and the U.K. to Japan, from Japan and the U.S. to the U.K., and from the U.K. to the U.S. (and not from Japan). For the pre-crash sub-period, significant volatility spillovers are reported from the U.S. and the U.K. to Japan, and no evidence of volatility spillovers is found from Japan and the U.S. to the U.K., or form the U.K. and Japan to the U.S. The authors conclude: "While the inclusion of the post-October 1987 period does increase the measured spillover effect, the main finding is clear: the Japanese market is most sensitive to volatility spillover effects from foreign markets, while the other two major stock exchanges are at most moderately sensitive, if at all, to volatility spillovers from foreign stock markets." (p. 298). This asymmetry in spillovers across national stock markets documented in the Hamao, Masulis, and Ng (1990) study is consistent with

[11] The ARCH family of models was pioneered by Engle (1982). Bollerslev (1986) extended the original model to allow the current period's conditional variance to be a function of last period's squared error terms and conditional variance, hence giving birth to the GARCH representation. Engle, Lillien, and Robins (1987) extended the GARCH model further to allow the conditional mean to be function of the conditional variance, which gave rise to the GARCH-in-means model. See Bollerslev, Chou, and Kroner, (1994) for a review of the ARCH literature.

evidence uncovered in Eun and Shim (1989) and discussed earlier. Hamao, Masulis, and Ng (1990) considered the possibility of spillover effects in the returns by incorporating the open-to-close return of the most recent foreign market to trade into the domestic market's conditional mean return equation and preserving the foreign market's volatility surprise in the conditional variance specification. The asymmetric effect observed with respect to volatility spillovers is also manifest in mean returns. Significant spillover effects are observed in the conditional mean from the U.S. to Japan, from the U.K. to the U.S., but not from Japan to the U.K. The authors attribute the significant return spillover between London and New York to a one-hour overlap in trading between the two markets. They re-estimate their model using noon-to-close returns for the S&P 500 index and show that the return spillovers between London and New York are no longer significant when this is done. As for the return spillovers from U.S. to Japan, explanations are harder to find. Obviously, any evidence of significant spillover effects in returns across markets around the 24-hour clock runs counter to the notion of informational efficiency of international markets. However, as Becker, Finnerty, and Gupta (1990) found, profitable arbitrage of these return spillovers is nearly impossible once transactions costs and taxes faced by institutional investors are taken into consideration.

Theodossiou and Lee (1993) present further evidence of mean and volatility spillovers across national markets using weekly data, rather than intra-day data as in Hamao, Masulis, and Ng (1990), but with an expanded country set including the U.S., Japan, the U.K., Canada, and Germany and a longer sample period from January 11, 1980 to December 27, 1991. As per Hamao, Masulis, and Ng (1990), they model the conditional mean and variance of the return generating process using a GARCH-in-means representation but, instead of estimating the model for each country separately, as did their predecessors, they estimate the model as a multivariate system under the assumption of constant conditional correlations over time.[12] Although one would expect GARCH effects as well as return and volatility spillover effects to be much weaker with weekly data than with data sampled at a daily frequency, the authors report several interesting results. With regards to mean spillovers, positive and significant effects are reported

[12] See Bollerslev (1990) for details on the estimation of multivariate GARCH-M systems.

from the U.S. to the U.K., from the U.S. to Canada, and from the U.S. to Germany, and a negative and significant effect is reported from Japan to Germany. These mean spillover effects are, of course, inconsistent with the efficient market hypothesis but further tests reveal that their ability to predict future prices is so low that arbitrage trades attempting to exploit them would be unprofitable. As for volatility spillovers, significant effects are reported from the U.S. and Germany to Japan, from the U.S. to the U.K., from the U.S. and from the U.K. to Canada, and from the U.S. to Germany. Interestingly, the magnitude of volatility spillovers originating in the U.S. and transmitting to Canada is smaller than those originating in the U.K. Also, the significant volatility spillovers from the U.K. to the U.S. documented by Hamao, Masulis, and Ng (1990) are not present in Theodossiou and Lee (1993).

Using open-to-close and close-to-open market data, Lin, Engle, and Ito (1994) analyze the international return and volatility transmission mechanisms in the context of New York (S&P 500 index) and Tokyo (Nikkei 225 index) between September 29, 1985 and December 29, 1989 by describing two ways in which investors can learn from information revealed in the foreign market overnight. The first one is an aggregate shock (AS) model in which the domestic overnight return is specified as a function of the preceding domestic daytime return and return innovations in the foreign market. This model differs from the one specified by Hamao, Masulis, and Ng (1990) in that 1) it specifies the conditional mean equation differently by including the foreign market's return innovations as opposed to its raw returns, and 2) it does not recognize the possibility of volatility spillovers from the foreign market to the domestic market. The second model investigated by Lin, Engle, and Ito (1994) relies on a signal-extraction procedure (a Kalman filter) in which the domestic return surprises are decomposed into two uncorrelated shocks, a global shock and a local one. Unlike the AS model, this second model admits both return and volatility spillovers (contagion effects) which come into the conditional mean and the conditional variance through the signals emitted by the unobservable global factor. These two models are estimated for the full sample period (9/29/85-12/29/1989) and two sub-sample periods (9/29/1985-9/30/1987 and 1/1/1988-12/29/1989). Two important findings are reported for the AS model. First, the effect of foreign return innovations on domestic overnight returns is significant for both New York and Tokyo before and after

the crash. Second, there is the noticeable increase in the impact of ‘news’ from Tokyo on New York returns over time. This finding contradicts earlier results discussed above indicating that the New York influences Tokyo but that Tokyo exerts no influence on New York. As for the signal extraction model, there is weak evidence that it performs better than the AS model or a GARCH-M representation for Tokyo overnight returns.

Bae and Karolyi (1994) extend the GARCH models of previous international volatility spillovers studies to allow for asymmetric effects of negative ("bad news") and positive ("good news") foreign market return shocks for volatility. This extension, which accommodates the so-called leverage effect by Black (1976), French, Schwert, and Stambaugh (1987), and Nelson (1990), is motivated by the apparent weakening of cross-market influences of stock market comovements between the U.S. and Japan discussed earlier. Their study focuses on the joint dynamics of daytime (open-to-close) and overnight (close-to-open) returns for the Nikkei 225 index and the S&P 500 index from May 31, 1988 to May 29, 1992. Using a two-stage estimation strategy, the authors model the volatility spillovers with and without asymmetric effects and use both a parametric and a partially non-parametric model to evaluate the importance of these effects. The authors examine volatility spillovers in overnight returns and in daytime returns. For overnight returns, results from the symmetric GARCH model for both the S&P 500 index and the Nikkei index support the findings of Hamao, Masulis, and Ng (1990) and Lin, Engle, and Ito (1994) for the post-October 1987 crash period indicating a weak spillover effect from the U.S. to Tokyo. However, results from both parametric and non-parametric asymmetric GARCH models provide a striking contrast with those produced by the GARCH model. The asymmetry coefficients associated with the foreign market return surprises are all statistically significant for both markets. Furthermore, the evidence from this estimation reveals that bad news from the foreign market has a much greater impact on the next period’s volatility than good news. Significant asymmetric effects are also presented for next-day open-to-close returns. The evidence reported in Bae and Karolyi (1994) demonstrates that the magnitude and the persistence of volatility surprises originating in New York or Tokyo that carry on to the other market are

significantly understated when the asymmetric effect of good and bad news on the volatility of the domestic market is ignored and that bad news appears to have a much more significant impact on subsequent return volatility than good news.

Susmel and Engle (1994) use a univariate asymmetric GARCH model to study the impact of news from the New York market on the London market, and vice versa, using hourly data on the Dow Jones 30 Industrials Average and the Financial Time 30 Share Index for the period January 2, 1987 to February 29, 1989. With two minor exceptions, the authors uncover no mean spillovers when returns are measured using non-overlapping intervals. Though weak evidence of bi-directional volatility spillovers is detected between the two markets, these spillovers are short-lived and occur mainly around the New York open. When the conditional variance equation is augmented to incorporate asymmetries in the response to good and bad news from the other market, only weak non-linearities seem to be present and these occur mainly at the New York open.

Kootsmos and Booth (1995) investigate the presence asymmetries in the volatility transmission process by modeling the return and volatility spillovers between New York, Tokyo, and London with a multivariate exponential GARCH representation (See Nelson(1991)). Their sample period is from September 3, 1986 to December 1, 1993. Significant spillover effects are reported from New York and London to Tokyo, from Tokyo and New York to London, as well as from London and Tokyo to New York and the volatility spillover mechanism entails asymmetries in all cases. Hence, both the size and the sign of the innovation in one market seem to have a bearing on the next market's volatility response. Furthermore, confirming Bae and Karolyi's evidence, the authors find that negative news in one market increases the volatility in the next market to a far greater extent than good news. Indeed, their estimates reveal that a negative innovation in New York, London, and Tokyo increases volatility in the two other markets 2.6, 1.68, and 3.12 times more, respectively, than a positive return innovation. Finally, Koutsmos and Booth (1995) find that the asymmetric impact of good and bad news documented in their study appears to be a post-Crash of 1987 phenomenon that coincides with the increase in international stock market linkages noted by previous authors in the post-crash period.

Karolyi (1995) examines the short-run dynamics of returns and volatility between Canada and the U.S. stock markets using daily close-to-close returns on the TSE 300 index and the S&P 500 index between April 1, 1981 and December 29, 1989. He postulates a vector autoregressive (VAR) model and a bivariate M-GARCH BEKK model to describe the joint return dynamics of the two markets. Since both the Toronto Stock Exchange and the New York Exchange have perfectly synchronous trading hours, this study circumvents the problem of disentangling the confounding effects non-synchronous trading hours and correlated price changes and volatility encountered by previous studies of international stock market linkages.[13] This study reveals that inferences about the magnitude and the persistence of innovations that originate in one country and that transmit to the other depend significantly on the way in which the conditional volatilities in the two markets are modeled. Karolyi's evidence indicates that the impact of return innovations in New York on the Toronto market had diminished over time in the latter part of his sample period. S&P 500 return innovations were also found to be much more significant and persistent for subsequent returns of non-interlisted Toronto stocks, suggesting that investment barriers associated with differences in accounting disclosure requirements, foreign ownership restrictions, and differences in tax regimes might be important considerations for the dynamics of international stock market comovements.

These articles discussed in this section report several empirical regularities: (i) the volatility of stock prices is time-varying; (ii) when volatility is high, the price changes in major markets tend to become highly correlated; (iii) correlations in volatility and prices appear to be causal from the United States to other countries at least before the Crash of 1987; (iv) lagged spillovers of price changes and price volatility are found between major markets, and (v) good news and bad news from one market seem to affect the other market's volatility differently, with bad news increasing volatility in the next market much more significantly than good news.

5. Economic fundamentals and international spillovers of returns and volatility

[13] Craig, Dravid, and Richardson (1995) found that empirically meaningful information about overnight returns in Japan is contained in the prices of Nikkei-based derivatives (futures and options) traded in the U.S.

What can we say about the fundamental determinants of return and volatility linkages explored in the previous section? Do volatility spillovers reflect international market frictions or are they driven by a combination of local and global risk factors? Are capital markets internationally integrated or is the price of risk for any given country established domestically as opposed to internationally? Chan, Karolyi, and Stulz (1992) examine, empirically, the influence of foreign returns on the U.S. risk premium. They model the daily excess returns of the S&P 500 and three separate portfolios of non-U.S. assets jointly, using a bivariate GARCH-in-mean representation. The first portfolio is the Nikkei 225 index, the second one is the Morgan Stanley Capital International (MSCI) Japan index, and the third one is the MSCI Europe Australia Far East (EAFE) index. Over the period January 3, 1980 to December 31, 1989, the authors find that irrespective of the foreign portfolio used in the test, the world price of risk is positive and statistically significant. At the 10% level, the authors are unable to reject the ICAPM when the foreign portfolio is either the MSCI Japan or the MSCI EAFE index but the model is rejected when the foreign portfolio is the (equal-weighted) Nikkei 225 index. The authors show that the international effect remains whether open-to-close or close-to-close returns are used, that it is robust to the length of observation interval (2, 3, 5-day returns), to day-of-the-week effects, and to alternative specifications of the conditional covariance process. In summation, the authors find that the conditional expected excess returns on the U.S. market portfolio are significantly related to the conditional covariance of the S&P 500 with the returns of foreign stocks when the foreign stocks are represented by either the MSCI Japan or the MSCI EAFE index.

King, Sentana, and Wadhwani (1994) examine the time-variation in the covariance between national stock markets documented in previous studies from the perspective of a dynamic version of the international Arbitrage Pricing Theory in which the excess return of an asset is a linear function of a set of factors which capture the systematic risk common to all stocks as well as an idiosyncratic component that represents unsystematic risk. Among the common factors underpinning the model, there is a subset of factors that are observable and that capture the impact of unanticipated changes in observable economic variables (e.g. industrial production, inflation, etc.) on stock returns and there is a subset of

unobservable factors assumed to be correlated with the returns process and hence uncorrelated with innovations in published statistics. The observable factors incorporate macro-economic influences while the unobservable factors are assumed to capture changes in returns fundamentals. The conditional variances of the common and the idiosyncratic factors are assumed to follow a univariate GARCH process. The authors estimate their multivariate factor asset pricing model on monthly data for the returns on sixteen national markets from January 1970 to October 1988.[14] The national market returns data are obtained from MSCI world indices. A total of four common factors were deemed to be sufficient to summarize the comovements in the innovations in the ten macro-economic variables. These innovations were obtained by fitting vector autoregressions to these series. The first factor is interpreted as an interest rate factor, the second one as a dollar exchange rate factor, the third factor appears to capture shocks to the Yen-DM cross rate, and the fourth factor is associated with innovations in the G3 money supply and is linked to inflation risk. The GARCH (1,1) model provides a good description of the time-varying volatility for these factors. The first unobservable factor underpinning international return innovations is highly volatile. It experiences a sharp spike in October 1987, a sharp downward movement in September 1974, and an upward surge in January 1975 and January 1987. The second idiosyncratic factor is also highly volatile and it exhibits more volatility persistence than the first one. Interestingly, the first unobservable facto is significantly positively associated with the U.S. and Canada (and negatively correlated with German returns) while the second factor is dominated by German stocks. Up to 80% of the variation in unobservable factors is explained by a world index while only 8% of the variation in the common factors is explained by the same index. A small proportion of changes in the comovements between national stock markets and in their time-variation can be explained by common factors or observable economic variables. Changes in correlations between these markets appear to be driven primarily by unobservable factors which the authors interpret as fundamental variables that have been ignored or investor sentiment. The authors reject the null that

[14] The countries included in King, Sentana, and Wadhwani's (1994) sample are Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, the U.K., and the U.S.

idiosyncratic risk is not priced and that the price of risk is equal across national jurisdictions. They conclude that global markets are not integrated.

Longin and Solnik (1995) examine the time-variation in the monthly return correlation for seven major countries (Germany, France, the U.K., Switzerland, Japan, Canada, and the U.S.) during the period 1960-1990. They condition the excess return for each market on a set of information variables (national dividend yield, short-term and long-term interest rates as well as a January seasonal) and postulate a bivariate GARCH (1,1) process to describe the joint dynamics of the U.S. market and each foreign country to circumvent the difficulties associated with the estimation of one single multivariate system incorporating each country. The authors report a significant time-trend in the conditional correlation between the markets. Using a variant of the GARCH model incorporating threshold effects in the conditional correlation parameterization, their evidence also shows that cross-market correlations increase by approximately 27% in periods of high market turbulence in the U.S. but there is no sign of asymmetry in the response to good and bad news. Interestingly, the conditional correlation tends to increase in periods of low dividends and high interest rates.

Karolyi and Stulz (1996) investigate the impact of macroeconomic news on the covariance dynamics between Japan and the U.S. Since trading hours in the two countries do not overlap, one might fail to detect the impact of macroeconomic news on comovements between the two countries simply because the returns reflect information revealed at different time intervals. The authors circumvent this problem in a novel way by using a portfolio of Japanese stocks trading in the U.S. in the form of American Depositary Receipts (ADR) and U.S. industry- and size-matched stock portfolios, whose returns are observed perfectly contemporaneously, to represent the two markets. The sample of intraday (open-to-close and close-to-open) returns covers the period May 31, 1988 to May 29, 1992. They estimate bivariate GARCH(1,1) systems for the joint intraday returns generating process of the Japanese ADR portfolio and U.S. (industry and size matched) portfolios in which conditional mean returns are a function of a set of information variables including a Monday dummy, a news announcement dummy, daily closing returns on the CME Yen/dollar currency futures, on the CMT

Treasury-bill futures, and on the CRSP value-weighted portfolio, preceding daytime returns on the Nikkei 225 index, overnight return on the S&P 500 index, demeaned volume on Nikkei stocks, and demeaned volume on S&P 500 stocks. Separate models are estimated that incorporate the information variables one at a time in the conditional correlation specification. With daytime and overnight returns, macroeconomic news announcements and interest rate shocks appear to have no influence on conditional correlations. Foreign exchange shocks exert a significant (at 10%) and negative influence on conditional correlations with daytime returns but none with overnight returns. The conditional correlations between Japan and the U.S. is high when absolute returns in either national market is high today or the previous day, whether daytime and overnight returns are used. Therefore, correlation between the two markets is high when the markets move a lot and seem to be unaffected by macroeconomic news announcement. This evidence suggests that international market comovements are not driven by fundamental news and that diversification benefits are reduced when markets move a lot, which is precisely when these benefits would be needed most.

Ammer and Mei (1996) devise a new framework enabling them to measure both financial and real economic integration which is capable of capturing long-term return comovements between countries that might be missed using alternative estimation methodologies. Their technique relies on financial market data rather than on macroeconomic data and thus avoids some of the problems related to measurement errors for this type of data. They decompose excess stock return innovations for different countries into news about future excess returns, dividend growth rates, interest rates, and exchange rates and assess the extent of market integration by examining the comovement of these excess return components across countries. For instance, real economic integration is measured by the correlation of dividend innovations between two countries and financial integration between two nations is measured by the correlation between innovations in future excess returns in the two countries. Relying on a vector-autoregressive estimation methodology, the authors perform the variance/covariance decomposition for the U.S. and the U.K. stock markets between 1957 and 1989 with monthly returns series for the value-weighted NYSE index and the Financial Times All Shares

index. The evidence reported by the authors suggests that there is a substantial degree of real and financial market integration between the two countries but that the bulk comovements between the two countries are associated with common news about future risk premiums, indicating that financial factors are the main instrument of market integration between the U.K. and the U.S. Results from a sub-sample period analysis also reveal that both real and financial linkages between the two countries have intensified since the collapse of the Bretton-Woods accord in 1973.

Ramchand and Susmel (1998a) examine a complex state-dependent model in which the joint return generating process between the U.S. and the foreign market is estimated with a bivariate-SWARCH representation allowing two volatility regimes per country, or four separate states (high volatility U.S. – high volatility foreign, high volatility U.S. – low volatility foreign, low volatility U.S. – high volatility foreign, low volatility U.S. – low volatility foreign). Their sample of weekly returns covers Japan, the U.K., Germany, the U.S. and goes from January 1970 to August 1990. The evidence reported in this study suggests that correlations across major stock markets are both time and state dependent. Focusing explicitly on the behavior of stock market correlations between county pairs, they report that the correlation between Japan and the U.S. is 1.94 times larger when the U.S. market is in the high variance regime, a statistically significant increase. Similarly, the correlation between the U.K. and the U.S. and Germany and the U.S. is 3 and 1.87 times higher, respectively, in periods of high U.S. market volatility. A similar result holds for the correlation between Canada and the U.S. To present the evidence in a different light, a U.S. investor was able to offset a loss in the domestic market with a gain from the U.K. market only 11.11% of the time, during the sample period considered. This evidence reinforces earlier findings from Karolyi and Stulz (1996) and others suggesting that diversification benefits available from international stock markets are reduced in periods of heightened market volatility.

Ramchand and Susmel (1998b) investigate international stock market comovements from the perspective of a state-dependent version of the international version of the Capital Asset Pricing Model where individual betas vary over time according to a switching ARCH (SWARCH) process. Under this

parameterization, the autoregressive coefficient is allowed to switch between two states, one characterized with high volatility and one with low volatility, implying two possible values for beta that depend on the state of the economy. With weekly returns data for ten national stock markets (Australia, Hong Kong, Japan, France, Germany, Sweden, Switzerland, the U.K., the U.S., and Canada) obtained from MSCI from January 1980 to the third week of April 1996, the authors find that the two-state Markov switching beta model has a higher explanatory power than the plain-vanilla time-varying GARCH (1,1) beta parameterization and that it yields better diagnostic test results. For all the countries in the sample, a two-state formulation appears satisfactory. Using an equally-weighted world index as a proxy for the World index, the authors find that beta increases significantly during periods of high volatility in the U.S. and in Japan but that no such influence prevails in the U.K. The increase in betas during periods of high market volatility reported in this study in periods of high market volatility is consistent with observed downturns in the business cycle and is in accordance with earlier finding in the literature.

Ng (2000) constructs a volatility spillover model to establish whether volatility shocks originating in Japan (regional shocks) or shocks originating the U.S. (the world) tend to spillover into Pacific–Basin stock markets and to uncover the fundamental forces driving these volatility spillovers to the region. She conducts her investigation on a sample of weekly national stock index returns compiled by Datastream International from January 1980 to December 1996, including the Hang Seng Index (Hong Kong), the Korean Composite Stock Price Index, the Kuala Lumpur Stock Exchange Composite Index (Malaysia), the Stock Exchange of Singapore All Share Index, the Taiwan Stock Exchange Weighted Price Index, the Stock Exchange of Thailand Index, the Tokyo Stock Price Index, and the Standard and Poor's 500 Index. These indices are value weighted. Weekly returns are employed in order to avoid problems associated with nonsynchronous trading and day-of-the-week effects. The experiment conducted by Ng (2000) entails two basic steps. The first step entails the estimation of a bivariate GARCH(1,1) model describing the joint dynamics of U.S. and Japanese conditional returns and variance/covariances. Four different specifications are considered for this stage but the most

general one, the general asymmetric dynamic covariance (ADC) model with asymmetry originally proposed by Kroner and Ng (1995) is retained given its superior fit. In the second stage, a univariate volatility spillover model for each Pacific-Basin country is estimated in which volatility surprises from Japan and the U.S. manifest themselves through that country's error term. The findings from this study may be summarized as follows: First, both regional and world factors are found to play an important role for market volatility in the Pacific–Basin region, although the world market influence tends to be greater. Second, the relative importance of the regional and world market factors is influenced by important liberalization events (such as the introduction of country funds and changes in foreign investment restrictions), fluctuations in currency returns, number of DR listings, sizes of trade, and closed-end country fund premium but the effects vary from country to country and from liberalization event to liberalization event. Third, the proportions of the Pacific–Basin market volatility captured by the regional and world factors are generally small. For instance, the U.S. accounts for 5.84% of Hong Kong volatility while Japan accounts for 2.16%.

Using intraday prices for the S&P 500 and Nikkei Stock Average stock indexes and aggregate trading volume for the New York and Tokyo Stock Exchanges from January 4, 1974 through April 24, 1997, Gagnon and Karolyi (2003) examine the short-run correlations in stock returns and volatility for the two largest international markets in an effort to establish how the levels and changes in these correlations relate to market fundamentals. They frame their analysis in the context of the heterogeneous-agent models of trading developed by Campbell, Grossman and Wang (1993) and Blume, Easley, and O'Hara (1994) and Wang (1994) which predict that trading volume acts as a signal of the information content of a given price move. While they find that there exists significant short-run dependence in returns and volatility among Japan, U.K. and the U.S., they offer new evidence that these return "spillovers" are sensitive to interactions with trading volume in those markets. The cross-market effects with volume are revealed in both close-to-open and open-to-close returns and often exhibit non-linear patterns that are not predicted by theory. Moreover, these patterns are robust to different measures of trading volume and to different conditioning information for market returns.

In a subsequent study of international stock return spillovers, Gagnon and Karolyi (2006) devise an experiment which centers on U.S. cross-listed stocks. Focusing on cross-listed stocks has several advantages from an experimental standpoint. First, since the cross-listed stock and its home-market counterpart represent identical claims to the underlying firm's cash flows, there is no need for an equilibrium model of returns in the study of the dynamics of return comovements between the U.S. and the home market. Second, this setting takes the investigation of international stock return spillovers to the level of individual firms and provides sufficient scope and breadth to explore the impact of country- and firm-level proxies for information asymmetry on return spillovers. The authors identify 556 U.S. cross-listed pairs from 36 countries with concurrent price and volume series for both markets drawn from Datastream and the NYSE's Trade and Quote (TAQ) database from February 1, 1993, to May 31, 2004. Their findings reveal a positive relationship between the degree of information asymmetry associated with a stock and the magnitude of its home-to-U.S. return spillovers. These findings are robust to reasonable firm-level proxies for information asymmetry (e.g. illiquidity in the U.S. and at home, share of aggregate turnover in the home market, U.S. institutional ownership, and analyst following) as well as to various home-country-level proxies for information asymmetry and market development (accounting standards, quality of investor protections, accessibility of local stocks to international investors, and trading costs). By documenting the link between information and return spillovers, this study lends support to the fundamental's view of international return spillovers.

Are international stock market comovements driven by economic fundamentals or by contagion? Connoly and Wang (2003) examine this question using a comprehensive data set of the macroeconomic news announcements made in the U.S., the U.K., and Japan from 1995 to 1996.[15] They establish the distinction between the two competing hypothesis by separating the influence of foreign markets into two components: one driven by economic fundamentals and the other driven by foreign market returns. Evidence in favor of the contagion hypothesis would result if foreign returns were

[15] In two related papers, Connolly and Wang (1998) demonstrate that the macro news shocks play a more important role in explaining volatility linkage between markets than in explaining return linkages and Connolly and Wang (2002) examine the effects of market volatility, dispersion of beliefs and extreme returns on equity market comovement.

shown to have a significant influence on domestic returns after controlling for the effect of macroeconomic news announcements. On the other hand, the case for the market contagion hypothesis would be weakened if foreign returns were found to be redundant once macroeconomic news is accounted for. They use intraday (open-to-close and close-to-open) returns data for the S&P 500 index, the Nikkei 225 index, and the FTSE 100 index and calculate returns using post-opening prices to minimize problems associated with stale opening prices documented in previous studies. They estimate conditional mean models in which domestic returns are a linear function of previous day domestic and foreign returns and macro news shocks from the other countries as well as non-linear models in which the domestic returns are influenced by the volatility of these factors. They also employ conditional volatility models based on the Glosten-Jaganathan-Runkle (GJR) asymmetric GARCH (1,1) parameterization. Corroborating the evidence reported by Karolyi and Stulz (1996), Connoly and Wang (2003) are unable to attribute international equity market comovements to public information about economic fundamentals conveyed in macroeconomic news announcements. They suggest that future enquiries on market comovements may focus instead on the distinction between market contagion and trading on private information. We now turn to enquiries that pursued this avenue of investigation.

6. Contagion models

Are international stock market comovements driven by news conveying information about economic fundamentals or are they simply driven by other more obscure forces, such as market contagion? The weight of the evidence certainly seems to point to the second explanation. In this section, we highlight recent and important research exploring new ways to measure market contagion, as well as identifying the factors that trigger contagious episodes across national equity markets and strategies to overcome market contagion, and explore the implications of international market contagion for international capital market integration, asset allocation and risk management.[16]

[16] In "Does international financial contagion really exist?", Karolyi (2003) challenges the very notion of market contagion. His analysis leads him in a different direction, namely that the role of international regulation (particularly domestic fiscal and monetary policy) in financial crisis in emerging markets has been overlooked.

Contagion may be described as an increase in cross-market linkages resulting from a shock to an individual country or group of countries. Dornbusch, Park, and Classens (2000) define market contagion as "the spread of market disturbances - mostly on the downside - from one (emerging market) country to the other, a process observed through co-movements in exchange rates, stock prices, sovereign spreads and capital flows".[17] They classify sources of market contagion into two categories. The first one is termed 'fundamentals-based contagion' and included spillovers from one market to the next arising from real and financial linkages. These create interdependence between the markets and imply that shocks (global or local in nature) will be transmitted across countries. The second type of contagion encompasses 'irrational' phenomena such as financial panic, herd behavior, loss of confidence, and increases in risk aversion. For instance, a crisis in one country may, for example, lead investors to withdraw their investments from many markets without distinguishing differences in economic fundamentals (Dornbusch, Park, and Claessens (2000), p.4). Such events may still be rational at the individual level.

Pownall and Koedijk (1999) highlight the limitations of the traditional Value-at-Risk (VaR) methodology mandated by the world's banking regulatory authorities for use by banks and other financial institutions when the extent of downside risk is underestimated. They argue that today's VaR measures understate the true amount of economic capital required by banks to support their market risks since they generally do not recognize the severe departures from normality observed during periods of market turmoil and evidenced by recent global financial crisis. They develop a conditional approach to Value-at-risk measurement which recognized the more pronounced fat-tailedness of return distributions and that captures the time-variation in these departures from normality. Their alternative measurement strategy relies on tail indices derived from the extreme value theory (EVT). Tail indices obtained from EVT provide a measure of tail fatness. They use the tail index to estimate the number of degrees of freedom needed to parameterize the Student-t distribution which forms the basis of their VaR-x

[17] There is no generally agreed upon definition for contagion. For a discussion of alternate definitions as well as their strengths and weaknesses, see Forbes and Rigobon (2001) or the web site http://www.worldbank.org/economicpolicy/managing%20volatility/contagion/Definitions_of_Contagion/definitions_of_contagion.html.

estimate. Using bi-weekly data for the returns on the Asia 50 index between January 1993 and January 1988, the authors compare VaR (99% confidence level) estimates from their conditional framework, which captures the downside risk induced by departures from normality, to those calculated according to JP Morgan's Value-at-Risk methodology.[18] If this alternative approach is better than the maintained VaR calculation methodology, it should give rise to fewer exceedences at the 99% confidence level than the RiskMetrics™ model. This is indeed what they find. In particular, during the period of financial turmoil included in their sample period (1997-1998), the VaR-x model yields a 13% improvement over the RiskMetrics™ at the 99% confidence level.

Susmel (2001) studies the diversification benefits offered by Latin American emerging markets to U.S. investors who allocate their wealth according to the safety-first principle proposed by Arzac and Bawa (1977) instead of the traditional mean-variance framework. Under the safety-first principle, an investor states a maximum loss level as well as the maximum probability of achieving that 'disaster' level of wealth. Hence, other things equal, an investor would allocate a smaller share of her wealth to an asset presenting a greater likelihood of extreme and adverse return outcomes (extreme values from the EVT perspective) than to an asset offering no such potential negative returns. They use weekly index returns data from six industrial countries (Australia, Canada, Germany, Japan, the U.K., and the U.S.) and four emerging Latin American markets (Argentina, Brazil, Chile, and Mexico) from MSCI covering the period from the last week of August 1989 to the last week of April 1996. During that period, Latin American markets experienced slightly fewer extreme return observations, defined as observations larger than two standard deviations in absolute value terms, than industrial markets but negative extreme observations were much larger than they were in the developed markets. Also, a significantly larger percentage of extreme observations observed in Latin American markets were clustered together while a very small percentage of extreme observations in developed markets were independent, i.e. neither preceded nor followed by another extreme observation in a four-week period.

[18] The methodology is now marketed by the RiskMetrics Group, which came into being in the late 1990's when JP Morgan spun-off of its quantitative risk management group. Parametric VaR estimates derived from this methodology are based on the assumption that conditional variances evolve over time according an exponentially-decaying moving average process akin to the integrated GARCH (1,1) process.

Moving to tail estimates inferred from the return distributions' tail indexes, Latin American markets revealed much fatter tails than their industrial counterparts. Based on these tail probability estimates, a U.S. investor would allocate 15% of her wealth to a Latin American index under the safety-first principle compared to a 32% allocation under the mean-variance framework. Thus, allocation rules focusing on the tails of the unconditional return distribution of Latin American assets would yield substantially lower allocations of a U.S. investor's wealth given the evidence showing that stock returns in these markets exhibit much fatter tails than their industrial counterparts.

Are financial crises driven by economic fundamentals or by herding behavior? Kaminsky and Schmukler (1999) examine this question during the East Asian meltdown in 1997-1998. They focus on the twenty largest 1-day swings in stock prices (in dollars) in nine Asian countries (Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand) from January 1997 to May 1998, i.e. a total of 180 price changes. For each day where a large price movement is observed (a market rally or collapse), all news stories are collected and classified into eight categories: (1) agreements with international organizations or financial community; (2) credit ratings by international agencies;(3) economic news, including both real, financial, and external sectors' news; (4) monetary policy; (5) fiscal policy; (6) political news, including political events and talk; (7) capital controls; (8) 'no news'. For each country, a news release is classified as foreign if it originates in one of the seven other countries or in the U.S. Each news release is codified as a dummy variable taking on the value of 1 if the news is positive for the country, -1 if it is has negative implications, and zero otherwise. Herding behavior is also examined by constructing a dummy variable set to 1 if there seems to be no apparent news associated with the large price swing occurring on a given day and zero otherwise, and the differential impact of good and bad news on returns is also examined to detect potential asymmetries in herding behavior and contagion. Political news as well as news releases associated with economic, capital control, international agreements, and credit rating changes exert a statistically significant impact on returns. Prices change by an average of 10% on days when news announcements pertaining to international agreements or credit rating changes are made. On average, market prices fall

by about 2.5% on days with no news, a statistically significant difference at the 5% level, which supports the herding behavior hypothesis. Also, markets tend to do somewhat more poorly, at the 10% significance level, following the release of good news. However, a closer analysis of the asymmetric impact of good and bad news in the context of an event study reveals that large market rallies seem to persist over time (consistent with momentum trading) and that large downturns tend to be reversed more quickly, especially following events associated with no apparent news, which supports the herding behavior/contagion hypothesis.

Hartmann, Straetmans, and De Vries (2001) study the international shock propagation mechanism between stock and bond markets during periods of crisis for the G5 countries (France, Germany, the U.K., the U.S. and Japan). Their sample consists of Friday-to-Friday stock and bond returns between February 27, 1999 and November 18, 1999 from the Financial Times/Standard & Poor's world price indices while their bond returns data are based on each country's 10-year government bond price indices. During this period, using non-parametric techniques based on extreme-value theory, the authors report statistically significant extreme linkages between stock and bond markets. These linkages are much stronger at the lower tail within stock markets than within bond markets, with a co-crash occurring roughly once out of every 5 crashes in the stock market and once out of every twenty crashes in the bond market. Furthermore, the multivariate normal distribution underestimates the probability of co-crashes in a significant fashion. Across asset classes, strong evidence of asymptotic dependence is presented both within country and across borders. Furthermore, joint crashes (contagion) are as likely to occur as flight-to-quality episodes, given that a crash has occurred in a given country. Hence, national boundaries do not seem to mitigate the potential for contagion or flight-to-quality. This may be one of the downfalls of market integration.

The 1997 "Asian flu," the 1998 "Russian virus," the 1994 Mexican "Tequila crisis", and the 1987 U.S. stock market crash are cases that substantiate the widely held view that dramatic price changes in one country can have a devastating impact on markets of very different sizes and structures across the world. Do these noteworthy periods of heightened correlation across international stock

markets constitute evidence of market contagion? Many of the papers surveyed so far seem to support this conclusion. Forbes and Rigobon (2002) show that tests for market contagion based on conventional methods (i.e. assessing whether cross-market correlation coefficients increase significantly after a crash) are biased and inaccurate due to heteroscedasticity in market returns. Cross-market correlation coefficients are conditional on market volatility so, during periods of crisis when markets are more volatile, estimates of correlation between markets tend to exhibit upward bias even if the unconditional correlation remains unchanged, thereby lending support to the market contagion hypothesis. The authors propose a methodology to specify the magnitude of this inherent source of bias and to correct for it.[19] When they apply their bias-correction procedure to test for market contagion during the 1997 East Asian crisis, the 1994 Mexican Peso devaluation, and the 1987 U.S. market crash, their evidence leads them to conclude that the high cross-market correlations documented during these periods of market turmoil represent a continuation of strong linkages that exist in all states of the world (which they refer to as interdependence) rather than an increase in these linkages (which they describe as market contagion). In summation, inferences based on conditional correlation coefficients tend to favor the contagion hypothesis while tests based on unconditional correlation coefficients estimated with Forbes and Rigobon's (2002) bias-correction procedure tend to reject it. Hence, the authors conclude: no contagion, only interdependence![20]

Are international markets more highly correlated in volatile times? The evidence reviewed so far seems to suggest so. However, Longin and Solnik (2001) point out that that the evidence from earlier studies may have been contaminated by the spurious relationship between correlation and volatility. Indeed, one can easily show that assuming that returns between two markets are bivariate normal and exhibit constant correlation, the correlation between the two markets conditional on small returns being observed in the first market is low. On the other hand, the conditional correlation between

[19] Similar bias-correction procedures are proposed by Boyer, Gibson, and Loretan (1999) and Loretan and English (2000).

[20] Corsetti, Pericoli, and Sbracia (2002) show that if returns are not i.i.d. (e.g. if variances increase during periods of crisis), the bias correction strategies proposed in the literature tend to err in favour of the null hypothesis of no contagion.

the two markets is large if large returns are observed in the first market. In fact, the conditional correlation between returns in two markets is a highly non-linear function of the level of the returns on which it is conditioned. Hence, Longin and Solnik (2001) argue that in order to make a reliable inference about whether international correlation is indeed larger in highly volatile markets, one must first spell out the distribution of the conditional correlation that is expected under the null hypothesis (e.g. the multivariate normal distribution). Using extreme value theory, they derive a formal statistical test to assess whether the correlation of large returns is higher than expected under the assumption of multivariate normality. They model the dependence function of extreme returns between markets with the logistic function [Gumbel(1961)] which, in addition to being parsimonious, leads (in the limit) to zero correlation between extreme returns when returns are multivariate normally distributed. Empirically, the dependence function is estimated and tests are performed to establish whether the correlation of extreme returns is equal to zero using different 'extreme' return thresholds (±0%, ±3%, ±5%, and ±10%). They conduct their tests on a sample that consists of monthly equity index returns for the U.S., the U.K., France, Germany, and Japan represented by the M.S.C.I. country indexes for the period January 1959 to December 1996 and perform their maximum-likelihood estimation in a bivariate setting focusing on the correlation of the U.S. market with the other four markets separately: U.S./U.K., U.S./FR, U.S./GE, U.S./JA. For all pairs considered, a very clear and statistically significant pattern in the correlation coefficient of return exceedances is observed. While under the multivariate normal distribution, these correlations should decrease to zero as the return exceedance thresholds increase in absolute value terms (leading to the no-correlation case in the limit as the absolute value of the threshold increases), the correlation of return exceedances characterizing their data actually increases with the absolute value of the threshold increases when negative return exceedances are examined and the correlation tends to decrease with the level of the threshold when they look at positive return exceedances. Hence, the multivariate normality assumption is strongly rejected for large negative returns but it is not rejected for large positive returns. Thus, when the spurious correlation between market volatility and correlations is factored into the null hypothesis, Longin and Solnik (2001)

conclude that the correlation between markets increases in bear markets but not in bull markets. Furthermore, these results are not only inconsistent with the case of multivariate normal return distributions but also with the multivariate GARCH model with constant correlations as well as a fairly general asymmetric GARCH representation. However, the asymmetric correlation in bear and bull markets documented here is consistent with a regime-switching return generating processes of the form recently proposed by Ang and Bekaert (2002).

Bae, Karolyi, and Stulz (2003) develop a novel approach to the measurement of market contagion. Instead of focusing on the cross-market correlation framework used by previous researchers to study contagion, they evaluate contagion by assessing the coincidence of large positive and negative return days across countries within a region and across regions. In order to establish whether joint occurrences of large returns, defined as return coexceedances, is larger than one would expect, they calibrate these outcomes using Monte Carlo simulations of the joint distribution of international stock market returns with different assumptions about their dynamics (multivariate normal, multivariate Student-t, and multivariate GARCH). They then develop an econometric model of coexceedances based on the multinomial logistic regression framework in which exceedance events are conditioned on a set of control variables, or covariates, measured with information available up to the previous day. Exchange rates, interest rates, and regional conditional market volatility are covariates found to be important predictors of return exceedances. In this experiment, contagion within regions is defined as the fraction of exceedance events that is not explained by the covariates. Cross-regional contagion is defined as the fraction of exceedances in a particular region that is not explained by its own covariates but that is explained by the exceedances from another region. The sample includes daily stock index data returns from the International Finance Corporation (IFC) database for ten Asian and seven Latin-American countries as well U.S. and European data from Datastream International from April 1, 1992, to December 29, 2000, a sample period that covers the three most recent stock market crisis. A number of very important results emerge from this study. First, with one exception, Monte Carlo simulations reveal that the number of negative and positive coexceedances observed during the sample period both

in Asia and in Latin America exceeds the number that would be expected under the three different models of return distributions. Contagion effects measured in this study are therefore not attributable to heteroscedasticity. The only notable exception is Asia whose negative coexceedances profile can be reconciled with the multivariate t-distributions. Hence, contagion is more important in Latin America than in Asia. In Asia, there is no evidence that coexceedances events are more likely for negative extreme returns than for positive extreme returns but the likelihood of negative coexceedances is significantly higher in Latin America. Of the three covariates contemplated in the experiment, interest rates exhibit the lowest predictive power. Second, contagion from Latin America to other regions is more important than contagion from Asia. Third, the United States is largely insulated from contagion from Asia. Furthermore, Europe is more insulated than the U.S. from contagion originating in Latin America but is more sensitive to contagion from Asia. Four, conditional on prior information, contagion is predictable.

Bekaert, Harvey, and Ng (2005) evaluate market contagion from the perspective of a two-factor asset pricing model and define contagion as excess correlation i.e. correlation in excess of what one would expect on the basis of economic fundamentals. The two factors underpinning their model are the U.S. equity market return and the return on a regional equity portfolio. Their model extends the traditional CAPM from a one-factor to a two-factor setting by splitting the world market into the U.S. and a particular region and allows both the U.S. factor and the local factor to be priced. Furthermore, they represent the variance of conditional return innovations as an asymmetric GJR-GARCH process. In the context of a factor model such as this one, the increased return correlation between two countries during a period of crisis could simply be due to their exposure to a common factor rather than being the result of market contagion. Instead, evidence of market contagion would stem from the presence of correlation in the model's residuals. The authors study a sample of 22 countries grouped into three geographical regions – Asia, Europe, and Latin America – during the period January 1980 through December 1998. The regional equity indices examined in this study are the Morgan Stanley Capital International (MSCI) Europe index, as well as an Asian index and a Latin American index constructed

by the authors. During the entire sample period, the authors report strong evidence of contagion within Europe and Asia and weak evidence of contagion within Latin America. Contagion worsened in Asia and intensified in Latin America during the second half of their sample period. However, insignificant contagion effects were found for Europe and Asia during the Mexican crisis but, during the Asian crisis, significantly higher contagion effects were noted in Asia as well as in Europe and in Latin America.[21]

While most studies of market contagion focus on country-level stock returns, Forbes (2004) takes a microeconomic approach and uses firm-level information to examine how companies located around the world were affected by financial crises that originate elsewhere around two of the most severe financial crises of the 1990s, i.e. the Asian crisis in 1997 and the Russian crisis in 1998. Using the event study methodology, this study shows that firms whose primary output competes with exports from crisis zones experienced average abnormal returns over -11% and -3% during the latter part of the Asian and the Russian crisis, respectively, compared to firms facing little product-competitiveness from these countries. Furthermore, firms with direct trade exposure to Asia or to Russia experienced significant abnormal returns during the crisis periods compared to firms with no or little exposure to these markets. This study provides strong evidence that two trade linkages, product-competitiveness and income effects, played a significant role in the manner in which the Asian and the Russian crisis were transmitted internationally.

In an empirical study examining the correlation dynamics of stocks that are eligible for purchase by foreigners (accessible) and those that are not, Boyer, Kumagai, and Yuan (2005) examine whether market contagion is driven by market frictions (e.g. international investors trading in order to rebalance their portfolios or in response to their wealth constraints) or by changes in country fundamentals. Using an interesting thought experiment, they argue that if contagion is induced by international investors, 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

[21] Using a three-variable latent factor model, Dungey and Martin (2001) find similar evidence of contagion for Asia. Their study also documents small contagion effects from equity markets to currency markets and, for a small subset of countries (the U.S., Indonesia, and South-Korea) substantial contagion effects from currency markets to equity markets.

during periods of turmoil. Alternatively, if market contagion is driven by fundamental forces, the increase in co-movement should be similar for accessible and inaccessible stocks. Using investable and non-investable stock index series from the International Finance Corporation's (IFC) Emerging Market Data Base (EMBD) for emerging markets and Datastream Total Index series for developed countries, they construct weekly return series for the period January 1989 through December 2002 in order to investigate the transmission mechanisms of the 1997 Asian crisis. Upon confirming the presence of contagion, the authors find that increases in co-movement with the crisis country are more pronounced for accessible stocks than for inaccessible stocks during the Asian crisis. They further report that accessible returns lead inaccessible returns during the period. These findings indicate that accessible returns act as an important channel for crisis transmission and lend support to the investor-induced contagion hypothesis. Is contagion due to portfolio rebalancing or to wealth constraints? An examination of tail correlations as well as correlation dynamics between government bonds and equity returns in all countries reveals that wealth effects are the dominant channel through which crises are spread among emerging countries. Contrastingly, for developed markets, the null hypothesis that stock market contagion is driven by portfolio rebalancing cannot be rejected.

7. Concluding Remarks

Early contributions to the international finance literature focused on the benefits associated with international diversification. These benefits stemmed from the low correlations among the returns of national stock markets. This key insight paved the way for the introduction of a host of innovative investment vehicles catering to institutional and retail investors wishing to exploit these benefits. However, the notion that national stock markets were poorly correlated was shaken to its foundation in the aftermath of large market breaks, including the International Crash of October 1987, European Currency Crisis in 1992, the Asian flu in 1997 or the Russian Government's default and the collapse of Long-Term Capital Management in 1998. These episodes of market turmoil brought international stock market linkages into focus and spawned a significant number of studies. This literature included studies

examining the influence of the U.S. on international markets (e.g. lead-lag relationship between markets) as well as studies documenting the rise in cross-market correlations over time. In turn, this work inspired a new strand of literature examining short-run return and volatility spillovers effects across national markets. Many of these studies rely on advanced econometric technology (e.g. ARCH and GARCH processes) and higher-frequency data, which provide much greater resolution on the joint dynamics of returns and covariances across markets. These studies deliver several interesting insights concerning the properties of international return and volatility transmission mechanisms. Most notably, we learn that episodes of high volatility in one market induce price changes in other markets to become more highly correlated. We also learn that the impact of news originating in one market depends on whether the news is good or bad. Indeed, bad news in one market is shown to have a much greater impact on the other market's volatility than good news.

While this strand of literature is largely preoccupied with the measurement of international return and volatility spillovers, the next wave of studies seeks to establish whether these spillovers are driven by fundamentals or by other forces. In most cases, this question is addressed from the perspective of an equilibrium model of returns (single or multi-factor) or of a theory modelling the interplay between information and price changes. The general tenor of this stream of literature is that 1) although information seems to have some influence over return and volatility spillovers, macroeconomic announcements and other public news do not seem to affect co-movements between stock markets in a meaningful way and 2) observable economic variables explain only a small fraction of international stock market co-movements.

The weak link established in the literature between macroeconomic news announcements and international stock market comovements led researchers to take a closer look at the tail of the joint return distribution of international stock markets where forces of contagion were most likely to be at play. While there is no agreed-upon definition for contagion, it is useful to think of it as the reaction of a stock (or other) market to a crisis that originates in another country. One stream of literature has focused on ascertaining the existence of market contagion and another, more recent, stream of research

has focused on the channels through which forces of contagion operate. In the first strand, the case for contagion has been established by examining cross-market correlations during crisis periods (both parametrically with bias-adjusted correlations and non-parametrically through an analysis of return coexceedances) as well as from the perspective of an equilibrium model of returns. As for the second strand of research, recent findings indicate that portfolio rebalancing activities and wealth constraints facing international investors constitute an important crisis transmission channel across countries. Other findings indicate that firm-level product competition and income effects play a significant role in the manner in which crises are transmitted internationally.

Where do we go from here? Just as new databases and new econometric technology provided the catalyst for innovative research on international spillovers of prices and volatility during the past decade or so, they are likely to serve as such for the next decade. One promising stream of research in time-series econometrics focuses on generalizing models of the dependence structure among random variables through *n*-dimensional distribution functions decomposed into *n* marginal distributions and copulae. Useful applications to stock returns and currency returns (Patton, 2006) are just now appearing in the literature. Another promising stream of research stems from ever increasingly higher quality databases and applications in terms of cross-sectionally-disaggregated firm-level analysis (Forbes, 2004) and investor-level analysis (Chan, Covrig and Ng, 2005) as well as higher-frequency intraday time-series analysis (Grammig, Melvin and Schlag, 2005).

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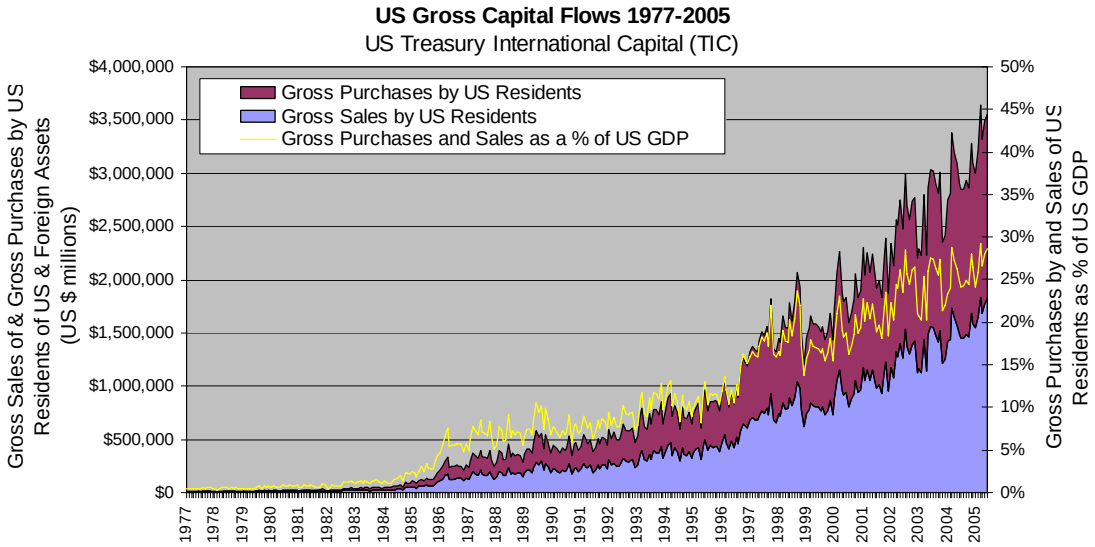
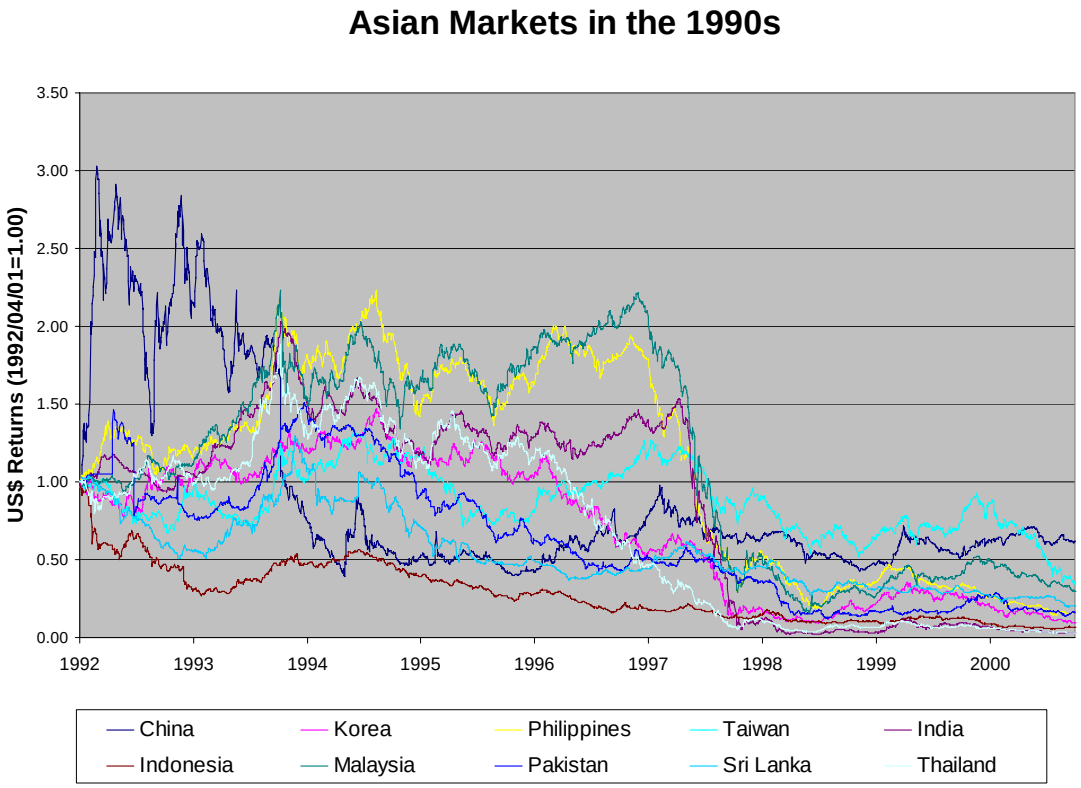
Figure 1: U.S. Gross Capital Flows, 1977-2005



Source: U.S. Treasury International Capital.

Figure 2: Stock Market Activity around the Asian Financial Crisis of 1997



Source: Datastream International.

Appendix: A Chronology of Research Studies on Price and Volatility Transmission Across Borders

Research Study	Topic	Sample	Major Findings
1) The Early Days – 1970's			
Grubel (1968)	Welfare gains associated with International diversification	Weekly index returns from 11 industrialized countries, 1959-1966	Capital movements across nations are motivated not only by the traditional argument of gains from trade but also by the existence of benefits due to international diversification.
Grubel and Fadner (1971)	Correlation analysis of international industry equity indexes	Weekly returns for 51 U.S., 28 U.K., and 28 German industry indexes, 1965-1967	Average correlation for industry pairs increases significantly with the length of the holding period. U.S.-U.K. correlations are higher, followed by U.S.-W.G., and U.K.-W.G.
Agmon (1972)	Relation among share price movements in the U.S, U.K., Germany and Japan	Monthly returns for 596 U.S, 71 U.K., 31 German, and 43 Japanese stocks, 1961-1966	Changes in share prices in the non-U.S. countries respond immediately (within one period) to price changes in the U.S. market index. Evidence provides indirect support for the 'one market' hypothesis.
Ripley (1973)	Systematic covariation between stocks in developed countries	Monthly industrial stock price indexes for 19 developed countries, 1960-1970	The first factor links countries whose stock markets are well developed and which are reasonably open to capital flows or markets where shares of multinational corporations are traded. The second factor is associated with countries that are linked financially to the same capital market. The third factor highlights the close relationship between the Canadian and the U.S. markets.
Panton, Lessig, and Joy (1976)	International equity market structure and structural change	Weekly stock index returns for 12 major international markets, 1963-1972	Evidence of substantial structural stability in comovement patterns for one and three-year periods but weak stability over 5-year periods. Canada and the U.S. have the strongest similarity and are joined next by the Netherlands, Switzerland, and Germany.
Hilliard (1979)	Relationship between equity indices on world exchanges during the OPEC crisis	Daily returns of major industrial indices on 10 world stock exchanges, 07/1973-04/1994	Spectral analysis reveals evidence of important intra-continental return commonality in North-American and European exchanges as well as return simultaneity in these markets. With the exception of the New York.-Amsterdam pair, inter-continental lead-lag effects are insignificant, suggesting the absence of a world-wide market factor.
2) Lead-Lag Effects in International Returns			
Eun and Shim (1989)	Understanding the mechanisms by which innovations in one stock market are transmitted to	Daily returns for 9 major MSCI stock market indices, 12/89-12/85	The U.S. market is by far the most influential market in the world. No single market can significantly explain U.S. market movements. Against U.S. innovations, the Canadian market responds most strongly on day 0 while the European and Asia-Pacific markets respond most strongly on

	other markets over time		day 1.Beyond one day, responses taper off rapidly. The evidence reported in this paper is broadly consistent with the hypothesis of informationally efficient international stock markets.
Roll (1988)	Was the stock market crash of 1987 due to institutional features of the U.S. stock market?	Monthly stock index returns for 23 international equity markets from FT-Actuaries World Indices, 06/81-10/87	October 1987 is the only month in the 81-87 sample where all markets declined at the same time. Evidence suggests that Crash was caused by the presence of an underlying fundamental factor rather than by institutional features of the U.S. stock market and the extent of the Crash was related to other characteristics than size.
Roll (1989)	Survey of empirical and theoretical papers investigating the cause of the stock market Crash of 1987		The Crash of 1987 remains an inexplicable event. Its international scope and similarities across markets makes it unlikely that it was caused by institutional practices or regulations from anyone country. There is no compelling theory explaining the sudden rise in the cross-market correlation during the period of the Crash. We are still unable to establish whether the Crash was caused by the bursting of a bubble.
Von Furstenberg and Jeon (1989)	The influence of time-zone stock price innovations on comovement in international stock prices before and after the Crash of 1987	Daily close-to-close FT Actuaries stock price indices for the U.S., Japan, U.K., and Germany, 1/86-11/ 88	The influence of time-zone innovations has tripled in the postcrash period. In the postcrash period, the importance of country-specific shocks and redistributive shocks has declined relative to common shocks. International stock price movements cannot be linked with broad economic fundamentals (exchange rate fluctuations, interest rate differentials, changes in the price of oil and gold). Industry effects were generally insignificant in explaining international stock price movements. Correlations across markets may simply be driven by contagious stock market shocks unrelated to fundamentals.
Becker, Finnerty, and Gupta (1990)	Empirical investigation of the synchronization of stock price movements between the U.S. and Japan	Daily opening and closing prices for the Nikkei index, the S&P 500 index, and yen/dollar exchange rates, 10/1985-12/1988.	The performance of the U.S. market has a significant influence on open-to-close stock returns in Japan the next day. This effect is unidirectional in that Japan only has a small impact on the U.S. Japanese open-to-close returns have no impact on U.S. overnight return either. Simulated buy and sell strategies from the perspective of a Japanese trader yield significant profits following both up and downward U.S. price movements but these trading profits disappear when transactions costs and taxes are taken into consideration.
Koch and Koch (1991)	Evolution of the contemporaneous and lagged structural relationship between Japan, Australia, Hong Kong, Singapore, Switzerland, West Germany,	Daily stock indexes and bilateral exchange rates with the U.S. dollar from MSCI, 1972, 1980, and 1987	Evidence reveals several clusters of markets that exhibit significant interactions on the same day and that international markets have grown more interdependent over time. Most significant same-day impacts occur within blocks of countries in the same geographic region and whose trading hours overlap considerably. Most intermarket responses are completed within 24 hours and it is unlikely that the lag relationships

	U.K., and the U.S.		documented could be exploited profitably by traders. Since 1972, Japan has shown fewer responses to other markets while the U.S. market has progressively shown increased response to other markets. Japan has grown to be more of a market leader while the U.S. market's influence has diminished.
3) Return and Volatility Spillovers Across National Markets			
King and Wadhwani (1990)	Transmission of volatility between stock markets	Hourly and half-hourly stock index prices from New York (Dow Jones index and S&P 500 index futures), London (FT 30 Share index), and Tokyo (Nikkei-Dow index), 7/1987-02/1988	In a non-fully revealing equilibrium model, price changes in one market will depend on price changes in another market through contagion effects. In this context, mistakes in one market will transmit to the other market and will increase volatility. Price volatility jumps in London when the NYSE opens, the rise in correlations between London, New York, and Tokyo around the Crash of 1987, and the significant reduction in volatility in London during the Wednesday market closings in New York in 1968 all provide empirical support for contagion model.
Hamao, Masulis, and Ng (1990)	Short-run interdependence of prices and price volatility across international stock markets	Daily opening and closing stock index prices from Tokyo (Nikkei 225 index), London (FSTE 100 share index) and New York (S&P 500 index), 4/1985 to 3/1988.	Returns measured from close-to-open and open-to-close are well approximated by a GARCH(1, 1)-M model. There is strong evidence of spillover effects in the conditional variance from the U.S. and the U.K. stock markets to the Japanese market but spillover effects from the Japanese market on the other two markets are much weaker. This result is robust to foreign currency translations. Spillover effects in the conditional mean are also present but these effects are most likely due to overlapping trading hours between London and New York and the inclusion of stale quotes in the calculation of the Nikkei and S&P opening prices.
Chan, Karolyi, and Stulz (1992)	The influence of Japan on the risk premium of U.S. stocks	Daily returns on the S&P 500, the Nikkei 225, and Japan's Morgan Stanley indexes, the Morgan Stanley the EAFE index, 01/1980-12/1989	The conditional expected excess-returns on U.S. stocks is significantly related to the conditional covariance between U.S. stocks and Japanese stocks but is not significantly related to the conditional variance of U.S. stocks. This result holds whether the model is tested using dollar-denominated excess returns or the yen-denominated excess returns for the Nikkei 225 index.
Theodossiou and Lee (1993)	Mean and volatility spillovers between the stock markets in the U.S., Japan, U.K., Canada, and Germany	Weekly returns data for the S&P 500 index, the Nikkei index, the FT 100 index, Toronto Stock Exchange, Commerzbank index, 1/1980-	Significant conditional mean return spillovers from the U.S. to the U.K., Canada, and Germany, as well as from Japan to Germany. Significant volatility spillovers from the U.S. to Japan, the U.K, Canada, and Germany, from the U.K. to Canada, from Germany to Japan, from Japan to Germany. Conditional volatility spillovers in the U.K. and Canada are

		12/1991	imported from the U.S. Tests failed to reject the hypothesis that the correlation structure between the five markets was constant during the sample period.
Bae and Karolyi (1994)	Asymmetries in the return volatility spillovers between the U.S. and Japanese stock markets	Overnight and daytime return volatility for the Nikkei Stock Average and the Standard and Poor's 500 Stock Index, 5/1988-6/1992	Their evidence demonstrates that the magnitude and persistence of shocks originating in New York or Tokyo that transmit to the other market are significantly understated if the asymmetric effects of negative ("bad news") and positive ("good news") foreign market returns shocks for volatility is ignored.
Lin, Engle, and Ito (1994)	International transmission mechanisms for stock returns and volatility	Opening and closing prices on the S&P 500 and NK 225 indexes, 10/1985-12/1989	Foreign daytime returns can significantly influence domestic overnight returns. Contrary to previous studies documenting return and volatility spillovers from New York to Tokyo only, there is evidence of bidirectional correlations between the Tokyo and New York stock returns, although the magnitude of the coefficient for Tokyo's influence on New York is about half that of New York's on Tokyo. Their results are consistent with King and Wadhwani's (1990) contagion effect hypothesis.
Susmel and Engle (1994)	Return and volatility spillovers between New York and London measured at very high frequency (hourly) interval	hourly prices from the Dow Jones 30 Industrial Average Financial Times 30 Share Index, 1/1987-2/1989	Both New York and London exhibit a high degree of efficiency in the use of past information from the foreign market in predicting both the mean return and variance. There is no strong evidence of international volatility spillovers, even for the period including the 1987 stock market crash. Simulation results reveal weak evidence of a few very short lived volatility spillovers from one market to the other. These weak spillovers occur at the opening of New York in both directions.
Koutsmos and Booth (1995)	Transmission mechanism of price and volatility spillover across New York, Tokyo, and London stock markets	Daily open-to-close returns for the S&P 500 index, the Nikkei 225 index, and the FTSE-100 indexes, 9/1986-12/1993	Multivariate EGARCH estimation reveals the existence of significant volatility spillovers from New York and London to Tokyo, from Tokyo and London to New York, and from London and Tokyo to New York. Pre- and post-crash estimations reveal that national markets have grown more interdependent over time. Significant asymmetries in the volatility transmission process emerge in the post-crash period. These findings confirm that both the size and the sign of the innovations are important determinants of volatility spillovers.
Karolyi (1995)	Dynamic relationship between daily returns and return-volatility between the Canadian and the U.S. stock market	Closing prices for the TSE 300 index and the S&P 500 index, 4/1981-12/1989	The bivariate BEKK GARCH model provides a useful representation of the joint returns process for the Canadian and U.S. stock markets. This framework reveals that the magnitude of shocks originating in New York and that spillover to the TSE has been overstated by previous studies, and that the impact of these shocks has been more moderated in the latter part of the sample period. The impact of the S&P on interlisted Canadian

			stocks is also much more modest than for non-interlisted stocks, suggesting that differential disclosure requirements, foreign ownership restrictions, and tax considerations may be important for understanding the dynamics of stock price comovements around the world.
Craig, Dravid, and Richardson (1995)	Relationship between overnight returns in Japan and daytime returns on Japanese-based derivatives in the U.S.	Daily opening and closing prices on Nikkei 225 index, the Nikkei index futures on the CME, the S&P 500 index, and on the FTSE index	Over 80% of the variation in overnight Nikkei futures returns is explained by daytime returns on the Nikkei index in Japan and in the U.K. while the S&P index exhibits negligible explanatory power. This result supports the notion that agents process information rationally across international markets and mitigates against the market contagion hypothesis. Further, evidence shows that the information flow is non-constant around the 24-hour clock. A greater proportion of the variation in the Nikkei index occurs just before the Tokyo market's open when London and New York are closed.
4) Economic Fundamentals and International Spillovers of Returns and Volatility			
King, Sentana, and Wadhwani (1994)	Explanatory power of economic variables on the stock return comovements across the world and their time-variation	Monthly total return data for sixteen national stock markets (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, U.K., and the U.S.) from MSCI and ten macroeconomic variables, 1/1971-10/1988	Only a small proportion of the covariance between national stock markets and their time-variation can be explained by observable economic variables. A greater share of these comovements and their time-variation is explained by unobservable factors that are likely linked to investor sentiment. The evidence from this paper does not support the hypothesis of global market integration in that idiosyncratic risk is priced and that the price of risk associated with the relevant factors is not the same across markets.
Longin and Solnik (1995)	Correlations between equity return across several countries	Monthly returns data for Germany, France, U.K., Switzerland, Japan, Canada, and the U.S. from MSCI, 1960-1990	Bivariate GARCH estimation reveals significant GARCH effects in monthly excess returns for six country pairs. The hypothesis of constant conditional correlation between the pairs is rejected. Conditional correlations exhibit a positive time trend over the past 30 years, they tend to increase in periods of high market volatility, and they can be predicted to increase in periods of low dividend yields, and high interest rates.
Karolyi and Stulz (1996)	The impact of macroeconomic shocks on conditional U.S.-Japan return comovements	Opening and closing prices for 8 Japanese ADRs, 8 size-matched U.S. firms, 8 industry-matched U.S. firms, 8 size and industry-matched	U.S.-Japan return correlations exhibit less variation across macro-economic news and no-news days than they do across days of the week. Neither macroeconomic news announcements nor interest rate movements have a significant impact on U.S.-Japan return correlations. Cross-country correlations and covariances are high when markets move

		U.S. firms, CME Nikkei Futures contract, 05/1988-05/1992	a lot, which suggests that international diversification does not provide as much protection against large shocks to national indices as one might have expected.
Ammer and Mei (1996)	Measuring real and financial integration between countries	Monthly NYSE index and FT All Shares index prices, 1957-1989	Stock return correlations between Britain and the U.S. are much higher than the correlation measures of the two countries' real output growth. Innovations in long-term dividend growth are much more highly correlated between the two countries than are measures of contemporary output growth. These findings are confirmed with a group of 15 industrialized nations.
Ramchand and Susmel (1998b)	Empirical investigation of a version of the ICAPM for a sample of ten industrial stock markets	Weekly stock returns of 10 national equity markets compiled by MSCI, 01/1980-04/1996	For six out of ten industrial stock markets, world beta is a non-linear function of domestic volatility. For European markets (with the exception of Switzerland), the world beta is not related to the state of the domestic volatility. The evidence presented in this paper suggests that the increases in correlation across markets during periods of high volatility are priced by the market.
Ramchand and Susmel (1998a)	International stock market comovements across volatility regimes	Weekly stock returns of major equity markets (Japan, U.K., Germany, Canada, and the U.S.) around the world compiled by MSCI, 1/1980-1/1990	The evidence shows that modeling variance as both time and state varying, using a bivariate SWARCH model, improves our understanding of the return generating process. The correlation between foreign markets and the U.S. market is twice as large during periods of high volatility in the U.S. market. The difference between the correlations in high and low U.S. volatility regimes is statistically different in all cases except Japan.
Ng (2000)	The fundamental forces driving return volatility in the Pacific–Basin region and the mechanisms through which and the extent to which volatility in a Pacific–Basin market is influenced by foreign shocks from other national markets	Weekly national equity indices for Hong Kong, Korea, Malaysia, Singapore, Taiwan, Thailand, Tokyo, and the U.S. compiled by Datastream International, -12/1996	Regional (Japan) and world (US) factors are important for market volatility in the Pacific–Basin region, although the world market influence tends to be greater. Second, the relative importance of the regional and world market factors is influenced by important liberalization events, fluctuations in currency returns, number of DR listings, sizes of trade, and closed-end country fund premium. Third, the proportions of the Pacific–Basin market volatility captured by the regional and world factors are generally small.
Connolly and Wang (2003)	Are international stock market comovements driven by economic fundamentals or by contagion?	Daily opening and closing stock index prices (intraday and overnight returns) from the U.S., U.K., and Japan as well as real and monetary economic announcements in each of the three countries,	Results suggest that the bulk of the observed comovement in the intraday and overnight returns of the international equity markets cannot be attributed to public information and, in particular, economic fundamentals. In light of these findings, comovement in international equity markets seem more likely to stem from contagion or trading activities driven by private information, rather than public information.

		01/1985-12/1996.	
Gagnon and Karolyi (2003)	The role of trading volume and information on international stock market comovements	Opening and closing prices for the S&P 500 and Nikkei Stock Average stock indexes and aggregate trading volume for the New York and Tokyo Stock Exchanges, 1/4/1974-4/24/1997	Returns and volatility spillovers between Japan and the U.S. exhibit sensitivity to interactions with trading volume in the respective markets. The cross-market correlations open-to-close and close-to-open returns are significantly lower following high volume days in one market or the other, but yet often exhibit non-linear patterns in the relationship which are not predicted by theory.
Gagnon and Karolyi (2006)	Study examines the link between information asymmetry and international stock return spillovers at the firm level in the context of cross-listed pairs of stocks which precludes the need for an equilibrium model of returns to control for risk.	Concurrent volume and price series sampled at a daily frequency from Datastream and the Transaction and Quote (TAQ) database for 556 home-U.S. stock pairs from 36 countries from February 1, 1993, to May 31, 2004 and various firm-level and country-level proxies for information asymmetry as well as country-level measures of market development.	For a large sample of cross-listed stocks, international return spillovers are positively associated with the degree of information asymmetry associated with the stock as well as with the degree of information asymmetry prevailing in the home market.
5) Contagion Models			
Pownall and Koedijk (1999)	Additional downside risk arising from departures from normality in return distributions	Daily IFC Asia Index, 1/1993-1/1998	Parametric-normal VaR estimates vastly underestimate potential losses during periods of financial turmoil. The VaR-x methodology which assumes a Student t distribution accommodates the fat-tailedness of return distributions and results in fewer exceedences than its parametric-normal counterpart.
Kaminsky and Schmukler (1999)	Impact of news on stock markets jitters in East-Asian countries during the Asian crisis	Daily national stock index prices for Indonesia, Hong Kong, Japan, Korea, Malaysia, the Philippines, Singapore, and Taiwan.,1/1997-5/1998.	Most of the large price changes were related to local news but foreign news mattered the most for some countries. In 62 events (34 percent), the fluctuations of stock prices could not be linked to the release of economic or other information. Foreign news releases seem to have a smaller effect on stock prices. The origin of news does not basically affect the degree of persistence of the shocks in the stock market but positive shocks are persistent while negative shocks tend to mean-revert. These results support herding behavior and contagion explanations for market

			comovements across countries in periods of crisis.
Dornbusch, Park, and Claessens (2000)	Causes of market contagion and channels through which contagion may occur		Survey of literature on contagion and spillovers
Hartmann, Straetmans, and De Vries (2001)	The linkages between stock and government bond markets in times of market turmoil	Weekly stock and government bond returns for the G-5 (France, Germany, U.K., U.S. and Japan) market indices from the Financial Times/Standard & Poor's world price indices, 1987-1999	A characterization of asset return linkages during times of market stress by an extremal dependence measure reveals 1) market crashes are much more likely to occur than the normal probability distribution would lead us to expect, 2) simultaneous crashes in stock markets are about twice as likely as simultaneous crashes in bond markets, 3) stock-bond contagion is about as likely as flight-to-quality from stock to bond market
Longin and Solnik (2001)	Correlation on international equity markets in bull and in bear markets	Monthly equity index returns for five countries: the U.S., the U.K, France, Germany, and Japan from MSCI, 1/1959 to 12/1996	Using "extreme value theory" to study the dependence structure of international equity markets, the evidence shows that the correlation structure of large returns is asymmetric. Correlation tends to increase in bear markets, contrary to multivariate normality, and to decrease in bull markets, consistent with multivariate normality. It appears that it is a bear market, rather than volatility per se, that is the driving force in increasing international correlation.
Susmel (2001)	The implications of the safety-first principle for international diversification in the Latin American stocks	Weekly returns of stock indexes from six industrial and four emerging Latin American markets MSCI, 8/1989 to 4/1996.	Latin American emerging markets have significantly fatter tails than their industrial counterparts. From the perspective of a safety-first U.S. investor, the optimal allocation in Latin American stocks is 15% of her initial wealth, rather than 32% suggested by mean-variance optimization.
Forbes and Rigobon (2002)	Correcting for the bias induced by changes in market volatility (heteroscedasticity) in tests of market contagion	Daily stock index returns for 28 markets around the 1997 East-Asian crisis and the 1994 Mexican Peso devaluation, and 10 countries around the U.S. stock market crash of 1987	Even if cross-market linkages remain constant, estimates of cross-market correlations will increase when one market experiences an increase in volatility. When cross-market correlations are adjusted for this heteroscedasticity bias, there is no evidence of market contagion during the 1987 U.S. stock market crash, the 1997 East Asian crisis, and the 1994 Mexican Peso devaluation.
Bae, Karolyi, and Stulz (2003)	A new testing methodology for market contagion using a measure which focuses on count of co-incidence of extreme returns across markets	Daily index returns constructed from stocks in the monthly investable indices of the International Finance Corporation (IFC indices) from April 1992 to December	Assuming that contagion is associated with extreme market returns, tests which focus on counts of co-incidences of extreme returns rather than on correlations of joint extreme returns reveal that 1) Contagion is more important in Latin America than in Asia, 2) Contagion from Latin America to other regions of the world is more important than contagion from Asia, 3) The U.S. is largely insulated from contagion from Asia,

		1995 and daily index returns provided by the IFC from January 1996 to December 2000 for 17 Asian and Latin American markets of the S&P's Emerging Markets Database (EMDB)	and 4) Contagion is predictable conditional on prior information.
Bekaert, Harvey, and Ng (2005)	Market contagion from an asset pricing perspective	Monthly equity index data for total of 22 countries that are grouped into three geographical regions – Asia, Europe, and Latin America. Data for developed markets is from MSCI and emerging markets is from the IFC of the World Bank, 01/1980-12/1998 for most of the MSCI data and 01/1986-12/1998 for the IFC data.	A two-factor asset pricing model in which contagion is defined as correlation among the model's residuals reveals economically meaningful contagion effects, especially in Asia, during the Asian crisis.
Forbes (2004)	Market contagion from a firm-level data perspective	Financial statistics, industry information, geographic data, and stock returns for over 10,000 firms from 46 different countries around the Asian and the Russian crises.	Using the event-study methodology, two types of firm-level trade linkages, product-competitiveness and income-effects, are shown to be important determinants of the manner in which the Asian and the Russian crises were transmitted internationally.
Boyer, Kumagai, and Yuan (2005)	Study examines whether market contagion is driven by market frictions (e.g. international investor trading to rebalance their portfolios or in response to a wealth constraint) or by changes in country fundamentals.	Weekly returns from investable and non-investable stock index series drawn from the International Finance Corporation's (IFC) Emerging Market Data Base (EMBD) for emerging markets and total index series from Datastream for developed countries, for the period January 1989 through December 2002.	Strong support for the investor-induced (i.e. market frictions-based) contagion hypothesis based on more pronounced increase in co-movement with the crisis country for accessible stocks than for inaccessible stocks. Further tests reveal that wealth constraints underpin the spread of the Asian crisis across emerging markets and that portfolio rebalancing propagated the crisis among developed countries.