# Volatility Transmission between International Stock Markets

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The world's economic and financial systems are becoming increasingly linked due to the rapid expansion of international trade caused by different processes of market liberalization and political integration. Indeed, an important outcome of globalization is increased comovement in asset prices across markets. This comovement, of course, also stimulates vulnerability to market shocks. Thus, shocks originated in one market are transmitted to other financial markets. Some argue that these linkages could even be destroying the very benefits that diversification offered in the first place. This dissertation contributes to the discussion on how to measure and analyze all these issues.

The study of comovements between stock market returns is at the heart of finance and has recently received much interest in a variety of literatures, especially in international finance. But what are the key forces driving this comovement? Traditional asset pricing models (such as the CAPM and its multifactor variants) and most of the studies analyzing international linkages between financial markets offer little hint, because they have mainly focused on the analysis of first moments. Thus, a significant number of researchers have evaluated correlations and cointegration structure of international equity markets. It was not until the 90s that academics started to realize the importance of modeling, as well, interactions in second moments. In fact, it seems that some markets have even more interdependence in volatility than in returns.

The importance of understanding volatility transmission mechanisms comes from their determinant consequences on monetary policy, optimal resources allocation, risk measurement, capital requirements and asset valuation. From an investor's point of view, a better understanding of how markets move together may result in superior portfolio construction and hedging strategies, while regulators may mainly be interested in the actual causes and consequences of such spillovers.

There is a very close connection between the terms integration and diversification. As financial markets are becoming increasingly integrated, there is a higher need to carefully monitor the varying benefits of diversification. A well known result in finance is that the lower the covariance between portfolio assets, the smaller the variance of a diversified portfolio. Therefore, the primary aim of diversification is to take advantage of the low correlations between stocks. No matter if the investor strategy is applied at the industry, national or international level. One of our objectives will be to analyze which level generates the greater risk diversification.

While there is considerable agreement that globalization and integration move together in the same direction, there is not a clear opinion on whether further integration should increase or decrease volatility transmission between financial markets. Our main hypothesis is that further globalization and integration will also increase interrelations in second moments. As a country becomes more integrated into world capital markets, more of its variance might be explained by changes in common world factors (and less by local factors).

Therefore, the aim of the four chapters in this dissertation is to increase the understanding of the interrelations between international stock markets. In order to do so, in Chapter 1 we analyze the different econometric methodologies available to model these dynamics. The remaining three chapters use multivariate conditional volatility models and link them to the analysis of volatility transmission (Chapter 2), diversification (Chapter 3) and integration (Chapter 4).

Chapter 1, entitled *Volatility Transmission Models: A survey*, reviews the literature on volatility transmission in order to determine what we have learnt about the different methodologies applied and which questions are yet to be answered. As far as we know, no other study reviews volatility transmission in such a broad manner. In particular, GARCH, regime switching and stochastic volatility models are analyzed. In addition, this chapter covers several concrete aspects such as their scope of application, the overlapping problem, the concept of efficiency and asymmetry modeling. Finally, emerging topics and unanswered questions are identified, serving as an agenda for future research. Thus, the main objective of this chapter is to offer a broad vision of the *state of the art* in volatility transmission models and, at the same time, motivate further research.

Chapter 2 is entitled *Volatility Transmission Patterns and Terrorist Attacks*. The main objective of this study is to analyze how volatility transmission patterns are affected by stock market crises. Thus, we analyze volatility transmission between the US and Eurozone stock markets considering the effects of the September 11, 2001, March 11, 2004 and July 7, 2005 financial crises. In order to do this, we use a multivariate GARCH model and consider both the asymmetric volatility phenomenon and the non-synchronous trading problem. The data consists of simultaneous daily stock market prices recorded at 15:00 GMT time for the period 2000 to 2006. This study innovates with respect the existing literature in two ways. First, as far as we know, these terrorist attacks have not yet been included in any paper analyzing volatility transmission in international markets. Second, we introduce a new version of Asymmetric Volatility Impulse Response Functions (AVIRF) which takes into account stock market crises. Results suggest that there is bidirectional and asymmetric volatility transmission and show the different impact that terrorist attacks had on both markets.

Chapter 3, entitled *Region versus industry effects and volatility transmission*, has two main objectives. First, it analyzes the relative importance of regional versus industrial effects in stock returns (as opposed to the extensively analyzed country versus industrial effects), using a sample including the period after the bursting of the TMT bubble. Second, it analyzes volatility transmission patterns within an industry across regions, in order to assess whether the same international linkages found in aggregate stock market indices exist at the industry level. The data set consists of daily price from 1995 to 2004 for 10 industry indices in 3 different regions (North America, European Union and Asia). We seek to contribute to the existing literature in several ways. Firstly, to our knowledge, this study is the first one to focus on specific regions rather than countries. Secondly, it analyzes volatility transmission, through multivariate GARCH models, using industrial indices. Thirdly, another important difference to other studies is the use of daily data. The vast majority of empirical studies use weekly and monthly data, though portfolio managers are surely interested in the behavior of daily returns. Finally, this study uses a wide sample that includes the bursting of the TMT bubble. The results confirm the overall dominance of regional effects over industry effects, except for the TMT bubble period. In the volatility transmission analysis, the results are suggestive of spillovers, more or less important depending on the industry being analyzed.

We find that region factors are more important than industry factors in explaining the benefits of international diversification. However, these findings do not identify the origin of these independent country/region movements. The greater diversification benefits for countries/regions could be the result of independent variation of country/region specific discount rates, resulting from segmented capital markets. Alternatively, this could result from a lack of integration in trade flows or industry specialization, leading to country/region specific innovations in expected cash flows.

Chapter 4 is entitled *Global versus regional and economic versus financial integration in European Stock Markets*. This chapter links the concepts of shock transmission and integration. Therefore, in order to measure global and regional integration we look at shock spillover intensities and proportions of variance explained by US and EU shocks for 21 local European countries, over the period 1973-2005. In general, shock spillover intensity has increased in time, suggesting a higher degree of both global and regional integration. Regarding proportions of variance, both the US and European markets have gained considerably in importance for individual European financial markets, though Europe has not taken over from the US as the dominant market in Europe.

This time, we also analyze the underlying drivers of return variation to determine whether the benefits of international diversification are being driven by the degree of integration in goods (economic integration) or financial markets (financial integration). Thus, the main goal of this chapter is to investigate to what extent the increased exposure of 21 local European equity markets with respect to US market shocks is the result of a convergence in cash flows or a convergence in discount rates. The former would be consistent with globalization and further economic integration, the latter with further financial integration. Therefore, the main innovation of this study is to look at exposures to cash-flow and discount-rate shocks as measures of economic and financial integration. In a first step, we decompose monthly US equity market returns into a component due to revisions in future cash flows (cash-flow news) and a component due to revisions in future discount rates (discount-rate news), using a VAR framework. Second, we confirm that betas of local Eopean equity markets with respect to the US market have increased substantially over time. We find that this increase is nearly fully the consequence of an increase in the discount-rate beta. We see this as evidence that the increased correlation of European equity markets with global equity markets is the result of improved financial integration, and to a much lesser extent economic integration.

Finally, we present an overview of the main contributions and results of this dissertation.