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# Intra-daily volatility spillovers in international stock markets

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ABSTRACT

Using a novel four-phase model based upon a conditional autoregessive Wishart framework for realized variances and covariances we quantify intra-daily volatility spillovers within and across the US, German and Japanese stock markets before and during the subprime crisis. We find significant short-term spillovers from one stock market to the next-trading market, which have substantially intensified during the crisis indicating a global volatility contagion coming from the US market. The strongest contagion with the largest burst of spillover effects from and to foreign markets is observed for the Japanese market, which was prior to the crisis fairly uncoupled from the German and US market. We also find that the crisis leads to a significant reduction of the general persistence of volatility shocks in international stock markets. Hence, it appears that during the turmoil of the crisis news generating volatility become outdated more quickly than before the crisis.

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## 1. Introduction

A common finding of empirical studies devoted to asset-return variances and covariances across international financial markets is their high degree of contemporaneous and temporal

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interdependence. This interdependence, which plays an important role for international portfolio allocation and financial risk management, is often attributed to information transmissions across financial markets. This view is based upon the hypothesis that the arrival process of economic news and the trading dynamics in response to news are key determinants of the short-run dynamics of asset-return volatility (see, e.g., Kyle, 1985). Against the background of an apparently increasing integration of international financial markets it is interesting to see to what extend a volatility shock generated by news in one market spills over onto the volatility observed in the next market to trade. Similarly, it is of interest whether those spillover effects are more pronounced during periods of very high volatility associated with severe financial crises like that of 2007–2009. While this crisis had its origin in the US sub-prime mortgage market, it spread out increasing the volatility across international financial markets above and beyond a level which can be explained by a ‘regular’ fluctuation pointing to a volatility contagion.

The strand of empirical literature concerned with volatility spillovers on international financial markets goes back to the early papers of Engle et al. (1990) and Hamao et al. (1990), in which GARCH models fitted to intra-day returns are used to measure volatility transmissions from one period to the next within markets (‘heat waves’) and across markets (‘meteor showers’).[1] The former study uses four intra-day returns per day of the yen-US dollar exchange rate associated with four distinct geographic market segments with non-synchronous trading hours (Tokyo, Europe, New York, Pacific), and reports significant spillovers between the different market segments, indicating that volatility in international markets behaves like a meteor shower. Hamao et al. (1990) rely on close-to-open and open-to-close returns and find spillovers from the US to the Japanese stock market but not conversely.

More recent studies examining volatility transmissions between international markets rely on high-frequency return data in order to construct realized variances or ranges between the largest and smallest log prices as ex-post estimates for the volatility of low-frequency returns. Those volatility estimates are obtained without the need to rely on an explicit model such as GARCH and offer the possibility of modelling volatility directly through standard time series techniques with low-frequency volatility observations, while effectively exploiting the information in high-frequency data (see, e.g., Andersen et al., 2006). As shown by Koopman et al. (2005), models for those ex-post estimates can produce far more accurate volatility forecasts than those obtained from the conditional variance under GARCH models. Studies analyzing international volatility spillovers using volatility estimates based on high-frequency data are found in Engle et al. (2012), Bubák et al. (2011) for markets with synchronous trading hours and in Melvin and Melvin (2003), Dimpfl and Jung (2012), Chiang and Wang (2011), for markets with nonsynchronous business hours. The study of Engle et al. (2012) uses a multivariate multiplicative error model (MEM) for the vector of daily volatilities approximated by the daily ranges and applies this approach to measure the volatility transmissions across eight East Asian stock markets and to examine changes in the transmission mechanism during the 1997-1998 East Asian crisis. In order to analyze the short-term interdependence of the realized variances for the exchange rates of four European currencies against the US dollar, Bubák et al. (2011) propose a multivariate version of the heterogeneous autoregressive (HAR) model of Corsi (2009). Melvin and Melvin (2003) investigate volatility spillovers of the Deutsche mark-US dollar and yen-US dollar exchange rate across geographical market segments, while Dimpfl and Jung (2012) examine spillovers across the stock markets in Europe, the US and Japan. Both studies rely on structural vector autoregressive (VAR) models for the realized volatilities accounting for the time differences in trading hours of the markets under consideration. Using a range-based conditional autoregressive volatility model for the stock markets of the G7 countries, Chiang and Wang (2011) examine changes in the volatility transmission mechanism due to the subprime mortgage crisis.

In the present paper, we investigate the interdependence of the realized variances and covariance of the US Dow Jones, the German stock index DAX and the Japanese index Nikkei. For this purpose, we propose a novel sequential phase model accounting for the four distinct geographical intra-day trading

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[1] Closely related to this literature on volatility spillovers on financial markets, are the studies focusing on the transmission of fundamental economic information in one market on the volatility of other markets, where economic information is defined as important macroeconomic announcements – see, e.g., Andersen et al. (2003), Kim (2003), and Wongswan (2006).

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