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Discussion

Comment on "Better to Give than to Receive" by Francis X. Diebold and Kamil Yilmaz

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Nowadays, financial markets are all integrated in one global system. Events in a given market affect other markets almost instantaneously. The recent financial crisis has showed how interconnected all financial markets are, raising important questions with regard to spillovers both across countries and across different markets within the same country. However, it is far from trivial to *measure* abstract notions such as spillovers.

Several authors have used correlation-related measures when trying to measure spillovers in financial markets. See King and Wadhwani (1990) and Lee and Kim (1993) for an early exposition of such approaches, and Corsetti, Pericoli, and Sbracia (2000) for a discussion of the methodology. The fact that classical correlation may be misleading as a measure has been discussed by Boyer, Gibson, and Loretan (1999), Forbes and Rigobon (2002), and Loretan and English (2000), and has led to the development of alternative measures. Various new correlation-related measures have been proposed, such as the conditional correlation of Bollerslev (1990) and the dynamic conditional correlation of Engle (2002), but true alternatives to correlation such as the synchronicity measure of Mink, Jacobs, and De Haan (2007) and the coVar of Adrian and Brunnermeier (2008) have also emerged.

Besides direct measures, less direct measurement techniques have also been advanced. In fact, as has been discussed by Corsetti, Pericoli, and Sbracia (2005) and Dungey, Fry, Gonzales-Hermosillo, and Martin (2005), most empirical approaches to modeling financial spillovers fit into this category. The underlying idea is to first adopt some latent factor model for the financial market property we are interested in (returns, volatility, etc.), after which the spillovers may be evaluated based on the amount of the unexpected moves in some markets which may be explained by moves in other markets. The measures proposed by Diebold and Yilamz in this article fit into this category.

Their proposal is to measure spillover effects through the explanatory power which specific moves in financial markets may have with regard to the *uncertainty* associated with *unexpected* similar moves in other markets. The key word here is *uncertainty*, as it depends on how much of the forecasting error *variance* can be explained. As in a previous paper by the same authors (see Diebold & Yilmaz, 2009), this study relies on a generalized vector autoregressive (VAR) framework. Nonetheless, it improves and extends the methodology introduced in the previous paper, as it suggests improvements for correcting one of the methodology's main drawbacks, namely the fact that, by relying on the Cholesky-factor identification of VARs, the resulting variance decompositions are dependent on the variable ordering; it also extends the previous methodology by introducing the concept of *directional* spillovers.

The proposed measures can be applied to all sorts of spillovers which one could think of. In the current article, the focus is on *volatility* spillover effects across four different US markets: stocks, bonds, foreign exchange and commodities. In the context of the recent financial crisis in particular, their choice of an empirical application is easy to justify. During crises, markets' volatilities tend to increase rapidly, and financial analysts seem to believe that volatility shocks in one market can easily have an impact on other markets. Moreover, the recent crisis is ideal for testing directional spillovers, as it started in bond markets, then spread to all other markets.

This article is thus an addition to the already large body of literature on *volatility spillovers*. Models of the ARCH/GARCH type have been used the most, as they provide us with an estimate of a time series for the conditional variance of the relevant variables and allow for time-varying second moments. The study by Hamao, Masulis, and Ng (1990) was the first to apply the univariate GARCH methodology to the analysis of relationships

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between international markets. Examples of other studies include, for instance:

- those of Engle, Ito, and Lin (1990), Hsin (2004), and Lin, Engle, and Ito (1994);
- the popular specification of Glosten, Jagannathan, and Runkle (1993), proposed to capture the leverage effect of volatility in stock returns, and used by Eom, Subrahmanyam, and Uno (2002), Kim (2003), Lee, Rui, and Wang (2004) and Wang, Rui, and Firth (2002);
- the analysis of volatility spillovers in connection with financial crises by Edwards and Susmel (2001, 2003);
- the investigations of Bekaert and Harvey (1995), Baele (2005), Bekaert and Harvey (2005), and Ng (2000) in relation to volatility-spillover effects on various equity markets;
- those of Kim (2003) and Pyun, Lee, and Nam (2000), in defense of the relevance of the variable trade volume as an explicative variable for the conditional variance; and
- the multivariate models of Booth, Martikainen, and Tse (1997) and Karolyi (1995);

to mention just a few.

In empirical terms, this article by Diebold and Yilmaz relies on daily return data from 25 January 1999 until 30 September 2009. Concretely, the authors examine the S&P500 index, the 10-year Treasury bond yield, the New York Board of Trade US dollar index futures, and the DJ-AIG commodities index. The period under analysis is interesting both because financial markets evolved over the time, becoming ever more integrated, and because an impressive number of specific events took place during this period (the bursting of the technology bubble in March 2000, the 9/11 terrorist attacks in 2001, the stock market downturn in October 2002, the invasion of Iraq in March 2003, the Chinese market drop in February 2007, and all of the events connected to the global financial crisis of 2007——2009), all of which had clear effects on financial markets. Both static and dynamic analyses of volatility spillovers are performed.

Most of the results obtained can easily be explained by the events which took place and the evolution of the various markets over the period under analysis. In this respect, the authors do a remarkable job of contextualizing most of the results and explaining their intuitions to the reader. For purely illustrative purposes, one can mention that the total spillovers attained their peak values in the second half of 2000 and the first quarter of 2001, immediately after the 9/11 terrorist attacks, in the third quarter of 2002, in June 2006, and, most importantly, in five waves during the global financial crisis, capturing the credit crunch (in July–August 2007), the panic in stock and foreign exchange markets, followed by an unscheduled rate cut of three quarters of a percentage point by the Federal Reserve (in January 2008), the worries about the burden of the crisis on government budgets, the increased volatility in the bond market which then spread to the other markets (in June 2008), the collapse of the Lehman Brothers (in September–October 2008), and when the crisis started to have its real effects on the world economy (in the first half of 2009).

It was also possible to conclude that before the global financial crisis which began in 2007, the cross-market volatility spillovers were quite limited, but that they increased considerably during the crisis, with particularly significant spillovers from the bond market to other markets after the collapse of the Lehman Brothers. Many more interesting results come out of the empirical results in this paper as well.

Besides its own contributions, this paper also has the merit of opening doors for future research.

One could use the exact same setup to study other types of spillovers and/or spillovers across different markets. For instance, it would be interesting to analyze the spillovers across countries or regions, say the US versus Europe, emerging markets, etc., during the current financial crisis. It would also be interesting to check whether volatility spillover effects will decrease now that the end of the financial crisis is (hopefully) approaching. What about return spillovers, spillovers across corporate bonds with different ratings, etc?

A more challenging — but also more interesting — task would be to apply the spillover measures while considering other statistical models or using classical direct measures. The main drawback of any forecast-based measure is that it is model dependent. Removing this limitation would allow us to check the robustness of the results obtained, outside the VAR setup assumption.

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