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A spatial analysis of international stock market linkages

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ABSTRACT

We employ spatial econometrics techniques to investigate to what extent countries' economic and geographical relations affect their stock market co-movements. Among the relations that we analyze, bilateral trade proves to be best suited to capture co-variations in returns. We find a strong effect of a unit shock to three regionally dominant countries, namely the US, the UK, and Japan, on other countries through the trade linkage. The degree of stock market dependence increases and the importance of proximity decreases over time and during recessions. We also analyze several regional crises and find a large impact of Thailand on its trade neighbors during the Asian crisis.

1. Introduction

In this study, we employ spatial econometrics tools to analyze to what extent different linkages between countries affect the degree of their stock market co-movements. In order to conduct risk hedging through global diversification, financial investors need to understand co-movements of financial markets and the sensitivity of the markets to exogenous shocks. Therefore, it is essential to explore the linkages that are important for the transmission of market-specific shocks to other markets. This is also important for policy makers since the propagation of shocks affects the stability of the financial system and the effectiveness of the monetary policy.

Interactions among international stock markets have been investigated in a considerable number of studies (see, e.g., Karolyi and Stulz, 1996; Bekaert and Harvey, 1995; Asgharian and Bengtsson, 2006; Asgharian and Nossman, 2011), where a majority of the works have focused on assessing the degree of dependence among international stock markets. An important and relatively unexplored issue in this context is to what extent the equity market integration depends on how countries are otherwise, financially or economically, integrated. Analyzing this issue may help us understand better the linkages that are important for risk spillover and contagion effects among equity markets. A few studies (see, e.g., Asgharian and Nossman, 2011; Ng, 2000) have used integration measures, such as countries' bilateral trade and exchange rate changes, to model time-varying spillover effects among international stock markets. In addition, several studies have investigated the importance of financial and economic integration on stock market co-movements using the so-called gravity model. In this model, the correlation among national stock markets is regressed on countries' economic sizes, measured by GDP or market capitalization, and bilateral distances, measured by cross-country-specific variables such as bilateral trade and geographical distance (see, e.g., Flavin et al., 2002; Wälti, 2010).

Recent developments in spatial econometrics have provided a powerful tool for performing thorough analyses of the linkages that are important for the co-movements of financial markets. With this approach, the structure of the relationship between observations at different locations is connected to the relative position of the observations in a hypothetical space. Using a spatial econometrics approach, we can relate the stock market integration of different countries to their relative distance or closeness as defined by various financial and economic integration measures. In contrast to gravity models, this approach is not purely bilateral, i.e., it does not capture the effects of different economic linkages on any purely bilateral correlation but rather their effects on the relationships between one country and many other countries at

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once. Moreover, the spatial econometrics approach allows us to model asymmetric relationships between countries' stock markets in order to capture differences in countries' relative importance. Lastly, the spatial econometrics approach used in this study is dynamic in nature and makes it possible to investigate how shocks in returns or in macroeconomic variables in one country affect the stock markets of other countries, while taking into account the feedback effects that amplify the impact of shocks.

Although spatial modeling of dependence structures has become very popular in recent years, it has to date hardly been used in financial applications. To the best of our knowledge, the recent work by Fernández-Avilés et al. (2012) is the only existing study that employs spatial techniques to analyze how the relations between stock market returns depend on the (economic) distances between the markets.[1] These authors use daily data on 17 market returns for the period between January 2002 and March 2010, and model the spatial dependencies between the markets by fitting theoretical semivariograms to their data. They use two different measures of distance (geographical distance and an economic distance measure) and compare them based on the kriging predictions obtained from the respective semivariograms. Their main finding is that the dependencies between market returns are unrelated to geographical proximity but strongly related to economic linkages, as measured by foreign direct investment (FDI) ties.

The study by Fernández-Avilés et al. (2012) is closely related to ours in that they also use bilateral distance measures to explain the dependencies between market returns. Moreover, unlike the various studies based on gravity models, they do not analyze pairwise correlations but (potentially asymmetric) dependencies between many markets simultaneously. However, there are also crucial differences between their study and ours, and we extend their work in a number of non-trivial ways. First, we employ a multiple regression approach, which allows us to account for the effects of covariates on market returns. This is important, since ignoring such effects may lead to spurious correlations between market returns. For example, synchronized changes in interest rates may effect that different markets yield similar returns in a particular period even if they are not close to each other according to any measure of distance. Moreover, our regression approach makes it possible to investigate how changes in fundamentals affect a market's returns and how these effects propagate throughout the spatial system. Second, the approach that Fernández-Avilés et al. (2012) use forces them to conduct a separate analysis of repeated cross-sections, whereas our regression approach allows us to conduct a panel data analysis. This way, we can study the co-movements of market returns over time and their dependence on the distances between the markets. Moreover, our panel regression approach allows us to model spatio-temporal dependencies, i.e., situations where a market's returns at time t are affected by another market's returns at time $t-1$. Third, our paper contains a detailed analysis of how shocks to a market's returns are propagated throughout the spatial system. We are able to do this because our approach is dynamic in nature. The static approach used by Fernández-Avilés et al. (2012) does not facilitate such an analysis. Fourth and last, our study is much more extensive. We investigate eight different measures of distance (geographical proximity, bilateral FDI, the volume of countries' bilateral trades, the stability of the bilateral exchange rate, two measures of convergence in expected inflation, and two measures based on interest rate differences), and we analyze data on 41 national stock market indexes over a period from 1995 to 2011.

Our empirical results indicate that bilateral trade outperforms the other linkages considered in capturing the dependencies between stock markets. Due to the spatial transmission and feedback effects among markets, a unit shock in a country can be amplified by more than 13% via this linkage. We also investigate the transmission of shocks from three regionally dominant countries, namely the US, the UK, and Japan, to other countries. We find a strong effect of a unit shock to these countries on other countries through the trade linkage. Furthermore, we find that the degree of stock market dependence increases and that the importance of proximity decreases over time. Similarly, during recessions, the degree of dependence increases, and the importance of proximity tends to decrease. We also analyze some specific regional crises and find, among other things, a large impact of Thailand on its trade neighbors during the Asian crisis.

To our knowledge, this is the first in-depth analysis of the importance of economic and financial integration for co-movements of stock markets, which employs a spatial regression approach. We provide new insights into the mechanism of transmission and feedback effects between stock markets. More specifically, we analyze to what extent return shocks in one country affect other stock markets via various spatial linkages, and to what extent the impact of shocks is amplified by feedback effects. Our approach and results can be interesting for further analyses of the channels through which adverse shocks may generate global crashes.

The remainder of the paper is organized as follows. Section 2 presents the spatial econometrics methods used in this paper. Section 3 presents the data and selected variables. Section 4 contains the empirical analysis, and Section 5 concludes.

2. Econometric modeling

The concept of spatial dependence in regression models reflects a situation where the values of the dependent variable at one location depend on the values of the observations at other locations. Depending on the source of the spatial correlation, a variety of alternative spatial regression structures can arise. The most commonly applied spatial regression models specify a spatial autoregressive (SAR) process in the dependent variable or the error term. These models are frequently referred to as the spatial lag model and the spatial error model, respectively.

Formally, the spatial lag model can be expressed as:

$$\boldsymbol{y} = \rho \boldsymbol{W}\boldsymbol{y} + \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon}, \tag{1}$$

where $\boldsymbol{y}$ is a vector of observations on a dependent variable, $\boldsymbol{X}$ is a matrix of observations on exogenous (explanatory) variables with an associated vector of coefficients $\boldsymbol{\beta}$, $\boldsymbol{\varepsilon}$ is a vector of idiosyncratic errors, $\boldsymbol{W}$ is a spatial weights matrix, and ρ is the SAR parameter. Similarly, the spatial error model can be expressed as:

$$\boldsymbol{y} = \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{v}, \tag{2}$$

where $\boldsymbol{v} = \lambda \boldsymbol{W}\boldsymbol{v} + \boldsymbol{\varepsilon}$, with λ being the SAR parameter.

The key difference between the spatial lag model and the spatial error model lies in the way that shocks are transmitted throughout the spatial system. The spatial lag model framework implies that shocks to both the error term and the explanatory variables at one location are transmitted to all other locations within the spatial system. By contrast, when using a spatial error model, only shocks in the error term but not shocks to the explanatory variables are transmitted to other locations (see, e.g., LeSage and Pace,

[1] Two further studies that are related to ours are the one by Fernandez (2011), who employs variables such as size and book-to-market ratio to measure the spatial distances between firms, and the study by Arnold et al. (2013), who consider two firms as neighbors if they belong to the same country or industry. However, none of these two studies uses bilateral economic variables to measure spatial distances. Using variables such as size and book-to-market ratio as distance measures is not coherent with the concept of spatial relationships; for example, the stock returns of two firms with high book-to-market ratios may have a similar pattern without having any impact on each other.