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## A study of linkages between frontier markets and the U.S. equity markets using multivariate GARCH and transfer entropy



Mary Schmid Daugherty\*, Thadavillil Jithendranathan

*Opus College of Business University of St. Thomas, United States*

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### ABSTRACT

This paper studies the integration of 20 frontier equity markets with the U.S. equity markets using variance ratios, conditional correlations and transfer entropies. The results show considerable regional variation in the level of integration. The volatility transfers, conditional correlations and transfer entropy are significantly affected by the housing market crisis of 2008–2009. The European debt crisis of 2011–2012 has less significant impact on the integration measures.

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## 1. Introduction

Global information flows are akin to the jet stream that creates weather patterns around the world. Local weather disturbances can often carry to long distances, get magnified and cause much larger disturbances elsewhere. Economic and other relevant information for pricing assets arrive continuously. When this new information first arrives the market that is open for trade will absorb the information and will adjust asset prices accordingly. The next market to open will look at the information and the reaction to the information in the previous market and will adjust its prices to reflect both events. There are two factors that the second market has to consider—the information itself and the reaction to it in the other market. If markets are efficient, the reaction to new information in the first market should not have much relevance in pricing the assets in the second market. Both markets will have similar reaction only when the information is relevant in pricing assets in both markets.

\* Corresponding author at: Department of Finance, MCH316, 2115 Summit Ave., St. Paul, MN 55105, United States. Fax: +1 651 962 5093.  
E-mail addresses: [msdaugherty@stthomas.edu](mailto:msdaugherty@stthomas.edu) (M.S. Daugherty), [t9jithendran@stthomas.edu](mailto:t9jithendran@stthomas.edu) (T. Jithendranathan).

If arrival of new information is what causes asset price changes, then the direction in which information flows from one market to another can explain the co-movement of asset prices in these markets. If markets are completely isolated, the macro and micro economic events in one market will have minimal effects in other markets. When markets are connected in varying degrees by factors such as trade, common currency, and cross-border investments, etc., it is safe to assume that information about any of these factors in one national market are likely to have some effect on the asset valuations in the other market.

The size of the economy and the market can also determine the significance of the information. Shocks to the economy in a larger market may cause ripples in other markets through the economic linkages, moving the markets in the same direction causing the asset return correlations to increase, causing a contagion. Yet empirical studies of contagion often find that economic fundamentals alone cannot explain the co-movement of the markets, especially during a period containing one or more shocks to the financial markets (Connolly and Wang, 2003). Information asymmetry between investors in various markets can be one of the main reasons for this so called “irrational behavior.” The basic belief of the efficient market hypothesis (EMH) (Fama, 1970) is that if all investors are rational and have the same set of information, they will value the stocks based on the information, and that information will be mainly focused on economic fundamentals. Thus, if investors in a market have information on the way the events in another market will affect the economic fundamentals in their market, then prices should reflect this information. If information asymmetry exists, the full extent of the impact of external shocks to the economic fundamentals of a country may be unknown to the investors. Hence, they may look at the external market and try to get the information content from the price changes in that market. Through this mechanism, even a mistaken price movement, as in the case of the October 1987 crash of the U.S. stock markets, can be transmitted to other markets, resulting in a contagion (King and Wadhvani, 1990).

The focus of this study is to develop a set of tools that can measure the information transmission between markets and how it impacts the co-movement of asset prices. Information flows are bidirectional. To reduce this impact we look at the information transfer from a dominant market to a set of minor markets, with minor markets exhibiting very limited economic linkages with the dominant market. The dominant market chosen is the U.S. equity market and the set of minor markets are 20 frontier markets. The study period covers two major economic events: the housing market crisis of 2008–2009 and the European debt crisis of 2010–2011.

Frontier equity markets are the last frontiers in international portfolio diversification. According to Speidell and Krohne (2007) about sixty of these markets exist in Africa, Asia, Europe and South America. Considering their geographic diversity and low return correlations with developed markets, these frontier markets are an interesting set of assets to be considered in portfolio diversification. Since many of these markets have only recently opened up for outside investors the academic interest in these markets has been low, resulting in very few detailed studies of the co-movement of these markets with the world markets. In this paper we study three issues; the volatility spillovers from the U.S. equity markets into frontier markets, the correlation dynamics of the frontier market returns with the U.S. equity returns, and how the correlation dynamics are affected by information transfers.

There are no uniform criteria for determining which countries can be considered as frontier markets. Frontier markets can be described as the smallest, least developed, least liquid countries among the developing markets. There are many risks associated with investing in frontier markets. Political instability is an inherent problem in many of these markets and may present risks to an investment. The daily trading volume in many of these markets is relatively low and the transaction costs are very high. The regulatory scheme within these countries varies and often provides far less oversight than in more developed countries. Many of these markets are still relatively inaccessible to outside investors and the quality of indices produced by the local exchanges are often not representative of the stocks that are available for foreign investors. To minimize this problem this study covers only twenty frontier markets for which investible indices are available from Morgan Stanley Capital International (MSCI).

There are several ways in which the market co-movements can be studied. In this paper we use GARCH models to estimate the volatility transmission from the dominant market to the regional markets and to individual frontier markets. The co-movements of frontier market returns with the U.S. markets are estimated using the dynamic conditional correlation (DCC) model. The information transfers from the U.S. market to frontier markets are calculated using transfer entropy. The main contribution of this paper is the development of a time-varying estimation technique for transfer entropy to measure the information transfer between two markets and estimating the effect of information transfer on conditional correlation.

The rest of this paper is organized as follows. The relevant literature survey is in Section 2. Section 3 describes the empirical methodology used in this paper, and Section 4 provides the details of data used. Results of the empirical analysis are discussed in Section 5 and Section 6 discusses the conclusion reached from this research.

## 2. Literature review

The most commonly used term for describing the transmission of returns shocks from one market to another is “contagion.” The term contagion is borrowed from epidemiology, where it is defined as transmitting a disease by direct or indirect contact. The cause of the disease may be a bacteria or virus, but the channels of these determines the intensity of the contagion. For financial markets, the equivalent of a virus is a shock to a certain part of the economy, such as the collapse of the housing market in the U.S. during 2007 and 2008. This shock carried over to other financial markets resulting in substantial losses in financial markets around the world. The results of the contagion are obvious, but no agreement exists about the

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