Research in International Business and Finance 36 (2016) 179–195

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

Global financial crisis and emerging stock market contagion: A volatility impulse response function approach

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ARTICLE INFO

Article history:
Received 21 January 2015
Received in revised form 10 May 2015
Accepted 10 September 2015
Available online 28 September 2015

JEL classification:
C32
G15

Keywords:
Volatility impulse response function
BRICSs' emerging markets
Financial crisis
Contagion

ABSTRACT

By employing the volatility impulse response (VIRF) approach, this paper presents a general framework for addressing the extent of contagion effects between the BRICSs' and U.S. stock markets and how the BRICSs' stock markets have been influenced in the context of the 2007–2009 global financial crisis. Our empirical results show during the period of 2007–2009 global financial crisis, there are significant contagion effects from the U.S. to the BRICSs' stock markets. Yet, the degree of stock market reactions to such shocks differs from one market to another, depending on the level of integration with the international economy. Besides, the strengthened degree of stock market integration among the U.S. and BRICS has adverse effect such that if the 2007–2009 global financial crisis occurs today it may result in heavier impact on stock market volatility nowadays compared to the crisis-era.

1. Introduction

The 2007–2009 global financial crisis was a chain reaction of credit risk inherent in engineered financial instruments, triggered by the liquidity shortfall in the United States banking system. It was the combination of three financial products, Residential Mortgage Backed Securities, Collateralized Debt Obligations, and Credit Default Swaps, in addition to some other major products, that caused the sub-prime mortgage crisis which later spread across global markets (Ding et al., 2012). Different from previous financial crises, such as the 1997–1998 Asian crisis, the 1998 Russian crisis, the 1999 Brazilian crisis, the 2007–2009 global financial crisis originated from the largest and most influential economy, the U.S. market, and had a contagion effect on all economies around the world. It is well-documented that international stock markets react, in terms of returns and volatility, quickly and simultaneously to major financial crises. However, the timing and magnitude of changes in stock returns and volatility differ across markets around the world (Roll, 1988). Therefore, the 2007–2009 global financial crisis provide a unique opportunity for investigating the dynamic interrelationships among global stock markets, as studies of the transmission of volatility shocks from one market to another are essential in finance, which have many implications for international asset pricing, assessing investment and leverage decisions, and portfolio allocation as well as policy makers to develop strategies to insulate economies.

As such, there is a growing body of literature on addressing the contagion effect of the 2007–2009 global financial crisis on stock markets (see Cheung et al., 2010; Aloui et al., 2011; Dimitriou et al., 2013; Wang, 2014). The general findings of

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http://dx.doi.org/10.1016/j.ribaf.2015.09.019
0275-5319/

these studies suggest that global stock markets' volatilities increase substantially during the crisis, which further implies that both stock markets' volatilities and correlations move together over time.[1] However, they did not expose how and to what extent the 2007–2009 global financial crisis impacts the dynamic adjustment of volatility and the persistence of these transmission effects. That is to say, there are not confirmative findings about how a shock to one market influences the dynamic adjustment of volatility to another market and the persistence of these transmission effects.

It is within the context of previous limited empirical work that the present paper is conducted to fill the literature gap by examining the information flow as well as their impact on conditional volatilities in the U.S. and BRICSs' stock markets during the course of the 2007–2009 global financial crisis. In the meantime, one of the most important motivations for considering the BRICS is that they are considered the growth engine of the world economy and their stock market is a very promising area for regional and global portfolio diversification. The impacts of the 2007–2009 global financial crisis on conditional volatilities in the BRICSs' stock markets may have significant implications for domestic and international investors. In sum, this study aims to answer the following questions: (1) Which markets are most responsive in terms of volatility in the BRICS during the 2007–2009 global financial crisis? (2) How did the global financial crisis influence the dynamic adjustment of volatility in the BRICSs' stock markets and the persistence of these contagion effects?

To investigate the above research questions, we use the volatility impulse response analysis (VIRF) approach proposed by Hafner and Herwartz (2006) to study the spread and impact of the 2007–2009 global financial crisis to the BRICS nations and then establish the pattern of information transmission between these markets.[2] This approach allows us to quantify the impact of the 2007–2009 global financial crisis on volatility in the BRICSs' stock markets adapting Sims' (1980) impulse response function to the volatility setting.[3] However, the initial impulse response analysis is designed for the invariant linear structure such that it leads to significant complexities compared to the linear case when applying in nonlinear systems. Therefore, Gallant et al. (1993) and Koop et al. (1996) develop two competing definitions of impulse response in nonlinear models.[4] Following the spirit of Koop's et al. (1996) methodology, Hafner and Herwartz (2006) propose the VIRF approach tracing the time pattern of the effects of independent shocks on volatility.[5] Even if the concept of VIRF is consistent with Koop's et al. (1996), there are two important differences: (1) VIRF focuses on the conditional variance rather than the conditional mean; (2) VIRF has a VARMA representation with non-Gaussian errors, which makes it feasible for calculating conditional expectations of volatility analytically rather than resorting to Monte Carlo techniques suggested by Koop et al. (1996). In comparison with traditional impulse response function, Panopoulou and Pantelidis (2009) argue that VIRF represents a convenient approach to analyze volatility spillovers. First, it allows financial practitioners to determine precisely how a shock to one market influences the dynamic adjustment of volatility in another market and the persistence of these spillover effects. Second, it depends on both the volatility state and the unexpected returns vector when the shock occurs, which effectively accommodates the asymmetric response of volatility on negative and positive "news" typically documented in the literature. Third, contrary to traditional impulse response functions, this specific methodology avoids typical orthogonalization and ordering problems, which would be hardly feasible in the case of high-frequency financial time series.

This present paper contributes to the related literature in that we provide a general framework for addressing the extent of contagion effects between the BRICSs' and U.S. stock markets and how the BRICSs' stock markets have been influenced in the context of the 2007–2009 global financial crisis. This is important since knowing only the degree of time-varying co-movements is actually not sufficient to make international investment decisions because stock market volatility might exhibit common extreme variations. Overall, our analysis points out that during the period of 2007–2009 global financial crisis, there are significant contagion effects from the U.S. to the BRICSs' stock markets.[6] Yet, although with the globalization

[1] The arrival of bad news causes significant increase in cross-market variances and correlations (Braun et al., 1995). However, Bekaert et al. (2012) refute the presence of cross-border contagion in global equity markets during the 2007–2009 global financial crisis after analyzing the pricing of 415 country-sector equity portfolios across 55 countries worldwide.

[2] According to Forbes and Rigobon (2002), the contagion effect between countries could be measured by many different statistics such as correlation in asset returns, the transmission of shocks or volatility, or even the probability of a speculative attack. With regard to the methodological choice, our work is broadly similar to that of Panopoulou and Pantelidis (2009) who study the dynamics of dependency and integration cost between seven major stock markets, i.e. G-7 stock markets.

[3] Due to the novelty of this innovative technique, few studies have employed it to analyze volatility dynamics in financial market. Pen and Sevi (2010) investigate the impact of shock on expected conditional volatility for three European forward electricity markets through employing the volatility impulse response analysis. Their findings suggest that a shock has a high positive impact only if its size is large compared to the current level of volatility. More recently, Jin et al. (2012) examine international crude oil markets integration on the second moment and quantify the size and persistence of these connections through employing the volatility impulse response analysis for two historical shocks, namely the 2008 financial crisis and the BP Deepwater Horizon oil spill. Their findings provide useful insights into the volatility transmission mechanism in international crude oil markets and their associated risk estimation.

[4] Gallant et al. (1993) define the shock which inflicts the difference between the "shocked" and the baseline trajectories as a perturbation in the conditionally heteroskedastic error term; Koop et al. (1996) further develop the theory of impulse response functions for nonlinear time series and define rigorously what is termed as generalized non-linear impulse response functions for the conditional expectation using the mean of the response vector conditional on history and a present shock, compared with a baseline that only conditions on history.

[5] Hafner and Herwartz (2006) do not follow Gallant's et al. (1993) approach as they argue that the method of obtaining shocks from the conditionally heteroskedastic error term is a priori for analyzing macroeconomic systems and then hardly feasible for high-frequency financial time series. Similar critique could be found in Koop's et al. (1996).

[6] Two explaining factors can be highlighted for this increasing international transmission in recent years: (1) the substantial development of technology, which allows traders to transmit information more quickly from one financial market to another (Charles and Darne, 2006), and (2) the increased flow of