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# An empirical analysis of currency volatilities during the recent global financial crisis

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ABSTRACT

This paper investigates the impact of the 2008–2009 global financial crisis on the co-movement of 16 currencies in the sample. It employs a two-step atheoretic empirical methodology; it i) applies change point estimation based on geometric Brownian motion to detect change points in volatilities and ii) applies Engle's (2002) dynamic conditional correlation (DCCR) approach to estimate time varying correlations and then, observes the behavior of volatility co-movements during the periods found in (i). The results show that volatilities increase at least two-fold with the outbreak of the crisis and there is an inverse relationship between volatility and the duration of the crisis. The DCCRs usually increase with the onset of the crisis and they fluctuate smoothly afterwards while keeping that increased level.



## 1. Introduction

The co-movements of financial assets and their returns as well as the financial market co-movements constitute an important research field in international finance. The evidence showed that co-movements became stronger during crashes and crises.[2] Accordingly, a co-movement literature proliferated taking into account and analyzing the effect of crashes and crises on the co-movements.

Crises usually spread from the originating country to other countries so that they are sometimes regional, sometimes global. Therefore, not only the crises themselves but also their impact on other financial assets and markets should be taken into consideration. Since crises result in co-movement of assets, their returns and markets, co-movement becomes an important component in the analysis of crises, which should not be neglected.

There are several important reasons to investigate the impact of crises on financial assets, their returns and financial markets; first, financial asset returns exhibit jump-like behavior during turbulent times, second, persistent fluctuations are observed during crises, third, co-movements are stronger in both assets and markets throughout periods of turmoil, and fourth, investors are averse to the risks that these crises generate. In other words, investment becomes riskier because of the increase in volatilities stemming from crises (Kole, 2006: 2–4). This shows us that the way actors and financial assets behave and financial markets function change during crises and they demonstrate a marked difference when compared with calm periods. Besides, the impact of crises on assets and markets are felt for a long period of time. Finally, crises and the consequential co-movements influence the financial decisions of portfolio managers and the international investors along with the policy makers and international financial organizations (IFOs) such as the IMF. Therefore, the issue of crises and co-movements is not only important from the viewpoint of theoretical and empirical academic studies but is also of great importance to risk management and portfolio allocation, and to the decision making processes of the governments and the IFOs. For these reasons, analysis of crises and co-movements are crucial in our understanding of the financial markets, and our study adds to the empirical literature in these respects.

Studies focusing on co-movements and contagion with regard to crashes and crises include but are not limited to *the October 1987 stock market crash* (Arshanapalli et al., 1995; Forbes and Rigobon, 2002; Jeon and Furstenberg, 1990; Lee and Kim, 1993; Roll, 1988), the crises in the emerging economies in the 1990s; *the 1994 Mexican crisis* (Bekaert et al., 2005; Calvo and Reinhart, 1996; Forbes and Rigobon, 2002; Rodriguez, 2007), *the 1997 Asian crisis* (Ferna'ndez-Izquierdo and Lafuente, 2004; Forbes and Rigobon, 2002; Jang and Sul, 2002; Kaminsky and Reinhart, 2002; Rodriguez, 2007), and *the 1998 Russian crisis* (Baig and Goldfajn, 2000; Kaminsky and Reinhart, 2002).

Interdependencies have been traditionally measured by means of correlation. Some recent studies employed copulas in fields such as decision making (Clemen and Reilly, 1999), actuarial risk analyses (Frees and Valdez, 1998), whereas the use of copulas in finance has also been

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[2] While a crash is specific to a single asset, sector or a single market, a crisis can be defined as a period of uncertainty with prolonged effects on many assets and many markets (Kole, 2006: 1–2).

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advocated (Embrechts et al., 2002) and accordingly, they have been used in the analysis of crises and co-movements (Adel and Salma, 2012; Boubaker and Jaghoubi, 2011; Kole, 2006; Rodriguez, 2007). While these studies mainly conducted time-domain analysis, a recent study investigates the link between crises and exchange rate co-movements by the frequency-domain analysis (Orlov, 2009).

There are different approaches on co-movements and crises. For example, by employing the dynamic correlation model suggested by Engle (2002) to analyze the co-movements of won–dollar and won–yen, Chung (2006) argues that the co-movement of the won–dollar has weakened since the crisis, whereas the won–yen co-movement has risen regardless of the crisis. Lin (2012) uses the autoregressive distributed lag (ARDL) model proposed by Pesaran et al. (2001) and finds evidence for stronger co-movements between the exchange rates and stock prices of the Asian emerging markets during crises.

In a recent study, rather than focusing on increasing or decreasing co-movements during crises, Didier et al. (2012) explore the determinants of co-movement between the US and 83 countries' stock market returns during the recent global crisis. Didier et al. conclude that financial linkages drive co-movement. Chow et al. (2011) employ time-varying correlations and regressions to investigate the co-movements of weekly returns of stock returns by including the newly industrialized economies in East Asia and the three large economies of Japan, the US and China. They find evidence for increasing dependence within East Asian stock markets.

Despite the vast literature on co-movements and crises, there is no consensus on the meaning of the related terms and concepts. Indeed, co-movement itself needs to be defined although its meaning is less controversial. Co-movement refers to the simultaneous movement of assets, of their returns or of financial markets such as the stock market. Co-movement means perfect simultaneously matching time series in this study. The meaning of the other frequently used terms such as the contagion, volatility spillovers and co-integration require clarification as well since they are defined in various ways in different studies.

One frequently used and controversial concept is contagion. Contagion was originally used in medical terminology and meant the spread of a disease. After the stock market crash in 1987, researchers started to use it abundantly in the finance literature (Claessens and Forbes, 2001). Whereas the broad definition would be the spread of a shock in one country to the other countries, the more strict definition is the "significant increase in cross-market linkages during crisis" (Claessens and Forbes, 2001: 12; Forbes and Rigobon, 2002: 2223; Poldauf, 2011: 4). If this more strict definition of contagion is adapted, then it would mean excessive co-movements after the beginning of a crisis (Pericoli and Sbracia, 2003: 575). The continuation of the already significant pre-crisis co-movements during a crisis may not be contagion but would rather simply be referred to as interdependence (Forbes and Rigobon, 2002: 2224). Hence, Forbes and Rigobon do not agree with the evidence of contagion of the previous studies (e.g. Calvo and Reinhart, 1996; King and Wadhwani, 1990; Lee and Kim, 1993 in Kim et al., 2011) and they claim that the correlation coefficients in those studies are subject to bias due to heteroskedasticity. However, Corsetti et al. (2005) puts forward that Forbes and Rigobon's test is biased toward the null hypothesis of no contagion. The evidence of contagion is found in subsequent studies, for example after the 1997 Asian crisis (Bekaert et al., 2005), and during the 1997 Hong Kong stock market crisis (Corsetti et al., 2005) (See Kim et al., 2011).

Contagion can alternatively be defined as volatility spillovers from one country to another (Pericoli and Sbracia, 2003: 574).[3] The literature on volatility spillovers is diverse and researchers find evidence of significant exchange rate volatility spillovers (see for example, Baillie and Bollerslev, 1990; Engle et al., 1990; Kitamura, 2010; Melvin and Melvin, 2003; Nikkinen et al., 2011; Pérez-Rodrìguez, 2006). In exchange rate co-movements and volatility spillover studies, Europe, in general, the Euro area, in particular, has received special attention from the researchers since the area is comprised of a number of developed economies that are subject to common monetary and fiscal policies. Again, strong evidence is found for exchange rate volatility spillovers in these studies (Black and McMillan, 2004; Kearney and Patton, 2000). It is also observed in the literature that there can be asymmetries in the volatilities of currencies. For example, during their appreciations and depreciations against the US dollar; the euro, pound and yen (Boero et al., 2011) and the Australian dollar, British pound and the Japanese yen (Wang and Yang, 2009) show varying degrees of co-movements.

The volatility spillover literature is not limited to only exchange rates but also covers equity markets (Hamao et al., 1990; Lin et al., 1994), bond markets (Christiansen, 2003), futures contracts (Abhyankar, 1995; Pan and Hsueh, 1998), various industries (Kaltenhauser, 2002), size-sorted portfolios (Conrad et al., 1991), commodities (Apergis and Rezitis, 2003) and swaps (Eom et al., 2002) (See Milunovich and Thorp, 2006). Although early studies focus on volatility spillovers from larger to smaller markets (see Hamao et al., 1990), volatility transmissions between developed and emerging markets have also received attention in later studies (see Wei et al., 1995).

Another important phenomenon is referred to as meteor shower (Engle et al., 1990) to describe the lags in volatility spillovers due to time zone differences. Several researchers examine volatility spillovers across different regions in the world (Lin et al., 1994; Martens and Poon, 2001).

The term co-integration also necessitates explanation since it has been used in the co-movement literature. In a recent survey, it has been emphasized that "the linear combination of two non-stationary time series generates a stationary time series" (Mollah and Hartman, 2012: 167). Then "co-integration might mean the existence of a long-term economic equilibrium and indirectly implies that the two time series move in the same direction" (Mollah and Hartman, 2012: 172). Lee and Jeon (1995) put forward that there would be a common stochastic trend between the two markets if co-integration exists, whereas Rangvid (2001) claim that stock markets have become more integrated over time because of this common trend.

It is no surprise that when the different usage of these terms and concepts are combined with the application of several different methodologies and the inclusion of different regions, different crises, and different financial assets/returns/markets in the analyses, the researchers reach differing results and it becomes hard to compare the performance of the methodologies used therein.

Although diverse methodologies have been employed and the results differ in the crises and co-movements literature, one of the central findings is that the crises cause increases in volatility, and large price changes have a tendency of clustering (Bollerslev, 1986; Engle, 1982; Kole, 2006). The evidence of strengthening co-movements during crisis has been reported by several researchers (Ang and Chen, 2002; Bae et al., 2003; Campbell et al., 2002; Hartmann et al., 2004; Kole, 2006; Longin and Solnik, 2001; Mollah and Hartman, 2012; Ramchand and Susmel, 1998). Another related finding is that the volatility after the crisis remains higher for a prolonged period, that is high volatility persists (Kole, 2006).

The aim of this study is to employ an atheoretic empirical methodology to analyze the foreign exchange rate behavior during the recent 2008–2009 global crisis. The global crisis creates a playground to analyze the behavior of the currencies. Although the world is more financially integrated, the starting dates and the durations of the effect of crisis on currencies differ due to several factors. The first step is then to identify the starting date of high volatility periods for the currencies separately. Secondly, the co-movements during crisis should be analyzed. For the first step, we employ the change point detection (estimation) methodology suggested by Iacus (2008) and Iacus and Yoshida (2010). Here, the assumption is that the movements of foreign exchanges follow geometric Brownian motions, which is probably the most widely used model for asset prices. For the second step, we employ Engle's (2002) dynamic conditional correlation to estimate time varying

[3] See Pericoli and Sbracia (2003) for the alternative definitions of contagion.