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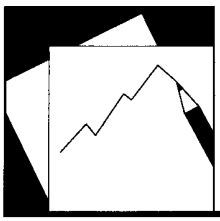

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Financial Spillovers to Emerging Markets During the Global Financial Crisis

Nathaniel Frank and Heiko Hesse

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IMF Working Paper

Monetary and Capital Markets Department

Financial Spillovers to Emerging Markets during the Global Financial Crisis

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Abstract

In this paper potential financial linkages between liquidity and bank solvency measures in advanced economies and emerging market (EM) bond and stock markets are analyzed during the latest crisis. A multivariate GARCH model is estimated in order to gauge the extent of co-movements of these financial variables across markets. The findings indicate that the notion of possible de-coupling (in the financial markets) had been misplaced. While EM stock markets reached their peak in the last quarter of 2007, interlinkages between funding stress and equity markets in advanced economies and EM financial indicators were highly correlated and have seen sharp increases during specific crisis moments.

JEL Classification Numbers: C32, E44, G12

Keywords: Emerging Markets, Subprime Crisis, Liquidity, Solvency, GARCH

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I. INTRODUCTION

The recent crisis began in the United States with the bursting of the sub-prime mortgage market and the unraveling of the securitization process in the summer of 2007, but it initially did not fully affect emerging markets (EM). In this context, EM stock markets peaked around November 2007, at a time when the repercussions of the crisis were already apparent in the U.S. with central banks injecting liquidity into the interbanking markets and major financial institutions announcing massive writedowns from structured financial products.

The Lehman collapse on September 15, 2008 is seen as a key event, both in advanced economies but also EM countries, that unleashed a full-blown systemic crisis with global risk aversion dramatically increasing, asset markets across countries and regions plunging and the unwinding of carry trades that saw high-yielding EM currencies sharply depreciate within a short period of time. Even EM countries with sound macroeconomic and financial pre-conditions, built-up over the previous years, have been strongly affected by the financial contagion that in late 2008 spilled over to the real sector with export and GDP growth rates plunging and trade finance being contracting across the world.

This paper examines the financial interlinkages between advanced and EM countries by focusing on the co-movements of a pertinent number of key financial variables. Specifically, proxies for general stress in the interbanking market, market volatility and default risk of major financial institutions in advanced economies are related to stock market, bond spreads and CDS indices of some selected EM countries.

Since standard correlations are potentially biased when examining spillovers and the potential for systemic risks to spread (Forbes and Rigobon, 2002), the Dynamic Conditional Correlation (DCC) GARCH model by Engle (2002) is used to avoid many of the pitfalls. This GARCH framework allows us to analyze the co-movement of markets by inferring the correlations of the changes in the financial variables examined, which in turn is essential in understanding whether the recent episode of financial distress has become systemic.

The main findings suggest that implied correlations between the U.S. Libor-OIS spread, a proxy for funding illiquidity, and EMBI+ sovereign bond spreads of Asia, Europe, and Latin American countries, sharply increase following the onset of the subprime crisis. In addition, the Shanghai stock market correction in February 2007 led to a temporary spike of the correlation measures, whereas the Lehman collapse caused the largest increase of co-movements among these variables. Similarly, the relationship between the S&P 500 and the EMBI+ regional bond spreads exhibits a potential break during the Chinese episode, after which correlations increase from the beginning of the subprime crisis, and reach their peak after the Lehman failure.

In terms of individual country interlinkages, the U.S. Libor spread is related to sovereign bond and the sovereign CDS spreads of the EM countries Brazil, Russia, and Turkey, Mexico and South Africa. As before, the Shanghai stock market correction in February 2007 is evident, in addition to the beginnings of the subprime and the Lehman collapse. The Bear Stearns rescue in March
2008 also becomes visible with co-movements sharply reversing their down-ward trend prior to that.

Overall, the findings from the DCC GARCH models indicate that the notion of possible de-coupling (in the financial markets) had been misplaced. It is true that EM stock markets reached their peak around November 2007, but interlinkages between funding stress and equity markets in advanced economies and EM financial indicators were highly correlated and have seen sharp increases during specific crisis moments. Given the interconnectedness of global financial markets, investors' increase in global risk aversion from problems in advanced economies rapidly spilled over into EM countries, as investors sought to pull out from the latter countries and only invest into the safest and most liquid assets in their home markets, such as fixed income securities.

The paper this related to the existing literature as follows. It builds upon Frank, Gonzalez-Hermosillo and Hesse (2008) that analyze liquidity spillovers across asset markets in the United States as well as in IMF (2008). This is also related to a very substantial literature on spillovers and contagion that especially our-ished after the Asian Crisis. The identification of channels of shock transmission across countries is, for instance, discussed in Dungey, Fry, Gonzalez-Hermosillo and Martin (2005), Dornbusch, Park and Claessens (2000) and Pericoli and Sbracia (2003). Beirne, Caporale, Schulze-Ghattas and Spagnolo (2008) examine volatility spillovers from mature to EM countries and test for their changes during crisis periods. Similarly, some other studies that jointly investigate spillovers of EM and mature countries are Dungey, Fry, Gonzalez-Hermosillo and Martin (2006, 2007) and Kaminsky and Reinhart (2003).

In this context, a large body of literature investigated conditional correlations during crisis periods in order to examine any possible breaks in the underlying data. Examples besides Forbes and Rigobon (2002) are King, Sentana, and Wadhwani (1994), King and Wadhwani (1990) and Caporale, Cippollini, and Spagnolo (2005). Investors' risk appetite can rapidly change during financial crises when suddenly nonrelated asset markets feel the impact by seemingly unrelated financial shocks. Gonzalez-Hermosillo (2008) and Coudert and Gex (2007) are some papers that study its importance during crises periods. Finally, some of the theoretical foundations of contagion are studied by Kodres and Pritzker (2002).

This paper makes several important contributions to the emerging literature on financial spillovers during the current global financial crisis. It examines the daily co-movements between key financial variables in advanced economies such as stress in the interbanking

market, market volatility and solvency concerns of large financial institutions with stock market, bond spread and CDS measures in EM countries. The DCC framework takes time varying volatility into account and addresses possible feedback effects since unidirectionality is not imposed. Furthermore, our findings that end-February 2007 was a temporary period where early signs of stress began to emerge in global markets prior to the time when the subprime crisis was revealed in mid-2007 is consistent with The Federal Reserve Bank of Dallas (2008), Gorton (2008) and Gonzalez-Hermosillo (2008) as well as IMF (2008).

The rest of the paper is organized as follows. Section II reviews some of the possible transmission mechanism of spillovers to EM countries during the global financial crisis. Section III details the data selection and Section IV discusses the empirical methodology. Section V examines the main results whilst Section VII concludes.

II. Transmission of Spillovers to EM Countries During the Subprime Crisis: A Qualitative Overview

This section examines the role of global market conditions in the current financial crisis and argues that the Lehman collapse on September 15, 2008, was a key event that led to rapid spillovers to emerging market countries. The event sharply increased uncertainty across markets as well as caused a scramble for U.S. dollars with the break-down of the carry trade and the need for financial institutions to refinance U.S. dollar positions. First, a brief overview of the different financial linkages across asset markets in the United States during the crisis is provided, before discussing some of the financial spillovers to EM countries.

The subprime crisis that began in the summer of 2007, was triggered by deteriorating quality of U.S. subprime mortgages, a credit, rather than a liquidity event.[2] This rapidly propagated across different asset classes and financial markets. Increased delinquencies on subprime mortgages, driven by rising interest rates for refinancing and falling house prices, resulted in uncertainty surrounding the value of a number of structured credit products which had these assets in their underlying portfolios. As a result, rating agencies downgraded many of the related securities and announced changes in their methodologies for rating such products. Meanwhile, structured credit mortgage-backed instruments measured by the ABS indices (ABX) saw rapid declines, and the liquidity for initially tradable securities in their respective secondary markets evaporated. The losses, downgrades, and changes in methodologies shattered investors' confidence in the rating agencies' abilities to evaluate risks of complex securities, a result of which, investors pulled back from structured products in general.

[2] See Kifi and Mills (2008) and Dell'Ariccia, Igan and Laeven (2008) for details on the structure of the U.S. subprime mortgage market and the deterioration of lending standards.

It soon became apparent that a wide range of different financial institutions had exposures to many of these mortgage-backed securities, often off-balance sheet entities such as conduits or structured investment vehicles (SIVs).[3] Due to the increasing uncertainty with regard to their exposure to and the value of the underlying mortgage-backed securities, investors became unwilling to roll over the corresponding ABCP. As the problems with SIVs and conduits deepened, banks came under increasing pressure to rescue those that they had sponsored by providing liquidity or by taking their respective assets onto their own balance sheets. As a result, the balance sheets of those financial institutions were particularly strained by this reabsorption, which in addition was amplified by losses due to declining asset values. Consequently, the level of interbank lending declined both for reasons of liquidity and credit risk and a run for "liquidity" occurred.[4] With the evaporation of liquidity in many asset-backed mortgage securities, in particular in the United States initially, liquidity spirals occurred where both market and funding liquidity became significantly impaired and mutually reinforcing (GFSR, 2008; Brunnermeier, 2007). While the Libor-OIS spread, a proxy for stress in the interbank money markets, widened during the on- set of the crisis and under the influence of end-of-year effects in December 2007, the Lehman Brothers collapse exposed the interbank market to even more counterparty and liquidity risk, leading market participants to globally withdraw from these market segments. Following this event, the failure of counterparties to honor the delivery of US Treasuries in repo transactions due to inability or unwillingness drastically soared showing even more stress in funding markets.[5]

With interbank markets across various advanced economies becoming dysfunctional in early August 2007, there was clear evidence of a run for "quality" by investors. For example the price of gold, which is regarded as a storage of value during times of financial turbulence, rose from $660 per ounce in August 2007 to $1002 around the Bear Stearns rescue by JP Morgan and the Fed's announcement of the Primary Credit Dealer Facility on March 16, 2008, after which the gold spot price dropped 10% in a short time.[6] In addition, there was a strong demand for 10-year US Treasuries as a 'safe' haven, and accordingly, yields almost halved between the beginning of the crisis and the Bear Stearns and Lehman

[3] The SIVs or conduits were funded through the issuance of short-term asset-backed commercial paper (ABCP) in order to take advantage of a yield differential resulting in a maturity mismatch.

[4] The former is based on a prudency motive whereby banks hoarded liquid assets in order to insure themselves against contingent liabilities. In contrast, the latter was due to uncertainty with regard to the mortgage exposure of counterparties and the inability to value their respective assets.

[5] This indicated that despite the higher supply of US Treasuries, market participants had very high demand for US Treasury collateral and were very concerned about counterparty risk, even though governments had implemented a systematic response by re-capitalizing major financial institutions and guaranteeing liabilities of banks.

[6] The bankruptcy of Lehman Brothers saw the gold price soar over 20% within a few weeks, as global risk appetite dramatically deteriorated and precipitated a run for quality across asset classes and markets.

Brothers episodes. The frequency of deviations from the usual bid/ask pattern of the 10-year US Treasuries also increased.

As turbulence related to the U.S. subprime mortgages heightened, financial markets more generally showed signs of stress, as investor preference moved away from complex structured products in a flight to quality and liquidity, and global investors' risk appetite sharply decreased due to a widespread re-pricing of risk (see Gonzalez-Hermosillo, 2008). Volatility in various asset classes was affected, mirroring the widening of the Libor-OIS spread. For instance, a structural break in the VIX index since the Lehman collapse is apparent, with other implied volatility equity indices also revealing similar patterns. An inspection of the at-the-money implied volatility of major financial institutions shows a very close co-movement with their respective CDS spreads.[7]

Furthermore, hedge funds that held asset-backed securities and other structured products were burdened by increased margin requirements, driven in turn by greater market volatility. As a consequence, they attempted to offload the more liquid parts of their portfolios in order to meet these margin calls and also respond to redemptions by investors. As argued by Khadani and Lo (2007), quantitatively driven hedge funds were especially engaged in liquidation sales across different asset classes, thus leading to a transmission of market stress in the beginning of the subprime crisis. As a result, trading volumes and numbers of trades in both the bond and the stock markets in the developed and emerging countries increased markedly, whilst the liquidity surrounding structured investments evaporated.

Volatility also spilled over into the foreign currency markets with the carry trades starting to rapidly unwind at the end of September 2008, whereby this breakdown was reflected by the implied volatilities of major EM currencies. High-yielding and previous investment currencies saw large depreciations against the U.S. dollar, while funding currencies such as the Japanese yen benefited by a repatriation of funds into Japan. There was a scramble for U.S. dollars, which was reflected in the higher volatility of the euro-U.S. Dollar swap rates. Relatedly, during the crisis there has been increasing divergence from the assumption of covered interest rate parity (CIRP). This relationship postulates that the currency forward premium equals the interest rate differentials of the home and foreign interest rate, such that a violation would imply possible arbitrage opportunities. The daily deviations from the CIRP jumped at the time of the Bear Stearns rescue, and then completely broke down for various EM currencies after Lehman's bankruptcy.

EM countries were less affected during the initial stages of the subprime crisis than advanced economies, as for example EM equity markets peaked in November 2007. But the persistence of the market dislocations, the deterioration of economic fundamentals in

[7] Humps occur at the time of the Bear Stearns rescue by JP Morgan in March 2008, during the Fannie and Freddy bailout by the U.S. government in mid-July 2008 and around the time of Lehman's bankruptcy.

advanced economies and rising global risk aversion significantly affected EM countries by late 2008. In particular, flows to EM equity and debt mutual funds turned negative. Total foreign assets held by the former peaked in November 2007, but investments in the equivalent EM debt mutual funds began to fall rapidly beginning in September 2008, driven by the sharp fall in global risk appetite after the Lehman collapse and fear that EM economies would be affected by the looming recession in advanced economies. Equity markets in EM countries saw their gains from the previous boom years wiped out in a short period of time. Relatedly, while EM corporate spreads (over treasuries) gradually began to increase following the onset of the subprime crisis, they escalated sharply across the various EM regions after the Lehman bankruptcy. Similar behavior can be observed for the cost of corporate credit, especially for high-yield bonds, in the U.S. and Europe. Sovereign spreads and the costs of insuring against a sovereign default, CDS, soared across a wide range of EM countries as portfolio outflows and a flight to quality accelerated.

EM countries with large current account deficits and whose banks prior to the crisis have been most reliant on foreign wholesale funding have been affected the most by the ramifications of the financial crisis. For instance, the IMF provided substantial financial support to the Ukraine and Hungary (October 2008), Pakistan (November 2008) and Latvia (December 2008). EM countries such as South Korea and Russia which had built up large foreign reserves prior to the crisis increasingly had to employ these in order to stem the currency depreciation pressures arising from an unwinding of portfolio positions and capital flight as well as severe strains in their banking sectors.

Initial financial spillovers to EM countries quickly morphed into real sector problems, whereby economies reliant on declining demand and available trade finance saw their domestic industrial production and GDP growth rates plunging. In order to counteract the looming adverse real sector impacts as well as to provide liquidity and credit support to the domestic banking systems, large fiscal stimulus plans were implemented, such as in China for over $500 billion in November 2008.

Interestingly, emerging market equity, fixed income and currency markets already saw a sharp sell-off in February 2007, a relatively short-lived episode, but it revealed how fast and broad-based a worldwide reappraisal of risk and flight to quality can occur. Starting in late-February 2007, there was a significant correction in the Shanghai stock market due to an unwinding of large long equity positions. This reverberated across emerging and mature markets. At the same time, the price of the ABX (BBB) index (based on CDS written on subprime mortgages, investment grade tranche) began to decline whilst the outlook on the U.S. housing market worsened further (see also GFSR (2007)). In particular, carry trades in high-yielding currencies such as in Brazil, South Africa and Turkey, were rapidly unwound, causing them to decline and the yen to appreciate. In addition, implied volatilities across a range of other asset markets, notably fixed-income and equity, sharply increased and stock

markets in previously booming economies such as China, Malaysia, Philippines or Turkey observed the largest declines. The fall in global risk appetite was broad-based without much differentiation across regions. Compared to equity markets, sovereign spreads across EM countries did move in tandem with the general market direction but were less affected.

In the following section our approach to examine the financial interlinkages between advanced and EM countries during the global financial crisis is presented. In this context, we focus on the co-movements of a number of pertinent key financial variables such as equity market and sovereign spreads in EM economies.

III. DATA

As mentioned above, in this paper, we use the daily 3-month US dollar Libor-overnight index swap (OIS) spread as a measure for bank funding liquidity and general stress in the interbank money market.[8] With the onset of the subprime crisis in the summer of 2007, this market segment exhibited severe dislocation. In addition, S&P 500 stock market returns are included in the reduced form model, controlling for common shocks. Moreover, the variance serves as a proxy for market volatility.

As a measure of the default risk of large complex financial institutions, we use the average credit default swap spread (CDS) of a number of banks, namely those of Citigroup, Bank of America, JP Morgan, Wachovia, Merill Lynch, Morgan Stanley, Goldman Sachs, Lehman Brothers, HSBC, Royal Bank of Scotland, UBS and Deutsche Bank.[9,10] Regarding EM financial variables, EMBI+ spreads for the regions Latin America (LAC), Europe and Asia are used as a measure of their respective sovereign risks. In terms of individual countries, we analyze the potential financial-to-financial spillovers to prominent emerging market countries with open capital accounts which have seen a significant impact due to the financial crisis. Amongst these are Brazil, Russia, Turkey as well as Mexico and South Africa. We also relate the advanced economy indicators such as the Libor spread and stock market returns to the CDS spreads in Brazil, Russia and Turkey. This allows us to analyze co-movements between default measures of sovereign risk in EM countries and financial stress in advanced economies.

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[8] Funding liquidity refers to the availability of funds such that a solvent agent is able to borrow in the market in order to service his obligations.

[9] After the Lehman Brothers collapse, we use the average CDS values for Goldman Sachs, Merrill Lynch and Morgan Stanley for the Lehman Brothers time series data.

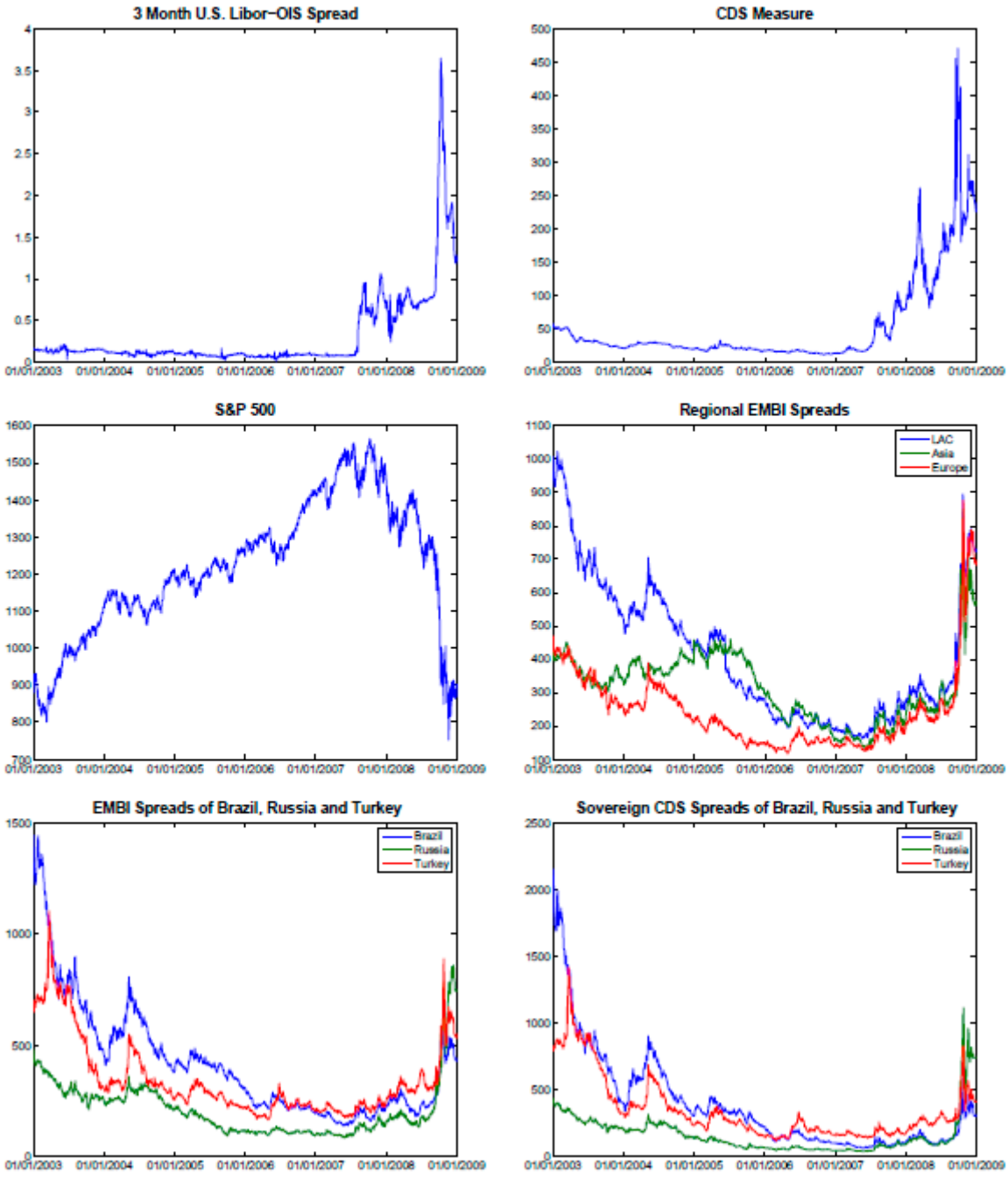
[10] Note also that market-traded prices such as CDS spreads contain a liquidity risk component—the risk that an investor may or may not be able to trade at a price close to the last traded price.Such risks rise during periods of stress.

The data sample encompasses January 3rd 2003 until December 31st 2008. We conduct unit root tests for the crisis period and formally identify nonstationarity in the data. Therefore, first differences of the spreads are taken, such that they can be applied to the estimation framework set out below.

As previously argued, the three main indicators capturing financial stress in the U.S. and other advanced economies are provided in Figure 1. Funding liquidity pressures in the interbank market, as measured by the Libor-OIS spread, were negligible prior to the subprime crisis, after which this proxy drastically increased in late July 2007. Following central bank interventions in mid August, the Libor spread subsided somewhat before widening again sharply, driven in part by end-of-year effects as well as by increased losses and writedowns of major financial institutions. In the run-up to the Bear Stearns rescue, heightened funding liquidity pressure again became evident, and finally, the Lehman failure led to an almost breakdown of the interbank money market with a massive dollar shortage and with margins and haircuts rising across the board, as well as a sharp increase in counterparty risk.

The S&P 500 peaked in October 2007 but has seen temporary corrections during the Shanghai stock market crash in late February 2007 as well as in the beginning of the subprime market turmoil in July 2007. Sharp falls occurred during January 2008 with financial institutions announcing new writedowns and losses, before the Bear Stearns rescue in March and after the Lehman collapse in September 2008. Meanwhile, the CDS measure of LCFIs is characterized by the two spikes, namely during the Bearn Stearns rescue as well as the Lehman bankruptcy.

Figure 1. U.S. and EM Financial Variables



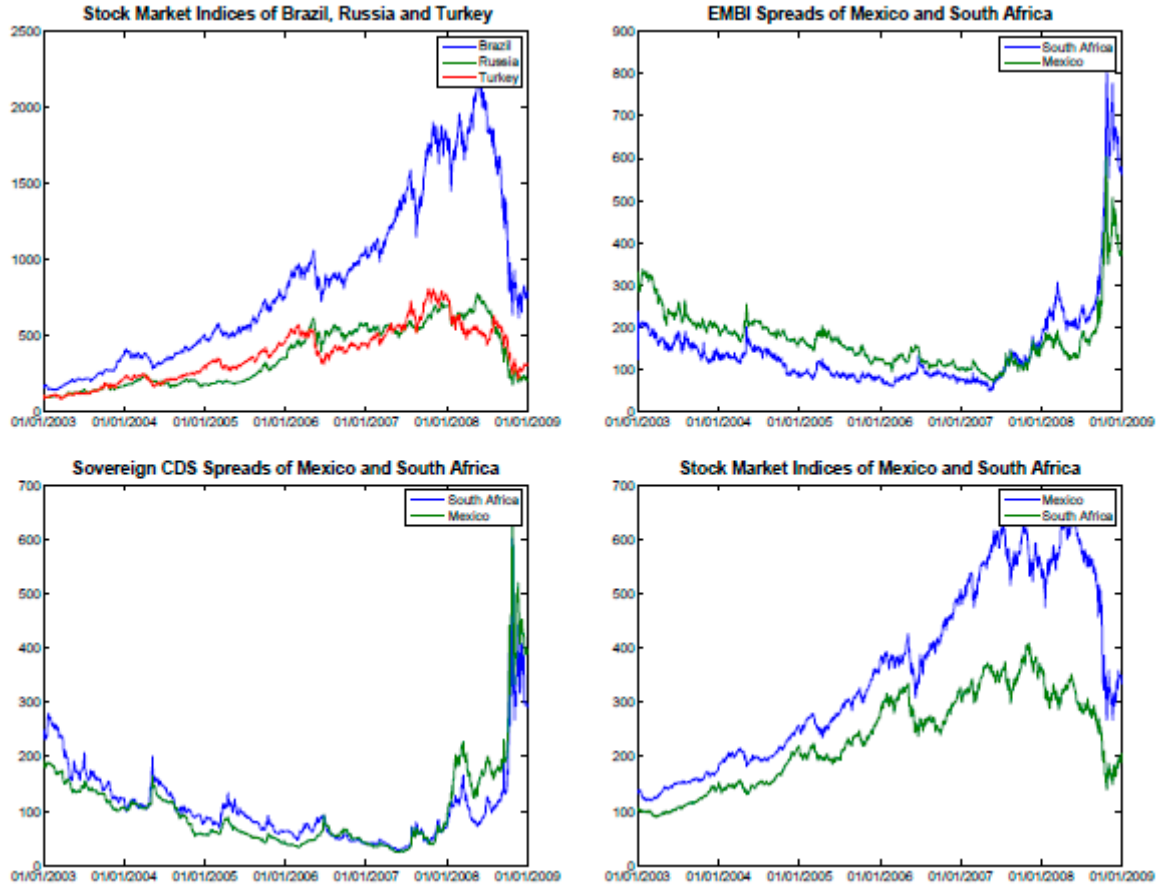
Source : Bloomberg L.P.

The financial variables for the emerging markets are briefly discussed below. While the regional EMBI+ spreads for Asia and LAC have remained elevated relative to those of Europe, between 2003 and 2006 convergence to historically low levels has been observed. With the onset of the subprime crisis, some moderate widening occurred. Following the Lehman bankruptcy, global risk aversion sharply increased across asset classes and the regional EMBI+ spreads jumped to over 800 basis points in late October 2008. Since then

some tightening has been recorded but spreads still remained at very high levels compared to the pre-subprime period.

EMBI+ and CDS spreads for individual countries such as Brazil, Russia and Turkey exhibit similar patterns of being compressed before the subprime crisis and then suffering increasing widening whilst the crisis period unfolded. Stock markets in these countries continued their upward trend well into 2007 and 2008 with Turkey peaking in October 2007 and Brazil and Russia in May 2008, before the contagious reversal thereafter. During the financial crisis, these markets appear to move increasingly in tandem as events unfold in advanced economies. While relatively small compared to post-Lehman movements, these equity markets were also affected by the brief Shanghai stock market correction in February 2007, which resulted in temporary large drops in these equity indices. Finally, it is shown in Figure 2 that the bond and CDS spreads, as well as equity markets in Mexico and South Africa follow similar price dynamics compared to those outlined above.

Figure 2. U.S. and EM Financial Variables



Source : Bloomberg L.P.

IV. METHODOLOGY

We use a multivariate GARCH framework for the estimation, which allows for heteroskedasticity of the data and a time-varying correlation in the conditional variance. Specifically, the Dynamic Conditional Correlation (DCC) specification by Engle (2002) is adopted, which provides a generalization of the Constant Conditional Correlation (CCC) model by Bollerslev (1990).[11] These econometric techniques allow us to analyze the co-movement of markets by inferring the correlations of the changes in the spreads discussed above, which in turn is essential in understanding whether the recent episode of financial distress has become systemic.

The DCC model is estimated in a three-stage procedure. Let r_t denote an *n x 1* vector of asset returns, exhibiting a mean of zero and the following time-varying covariance:

$$r_t \mid \Im_{t-1} \sim N\left(0, D_t R_t D_t\right) \qquad (2)$$
$$\text{where } D_t = diag\left\{\sqrt{h_{it}}\right\}$$

Here, R_t is made up from the time dependent correlations and D_t is defined as a diagonal matrix comprised of the standard deviations implied by the estimation of univariate GARCH models, which are computed separately, whereby the i^{th} element is denoted as $\sqrt{h_{it}}$. In other words in this first stage of the DCC estimation, we fit univariate GARCH models for each of the five variables in the specification. In the second stage, the intercept parameters are obtained from the transformed asset returns and finally in the third stage, the coefficients governing the dynamics of the conditional correlations are estimated. Overall, the DCC model is characterized by the following set of equations (see Engle, 2002, for details):

$$\begin{aligned} D_t^2 &= diag\left\{\omega_i\right\} + diag\left\{\kappa_i\right\} \circ r_{t-1} r_{t-1}' + diag\left\{\lambda_i\right\} \circ D_{t-1}^2 \\ \varepsilon_t &= D_t^{-1} r_t \\ Q_t &= S \circ (\iota\iota' - A - B) + A \circ \varepsilon_{t-1}\varepsilon_{t-1}' + B \circ Q_{t-1} \\ R_t &= diag\left\{Q_t\right\}^{-1} Q_t diag\left\{Q_t\right\}^{-1} \\ S &= E\left[\varepsilon_t \varepsilon_t'\right] \end{aligned} \qquad (3)$$

Here, S is defined as the unconditional correlation matrix of the residuals ε_t of the asset returns r_t. As defined above, R_t is the time varying correlation matrix and is a function of Q_t, which is the covariance matrix. In the matrix Q_t,ι is a vector of ones, A and B are square, symmetric and $\circ$ is the Hadamard product. Finally, λ_i is a weight parameter with the

[11] Given the high volatility movements during the recent financial crisis, the assumption of constant conditional correlation among the variables in the CCC model is not very realistic especially in times of stress where correlations can rapidly change. Therefore, the DCC model is a better choice since correlations are time-varying.

contributions of D_{t-1}^2 declining over time, while κ_i is the parameter associated with the squared lagged asset returns. The estimation framework is the same as in Frank, Gonzalez-Hermosillo and Hesse (2008).

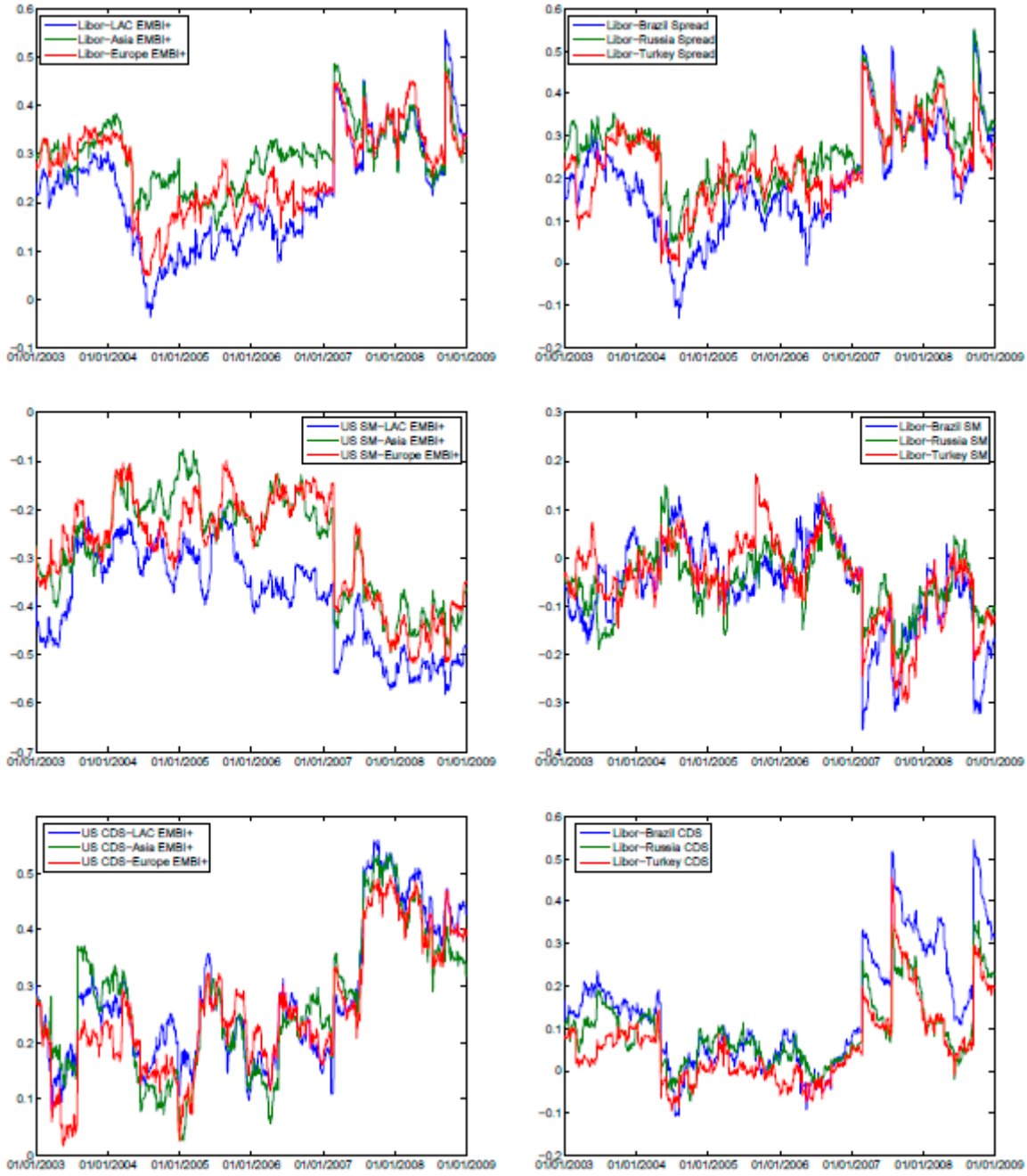
V. RESULTS

The findings in this paper suggest that the implied correlations between the 3-month US Libor-OIS spread and EMBI+ bond spreads of Asia, Europe and LAC sharply increase after the subprime crisis (left column of Figure 3). In addition, the China stock market correction in late February 2007 led to a temporary spike of the correlation measures from 0.20 to almost 0.50. The Lehman collapse caused the largest increase of co-movements between these variables. In terms of regional differences, the Asian EMBI+ spread exhibits the largest correlation for the pre-subprime crisis with some exceptions, followed by Europe and LAC. All regional spread's co-movements jump up around the China stock market burst in similar magnitude and move closely during the subprime period. Interestingly, the correlation for the LAC EMBI+ spread exhibits the greatest rise immediately following the Lehman failure, compared to those of the other regions.

These results are mirrored in the other multivariate GARCH specifications for the EMBI+ spreads. The relationship between changes in the S&P 500 and the EMBI regional bond spreads abruptly changes during the Shanghai stock market correction with correlation magnitudes moving to almost -0.60. Subsequently, the degree of co-movement remains elevated following the beginning of the subprime crisis and peaks in September 2008. In terms of regional differences, it appears that the interlinkages between the S&P 500 and the EMBI spread for LAC dominate the other regional spreads. In addition, the relationship between the CDS default risk measure and the regional bond spreads highlights a substantial and persistent increase in correlations beginning in July 2007 and magnitudes remaining high throughout the crisis period.

In the right column of Figure 3 we examine possible individual country interlinkages with the Libor-OIS spread. Changes in this measure are related to sovereign bond and CDS spreads, as well as with stock markets in Brazil, Russia and Turkey. As before, the China episode in February 2007 is evident, such as market dislocations during the subprime crisis and the Lehman collapse. The Bear Stearns rescue in March 2008 also becomes visible with co-movements sharply reversing their downward trend prior to that. Brazil has the largest correlation for the bond spread, CDS and stock market volatility measures during the crisis period. This potentially can be attributed to the fact that Brazil has a very open capital account and has witnessed a dramatic increase in bond risk premia coupled with large foreign equity outflows precipitating a plunge in the domestic equity market, despite obtaining an investment grade rating in 2008. Given the relative liquidity of foreign bond and equity markets in Brazil, mutual and hedge funds were able to unwind these positions to cover their domestic losses (or margin calls in some cases).

Figure 3. Implied Correlations between U.S. and EM Financial Variables



Source: Own calculations.

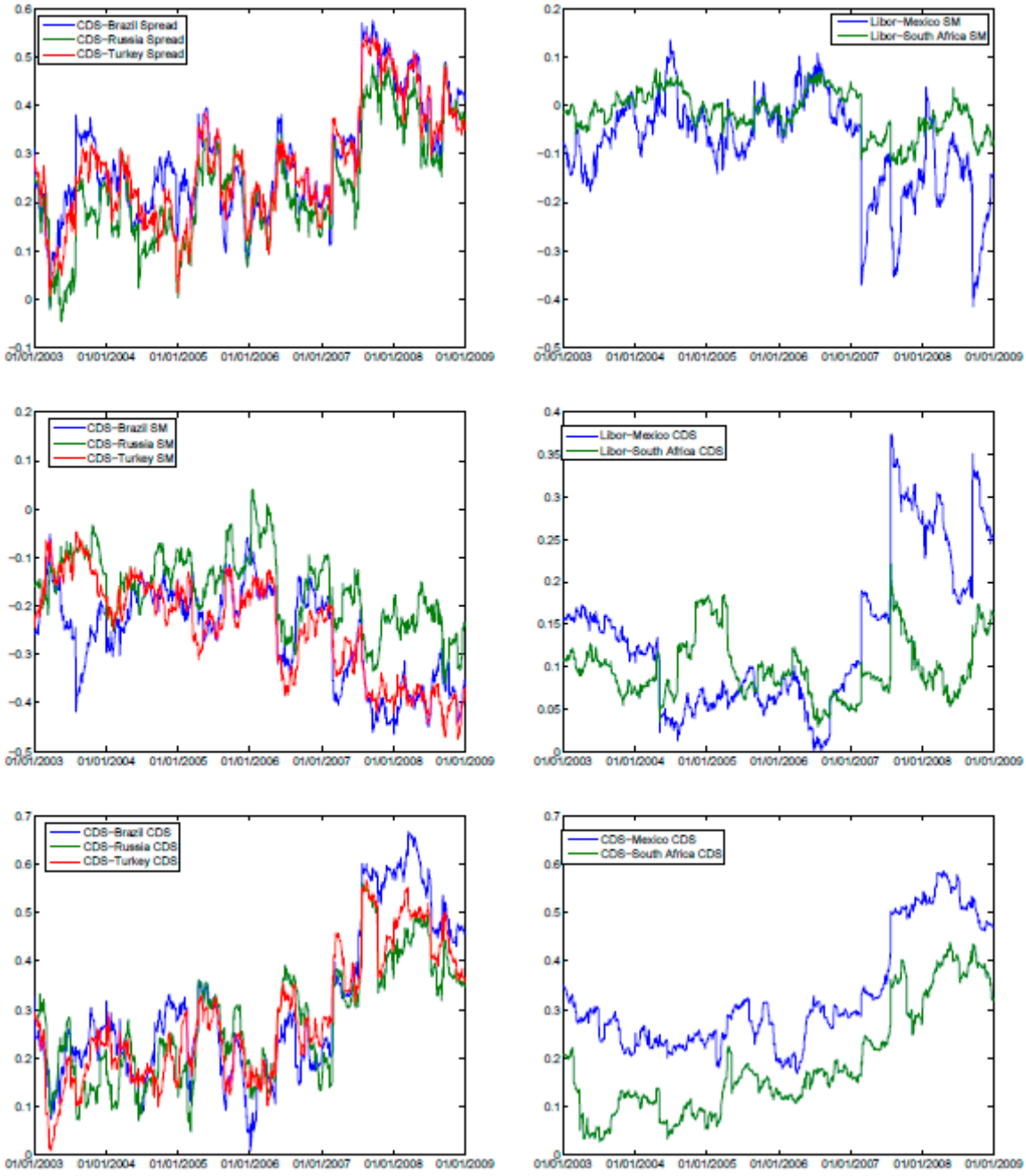
Above, the correlations between the U.S. Libor-OIS spread, a proxy for funding liquidity stress, and bond risk premia and equity market volatility in Brazil, Russia, and Turkey were quantified. In what follows, we extend this analysis to include CDS changes for LFCIs during the recent crisis period. In the left column of Figure 4 spikes in the correlation patterns are less pronounced than in the case of the Libor-OIS spread. Simlutaneously, the

co-movement among the CDS measures is highly persistent suggesting that both liquidity and solvency aspects were central in explaining financial market spillovers.
Finally, the DCC GARCH analysis is extended to the countries Mexico and South Africa. Results in the right column of Figure 4 indicate similarities to the findings from Brazil, Russia and Turkey with co-movements significantly increasing during the subprime crisis period, while providing some evidence that the China stock market correction also led to temporally higher correlations. As expected and given the proximity of Mexico to the United States, co-movements of the Mexican financial variables are more pronounced with the proxies for stress in the interbanking market, stock market volatility as well as default risk than of South Africa.

Overall, the findings from the DCC GARCH models indicate that the notion of possible de-coupling (in the financial markets) had been misplaced. Despite EM stock markets reaching their peak in November 2007, interlinkages between funding stress and equity markets in advanced economies and EM financial indicators became highly correlated and have seen sharp increases during specific crisis moments. Given the interconnectedness of global financial markets, investors' increase in global risk aversion from problems in advanced economies rapidly spilled over into EM countries, as funds were pulled out from the latter and subsequently invested into the safest and most liquid assets such as mature market fixed income securities.

In addition, co-movements between funding stress and bank default risk (proxied by the CDS measure) in advanced economies with bond spreads as well as stock market returns in EM countries have been fairly similar in terms of their magnitudes during the financial crisis. As a result, we believe that these factors are important when analyzing potential financial market spillovers.

Figure 4. Implied Correlations between U.S. and EM Financial Variables



Source: Own calculations

VI. CONCLUSION

In this paper the interaction between liquidity and bank solvency measures with stock, bond and credit markets in EM economies is analyzed during the Global Financial Crisis. A multivariate GARCH model is estimated in order to quantify the extent of co-movement of these financial variables across markets. We find that during the recent period of financial turbulence both the Libor-OIS spread, a proxy of interbank money market pressure, and the CDS spread, a measure of bank solvency, became more correlated with EM bond, stock and credit markets. These relationships become especially apparent during the Shanghai stock market correction, the beginning of the subprime crisis in summer 2007, the Bear Stearns rescue and the Lehman Brothers bankruptcy. As a result, we provide evidence that the notion of possible decoupling of financial markets has been misplaced.

In this paper, we did not analyze the exact causal relationships among the financial variables in advanced as well EM countries. With daily high-frequency data, there are likely to be significant feedback loops that can affect the causal relationships. We reserve this topic for future research. One of the key policy implications of the paper is that spillovers need to be closely attended to especially in light of the interconnectedness of global financial markets.

REFERENCES

Beirne, J., G. M. Caporale, M. Schulze-Ghattas, and N. Spagnolo, 2008, "Volatility Spillovers and Contagion from Mature to Emerging Stock Markets," IMF Working Paper 08/286 (Washington: International Monetary Fund).

Bekaert, G, C.R. Harvey, and A. Ng, 2005, "Market Integration and Contagion," *Journal of Business,* Vol. 78, No. 1, pp. 39–9.

Capiello, L., R. F. Engle, and K. Sheppard, 2006, "Asymmetric Dynamics in the Correlations of Global Equity and Bond Returns," *Journal of Financial Econometrics*, Vol. 4, No. 4, pp. 537–72.

Caporale, G.M., N. Pittis, and N. Spagnolo, 2006, "Volatility Transmission and Financial Crises," *Journal of Economics and Finance*, Vol. 30, No.3, pp.376–90.

Coudert, V., and M. Gex, 2007, "Does Risk Aversion Drive Financial Crises? Testing the Predictive Power of Empirical Indicators," Centre d'Etudes Prospectives et d'Informations Internationales, Working Paper No. 2007–02.

Dell'Ariccia, G., D. Igan, and L. Laeven, 2008, "Credit Booms and Lending Standards: Evidence from the Subprime Mortgage Market, (unpublished; Washington: International Monetary Fund)

Dornbusch, R., Y.C. Park, and S. Claessens, 2000, "Contagion: How it Spreads and How it can be Stopped," *World Bank Research Observer*, 15, pp. 177–97.

Dungey, M., R. Fry, B. González-Hermosillo, and V. Martin, 2006, "Contagion in International Bond Markets during the Russian and LTCM Crises," *Journal of Financial Stability*, Vol. 2, pp. 1–27.

Dungey, M., R. Fry, B. González-Hermosillo, and V. Martin, 2005, "Empirical Modeling of Contagion: A Review of Methodologies," *Quantitative Finance*, Vol. 5, pp. 9–24.

Engle, R. 2002, "Dynamic Conditional Correlation: A Simple Class of Multivariate Generalized Autoregressive Conditional Heteroskedasticity Models," *Journal of Business & Economic Statistics*, Vol. 20, pp. 339–50.

Forbes, K., and R. Rigobon, 2002, "No Contagion, Only Interdependence: Measuring Stock Market Co-movements," *Journal of Finance*, Vol. 57, No. 5, pp. 2223–61.

Federal Reserve Bank of Dallas, 2008, *Economic Letter*, "Fed Intervention: Managing

Moral Hazard in Financial Crises," Vol. 3, No. 10 (October).

Frank, N., B. González-Hermosillo, and H. Hesse, 2008, "Transmission of Liquidity Shocks: Evidence from the 2007 Subprime Crisis," IMF Working Paper 08/200 (Washington: International Monetary Fund).

González-Hermosillo, B., 2008, "Investor's Risk Appetite and Global Financial Market Conditions" (Washington: International Monetary Fund).

Gorton, G., 2008, "The Panic of 2007," Prepared for the Federal Reserve Bank of Kansas City, Jackson Hole Conference, August.

International Monetary Fund, 2009, *Global Financial Stability Report,* "Warnings of Systemic Risk" (Chapter 3), World Economic and Financial Surveys (Washington, April).

Kaminsky, G.L., and C.M. Reinhart, 2003, "The Center and the Periphery: The Globalization of Financial Turmoil," NBER Working Paper No. 9479 (Cambridge: National Bureau of Economic Research)

Khandani, A. E., and A. Lo, 2007, "What Happened to the Quants in August 2007?" MIT Working Paper (Cambridge, Massachusetts: Massachusetts Institute of Technology,

Kiff, J., and P. Mills, 2008, "Money for Nothing and Checks for Free: Recent Developments in U.S. Subprime Mortgage Markets," IMF Working Paper 07/188 (Washington: International Monetary Fund).

King, M., E. Sentana, and S. Wadhwani, 1994, "Volatility and Links between National Stock Markets," *Econometrica*, Vol. 62, pp. 901–33.

King, M., and S. Wadhwani, 1990, "Transmission of Volatility between Stock Markets," *Review of Financial Studies*, Vol.3, No.1, pp. 5–33.

Kodres, L., and M. Pritsker, 2002, "A Rational Expectations Model of Financial Contagion," *Journal of Finance*, Vol. 57, pp. 769–99.

Pericoli, M., and M. Sbracia, 2003, "A Primer on Financial Contagion," *Journal of Economic Surveys*, Vol. 17, pp. 571–608.