



Global Financial Crisis and the Volatility Spillovers across Stock Markets

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The US sub-prime mortgage crisis has already taken a serious toll on global financial markets. The total sub-prime mortgage market losses suffered by the world's largest banks once estimated \$300 and \$600 billion in a matter of several months, are now estimated by several institutions to surpass \$1 trillion. The major stock market indices have declined by more than 10 %, while stocks in some emerging market economies slid by close to 30 %, since mid-October, while all stock markets went through episodes of volatility outbursts.

The near-collapse of Bear Stearns, one of the five largest US investment banks, and its immediate fire-sale purchase by JP Morgan Chase on March 16 has proven that the extent of the financial crisis could be larger than was previously thought. While

the Bear Stearns operation was successfully carried out by the Federal Reserve, it has shown the possible repercussions of the current financial market turmoil.

So far the single most quoted instrument as the indicator of the current global market turmoil has been the Chicago Board Options Exchange's Volatility index (VIX). As the measure of implied volatility of S&P 500 index options, VIX gauges the "investor fear" in the United States.

Similar to the East Asian and Russian crises of the late 1990s, the current financial crisis has been characterized by the rather unnerving speed with which volatility spreads around the global stock markets. Given the global character of these financial crises, it does not suffice just to focus on the VIX index, which is supposed to measure volatility in the US only. There is definitely a need for new instruments that help us gauge how fast the "investor fear" spreads around the world.

In our recent research with Francis X. Diebold of the University of Pennsylvania, we offer a simple and yet powerful measure of global return and volatility spillovers.² Our index measures how much of an unexpected increase in volatility in a group of major developed and emerging stock markets stems from spillovers of shocks across markets rather than from indigenous shocks.

On Methodology

Using opening, high, low and closing values of market indices, we first obtain measures of weekly

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² See NBER Working Paper No: 13811 at <http://www.nber.org/papers/w13811>

volatility in 19 stock markets.³ Our return and volatility spillover indices are based on a vector autoregression (VAR) of return and volatility in those 19 markets over 200-week rolling windows starting in January 1992. Decomposing the forecast error variance for volatilities for each market into indigenous shocks and spilled-over shocks, the sum of the spilled-over shocks over all countries gives us what we call the Global Volatility Spillover Index.

For the first sample window considered (Jan. 1992-November 1995) the volatility spillover index is equal to 41, which implies that 41 % of the volatility in the 19 stock markets is due to spillover of volatility shocks across markets, whereas only 59 % is due to indigenous volatility shocks. Moving the sample window one week ahead over time, we calculate the volatility spillover index for every 200-week long sample window. Applying the same methodology to weekly real stock return for 19 global stock markets, we obtain the global return spillover index.

In Figure 1, we plot the global volatility and return spillover indices for all rolling 200-week windows from January 1992 to May 2008.⁴ The spillover plots of Figure 1 are available on ERF's data website.⁵ The spillover plots are updated on a weekly basis, using that week's volatility and return observations.

³ In our sample of markets we include seven developed stock markets (U.S., U.K., France, Germany, Hong Kong, Japan and Australia) and twelve emerging stock markets (Indonesia, South Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, Argentina, Brazil, Chile, Mexico, and Turkey).

⁴ As part of the research project, daily spillover indices are also calculated along with weekly indices. In addition, we checked for the robustness of the behavior of the return and volatility indices over time to the size of the sample window and the ordering of the stock markets in the VAR analysis.

⁵ See <http://data.economicresearchforum.org/erf/SpillOverIndex.aspx?lang=en>

The comparison of the global volatility spillover index, to its close cousin, the global return spillover index provides us with further important clues to the spillover of returns vs volatility shocks across markets. During the crises of 1997-1999, as well as the current one, return spillover index displays a smooth upward move but no bursts, whereas the volatility spillover index displays no trend but clear bursts.

Volatility Spillover Index Since March 2007

After providing brief information on the methodology of the spillover indices, now we can have a closer look at the behavior of the volatility spillover index since the beginning of the market turmoil in global financial markets.

The behavior of the volatility spillover index indicates that as more and more bad news about the state of the financial markets and the major economies arrive (Feb. 27-March 5 2007, July 25-August 21, 2007, January 18-31, 2008), the build up of investor fears take the form of bursts in the volatility spillover index. When the first signs of sub-prime worries appeared in late-February early-March 2007 (25 finance companies that used to provide sub-prime mortgage loans declared bankruptcy), the volatility spillover index jumped from 45 to 55 and then stabilized at 50, before steadily climbing to 53 until July 2007.

Following the collapse of three hedge-funds of the Bear Stearns in mid-July, the involvement of the major US and international banks in the sub-

prime mortgage market became apparent. Initial loss estimates reached more than \$100 billion dollars and sub-prime worries turned into a liquidity crisis as banks and other financial market players decided to hold cash rather than lending to each other and the liquidity in the interbank market dried up quickly.

Despite the injection of tens of billions of dollars to the markets by the central banks on both sides of the Atlantic, stock markets went through an unprecedented gyrations until the last week of August. The volatility spillover index jumped from 53 to 65 within the four weeks from July 25 to August 21. With the turmoil spreading to all segments of financial markets and around the globe, no one could deny the possibility of a full-blown financial crisis hitting the major markets.

While the central banks' liquidity injection helped ease the tensions in the market by the end of August, the balance sheets of the major banks towards the end of the year led to another period of high volatility in stock markets. After rising couple of points in late November, the volatility spillover index went through another burst in the third week of January. As the news about the difficulties faced by MBIA and Ambac (the monoline insurance companies that insure the corporate and municipal bonds), and their immediate need to raise \$15 billion capital, spread around, the markets went through another period of turmoil. As a result, the Federal Open Market Committee (FOMC) of the FED had an emergency meeting on Martin Luther King Day and lowered the FED funds rate by 75 basis points.

As a reflection of the wide fluctuations in the US and other global financial markets, volatility spillover index went through another short period of outburst between January 18 and 31 and jumped

from a level of 67 to 73.8, its highest level calculated.⁶ A value of 74 for the index implies that close to three quarters of the unexpected changes in volatility in the global stock markets was explained by the spillover of volatility shocks across markets, whereas own shocks can explain only a quarter of the forecast error for volatility. Considering that the contribution of volatility spillovers was only 45 % in February 2007, one can easily grasp the gravity of the situation as of the end of January 2008.

Even though the tensions in the markets eased throughout February, US banking sector came under pressure in the first two weeks of March again. The fire-sale purchase of Bear Stearns by JP Morgan Chase on Sunday, March 16th, had initially created a shock on the markets. The FED cut its policy rate by another 50 basis points on March 18. On the following days it became apparent that the Bear Stearns operation orchestrated by the Federal Reserve was successful in preventing potential domino effects in the banking sector. The volatility in financial markets declined slightly and so did the volatility spillover index. By April 11 the volatility spillover index declined to 71.9 and as of May 9, it stands at 71.5.

A Comparison with the VIX index

⁶ Since the VAR model for volatility becomes unstable during times of volatility bursts (such as the windows ending on January 25 and February 1, 2008, as well as March and August 2007, and the East Asian and Russian crises of the late 1990s), we do not report the values for the volatility spillover index for these windows.

In the introduction we referred to the VIX index, which is widely recognized as a measure of investor fear in the US markets. Now, we can compare the volatility spillover index with the VIX index as a measure of the volatility in stock markets and its spillover across markets.

As can be seen in Figure 2, after falling down to a level of 10 by the beginning of 2007, VIX index reached to 15 at the end of February 2007 and increased at several steps to 25-30 range within one year. We further observe in Figure 2 that VIX index has gone up steeply during times of increased tensions in the financial markets, followed by commensurate downward movements as the tensions ease. Even though the behavior of the VIX index reflects the increased investor fear in the US markets quite well, a comparison of the current values of the index with the values it took over the last 12 years can lead us to a completely different conclusion. For one thing, the maximum daily value the VIX index reached over the last year (32.24 on March 2008) is certainly below its maximum daily value during the 1997 East Asian crisis (37.6) and the 1998 Russian crisis (45.7). Furthermore, after the 9/11 terrorist attacks and during the brief stock market turmoil in mid-2002, VIX index shut up to reach 45.

Looking only at the respective values of the VIX index, one can therefore easily conclude that the current problems in US financial markets are nowhere close to the ones the markets suffered during the East Asian and Russian crises, as well as the brief bear stock market in mid-2002.

In comparison, the volatility spillover index reflects the magnitude of the problems in financial markets quite well over time. The gradual build up of tensions and the reach to the climax is clearly

visible during the East Asian Crisis of 1997. When Thai government was forced to devalue Baht in July 1997, it was the first and the only country that fell through the cracks. As a result, the volatility spillover index fluctuated slightly in the 45-50 range. Once the crisis spread to Hong Kong the index shut up from 50 to 68 in October and went through another burst to 73 when the crisis spread from Hong Kong to others by January 1998. The spikes in the index in the third quarter of 1998 and in January 1999 correspond to the outbreak of the Russian and the Brazilian crises with a year after the East Asian crisis.

As we move the sample window forward, the influence of the data points belonging to the East Asian, Russian and Brazilian crises decline gradually and the index falls to the pre-East Asian crisis level of 45 once the observation pertaining to this crisis are dropped out of the sample window. The impact of the Turkish crisis of February 2001 and the terrorist attacks in the US on the index are quite limited. The index increased gradually before the Iraq War in March 2003. When officials from several East Asian countries expressed the need to reduce the weight of the US dollar in their official reserves, there was a sharp increase in the volatility spillover index reaching close to 60.

The previous paragraph highlights another important difference between the volatility spillover index and the VIX index. While the VIX index comes down quite fast after a major crisis period, it takes 200 weeks for the volatility spillover index to return to the pre-crisis levels. This is a result of the fact that the volatility spillover index is calculated over a sample window of 200 weeks. Despite this shortcoming over the post-crisis period, the volatility spillover index performs very well in capturing how

fast the tensions spread across markets during times of major financial crises. The spillover index clearly shows the build up of tensions in the global financial system with each volatility outburst since March 2007 carrying it to a higher level. It is the barometer that the analysts need to follow, because unlike VIX-type measures, it doesn't come down very quickly from one week to the other.

How Long will the Global Financial Crisis Last?

Nowadays this is the most commonly asked question across financial markets. Before focusing on this question, let us look at the experience during the East Asian crisis. From the outburst of the crisis in Thailand in July 1997 to the trough of the financial markets in January 1998, the East Asian financial crisis lasted only six months. Within those 6 months it spread quite rapidly across 7 economies (Thailand, Indonesia, Philippines, Malaysia, Korea, Singapore and Hong Kong) of the region, and the first signs of recovery from the financial crisis were seen in some of the countries.

Even though it has been almost 14 months since the first signs of sub-prime problems and 9 months since the liquidity crisis in August 2007, there is still a debate on whether the current financial crisis has already reached its bottom and whether things will get better in the future.

The difference between the duration of the two crises is closely linked to the differences in the depth of financial markets in the US and other industrial countries, on the one hand, and the East Asian countries, on the other. If it were only for a single country in the region, the East Asian crisis

would have definitely lasted shorter. One can look at the Russian, the Brazilian and the Turkish crises as examples. Once these countries showed first signs of problems it took shorter than a few months before the isolated incidents turned into a financial crisis.

Stock markets have recently followed an upward trend indicating markets have already bottomed out. At the same time, the realized financial losses during the crisis have reached \$250 billion only, less than a quarter of the total losses forecasted recently by Goldman Sachs and the IMF. If the crisis has already bottomed out, why should the banks and other financial institutions lose three times more than they have already suffered?

We think the behavior of volatility spillover index over the last 14 months provides some clues that are open to interpretation. A closer look at Figure 1 shows that significant jumps in the index since February 2007 correspond to major instances of the crisis. As the sample window is rolled to include the data for the last week of January 2007, data pertaining to the end of March 2003 (the beginning of the Iraq War) is dropped out of the moving sample window. As a result, the index drops from 51 to 45. Above we analyzed the behavior of the index since March 2007 in great detail.

While only five months passed from the first round of the crisis in March 2007 to the liquidity crisis of August 2007, it took approximately 3 months from the second to the third round at the end of November 2007 as the volatility index rose several points to climb to 67 for a brief period. The fourth round of the crisis took place two months later; in the week ending on January 25th when the Federal Reserve was forced to lower its policy rate by 75 basis points on the Martin Luther King Day. The index jumped

significantly over the next three week to reach 73.8 by the week ending on February 8th and then declined to 71.8. Only five weeks passed by from the week of February 8th to the final round of the crisis unfolded in the middle of March as Bear Stearns was taken over by JP Morgan Chase and the index reached back to 73.8.

Above, we identified five major rounds of the global financial turmoil. The upward jumps in the volatility spillover index are clearly associated with increased stock market tensions around the globe. Our analysis shows that the time interval from one round of the crisis to the next gets shorter and shorter as the financial crisis advances to further stages.

The fact that the time interval gets shorter from one round of the crisis to the next is consistent with the expected balance sheet effects of the crisis. As the crisis unfolds, the impact of each round of the crisis on balance sheets of the financial corporations can be expected to intensify. At the beginning (March-July 2007), those smaller financial corporations that provided sub-prime mortgage loans faced calamities and many of them became insolvent. As the situation in the sub-prime mortgage market deteriorated further, larger financial

corporations that invested on mortgage backed securities and derivatives, faced substantial damage on their balance sheets. As this information became public, major banks tried to stay liquid and shied away from providing over-night loans to each other which led to the liquidity crisis of August 2007. As the November 2007, January 2008 and March 2008 rounds got under way, the losses faced by some of the big players increased substantially and forced some smaller and some larger banks into insolvency or take-over. The collapse of Bear Stearns was a turning point. Since then the markets calmed down.

A look at the behavior of VIX index since the beginning of the crisis in March 2007 (see Figure 2) also shows that the time interval between the stages of the crisis gets shorter as we reach to the climax of the crisis.

If the above analysis has some merit, the next stage of the crisis should have taken place within one-and-a-half months after the Bear Stearns operation. Since we have not yet witnessed another bout of volatility surge in financial markets since mid-March, one is tempted to conclude that the worst was over in the latest episode of global financial crisis.

Figure 1. Diebold-Yilmaz Global Equity market Spillover Index
(Jan. 1992 - May 2008)

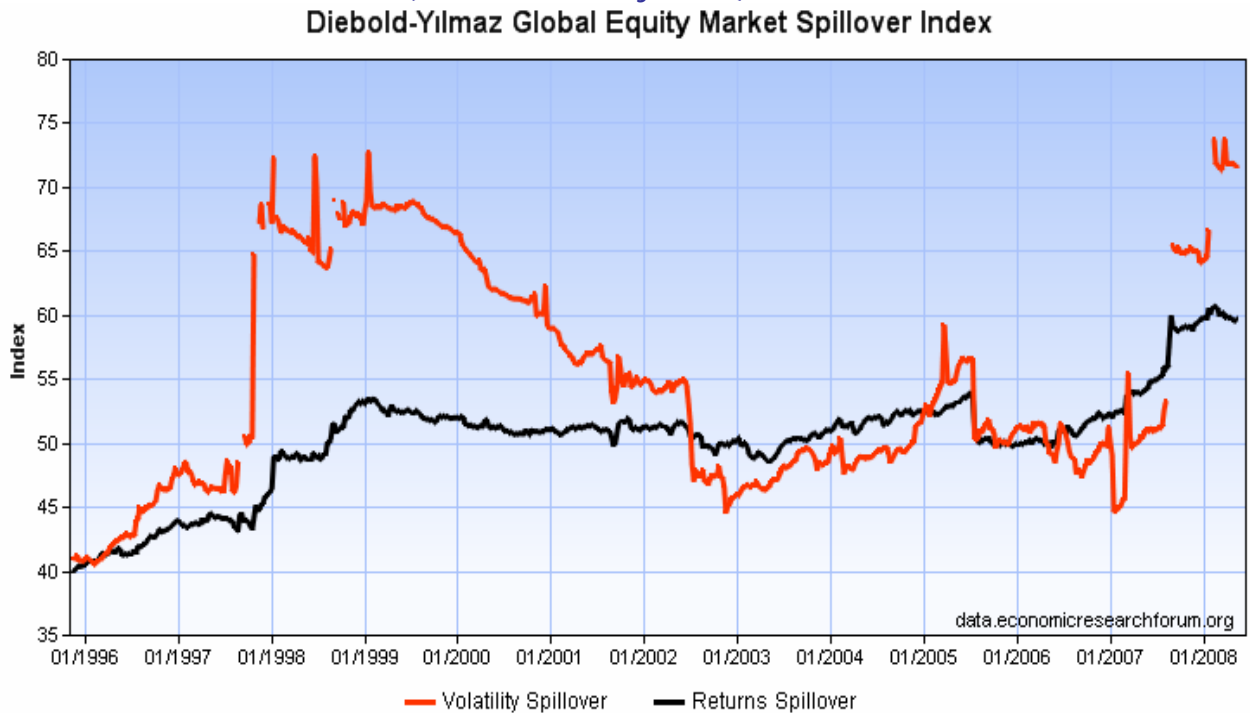


Figure 2. Chicago Board of Options Exchange Implied Volatility Index (VIX;
Weekly Average, Jan. 1996 - March 2008)
VIX

