The Spread of the Credit Crisis: View from a Stock Correlation Network

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The credit crisis roiling the world's financial markets will likely take years and entire careers to fully understand and analyze. A short empirical investigation of the current trends, however, demonstrates that the losses in certain markets, in this case the US equity markets, follow a cascade or epidemic flow like model along the correlations of various stocks. A few images and explanation here will suffice to show the phenomenon. Also, whether the idea of "epidemic" or a"cascade" is a metaphor or model for this crisis will be discussed.

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I. INTRODUCTION

The barely covered story of rising foreclosures among the condominiums of Florida or California in early 2007 was a harbinger of a much larger collapse in the worldwide financial system. The increase of foreclosures over the priced in foreclosure risk in mortgage backed securities, otherwise deemed high-grade assets, began the confusion of the value of collateral assets and subsequent seizing up of credit markets around the globe. The collapse of several institutions such as Bear Stearns, Lehman, and Fortis has accentuated the level of crisis now facing the world markets. Previous loosely regulated titans of finance such as hedge funds and private equity groups have been hit by waves of unprecedented losses and demands by investors for redemptions, causing them to sell even more assets or close positions and creating a positive feedback death spiral.

Though the hardest hit markets are lesser-known markets such as commercial paper, the equity markets have become the most widely known indicators of the ongoing meltdown. In fact, most non-experts likely use the movements of the equity markets, fallaciously, as a key gauge of the severity or progress of the crisis. The equity markets, however, did not originate the crisis nor are they the key force perpetuating it. In this short paper, the spread of the credit crisis will be discussed by referring to a correlation network of stocks in the S&P 500 and NASDAQ-100 indices. The fact that the spread resembles a contagion or cascade, however, may be mainly superficial given the underlying dynamics are completely different.

II. NETWORK CONSTRUCTION

In this paper, a stock correlation network is created similar to the one in work by [1–3]. A correlation matrix of the returns between the two stocks is created where the correlation between stocks i and j is defined as

$$\rho_{ij} = \frac{E((X_i - \mu_i)(X_j - \mu_j))}{\sigma_i \sigma_j} \tag{1}$$

The correlation is taken over the time period August 1, 2007 to October 10, 2008 where each daily value of X is the log-return of the closing price from the previous day. As [1, 2] demonstrate, however, correlation is not a distance metric, therefore we create an adjacency matrix with weights on the edges matching the distance metric between stocks, i and j, defined as

$$d = \sqrt{2(1 - \rho_{ij})} \tag{2}$$

Using these distances we finally create a minimal spanning tree using the python-graph module and animate using pydot and Graphviz. Because over 500 stocks are included, the ticker labels are relatively small but the central part of the component is dominated (though not exclusively) by FIRE (finance, insurance, real estate) stocks which are heavily cross-correlated and thus tightly linked with each other, while the outer branches are more industry specific and are the later impacted stocks by the credit crisis.

The stocks, represented as nodes, are colored according to the following methodology based on the stock return since August 1, 2007.

Green nodes represent a current return greater than -10%. Yellow nodes represent a current return between -10% and -25%. Red nodes represent a current return less than -25%.

Events in the figures are taken from the timeline at [4].

III. DISCUSSION & CONCLUSION

As has been viewed by the wider market, the collapse in stock price returns begins in the FIRE sector of the economy first affecting housing and subsequently finance stocks. Soon it moved across more mainline banks and

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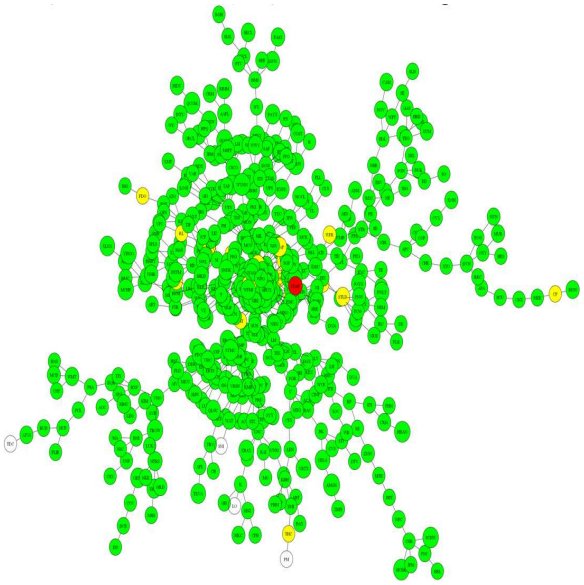

FIG. 1: August 10, 2007 - the beginning of the trouble

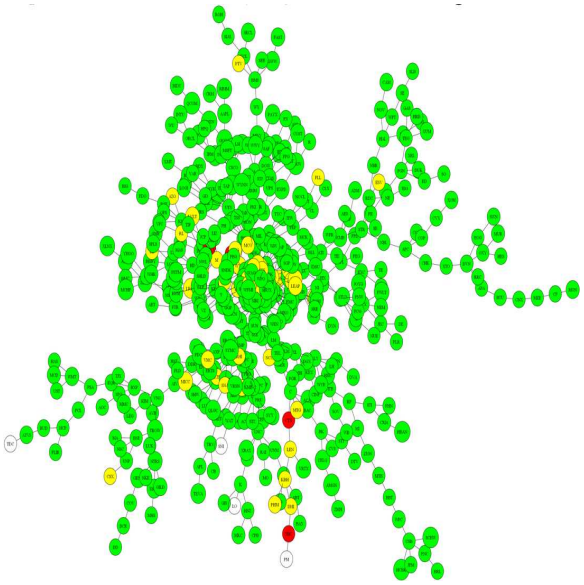

FIG. 2: September 14, 2007 - Northern Rock bailout by the British government

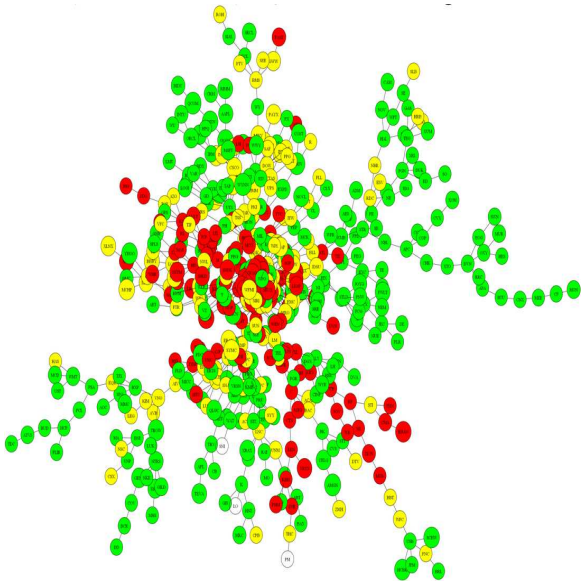

FIG. 3: January 17, 2008 - January 2008 market turbulence

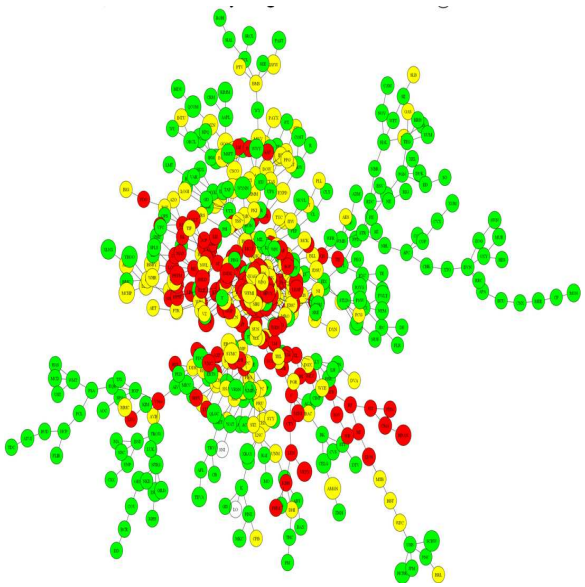

FIG. 4: March 17, 2008 - Bear Sterns collapses

firms and finally, more recently has affected stocks across the board. Though the paper title contains the word epidemiology and though the spread of the collapse in stocks down the tree resembles an infection or cascade on a network, such ideas are more appropriately viewed as analogies or metaphors than explanations. Unlike a disease or cascading collapse, the stock crash is not being transmitted from one stock to another. The correlation just reveals a concerted collapse caused and underlined by a systemic crisis in the financial system.

The spread is more likely carried by the news of the extent of the crisis expanding and the fact that similar asset bases and capital structures make highly correlated stocks similarly vulnerable. As panic and the extent of the devastation spreads, stocks are punished accordingly. In normal times, the failure of a company and its stock is not a cause for a systemic crisis. Also, since the correlation was calculated over an entire year's activity, the stock prices are correlated since they tend to fall similarly over time. The correlation shown in this network does not cause the transmission chain of collapse but is inextricably tied to it. In addition, correlation generally increases with volatility (for example, see [5]) and negative returns effect volatility more than positive returns of the same magnitude [6, 7]. So over time the correlation

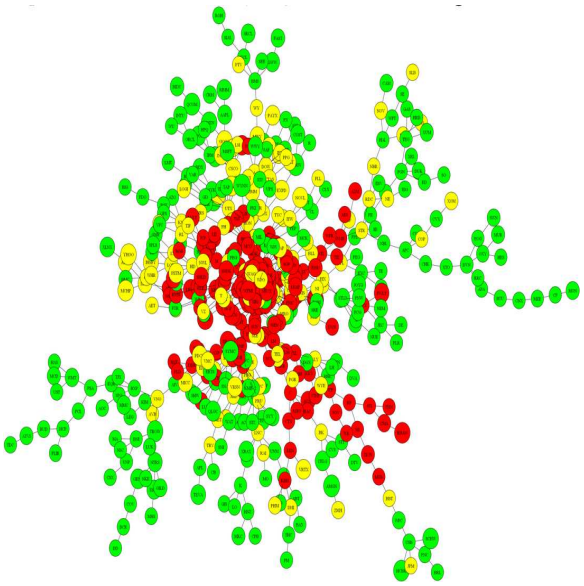

FIG. 5: September 15, 2008 - Lehman Brothers collapses

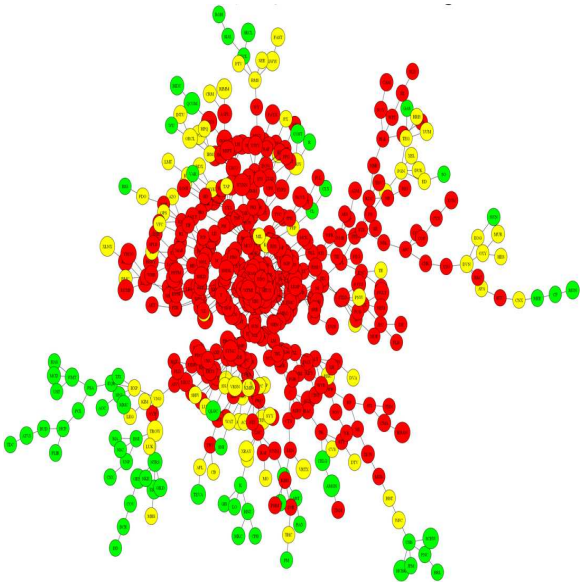

FIG. 6: October 10, 2008 - Largest Dow closing drop in history

has been increasing among stocks and the network will likely be more dense and structure differently due to the steadily increasing market volatility.

Finally, one should note, this is not an example of the widely cited 'financial contagion' in the press. Financial contagion refers to the coupling of financial panic across national borders and not among stocks in an exchange. However, these do illustrate the spread of the credit crisis and how what was once a problem among home builders and mortgage finance companies has engulfed the entire economy.

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