

**GLOBAL CONNECTEDNESS OF EQUITY MARKETS IN CRISIS TIMES: THE
CASE OF SOCIETE GENERALE**

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İSTANBUL BİLGİ ÜNİVERSİTESİ
SOSYAL BİLİMLER ENSTİTÜSÜ
FİNANSAL EKONOMİ YÜKSEK LİSANS PROGRAMI

HARALD SCHMIDBAUER
2013

Financial Connectedness of Equity Markets in Crisis Times: The Case of Societe Generale
Kriz Zamanlarında Sermaye Piyasalarındaki Bağlılık: Societe Generale Vakası

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Tezin Onaylandığı Tarih
Toplam Sayfa Sayısı

: 29/05/2013
: 30

Anahtar Kelimeler

- 1) Finansal Bağlılık
- 2) Yeni Bilgi Akışı
- 3) Finansal Şoklar
- 4) KLIC Değerleri
- 5) Yayılma Değerleri

Key Words

- 1) Financial Connectedness
- 2) Information Transmission
- 3) Financial Shocks
- 4) KLIC Values
- 5) Propagation Values

ABSTRACT

This thesis investigates the effect of the fraud in Societe Generale Bank in the global financial connectedness in crisis times. This fraud was exposed and released to the public towards the end of January 2008, in the middle of the sub-prime mortgage crisis. Furthermore, the research focuses on two years' time period and divides this period into three sub periods according to literature. These three sub periods contain three different market structures. This division is used for assessing the effects of this fraud with information gain theory and financial connectedness. Two hypotheses are tested in this thesis. First one is the impact of the fraud depending on these three periods. That is tested with KLIC values, which measures the difference between today's news balance and yesterday's news balance, in order to denote how much information is created today. The second hypothesis is the propagation values of selected data would decline if this fraud happened in another week after the crisis. That is tested with propagation values. The propagation values measure the strength of repercussions in markets when a hypothetical shock comes from these markets. As results of these two tests, empirical findings support the two hypotheses. This fraud had different impacts in different market structures. The amount of the information that one event can create, differs in different market structures.

ÖZET

Bu tez, kriz zamanlarındaki finansal bağıllığı, bir Fransız bankası olan Societe Generale'de yaşanan usulsüzlük ve dolandırıcılık üzerinden incelemektedir. Bu olay 2008'in Ocak ayının sonuna doğru ortaya çıkmıştır. Amerika'da başlayan konut kriziyle aynı zamana denk gelmektedir. Bu araştırma da kabaca, krizin ilk iki yılını kapsamaktadır. Bu süreç literatürde tartışıldığı üzere, finansal piyasalarda oluşan yapısal değişiklikler temel alınarak üç alt döneme ayrılmıştır. Bu bölünme, piyasaya gelen yeni bilgi akışının ve finansal bağıllığın değerlendirilmesine imkân tanımıştır. Bu konu ile alakalı iki hipotez bu çalışmada test edilmiştir. İlki; Societe Generale bankasında yapılan dolandırıcılığın etkisi üç alt dönemde birbirinden farklı olacaktır. İkincisi; eğer bu olay ilerideki kriz sonrası bir dönemde olursa, bu dolandırıcılığın yayılma etkisi daha az olacaktır. İlk hipotez KLIC değerleri, denilen ve piyasayı etkileyecek bilgilerin miktarındaki değişimin gün be gün ölçülmesine imkân sağlayan yöntem ile test edilmektedir. İkinci hipotez ise yayılma değerleri ile ölçülmektedir. Testlerin sonucunda çıkan değerler iki hipotezi de destekler mahiyettedir.

List of Abbreviations

AIG	American International Group, multinational insurance company
CAC	French stock index
CDS	Credit Default Swap
CEO	Chief Executive Officer
CESE	Central, East, Southeast Europe
DAX	German stock index
DW	Deutsche Welle
FED	Federal Reserve
FTSE	British stock market index
IMF	International Monetary Fund
Jr.	Junior
KLIC	Kullaback-Leiber Information Criterion
LIBOR	London Interbank Offered Rates
MBS	Mortgage Backed Security
OIS	Overnight Index Swap
UBS	Swiss financial services company
US	United States (of America)

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1. Introduction

In order to compare its effects, the Sub-prime Mortgage Crisis is the first global financial crisis since the Great Depression. In this thesis, I focus on the first two years of this crisis. The period starts from the beginning of March 2007 and ends to the last day of January 2009. In several articles, it is mentioned that the first signs of the crisis were observed in the last days of February 2007. Also, it can be said that the worst part of the crisis was after January 2009. Moreover, this time is also consistent with the election of US President Barack Obama, and his first recovery plans against crisis. Furthermore, I divide these two years in three sub periods, with two events that are generally accepted in literature as structural break downs in financial markets. These are August 2007, as the first peak in the crisis that was caused by the problems in mortgage backed securities; and September 2008, as the greatest peak in the crisis that was caused by substantial problems in the biggest financial institutions in the US. The first sub-period, which triggered the global crisis in fact started in the US and affected a few US banks and financial markets. In the second sub-period, the crisis spread into global markets and the banking sector, resulting in declines in stock prices and credit markets due to first signs of panic and liquidity shortages. In the third sub-period, the world experienced real difficulties and concerns involving solvencies at global level, especially after the Lehman Brothers collapse.

In these periods, I look at the global connectedness at equity markets in the aspect of the fraud in Societe Generale Bank in France which occurred in January 2008, in the middle of these periods, as a result of unauthorized trades of a rogue trader. This fraud caused approximately five billion Euros loss to the bank. I test two hypotheses relevant to this issue in these periods. The first one is that the impact of this fraud depends according to these periods. The impact differs following the changes in the information that was injected in the system during these periods. It is tested with KLIC values. The second hypothesis is that would the propagation values decline if this fraud had occurred in a different time after the crisis. It is tested with propagation values.

1.1 Summary of the Subprime Crisis

Deutsche Welle denoted the roots of Subprime Mortgage Crisis as a decline in the US real estate markets in late 2006 which caused the banks a global loss of more than 550 billion dollars in assets. Again DW, used as an abbreviation for Deutsche Welle, mentions the chronology of the major events from March to April in 2007 as such: New Century Financial Corporation stopped generating new loans as the risky mortgages become a problem due to borrowers' who had bad credit payback histories and therefore fell in difficulties for repayments of loans. The International Monetary Fund (IMF) continually advised the financial institutions to take precautions against the risks in global financial markets because of the deteriorating US home mortgage market. But the major response from the financial sector was that the two hedge funds of New York based investment bank Bear Stearns dropped to a brink of collapse on account of their extensive investments in mortgage backed securities in June 2007. Through July and August some other banks which had losses from their investments in the US real estate market were caught up in the crisis rather quietly. US President George W. Bush rejected government intervention in the mortgage market for restoring the poise; and said he wanted the markets to continue working on their own. Then, markets worked painfully and caused 180 000 foreclosures of US homes which was 93 percent increase from a year earlier in July. ¹

In September 2007, the British bank Northern Rock was surrounded by worried savers; this situation forced the British Government and the Bank of England to guarantee the deposits, then the bank was nationalized. The US Federal Reserve (FED) started series of interest rate cuts for smoothing the effects of the crisis in housing and mortgage sector. Then, bad news continued through the end of the year. City Group's profits dropped sharply; IMF lowered the growth forecast of the Euro Area for 2008, from 2.5 to 2.1 percent, because of spillover from the US subprime mortgage crisis and credit market crunch. These actions led US President Bush to unveil a plan for 1.2 million homeowners to pay their loans, as a contrast to his previous remarks.²

¹ <http://www.dw.de/chronology-financial-crisis-spreads-from-us-to-world-markets/a-3689713>, 2008, ¶1-¶5

² <http://www.dw.de/chronology-financial-crisis-spreads-from-us-to-world-markets/a-3689713>, 2008, ¶6-¶8

2008 began with other bad news; as a highly respected Swiss bank UBS reported more than 18 billion dollars losses as a result of harmful impacts of the US real estate markets declines. In the US, Bank of America acquired Countrywide Financial, the country's biggest mortgage lender. Besides, all the equity markets were in downward movement, especially in Asian markets. Moreover, finance sector had one of the Black Mondays on its history on 21st of January, where the US markets were closed for public holiday, but they reopened with losses on Tuesday. Most of the equity markets had significant drops. In France, Societe Generale, the country's second largest bank, announced large losses because of an internal fraud, which consisted of large unauthorized transactions in European Futures markets. Contemporaneously, European futures markets suffered great losses. Fed slashed interest rate by three quarters of percent point, following sell off on global markets.³

In consistence with this harsh beginning, 2008 continued with other unpleasant events. For instance; lots of big companies in finance sector announced huge losses for 2007 or first quarters of 2008, such as Fannie Mae, Deutsche Bank; and some others faced with unwilling mergers and acquisitions, such as Bear Stearns. US government had grudgingly admitted to guarantee debts of Fannie Mae and Freddie Mac. But the most detrimental month was September 2008. In 15 September Lehman Brothers as a giant Investment bank declared 600 billion dollar bankruptcy, which was called as one of the "too big to fail" companies but US government let its bankruptcy. Then Merrill Lynch acquired by Bank of America. Since the effect of Lehman Brother's fail, US government did not let any more "too big to fail" company's bankruptcy; and bailed out AIG insurance company for 85 billion dollars, just two days later from Lehman Brothers. Subsequently, White House requested 700 billion dollars bailout plan from Congress for all financial firms with toxic mortgage securities to free up tightening credit flow. That request rejected by House of Representatives, but one way or another, it was accepted by Senate and signed by the President. Definitely, additional bailouts for banks occurred in other countries in order to prevent new bankruptcies and its harmful effects. For instance; Britain, Benelux, Germany, Iceland, Netherlands, Belgium, Luxemburg, and some other countries did some bailouts, inject money to companies or directly state takeover of some banks. As a last important event through the end of the 2008; US Government decided to rescue City Group. In order to emphasize the importance of

³ <http://www.dw.de/chronology-financial-crisis-spreads-from-us-to-world-markets/a-3689713>, 2008, ¶9

September 2008 it can be said that, before that time the argument was; should the governments do interventions to the markets? After that time; in which way the governments should do interventions; should the governments buy toxic assets or should they recapitalize the companies?^{4 5}

On January 20, 2009 US President Barack Obama officially took office and through the end of this month his new recovery plan came to House of Representatives. Subsequently, through the middle of February 2009, this plan enacted by the Congress as the name of The American Recovery and Reinvestment Act of 2009, and signed by the President. This is the beginning of new period and this action was followed by the other movements against the crisis.⁶

2. Literature Review

2.1 Contagion

Since most of the articles in references part of this thesis, mentioned contagion; it is needed to explain contagion in advance. One theory that is mentioned in Allen and Gale's article is "*small shocks, which initially affect only a few institutions or a particular region of the economy, spread by contagion to the rest of the financial sector and then infect the larger economy*" (2000, p.2). That theory seems consistent with Sub-prime Mortgage Crisis. At the same article, contagion is described with an example. For instance; when a bank crisis occurred in a region, the other regions may also have losses from their positions on the troubled region. If this spillover effect is strong enough, that may cause a crisis in the related regions. In extreme cases, "*the crises passes from region to region and become a contagion*" (2000, p.2). Moreover, contagion is also described with different definitions. One of them defines contagion as if one or a group of markets, countries, or institutions suffers a shock then it spreads to other markets, or countries, or institutions it is called a contagion (Pritsker, 2000, p.3). Another one, which is narrower, defines it as "*a significant amount of increase in*

⁴ <http://www.dw.de/chronology-financial-crisis-spreads-from-us-to-world-markets/a-3689713>, 2008, ¶10-¶30

⁵ http://en.wikipedia.org/wiki/Subprime_crisis_impact_timeline, relevant parts are under the the topics of "2007", and "2008".

⁶ http://en.wikipedia.org/wiki/American_Recovery_and_Reinvestment_Act_of_2009, relevant part is under the topic of "Legislative History"

cross-market linkages only after the shock to one country or group of countries". The main difference is if the significant increase in cross-market co-movements does not occur within different countries in different markets, it would not be a contagion. Although, if two markets show a high degree of co-movements during period of stability, and if the markets continue to be highly correlated after a shock in one market, this also may not constitute a contagion (Forbes&Rigobon, 2002, pp: 2223-2224). In any case none of these definitions conflict with Sub-prime Mortgage Crisis.

2.2 Transmission Channels

The transmission mechanism of shocks in one country, region or a sector to others is another important issue and there is a significant amount of research papers about this topic. In relatively early articles, this issue was discussed with "*at least five separate channels which real shocks are transmitted from one country to another*". These are shocks via real linkages, via a common lender, via financial markets, via financial institutions and via the interaction of financial institutions and markets (Pritsker, 2000, p.20).

In more recent articles, writers discussed transmission channels in Sub-prime Mortgage Crisis. In Longstaff's article, it is said that the effects of the last crisis might have been propagated through different financial markets with at least three channels. The first channel is the correlated information channel. In this mechanism, one shock which create economic news for a financial market impacts relevant security prices in other markets. The second channel is the liquidity channel. In this mechanism, one shock on a financial market causes bring downs in the overall liquidity of the global financial markets. Moreover, this could have effects on investors' behaviors and the asset prices. The third channel is risk premium channel. In this mechanism, financial shocks in a market could have effects on the willingness of market participants to have risks in markets. "*Thus, prices in all markets might have been affected as equilibrium risk premium adjust in response*" (Longstaff, 2010, p.438).

In another article, Jack Boorman described five major channels which bring the crises from advanced market economies to emerging market economies, where the markets shied away from more exotic instruments. The first one was the taking out of some funds by some of the major financial institutions from their subsidiaries which are located in the emerging economies, to the host countries which are generally more advanced countries. The second

one was the breakdown of the international credit markets. In normal times, the Credit flows are from the advanced markets to emerging markets by the international banks and global bond markets but then this way was devastated. The third was the impact of the crisis on economic activity. The impact of this channel can be observed on international trade as a sharp shrink in exports from emerging countries. This effects economic activity in emerging markets whose became largest exporters to the industrial world. The fourth one was remittances which are important source of income and foreign exchange for emerging economies. It was calculated to decrease during the crisis. *“Interestingly, the transfer of domestic remittances, from individuals who have moved to urban areas in search of employment and higher income to those left behind in rural or less developed regions of a country, have also declined”*. The fifth one was psychological factor. The financial markets and all the other participants of economies had already become familiar with financial crisis in emerging markets. *“But such a crisis originating from the United States and spreading quickly to other industrial countries took most of the world by surprise”* (Boorman, 2009, pp: 3-6).

In other two articles authors mentioned transmission channels within Europe. In the first article Alter and Beyer investigate interlinkages between sovereign credit markets and systematically relevant banks, in order to measure spillover effects. In this article, they specify that spillovers of Euro zone sovereign bonds are linked by the joint monetary policy transmission mechanism. Moreover, the Eurosystem’s collateral framework and shared default risk of euro member countries are also important transmission mechanisms within Euro. They also mentioned several transmission channels within the banking sector alone, for example; common credit exposures, and interbank lending or trade of derivatives (Alter&Beyer, 2012, p.3).

In the other European focusing article Arvai, Driessen and Ötker-Robe investigate cross-border financial exposures between Western and emerging countries in Europe. They noted that, the degree of financial interlinkages between Western European countries and Central, Eastern, and Southeastern Europe (CESE) countries has apparently increased as a result of important amount of rising in foreign ownership of the banking systems in CESE. This situation also increases weaknesses of the host countries against contagion. Moreover, they claimed that most CESE countries are significantly dependent on Western European countries’ banks in two ways; such as via their local banking sectors and via private sector.

Finally, they denote one last transmission channel for Europe as common lender mechanism. They called some big Western European banks as parent banks and these are funding source for CESE countries. If one of them faced difficulties for its risky operations in various countries, it could transfer the harmful effects in other countries as a common lender. The authors describe this mechanism as, “*a shock affecting the trigger country may result in pressures in the banks of common lender, given its high exposure to the trigger country, and could spill over to another CESE country, simply because of the large presence of the common lender in both countries*” (Arvai&Driessen&Ötker-Robe, 2009, pp: 4-5).

Finally Diebold and Yilmaz emphasize the importance of counterparty linkages of financial institutions, in the aspect of connectedness. They summarize it as “*the counterparty linkages associated with positions in various assets, through contractual obligations associated with services provided to clients and other institutions, and through deals recorded in their balance sheets*” (2011, p.13).

2.3 Three Periods

In literature, there are very few dates which were detected when structural breaks occurred or general stress in financial markets were increased significantly and risk appetite was obviously changed. These changes were measured with different variables in various articles. However, two specific times were detected in all of the articles which were published after those dates. First one is August 2007, as the first peak of financial crisis in the beginning period. The second one is September 2008, as the biggest peak in financial turmoil in the second half of the first decade of twenty first century.

In Angelini, Nobili and Picillo’s article, they used microeconomic data to gain insights into the sharp increase recorded by interbank rates in the main currencies, and by the spread on the corresponding collateralized rates, from August 2007 through the crisis period. They recorded a substantial increase in both the average value of a proxy of risk aversion, which was extracted from stock market option data, and in the reactivity of the spread to the proxy itself. They regressed spreads on set of bank specific and market wide explanatory variables, allowing for structural breaks in the estimates relationships after August 9, 2007, the day in which the spread began to widen. Moreover, they noted that large jumps in the spread were accounted after August 2007. Furthermore, they interpret it as those banks became more

unwilling to incur interbank exposures, and did not hesitate to make them public. Similarly, the significant increase in the spread volatility observed since August 2007 and that reflected aggregate volatility (Angelini&Nobili&Picillo, 2011, p.953). In other words, lending conditions were broadly insensitive to borrowers' creditworthiness before August 2007; things changed afterwards. But the amount of cross sectional variability in lending rates explained by borrowers' creditworthiness still appears small (Angelini&Nobili&Picillo, 2011, p.927).

In Frank, Gonzalez-Hermisso and Hesse's article, they investigate transmission of liquidity shocks in Sub-prime crises, and especially they focused on asset backed securities. They noted the propagation of the crisis across different asset classes and financial markets is attributable to an amplification mechanism due to asymmetric information resulting from the complexity of the structured mortgage products. This caused the repricing of risks which led the form of decrease in global investors risk appetite. Therefore, rating agencies changes lot of the securities grades and most of the asset backed securities lost their investment grade. In addition, rating agencies also announced changes in their methodologies for rating such products first in middle of July 2007 but then again in middle of August 2007. Meanwhile, structured credit mortgage backed instruments measured by the ABS indices saw rapid decline, and the liquidity for these securities in secondary markets also fell sharply (Frank&Gonzalez-Hermisso&Hesse, 2008, p.7). Gonzalez-Hermisso and Hesse present a figure of selected conditional correlations between Asset Backed Commercial Papers, LIBOR, CDS and Returns. That figure shows the evidences of great correction by the correlations to their long run means, such as Asset Backed Commercial Papers to LIBOR and Asset Backed Commercial Papers to CDS spreads. It also shows a large jump on July 24th 2007 which can be observed simultaneously across all markets (Frank&Gonzalez-Hermisso&Hesse, 2008, p.16). Last but not least, they also mentioned that new transmission channels for liquidity shocks were also established in the second half of 2007 (Frank&Gonzalez-Hermisso&Hesse, 2008, p.20).

In one of the Diebold and Yilmaz's article, they pinpoint the importance of volatility spillovers from the stock markets to other markets during the crisis. They used daily volatility spillovers across US stock markets, bond markets, foreign exchange markets and commodities markets from January 1999 through January 2010. In spite of the significant volatility fluctuations in these markets during the sample, "*cross market volatility spillovers were quite*

limited until the global financial crisis that began in 2007 (Diebold&Yilmaz, 2010, p.1).

They state that, since August 2007, stock market volatility reflects the dynamics of the Sub-prime crisis quite well. And again, since August 2007, volatility in bond markets has increased significantly (Diebold&Yilmaz, 2010, p.1).

In another article of Diebold and Yilmaz, they studied on stock return volatilities for thirteen US financial institutions that survived the crisis of 2007-2008. These are seven commercial banks, two investment banks, one credit card company, two mortgage finance companies and one insurance company. This is another important measure of the structural breaks in financial turmoil times. They describe it as, *“the volatility connectedness is the fear connectedness expressed by market participants as they trade, and it is particularly crisis sensitive”* (Diebold&Yilmaz, 2011, p.13). Moreover, they specify the first signs of the crisis are in February 2007. Where the total volatility connectedness index jumped from nearly 56% in February 2007 to reach nearly 90% in August 2007, and stayed above 80% until mid-2009 (Diebold&Yilmaz, 2011, p.20). They begin to summarize this period from the New Century Financial Corporation, which was reported to have troubles with its debt in late February 2007. They continued it with three small mortgage companies the bankruptcy. Bad news continued with the expectations of real estate markets, the mortgage-backed securities (MBS) markets and the stock market. Furthermore, Diebold and Yilmaz stated that, *“on the last day of February 2007, the total connectedness measure jumped by more than 17 points which was the biggest increase on a single day”*. This increase was not result of a volatility shock to the stock of one single financial institution; in fact, all bank stocks were damaged by the new environment of the MBS markets. They continued their analysis with Lehman Brothers' bankruptcy which they declared on the morning of September 15, 2008. That same day, Merrill Lynch also announced that it was being acquired by Bank of America. *“The total volatility connectedness index increased further to reach its maximum level of 89.2%”* (Diebold&Yilmaz, 2011, pp: 27-28).

In Frank and Hesse' article, they examine the financial interlinkages between advanced and Emerging market countries. They focus on co-movements between emerging market economies and advanced market economies, by proxies for general stress in the inter-banking money markets. They also used related to stock market prices and return volatilities, bond spreads, and CDS indices. They noted that the Shanghai stock market correction in February 2007 motivated a sudden but temporary increase in correlation measures, but the Lehman

Brothers' collapse in September 2008 caused the largest increase in co-movements of these variables (Frank&Hesse, 2009, p.3). Moreover, funding liquidity pressures in the interbank market, which is measured by the Libor-OIS spread, were insignificant before the crisis. But they mentioned that; *"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, in addition to a sharp increase in counterparty risk"* (Frank&Hesse, 2009, p.10).

In another article, Aragon and Strahan states that hedge funds which use Lehman as prime broker faced with a decline in funding liquidity after the September 15, 2008 bankruptcy. They showed that *"stocks held by these Lehman-connected funds experienced greater declines in market liquidity following the bankruptcy than other stocks; the effect was larger for ex ante illiquid stocks and persistent into the beginning of 2009"* (Aragon&Strahan, 2010, p.1).

In another research paper Kuo, Skeie, and Vickery investigate the impact of bank Libor surveys to two measures of borrowing rates; first one is Federal Reserve Term Auction Facility and the second one is inferences of term of borrowing from Fedwire payments data. The importance of this article is they define four time periods in financial crises in order to transaction pairs identified by Fedwire algorithm. First period is starts from January 1,2007, making the start of problem in interbank and commercial paper markets. The second periods starts from August 9, 2007, the date when BNP Paribas suspended convertibility on two hedge funds. The third period is from the Lehman bankruptcy on September 15, 2008, as the crisis peak, to the November 11,2008 as the first date when one month Libor falls below its peak pre-Lehman level. The fourth and final period as crisis easing period is from November 11, 2008 to March 30, 2009. Furthermore, they state that *"the one month interbank loan spread to Overnight Index Swap (OIS) is only around 10 basis points before August 2007, but then rises strikingly to an average of around 200 basis points during the peak crisis period, before subsiding"* (Kuo&Skeie&Vickery, 2012, pp:13-14).

The last paper under this topic is Taylor and Williams' article which is focusing on the first phase of the crisis, more specifically between August 9, 2007 and March 20, 2008. In consistence with the previous articles, they used Libor-OIS spreads and Libor-Repo spreads as measures of risk. They also, mentioned dramatic change in conditions in the money markets in August 9, 2007. They state the interest rate on overnight loans between banks, named as effective federal fund rate; sharply increase to extraordinary high levels in

comparison with the Fed's target rate for federal funds. "During the period from the beginning of the year through August 8, 2007 the standard deviation of the difference between the effective funds rate and the target was only three basis points. From August 9, 2007 to March 20, 2008 the standard deviation was twenty basis points". Years back to the beginning of 2002 the volatility is six basis points. In addition to this, since August 2007 the spread between three month Libor and the Fed's overnight federal funds rate target increased dramatically (Taylor&Williams, 2008, p.4).

3. Societe Generale Scandal

On January 2008, European Equity markets were pegged down as a result of a fraud in Societe Generale, France's second largest bank. Through the end of the month, Daniel Bouton as the Bank's chief executive officer (CEO) and chairman of the board announced that the Bank lost approximately 4.9 Billion Euros during three days, from 18th to 21st of January 2008. This loss was a result of a rough trader's unauthorized trading. This trader was Jerome Kerviel (Knapp, 2011, p.501).

3.1 Societe Generale

Societe Generale was founded in 1864 as a result of industrial revolution. The aim was to finance the growth of commerce and industry in France. First; it was started to fund the steelmakers and railroad companies (Engqvist&Kristiansson, 2012, p.1). Then, new permanent office was opened in London and the bank became a modern credit institution. The new departments and services were added to the Bank's body. Besides, accepting deposits from firms and private individuals, it was also issuing shares of stocks, and doing business in other countries.⁷ Today, as the bank mentioned at their *Activity and Sustainable Development Report* in 2011 and their article named *More Than 140 Years of History* in 2009 (Engqvist&Kristiansson, 2012, p.1), Societe Generale is the 8th biggest bank in Europe with 33 million customers and 160 000 employees. The Bank has three main operation areas,

⁷ <http://www.thefreelibrary.com/The+tale+of+two+banks%3A+Societe+Generale+and+Barings.-a0267976158> , 2011, ¶11

which are Retail Banking & Financial Services, Corporate & Investment Banking and Global Investment Management & Services. Since Societe Generale was the first bank that started to trade with equity derivatives, the French banks now controls approximately one third of this market which accounts hundreds of trillions dollars.

3.2 Jerome Kerviel

Jerome Kerviel was born and raised in a small coastal village called Pont-l'Abbe at northwestern France. As written in Daily Telegraph by Martin, Allen, Allen and Samuel (Engqvist&Kristiansson, 2012, p.1) he was born in a working class family as one of two sons. He gained his Bachelor's degree in finance in 1999 from the University of Nantes. Sequentially; he completed a Master in Finance at the University of Lyon and then started to working at Societe Generale in August 2000. Furthermore, he was accepted for an entry level position in back office, and served there as an internal auditor for four years. His responsibilities were monitoring the bank's securities trades in order to identify unauthorized trades, such as trades that exceeded the monetary limits that had been established for individual traders. In 2004, he was promoted to a security trader in security division of the bank. That brought him opportunities to better use his educational background and show his personal abilities instead of relative anonymity in back office. He worked hard for impressing his superiors and did not even take few weeks of holiday although he had the right to have each year. Basically, the mission of his new department was to mitigate the risks which the Bank faces naturally because of its high volume of derivatives trading. Therefore, his job involved issuing and trading plain vanilla hedges contracts which is a standard type of option as an opposite of more exotic products, on European stock market indices (Knapp, 2011, pp: 501-502).

3.3 The Fraud

From the beginning of 2005, Jerome Kerviel began exceeding the maximum transaction limits as an individual securities trader and then he practiced some other unauthorized transactions. Since he was familiar with the manual and also electronic control system from his back office experience, he was able to use various methods to circumvent the control mechanism of the bank and managed to hide his unauthorized trades. For instance, he created fake emails from his superiors for allowing his unauthorized transactions, block and interfere with warning messages which releases his unauthorized trades, and prepared false documents that shows some fictitious trades for hedging his open positions, or showing his permission from his supervisors. Despite his efforts to avoid alerts, these irregularities came to the attention of the back office control personnel; but he convinced or at least confused and discouraged them with his nonessential but impressive explanations. That is also mentioned in the report of the bank's special investigation committee which was established after the fraud was revealed, as Kerviel and his trading colleagues intimidated the back office personnel and that caused them to be reluctant to investigate vigorously the apparent trading irregularities (Knapp, 2011, pp: 501-502).

The most significant part of Kerviel's fraud is the technique that he used, which is similarly used in some other previous frauds as a main way of making deceits invisible. The technique is mainly based on recording fictitious transactions in order to make the fraud appear to be hedged or offset. Michael C. Knapp, professor of accounting from University of Oklahoma, explains that in his book, named *Contemporary Auditing*, as "... *if Kerviel purchased a large block of securities, he would then record an offsetting but fictitious sale of similar securities. When he shorted a large block of securities, the fictitious hedge transaction that he recorded would be a long position in those securities or similar securities. These fictitious hedge transactions made it appear as if Societe Generale faced only minimal losses, at worst, on the large securities positions being taken by Kerviel.*" (2011, p.503). This approach enables him to bypass the Basel 2 and Basel 3 minimum capital requirement ratio (Engqvist&Kristiansson, 2012, p.2).

Kerviel's trades based on his anticipations on near term moves of major European stock market indices. As a result of these trades, he produced more than one billion euro gains for the bank in 2007, but sometimes these dangerous transactions caused his outstanding positions exceed the shareholders' equity of 33 billion Euros.

He told about his trades details in an interview to Der Spiegel. He specialized in German stocks just after joining the trade department. Then, he took his first position on Allianz stock, which is a German multinational financial services company that specialized in insurance. He was betting on a fall in the market, while the market was in a converse mode and his positions were going red. But then a series of terrorist attacks occurred on London's subways in 7 July 2005, which caused stock prices to collapse. As a result of this action, the bank reaped 500.000 Euro in profit from his transactions. Kerviel claimed that his supervisors praised him and increased his freedom to make speculative deals, right after his success in German market as a trader with only six months on the job. He said, he raised the magnitude of his positions, exceeded his limits and he thought his supervisors covered up his positions because everyone benefitted his action; Kerviel, his supervisors and the Bank.

In late 2006, he established a major short position on DAX, Germany's stock index, worth several billion Euros. Then, he sold off for a 20 Million Euro profit in February 2007. He claimed his supervisors overlooked him when he made huge losses also. For example; in March 2007, Jerome Kerviel anticipated there would be a crash in market because of the risks in American subprime loans, and he took out positions which worth 30 billion Euros. But, between March and July, the stock market experienced a continuous climb and that caused potential losses up to 2 billion Euros. Of course, these losses were not realized, the assets were not sold; it would pay for marginal calls and try to cover these losses. In July, the market had its first panic attack, and he was able to pull out with a gain of 500 million Euros. Kerviel got his confidence back. He made 1.5 billion in profits through the end of the year.⁸

⁸ <http://www.spiegel.de/international/business/rogue-trader-jerome-kerviel-i-was-merely-a-small-cog-in-the-machine-a-729155.html>

In the beginning of 2008, Kerviel made huge volume of trades on his belief that European stock market indices would turn sharply higher by late January. On the contrary, those markets declined and massive unrealized losses occurred. On Friday, January 18th 2008, Kerviel's open positions were discovered because abnormal counterparty risk on a broker was detected several days earlier and the confirmation information emails raised suspicions. Then, the trader's superiors were informed and they alerted the management of the division. A team was created to investigate the situation. During the weekend, the investigation team pieced together his real positions and reported to Daniel Bouton, CEO and chairman of the board. He decided to close all of Kerviel's open positions, as soon as possible, otherwise that may have caused catastrophic losses; because Kerviel's open positions was approximately 49 Billion Euros which far exceeds shareholders' equity with 33 Billion Euros.⁹

3.4 The Effect of Fraud

On January 21, Monday, 2008, European stock markets suffered heavy losses about 6%, which was the biggest decline since 11 September 2001. This day is also known as one of the Black Mondays in the finance history. Actually, European stock indexes were not the only one for losses, but all global indexes declined, except US markets because they were closed on Monday for Martin Luther King Jr. Day. Thus, US markets reopened with losses on Tuesday. As in details; German DAX Index fell by 7.2%, French CAC Index fell by 6.8%, Japan Nikkei fell by 4%, UK FTSE fell by 5.5%, Hong Kong Hang Seng fell by 5.5%, India Sensex fell by 7.4% and on Tuesday US Indexes like Dow Jones Industrial Average and S&P500 were likely to open down more than 5%.^{10 11}

These crashes followed by Federal Reserve announcement for an emergency cut on federal funds rate by 0.75 percent which was the biggest cut since 1984. A Federal Reserve Spokesman said they did not know Societe Generale's situation when they decided to make this announcement. It is estimated that over the period the total trading in futures and the cash

⁹ <http://ciasecurity.blogspot.com/2008/05/security-lessons-learned-from-socit.html>

¹⁰ <http://news.bbc.co.uk/2/hi/business/7199552.stm>

¹¹ http://articles.marketwatch.com/2008-01-21/news/30712200_1_recession-fears-german-dax-index

market for the Euro Stoxx 50 was 544 Billion Euros. This is much more than Kerviel's open positions which were approximately 50 Billion Euros. Societe Generale's investment banking chief, Jean Pierre Mustier acknowledged that *"the three days of forced selling played a role in the market's overall decline, but characterized that impact as minimal"*.¹²

4. Data

In this paper, I use daily return quotations of five stocks in the banking sector and two indices. These are Societe Generale's stock as glepa, Deutsche Bank's stock as db, UBS's stock as ubs, Citigroup's stock as c, JP Morgan's stock as jpm, Dow Jones Index as dji, and Euro Stoxx 50 as sx5e. Since most of the open positions of Jerome Kerviel, rogue trader in Societe Generale, are in European futures contracts; I use Euro Stoxx 50 as a proxy. In addition, I use Dow Jones Index as a US markets benchmark and stocks of major financial institutions from France, Germany, Switzerland, and US for proxy of these markets. In European side, right along with France, I use stocks from Germany and Switzerland because these countries have major impact on Euro Stoxx 50 that is designed by Stoxx Ltd, and which is owned by German and Swiss exchange markets.¹³

As I explained the reasons in introduction part, I worked on three sub periods. The first period is from March 1st 2007 to August 8th 2007. The second period starts from August 9th 2007, which is mentioned in literature review as a date for markets' structural change, ends on September 12th 2008 as the last trading day before Lehman Brothers collapse on September 15. The third period is from September 15th 2008 to January 1st 2009. Hence, I used daily closing return quotations of selected stocks and indices at these three periods.

¹² <http://stockthoughts.wordpress.com/2008/02/06/january-2008-societe-generale-trading-loss-incident/>

¹³ http://en.wikipedia.org/wiki/Euro_Stoxx_50

5. Methodology

In this paper, I use mainly same methodology with Schmidbauer, Rösch, and Uluceviz [2012, 2013]. In order to investigate the spread of information through the network of markets; Schmidbauer, Rösch, and Uluceviz built their methodology on return spillovers which was developed by Diebold and Yilmaz (2009, 2011). All their studies about this topic and my paper are based on forecast error variance decompositions of fitting vector auto regressive models of return series. In this approach, the aim is not to forecast future returns, but investigates the market connectedness as spillovers of shocks from one market to other markets. For this perspective Diebold and Yilmaz created volatility spillover indexes as the sum of all variance decomposition contributions to others. Moreover, it is necessary to mention that population dynamics and information theory are methodological foundations of these studies (Schmidbauer&Rösch&Uluciviz, 2012, p.2).

These hypotheses are tested with propagation values and KLIC values. The propagation values were described in Schmidbauer, Rösch, and Uluceviz's article as the possible future impacts or transmissions of the shocks that were faced or hypothetically faced in a specific time. Hence, the high propagation value determines that specific news that come from one market will have strong repercussions in other markets in the future (2013, p.4). In other words, propagation values measure the strength of repercussions in markets when hypothetical shocks come from these markets (2013, p.8). I created a hypothetical situation, in favour of applying this method to the second hypothesis which is that the propagation values would decline if the fraud in Societe Generale had occurred in a different time after the crisis. I assumed that nothing happened in the real fraud week and assumed zero returns for the whole week from 21st to 25th January 2008. Then, I adapted the returns of the actual fraud week to a relatively calm week in the future that starts 12th and ends 16th March 2012. That scenario shows what would have been the propagation values of five stocks and two indices, if Jerome Kerviel Fraud happened in such a calm week in the future.

Instead of the propagation values, I used KLIC values to test the other hypothesis that, the impact of Jerome Kerviel Fraud depends on the period. Moreover, KLIC is an abbreviation of

Kullback-Leiber information criterion, which is also known as Kullback-Leiber distance, or divergence. That theory simply demonstrates the difference between today's news balance and yesterday's news balance; in order to denote how much information is created today. Of course this theory is applying with generalized version by replacing *today* with *t* and *yesterday* with *t-1* for measuring information gain from day to day (Schmidbauer&Rösch&Uluceviz, 2013, p.5). In order to apply this method to the first hypothesis, I created other hypothetical situations. This time, I used three different weeks in three different periods which were explained in the introduction. These are the weeks that start from 7th May 2007, 5th November 2007 and 3rd November 2008. All these weeks have exactly five trading days from Monday to Friday. The scenario is based on what will be the differences between the actual KLIC values and the KLICK values if the Fraud occurred in these weeks. I used median KLIC values of each week. That shows the size of information gain from Jerome Kerviel Fraud, or the size of the shock that comes from the Fraud. In another words, this scenario shows the impact of the Fraud for each period.

6. Empirical Findings

In this section, data is interpreted by applying the basis of the methodology, in order to investigate financial connectedness in the recent crisis times from the aspect of the fraud in Societe Generale. It starts with testing the first hypothesis by KLIC values, and then continues with testing of the second hypothesis by propagation values.

6.1 KLIC Values

There are four figures and a table in following pages, where the figures show KLIC values in relevant dates and the table shows the impact of hypothetical shock in different periods. The figures contain KLIC values of selected data in a large period of time that exceeds research area of this thesis. But that provides large perspective for readers to assess the impact of events with respect to information gain that was created. Broadly, that period starts from the middle of 2000 and ends to the beginning of 2013.

The Figure 1 shows the real KLIC values that occurred in the fraud week which starts from 21st January 2008, ends 25th January 2008. The values slightly exceed 0.0020 point. That value represents the impact of the news come from fraud and the news come from Societe Generale's transactions against the open positions that caused by fraud.

The Figure 2 shows the KLIC values that if this fraud happened in another week in the first period. That week starts from 7th May 2007, ends 11th May 2007. The values exceed 0.0050 point. That is a high number in comparison with the KLIC values of the original week. That means, if this fraud had happened in that week, it could have created much more information than the original week.

The Figure 3 shows the KLIC values of another week which is in the second period. It starts from 5th November 2007, ends 9th November 2007. The values slightly exceed 0.0025 which is 25% higher than the original week's value, but 50% less than the values of the week which is in the first period.

The Figure 4 shows the KLIC values of the week in third period. This week starts from 3rd November 2008, ends 7th November 2008. The values of this week are nearly about 0.005 points. That is far less than all the other values. This means if the fraud had happened in that week, its effect would have been much smaller than other weeks.

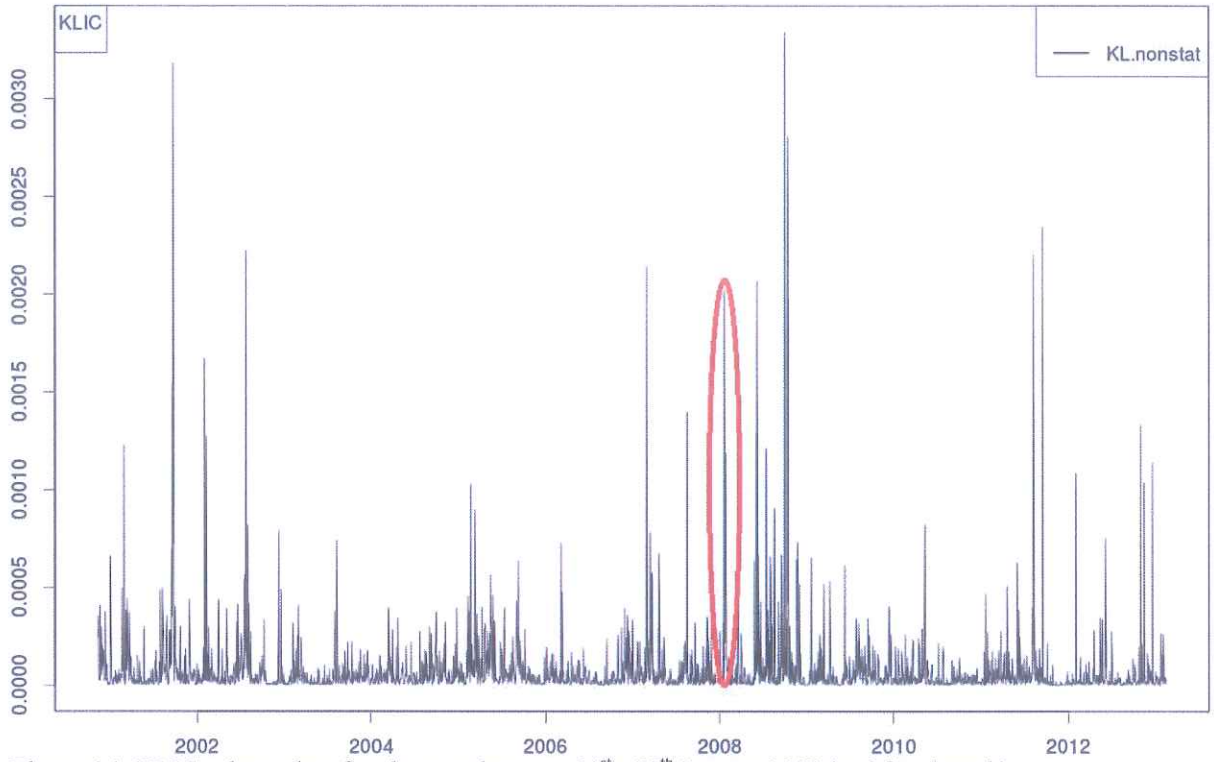


Figure 6.1: KLIC values when fraud occurs between 21st - 25th January 2008 (real fraud week)

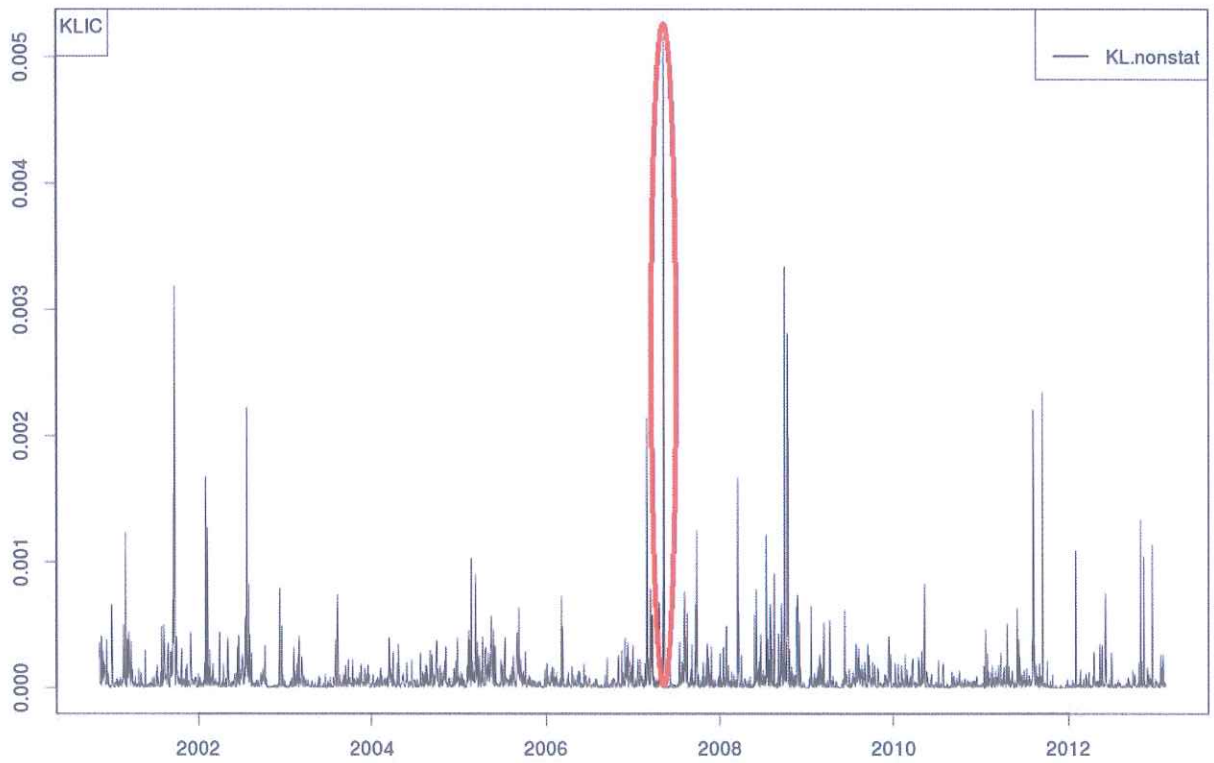


Figure 6.2: KLIC values when fraud occurs between 7th - 11th May 2007 (in Period 1)

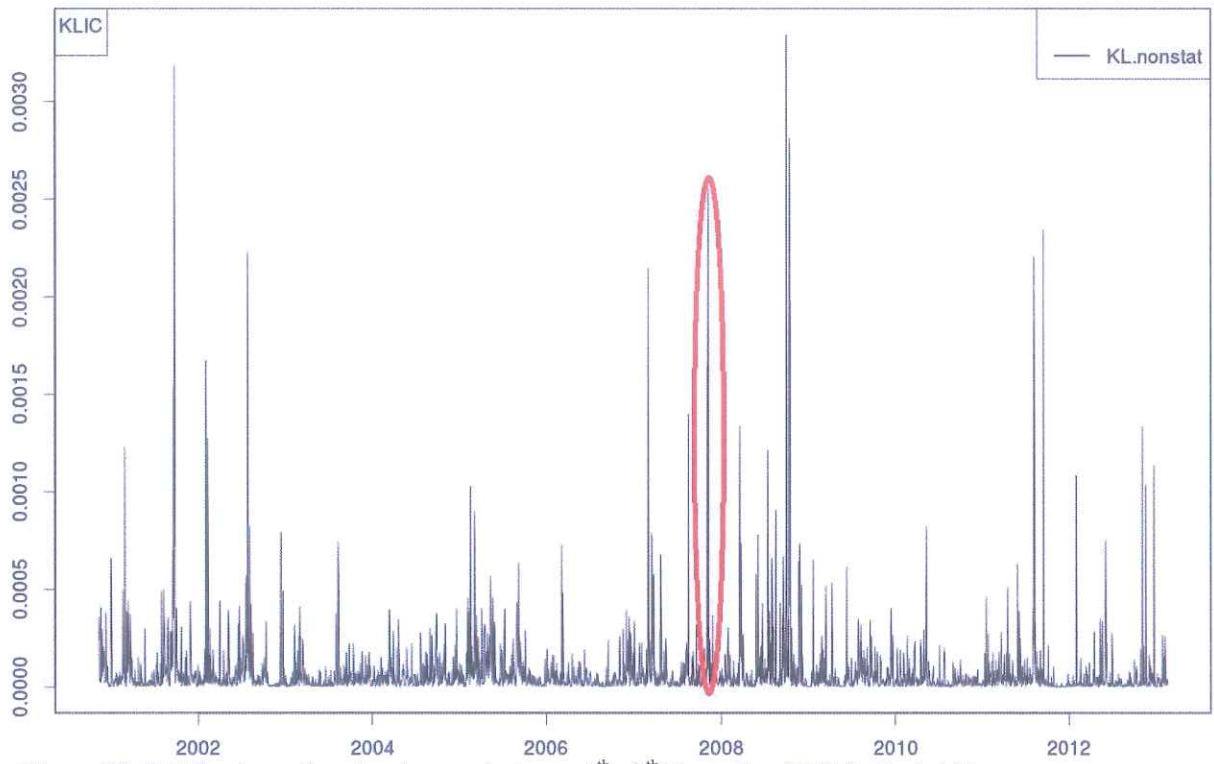


Figure 6.3: KLIC values when fraud occurs between 5th - 9th November 2007 (in Period 2)

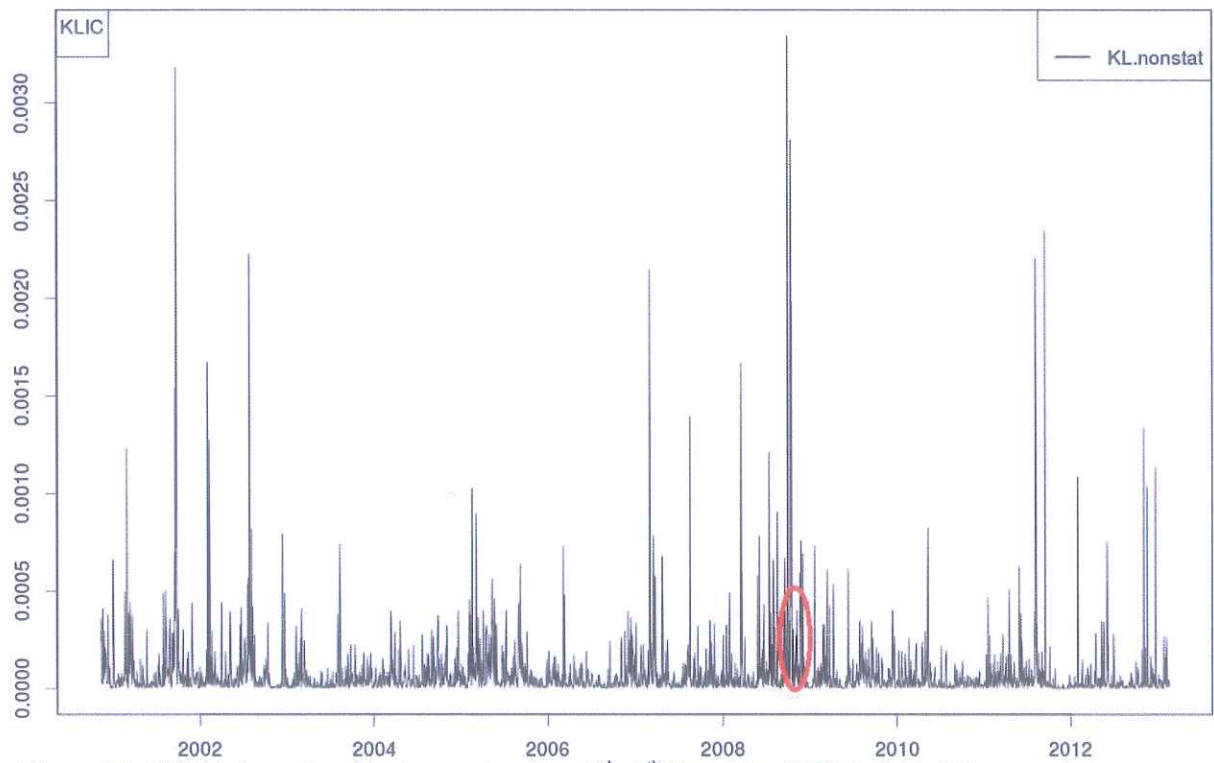


Figure 6.4: KLIC values when fraud occurs between 3rd - 7th November 2008 (in Period 3)

Table 1 shows the period specific KLIC values. These values represent what would have been the period based perspective of KLIC values, if Jerome Kerviel Fraud had happened in one of these periods or if it had not. The difference between values with fraud effect and values without fraud effect shows the strength of the impact of Jerome Kerviel fraud in each period. It can be inferred from Table 1 that the impact of this event would be stronger if it happened in first period instead of second period. Besides, its impact would be weaker if it happened in third period instead of second period.

Table 6.1: Median KLIC values and Median hypothetical differences by period

	Median KLIC values ($\times 10^{-5}$)	Median differences ($\times 10^{-5}$)
Period 1	3.0	99.9
Period 2	3.2	25.1
Period 3	2.4	2.3

6.2 Propagation Values

There are two figures in the following page, which are about the propagation values of the selected data. These show if the fraud happened in different time after the crisis, the repercussions would be less than the original repercussions in the original fraud week. Figure 5 represents the real situation. Figure 6 represents a hypothetical situation that, the fraud did not occur in week 21st to 25th January 2008, but it occurred in week 12th to 16th March 2012. In this situation, the propagation values of the two weeks, both in two pictures, are changed. But the important point is first week's (real week) propagation values in Figure 5 are higher than the second week's (fiction week) propagation values in Figure 6. In other words, when the fraud postponed to after crisis period and a relatively calm week, the propagation values of five banking stocks and two indices goes down.

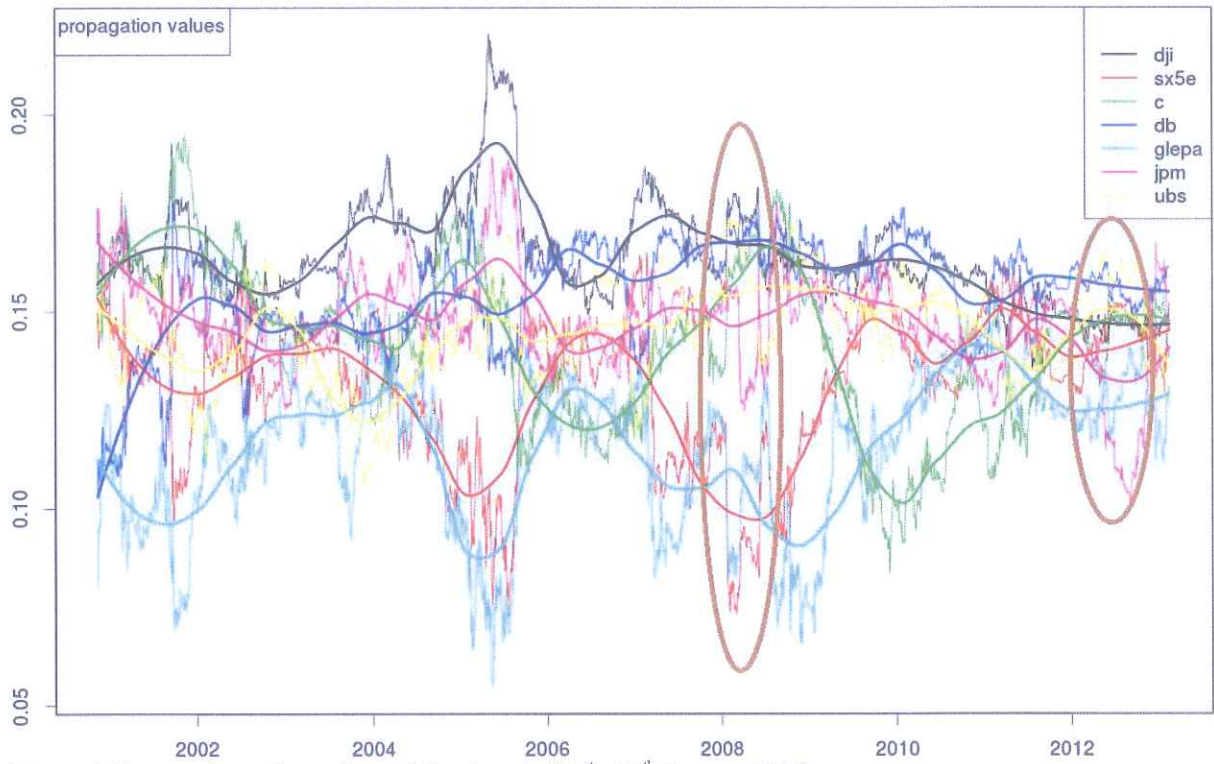


Figure 5: Propagation values of actual fraud week (21st - 25th January 2008)

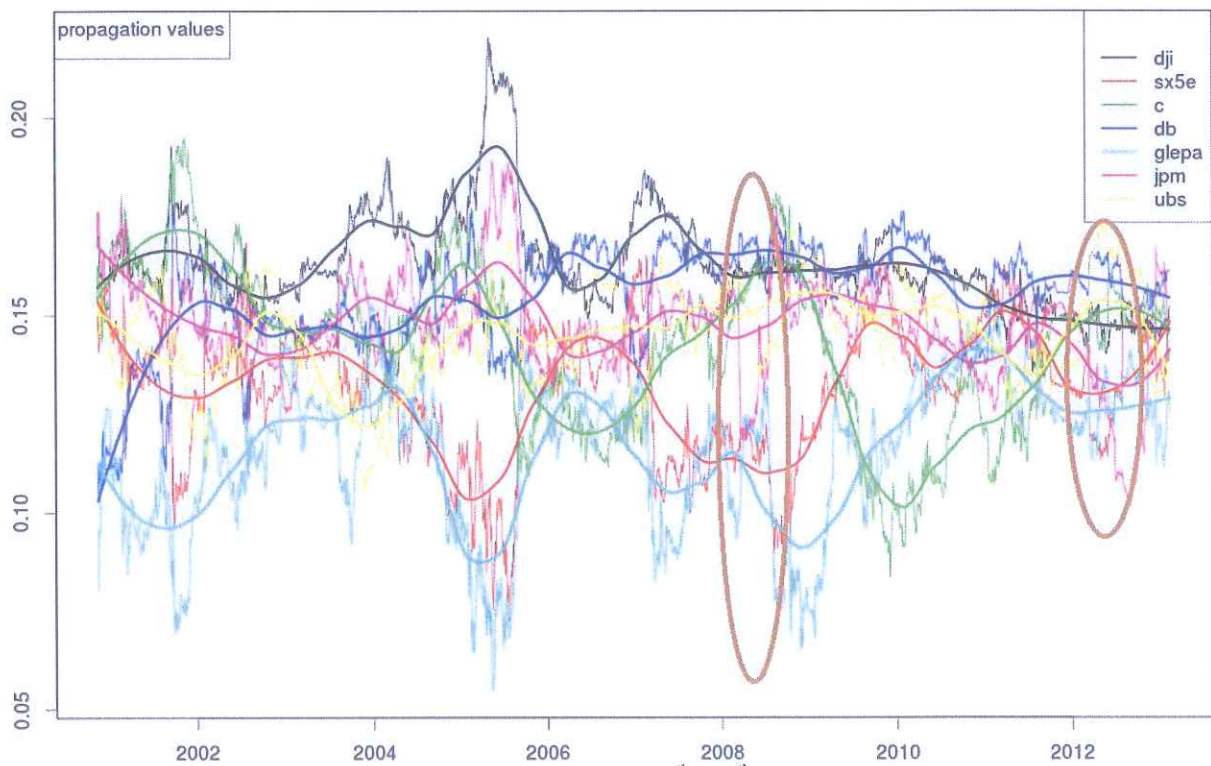


Figure 6: Propagation values of hypothetical fraud week (12th - 16th March 2012)

7. Summary and Conclusions

In this thesis, effects of Jerome Kerviel fraud in Societe Generale Bank on the global connectedness in equity markets in crisis times are investigated. The fraud took place in the middle of the sub-prime mortgage crisis and lots of financial complications occurred in the fraud's exposure week. Thus, so much information created in this crisis period effects financial asset prices, returns, and general mood in the markets. Since these financial complications had an effect on the financial system worldwide, this topic fits with financial connectedness and information gain theories. The main idea of this thesis came out from this perspective.

Firstly, three periods which are separated by structural break downs in the financial markets, were determined from the literature. These three periods with different market structures, provides opportunity to compare and assess this fraud's effects in order to information gain and financial connectedness. Then, the data is selected from European markets relevant to the rogue trader's open positions, and US markets which reflects the mortgage crisis. Furthermore; the methodology, which is mainly followed from Schmidbauer, Rösch, and Uluceviz's articles (2012, 2013) applied to the data.

Moreover, there are two hypotheses that are tested in this thesis by two methods. First one is that the impact of the fraud in Societe Generale depends on those three periods. That is tested with the concept of information gain, by using KLIC values. The empirical findings give evidence for this hypothesis. The KLIC values are totally different in three periods and they are declining from the first period through the third period. This means the market structure is different in these periods and the impact of this fraud would be different in these periods.

The second hypothesis is the propagation values of the selected data would be declined if this fraud happens after the crisis. That is tested with the propagation values. The empirical findings also give evidence for this hypothesis. These two tests show us, the financial connectedness differs in different market structures, especially in crisis times. One event can

have different effects and with different strengths in different market structures. Because the amount of the information that one event can create depends on the market's ability to receive it. This is also mentioned in literature with different words. As it explained in the Literature Review part, the borrower's creditworthiness changes after August 2007, or spread between FED rates and Overnight Index Swap, or spread between effective funds rate and Fed funds rate, and other measures change in different times. These represent changes in risk appetites. Thus, this thesis shows Jerome Kerviel Fraud, as one specific event, can have different effects in different market structures.

References

Allen, F. & Gale, D. (February 2000). Financial contagion. *Journal of Political Economy*, 108(1), 1-33.

Alter, A. & Beyer, A. (October 2012). The dynamics of spillover effects during the European sovereign debt turmoil. *Center for Financial Studies Working Papers 2012/2013*. Goethe University, Germany

American Recovery and Reinvestment Act of 2009. (n.d). Retrieved May 1, 2013 from http://en.wikipedia.org/wiki/American_Recovery_and_Reinvestment_Act_of_2009

Angelini, P., Nobili, A. & Picillo, C. (August 2011). The interbank market after August 2007: What has changed, and why?. *Journal of Money, Credit and Banking*, 43(5), 923-958.

Aragon, G. & Strahan, P. (2010). Hedge funds as liquidity providers: Evidence from the Lehman Bankruptcy. *Working paper, presented at Western Finance Association, and Securities and Exchange Commission USA*.

Arvai, Z., Driessen, K. & Ötöker-Robe, I. (January 2009). Regional financial interlinkages and financial contagion within Europe. *International Monetary Fund Working Papers, 2009*.

Boorman, J. (June 2009). The impact of financial crisis on emerging market economies: the transmission mechanism policy responses and lessons. *Discussion paper, presented at Global Meetings of the Emerging Markets Forum 2009, India*.

Canac, C. & Dyakman, C. (2011). The tale of two banks: Societe Generale and Barings.
[http://www.thefreelibrary.com/The+tale+of+two+banks%3A+Societe+Generale+and+Baring
s.-a0267976158](http://www.thefreelibrary.com/The+tale+of+two+banks%3A+Societe+Generale+and+Baring+s.-a0267976158)

Chronology: financial crisis spreads from US to world markets. (October 4, 2008).
<http://www.dw.de/chronology-financial-crisis-spreads-from-us-to-world-markets/a-3689713>

Diebold, F. & Yılmaz, K. (January 2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, 119, 158-171.

Diebold, F. & Yılmaz, K. (January 2010). Better to give than to receive: predictive directional measurement of volatility spillovers. *The TÜSİAD-Koç University Economic Research Forum Working Paper Series*.

Diebold, F. & Yılmaz, K. (October 2011). On the network topology of variance decompositions: measuring the connectedness of financial firms. *The TÜSİAD-Koç University Economic Research Forum Working Paper Series*.

Engqvist, T. & Kristiansson, M. (November 21, 2012). Reading project Jerome Kerviel.
<http://www.math.chalmers.se/~rootzen/finrisk/Reading%20Project%20Jerome%20Kerviel.pdf>

Euro Stoxx 50. (n.d). Retrieved May 1, 2013 from
http://en.wikipedia.org/wiki/Euro_Stoxx_50

Frank, N., Gonzales-Hermisso, B. & Hesse, H. (August 2008). Transmission of Liquidity Shocks: evidence from the 2007 subprime crisis. *Presented in conferences at Bank de France and Brunel University.*

Frank, N. & Hesse H. (May 2009). Financial spillovers to emerging markets during the global financial crisis. *International Monetary Fund Working Papers.*

Forbes, K. & Rigobon, R. (October 2002). No contagion only interdependence: measuring stock market comovements. *The Journal of Finance*, 57(5), 2223-2261.

Global shares tumble on US fears. (January 22, 2008).

<http://news.bbc.co.uk/2/hi/business/7199552.stm>

January 2008 Societe Generale trading loss incident. (n.d). Retrieved May 1, 2013 from <http://stockthoughts.wordpress.com/2008/02/06/january-2008-societe-generale-trading-loss-incident/>

Knapp, M. (2011). *Contemporary auditing: real issues and cases, eight editions.* United States of America: South Western Cengage Learning.

Kuo, D., Skei, D. & Vickery J. (June 2012). A comparison of Libor to other measures of bank borrowing costs.

http://www.newyorkfed.org/research/economists/vickery/LiborKSV_staff_webpage.pdf

Longstaff, A. (2010). The subprime credit crisis and contagion in financial markets. *Journal of Financial Economics*, 97, 436-450

Pritsker, M. (August 11, 2000). The channels for financial Contagion.

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.197.4356&rep=rep1&type=pdf>

Rogue trader Jerome Kerviel: 'I was merely a small cog in the machine'. (2010).

<http://www.spiegel.de/international/business/rogue-trader-jerome-kerviel-i-was-merely-a-small-cog-in-the-machine-a-729155.html>

Schmidbauer, H., Rösch A. & Uluceviz, E. (2012). Understanding market connectedness: a Markov chain approach. *The International Institute of Forecasters' Edition; Proceedings of the 32nd International Symposium on Forecasting ISF 2012.*

Schmidbauer, H., Rösch A. & Uluceviz, E. (2013). Information propagation between equity markets: the case of the BRICT. *Working paper, to be presented at EcoMod 2013, July 2013, Prague.*

Epstein, J. (May 2008). Security lessons learned from Societe Generale. *Security & Privacy, IEEE, 6(3), 80-82.*

Turner, S. (January 21, 2008). <http://www.marketwatch.com/story/stocks-turn-bearish-after-worst-day-since-sept-11-2001>

Subprime crisis impact timeline. (n.d). Retrieved May 1, 2013 from

http://en.wikipedia.org/wiki/Subprime_crisis_impact_timeline

Taylor, J., Williams, J. (April 2008). A black swan in the money market. *Federal Reserve Bank of San Francisco Working Paper Series*.