A Comparative Analysis of US Financial Stress Indicators

by

Nimantha P. Manamperi
Texas Tech University, Lubbock, Texas

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ABSTRACT

This paper provides a comparative analysis of the financial stress indexes available for the U.S. The main objective of these stress indexes is to provide detailed insights about the financial conditions in the U.S. economy. There are number of financial stress indexes issued by different financial entities including the Federal Reserve Bank of US, International Monetary Fund and several other private financial institutions. In general, the financial stress indexes indicated a higher financial risk during the 2008 financial crisis. Among the Federal Reserve financial stress indexes, Kansas City Fed Financial stress index (KCFSI) and St. Louis Fed Financial stress index (STLFSI) show similarities during 2008 financial crisis. Almost all financial stress indexes are non-stationary in their original data levels. Moreover only the CITI Group Financial Stress Index (CITI_FSI) shows a structural break. The out-of-sample forecast predicts an almost zero level financial stress closer to mid-2013. The in-sample forecast which uses the financial stress data up to the start of late 2007 recession predicts that the U.S. economy would have been operated with a much lower financial stress after December 2007 than it with the stress data for the 2007 recession. The last in-sample forecast analysis which uses the financial stress data up to September 15th 2008, the day which Lehman Brothers filed for Bankruptcy, predicts that the actual financial stress after the bankruptcy would have been much lower than it with the effect of the Lehman Brother collapse.

Keywords: Financial Stress, Forecasting, Financial Crisis, Financial Stress Index
JEL Classification: C53, G01, G32

Chapter 1: A Comparative Analysis of US Financial Stress Indicators

1. INTRODUCTION

The recent financial crisis which started in late 2007 has created significant uncertainties in the global economic conditions. This great recession is also identified as the most serious financial disruption since the Great Depression in early 1930 (Hatzius, Hooper, Mishkin, Schoenholtz and Watson 2010). Financial crises typically involve significant disruptions in asset prices and failures in financial institutions. The 2007 – 2009 financial crisis was also started as a result of a significant price drop in the housing market in the US. This later created significant amount of adverse influences on the financial sector in the US and later around the world. The disruptions in the financial market negatively influenced the macroeconomic outcomes like Gross Domestic Product, Economic Growth, Employment, interest rates, stock market values etc… (Reinhart and Rogoff 2008, Hall 2010). Moreover the 2007 - 2009 financial crisis made the monetary and fiscal policy actions more volatile and inappropriate to solve the given economic problems (Curdia and Woodford 2009, Gertler and Karadia 2010, Hamilton and Wu 2012). Also the high volatility in financial stability made the policy makers more uncertain and more unconfident in their policy making process (Baxa, Horvath and Vasicek 2012). These facts stimulated the researchers to further investigate the insights of the financial crises and the resulting economic conditions.

Once the Federal Reserve Bank chairman, Ben Bernanke[1], has mentioned that the monetary policy makers should provide significant attention on studying the financial stability similar to the effort they allocate on the monetary policy decisions as it can provide valuable insights to manage the financial crises efficiently. Today, the financial stability has become one of the key concerns for the policy makers as it should be clearly monitored to achieve the stability in economic activities. As a result, the development of tools which can monitor the vulnerability in financial markets has become one of the key research areas in the current literature. The financial stress indicator is one of the key tools.

[1] Crutsinger 2012 ; *http://www.huffingtonpost.com/2012/04/13/ben-bernanke-financial-crisis_n_1424128.html*

An exogenous shock to financial conditions can create changes to the existing financial structure of an economy. If the shock is negative, then it can create a negative financial stress in the economy (Illig and Liu 2006). The 1973 oil price shock and the 2007 asset price shock are some of the many shocks which created financial stress episodes in the U.S. history. Financial stress indicators are created to provide information on current levels of the financial variables which can influence the future economic conditions (Hatzius, Hooper, Mishkin, Schoenholtz and Watson 2010). These indicate that the financial stress indexes can be used as an effective tool to manage the monetary policy decision making process (Baxa, Horvath and Vasicek 2012). These indexes can also be used to forecast the future financial conditions which provide a society with better decision making opportunities.

The objective of this paper is to provide a comparative analysis on different financial stress indexes available for the US. Section 2 provides a historic evolution of the financial stress indexes. Section 3 describes available financial stress indexes for the US. Section 4 compares the differences between financial stress indexes in the US. Section 5 provides a forecasting analysis of the Federal Reserve Bank issued Financial Stress Indexes. Section 6 concludes the results.

2. A HISTORIC EVOLUTION OF FINANCIAL STRESS INDEXES

The early researches on financial conditions have considered single variables to measure the financial stress in an economy. These include the slope of the yield curve, the spread between 10 year treasury notes and the federal funds rate, the real Money2 (M2), the S&P 500 index[2], the short term credit spread measured as the spread between the three month commercial paper rate and the three month treasury bill rate and federal funds rate (Estrella and Hardouvelis 1990, Laurent 1989, Freidman and Kuttner 1992). Some studies used binary variables, 1 for stress period and 0 for non-stress period, to define the financial conditions in an economy (Goldstein et al. 2000). But these indexes outperformed the following mentioned comprehensive financial stress indexes on predicting recessions and forecasting complex financial conditions of an economy (Hatzius, Hooper, Mishkin, Schoenholtz and Watson 2010). The Bank of Credit Analyst

[2] S&P 500 Index : http://www.standardandpoors.com/indices/sp-500/en/us/?indexId=spusa-500-usduf--p-us-l--

(BCA)[3] reports a monthly financial stress index (BCA-FSI) for the US by comparing the composition of banking shares to total market shares. But this index only provides the stress in the banking sector not the stress in the entire financial sector. The Chicago Board of Exchange provides the VIX index[4]. This does not capture the stress in the entire financial market but measure the stress in the exchange market. Therefore the lack of measuring the stress in the entire financial market is one of the key limitations associated with these indexes. These indexes were introduced in early 2000. The limitations in these indicators paved the pathway to find new financial stress indictors which capture the stress in the entire financial market. The Bank of Canada developed a well-established financial stress index for Canada which is the very first comprehensive index to be created in this area (Illing and Liu 2006). This index covered all three sectors in the financial market; equity, bond and foreign exchange. Later four Federal Reserve Banks in the US Federal Reserve System came up with four different financial stress indexes for the US; The Chicago Federal Reserve Bank's Financial conditions index (NFCI) in 2006, The Kansas City Federal Reserve Bank's Financial Stress Index (KCFSI) in 2009, The St. Louis Federal Reserve Bank's Financial Stress Index (STFSI) in 2010 and the Cleveland Federal Reserve Bank's Financial Stress Index (CFSI) in 2011. They measure the financial stress in the US.

The requirement of having a financial stress index for all the countries in the world became significant during the 2007-2009 financial crisis. The International Monetary Fund (IMF) created a financial stress index to measure the financial conditions in the advanced economies named advanced country Financial Stress Index (AE_FSI) (Cardarelli, Elekdall and Lall 2009). IMF has also created another financial stress index to capture the financial stress in the emerging countries named Emerging country Financial Stress Index (EM_FSI) (Balakrishnan et al. 2009). In addition, there are other financial stress indexes available for the US such as the Bloomberg Financial conditions Index, the Citi Financial Conditions Index, the Deutsche Bank Financial Conditions Index, the Goldman Sachs Financial Conditions Index, the Macroeconomic Advisor's financial

[3] BCA : http://www.bcaresearch.com/
[4] VIX Index : http://www.cboe.com/micro/VIX/vixintro.aspx

conditions Index[5] and OECD Financial conditions Index. These indexes measure the financial conditions in an economy. A variety of construction methodologies were used to create these financial stress indexes over time. The two main methodologies used are a principal component approach and a weighted sum approach. The principal component method obtains the first principle component to represent a larger portion of the variations in the financial variables. The weighted sum approach typically uses the relative impact of financial variables on the changes in the real GDP as the weighting scheme. Most of the financial stress indexes only use current financial variables to calculate the FSI but some methodologies have tried adding the lagged financial variables in to the model so as to understand how the past financial stress episodes influence the current financial conditions. Most of the established Financial Stress indexes use some common financial variables like short term interest rates, equity market performances, exchange rates, yield spreads and stock market performances in their construction process. Generally each and every financial variable is standardized by subtracting the respective mean values from their original data set and dividing the result by the respective standard deviations. This is done to convert all variables unit free in the financial stress construction process to avoid any interpretation contradictions.

This paper focuses on providing a comparative analysis on different financial stress indexes available for the US. The financial stress indexes which are in monthly frequency are chosen for this study due to the data availability issues in handling econometric techniques. The following financial stress indexes are chosen; St. Louis Fed Financial Stress Index (STLFSI), Kansas city Fed Financial Stress Index (KCFSI), Chicago City Fed National Financial Conditions Index (NFCI), Cleveland Fed Financial Stress Index (CFSI), International Monetary Fund Financial Stress Index (AE_FSI), Bloomberg Financial Conditions Index (BFCIUS) and the City Financial Stress Index (CITI_FSI)[6]. The following is a detailed description of these indexes.

[5] These, however are generated by private institutions and look at risk in the market for a long period of time. The important distinction is that presumably they do so to find arbitrage opportunities in the market whereas the stress indicators by the Federal Reserve System banks, OECD and the IMF are presumably generated to inform policy.

[6] Although the OECD Financial Conditions Index is much broader than CITI_FCI and BFCIUS, this paper does not analyze the OECD FCI as it comes only with quarterly frequencies.

2.1: Chicago Fed's National Financial Conditions Index (NFCI)

Scott Brave and Andrew Butters of the Federal Reserve Bank in Chicago introduced the NFCI in 2006 to measure the financial conditions in the US economy. It provides weekly and monthly updates on financial conditions in banking systems, money markets and debt and equity markets in the US. Since the US economic conditions are correlated with financial conditions, an adjusted financial conditions index (ANFCI), which measures the financial conditions uncorrelated with economic conditions is introduced to interpret the behavior of financial conditions relative to current economic conditions more accurately. This index is available since 1973 and is the longest financial stress index provided by a federal reserve bank in the US. The NFCI and ANFCI are revised on a weekly basis at 8.30 am Eastern Time on every Wednesday. One of the prominent features of NFCI is the use of 100 different financial variables to construct the index. This helps identifying a wide range of possible influences of economic conditions on the financial stress in the US. Further the comparison of current financial conditions to its historical average levels is more informative in analyzing the financial situations in an economy (Brave and Butter 2010, 2011). The construction of NFCI involves 100 different financial activity measures which covers the three market segments; Money Market, Debt and Equity Market and Banking system. The table 1 provides the composition of the variables used in this index construction. Among the variables considered, 41 of them are on weekly, 41 of them are in monthly and the rest 25 are on quarterly data frequency. A dynamic factor analysis is used to construct the NFCI (Doz, Giannone and Reichlinis 2006). This method provides the technical capability on working with data series which begins and ends in different time periods as in this study. First, each data series are expressed relative to their sample mean. Then they are divided by the respective sample standard deviations to convert in to a same scale. A dynamic factor analysis is then applied to construct the NFCI (Brave and Butters 2011). This method identifies the variables which are highly correlated with each other and which show a similar evolutionary behavior by assigning optimal weights through the dynamic factor analysis. Following table shows the highest weighted variables in each market segment.

Category	Market	Count of Indicators
Money Markets	Repurchase Agreements	10
	Treasuries	9
	Commercial Paper	5
	Interbank Lending	4
Money Markets Total		**28**
Debt and Equity Market	Corporate Bonds	7
	Securitized Debt	7
	Stock Markets	6
	Municipal Bonds	4
	Collateral Prices	3
Debt and Equity Market Total		**27**
Banking System	Consumer credit conditions	13
	Banking system Conditions	9
	Shadow Bank Assets and Liabilities	8
	Business Credit Conditions	8
	Commercial Bank Assets and Liabilities	7
Banking System Total		**45**
Total number of variables		**100**

Table 1: The market composition of the variables used in this study

Market	**Indicator with the Greatest Weight in the NFCI**
Repurchase Agreements	Total Repo Market volume
Treasuries	2-year Interest rate Swap/Treasury Yield Spread
Commercial Paper	1-month Nonfinancial commercial paper A2P2/AA credit spread
Interbank Lending	3-month TED Spread (LIBOR-Treasury)
Corporate Bonds	Merrill Lynch High Yield/Moody's Baa corporate bond yield spread
Securitized Debt	Citigroup Global Markets ABS/5-year Treasury yield spread
Stock Markets	CBOE S&P 500 Volatility Index (VIX)
Municipal Bonds	Bond Market Association Municipal Swap/20-year Treasury yield spread
Collateral Prices	MIT Center for Real Estate Transactions-Based Commercial Property Price Index
Consumer credit conditions	30-year Jumbo/Conforming fixed rate mortgage spread
Banking system Conditions	Credit Derivatives Research Counterparty Risk Index
Shadow Bank Assets and Liabilities	Total Assets of Funding Corporations/Nominal GDP
Business Credit Conditions	Senior Loan Officer Opinion Survey: Tightening Standards on Small C&I Loans
Commercial Bank Assets and Liabilities	Commercial Bank C&I Loans/Total Assets

Table 2: The Indicator variable with the greatest weight in the respective markets in the NFCI

A positive NFCI indicates a tighter financial condition than average while a negative value indicates a looser financial condition than average. The level of how 'tight' or how 'loose' the

financial market conditions is determined by the deviation of the NFCI from its average. A zero value indicates the economy is at average risk level. The positive value indicates the economy is at above the average risk level while a negative value indicates the economy at below the average risk level. The following figure shows the most updated NFCI fluctuations since 1973.

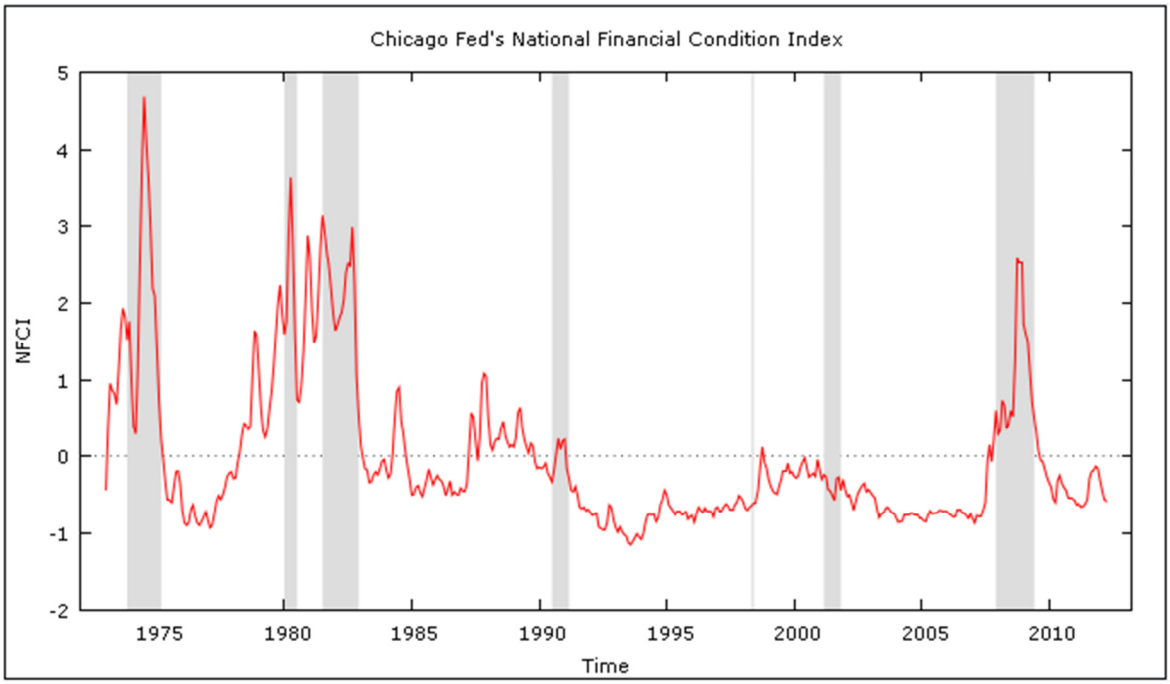


Figure 1: The Chicago Fed Financial Conditions Index (NFCI) *: Shaded areas indicate Recessions in the US history (http://www.nber.org/cycles/cyclesmain.html)*

The NFCI indicates a higher financial stress during mid-1970 recession and early 1980s than that during the late 2000s recession. In general, index shows higher values during all the past recessions.

2.2: Kansas City Fed's Financial Stress Index (KCFSI)

In 2009, Craig S. Hakkio and William R. Keeton introduced the KCFSI from their paper *"Financial Stress: What is it, How Can It be Measured, and Why does it matter?".* They tried to identify all possible key phenomena of financial crises as they show different characteristics to one another. The following five phenomena were identified as the most important features of any given financial stress although their relative importance may differ from one another.

Phenomenon 1: Increased uncertainty about the fundamental values of assets; During financial crisis times the uncertainty of the fundamental values of the asset prices increases (Hakkio and Keeton 2009). Therefore the confidence of investors and lenders on the dividend payments and interest rate payments goes down. This can create more volatility in the asset prices which makes the investors react more carefully in the financial markets. Therefore investors may review all possible new information frequently and take more time to make an investment decision. This will create a significant volatility in the stock prices and reduce the future investor confidence in the stock market. So increased uncertainty about the fundamental values of assets is a common feature of most of the financial crisis we had (Hakkio and Keeton 2009).

Phenomenon 2: Increased Uncertainty about behavior of other investors; In the asset pricing market the expected return from an asset that may need to be sold before its maturity totally depends on the behavior of the other investors. If other investors do show a higher volatility in confidence of the market then the volatility in the asset prices gets higher as investors make their decisions on guesses about other investors' decisions (Hakkio and Keeton 2009). Therefore higher uncertainty about behavior of other investors and its consequences are possible signs of financial crisis.

Phenomenon 3: Increased asymmetry of information; An increase in asymmetry of information between buyers and sellers or borrowers and lenders is a common feature during financial stress times. This can occur when borrowers know more about their actual financial condition than lenders or sellers know more about actual value of the assets than the buyers. This can create strategic conflicts between these parties and therefore ineffective asset valuations. Further asymmetry of information can increase the cost of borrowings than what it should be and increase the value of the asset what it should be under the given market conditions. When lenders realize that they know much less about the borrowers then they reduce the lending which can slowdown the investments and economic growth. So an increase in asymmetry of information is a key feature during a financial crisis.

Phenomenon 4: Decreased Willingness to hold risky Assets (Flight to quality) ; During financial crisis times the willingness to hold risky assets goes down while the willingness to hold safe assets increases due to higher uncertainty in the asset (Hakkio and Keeton 2009, Guttentag and Herring 1986). During financial crisis times investors and lenders face higher uncertainty in the returns, market activities and etc… Therefore they will move on buying safe assets than risky assets. This increases the gap between the returns of these two types of assets. This change also increases the cost of borrowing risky assets than borrowing safe assets (Caballero and Kurlat 2008).

Phenomenon 5: Decreased Willingness to hold illiquid Assets (Flight to liquidity) ; During financial crisis times a decrease in willingness to hold illiquid assets occur due to two main reasons; unexpected need for cash or decrease in liquidity of some assets. When the economic and financial conditions are unpredictable people will face unexpected cash requirements. Therefore they may have to sell the illiquid assets to get cash. Moreover a decrease in liquidity of some assets encourages people to sell illiquid assets (Hakkio and Keeton 2009). Since the demand for liquid assets goes up the cost of borrowing liquid assets increases during financial crisis times. Further the asymmetry of information distribution makes the asset prices more uncertain during a financial crisis period. This makes the investors not to invest large amount of money in illiquid assets. Instead they invest in liquid assets which can be easily converted to cash whenever it is required. So a decrease in willingness to hold illiquid assets is one of the main features of financial crisis times.

The following criterion is used for the variable selection process. First, each variable should represent one or more of the above mentioned five main characteristics of a financial crisis. Second, each variable had to be related with either prices or yields of the financial markets as they show possible fluctuations in financial markets accurately. Third, each variable had to be in at least monthly basis as the objective to construct a monthly financial stress index. Finally, each variable had to be obtainable since 1990. The following 11 variables which satisfied the above conditions were selected to generate the KCFSI.

[A]. 3 Months LIBOR/T-Bill Spread (TED Spread): London Interbank Offered Rate (LIBOR) measures the cost of short term interbank lending. This rate depends on the risk estimated on borrowing banks by the lending banks. The Treasury bill rate may differ from LIBOR due to two main reasons. First, lending bank may be uncertain about the repayment of the loan. Second, lending banks may assume that they may need unexpected need for funds before it matures. Therefore these events can change the LIBOR rate. This variable represents information asymmetry, flight to liquidity and flight to quality and is available since 1986.

[B]. 2 Year Swap Spread: Under an interest rate swap one party agrees to pay fixed rate payments (which are based on Treasury yield) for floating rate payments (which is based on LIBOR). Interest rate swap is always positive due to following two reasons (Grinblatt 2002). First, the swap spreads can be easily sold in a secondary market as the fixed rate payments are led liquid than treasury yield of the same maturity. Second, the LIBOR which determines the floating rate is always higher than the short term treasury yield. This makes the interbank lenders are well compensated for the default and liquidity risk at any point in this method. Since these two reasons are related with the concepts, flight to liquidity and flight to quality, 2 year swap spread was considered as another variable. This variable is available since 1988.

[C]. Off the run/on the run 10 year treasury spread : On the run security is a most recently issued security at the same maturity while off the run security is a previously issued security with the same maturity. Generally the second hand market for the off the run securities are lower than that for the on the run securities (Hakkio and Keeton 2009). Therefore the yield of off the run securities has to be higher. This yield difference between off the run and on the run securities get larger with an increasing investor concern on unexpected cash requirements which can occur during financial crisis times. Therefore this variable represents the flight to liquidity characteristic and is available since 1986.

[D]. Aaa / 10 Year Treasury Spread: Generally the Aaa rated corporate bonds have no or minimal default risk than that of treasury securities. Moody's Aaa rated corporate bonds have higher yields than a typical treasury securities of similar maturity as the company that issued the debt

can prepay the loan if a decline in interest rates makes refinancing more attractive. Another reason is the less liquidity of the Aaa bonds than treasury securities. Therefore the spread between Moody's Aaa index and 10 year treasury yield captures the flight to liquidity characteristic of financial stress. This variable is available since 1953.

[E]. Baa/Aaa Spread: Baa is the lowest rank for a corporate bond. During economic expansions the yield on Baa bonds exceeds the yield on Aaa bonds as the default risk of Baa bonds as low as the Aaa bonds. But during financial stress times and many other economic stress periods, investors do not prefer Baa bonds over Aaa bonds as their default risk is higher. This will significantly increase the Baa rated bond yield in order to attract more investors during financial crisis times. Moreover investor preferences on Baa and Aaa bonds also depend on the information asymmetries. So the Baa/Aaa spread was considered as a variable in this model as it represents two of the main five characteristics of financial crisis; information asymmetry and flight to quality. This variable is available since 1919.

[F]. High yield Bond / Baa Spread: In general low rated bonds (junk bonds) offer high yields to motivate the investors for buying them. Generally the difference between the yield of junk bonds and Baa rated bonds are higher than the yield difference between Baa and Aaa rated bonds as junk bond try to be more competitive as Baa bonds (Hakkio and Keeton 2009). During financial crises investors do not like to hold risky assets. Therefore the yield of the junk bonds even gets higher to maintain their competitiveness in the bond market. Moreover the decreasing liquidity of the junk bonds during financial stress periods deviate the investors from buying them. As a precaution, the junk bond yield may go up significantly (Kwan 2001). Therefore high yield/Baa Spread represents the following characteristics of a financial crisis; flight to liquidity, information asymmetry and flight to quality. This variable is available since 1986.

[G]. Consumer ABS/5-year Treasury Spread: Consumer asset backed securities are backed by several loans including auto loans, credit card loans or student loans. When the economy is at its best or normal conditions, these securities do have a low risk but during financial crises they do have a high risk. The risk of treasury securities with same maturity is relatively low during both times. Investors do not like to hold risky assets during financial crisis times so the demand for

consumer backed securities goes down. In such times it is evident that the yield on consumer backed securities increases significantly and therefore the consumer ABS/5-year treasury spread also increases. Moreover the information asymmetry can significantly increase the yield of consumer ABS by developing an uncertainty in the investors' decision making process. Therefore the consumer ABS/5-year Treasury Spread can be identified as a variable which represents flight to quality and increased asymmetry of information in the financial crisis characteristics. This variable is available since 1990.

[H]. Correlation between returns on stocks and Treasury Bonds: The returns on stocks and government bonds are generally positively corrected during normal financial situations. During financial crisis times, investors believe that the risk associated with the stock returns is higher than that of the Treasury bond returns. Therefore during financial crises, the correlation between the stock returns and the Treasury bond returns show a negative relationship (Gonzalo and Olmo 2005, Baur and Lucey 2010). Therefore this variable represents the flight to quality feature in the financial crisis. Stock return was measured using the S&P 500 index and the Treasury bond return was measured by 2 year Treasury bond index. The negative correlation values were used to represent the financial crisis periods. This variable is available since 1988.

[I]. Implied Volatility of overall stock prices (VIX): VIX index which is constructed by the Chicago Board Options Exchange measures the volatility in the stock market. This index has the ability to capture the uncertainty in the fundamental values of assets. Also it indicates the uncertainty in the behavior of the investors. So this variable captures the following two characteristics of a financial crisis; flight to quality and information asymmetry. This variable is available since 1990.

[J]. Idiosyncratic volatility of bank stock prices: Commercial banks play a significant role in the financial markets and their behavior highly depends on the prevailing market conditions. During financial crises the bank stocks face higher market uncertainties than in normal financial conditions. So flight to quality, information asymmetry and flight to liquidity are the main characteristics which are commonly seen in banking decisions during financial crisis times. Therefore this variable is introduced in this model to capture the volatility in returns to commercial bank stocks and is available since 1990.

[K]. Cross section dispersion of bank stock returns: Information asymmetry, a characteristic of financial crisis, can increase the investor uncertainty on the relative quality of the banks. This can lead the investors to make inefficient choices in bank stock buying. Therefore investor uncertainty on relative quality of banks can be considered as a good indicator of the financial conditions. This was measured using the cross section dispersion of bank stock returns. Daily data on S&P 500 and the stock prices of 100 largest commercial banks in the US were used to calculate this variable. This variable is available since 1988.

Hakkio and Keeton assumed the financial stress as the most responsible factor which explains the co-movements in the 11 variables considered. Therefore the principle components method was used to obtain this factor. First, each of the 11 variables were converted in to same unites by subtracting each and every value by their respective mean values and dividing by their respective standard deviations. Second, the coefficients of these converted variables in the index were calculated.[7] The best possible combination of coefficients is selected for the index to explain the maximum possible amount of total variation in the 11 variables. The following table summarizes the above explained variable composition of KFSI.

Characteristics of the Financial Crisis	**Variables**
Increased Uncertainty of the Fundamental values of Assets	A, B, D, F, K
Increased Uncertainty of the Investor Behavior	C, E, F, I, K
Increased Asymmetry of Information	A, E, F, I,J, K
Flight to Quality	A, B, F, G, H,I, J
Flight to Liquidity	A, B, C, D, F, J

Table 3: The Variable Composition of KFSI[8]

[7] Read page 18 of Hakkio and Keeton (2009)

[8] *[**A**]-TED Spread, [**B**]-2 Year SWAP Spread, **[C]**-Off the run/on the 10 year treasury Spread, **[D]**-Aaa/10 Year Treasury Spread, **[E]**-Baa/Aaa Spread, **[F]**-High yield bond/ Baa Spread, **[G]**-Consumer ABS/5-year Treasury Spread, **[H]**-Correlation between returns on Stocks & Treasury Bonds, **[I]**-VIX Index, **[J]**-Idiosyncratic Volatility of Bank Stock prices, **[K]**-Cross section dispersion of Bank Stock Returns*

A positive value of the KCFSI indicates that the financial stress is above the long run average level while a negative value indicates the opposite of it. When the data series get new data with the time, it is required to calculate updated coefficients for the variables each and every time. So this may replace the existing FSI data values time to time. Further expansion of the sample period can change the values of the original

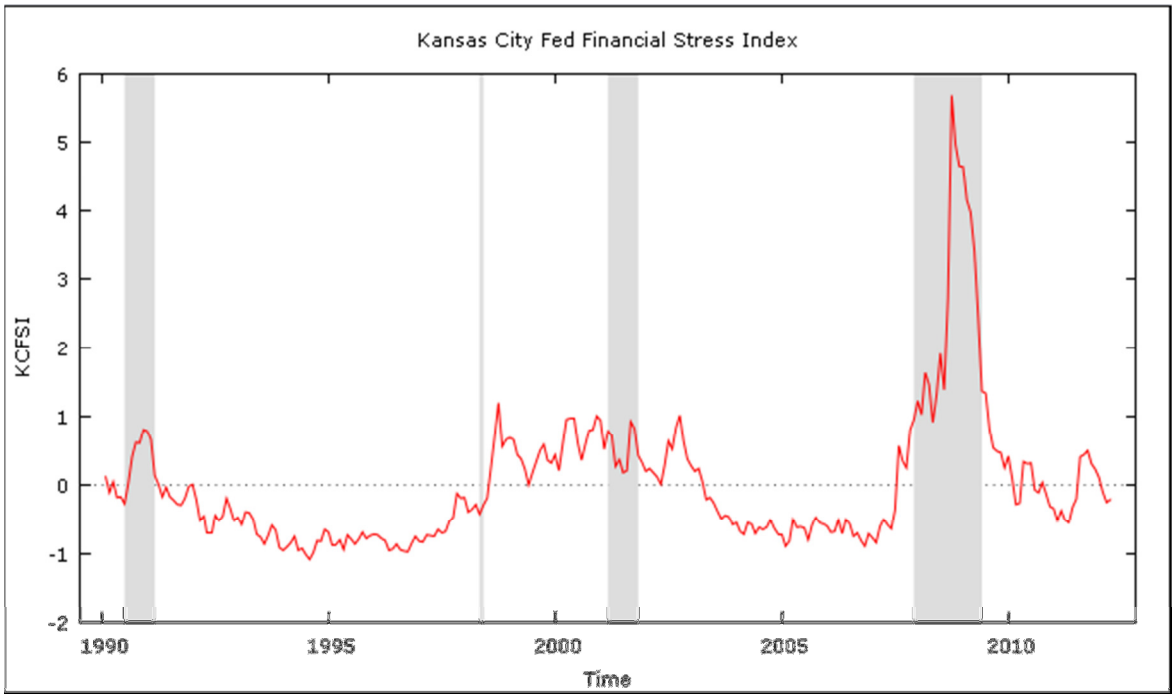


Figure 2: Kansas City Fed Financial Stress Index (KCFSI)

standardized demeaned data series and this can also change the existing FSI values. Therefore expansion of the data series requires repeating the principle component analysis from the beginning. The KCFSI shows a significant financial stress during the late 2000s recession.

2.3 St. Louis Fed Financial Stress Index (STLFSI)

The St. Louis Federal Reserve Bank constructed the St. Louis Financial Stress Index (STLFSI) in 2010 to measure the stress conditions in the financial market. The principal component method was used to construct the index. In statistics theory, Principal component analysis is used to extract the factors which are most responsible for the co-movements in a group of variables. In this scenario, the financial stress is considered as the first principal component of the co-movements of all variables in the financial stress analysis. The index is composed of weekly data

for 18 different variables for the period December 31, 1993 to December 11, 2009. The variables can be categorized in to three different segments; interest rate category, yield spreads category, exchange market and inflationary pressures, which generally represent the behavior of the financial conditions of an economy.

Market Segment	Variables
Interest Rates	The effective federal funds rate
	Two year treasury interest rate
	Ten year treasury interest rate
	Thirty year treasury interest rate
	Baa rated corporate interest rate
	Merrill Lynch High Yield corporate master II Index
	Merrill Lynch Asset Backed Master BBB-rated interest rate category
Yield Spreads	The Yield curve (10 Year treasury minus 3 months treasury)
	Merrill Lynch High Yield Corporate Master II Index minus 10 year treasury
	Corporate Baa rated bond minus 10 year treasury
	3 Month treasury Eurodollar (TED) Spread
	3 Months commercial paper minus 3 months Treasury Bill
	3 Months London Interbank Offering Rate-Overnight Index Swap Spread
Exchange & Inflationary Pressures	J.P. Morgan Emerging Markets Bond Index
	Chicago Board Operations Exchange Market Volatility Index (VIX)
	Merrill Lynch 1 Month Bond Market Volatility Index
	10 Year nominal treasury yield minus 10 year Treasury security yield
	Vanguard Financials exchange traded Fund

Table 4: The Variable Composition of STLFSI

As of July 15th 2010, the Vanguard Financial Exchange Traded Fund series was replaced with the S&P 500 Financials Index to make the STLFSI calculation process easier and timely. The following construction methodology is used for the index construction. First all the data series are demeaned. Then demeaned series are divided by their sample standard deviations to represent all the data series in the same units. Then the Principle components analysis is used to calculate the coefficients of the variables in the Financial Stress Index. Then those coefficients are scaled to make the standard deviation of the index to be 1. Next all the variables are multiplied by their respective adjusted coefficients and the financial stress index for any time 't' is calculated by

summing up all those values. The STLFSI also shows a significant financial stress during the late 2000s recession.

Figure 3: The St. Louis Financial Stress Index (STLFSI)

2.4 : Cleveland Fed's Financial Stress Index (CFSI)

Cleveland Financial Stress Index was originally constructed by Mikhail Oet, Timothy Bianco, Dieter Gramlich and Stephen Ong in early 2009 but it was published in November 2011. CFSI provides information on financial conditions in number of financial markets on a continuous basis. This helps analysts and policy makers to monitor the stressful situations as they are building. This measure can be used as a valuable tool on making various financial decisions for the US. CFSI has some novel contributions to the financial stress indices literature. The contribution of identifying the dating of the systematic risk episodes in the US is some of them. More importantly, unlike the KCFSI, STLFSI and NFCI, the CFSI has a unique ability to measure the financial stress in the following four markets separately; interbank, foreign exchange, credit and equity markets. These markets were considered in the financial stress index construction as they can represent the entire US financial market. This helps CFSI to provide more focused and accurate signals on the financial stress in the US. Daily data since 1991 on eleven variables were chosen for this study. The following provides a detailed explanation on the variables selected and their market

representation. Four out of eleven variables were selected to represent the stress originated in the Interbank Markets.

- **Financial Beta:** This variable is used to measure the volatility of the banking sector share prices with the overall stock market volatility. The covariance between banking sector share prices and the overall stock market prices divided by the variance of the overall stock market prices is used to define the Financial Beta variable. S&P 500 Financials Total Return Index was used for banking sector share prices and S&P 500 Total Returns Index was used for overall stock market prices.
- **Bank Bonds Spread:** This variable is calculated as the difference between 10 year A rated bank bond yields and 10 year treasury yields. This variable measures the medium to long term risk of the A rated bond issued by the banks.
- **Interbank Liquidity Spread:** This is measured through TED spread as it indicates the risk premium associated with lending to commercial banks. A growth in the TED spread indicates a financial stress in the interbank market a possible vulnerability in the banking sector. This variable is calculated as the difference between the 3 months LIBOR rate and the 3 months Treasury Bill Rate.
- **Interbank Cost of Borrowing:** The behavior of interbank lending and borrowings is a good indicator of the volatility and the riskiness in the banking sector. This variable is used to measure that volatility and the risk factor in interbank lending process. The difference between 3 months LIBOR rate and the Fed Funds Rate is considered as the Interbank Cost of Borrowings.

Following variables were selected to represent the foreign Exchange Market.

- **Weighted Dollar Crashes:** This measures the volatility and the uncertainty in the foreign exchange markets by quantifying the deviation of demand on US dollars towards other foreign currencies.

The Stock Market crash was used to represent the Equity Market.

- **Stock Market Crashes:** This variable measures the volatility in the stock market values by comparing the change in the current stock market values to the maximum stock market value in the earlier year.

Credit Market is represented by the following variables.

- **Covered Interest Spread:** This variable is used to measure the uncertainty in the government bond markets by comparing the 90 day US treasury bill rate with the 90 day UK treasury Bill Rate.
- **Corporate Bond Spread:** When the probability of making losses increases, firms may face difficulties in obtaining liquidity and in debt financing. This behavior can be quantified through the corporate bond spread. Therefore corporate bond spread is considered as a sophisticated stress indicator for the credit markets and is calculated as the difference between 10 year Moody's Aaa rated corporate bond yield and 10 year Treasury yield (Bianco, Oet and Ong 2011).
- **Liquidity Spread:** This measures the fluctuations in the short term differences between the bid prices and ask prices of three months treasury bills. A widened spread indicates a greater illiquidity in the market. Therefore a greater stress in the credit market.
- **90 Day Commercial Paper Treasury Bill Spread:** This is the difference between 90 day financial commercial paper rate and the 90 day U.S. Treasury Yield. It measures the short term risk premium on financial companies' debt. When the financial companies face higher risks during financial crisis times, this spread gets wider.
- **Treasury Yield Curve Spread:** The slope of the yield curve provides valuable insights about the economic activity, long term uncertainty and the short term liquidity risks in the economy.

Following table summarizes the variable composition of CFSI.

Market	**Variables**
Interbank Market	Financial Beta
	Bank Bond Spread
	Interbank Liquidity Spread
	Interbank Cost of Borrowing
Stock Market	Stock Market Crashes
Foreign Exchange Market	Weighted Dollar Crashes
Credit Market	Covered Interest Spread
	Corporate Bond Spread
	Liquidity Spread
	90 Day Commercial Paper Treasury Bill Spread
	Treasury Yield Curve

Table 5: The Variable Composition of CFSI

The following methodology was used to construct the financial stress index for the US economy.

$$FSI_j = \sum_j [w_{jt} * \int_{-\infty}^{x_j} f(x_{jt}) dx_{jt}] * 100 \quad \textbf{(1)}$$

Where x_{jt} is the value of variable j at time t, the integration term is the cumulative density function of the variable j and w_{jt} is the weight given to the variable j at time t. The weights for each and every variable were allocated using the composition of the Federal Reserve Board's flow of funds to the four market sectors; banking, foreign exchange, debt and equity and credit markets. Initially a daily FSI was constructed and later a monthly FSI was constructed by getting the average of the daily FSI values for a particular month. Following table shows the interpretation of stress episodes based on the CFSI values.

Stress Episode	**CFSI Range**
Grade 1 (Below Normal Stress)	Less than or equal to -0.5
Grade 2 (Normal Stress)	Between -0.5 and 0.59
Grade 3 (Moderate Stress)	Between 0.59 and 1.68
Grade 4 (Significant Stress)	Greater than 1.68

Table 6: Stress Episode and the corresponding CFSI values

The following figure shows flow of CFSI values since September 1991 to March 2012.

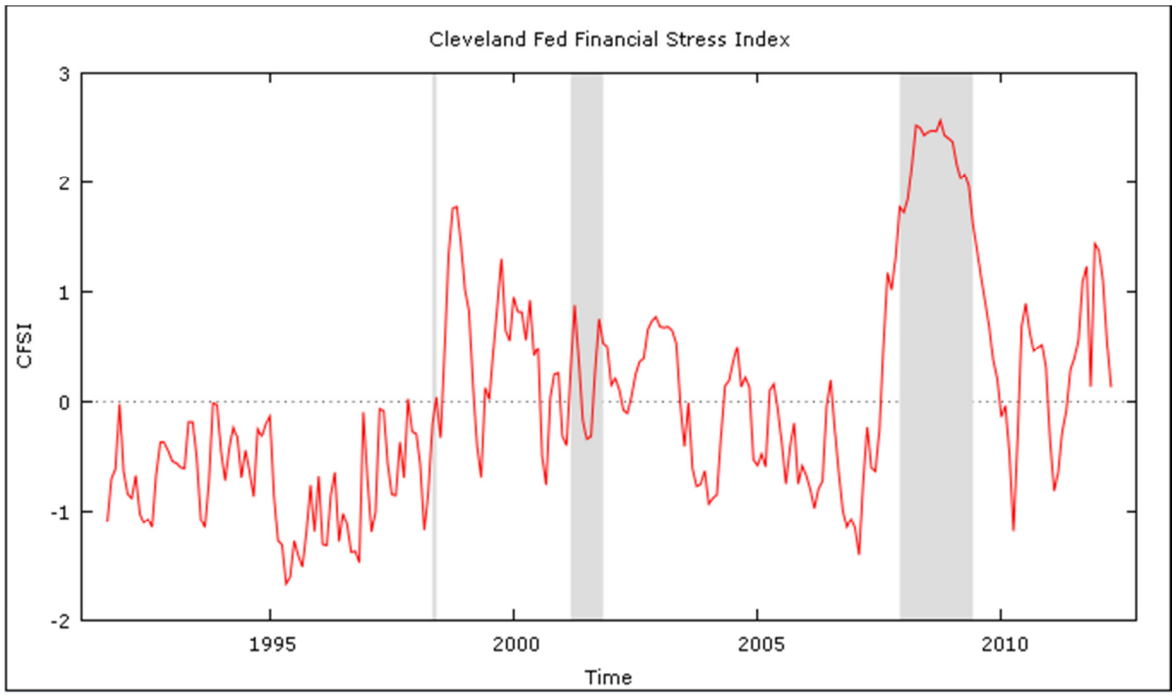


Figure 4: The Cleveland Fed Financial Stress Index (CFSI)

In addition to the above indexes, Bloomberg Financial Conditions Index, City Financial Conditions Index, Deutsche Bank Financial Conditions Index, Goldman Sachs Financial Conditions Index, Macroeconomic Advisors Monetary and Financial Conditions Index, OECD Financial Conditions Index and Mishkin Financial Conditions Index are available for measuring the financial stress condition in the US. A short description of some of them is as follows[9].

2.5. Bloomberg Financial Conditions Index (BFCIUS):

This index, developed by Rosenberg in 2009, provides valuable insights about the stress conditions in the US financial market. Monthly and daily data for BFCIUS are readily available in Bloomberg. There are totally 10 variables from Money market; Bond Market and Equity market used to calculate this composite index. Variables in each and every sub index were equally weighted inside their respective sub-indices. Then individual sub-indexes were normalized and presented as Z score values. Finally, the composite financial conditions index is constructed as an equally weighted sum of the above three normalized sub-indices and is available since 1991. The following table explains the variables used and the composition of BFCIUS. The magnitude of the stress was identified through the number of standard deviations that financial conditions lay above or below the average level of financial conditions index. In general, financial condition indexes go below the neutral financial conditions during stressful situations.

[9] Graphs were provided only for the Financial Stress Indexes which are available in Monthly frequencies.

Bloomberg's U.S. Financial Conditions Index Components and Weights

	Index Weight
Money Market	
Ted Spread	11.1%
Commerical Paper/T-Bill Spread	11.1%
Libor-OIS Spread	11.1%
	33.3%
Bond Market	
Investment-Grade Corporate/Treasury Spread	6.7%
Muni/Treasury Spread	6.7%
Swaps/Treasury Spread	6.7%
High Yield/Treasury Spread	6.7%
Agency/Treasury Spread	6.7%
	33.3%
Equity Market	
S&P 500 Share Prices	16.7%
VIX Index	16.7%
	33.3%
Total	**100%**

Table 7 : Bloomberg's Financial Condition Index Components and Weights

The following figure indicates the distribution of the Bloomberg Financial Conditions Index from January 1991 to December 2009.

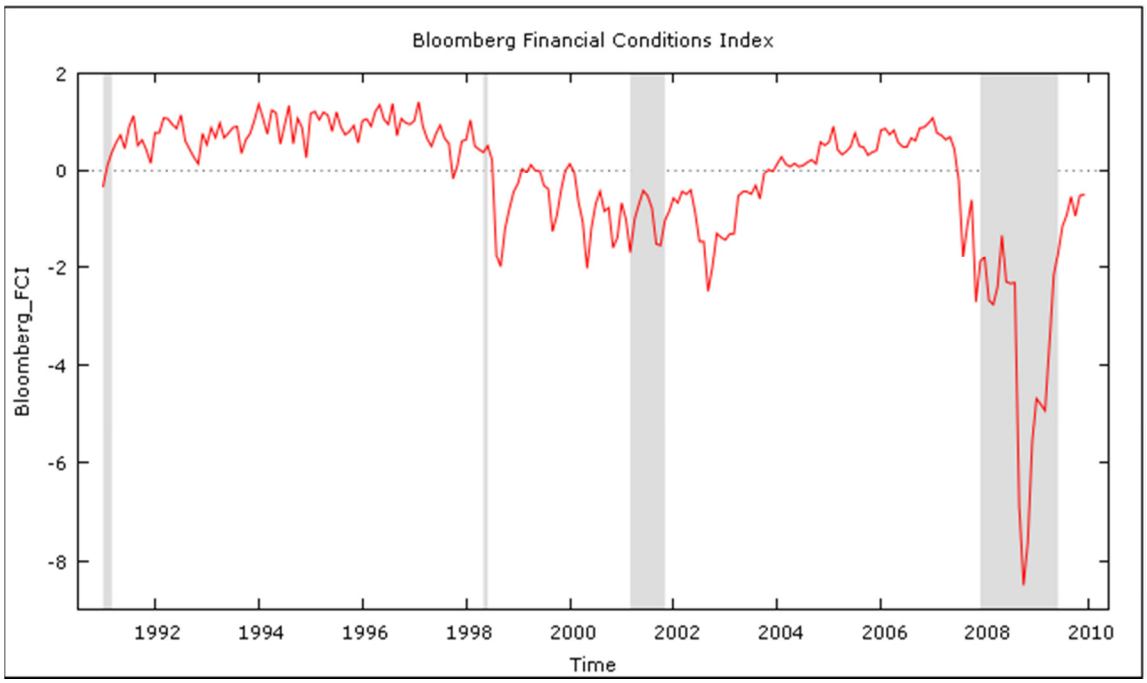


Figure 5: The Bloomberg Financial Conditions Index (BFCIUS)

2.6. CITI Financial Conditions Index (CITI_FCI):

The Citi Financial Conditions Index is constructed to capture the cumulative effect of series of financial variables on the economic activity. Variables are chosen based on the underlying relationships between financial variables and the real economy. The Citi Financial Conditions Index is calculated as a weighted sum of the six financial variables; corporate spreads, money supply, equity values, mortgage rates, the trade weighted dollar and energy prices. The nominal variable values were deflated. A reduced form forecasting regression model is used to identify the coefficients of the above explanatory variables given the economic activity variable, the Conference Board's index of Coincident indicator (COINC), the dependent variable. Then the coefficient values are converted in to FCI weights by normalizing the variables to mean zero, standard deviation one and dividing by their sum (D'Antonio 2008). This weight allocation calculates the Citi Financial Conditions Index. A zero Citi FCI value represents a normal financial and economic condition.

A positive Citi FCI represents an expansionary pace in the economy while a negative Citi FCI indicates a contractionary economic condition in the economy. The City FCI is available since 1983. Although this index does not capture the stress in all three market segments; Banking, Security and the Exchange, it can still be used as a possible measure of financial stress as it uses some of the key financial variables. The following figure indicates the distribution of the CITI Financial Conditions Index from January 1983 to December 2009. According to Figure 6, the financial conditions go below its neutral levels during recessions.

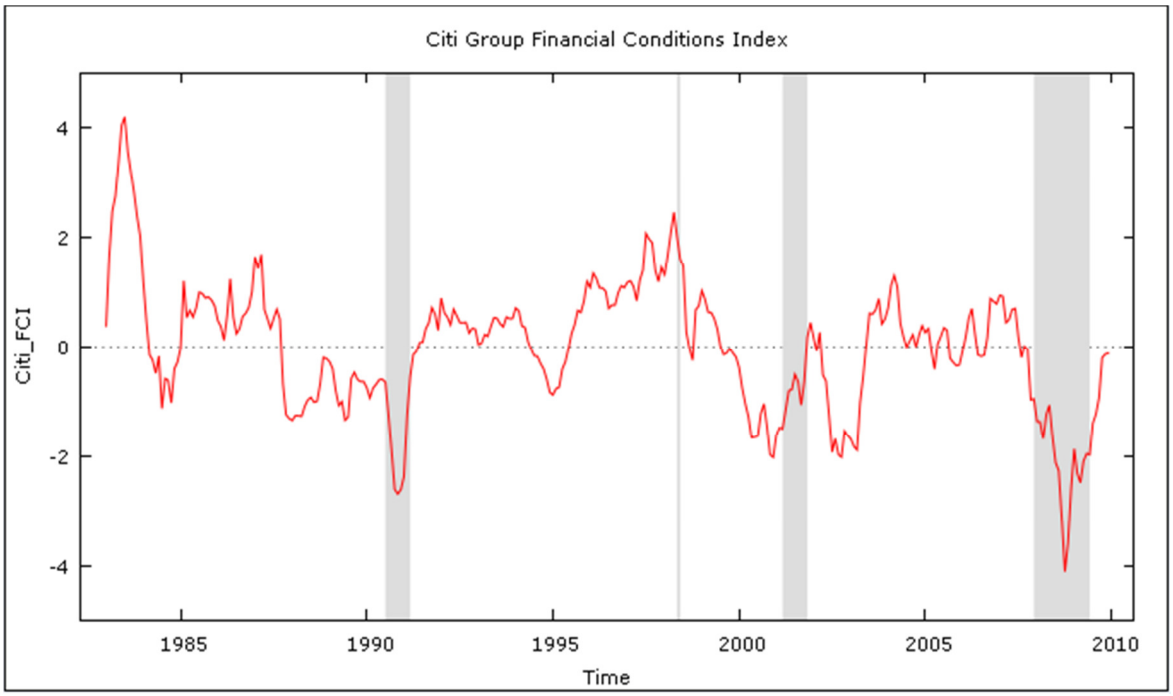


Figure 6 : The CITI Financial Conditions Index

2.7. Goldman Sachs Financial Conditions Index (GS_FCI):

This index is calculated as a weighted sum of a long term corporate bond yield, a short term bond yield, the exchange rate and a stock market variable (Dudley and Hatzius 2000). The weighting scheme was constructed using both the Federal Reserve Board's Macroeconomic Model (FRB/US Model) and Goldman Sachs Modeling (Dudley and Hatzius 2000). An increase in the index shows a tighter financial condition while a decrease shows looser financial conditions. The following figure indicates the distribution of the Goldman Sachs Financial Conditions Index from January 1980 to December 2009.

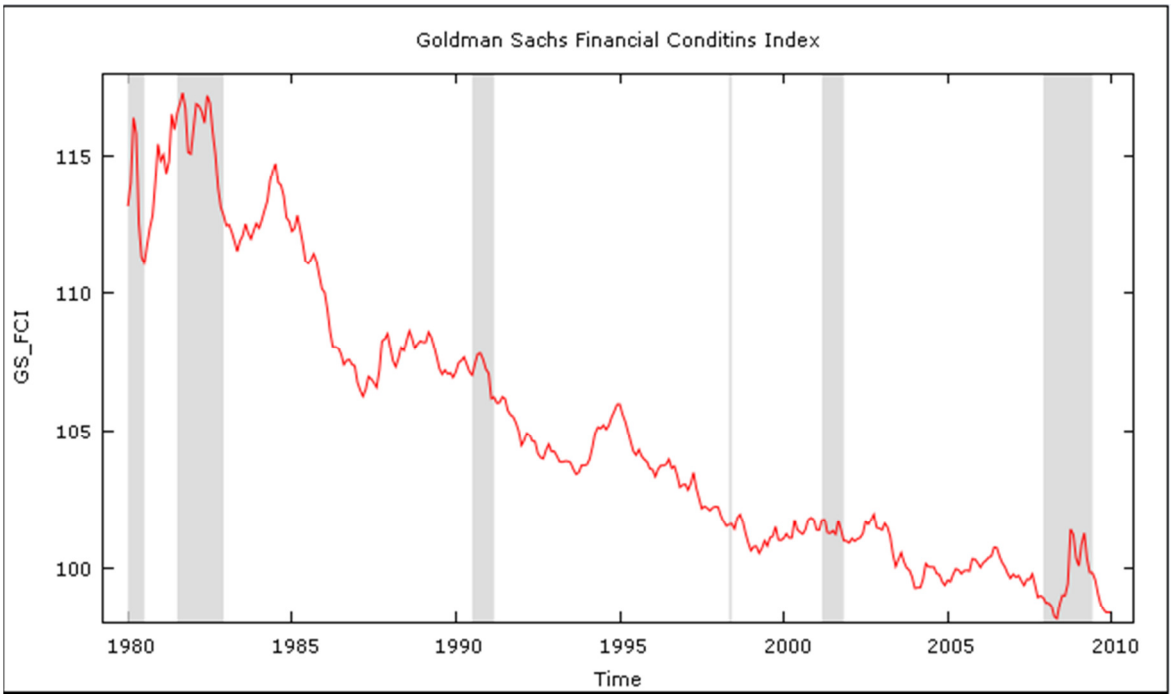


Figure 7: The Goldman Sachs Financial Conditions Index

2.8. OECD Financial Conditions Index:

This index provides valuable insights on the volatility in the financial conditions for the US. This was constructed by Guichard and Turner in 2008. The weighted sum of six financial variables was used to calculate this FCI. Weights were selected based on the effects of the variables on the GDP over the next four to six quarters. Variables were assigned following weights; Real Short term interest rate (0.29), Real long term interest rate (1.00), High Yield bond Spread (0.47), Credit Standards tightening (0.04), Real Exchange rate (0.15) and Stock Market Capitalization (-0.03). An increase in this FCI indicates a tighter financial condition and a decrease indicates a looser financial condition. This index is available in quarterly frequencies since 1995. Following figure provides the behavior of the OECD financial conditions Index from 1995 to 2008.

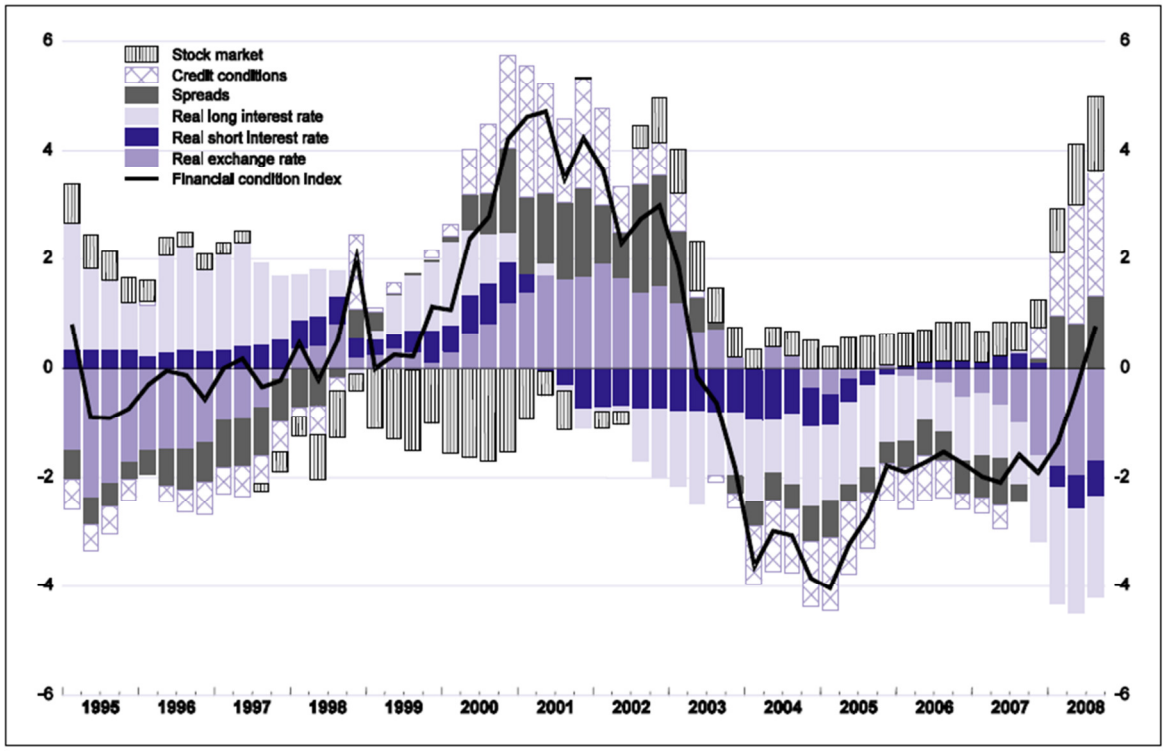


Figure 8: A unit increase in the index corresponds to an effect on GDP equivalent to an increase in real long-term interest rates of 100 basis points. *Source – Guichard and Turner (2008)*

2.10 : The International Monetary Fund (IMF) Advanced Country Financial Stress Index (AE_FSI)

The Advanced country financial stress index (AE_FSI) was constructed by Roberto Cardarelli, Selim Elekdag and Subir Lall from their IMF working paper "Financial Stress, Downturns and Recoveries" in 2009. The AE_FSI comprises with seven different variables which represent three main financial market segments; Banking, Securities and Exchange markets. This procedure provides an individual Financial Stress Index for 17 advanced countries[10] including USA and is available in monthly basis since 1981. This construction also provides sub stress indexes for the three sub markets as banking stress index, security market stress index and exchange market stress index. The following variables from the three sub market were chosen for the index construction. All the variables are in monthly frequency.

[10] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom and USA.

Banking Sector

- **The slope of the yield curve:** This is measured as the difference between the short and long term yields on government securities and has the ability to measure the volatility and risk associated with the bank profitability.
- **The TED Spread:** This is constructed as 3 months LIBOR or commercial paper rate minus the yield on 3 months Treasury bill rate. A higher spread indicates a higher banking sector risk as banks will charge higher interest rates in interbank lending to short term Treasury bill rates during higher stress periods.
- **Banking Beta**: This measures the correlation between the total returns to banking stocks and overall stock market returns. A beta greater than one indicates a higher return to banking sector stocks compared to return on the total stock market. This implies a higher risk in the banking sector.

Foreign Exchange Market

- **Time Varying Real Effective Exchange rate Volatility:** This variable captures the foreign exchange market risk and is calculated via a GARCH (1,1) specification. This is the volatility of monthly changes in the real effective exchange rate.

Security Market

- **Corporate Bond Spread:** This is the difference between corporate bond yields minus long term government bond yields and is used to measure the risk and volatility in this market.
- **Stock Decline:** This measures the volatility in the stock market. A higher decline in stock returns shows a higher risk. This is calculated by dividing the difference between stock index at time t and stock index at time t-1 by the index at time t-1.
- **Time Varying Stock Volatility:** This is used to capture the volatility associated with the monthly returns of the overall stock markets.

Market	Variables
Banking Sector	Banking Beta
	The TED Spread
	The Slope of the Yield Curve
Foreign Exchange Market	Time Varying Real Effective Exchange Rate Volatility
Security Market	Corporate Bond Spread
	Stock Decline
	Time Varying Stock Volatility

Table 8: Variable Composition of AE_FSI

The following methodology was used to construct the financial stress index. First all the variables were demeaned and standardized. Then AE_FSI was constructed by adding the average values of all the standardized variables.[11] The FSI values for the three sub market segments were calculated by adding the average values of all the standardized variables in each market separately. When the index value is one standard deviation above its trend, a financial stress is identified. The ability to represent all three sub markets of a financial crisis in one financial stress index is one of the distinct advantages of AE_FSI. Moreover the inclusion of additional variables in to the construction process does not change the original AE_FSI values significantly (Cardarlli et al. 2011). Therefore AE_FSI can be considered as one of the most reliable financial stress measurements available in the current literature. The following figure shows the distribution of the AE-FSI values since 1983 to 2009. Unlike the NFCI, International Monetary Fund's AE_FSI does not show a higher financial stress during the mid-1980s recession compared to the late 2000s recession.

[11] Alternative aggregation methods such simple sum, Principle Component Analysis weighting and Variance-Equal weighting are tested in other research papers. However they failed to recognize any systematic differences in the final results (Baxa, Horvath and Vasicek 2012).

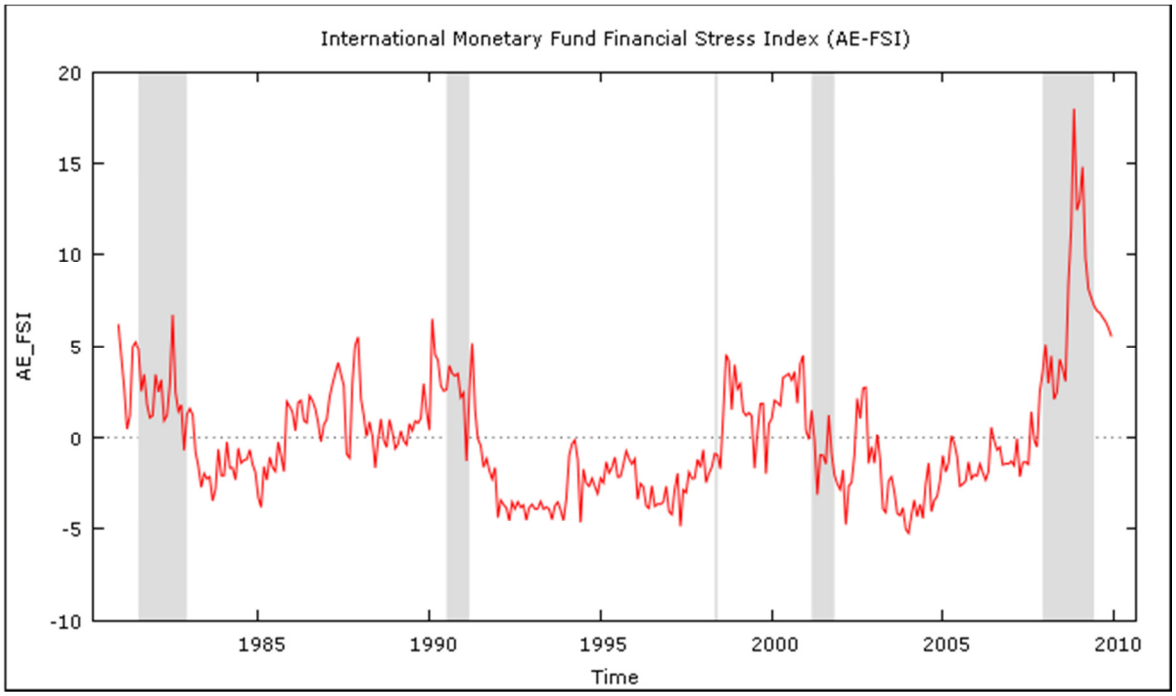


Figure 9: The International Monetary Fund Financial Stress Index (AE-FSI)

3. A COMPARATIVE ANALYSIS of the U.S. Financial Stress Indexes

3.1. A Comparative Summary of U.S. Financial Stress Indexes

The following table provides a comparative summary of financial stress indexes considered in this analysis. All the following FSIs are available in monthly frequencies.

Index	Frequency	Available from	Construction Method
NFCI	w,**m**	Jan-1973	Principal Components
AE_FSI	**m**,q	Jan-1980	Equal Weights
GS_FCI	**m**,q	Jan-1980	U.S. Macro Weight Model
STLFSI	w,**m**,FOMC,q	Dec-1980	Principal Components
CITI_FCI	**m**,q	Jan-1983	U.S. CB Weights
KCFSI	**m**,q	Feb-1990	Principal Components
BFCIUS	d,w,**m**,FOMC,q	Jan-1991	Equal Weights
CFSI	d,w,**m**,FOMC,q	Sep-1991	U.S. Credit Weights

Table 9 : A Comparative Summary of the Financial Stress Indexes [12]

[12]Note :- Frequencies are as follows; d-daily, w-weekly, m-monthly, q-quarterly. FOMC - available data can match FOMC meeting schedule.

NFCI, STLFSI and KCFSI use the principal components analysis as the index construction methodology. AE_FSI and BFCUIS use the equal weights as the construction methodology. Both BFCIUS and CFSI are available at daily frequencies. Availability of a financial stress index in all frequencies typically makes the researcher better off as it allows the researcher to deal with any types of data frequency.

3.2. Descriptive Statistics of the U.S. Financial Stress Indexes

The following tables represent the basic descriptive statistics of the above Financial Stress Indexes. Table 10 provides the descriptive statistics for the entire data sample. Table 11 represents the statistics of data before December 2007 and table 12 shows the statistics for the data after December 2007. It is evident that the mean values were considerably higher for all the financial stress indexes after December 2007. The moderate values can be seen during the pre-December 2007. This shows how intense the stress after the late 2000s Financial crisis.

	Mean	Stdev	Max	Min	Skewness	n
NFCI	-1.42E-18	0.9985	4.6700	-1.1500	1.7779	472
AE_FSI	0.2183	3.4165	17.9650	-5.2293	1.2539	361
GS_FCI	105.17	5.1083	117.2600	98.1230	0.7188	360
STLFSI	0.0007	0.9982	4.9940	-1.2410	2.5239	220
CITI_FCI	-0.0182	1.1882	4.1861	-4.1118	0.0234	324
KCFSI	7.49E-05	1.0004	5.6700	-1.0900	2.6825	267
BFCIUS	-0.1846	1.4783	1.3920	-8.4980	-2.5019	228
CFSI	-0.0019	0.9562	2.5607	-1.6666	0.8262	248

Table 10 : A Summary Statistics of the Financial Stress Indexes (All Data)

	Mean	Stdev	Max	Min	Skewness	n
NFCI	-1.75E-02	1.0132	4.6700	-1.1500	1.8188	420
AE_FSI	-0.50274	2.5402	6.6996	-5.2293	0.4534	325
GS_FCI	105.58	5.0351	117.2600	98.9160	0.6752	336
STLFSI	-0.34032	0.5060	1.0050	-1.2410	0.6547	168
CITI_FCI	0.12365	1.0846	4.1861	-2.6904	0.3272	300
KCFSI	-2.39E-01	0.5827	1.1900	-1.0900	0.6246	215
BFCIUS	0.15093	0.8764	1.3920	-2.6970	-0.9481	204
CFSI	-0.27101	0.7211	1.7740	-1.6667	0.5370	196

Table 11 : A Summary Statistics of the Financial Stress Indexes (Data before December 2007)

	Mean	Stdev	Max	Min	Skewness	n
NFCI	1.41E-01	0.8666	2.5900	-0.6600	1.4377	52
AE_FSI	6.7276	3.4523	17.9650	2.1170	1.5081	36
GS_FCI	99.414	1.0279	101.3900	98.1230	0.6059	24
STLFSI	1.1024	1.3490	4.9940	-0.1850	1.6817	52
CITI_FCI	-1.7919	0.9948	-0.1300	0.9948	-0.3383	24
KCFSI	9.81E-01	1.5998	5.6700	1.5998	1.4736	52
BFCIUS	-3.0361	2.3036	-0.5100	2.3036	-0.9647	24
CFSI	1.0125	1.0546	2.5607	1.0546	-0.0398	52

Table 12 : A Summary Statistics of the Financial Stress Indexes (Data after December 2007)

3.3. A Graphical Comparison of the Financial Stress Indexes

3.3.1. A comparative graphical representation between all the financial stress indexes

Figure 9 provides a comparative graphical representation between all the financial stress indexes considered in this paper. First each index is transformed to a Z-Score[13] value in order to represent them in same units.

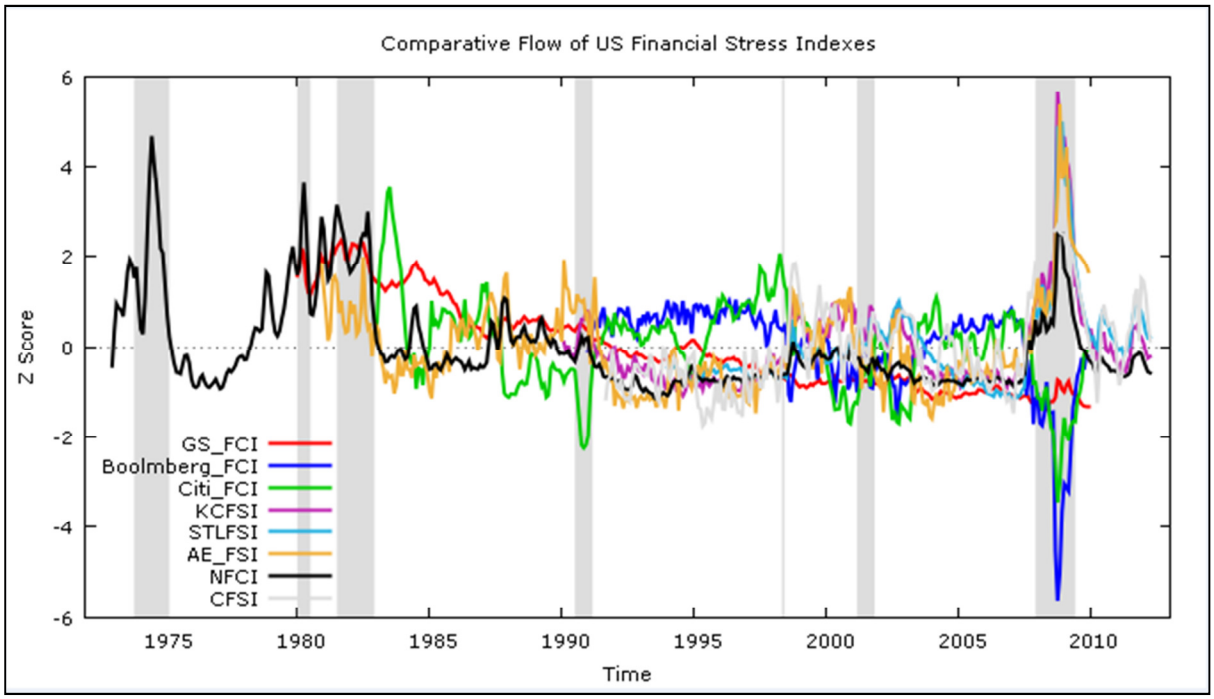


Figure 10: A Comparative Flow of All US Financial Stress Indexes. The ash colored lines for U.S. Recession periods.

[13] Z-score is calculated by subtracting the sample mean from a target data point and by dividing it by the standard deviation. This method transforms different data scales and data units in to the same scale and unit less. Therefore Z-score values can be used to compare different data units and scales.

The National Financial Conditions Index (NFCI) issued by the Federal Reserve Bank in Chicago is the longest financial stress index for the U.S. The Cleveland Fed Financial Stress Index is the shortest of that kind for the U.S. According to the above graph, all financial stress indexes have significantly responded to almost all recessions in the U.S. history. Both the 1973 Oil crisis and the 1973-1974 Stock market crash created the 1973 -1975 U.S. Recession (NBER)[14]. The above graph shows a significant response in the NFCI stress index during that period. Moreover both NFCI and GS_FCI have responded to the early 1980's recession which emerged as a consequence of the increased interest rates to fight the inflation in 1970's. Both NFCI and GS_FCI do not indicate a significant financial stress during the early 1990's recession. But the Bloomberg financial Conditions Index and the AE_FSI shows significant changes in their values to indicate a significant financial stress during that time. The Early 2000's recession which was a result of the September 11th terrorist attacks and the collapse of the "*dot com"* bubble does not show an immediate significant influence on the financial stress in the U.S. But it's after effects are clearly visible in the stress index fluctuations. More importantly, almost all financial stress indexes significantly responded to the late 2000's recession and the response was relatively higher than the responses of those indexes to other recessions in the U.S. history. But the behavior of the GS_FCI during early 1980's recession and the late 2000's recessions are in contradictory. So this may not be an ideal representation of the financial stress in the U.S. economy given the other well behaved financial stress indexes. The financial stress indexes issued by the Federal Reserve Banks in the U.S. show higher financial risks during recessions while lower financial risks during better economic conditions.

Figure 11 provides the behavior of the stress indexes which used the principle component construction method. These indexes react to the financial stress in similar ways. Figure 12 represents the indexes which used a weighting method to construct the index. In this regard, the AE_FSI and CFSI shows higher positive values during recessions to indicate the severity of the stresses while all the financial conditions indexes; GS_FCI, Bloomsberg_FCI and CITI_FCI, show higher negative values to represent tighter financial conditions during recessions. They also identify the late 2000s financial crisis as the worst condition during the considered time span

[14] NBER – National Bureau of Economic Research reports the history and the evolution of the U.S. recessions. List of Recessions are listed in Appendix 6.1.

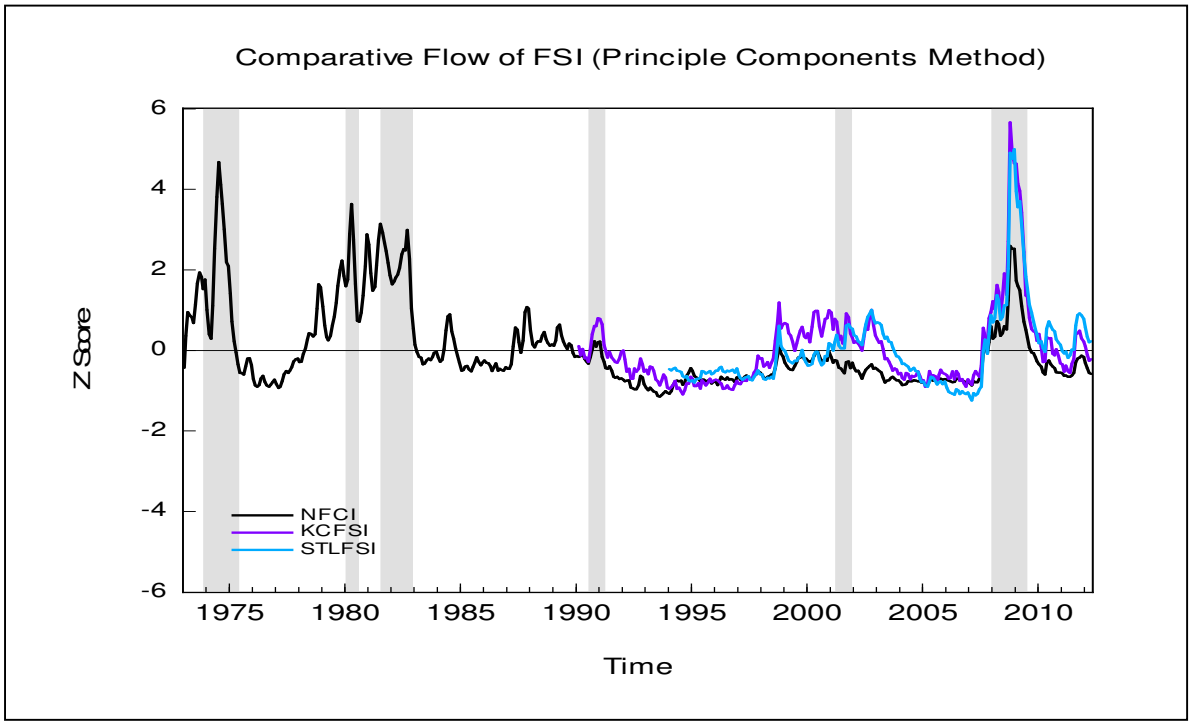


Figure 11: A Comparative Flow of US Financial Stress Indexes (Principle Component Method)

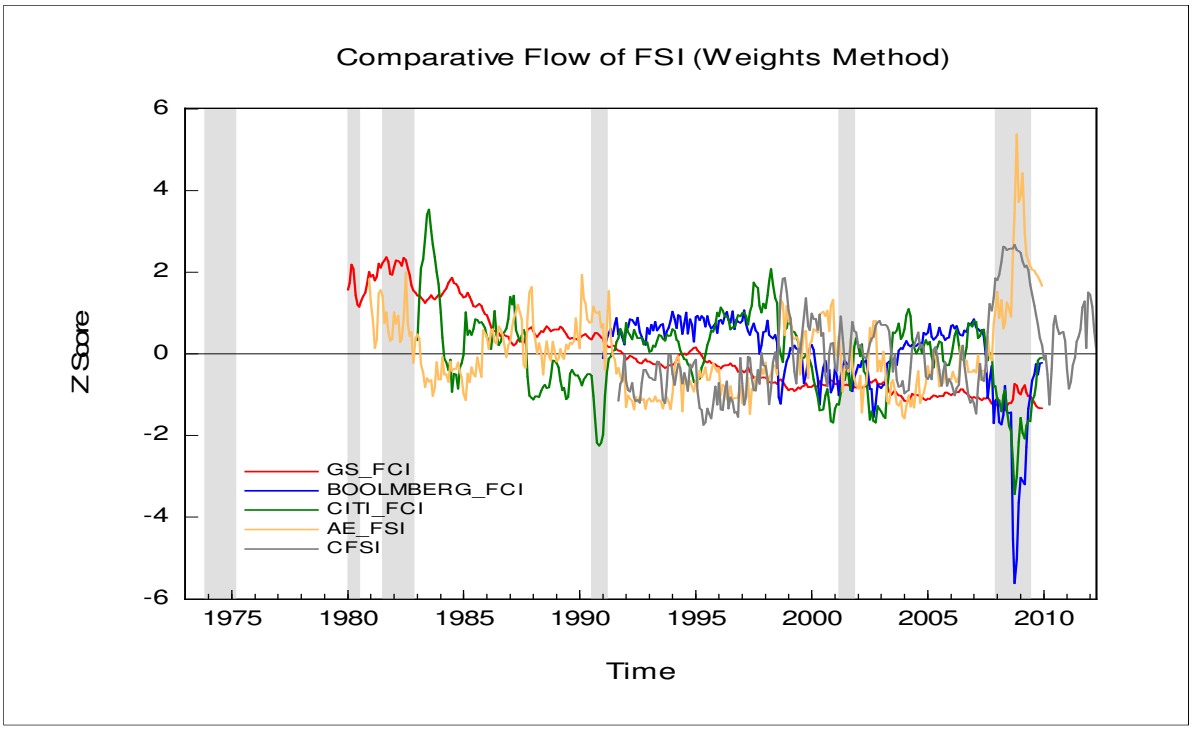


Figure 12: A Comparative Flow of US Financial Stress Indexes (Weights Method)

3.3.2. A comparative graphical representation of Indexes issued by Federal Reserve Banks in the U.S.

Figure 13 provides a comparative graphical representation of financial stress indexes issued by regional Federal Reserve Banks; KCFSI, STLFSI, NFCI and CFSI. The KCFSI and STLFSI indicate a higher financial risk during the 2008 recession compared to NFCI and CFSI. Moreover all financial stress indexes indicate a considerable increment in their risk values after the 1998 U.S. financial regulation change. However this risk increase is considerably lower than the risk increase during the late 2000's recession. This risk difference is clearly displayed by KCFSI, STLFSI and NFCI as it has relatively lower risk level after 1998 financial regulation change than the risk level at late 2008 recession. But CFSI does not significantly distinguish the risk levels between these two periods. Instead it indicates a long lasting high risk during the late 2000's recession. During late 90's and mid 2000's when the U.S. economy was operating at its prosperous levels, the financial stress indexes show negative financial risk levels in the economy.

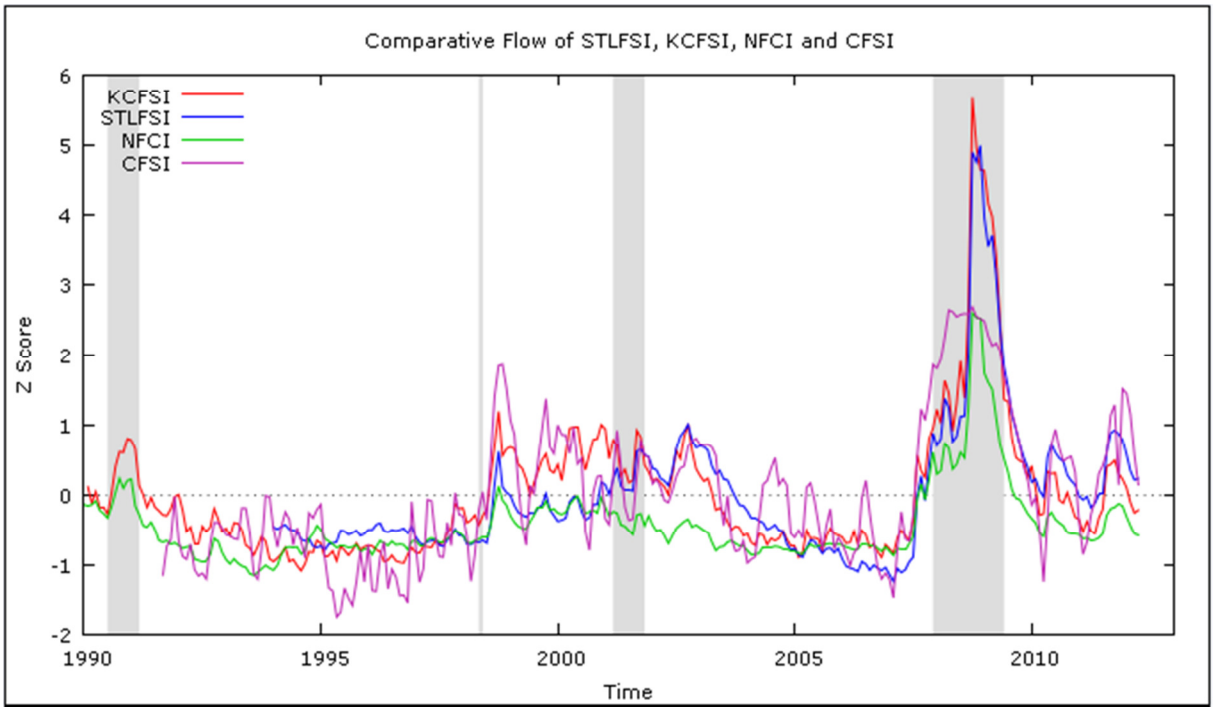


Figure 13: A Comparative Flow of All Financial Stress Indexes issued by U.S. Federal Reserve Banks

The following graph provides a comparative graphical representation between the Financial Stress Indexes issued by regional Federal Reserve Banks; KCFSI, STLFSI, NFCI, CFSI and IMF's Stress Index (AE_FSI).

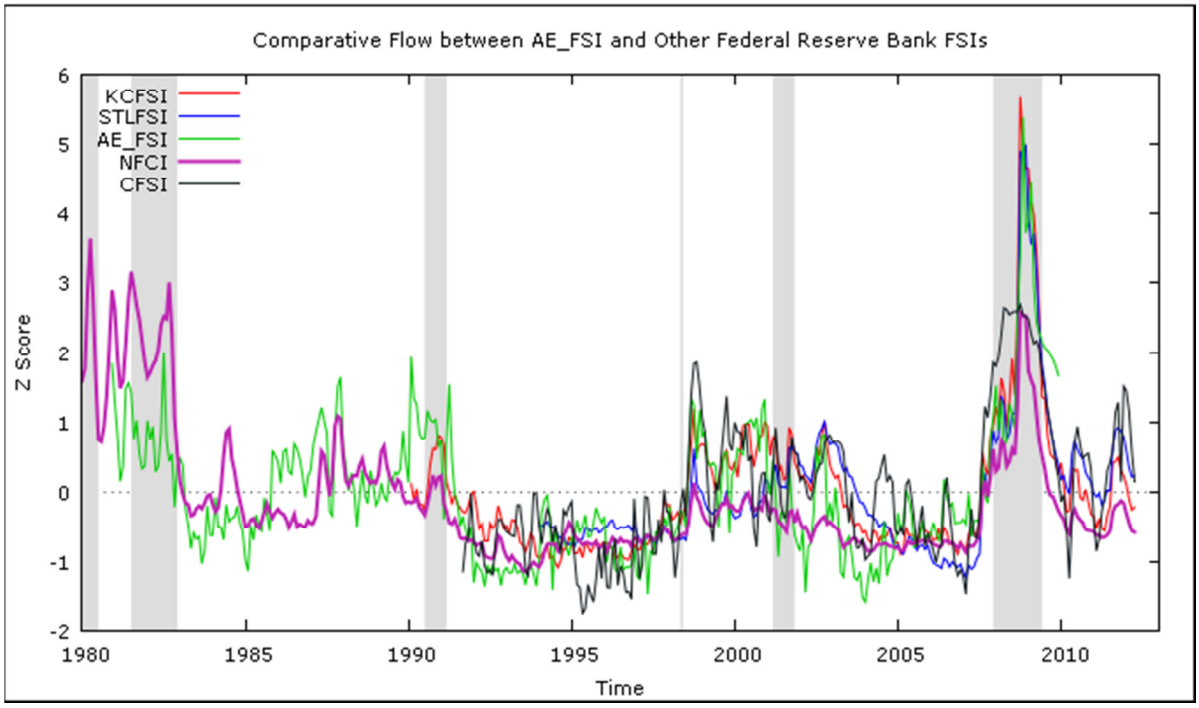


Figure 14: A Comparative Flow between AE_FSI and Federal Reserve Bank issued Financial Stress Indexes.

As mentioned above, AE_FSI shows higher financial stress conditions during recession periods and lower or negative financial stress values during non-recession periods. It is evident that AE_FSI and KCFSI, STLFSI show similar behaviors during the late 2000's recession. They all show very high financial stress values while CFSI and NFCI shows relatively lower financial stress values. They all indicate that the financial stress get reduced after the late 2000's recession.

Figure 15 provides a comparative graphical representation between the Financial Stress Indexes issued by regional Federal Reserve Banks and IMF's Financial Stress Index (AE_FSI) during 2007-2009 Financial Crisis (late 2000's Recession).

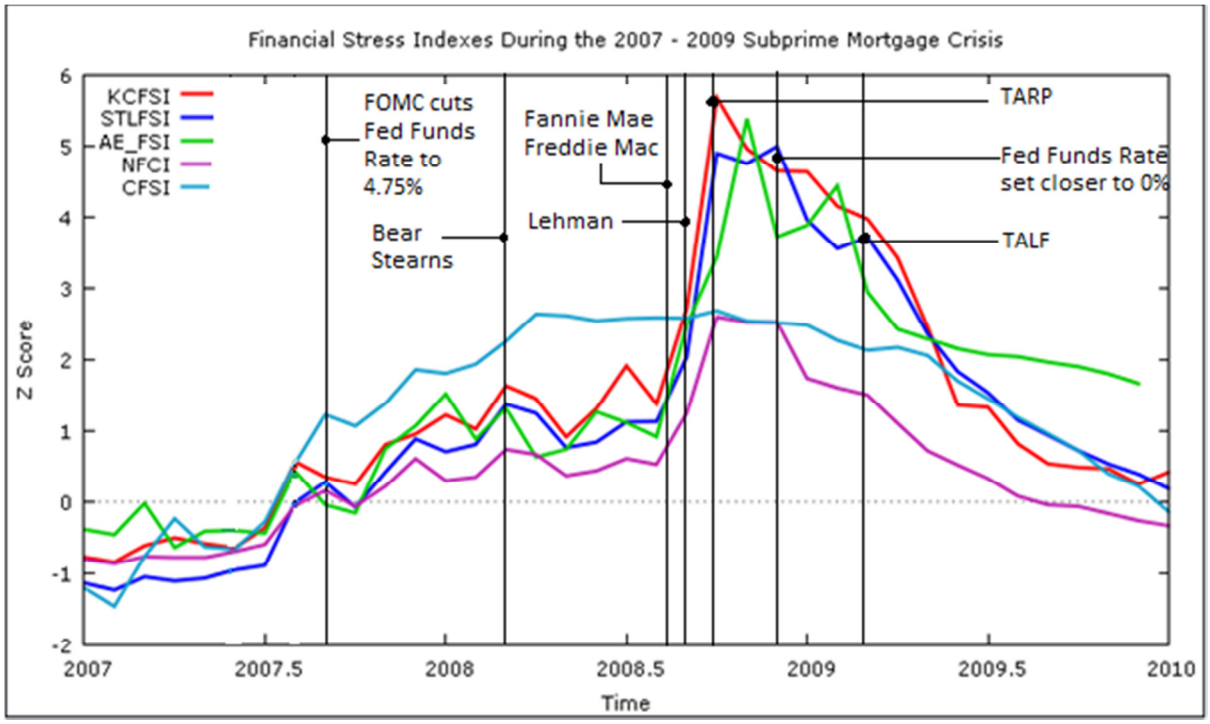


Figure 15: Financial Stress Indexes during 2007 – 2009 Financial Crisis. TARP[15] and TALF[16]

This figure is used to evaluate the performances of the financial stress Indexes during the 2007 – 2009 Financial Crisis. All financial stress indexes started having positive Z score values starting from July 2007. All FSIs identify the significance of Fannie Mae/Freddie Mac and Lehman Brother bankruptcies in the U.S. financial system as all they show highest values during these two events. Therefore these two can be considered as the most influential events in the 2007-2009 financial crisis. It is also evident that the all FSIs responded to the healing processes which is undertaken to control the financial stress during that period. The stress indexes went down after TARP, TALF and Fed funds rate cut down actions. KCFSI, STLFSI and AE_FSI show relatively similar fluctuations during this period. However CFSI does not highlight the significance of Fannie Mae/Freddie Mac and Lehman Brothers bankruptcies in the calculations of the financial stress. Moreover NFCI shows relatively lower financial stress levels after the FOMC decision of reducing the Fed Funds rate to 4.75%. KCFSI, STLFSI, NFCI and CFSI reach to lower financial stress levels in 2010.

[15] TARP – Troubled Asset Relief Program (Black and Hazelwood 2012)
[16] TALF – The Term Asset Backed Securities Loan Facility (http://www.newyorkfed.org/markets/talf.html)

3.4. Correlations between Financial Stress Indicators

Table 13 provides the correlations of the stress indexes for the entire time period considered. The Goldman Sachs Financial Conditions Index (GS_FCI) shows the lowest correlation between other financial stress indexes. The City Financial Conditions Index shows moderate correlations with other financial stress indexes. The Bloomberg Financial Conditions Index shows strong negative correlations to almost all other indexes. Higher correlations between financial stress indexes issued by different Federal Reserve System banks indicate the common information sharing between regional central banks. NFCI is strongly correlated with all the other regional central bank FSIs and Bloomberg FCI. This indicates the use of NFCI concepts, which were considered at earliest, in construction methods of other FSIs. AE_FSI has a lower negative correlation with GS_FCI and a moderate negative relationship with CITI_FCI and GS_FCI. Moreover it has a strong negative correlation with BFCIUS and a strong positive correlation with all the Federal Reserve System Banks' Stress Indexes.

	GS_FCI	BFCIUS	CITI_FCI	KCFSI	STLFSI	AE_FSI	NFCI	CFSI
GS_FCI	1							
BFCIUS	0.412	1						
CITI_FCI	0.2114	0.7637	1					
KCFSI	-0.2546	-0.9363	-0.726	1				
STLFSI	-0.2368	-0.908	-0.7115	0.9226	1			
AE_FSI	-0.0683	-0.7968	-0.5768	0.8044	0.7785	1		
NFCI	-0.5887	-0.9052	-0.555	0.9471	0.9042	0.6144	1	
CFSI	-0.4928	-0.8152	-0.6839	0.7972	0.7564	0.7087	0.7984	1

Table 13: Correlations between Financial Stress Indexes (All Data)

Table 14 provides the correlations of these indexes using the data up to great recession which began in December 2007. Almost all the correlations in this situation got weakened compared to the correlation vales for the entire data sample. The correlations between the private GS_FCI and other FSIs are not clear as it shows opposite correlations to the previous scenario.

	GS_FCI	BFCIUS	CITI_FCI	KCFSI	STLFSI	AE_FSI	NFCI	CFSI
GS_FCI	1							
BFCIUS	0.4152	1						
CITI_FCI	0.1052	0.6245	1					
KCFSI	-0.1044	-0.8619	-0.6201	1				
STLFSI	-0.085	-0.8142	-0.5468	0.7527	1			
AE_FSI	0.3351	-0.5734	-0.4307	0.689	0.334	1		
NFCI	0.7388	-0.7262	-0.3733	0.8273	0.5969	0.6118	1	
CFSI	-0.3765	-0.743	-0.475	0.7504	0.6335	0.5665	0.7202	1

Table 14: Correlations between Financial Stress Indexes (Data up to December 2007)

The following table provides the correlation values for the stress indexes after the late 2000s great recession. The correlation between the indexes got significantly higher during this period. This indicates how closely these indexes reacted to the most significant financial crisis we had in the recent times. However the correlation between the GS_FCI and other financial stress indexes got further weakened during this time period. This may indicate the inability of GS_FCI to measure the entire nature of a complicated financial crisis as it only considers the nature of the bond and exchange market in the construction process. Since the great recession includes the issues in all three sub markets in a financial crisis; *exchange market, security market and banking sector*, the GS_FCI may have lost its ability to capture the entire nature of the crisis as the other indexes do.

	GS_FCI	BFCIUS	CITI_FCI	KCFSI	STLFSI	AE_FSI	NFCI	CFSI
GS_FCI	1							
BFCIUS	-0.0771	1						
CITI_FCI	-0.0956	0.7927	1					
KCFSI	0.1151	-0.9344	-0.7533	1				
STLFSI	0.0246	-0.9186	-0.7321	0.9228	1			
AE_FSI	-0.0137	-0.7856	-0.6707	0.8047	0.761	1		
NFCI	-0.0492	-0.9178	-0.7104	0.9651	0.9024	0.8166	1	
CFSI	-0.1045	-0.7825	-0.6741	0.7721	0.7568	0.6155	0.8017	1

Table 15: Correlations between Financial Stress Indexes (Data after December 2007)

3.5. Unit Root Testing

Financial Stress Indicators are designed to measure the financial conditions in an economy. Therefore they are highly subjected to the changes in economic conditions and this may result inconsistent volatilities in the data. Therefore the stationarity of the data is a major concern to

check with. The Augmented Dickey Fuller (ADF)[17] test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS)[18] test are used to check the stationairty of the financial stress indexes considered in this study. The following table presents the results of each test on all the financial stress indexes considered. Augmented Dickey Fuller (ADF) Test cannot reject the null of a unit root for GS_FCI, BFCIUS, CITI_FCI, STLFSI, AE_FSI and CFSI at levels. KPSS Test rejects the null of a stationary for all indexes at levels. ADF Test cannot reject the null of a unit root for GS_FCI, CITI_FCI, and AE_FSI at levels given a drift in the procedure. KPSS rejects the null of a stationary for GS_FCI, BFCIUS, CITI_FCI, and AE_FSI at levels given a drift in the procedure. Moreover the null of a unit root could not be rejected for GS_FCI, CITI_FCI and AE_FSI at levels given a linear trend term plus a drift term are introduced in ADF. KPSS cannot reject the null of a stationary for all FSIs in both with a *drift* and with *drift plus trend*. According to above table, both tests prove that the fist difference of the original FSIs are stationary at 5% significant level.

Stress Index	Data Level	ADF		KPSS	
		Drift	Drift+Trend	Drift	Drift+Trend
GS_FCI	**Levels**	-2.1140	-2.6756	5.5544*	0.8683*
	First Difference	-5.6788*	-5.8414*	0.0429	0.0313
BFCIUS	**Levels**	-2.7610	-3.3578*	1.5199*	0.4632*
	First Difference	-8.8599*	-8.8391*	0.0329	0.0315
CITI_FCI	**Levels**	-2.3592	-2.5121	0.6392*	0.4757*
	First Difference	-8.1172*	-8.0939*	0.0202	0.0200
KCFSI	**Levels**	-3.0211*	-3.4097*	0.6938*	0.1177
	First Difference	-6.7230*	-6.7113*	0.0341	0.0341
STLFSI	**Levels**	-2.8239	-3.0832*	0.9441*	0.1352
	First Difference	-11.3427*	-11.3173*	0.0333	0.0331
AE_FSI	**Levels**	-2.2585	-2.4183	0.5710*	0.4913*
	First Difference	-5.5339*	-5.5995*	0.0901	0.0218
NFCI	**Levels**	-3.2897*	-3.6590*	1.9761*	0.3731
	First Difference	-5.6958*	-5.6919*	0.0246	0.0229
CFSI	**Levels**	-2.2867	-3.2414*	1.3153*	0.0975
	First Difference	-6.6274*	-6.6124*	0.0294	0.0231

Table 16: Unit Root Test Statistics of Financial Stress Indexes. The 5% critical values of ADF is -2.8674, KPSS is 0.4630. Moreover * shows significance at 5% level.

[17] ADF test: H_0 is a unit root, H_1 is stationary.
[18] KPSS test: H_0 is stationary, H_1 is a unit root.

3.6. Structural Break Testing (Single Break Testing)

Besides conducting unit root tests, it is suggested by different studies that checking for structural breaks as an important diagnostic process in evaluating macroeconomic data (Perron 1989). The instability in the intercept alone is detected by a CUSUM test (Durbin and Evans 1975). This test suggests that except for CITI_FSI all other financial stress indexes do not have a structural break for the considered time period. CITI_FSI shows a structural break around December 1999. The following table shows the results of the CUSUM test.

Index	CUSUM Test Statistics	Result
GS_FSI	0.5893	No Break
BFCIUS	0.4832	No Break
CITI_FSI	1.3541	Break around December 1999
KCFSI	1.0367	No Break
STLFSI	0.9195	No Break
AE_FSI	1.78E-05	No Break
NFCI	0.7929	No Break
CFSI	0.4573	No Break

Table 17: CUSUM Test Statistics for the Financial Stress Indexes[19].

Achim Zeileis et al. (2003) introduced the "strucchange" R software package to provide a graphical representation of the CUSUM test. According to the 'OLS-CUSUM' graphs in Figure 16, only the CITI financial stress index shows a peak which exceeds the significance boundaries. Therefore it indicates a structural shift in the data around December 1999. The lower power of the CUSUM test may create incorrect decisions on identifying a structural break in a variable (Kramer, Ploberger and Raimunt Alt 1988).

Therefore Andrews 1993 Sup Wald Test[20] (Andrews 1993) is used to verify the parameter instability and structural changes in the financial stress indexes considered. This test also is

[19] The CUSUM test Critical value for the 5% significant level is 1.32

[20] Andrews (1993) shows that under appropriate regularity conditions the Quadant Likelihood ratio (QLR) statistic which is also referred to as SUP LR statistic has a non-standard limiting distribution. Under the Null hypothesis;

$$QLR_T \rightarrow \frac{SUP}{r\varepsilon\,[\,r_{min},r_{max}\,]}\left(\frac{B_k(r)'B_k(r)}{r(1-r)}\right)$$

Where $0 < r_{min} < r_{max} < 1$ and $B_k(\,.\,)$ is a Brownian Bridge process defines on [0,1].

designed to identify only one possible break in a variable (Andrews 1993). The results indicate a structural break for CITI_FSI around in December 1999 and no structural breaks are identified for other financial stress indexes. These results are similar to the CUSUM test conclusions gathered earlier. The following table shows the results of Andrews (1993) Sup Wald test.

Index	Andrews Test Statistics	Result
GS_FSI	3.1877	No Break
BFCIUS	1.0524	No Break
CITI_FSI	15.3754	Break in December 1999
KCFSI	9.3844	No Break
STLFSI	7.8241	No Break
AE_FSI	3.0326	No Break
NFCI	3.8298	No Break
CFSI	4.3041	No Break

Table 18: Andrews Test statistics for the Financial Stress Indexes[21].

Achim Zeileis et al. (2003) also introduced a graphical representation for the Andrew's test. Following graphs represent the corresponding results. A peak which exceeds the significance boundaries can be found around December 1999 only for CITI_FSI. Therefore CITI_FSI indicates a structural break around December 1999. The above two tests are designed to identify only one break in a data set (Bai and Perron 1998). Therefore these two tests can provide misleading results when a variable has more than one structural break in the data set. Therefore the following section is designed to identify any possible multiple breaks in these financial stress indexes.

[21] Critical Value for 5% significant level is 11.79 and a Matlab code is used to get these results for the Andrews test.

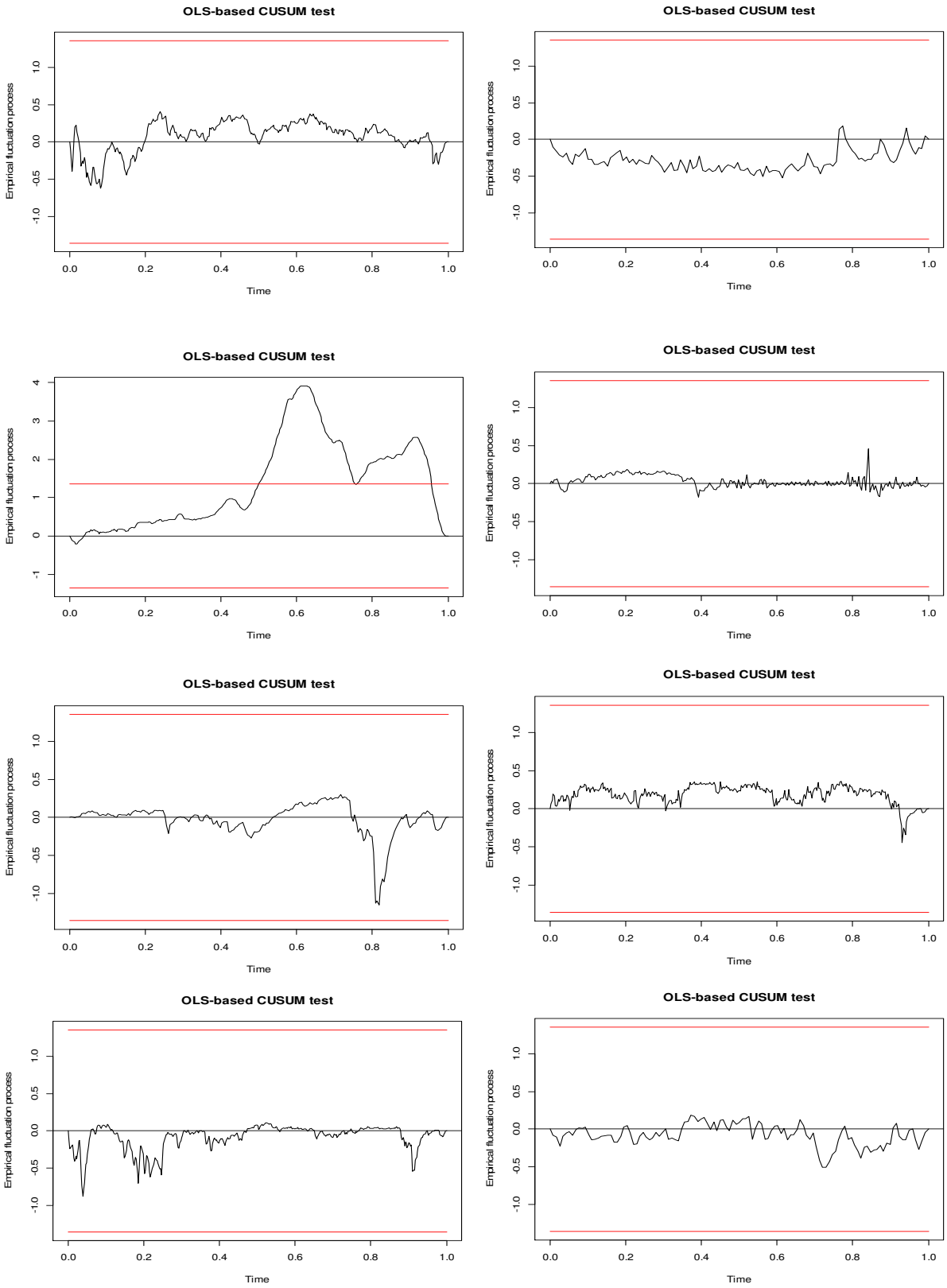


Figure 16: The OLS CUSUM Test Graphs for Single Break testing

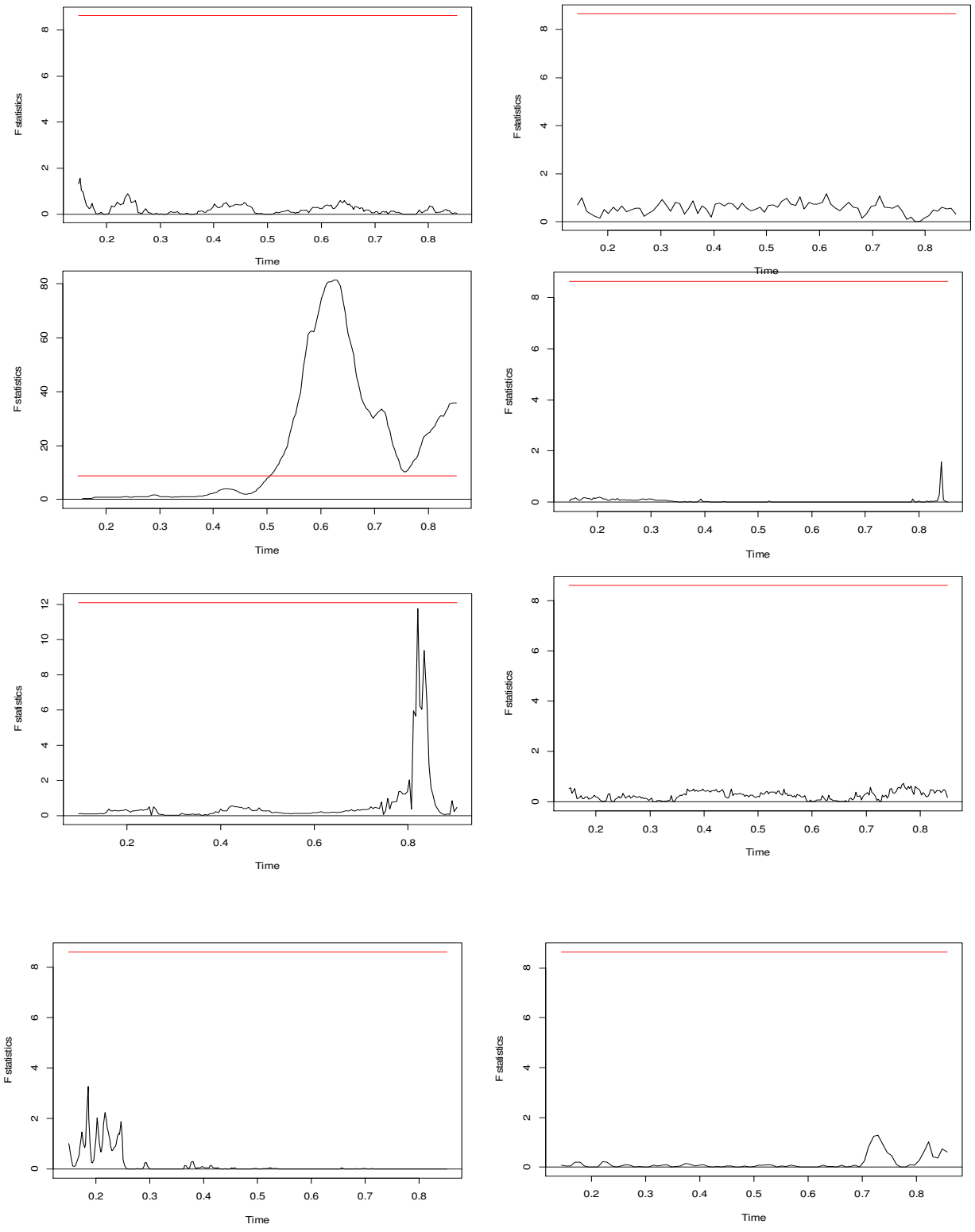


Figure 17: Andrew's 1993 Single Break Test Graphs

3.7. Structural Break Testing (Multiple Break Testing)

Chow type structural break tests assume that the type of the break and the date of the break are known prior to the analysis (Chow 1960). Under such circumstances, a researcher either should select an arbitrary candidate break date or select a break date based on the features of the data. These two choices are highly sensitive to arbitrage choices and individual knowledge. Moreover this test may indicate a break date even under no actual structural break possibilities (Hansen 2001). These limitations encourage the econometricians to identify a method which can identify structural breaks under no prior knowledge of a break date. Quandt Likelihood Ratio Test (Quandt 1960), Andrews Sup Wald Break Test (Andrews 1993), CUSUM test are some of the many classical tests which were designed to capture a single structural break. These tests are also born with the limitation of not having the ability to capture two or more structural breaks in the data (Bai and Perron 1998). In recent literature there have been a considerable amount of research has been done on finding methods to identify more than one break in a data set (Bai and Perron 1998 and 2003, Hawkins 2001, Sullivan 2002).

Achim Zeileis et al. (2003) introduced the "strucchange" R software package which follows Bai and Perron's (1998) multiple structural break test strategies[22] to find the number of breaks in a data set[23]. This method is used to investigate the possibility of having multiple breaks in the financial stress indexes. The Bayesian Information Criteria (BIC) is considered as a suitable method to identify multiple structural beaks in a data set over the Akaike Information Criteria (AIC) (Bai and Perron 2003). According to BIC and Residual Sum of Squares graphs in figure 18, BIC shows the lowest values for 3 break points for CITI_FSI. But for all other financial stress indexes, BIC shows its lowest values at 0 break point level. Therefore it can be concluded that only CITI financial stress index shows multiple structural breaks compared to the other financial stress indexes considered in this study.

[22] *Zeileis A. et al., (2003)*.

[23] Bai and Perron (1998) Test : H_0 : There are no Multiple Structural Breaks H_1: There are Multiple Structural Breaks

Index	Lowest BIC at	Result
GS_FSI	0	No Break
BFCIUS	0	No Break
CITI_FSI	3	Three Break Points
KCFSI	0	No Break
STLFSI	0	No Break
AE_FSI	0	No Break
NFCI	0	No Break
CFSI	0	No Break

Table 18: Bai and Perron Multiple Structural Break Test Results

3.5. Forecasting Performance Comparison of Federal reserve Bank issued Financial Stress Indexes

This section compares the forecasted performances of Federal Reserve Bank issued financial stress indexes (KCFSI, STLFSI, NFCI and CFSI). In general, univariate time series analysis has the ability to predict more accurate future observations over multivariate time series analysis. It is assumed that these financial stress indexes follow an Auto Regressive process. The autocorrelation (ACF) and partial autocorrelation (PACF) plots are used to identify the degree of lagged order in the AR models. This choice is also been verified by the Akaike Information Criteria (AIC). The results[24] are shown in Appendix 6.3. The Autocorrelation plots of all the Financial Stress Indexes show a tails off pattern and their corresponding Partial Autocorrelation Plots show a cut off pattern at different lag levels. They suggested an AR(4) process for KCFSI, AR(2) for STLFSI, AR(5) for NFCI and AR(3) for CFSI. These models were further verified by the Akaike Information criteria by identifying the lowest AIC values for above mentioned lagged orders. However the validity of the model specification depends on the residual analysis. The residual results for KCFSI and CFSI could not reject the null hypothesis of no correlation among the residuals at 5% significance level. But the results for both NFCI and STLFSI show that at two lagged values the null hypothesis of no correlation among the residuals can be rejected. Regardless of this minor issue, the obtained models seem to be well defined. Therefore an AR(4) process for KCFSI, AR(2) for STLFSI, AR(5) for NFCI and AR(3) for CFSI are considered in following forecasting proceedings.

[24] Gretl Software is used for the forecasting analysis.

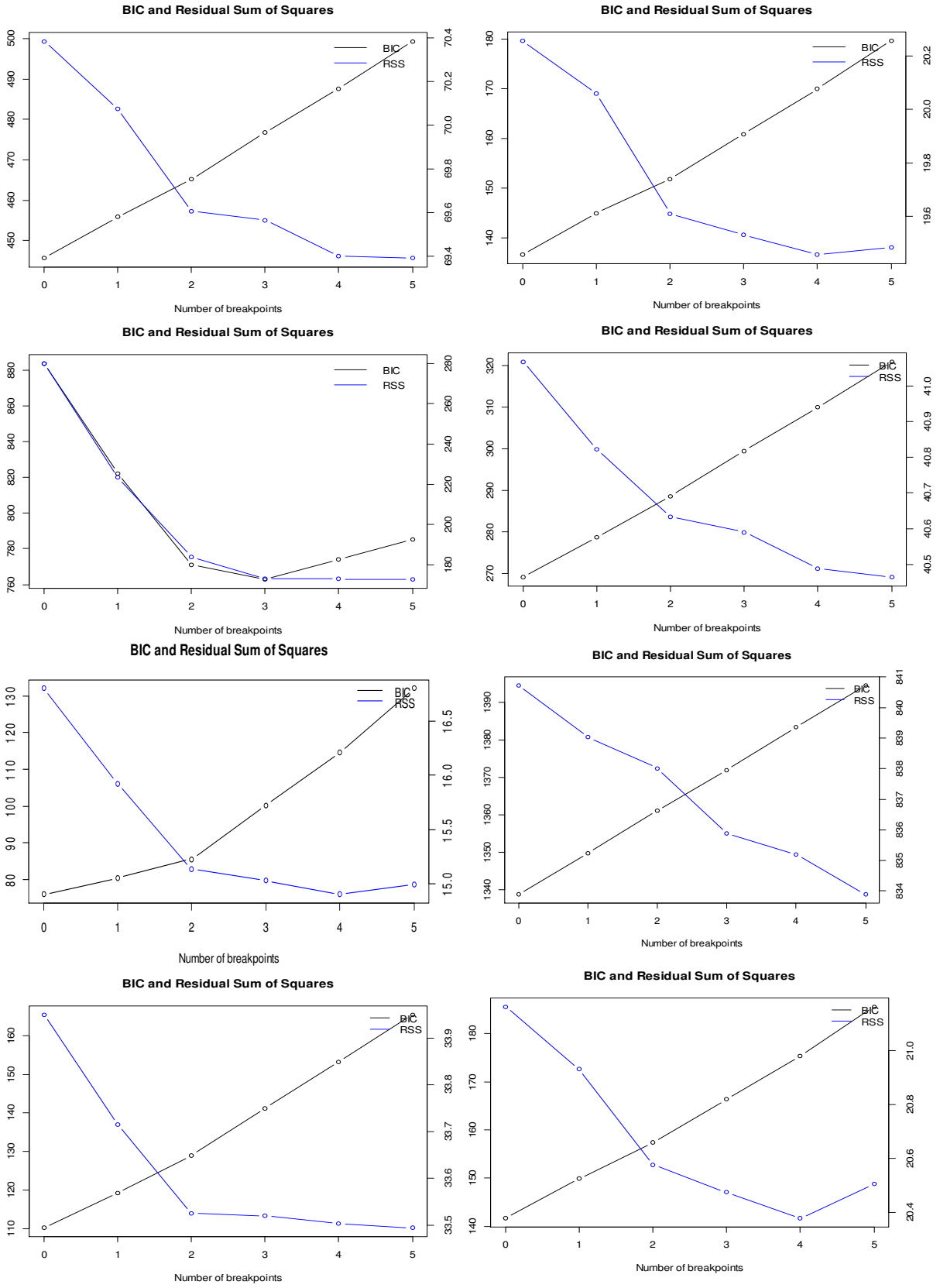


Figure 18: Multiple Structural Break Test Graphs.

A dynamic forecasting model is used. For an Example, consider the following simple AR(1) forecasting model with a random variable y_t;

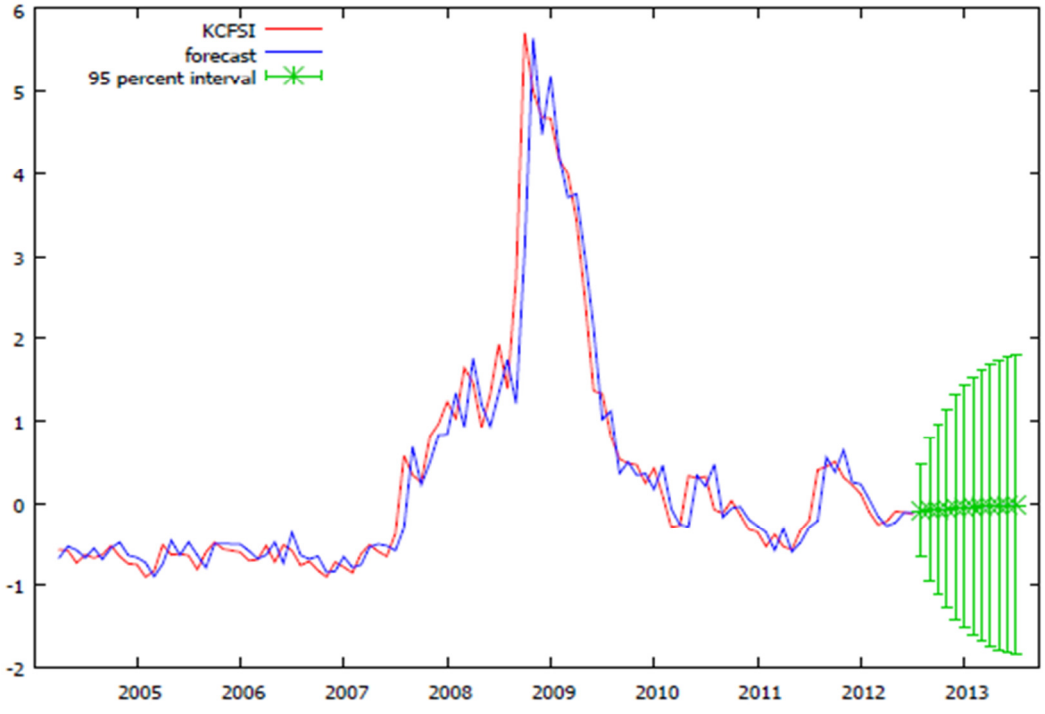
$$y_t = \propto_0 + \propto_1 y_{t-1} + \varepsilon_t \quad \textbf{(2)}$$

$$\breve{y}_s = \breve{\propto}_0 + \breve{\propto}_1 y_{s-1} \quad \textbf{(3)}$$

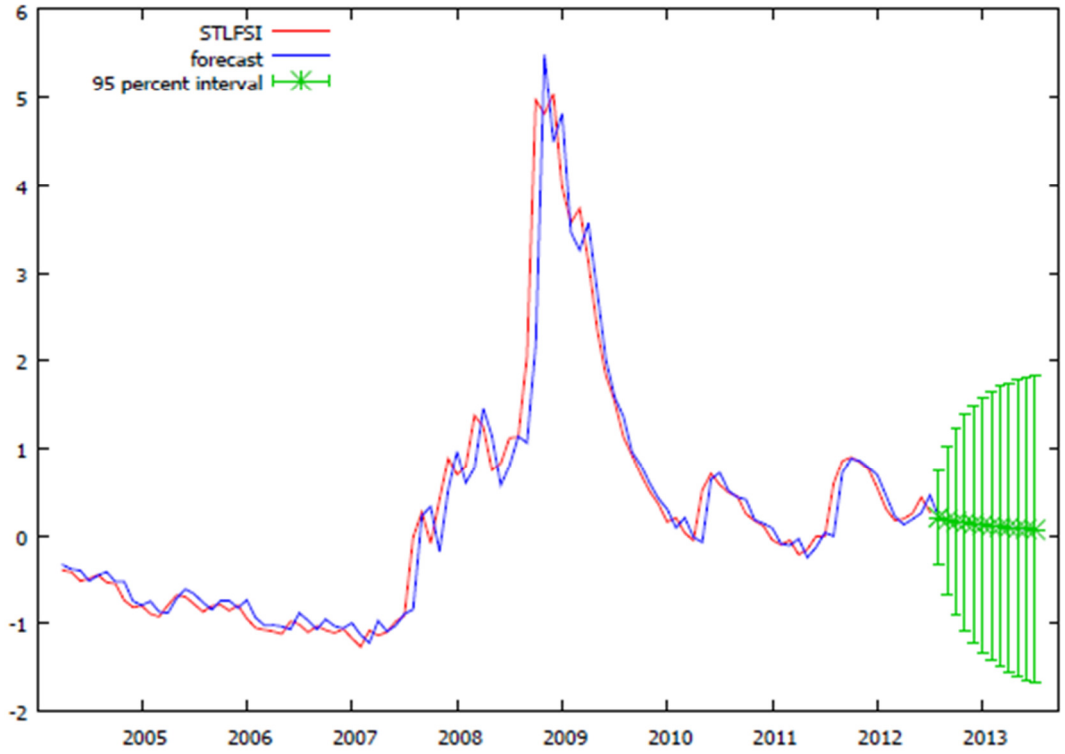
3.5.1. Forecasting the Financial Stress Index from July 2012 to July 2013

The figure 19 shows the out-of-sample forecast of KCFSI, STLFSI, NFCI and CFSI for the period August 2012 to July 2013. The forecasted values of KCFSI and NFCI show an upward sloped trend while STLFSI and CFSI show a downward sloped trend. Moreover all forecasts predict the financial stress index to reach closer to zero in the coming year. However this result is highly subjected to the past values but not both past and future values of the data series we consider. Therefore these forecast values may change because of future political, economical, social and many other influential changes. However these forecasting results still can provide handful signals for decision makers about the likeliness of the future financial stress which is required for their decision making process.

Figure 19: The out-of-sample (July 2012 – July 2013) forecast for the KCFSI, STLFSI, NFCI and CFSI.[25]



[25] The Graphs in Figure 19 display only the last 100 in-sample data points.


STLFSI
forecast
95 percent interval
6
5
4
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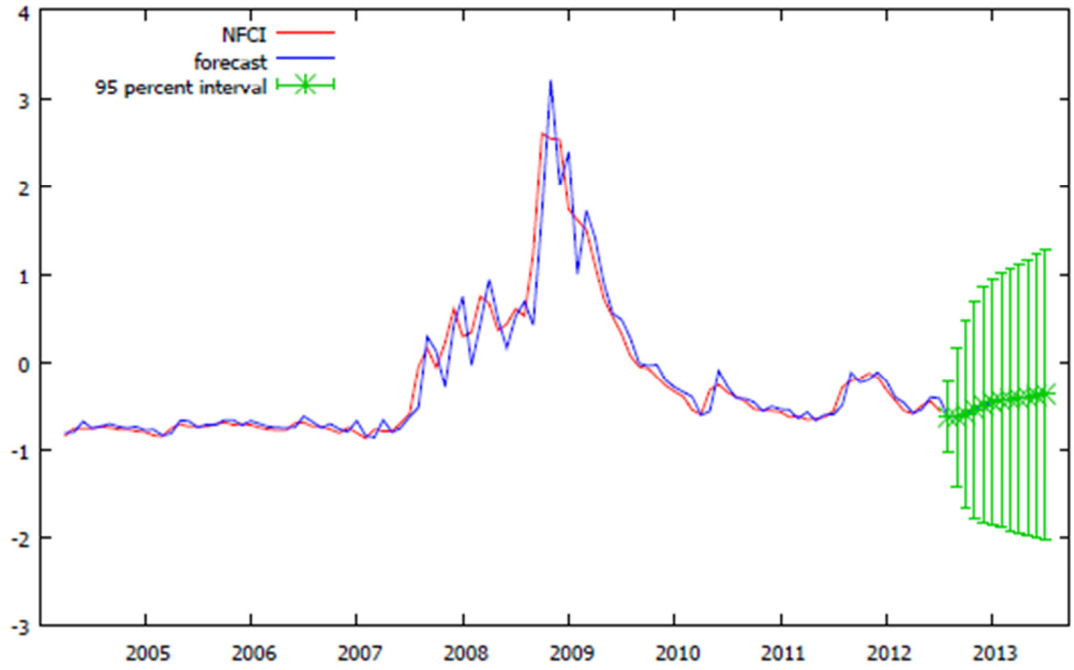
1
0
-1
-2
2005
2006
2007
2008
2009
2010
2011
2012
2013


NFCI
forecast
95 percent interval
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2005
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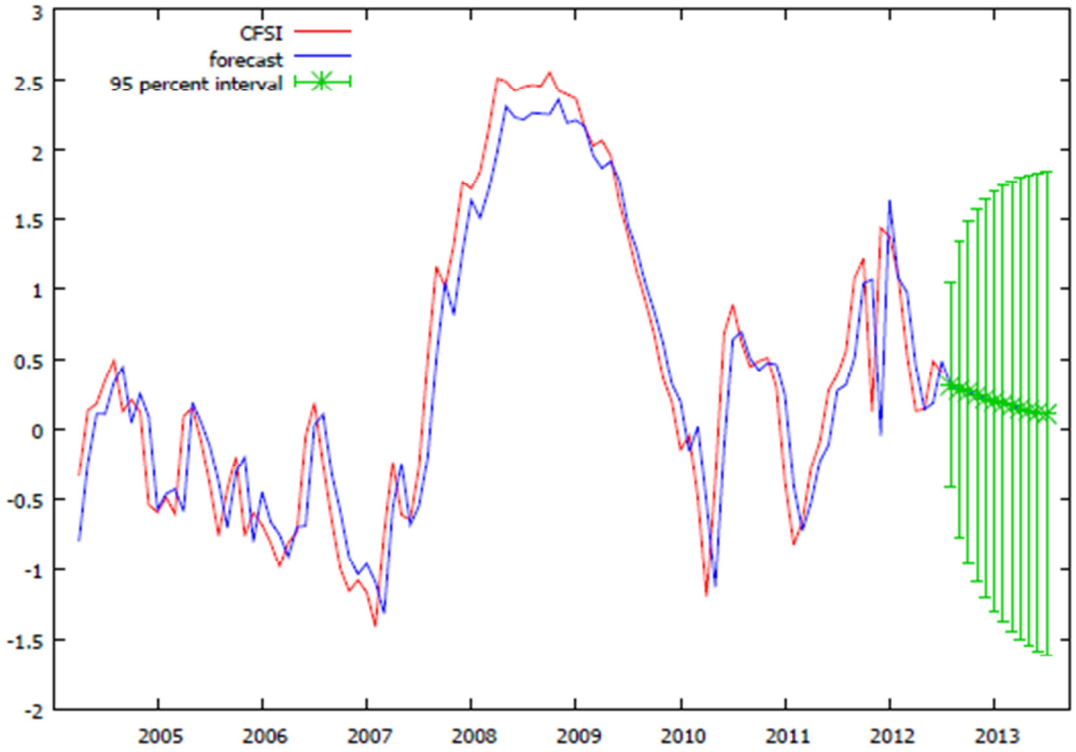
2013



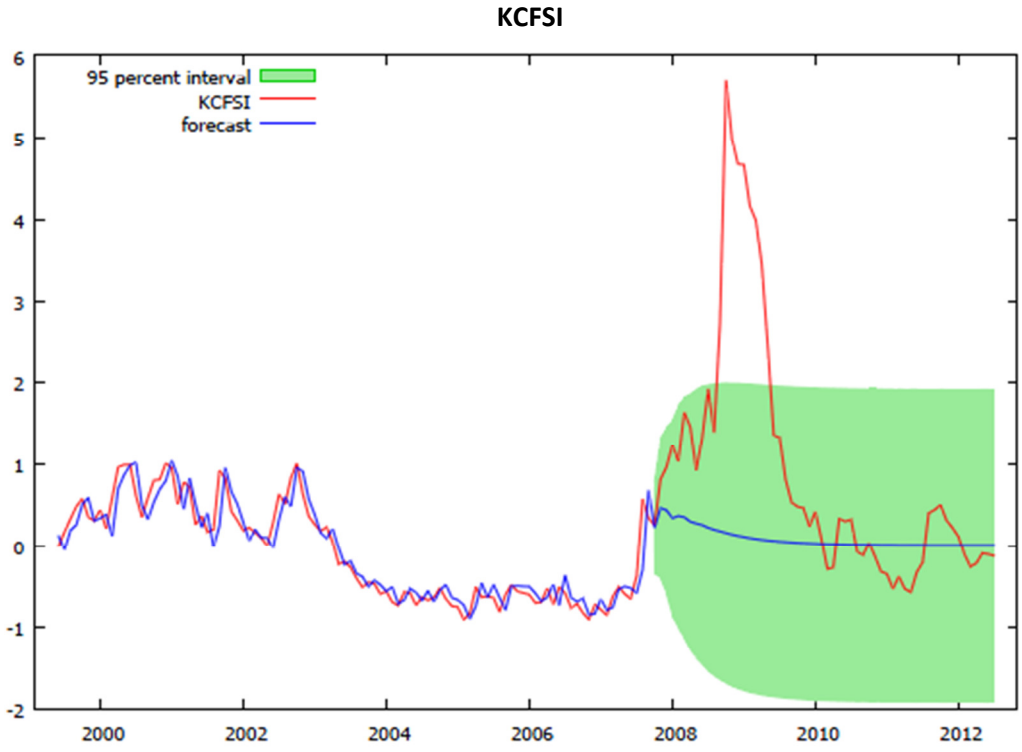
3.5.2. Forecasting the Financial stress index using the information prior to the late 2000's Recession

According to the U.S. National Bureau of Economic Research (NBER), the late 2000's recession began in December 2007 and ended in June 2009. The main purpose of the next analysis is to predict the behavior of the financial stress index using the information prior to late 2000's recession. An interrupted time series forecasting analysis is used for this purpose. In other words, the financial stress indexes were forecasted using the data from the beginning to November 2007[26]. The figure 20 plots the forecasted values and the actual values of each financial stress index. According to figure 20 – KCFSI below, when we miss the actual financial stress spike that occurred in December 2007, the forecasted financial stress is supposed to be below 1 in general. Moreover the actual financial stress index values are higher than the predicted financial stress values during December 2007 through January 2010. Especially the actual financial stress index values are significantly higher during late-2008 to mid-2009 denoting the possibility of having more negative events during that time period. However the actual financial stress index randomly

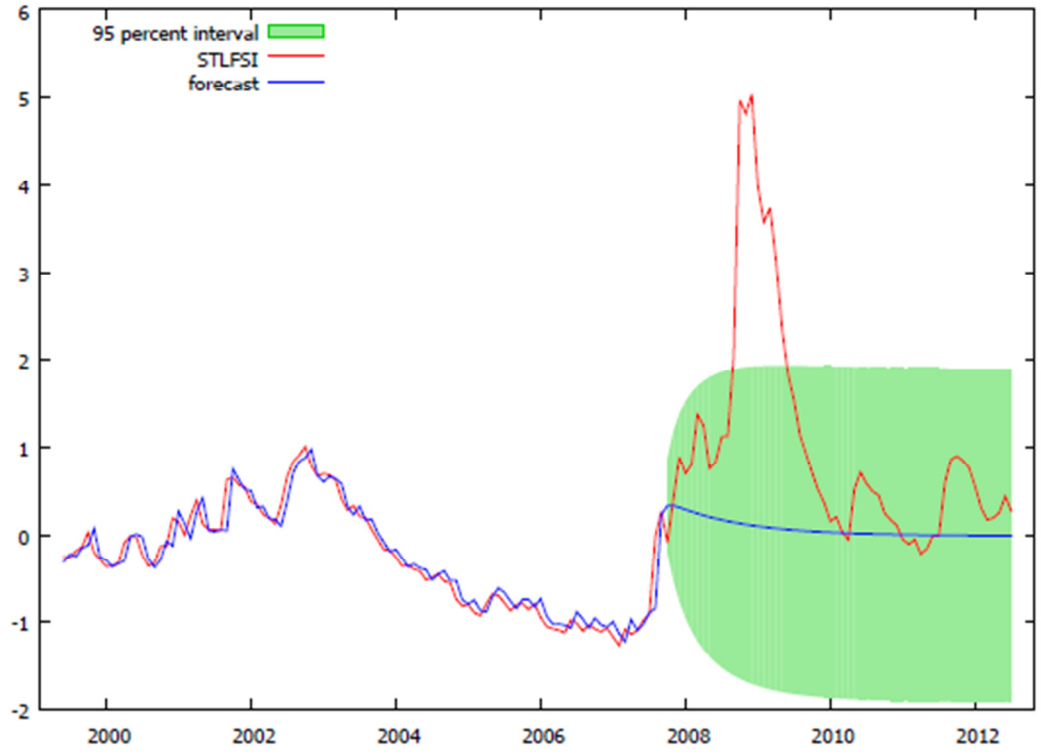
[26] November 2007 has been considered as the last data point before the recession hits the U.S. economy in December 2007

fluctuates around the forecasted values after February 2010. Moreover the actual FSI was below the predicted FSI in early 2011 indicating the positive influences of TARP, TALF and other Unconventional monetary policies in controlling the financial crisis. STLFSI also shows similar results as KCFSI. NFCI's actual index values are relatively higher than the predicted FSI values during December 2007 through November 2009. But after that the actual FSI is lower than the predicted FSI .This can be considered as an evident to prove the success of the implemented policies to solve the financial crisis. The actual CFSI values are higher than the predicted values during December 2007 through November 2009. But after that actual FSI randomly fluctuates around the predicted FSI. This indicates a significant instability in the financial conditions during that time. But the actual FSI values got higher than the predicted values after mid-2010. This suggests that the policy changes which were implemented to control the financial crisis were only effective in the short run than in the long run. In general, all financial stress indexes indicate that during late 2008 to late 2009 the actual financial stress is significantly higher than what it would have been using the data prior to the late 2000's Recession.

Figure 20: The in-sample forecast of KCFSI, STLFSI, NFCI and CFSI using the information prior to the late 2000's Recession



STLFSI


95 percent interval
STLFSI
forecast
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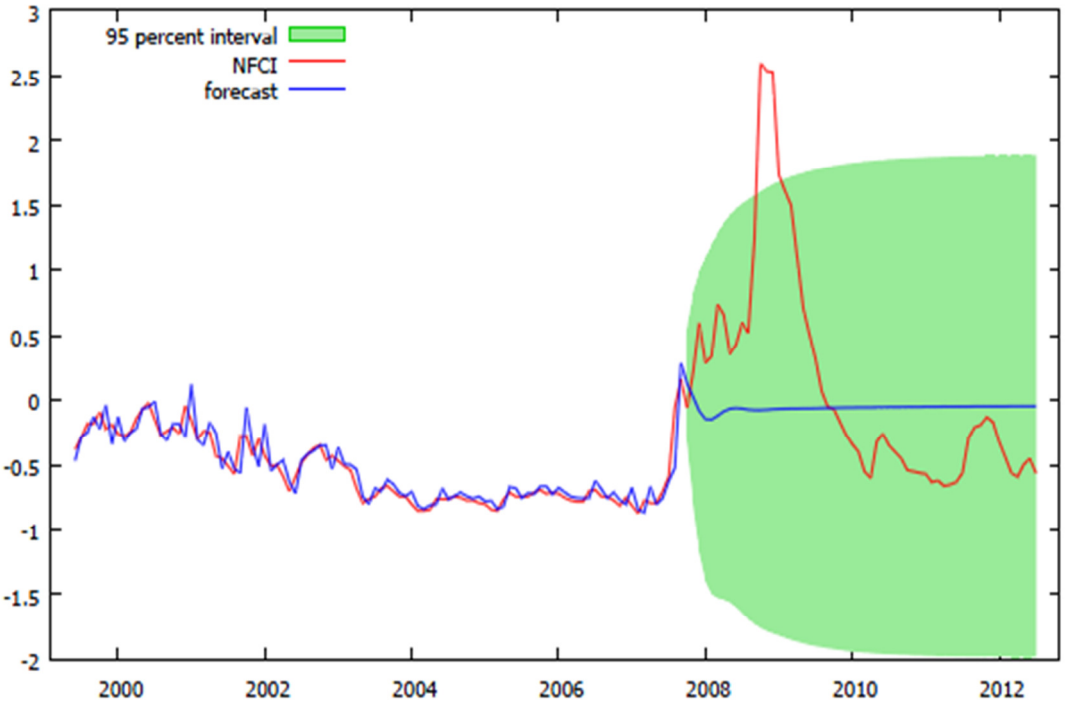
2000
2002
2004
2006
2008
2010
2012

NFCI


95 percent interval
NFCI
forecast
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2.5
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1.5
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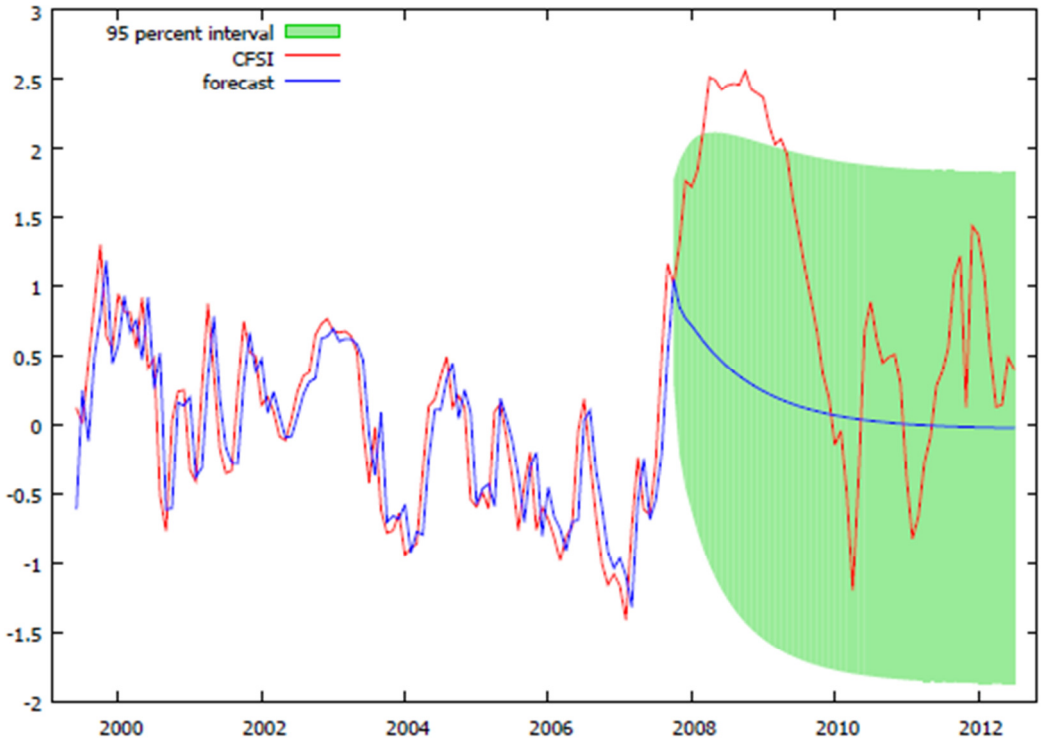
2008
2010
2012

CFSI



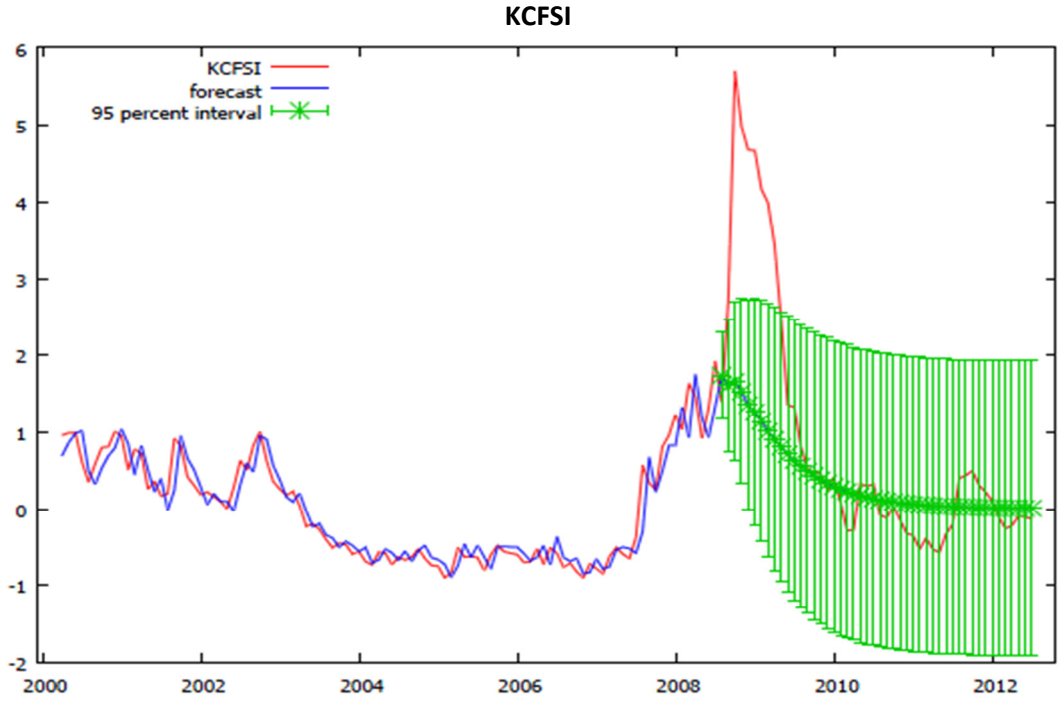
3.5.3. Forecasting the Indexes based on the information prior to the Lehman Brothers Bankruptcy

On September 15 2008, Lehman Brothers filed for Chapter 11 bankruptcy protection. The failure of this financial giant simply provided the required acceleration for a serious financial meltdown in the global financial system (Azadinamin 2012). This was also the largest bankruptcy filing in the U.S. history (The Market Watch 2008)[27]. It created a significant uncertainly both in the U.S. and the world financial market while changing the entire pace of the late 2000's recession which began in December 2007 (Swedberg 2009). This idea also has been pointed out by Robert Lucas in his own wordings ; *"Until the Lehman failure the recession was pretty typical of the modest downturns of the post-war period…After Lehman collapsed and the potential for crisis had become a reality, the situation was completely altered"* (Lucas 2009). The Federal Reserve Bank chairman, Ben Bernanke also expressed this idea in his own words as follows *"we may not have an economy on Monday"* (Thomas and Hirsh 2009, Swedberg 2009). All these evidences prove the significance of the Lehman Brothers Bankruptcy on the US financial crisis.

[27] The Marketwatch : http://www.marketwatch.com/story/lehman-folds-with-record-613-billion-debt?siteid=rss

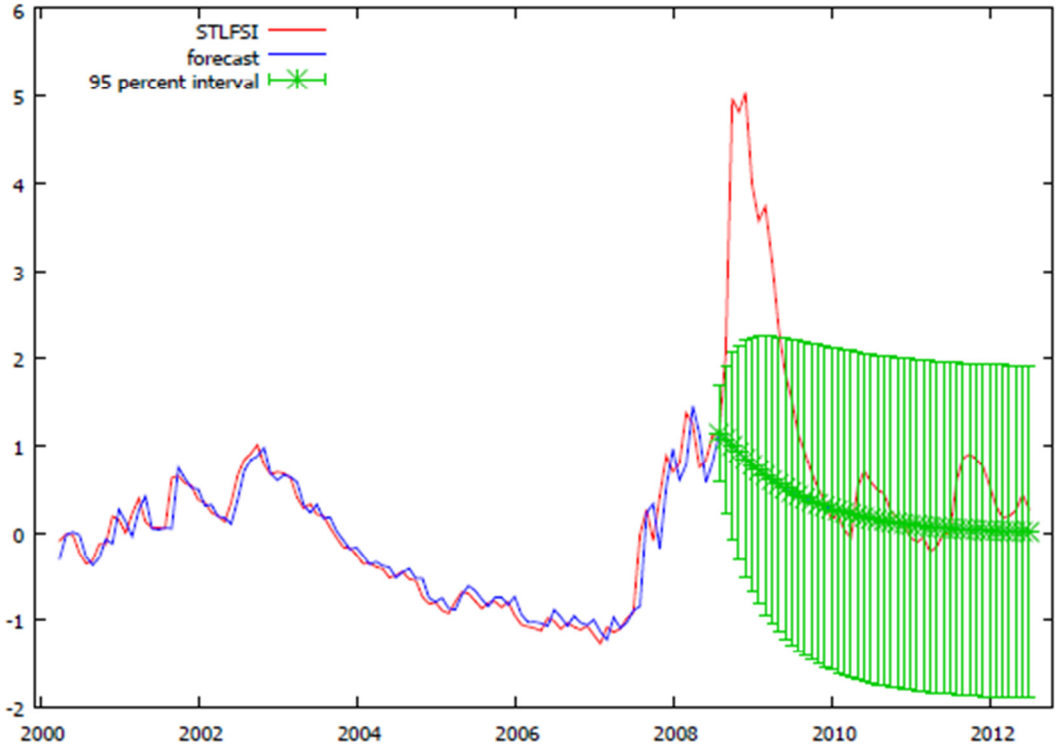
In this analysis I forecast KCFSI, STLFSI, NCFI and CFSI by considering the data up to the Lehman Brother failure. The past financial stress data[28] up to September 2008 has been used as the in-sample for this analysis. Figure 21 plots the forecasted values and the actual values of each financial stress index. According to figure 21, in general, the actual FSI is significantly higher than the predicted FSI during the time period September 2008 – November 2009. This shows the significance of the Lehman Brother collapse on the U.S. financial crisis. In general, the negative impacts of the financial crisis seem to be solved after 2010 as the predicted values reach to zero level. But the impacts of both Lehman Brother collapse and post Lehman Brother Collapse conditions kept the actual financial stress more volatile even after year 2010. This is evident by having the actual FSI to be fluctuated around the predicted FSI more frequently after year 2010. KCFSI, STLFSI and NFCI commonly distinguish the significance of the Lehman Brother bankruptcy on the U.S. financial stress by increasing their index values to highest levels after September 2008. But according to figure 21, CFSI does not show a significant increase in its values after the Lehman Brother bankruptcy instead it provided a higher significance to the start of this recession as the FSI suddenly increases to higher levels after December 2007.

Figure 21: The in-sample forecast of KCFSI, STLFSI, NFCI using information prior to the Lehman Brothers Bankruptcy



[28] August 2008 data point has been considered at the last data point before the Lehman Brother Bankruptcy in September 2008

STLFSI


STLFSI
forecast
95 percent interval
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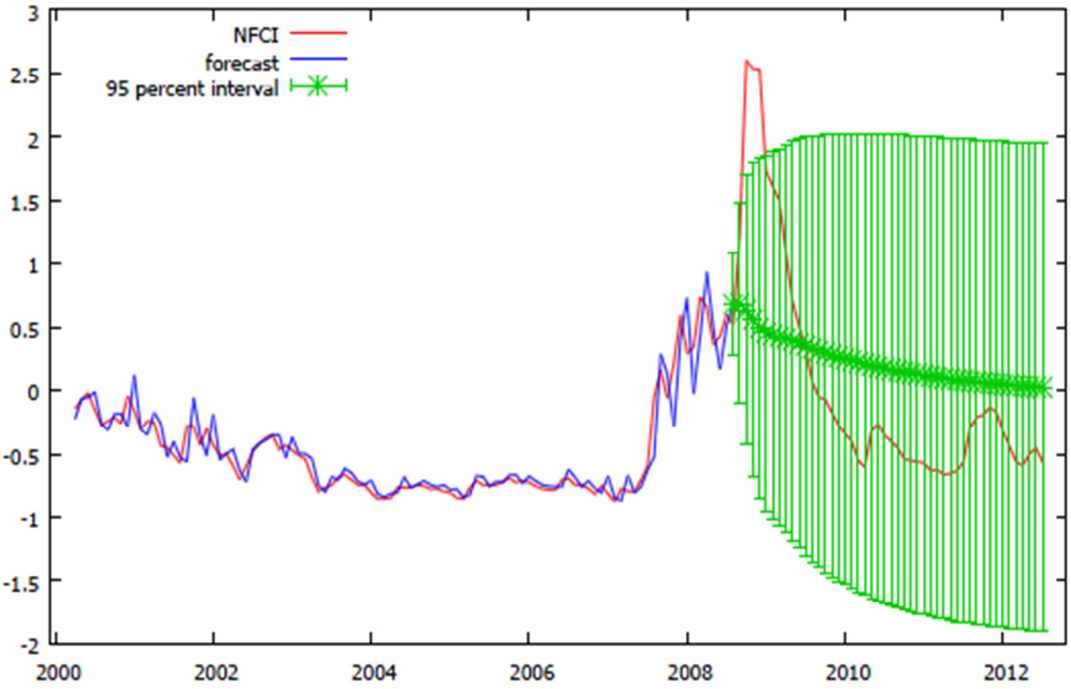
2012

NFCI


NFCI
forecast
95 percent interval
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
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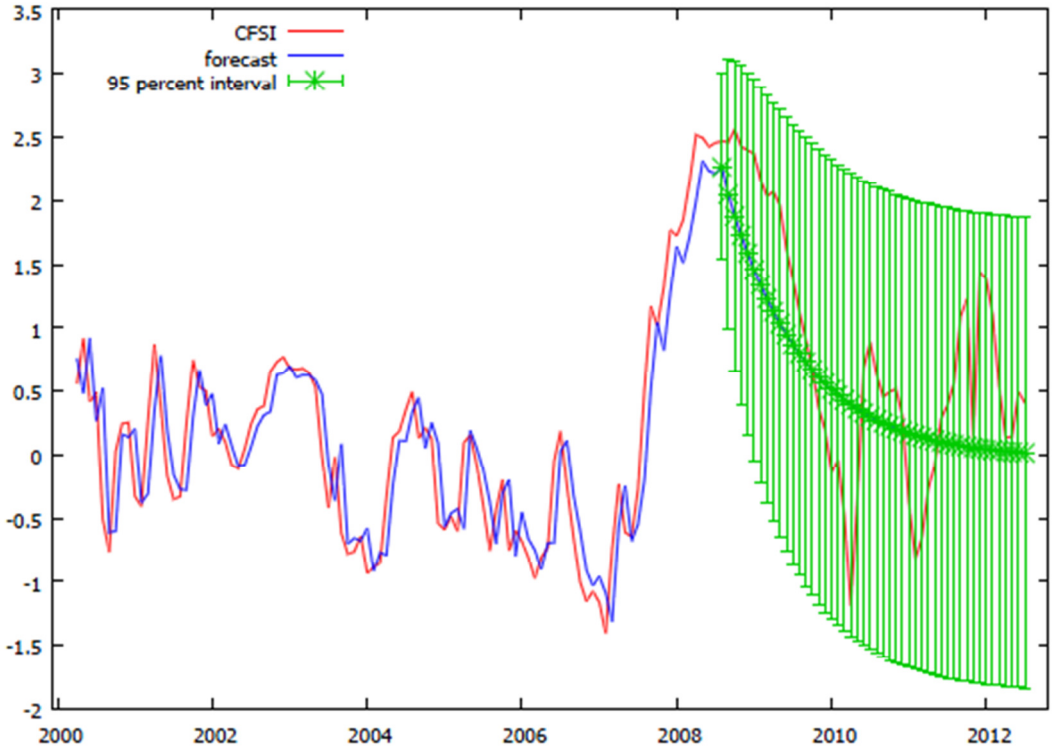
2010
2012

CFSI



4. Conclusion

This paper provides a comparative analysis on the financial stress indexes available for the U.S. The main objective of these stress indexes is to provide detailed insights about the financial conditions in the U.S. economy. In general, all financial stress indexes indicated a very high financial risk during the 2008 financial crisis. Among the Federal Reserve Bank issued financial stress indexes, Kansas City Fed Financial stress index (KCFSI) and St. Louis Fed Financial stress index (STLFSI) show considerable amount of similarities during 2008 financial crisis. However the behavior of Chicago Fed's National Financial Conditions Index (NFCI) and the Cleveland Fed's Financial Stress Index (CFSI) are different to the behavior of KCFSI and STLFSI's during that time. Almost all financial stress indexes were non stationary in their original levels. But the first difference of them was stationary. According to the structural break tests, except the CITI_FSI, all other financial stress indexes did not show any kind of a structural break.

The out of sample forecast predicted almost zero level financial stress indexes closer to mid-2013. The in sample forecasts suggested that when I omit the financial stress data starting from the late 2000s recession in the original data, the U.S. economy would have been operated with a much lower financial stress after December 2007. Further the last in sample forecasting analysis projects that the financial stress gets to much lower levels when I omit the stress spike that occurred for the 2008 Lehman Brothers Bankruptcy. If a researcher wants to study the financial conditions of the U.S. economy then these financial stress indexes should be the first choice. However it is more practical to select the Federal Reserve Bank issued financial stress indexes as they are easily and freely accessible through Fred[29] data. However if a researcher wants to study the financial stress of other advanced (industrialized) countries, then AE_FSI would be a better choice as it is available for 17 advanced countries. In general, these financial stress indexes are highly useful in understanding the financial conditions in the U.S. economy.

[29] Fred data : http://research.stlouisfed.org/fred2/

5. REFERENCES

(1). Andrews, D.W.K., (1993). "Tests for Parameter Instability and Structural Change with Unknown Change Point", Econometrica, 59, pp. 817-858.

(2). Bai, J., and Perron, P., (1998), "Estimating and Testing Linear Models with Multiple Structural Changes, Econiometrica 66, pp. 47-78.

(3). Balakrishnan, R., Danninger S., Elekdag S, and Tytell I. (2009), "The Transmission of Financial Stress from Advanced to Emerging Economies." IMF Working Paper No. 09/133.

(4). Baur, D.G., and Lucy, B. M., (2010), "Is Gold a Hedge or a Safe Heaven? An Analysis of Stocks, Bonds and Gold", The Financial Review, 45, pp. 217-229.

(5). Baxa J., Horvath R. and Vasicek B. (2012), "Time-Varying Monetary-Policy Rules and Financial Stress: Does Financial Instability Matter for Monetary Policy?", Journal of Financial Stability, forthcoming.

(6). Bianco, T., Oet, M., Ong, S. J., (2012), "The Cleveland Financial Stress Index: A Tool for Monitoring Financial Stability", The Cleveland Federal Reserve Bank.

(7). Brown, R. L., Durbin, J., and Evans, J. M., (1975), "Techniques for Testing the Constancy of Regression Relationships over Time", Journal of the Royal Statistical Society, Series B, 35, pp. 149-192.

(8). Caballero, Ricardo J., and Pablo Kurlat. 2008. "Flight to Quality and Bailouts: Policy Remarks and Literature Review," working paper, October.

(9). Cardarelli R., Elekdad S., Lall S., (2011): "Financial Stress and Economic Contractions." Journal of Financial Stability, 7(2), pp. 78–97.

(10). Chow, G. C., (1960), "Tests of Equality Between Sets of Coefficients in Two Linear Regressions", Econometrica, 28, pp. 591–605.

(11). Doz, C., D. Giannone, and L. Reichlin, (2006), "A quasi maximum likelihood approach for large approximate dynamic factor models", European Central Bank, working paper, No. 674, September.

(12). Dudley, W., and J. Hatzius (June 8, 2000). The Goldman Sachs Financial Conditions Index: The Right Tool for a New Monetary Policy Regime. Global Economics Paper No. 44.

(13). Dudley, W., J. Hatzius, and E. McKelvey (April 8, 2005). Financial Conditions Need to Tighten Further. US Economics Analyst, Goldman Sachs Economic Research.

(14). D'Antonio, P., Appendix, pages 26-28, in DiClemente, R. and K. Schoenholtz (September 26, 2008), "A View of the U.S. Subprime Crisis," EMA Special Report, Citigroup Global MarketsInc.

(15). Estrella, A., and G. Hardouvelis (1991), "The term structure as a predictor of real economic activity," Journal of Finance 46, 555-576.

(16). Evan, T., and Hirsh, M., (2009), "Paulson's Complaint", Newsweek May 25.

(17). Friedman, B. and K. Kuttner (1992), "Why Does the Paper-Bill Spread Predict Real Economic Activity?" in Business Cycles, Indicators and Forecasting, Stock, J. and M. Watson, eds., Chicago: University of Chicago Press.

(18). Gertler, M., and Karadia, P., (2011), "A model of unconventional monetary policy", Journal Monetary Economics, 58, pp.17-34

(19). Goldstein M., Kaminsky G. L., Reinhart C. M., (2000), "Assessing Financial Vulnerability: An Early Warning System for Emerging Markets." Washington, DC: Institutefor International Economics.

(20). Gonzalo, Jesus, and Jose Olmo. 2005. "Contagion versus Flight to Quality in Financial Markets," Universidad Carlos III de Madrid, Working Paper No. 05-18, April.

(21). Goodhart, C, C Osorio and D Tsomocos (2009), "An Analysis of Monetary Policy and Financial Stability: A New Paradigm", CESifo Working Paper No. 2885.

(22). Grinblatt, Mark. 2002. "An Analytic Solution for Interest Swap Spreads," Yale ICF Working Paper No. 02-02. January.

(23). Guttentag, Jack M., and Richard J. Herring. 1986. Disaster Myopia in International Banking, Princeton University Essays in International Finance, No. 164. September.

(24). Hakkio, C. S., Keeton W. R., (2009), "Financial Stress: What Is It, How Can It Be Measured, and Why Does It Matter?" Economic Review (2Q 2009), Federal Reserve Bank of Kansas City, 1–50.

(25). Hall, R. E., (2010), "Why Does the Economy Fall to Pieces after a Financial Crisis?", The Journal of Economic Perspectives, 24, pp. 3-20

(26). Hamilton, J. D., and Wu, J. C., (2012), "The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment", Journal of Money, Credit and Banking, 44, pp. 3-46

(27). Hatzius, J., Hooper, P., Mishkin, F.S., Schoenholtz K. L., Watson, M., (2010), "Financial Conditions Indexes: A Fresh Look after the Financial Crisis", NBER Working Paper No. 16150.

(28). Illing, M., Liu Y., (2006), "Measuring Financial Stress in a Developed Country: An Application to Canada." Journal of Financial Stability 2(3), pp. 243–265.

(29). Kim, H. J., and Siegmund, D., (1989), "The Likelihood Ratio Test for a Change-Point in Simple Linear Regression",Biometrika, 76, pp. 409-23.

(30). Kwan, Simon. 2001. "Rising Junk Bond Yields: Liquidity or Credit Concerns?" Federal Reserve Bank of San Francisco, Economic Letter, No. 2001-33, November 16.

(31). Kramer, W., Ploberger, W., and Alt, R., (1988), "Testing for Structural changes in Dynamic Models", Econometrica, 56, pp. 1355-1369

(32). Laurent, R. (1989), "Testing the Spread," Federal Reserve Bank of Chicago, Economics Perspectives, 12:1, pp. 3-14.

(33). Lucas, R., (2009), "In Defense of the Dismal Science", The Economist August Issue.

(34). Lumsdaine, R. L and. Papell, D. H. (1997), "Multiple Trend Breaks and the Unit Root Hypothesis", Review of Economics and Statistics, 79 (2), pp. 212-218.

(35). Perron, P., (1989), "The great crash, the oil price shock, and the unit root hypothesis", Econometrica, 57, pp.1361-1401.

(36). Phillips, P., and Perron, P., (1988), "Testing for a Unit Root in Time Series Regression", Biometrica, 75(2), pp. 335-346.

(37). Reinhart, C. M., and Rogoff, K. S., (2008), "Is the 2007 U.S. Sub-Prime Financial Crisis So Different? An International Historical Comparison", NBER Working paper No. 13761.

(38). Rosenberg, M. (December 3, 2009), "Financial Conditions Watch," Bloomberg.

(39). Zeileis A. et al., (2003), "Testing and Dating Structural Changes in Practice", The Computational Statistics & Data Analysis, 44, pp. 109-123.

6. APPENDIX

6.1. APPENDIX 1

Recession	Time Frame	Reason
1973-75 Recession	Nov 1973 - Mar 1975	OPEC Oil Price Hike
1980 Recession	Jan 1980 - July 1980	Interest Rate Hike under Paul Volcker
Early 1980s Recession	July 1981 - Nov 1981	Oil Price hike
Early 1990s Recession	July 1990 - Mar 1991	1990s Oil Price Shock, 1980's Debt Accumulation
Early 2000s Recession	Mar 2001 - Nov 2001	Dot_com Bubble, Sep 11 Attacks
Great Recession	Dec 2007 - June 2009	Subprime Mortgage Crisis

Table 19: List of NBER Recessions

6.2. APPENDIX 2

The following table represents the Root Mean Square Errors for two forecasting analysis above.

	RMSE Values	
FSI	**Forecasting the FSI using the information prior to the late 2000's Recession**	**Forecasting FSI based on the information prior to the Lehman Brothers Bankruptcy**
KCFSI	0.193818	0.231174
STLFSI	0.154596	0.167639
NFCI	0.194894	0.208556
CFSI	0.371199	0.374658

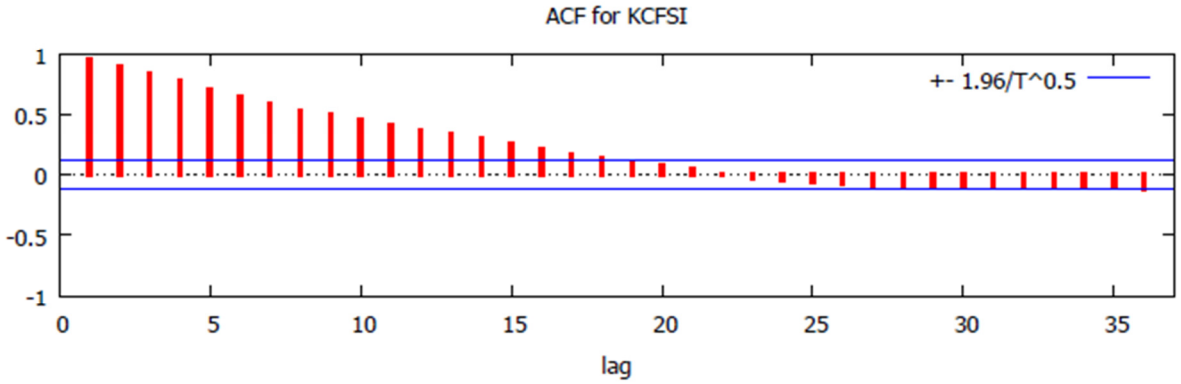
Table 20: RMSE Values for the Forecasting Analysis

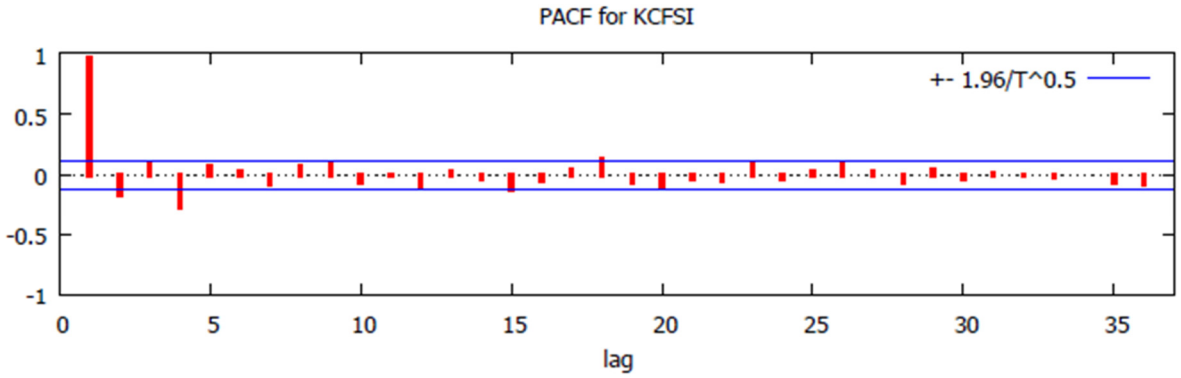
6.3. APPENDIX 3

The Model Selection Criteria for forecasting Federal Reserve Bank Issued Financial Stress Indexes

The following figures show the ACF and PACF plots for the different financial stress indexes considered, KCFSI, STLFSI, NFCI and CFSI. The Maximum number of lagged values selected is 36. The table next to each graph shows the Akaike Information Criteria (AIC) values for different AR model selections. The Lowest AIC value is indicated with **.

1. Kansas City Fed Financial Stress Index (KCFSI)

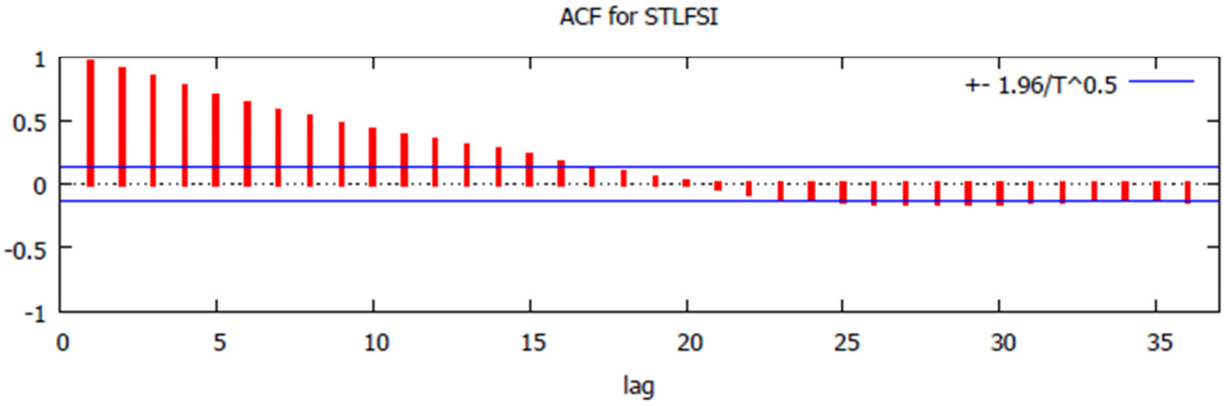


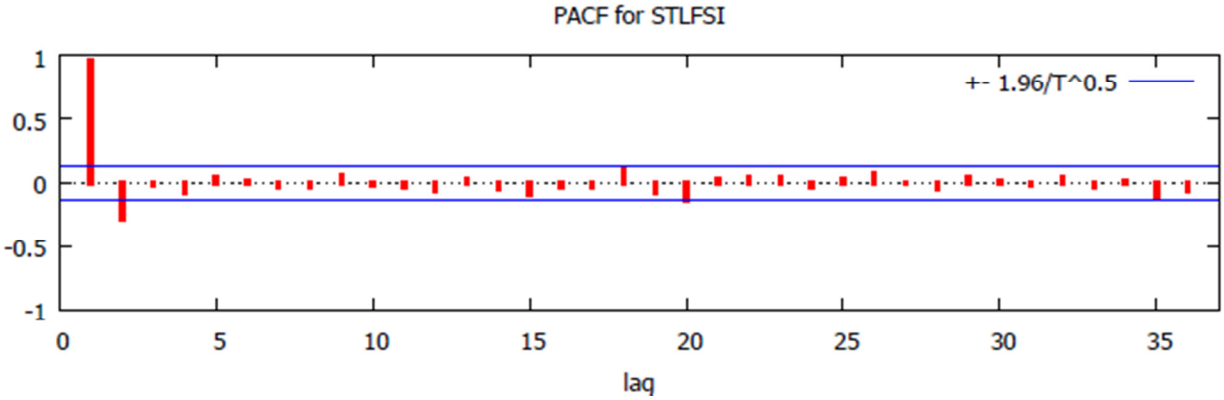


ρ	1	2	3	4	5	6	7
AIC	134.7114	129.3910	128.9304	**110.9379 ****	111.8230	113.7513	114.4719

According to ACF, PACF plots and the AIC criteria, AR(4) is a better Model selection for KCFSI.

2. St. Louis Fed Financial Stress Index (STLFSI)

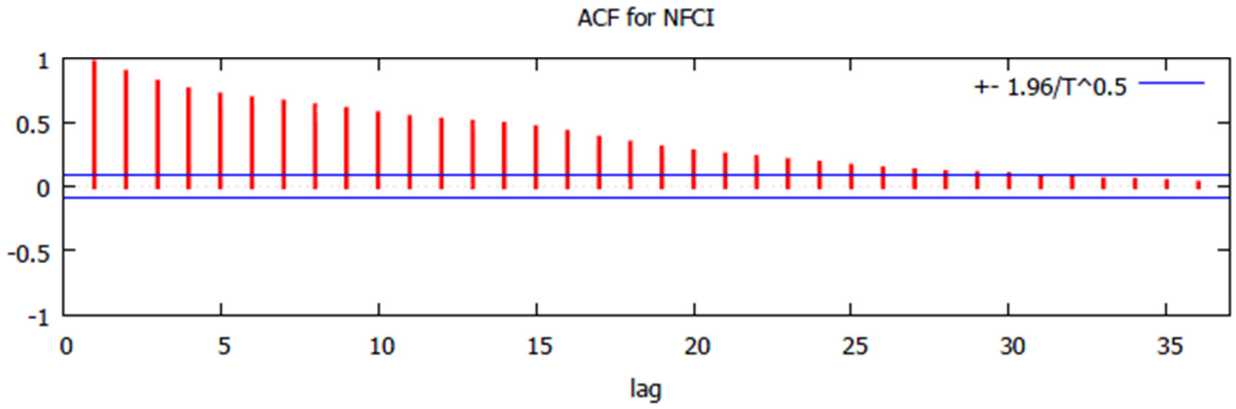


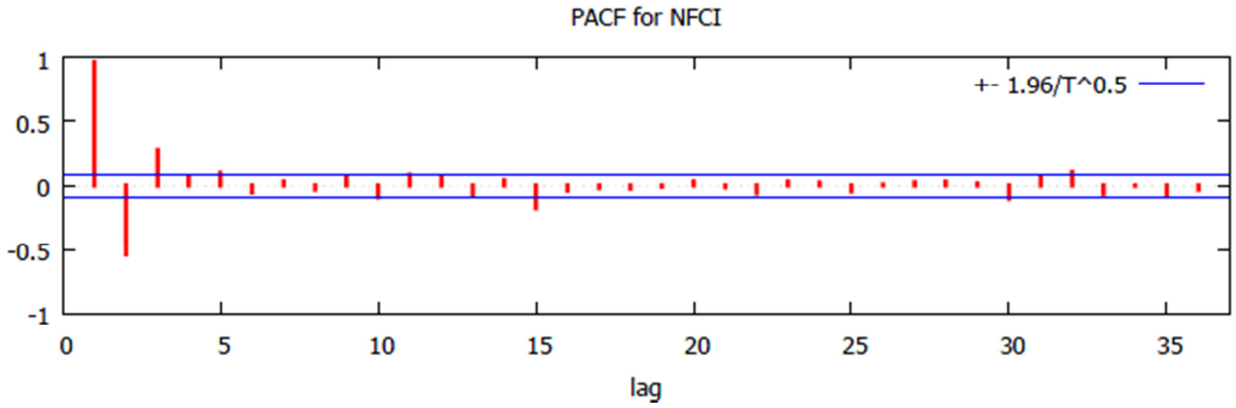


ρ	1	2	3	4	5
AIC	83.0869	67.5266 **	69.4978	70.2061	71.9561

According to ACF, PACF plots and the AIC criteria, AR(2) is a better Model selection for STLFSI.

3. Chicago Fed National Financial Conditions Index (NFCI)

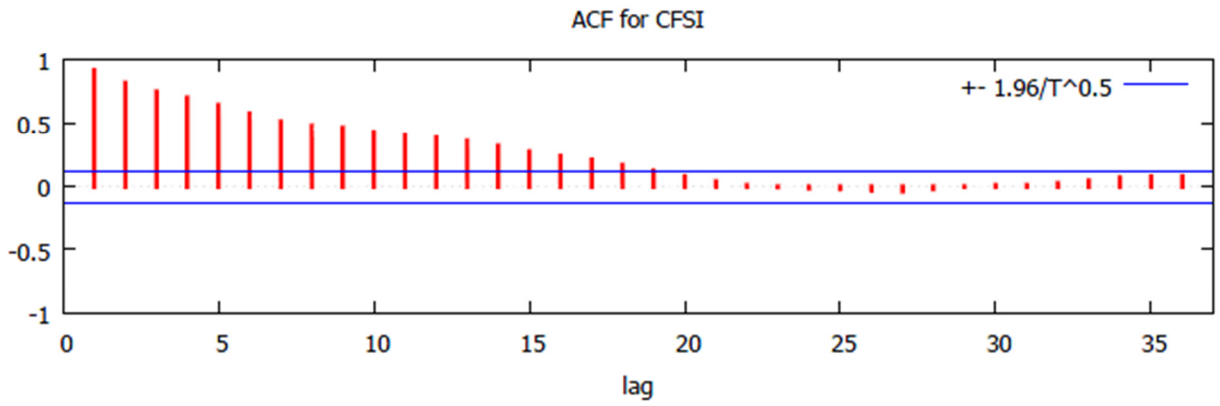


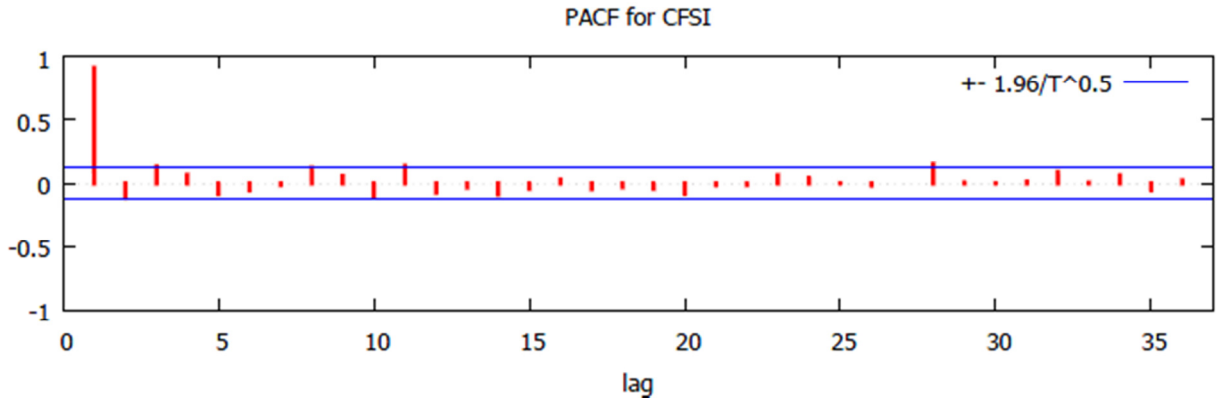


ρ	1	2	3	4	5	6	7
AIC	97.82	-76.97	-122.99	-122.53	-124.06**	-123.39	-121.50

According to ACF, PACF plots and the AIC criteria, AR(5) is a better Model selection for NFCI.

4. Cleveland Fed Financial Stress Index (CFSI)





ρ	1	2	3	4	5
AIC	234.992	233.0847	230.3324 **	231.1855	232.7699

According to ACF, PACF plots and the AIC criteria, AR(3) is a better Model selection for CFSI.