

**Financial Crisis Prediction: Constructing a viable financial stress index**

Shubham Shanker ID – 2016B3A30446P

Pranit Bhavishi ID – 2016B3A30332P

*Abstract*

Trade and other international transactions is bringing the world closer. But the countries are also becoming more and more open and prone to getting affected by each other. The major implication is the fact that widespread financial crisis in one country can now spread to other countries very quickly. No one is new to the global financial crisis of 2007-08 which made an impact so large; it took years to fully recover. Therefore it becomes immensely important that we successfully predict these crises even before they occur, so that necessary action can be taken to minimize the damage. To do this, we have attempted to create a stress index, commonly known as Financial Stress Index (FSI) for 8 countries in the European Union. To do this we have used various economic indicators of stress as sub-indices. Finally, all sub-indices are combined to form a fully working FSI. The countries selected are the ones having highest intra European-Union trade. However there are also various limitations and the different facets must be thoroughly examined before using this final statistical value to draw conclusions.

**1. Introduction**

Financial crisis gained a lot of attention in the recent past. Almost everyone is aware of the chain of events that started to occur after the collapse of Lehman Brothers in September 2008. The queen is known to have asked that how did no one see it coming? A financial crisis is one of the deadliest hits that can affect an economy. It can be in many forms- currency crisis, bank crisis and sovereign debt crisis. The losses amount to significant values which can be compared with the country’s GDP. For example, the crisis of 2008 cost Americans $12.8 trillion. Thus, a need for developing an early warning system becomes essential. Early warning systems work by using dummies as dependent variable (Vermuelen).

Thus, a FSI can be defined as an index which measures the current level of friction and stress in the economy and can be displayed as a single continuous statistic. Balakrishnan, in his paper wrote - “an episode of financial stress is defined as a period when the financial system is under strain and its ability to intermediate is impaired. Financial stress tends to be associated with at least four fundamental characteristics: large shifts in asset prices, an abrupt increase in risk and/or uncertainty, liquidity droughts, and concerns about the health of the banking system. The events affecting financial market conditions can be varied and have external or domestic origins, such as risk-reassessments of investors, changes in such events shape the supply or demand of funds in financial markets—and therefore asset prices—and may thereby afflict multiple segments of the financial system.” Policymakers can be greatly benefited from a FSI because an increase in the value of FSI indicates an increased likelihood of stress; hence they can use it to constantly measure stress. Therefore, FSIs provide alerts to the concerned policymakers.

Many financial indices have been drafted over the years, be it for a single country or a group of countries. We have in the subsequent paper developed a financial index particularly for the highly active group of European Union countries. We found out the highly active countries by analyzing the statistic which shows the amount of intra EU trade carried out by various countries. We took advantage of the fact that most of them use the same currency (except UK). This helped us in modeling our index and gave the index a high predicting power when used for a different country with the same currency. The reason why we selected a group of countries and not a single country, and the basis of selection etc. will all be discussed in detail under the Methodology section.

The report is structured as follows- Introduction, followed by literature review in which we provide information on all the previous papers we reviewed. After summarizing their results which helped us develop our own way of constructing FSI, we move on Methodology where we explain in detail about the method used by us to construct the index. Then we show our results, followed by limitations of our work. Finally, we provide the conclusion.

**2. Literature Review**

After reviewing different papers we found out there exists a variety of indices that indicate the financial stress in a given region and there is no hard and fast rule to constructing such an index. The main consensus seems to be that the value of such constructed FSI should indicate the onset of a financial crisis and the therefore the indicators chosen should be leading indicators and not lagging ones(affected most after or during the crisis is taking place).

Some of the indices that we looked into are given below:-

1) STLFSI

The Saint Louis Financial Stress Index (STLFSI) measures the degree of financial stress in the markets and is constructed from 18 weekly data series: seven interest rate series, six yield spreads and five other indicators.

2) OFR FSI

The OFR Financial Stress Index (OFR FSI) is a daily market-based snapshot of stress in global financial markets. It is constructed from 33 financial market variables, such as yield spreads, valuation measures, and interest rates. The OFR FSI is positive when stress levels are above average, and negative when stress levels are below average.

3) A Financial Stress Index for Turkey (Yıldırım, İ. (2018)

Nominal exchange rate, interest rate and international reserves were generally used in the calculation of Financial Stress Index. In order to define financial crises, FSI was formed with the help of this formula: FSI= [$/TL Nominal Exchange Rate Variation (%)] + [TL Interest Rate Variation (%)] - [Variation in Gross Reserves (%)] FSI period in which it is indicating the financial crises, were determined according to the threshold value. Threshold value can be formulized as follows:

FSI ≥ μ+1,5σ→Crisis exists, D=1

FSI ≤ μ+1,5σ→Crisis does not exist, D=0

4) Financial Stress, Downturns, and Recoveries – (Cardarelli,R et al. 2009) The FSI is an equal-variance weighted average of seven variables, grouped into three categories Banking Sector, securities Market and Foreign exchange.

We took into account the different types of FSI and their methods of construction and decided on the type of FSI by balancing the amount of data that we could collect and the explanatory power of the selected variables. We decided to chose our variables ion the basis of the paper Financial Stress, Downturns, and Recoveries (Cardarelli, R et al. 2009) with a few modifications.  We learnt that financial turmoil in any region can be due to periods of stress in three broadly different areas that may themselves also be linked (see Carderelli, R). These areas are

1. Banking Sector

There are several factors that could be included to indicate the banking sector performance, for example :-

1. Banking sector β: covariance of the year-on-year percentage change of a country’s banking sector equity index and its overall stock market index, divided by the variance of the year-on-year percentage change of the overall stock market index.
2. TED spread: 3-month LIBOR or commercial paper rate minus the government short-term rate.
3. Inverted term spread: government short-term rate minus government long-term rate.

   2. Securities market

This is the integral component of the financial market where securities( equity,debt) can be bought and sold. The different types of identifier for this market are :-

1. Time-varying stock volatility: GARCH(1,1) volatility of overall stock market index monthly return.
2. Stock decline: Percentage change in the stock index on a quarterly basis
3. Corporate spread: corporate bond yield minus long-term government bond yield.
4. Sovereign risk: domestic long-term interest rate minus the US long-term interest rate.

   3. Foreign Exchange

This is one of the most important components to the FSI as it ensures that shocks that occur in different countries are transmitted to the rest of the world can be accounted for reliably. The different indicators may include:-

1. Time-varying real effective exchange rate volatility: GARCH(1,1) volatility of real effective exchange rate quarterly percent change

There are a lot of different leading indicators to identify financial crisis that we could incorporate into our analysis but we have chosen only four as they cover these three different sections of the economy pretty well and they also account for a lot of the variation in the FSI. In the banking sector we decided to take into account only Inverted term spread as TED spread had an overall negative correlation with the total FSI Constructed(see Vermeulen) and the data available for calculating beta was not readily available. In the securities market we take into account three of the four above mentioned indices excluding stock price decline as we had already included stock price volatility modeled through GARCH(1,1) specifications.  For the changes in foreign sector we have included volatility of real effective exchange rate using GARCH(1,1) specification.

1. **Methodology** 
   1. **Selecting the country/countries:**

The first step in building the FSI was to select the country/group of countries. For this we reviewed various already existing FSIs and concluded that stress indices for a single country combine more indicators into one statistic than multicounty stress indices. A possible reason for this is the availability of data. Also, financial crises are known to occur at a much lower frequency in industrial countries. Another important factor is that if a group of countries is selected, crisis is more likely to be noticed in the sample space. Hence, our conclusion was to choose a group of countries which are developed and are not industrial in nature.

As we will see below in the report, exchange rate was used as a sub index while constructing FSI. Therefore, having a group of countries with the same currency would strengthen our index because it will not have to deal with the change in exchange rate volatility every time it was used for some other country. An obvious choice given these constraints was the European Union. Almost all the countries in the EU follow the same currency (Euro). And most of the countries are developed as well. Plus given the fact that the trade is highly interlinked between the member states, it is very likely that a crisis started in one country will spread to other trade partners without much lag. We chose the top 8 countries which have the highest intra EU trade(Fig 1.) because of the above mentioned reasons, expecting that this selection will boost the integrity of our FSI when switched from one country to another. Therefore the selected countries are Germany, Netherlands, France, Belgium, Italy, Spain, UK and Greece. Greece was selected because it recently faced a crisis.

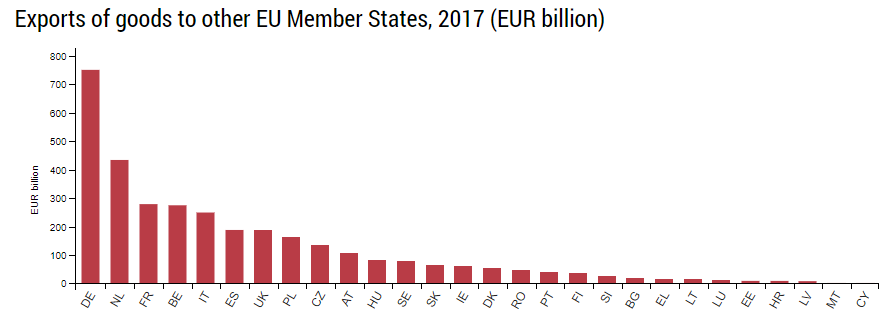


Fig. 1

**3.2. Selecting Time period and frequency:**

After deciding what countries to work on, we had to select what time period should we focus on and what should be the frequency of data collection. We worked on the data from 1995 to 2018 because it covers at least one episode of crisis. For data collection, following constraint is a must - that it should be available for many countries at a high frequency. The highest frequency being weekly or daily was disregarded because such data will be sensible to even the minute shocks which quickly fade off. After seeing this trend in almost all the papers we reviewed which worked on our scale, we decided to use quarterly data.

**3.3. Selecting the sub indices:**

This has been covered in literature review but the following constraints were put on the variables to be chosen - It should be available for many countries at a sufficiently high frequency, it should be comparable between different countries and finally, the FSI made through it should cover as much of the financial system as possible.

Owing to these reasons, we chose the following four variables-

1. Stock price volatility (FSI 1)
2. Volatility of monthly changes in exchange rate (FSI 2)
3. Long term interest rate - US long term interest rate (FSI 3)
4. Inverse yield curve i.e., short term interest rate - long term interest rate(FSI 4)

Banking sector is covered by the inverse yield curve; exchange market is covered by the exchange rate volatility whereas securities market is covered by the volatility of stock price. The difference in long term interest rates measures sovereign risk.

As we were dealing with time series data, the problem of heteroscedasticity had to be acknowledged. Therefore, we used the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model to incorporate stock price and exchange rate volatility.

The general equation for variance through which volatility was determined turns out to be -

𝝈n2 = 𝞪0 + 𝞪1𝙮n2-1 + 𝜷1𝝈n2-1  where 𝞪0 = 𝜸VL

Here 𝝈n & 𝝈n-1 are the volatilities of a given variable at time n and n-1 respectively, whereas 𝙮n-1 is the returns at time n-1. VL is the long run average variance rate and 𝜸 is the weight assigned to it.

To carry out GARCH analysis, we used the Eviews software.

**3.4. Constructing the FSI:**

We collected the data on the four selected variables and calculation was basic for FSI 3 and FSI 4, we just had to subtract the required components and we had the sub-index. For FSI 1 and FSI 2 however we had to collect the data and then run a GARCH(1,1) model to determine the volatility of the variables at the given time and then incorporate that into our analysis. While running GARCH(1, 1) model the condition for stationary (0 < 𝞪1+ 𝜷1 < 1) held in all of the cases even though some of the coefficients were not significant at the 15% level. Also in most of the cases the value of 𝞪1+ 𝜷1 was close enough to 1 which is usually the case when volatility is being forecast. After the value of the sub-indices was determined the final FSI was constructed by standardizing each of the individual indices and then summing them up. Higher values of the FSI correspond to adverse periods of instability. Data was available for three FSI’s from 1990 but due to the data on exchange rate being available only from 1995 onwards we have included all the final results from 1995 Q1 only.

**3.5. Testing the goodness of the constructed FSI**

Once the FSI was ready we needed to identify periods of actual crisis to compare our statistic with. Such periods of high financial stress were obtained from ECB/ESRB EU crises database. It provided a detailed overview of crisis episodes specific to European countries. Crisis periods were broadly classified into systemic and residual crisis. Systemic referring to situations which are much more likely to get out of hand due to the interconnectedness of the financial systems and can cause a cascading or domino like effect thereby causing even more damage. The whole financial system is unstable and extremely prone to get worse unless policy makers take decisive measures. Residual refers to the negative impact that an independent sector has but the system as a whole is still stable. It is contained and not prone to spreading.

**4. Results**

Above constructed are the final index for 8 chosen countries and shaded in grey are the regions of systemic crisis while those in red indicate residual crisis periods. Usually whenever an FSI is constructed a threshold value is assigned above which the economy is said to be unstable or the crisis said to be happening, but we have refrained from doing so. Any peak reasonably farther than zero could be indication of a crisis that is going to take place. On comparing our FSI with the actual data(shaded) we find a decent amount of correlation. Graphs of countries Germany, Netherlands and UK are very well explained whereas the rest are moderately well explained.

**5. Limitations**

The limitations which we faced are –

1. The first concern was about the weights to be assigned to the sub indices. It is true that weighted analysis will be better because different crises have different magnitudes of impact on the economy but there is no way of knowing in advance. Therefore, we stuck to the non weighted method because we saw several papers using that approach.

2. We were unable to find data on the beta of the banking sector. It is an important part of the making of the FSI because it takes into account the covariance of the returns of the banking sector and returns of the total market. While we did find out the returns of the overall market for all the countries, we weren’t able to find any one particular stock which would work as a proxy for the banking sector. Due to opposing views pointed out by various papers, we did not incorporate this variable. This restricts the explanatory power of our FSI when it comes to any banking sector crisis.

3. The FSI can show significantly high value even without an overall crisis happening. This is because any one sub index can peak due to a temporary adjustment effect by the government and because we are not using weights, the effect can be clearly seen in the FSI. For example, the Indian government raising the short term interest rate as some policy measure will cause FSI4 to shoot up even without a crisis in sight. Also another reason for peaks without actual crisis taking place is the government might have identified and fixed the problem or it might have also been sorted on its own and the value of the sub-index then subsequently declines in the coming quarters. There are also periods of crisis where the value of the FSI isn’t high and it s because the government might be aware and taking actions to curb such a crisis.

4. A final limitation is that while the indicators we chose as our sub-indices are leading indicators, the value of the constructed FSI peaks (in most cases) only when the actual crisis begins and the hence there isn’t much time for policy makers to take definitive action. Maybe including more leading indicators would help identify periods of crisis much more in advance with leads of 2 or 3 quarters and thus we would have ample time to resolve the situation before it getting out of hand.

**6. Conclusion**

With globalization taking its course we are becoming more and more interconnected and while that is a good thing like every good thing it also has cons. With so many connections and the everlasting human pursuit of profits, financial bubbles are guaranteed to be created leading to financial global crisis and now more than ever will the effects be transmitted far and wide and cause the most amount of damage. Thus comes into play the creation of an early warning system, or an index to measure stress of a given economy.

The components of FSI are extremely important as they determine its composition and its effectiveness. We ensured that the variables selected adequately cover the very broad financial sector to capture as much instability as possible. After constructing the index and comparing it with the actual periods of instability we find that the FSI value does indeed identify periods of crisis albeit with some false positives as well (maybe due to omission of a banking sector index which could not be included due to data not being available). Although the values shoot up very close to the starting points of the actual crisis in most cases which would restrain the ability of the policy makers it still better than going into a crisis period completely unaware.

There is a good amount of explanatory power that this the index provides us and in this modern day and age where everything is digitalized, construction of such an index with more parameters that could better explain the crisis and also provide a better time frame for action to be taken might prove an invaluable tool. We must keep in mind the limitations and not get carried away as the FSI does give a lot of false positives as well and .the relationship between the index and the onset of the crisis is not exactly very powerful. Maybe collecting data and modifying it over time could lead to a better FSI with much more explanatory power.

Citations:

* Bank for International Settlements, Real Broad Effective Exchange Rate for United Kingdom [RBGBBIS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/RBGBBIS, April 20, 2019.
* Babecký J, Havránek T, Matějů J, Rusnák M, Šmídková K, Vašíček B (2014) Banking, debt and currency crisis: early warning indicators for developed countries. J Financ Stabil
* Intra-EU trade in goods - recent trends, <https://ec.europa.eu/eurostat/statistics-explained/index.php/Intra-EU_trade_in_goods_-_recent_trends>
* Babecký J, Havránek T, Matějů J, Rusnák M, Šmídková K, Vašíček B (2013) Leading indicators of crisis incidence: Evidence from developed countries. J Int Money Financ
* Vermeulen R, Hoeberichts M, Vašíček B, Žigraiová D, Šmídková K, Haan J (2015) Financial Stress Indices and Financial Crises
* Bank for International Settlements, Real Broad Effective Exchange Rate for Euro Area [RBXMBIS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/RBXMBIS, April 20, 2019.
* Koima, J.K, Mwita, P.N Nassiuma, D.K (2015) Volatility Estimation of Stock Prices using GARCH Method
* FRM: GARCH(1,1) to estimate volatility (2008) <https://www.youtube.com/watch?v=o-Kf6Y419hU>
* Yıldırım, İ. (2018). Measuring the Impact of Financial Crisis: A Financial Stress Index for Turkey.
* Lall, M. S., Cardarelli, M. R., & Elekdag, S. (2009). Financial stress, downturns, and recoveries (No. 9-100). International Monetary Fund.