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ARTICLE

Financial stress index, growth and price stability in India: some recent evidence

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ABSTRACT

In this paper, an aggregate financial stress index for India is constructed by taking monthly data from different segments of the financial market like money market, bond market, equity market, foreign exchange market, and the banking sector, for the period March 2007 to December 2016. The interrelationship and feedback effect between financial stress, economic growth and price stability are tested by using correlation and an unrestricted VAR model. The impulse response analysis shows that financial stress leads to a decline in growth after a lag period and a higher growth rate for a longer period of time increases stress in the financial system. The variance decomposition result indicates that the contribution of FSI to the variation of other variables are not much high, whereas other variables can affect FSI to some extent. In the Short-run price stability increases financial stress but in the long run, the result is the opposite.

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1. Introduction

Maintaining financial and monetary stability are the most important factors for effective or smooth functioning of a market economy and for achieving higher economic growth. The financial system all over the world has been undergoing significant changes over the last few decades. The nature and function of the financial system have been changed due to significant expansion in financial transaction, growing financial liberalisation, increasing financial integration, and introduction of complex financial instruments. With all of these changes, the possibility of larger financial instability has been increasing, which can have adverse effect on the overall economic performance.

Safeguarding the stability of the financial system has become an increasing concern of policymakers since the early 1990s and especially, after the global financial crisis of 2008–2009. During 1980s, the main focus of the central bank monetary policy was to maintain price stability or inflation targeting. The issue of financial stability had not gotten much importance then. The concern about the issue was taken into consideration only if imbalances in the financial system affected the objective of inflation stabilisation. In addition, under this framework, it was believed that achievement of price stability was necessary and sufficient condition for the overall economic and financial stability. But the financial crisis of 2008–2009 has changed this view, as the crisis has occurred during the period when the global economy was in a state of low and stable inflation. Thereafter, financial stability has witnessed increased attention all over the world. The 2008–2009 crises revealed that instability in the financial system not only affects the financial sector but also adversely affects the real economy by decreasing production, investment and growth.

The global financial crisis of 2008–2009 had a serious impact on the whole world economy. In advanced economies the real GDP declined by 7.5 per cent during the fourth quarter of 2008 and output continued to fall till the first quarter of 2009. Emerging economies also suffered badly and contracted by 4 per cent in the fourth quarter (World Economic Outlook, 2008). India also suffered from the financial crisis of 2008–2009. Before the onset of the crisis, India was growing at an annual average growth rate of 8.8 per cent during 2003–2004 to 2007–2008. Growth rate of GDP came down to 7.8 per cent during April–September 2008 from the growth rate of 9.3 per cent in September 2007. In 2008–2009 Q-2, the growth of IIP declined to 4.7 per cent from 5.3 per cent in Q-1 2008–2009. In Q-3 2008–2009, it declined to 0.4 per cent and again reduced to −0.5 per cent in

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January 2009. Headline inflation declined to 0.84 per cent by end March 2009 from 12.9 per cent on August 2008. There were heavy capital outflows from India. Rupee depreciated from 40.02 US dollar in April 2008 to Rupees 51.23 per US dollar in March 2009. BSE Sensex and S&P CNX Nifty decreased by 37.9 per cent and 36.2 per cent respectively (RBI, 2010).

The adverse consequences of the financial crisis compel the policymakers and researchers all over the world to think more about financial stability and of later on defining and, measuring financial stability and examining linkages between financial stability and the macroeconomy. There is yet no universally accepted definition of financial stability. Some authors define it in terms of its absence, that is, financial instability or stress. According to Crockett (1997) financial stability is the stability of both financial markets and institutions. According to The South Arabian Reserve Bank (SARB), financial instability can be seen through systemic risk, failure of banks, large asset price volatility, exchange rate and interest rate volatility and the collapse of market liquidity. In addition, financial stability can be described as a situation where there is absence of macroeconomic cost of financial system disturbances. Gadanecz and Jayaram (2008) define 'financial stability is a situation when there is absence of excess volatility, stress or crises.'

For analysing and monitoring the risk in the financial system, one needs a measure of financial stability, which will help to identify the stress in the financial system and can show when the system is relatively stable, and when it is unstable. A financial system consists of different financial institutions and different types of financial markets like stock market, money market, and exchange market and so on. A single indicator representing a specific sector of the financial system may not be able to indicate the health of the overall financial system. Therefore, it will be better to use an aggregate measure, which should include indicators from different segments of the financial market. A good example of such a systemic measure of financial (in) stability is a *financial stress index (FSI)*. An FSI is a composite index that combines different market specific indicators of financial stress like, asset price volatilities, risk spreads, credit growth etc. into a single index to measure financial stress.

According to Cardarelli et al. (2011), a financial system can be said to be in a period of stress when there is large fluctuation in asset prices, rapid increase in uncertainty, financial illiquidity, and problem in banking system.

Many works have been done in construction of FSI and testing its interrelation with real economic variables at national and international level (Aboura & Van Roye, 2013; Balakrishnan et al., 2011; Cardarelli et al., 2011; Hakkio & Keeton, 2009; Hollo et al., 2012; Stolbov & Shchepelevab, 2016; Van Roye, 2011). But in the case of Indian, it is rare. The Indian financial system is developing rapidly and the integration of the Indian economy with the world economy increases the probability of stress period. Therefore, an aggregate indicator of financial stress for India will be useful to identify the stress events. The study on developing an aggregate financial stress index for a developing country like India is very rare. In view of this gap in research, this paper aims to construct a Financial Stress Index (FSI) for India. Secondly, it also aims to test the interrelationship and feedback effect between financial stress, economic growth and price stability. The FSI follows the methodology used by (Balakrishnan et al., 2011; Cardarelli et al., 2011), but it differs from their FSI, as it includes growth rate of credit and call spread as two additional indicators of financial stress. For a country like India, credit growth and the difference between call rates from the policy repo rate (call spread) are important indicators of stress in credit and money market of India. The rest of the paper is organised as follows: Section 2 describes literature review, Section 3 discusses the data and methodology, Section 4 presents the empirical results and analysis. Finally, Section 5 concludes the paper.

2. Review of Literature

2.1. Financial in (stability) and real economic growth

The global financial crisis has shown that instability in the financial system can have an adverse effect not only on the financial system but also on the overall economic system. Period of financial crisis is always followed by high recession in the economy (Cardarelli et al., 2011). As there is high interconnectedness between the financial and real sector the problem in one sector can hamper the other sector.

Hakkio and Keeton (2009) have identified three important reasons for how increasing stress in financial system can lead to a decrease in overall economic activity or growth. *The first* reason is, due to uncertainty in the economic outlook and return on asset prices. *The second* reason is through the increasing financing cost for the

businessman and households due to higher financial stress. The *third* reason is that during the stress period banks tighten their credit standards which may adversely affect economic activity.

In his famous financial instability hypothesis, Minsky (1992) explained about the interrelation between economic prosperity and financial instability. He claimed that during the period of economic prosperity, there will be higher flow of cash to the corporate sector which will develop a speculative euphoria and encourage the financial institution to take more risky activity. Such speculative activity will increase the amount of debt. And such an excess leveraged situation can lead to financial crisis.

Financial sector risk can affect the real sector through the balance sheet channel, which is explained by Bernanke and Gertler (1989) in the financial accelerator theory. According to them, the shock due to financial instability decreases the asset prices, deteriorates the balance sheet and net worth of borrower, and increases the external finance premium. This reduces the ability of the borrower to borrow and invest, which again leads to a decrease in their net worth. The financial accelerator in this way creates a vicious cycle of decrease in asset price, tightening credit condition, fall in economic activity and prices. Mishkin (2000) also explained the balance sheet channel through which financial instability affect real economic activity.

According to Demirguc-Kunt and Detragiache (1998), the banking crisis has an adverse effect on the economy. They explained that the crisis in the banking sector hampers the well-functioning of payment system and leads to disruption in the credit flow to the household and enterprises, which reduces the consumption and investment activity in the economy and adversely affects the economic growth.

2.2. Financial (in) stability and price stability

Papademos (2006) defines price stability as a state in which the general level of price is stable or the rate of inflation is sufficiently low. There are two approaches to the relationship between price stability and the stability of the financial system. One approach is called the conventional approach, which believes that these two types of stability support and reinforce each other. The second approach is the new environment hypothesis, who's more profound believes that price stability may not lead to financial system stability. They said that controlling inflation at a lower level may not guaranty the stability of the financial system.

The conventional wisdom regarding the relationship between price and financial stability has been given by Schwartz (1995), which is popularly known as Schwartz's hypothesis. She has explained two channels, both a micro and macro channel through which inflation affects financial condition of households, business firms, financial intermediaries and the whole financial system. Inflation creates uncertainty about the future value of assets, future return on investment, affects the stock market valuation of firms, leads to increase in speculative investment and thereby increasing the risk in the financial system. Hence, she advocated that a regime of monetary stability or price stability is the root of stability in the financial system.

Bordo and Wheelock (1998) was a supporter of the conventional approach. According to them, the relative shock in the prices, especially the sharp fall in the commodity and real estate market following several years of price increase were the cause of distress in the financial system. So they said that a central bank can contribute to financial stability by focussing on price level stability. Bordo, Dueker, and Wheelock (2002) constructed a financial condition index for the period 1790–1997. By using a dynamic probit model, they found that aggregate price shock can contribute to financial sector instability. It was stated by Demirguc-Kunt and Detragiache (1998) that most of the crisis has occurred under weak macroeconomic condition of higher inflation and lower growth. The higher inflation increases the banking sector risk because higher inflation is always associated with higher interest rate which creates difficulty for the banking sector to perform their maturity transformation. Thus, the higher rate of interest associated with the high rate of inflation increases the likelihood of crisis in the banking sector.

Papademos (2006) in a speech said that price stability also contributes to the stability and efficiency of the financial system by anchoring inflation expectation and eliminating market uncertainty due to inflation. Issing (2003) also supports the conventional approach and states that in the long run both price and financial stability reinforce each other. Many authors of the new environment hypothesis have criticised the conventional wisdom of the relation between price stability and financial stability. They advocated that price stability or lower inflation may not guarantee stability of the financial system. Borio and Lowe (2002) said that price stability or lower inflation may increase the imbalances in the financial system. The credible stabilisation policy by anchoring price

expectation generates optimism about future economic prospects, which leads to credit and asset price boom which are the seeds of future problems.

Leijonhufvud (2007) advocated that maintaining the stability of CPI or its growth rate does not assure the financial system stability. Rajan (2005) also pointed out that monetary stability can create problem in the financial system stability. He stated that low inflation allows the interest rate to below which may incentivize the participants in search for higher yield and increased risk-taking. This lower interest rate can create the asset price bubble which is riskier for financial stability.

2.3. The empirical literature on measuring financial stability and its relation to growth and price stability

Attempts have been made over the last two decades by researchers to measure the condition of the financial system stability with the help of different indicators of financial stress. Gadanecz and Jayaram (2008) have discussed in their paper about different measures of stability of financial system. According to them, aggregate measure of stability or stress are helpful to the policymakers and participants in the financial system because it helps to monitor the level of stability of the whole system and predicts the sources of stress and its impact.

Illing and Liu (2006) were the first to develop an FSI for Canada by taking high-frequency variables from banking sector, foreign exchange, equity and debt market and by using different weighting methods like, factor analysis, credit weight and variance equal weight method. They stated that there are no significant differences between the indices constructed by using different methods of weighting. Balakrishnan et al. (2009) have constructed an Emerging Market Financial Stress Index (EMFSI) using a variance equal weighting method Sandhal et al (2011) have constructed a financial stress index for Sweden using the same method. Hakkio and Keeton (2009) constructed the Kansas City Financial Stress Index (KCFSI) by using PCA method and taking 11 variables. Morales and Estrada (2010) have constructed a financial stability index for Colombia using three different weighting methods like variance-equal approach, the principal components method and count data models. Their index presents a similar behaviour under the three methodologies. Brave and Butter (2011) constructed a high-frequency financial condition index for USA by using PCA method and taking100 indicators of financial health. Cardarelli et al. (2011) developed a financial stress index by using variance equal weighting method for 17 advanced economies. Dhal et al. (2011) used CAMEL indicators for the period 1997 Q: 1 to 2012 Q: 3 for constructing Financial Stability Index for India. Van Roye (2011) developed a Financial Market Stress Index (FMSI) by applying dynamic factor model for German and Euro areas. Hollo et al. (2012), developed a Composite Indicator of Systemic Stress (CISS) for Euro area by using portfolio theory approach. Aboura and Van Roye (2013) construct an FSI for France using 17 financial variables through the dynamic approximate factor model. Shankar (2014) has constructed a financial condition index for India by taking monthly data from January 2004 to August 2013 using PCA method. Cevik et al. (2016) constructed a financial stress index by using dynamic factor model for some south-east Asian economies for the period 1995–2013. Stolbov and Shchepelevab (2016) constructed an FSI for 14 emerging countries for the period Feb 2008 to Sept 2015 using a principal component analysis method. Ramesh & Venkateswarlu (2017) constructed an FSI for India using credit weight method and taking quarterly data of four variables including NIFTY index, government security index, NIFTY bank index and exchange rate for the period 2002 to 2014.

The impact of financial stress on economic activity or growth has been examined by using different models like simple VAR, threshold VAR, regime-switching VAR model etc. Most of the empirical findings shows that financial stress have a negative relation with growth or economic activity (Aboura & Van Roye, 2013; Cardarelli et al., 2011; Cevik et al., 2016; Hakkio & Keeton, 2009; Hollo et al., 2012; Mallick & Sousa, 2013; Mittnik & Semmler, 2013; Van Roye, 2011; Stolbov & Shchepelevab, 2016; Ramesh & Venkateswarlu, 2017).

The empirical literature on the relationship between financial stability and price stability is very rare. Some of the studies found that financial stress has a negative impact on inflation (Apostolakis & Papadopoulos, 2015; Van Roye, 2011; Ramesh & Venkateswarlu, 2017). Blot et al. (2015) investigated the relationship between price stability and financial stability by using 3 different methods such as simple correlation, VAR and a DCC method for US and Eurozone. Against the conventional hypothesis they found that all three methods show negative relationship between price and financial stability. And DCC method shows unstable relationship between price and financial

Table 1. Summary of recent literature.

Authors/coverage	Methods	Findings
Raputsoane (2016)/South Africa	Extreme Bounds Analysis	He found that some financial indicators have strongly associated with monetary policy interest rates like bond and equity securities markets and some are weakly such as commodities markets and the exchange rate market.
Stolbov and Shchepeleva (2016), 2008–2015 monthly data.	Bayesian VAR	They found that an adverse impact of financial stress on economic activity in 9 countries.
Abdullah et al. (2017), 1991–2015 monthly data, Malaysia	VAR and IRF	The study reveals that changes in the Malaysian FSI (MFSI) negatively affect the economic activity of Malaysia whereas, changes in the economic activity are positively related to the MFSI.
Aboura and Van Roye (2017)	Markov-Switching Bayesian VAR model	They show that financial stress transmits very strongly to economic activity when the economy is in a high-stress regime, whereas economic activity remains nearly unaltered in a low-stress regime.
Galvao and Owyang (2018)	Factor Augmented VAR model with smooth-transition regime	They found that financial stress has a negative effect on growth and inflation at higher stress regime.
Landgren and Crooks (2018), China.	TVAR	They found that China experiences apparently cyclical periods of financial stress, resulting from both exogenous and endogenous sources.
Shukayev and Ueberfeldt (2018)	Taylor rules	They found that an optimised policy uses the extra tool to support investment at the expense of higher inflation and output volatility.
Gbenou (2019), 1990 to 2016, WAEMU countries	panel smooth transition regression estimation	He found that a high financial stress regime, a restrictive monetary policy, and a high debt-to-GDP ratio have a negative effect on economic growth.
Kırcı Çevik et al. (2019), 1987–1992, U.S	Markov regime-switching model	They found that Empirical results suggest that monetary policy is consistent with the Taylor rule in all countries except for India and all countries followed both low and high inflation targeting monetary policy regimes.
Li et al. (2019), China.	Bootstrap Rolling-Window	They found that financial stress has both positive and negative impacts on economic policy uncertainty in several sub-periods; meanwhile, economic policy uncertainty has the same effects on financial stress in China.
Polat and Ozkan (2019), Turkey	CISS methodology and DCC GARCH model	They found a negative relation between Turkey's FSI and economic activity.
Vo et al. (2019), 2000–2017	Fixed model and random effect	They indicate the key determinants of financial instability in developing countries are GDP growth rate, inflation rate, the growth rate of base money, the change in foreign exchange reserves, lending interest rate, returns in the stock market and the return on equity ratio of the banking sector.

Source: Authors' compilation.

stability where the correlation changes a sign over time. The summary of recent literature is present in Table 1. Table 2 discuss about the descriptive statistics of the variables.

3. Methodology

3.1. Data Sources

For the purpose of this study, secondary time series data are taken from three sources, that is, RBI's Handbook of statistics on the Indian economy, National stock exchange of India (NSE) and Economic and Political Weekly (EPW) publication on time series data for the Indian economy. Monthly data for the period March 2007 to December 2016 is used in the study. For the construction of Financial Stress Index (FSI), the following variables are used. They are monthly average call money rate, policy repo rate, exchange rate of rupee vis-à-vis dollar, foreign exchange reserve, credit to private sector, NSE nifty-fifty price index, NSE bank index and the Govt. yield spread data. For real economic variable, monthly average of WPI and IIP are taken. In this paper, changes in log of IIP and changes in log of WPI are used as proxy for economic growth and inflation respectively. The selection of the variables is done according to the literature on the financial stress index and by taking into account the availability of data. Here, we want to test whether the FSI of India can identify the crisis or stress period. Therefore, the period of March 2007 to December 2016 is used to include the period of 2008–2009 financial crises. Again the data on yield spread was not available before 2007.

Table 2. Descriptive statistics of all the variables.

Variables	FSI	GIIP	INF	R
Mean	0.002541	0.003898	0.003709	6.706017
Median	−0.070122	0.000453	0.003649	7.125000
Maximum	1.286090	0.139244	0.025459	12.42000
Minimum	−1.555480	−0.150016	−0.019094	0.510000
Std. Dev.	0.419438	0.058268	0.007859	1.906598
Skewness	0.368196	−0.192005	−0.325660	−0.672214
Kurtosis	5.177700	3.272330	3.525641	3.755945
Jarque-Bera	25.98287	1.089671	3.444204	11.69646
Probability	0.000002	0.579937	0.178690	0.002885
Sum	0.299797	0.459975	0.437689	791.3100
Sum Sq. Dev.	20.58362	0.397234	0.007226	425.3084
Observations	118	118	118	118

Source: Author's estimation.
Note: FSI is the financial stress index, GIIP is the log changes in the IIP, INF is the log changes in WPI to calculate inflation, R is the monthly average short term interest rate.

3.2. FSI construction

To construct the FSI, we have used the variance equal weighting method which is used by (Balakrishnan et al., 2009; Carderelli et al., 2011). In this method, first all the variables included in the composite index are standardised and then given equal weights. For standardisation, all the variables are demeaned and then divided by their standard deviation.

$$X_s = (x - \mu_x)/\sigma_x \tag{1}$$

where X_s = standardised variable; μ_x = mean of the variable; σ_x = standard deviation of the variable.

And the final FSI is calculated as the weighted average of these standardised variables.

$$\text{So, FSI} = \sum_{i=0}^{n} wix_{si} \tag{2}$$

A simple correlation and an unrestricted VAR model is used to empirically analyse the interaction between financial stress, growth (IIP) and price stability (inflation). Before running the VAR model the stationarity of all the variables are tested by using the Augmented Dickey–Fuller test (ADF), and Phillips–Perron test (PP test) . To find out the structural breakpoint in the time series, Zivot and Andrews (1992) structural break unit root test is used. GARCH (1) model is used to measure the volatility of the stock market. The maximum lag of the variables to be included in the VAR model is decided by various lag lengths selection criteria like LR, FPE, AIC, SIS, and HQ. The impulse responses are tested to show responsiveness of one variable to a unit shock in another variable in the VAR system. The variance decomposition of the VAR model shows how many percentages of the variation in one variable is explained by the other variable.

3.3. Construction of a Financial Stress Index for India

The aggregate financial stress index for India is constructed by taking monthly data from different segments of the financial market like money market, equity market, bond market, foreign exchange market, and the banking sector. There are six variables which are aggregated to construct the index of financial stress and the six variables include – a call spread, growth rate of credit to the private sector, a yield spread, stock market volatility, beta of the banking sector, and an exchange market pressure index (EMPI). A brief description of the variables included in the construction of the FSI is given below.

3.3.1. Call spread

The call spread is used for calculating the money market risk (Shankar, 2014). It is the difference between the weighted average call money rate and the official repo rate. Usually during normal times the call rate moves around the policy rate, but during stress period, the call rate becomes higher than the policy rate. Hence, higher the call rate from the policy rate higher will be stress in the money market. A higher call spread may indicate liquidity risk in money market.

Here, call spread = weighted average call rate – policy repo rate.

3.3.2. Inverted yield spread

To take into account the bond market risk an inverted yield spread is used which is proposed by (Carderelli et al., 2011). A yield spread is basically the difference between yields on two different debt instruments of different maturities, different credit ratings, and risk. The inverted yield spread is the difference between short-term government security yield and long-term security yield. According to Carderelli et al, banks usually earn income in the form of intermediating short-term liabilities into longer-term assets. So, when there is a negative sloping yield spread the profitability of banks is seriously hampered.

Inverted yield spread = short-term yield – long-term yield.

For calculating this, one year and ten-year government security yield is used.

3.3.3. Banking sector beta

The most commonly used measure of systemic risk in the banking sector is the banking sector beta which is used by many authors in constructing their financial stress index (Balakrishna et al., 2009; Cardarelli et al., 2011; Illing & Liu, 2006; Van Roye, 2011). The beta of a stock measures the volatility of the stock's return in relation to the overall market return. The beta of the banking sector is calculated by dividing the covariance between the banking sector equity return and overall stock market return, by the variance of the overall market return.

Mathematically:

$$\beta = cov(br, mr)/var(mr) \tag{3}$$

where β= banking sector beta; br = banking stock return; mr = overall stock market return

In accordance with the capital asset pricing model (CAPM) when the value of beta exceeds 1 this indicates that the banking stock is more volatile than the overall stock market. So higher is the value of beta riskier is the banking sector.

3.3.4. Credit growth

Credit-related indicators like credit to GDP gap or growth rate of credit are often used as indicator of financial fragility. According to Fouejie (2017), rapid credit growth may lead to declining loan standards, and increasing macroeconomic and financial instability. Higher credit growth may increase speculative activity, asset price bubble or may lead to increase in loan default. So here we have used the growth rate of credit to private sector (percentage change in non-food credit to the private sector) as an indicator of financial instability.

3.3.5. Exchange market pressure index

To capture the risk in the foreign exchange market most of the studies (Balakrishnan et al. 2011, Cevik et al., 2016) have used an aggregate index which is the EMPI, which captures not only changes in the exchange rate but also changes in the foreign exchange reserve. The fluctuation of exchange rate has an impact on macroeconomic variables like output, trade balance, inflation, etc. The exchange rate of currency comes under pressure when there is selling pressure of domestic currency or excess demand for foreign currency. With the help of EMPI, currency crisis can be defined as a period in which an attack on domestic currency leads to either depreciation of domestic currency or loss in foreign exchange reserve or a combination of the two. When there is significant increase in EMPI, the currency market is said to be in stress period.

The EMPI is calculated as:

$$EMPI = \frac{\Delta ex - \mu\Delta ex}{\sigma\Delta \mathrm{ex}} - \frac{\Delta \mathrm{res} - \mu\Delta \mathrm{res}}{\sigma\Delta \mathrm{res}} \tag{4}$$

where Δex and Δres are the month-over-month changes in the exchange rate and the total foreign exchange reserve, respectively. The symbols μ and σ stand for the mean and the standard deviation of the relevant series. The exchange rate is taken as the exchange rate of rupee vis-a-vis dollar.

3.3.6. Stock market volatility

Rapid growth or fluctuation in the share prices can be considered as a source of financial stress because it may be a signal of the creation or amplification of a financial bubble. Stock markets affect the economy through the wealth and the confidence channel. Higher fluctuation in the stock market may affect the investors' confidence in the market and may adversely affect domestic and foreign investment.

To capture the stock market stress the volatility of the month over month changes in the return of the NSE S&P CNX Nifty index is used. The stock market volatility is calculated by using GARCH (1) model which is proposed by Bollerslev (1986). The model can be represented as

$$y_t = X_t'\theta + \varepsilon_t \tag{5}$$

$$\sigma_t{}^2 = \lambda_0 + \lambda_1 \varepsilon^2{}_{t-1} \lambda_2 \sigma_{t-1}{}^2 \tag{6}$$

where y is the stock market index value, x include constant and autoregressive terms of stock market index value, ε_t is the error term and, $\sigma_t{}^2$ is the conditional variance of stock return which depends not only on the previous year return square but also on the previous year variance.

3.4. Estimation of the financial stress index for India

Various methods have been used by different authors for the construction of financial stress. The two main methods are variance equal weighting method and the method of principal component analysis. Illing and Liu (2006) have stated that there are not many significant differences between the indices constructed by using different methods of weighting. So in this paper, the FSI is constructed by using the most commonly used and simple method of constructing the financial stress index, which is the variance equal weighting method used by (Balakrishnan et al., 2009; Carderelli et al., 2011).

The main advantage of using this method is that it is simple to construct and can be easily interpreted. In variance equal weighting method, all the variables are first standardised so that they can be expressed in the same units and then they have given equal weights. The standardisation is done by subtracting each series from their respective mean and then divided by their standard deviation. The aggregate FSI is the weighted average of the different variables where each variable has given equal weights.

And the final FSI is the weighted average of these standardised variables.

$$\text{So, } \text{FSI} = \sum\nolimits_{i=0}^{n} w i x_{si} \tag{7}$$

Since here we have taken six variables for FSI so,

$$\text{FSI} = W_1 * X_{S1} + W_2 * X_{S2} + W_3 * X_{S3} + W_4 * X_{S4} + W_5 * X_{S5} + W_6 * X_{S6} \tag{8}$$

Here $W_1 = W_2 = \ldots \ldots \ldots = W_6 = 1/6$

Here for equal weight

$$\text{FSI} = 1/6 * \text{CL} + 1/6 * \text{YS} + 1/6 * \text{BETA} + 1/6 * \text{CREDIT} + 1/6 * \text{EMPI} + 1/6 * \text{NIFTY} \tag{9}$$

Here, CL = call spread; YS = yield spread; BETA = banking sector beta; CREDIT = growth rate of credit to the private sector; EMPI = exchange market pressure index; NIFTY = time-varying volatility of S&P CNX Nifty index.

The interpretation of the financial stress is very simple. In this case, a higher value of the FSI will indicate the period of higher financial stress or instability and the lower value of the FSI will indicate that there is lower stress in the financial system.

Following the above literature, an unrestricted VAR model is used to empirically analyse the interaction between financial stress, growth (GIIP) and price stability (inflation). A conventional macro VAR model which is generally used for monetary policy transmission mechanism includes mainly three variables like output, inflation and interest rate. So, to include the shock of financial stress, the FSI is included in the VAR model. This paper follows the VAR framework used by Dhal et al. (2011). So in this model, there are four endogenous variables such as, IIP growth, inflation, interest rate and FSI. The VAR model is represented as;

$$\text{VAR}(P) = f\ [\text{GIIP}_t, \text{INF}_t, R_t, \text{FSI}_t] \tag{10}$$

The ordering of the variables are done following the literature such that GIIP, INF and R shocks can have a contemporaneous effect on FSI while FSI shock impacts others with a lag.

A standard VAR (p) model can be written as

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \ldots\ldots + A_P y_{t-p} + \varepsilon t \quad (11)$$

where $y_t = n \times 1$ vector of endogenous variable included in the model
$c = n \times 1$ vector of constants
$A = n \times n$ matrix of the coefficient of the variables
$\varepsilon t = n \times 1$ vector of error terms.

4. Empirical Results and Analysis

The trend of FSI of India

The trend of FSI of India is shown in Figure 1 given below. In Figure 1, it can be shown that during most of the period the FSI hover around its mean value showing normal periods. But there are also some stress periods where the value of FSI increases. During the period of 2007, the financial sector was at lower stress where there was higher growth in the economy. The FSI has increased during the second quarter of 2008 and remains high till the first quarter of 2009 which is due to the effect of global financial crisis. The adverse impact of GFC on Indian financial market is felt especially after the collapse of Lehman brothers in September 2008, when there was withdrawal of funds from equity market and reduction of access of Indians to funds from international market putting pressure in the domestic foreign exchange market (RBI, 2010). The index shows that the effect of the crisis remains for a longer period. Then, the FSI decreases and remain within its average. In December 2010, there was slight increase in FSI because during this period the interest rate was high and also some liquidity problem was there. Another peak is in September 2013 where there was higher volatility in the financial market due to the US tapering announcement which created pressure in equity and foreign exchange market. The FSI of India effectively pointed out the period of instability in the financial system. The period of global financial crisis is captured by the FSI.

Figure 2 shows the trend of the aggregate FSI and its individual components. All the variables have high value during 2008–2009 crisis periods.

Table 3 shows that the correlation between FSI and GIIP is positive that is 0.28 but, the correlation between FSI at one lag period and GIIP is negative, that is, −0.19. This can be interpreted in this way that the stress in financial stability can have an adverse effect on the growth after a lag period. The positive correlation can be interpreted in accordance with the Minsky's instability hypothesis that higher growth or prosperity increases speculative activity and thereby increases risk in the financial system. The correlation between FSI and INF is negative (−0.0034) which is very negligible. But the relation between INF and FSI at one period lag is positive (0.03) which is also very negligible. While the relation between FSI and GIIP is significant but the relation between INF and FSI are not significant. So these results show that financial stress negatively affects growth with a lag period of time.

It is also clear from the Table 4, ADF and Phillips-Perron test that all the variables are stationary at 5% level of significance as their test statistics are higher than their 95% critical value.

The ADF and PP tests fail to provide any information regarding the structural breaks in the series. Therefore, Zivot and Andrews (1992) structural break unit root test is used to find out the structural break point in the

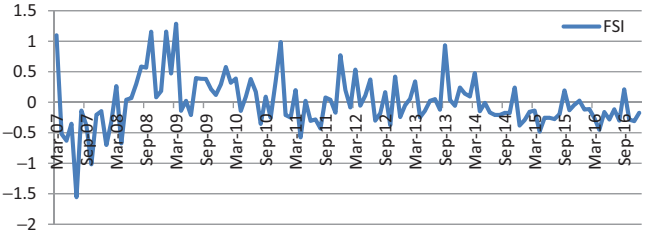

Figure 1. Trend of FSI. Source: Author's estimation.

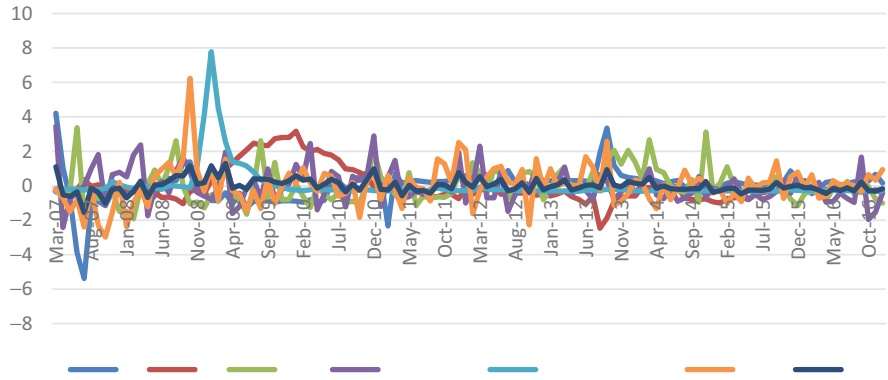

Figure 2. Trends of the individual variables. Source: Author's estimation.

Table 3. Correlation between price stability, financial stability, and GIIP.

Variables	GIIP	INF	FSI	FSIL1
GIIP	1.000000			
	———			
	———			
INF	−0.126168	1.000000		
	[-1.363902]	———		
	(0.1753)	———		
FSI	0.276449	−0.003438	1.000000	
	[3.084803]	[-0.036869]	———	
	(0.0026)	(0.9707)	———	
FSIL1	−0.186214	0.033605	0.256290	1.000000
	[-2.032468]	[0.360582]	[2.843373]	———
	(0.0444)	(0.7191)	(0.0053)	———

Source: Author's estimation.
Note: Value in [] and () represents t-statistics and p-value respectively.

series. The result of the structural break trended unit root test is presented in Table 5. The results show that all the variables are stationary at level and they have different break points.

The result of the lag length selection criteria is given in Table 6, which shows that the appropriate lag length to be included in the model is two.

System equations of the VAR model are follows:

$$\begin{aligned}\text{GIIP} = {} & -0.810 * \text{GIIP}\ (-1) - 0.265 * \text{GIIP}\ (-2) - 2.179 * \text{INF}\ (-1) + 0.957 * \text{INF}\ (-2) \\ & -0.004 * \text{R}\ (-1) + 0.002 * \text{R}(-2) + 0.013 * \text{FSI}(-1) - 0.012 * \text{FSI}(-2) + 0.027 \end{aligned} \tag{12}$$

$$\begin{aligned}\text{INF} = {} & 0.015 * \text{GIIP}\ (-1) - 0.012 * \text{GIIP}\ (-2) + 0.525 * \text{INF}\ (-1) + 0.012 * \text{INF}\ (-2) \\ & +0.0002 * \text{R}\ (-1) - 0.001 * \text{R}\ (-2) - 0.0008 * \text{FSI}\ (-1) - 0.0007 * \text{FSI}\ (-2) + 0.006 \end{aligned} \tag{13}$$

$$\begin{aligned}\text{FSI} = {} & -2.075 * \text{GIIP}\ (-1) - 1.347 * \text{GIIP}\ (-2) - 9.905 * \text{INF}\ (-1) + 7.038 * \text{INF}\ (-2) \\ & +0.065 * \text{R}\ (-1) - 0.080 * \text{R}(-2) + 0.239 * \text{FSI}(-1) + 0.305 * \text{FSI}(-2) + 0.123 \end{aligned} \tag{14}$$

$$\begin{aligned}\text{R} = {} & -3.352 * \text{GIIP}\ (-1) - 2.996 * \text{GIIP}\ (-2) + 3.869 * \text{INF}\ (-1) - 3.552 * \text{INF}\ (-2) \\ & +0.973 * \text{R}\ (-1) - 0.140 * \text{R}\ (-2) - 0.524 * \text{FSI}\ (-1) - 0.209 * \text{FSI}\ (-2) + 1.117 \end{aligned} \tag{15}$$

From Figure 3, it is shown that with a one-unit shock in FSI the GIIP first increases, then falls and after 5 month period it is stabilised. The result shows that increasing financial stress does not have immediate negative impact on the growth rate. It is shown that financial instability or stress adversely affects the growth rate but with certain time lag. Here, financial stress negatively affects growth after two-month period. The shock is absorbed after five-month period.

Figure 3 also shows the impulse response of inflation to one standard deviation shock to financial stress. This result shows that a positive shock to financial stress leads to a negative impact on inflation for a long period of time. This result is similar to the result of Blot et al. (2015) who said that higher financial fragility leads to decrease in inflation and debt deflation. We can interpret it in another way that, stress may negatively affect inflation in indirect way by lowering growth rate and thereby prices.

Figure 4 shows the impact of Cholesky's one standard deviation shock to growth rate of IIP on financial stress. The figure shows that with a one standard deviation shock to GIIP, the FSI first falls, and then slightly increases,

Table 4. ADF and Phillips–Perron test at level.

Variables	ADF test statistics	Probability	95% critical ADF value	Remark	PP test statistics	Probability	95% critical PP value	Remark
FSI	−8.594432	0.0000	−3.448681	I(0)	−9.668784	0.0000	−3.448681	I(0)
GIIP	−4.225522	0.0058	−3.452764	I(0)	−39.53194	0.0001	−3.448681	I(0)
INF	−6.292844	0.0000	−3.448681	I(0)	−6.306224	0.0000	−3.448681	I(0)
R	−4.501129	0.0023	−3.448681	I(0)	−4.811976	0.0008	−3.448681	I(0)

Source: Author's estimation.

Table 5. Zivot–Andrews structural break trended unit root test.

	At level	
Variable	t-test	Time break
GIIP	−5.7662(1)**	2012(July)
INF	−6.9952(1)*	2014(September)
FSI	−3.5887(1)*	2014(April)
R	−6.2372(1)***	2011(March)

Source: Authors' calculation.
Note: () Lag order shown in parentheses. *, ** and *** represents 1% and 5% level of significance.

Table 6. Lag order selection criteria of the VAR model.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	279.1671	NA	7.89e-08	−5.003038	−4.904838	−4.963208
1	446.1952	318.8718	5.07e-09	−7.749003	−7.258007*	−7.549853
2	471.8838	47.17369	4.25e-09*	−7.925161*	−7.041367	−7.566689*
3	486.5699	25.90090	4.37e-09	−7.901271	−6.624680	−7.383479
4	495.5196	15.13318	5.00e-09	−7.773084	−6.103696	−7.095972
5	516.5966	34.10635	4.60e-09	−7.865393	−5.803208	−7.028959
6	528.3273	18.12932	5.03e-09	−7.787770	−5.332788	−6.792016
7	539.1155	15.88801	5.64e-09	−7.693009	−4.845230	−6.537934
8	563.5889	34.26275*	4.96e-09	−7.847070	−4.606494	−6.532675

Source: Author's calculation.
* indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level); FPE: Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion.

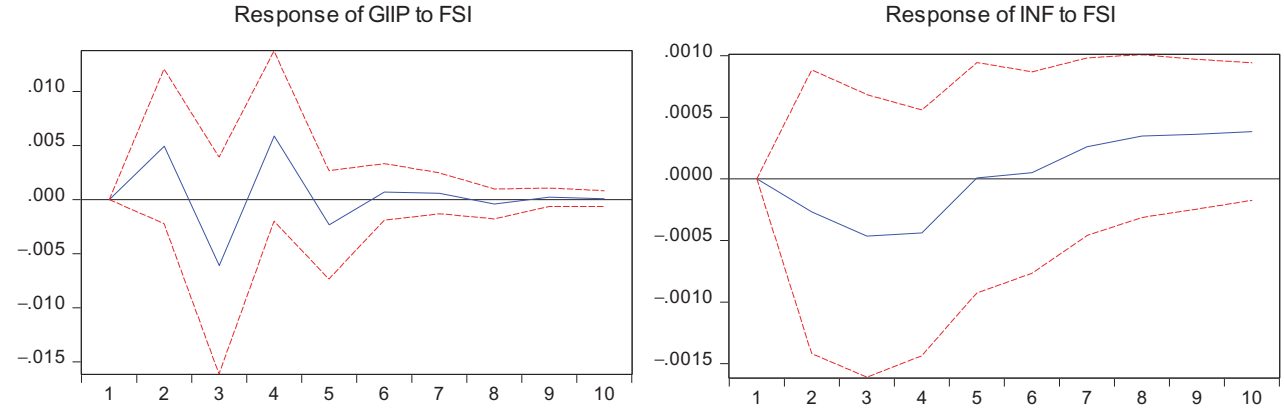

Figure 3. Impulse response of GIIP and INF to FSI. Source: Author's estimation.

and after five-month period, it is stabilised. The immediate impact of GIPP on FSI is negative. This indicates that higher growth rate can lead to lower financial stress or instability. This result is in confirmation with the result of many other papers in empirical literature. It can be explained that higher growth may increase the net worth of borrowers, may strengthen the balance sheet of borrowers and reduces loan default and thereby reduces financial stress and foster stability. But after some time lag higher growth leads to increase in stress or instability in the financial system. This may be due to the fact that prolonged periods of economic growth may lead to higher risk-taking and thereby increasing financial stress.

Figure 4 also shows the response of financial stress to one standard deviation shock to inflation. The result shows that inflation shock has an immediate negative impact on FSI and, after two lag periods in has positive impact on FSI. The shock is absorbed after four-month period. From this result, it can be concluded that higher

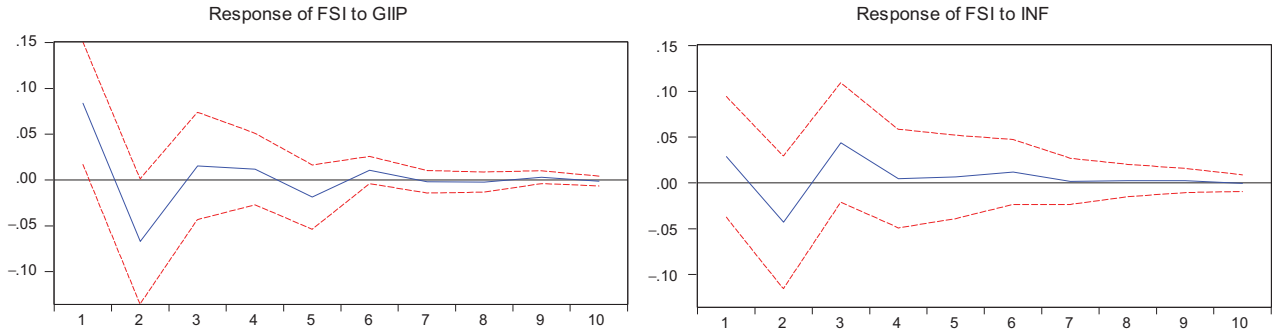

Figure 4. Impulse response of FSI to GIIP and INF. Source: Author's estimation

Table 7. Variance decomposition of GIIP.

Period	S.E.	GIIP	INF	R	FSI
1	0.039938	100.0000	0.000000	0.000000	0.000000
2	0.054507	92.63227	6.320134	0.340715	0.706883
3	0.057249	90.15287	8.054965	0.310806	1.481360
4	0.057580	89.14064	8.235361	0.336546	2.287451
5	0.057952	89.09449	8.195930	0.332237	2.377339
6	0.058191	89.00989	8.287947	0.333945	2.368215
7	0.058235	88.95597	8.337023	0.336544	2.370466
8	0.058239	88.94869	8.340057	0.336493	2.374763
9	0.058249	88.94878	8.339379	0.337159	2.374677
10	0.058254	88.94745	8.341120	0.337144	2.374283

Source: Author's estimation.

Table 8. Variance decomposition of inflation.

Period	S.E.	GIIP	INF	R	FSI
1	0.006424	2.224448	97.77555	0.000000	0.000000
2	0.007324	3.931198	95.85492	0.065347	0.148539
3	0.007577	4.281791	94.01879	1.197860	0.501563
4	0.007779	4.364526	91.46549	3.378972	0.791012
5	0.007878	4.269586	89.41414	5.544888	0.771387
6	0.007949	4.200252	87.83933	7.194896	0.765527
7	0.007999	4.181762	86.75288	8.196303	0.869052
8	0.008033	4.146671	86.02694	8.777779	1.048608
9	0.008057	4.122564	85.52343	9.115508	1.238494
10	0.008075	4.106362	85.15031	9.304707	1.438623

Source: Author's estimation.

inflation leads to lower FSI or in another way lower inflation leads to higher FSI in short run, which is in accordance with the new environment hypothesis that lower inflation corresponds with lower interest rate and increases risk-taking (Leijonhufvud, 2007; Rajan, 2005). But after 2 lag period increase in inflation leads to increase in financial stress. This may be due to the fact that increase in inflation leads to increase in uncertainty as described by Schwartz (1995). So, we can say that price stability or lower inflation leads to financial instability in the short run but in the long-run price stability leads to financial stability.

It is clearly shown in Table 7 that most of the variation in IIP is explained by its own shock over the 10-month period. The variable which explained the second most variation in GIIP is inflation. However, our intention here is to see how many percentages of variation in GIIP are explained by FSI. The contribution of FSI to the variation in GIIP is 0.7 per cent in the 2nd month, and gradually, it increases though it is not very high. In the 10th month, the contribution of FSI is 2.37 per cent.

In Table 8, it is shown that most of the variation in inflation is explained by its own shock. The contribution of FSI in the total variation in inflation is very low. The contribution of FSI in total variation in inflation is increasing, in 2nd month, it is 0.14 per cent, in 3rd month, it is 0.50 per cent and in the 10th month, its contribution is 1.43 per cent.

Table 9 shows the variance decomposition of FSI. In the first period, maximum percentage of the variation in FSI is explained by its own shock but, other variables also contribute to its variation. In first month, the variation

Table 9. Variance decomposition of FSI.

Period	S.E.	GIIP	INF	R	FSI
1	0.365286	4.566022	0.582492	7.455371	87.39611
2	0.393162	6.701621	2.324988	11.19782	79.77557
3	0.410328	6.186341	2.896962	11.06333	79.85336
4	0.414331	6.153449	2.845363	11.10691	79.89428
5	0.417147	6.278034	2.813259	10.95903	79.94968
6	0.418228	6.299469	2.845495	10.93656	79.91848
7	0.419258	6.270358	2.831647	10.96534	79.93265
8	0.419852	6.254700	2.824230	11.03348	79.88759
9	0.420417	6.242124	2.817848	11.09239	79.84764
10	0.420835	6.230228	2.812707	11.14374	79.81332

Source: Author's estimation.

of FSI explained by FSI, GIIP, inflation and interest rate are 87.39 per cent, 4.56 per cent, 0.58 per cent and 7.45 per cent, respectively. Excluding its own shock, the other variables which explain large percentage of variation in FSI are interest rate, next GIIP and the least is the inflation. In the 10th-month period, the variation in FSI explained by GIIP, inflation, interest rate and its own shock is 6.23 per cent, 2.81 per cent, 11.14 per cent and 79.81 per cent, respectively. The result shows that financial stability in India can be influenced by growth, inflation and interest rate but with a smaller extent.

5. Conclusion

In this paper, an attempt is made to construct an aggregate financial stress index for India by taking monthly data from different segments of the financial market like money market, bond market, equity market, foreign exchange market, and the banking sector, for the period Mar 2007 to December 2016. An FSI is a composite index that combines different market-specific indicators of financial stress like asset price volatilities, risk spreads, credit growth etc. into a single index to measure financial stress. The FSI of India effectively pointed out the period of instability in the financial system. The period of global financial crisis is captured by the FSI. So, this FSI can be used as a leading indicator of financial instability. Hence, it will benefit the participants in the financial market and policymakers to monitor the functioning or working of the financial system, as it gives information about the stress events which were not captured by the stress indicator of individual sector or market. And it can also tell about the sources of financial stress.

The interrelationship and feedback effect between financial stress, economic growth, and price stability are also tested by using correlation and an unrestricted VAR model. The correlation result indicates that financial stress can have negative relation with growth after one-period lag. And inflation has a negative relation with FSI and a positive relation with 1 period lag of FSI, though the result is not significant. The impulse response function of the VAR model shows that financial stress leads to decline in growth after a lag period and higher growth rate for a longer period of time increases stress in the financial system. The result also shows that in short-run price stability or lower inflation increases financial stress but in the long run the result is opposite .The variance decomposition result shows that the contribution of FSI to the variation of other variables are not much high but other variables can contribute to the variation in FSI to some extent. So it is clear that instability in the financial sector can have an adverse effect on growth and price stability. Hence emphasis should also be given to the objective of maintaining financial stability like other objectives such as price stability and growth.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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