Appendix A: Financial Sector Vulnerability Index (FSVI) and Financial Sector Heat Map (FSHM)

The financial sector vulnerability index (FSVI) and financial sector heat map (FSHM) have been estimated covering the period from the year 1996 to year 2016 following the methodology described by Aikman et. al. (2015)[221].

The FSVI represents the equal-weighted average risk arising from the four key areas i.e. the banking sector, the corporate sector, the financial markets, and the macro-economy. Each area is assessed based on various risk dimensions. For example, banking sector's risk dimensions include capital adequacy, earnings, liquidity etc. Within each risk dimension, in turn, various risk indicator(s) are used. For example, asset quality includes NPLs to loans ratio, Loss to NPLs etc. Generally, higher values of an indicator read higher risk. However, to make the direction of risk consistent, few indicators (such as CAR, ROA, GDP etc.) are pre-multiplied by negative unity.[222] See **Table 1** below for details.

The risk is depicted in terms of cumulative probability ranging from 0 to 1 such that closer to 0 means lower risk and closer to 1 is the higher risk. The risk magnitude of FSVI is, then, represented by various color scaling (blue with the lowest risk and red with the highest risk) to form Financial Sector Heat Map (FSHM).

In order to calculate the magnitude of risk, each indicator is standardized around its mean. Taking simple average of all the standardized indicators in all risk dimensions of a particular area yields the average standardized values of the area. For example, the values for banking is derived from averaging all standardized indicators of the banking sector in various risk dimensions i.e. capital adequacy, liquidity, earnings etc. The aggregate values are then derived by taking equal weighted average of values of all areas (i.e. banking, financial markets, etc.). The FSVI is then derived by rescaling the aggregate values, between 0 and 1, using the empirical cumulative distribution function (ECDF) of the entire time series data.

The FSVI is then mapped into color spectrum (blue to red) to obtain the FSHM. FSHMs of all sectors are also estimated separately.[223]

For completeness, a number of alternative measures for scaling the aggregate index between 0 and 1 have been explored, such as Normal Cumulative Distribution Function (NCDF) and Cumulative Probability by assigning equal probabilities to each value. All methodologies yield similar results for the FSVI and FSHM.

[221] https://www.federalreserve.gov/econresdata/feds/2015/files/2015059pap.pdf

[222] Otherwise, higher value of indicators would have shown lower risk.

[223] For sector-wise heat maps, each sector standardized values is also rescaled with empirical cumulative distribution function

Table 1: FSVI and FSHM: Risk Areas, Risk Dimensions and Indicators				
Sr. No.	**Risk Area**	**Risk Dimension**	**Risk Indicator(s)**	**Impact on Financial Stability**
1	Banking	Capital Adequacy (C) $C = \frac{1}{n}\sum_{i=1}^{n} c_i, n = 3$	c_1 = *Capital Adequacy Ratio(CAR)* c_2=*TIER 1 (CAR)* c_3=*Capital to Asset Ratio*	Positive Positive Positive
		Asset Quality (AQ) $AQ = \frac{1}{n}\sum_{i}^{n} aq_i,$ *n = 4*	aq_1 = *NPLs to Total Loans* aq_2 = *Provisions to NPLs* aq_3 = *Net NPLs to Capital* aq_4 = *Loss to NPLs*	Negative Positive Negative Negative
		Earnings (E) $\mathrm{E} = \frac{1}{n}\sum_{i=1}^{n} e_i,$ *n = 5*	e_1= *Return on Assets Before Tax* e_2=*Return on Equity(Avg. Equity and Surplus) Before Tax* e_3 = *Net Interest Margin* e_4 = *Net Interest Income/Gross Income* e_5 = *Cost to Income Ratio*	Positive Positive Positive Positive Negative
		Liquidity (L) $L = \frac{1}{n}\sum_{i=1}^{n} l_i,$ *n = 3*	l_1= *Liquid Assets/Total Assets* l_2= *Liquid Assets/Total Deposits* l_3= *Earning Assets/Deposits*	Positive Positive Positive
		Residual Growth (RG) $RG = \frac{1}{n}\sum_{i=1}^{n} rg_i,$ *n =4*	rg_1 = *Growth in Investment* rg_2= *Growth in Borrowings* rg_3= *Growth in Advances* rg_4= *Growth in Deposits*	Negative Negative Negative Positive
2	Corporate	Corporate Debt	*Debt Burden (average of asset/equity, debt/equity and debt/asset ratios)*	Negative
3	Financial	Foreign Exchange	*Mid-Weight Interbank Exponential Moving Weighted Average (EMWA) Volatility*	Negative
		Money Market	*Overnight Repo Rate Exponential Moving Weighted Average (EMWA) Volatility*	Negative
		Capital Market	*KSE-100 Index Exponential Moving Weighted Average (EMWA) Volatility*	Negative
4	Macroeconomic	External Sector (Ex) $Ex = \frac{1}{n}\sum_{i=1}^{n} ex_i,$ *n = 3*	ex_1 = *Total Liquid Foreign Reserve Position* ex_2 = *Current Account Balance* ex_3 = *Balance of Trade*	Positive Positive Positive
		Real Sector (R) $R = \frac{1}{n}\sum_{i=1}^{n} r_i,$ *n = 2*	r_1 = *Real GDP Growth* r_2 = *Inflation*	Positive Negative
		Fiscal Sector	Fiscal Deficit as Percentage of GDP	Negative