

Modeling Systemic Risk in a Developing Economy: Application of Marginal Expected Shortfall

Hasan Hanif^{*}, Muhammad Naveed[†] and Mobeen Ur Rehman[‡]

Abstract

The study examines the systemic risk of banking sector in Pakistan for the first time using marginal expected shortfall. The data set is based on a period of 16 years from 2002 to 2017. The top five systemically important financial institutions are Habib bank limited, United bank limited, Muslim commercial bank limited, Bank AlFalah limited and Bank of Punjab limited. Moreover, the study highlights firm and country level variables that are significant in explaining systemic risk taking notably, market power, deposit ratio, size, non-performing loans, regulatory quality and government borrowing. The results outline that systemic risk can be curbed by increasing the deposit ratio that reduces the sensitivity of financial institutions to the stress of the market. By the same token, large organizations are more prone to infecting others and are involved in higher systemic risk taking. Moreover, the study also elucidates the role of high concentration (low competition) in exacerbating systemic risk. Improved regulatory quality deters systemic risk taking, whereas increased government debt contributes to the buildup of systemic risk. The study outlines that micro prudential policies should be aligned with macro prudential policies to ameliorate excessive systemic risk taking.

Keywords: Systemic risk; Marginal expected shortfall; Dynamic conditional correlation; Concentration; Micro and macro prudential policy.

Introduction

Economic growth plays a pivotal role in the development of the economy and depends on the scale of investment that eventually transforms in to increased gross domestic product. Financial institutions are an important source of providing impetus to investment by mobilizing savings and channelizing them to meet much needed capital requirements of other

^{*} Hasan Hanif, PhD Scholar, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology. Email: hasanhanifjanjua@gmail.com

[†] Muhammad Naveed, Associate Professor, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology.

[‡] Mobeen Ur Rehman, Assistant Professor, Shaheed Zulfiqar Ali Bhutto Institute of Science & Technology

sectors. According to Anwar (2012), nonfinancial sector is heavily dependent upon the banking sector of Pakistan. Banks provide loans to the industry and play an important role in development of capital markets thus making them an important constituent of economic growth. By the same token, Zedda and Cannas (2017) report long run relationship between development of financial institutions and economic growth. Analogously the scale, of loss resulting from failure of financial sector is also large as it also encompasses other sectors, thus hampering the growth of the whole economy (Stolbov, 2017). According to Basel III, implementation of adequate risk framework of the financial institutions is imperative for the stability of the financial sector and the economy as a whole.

The global financial crisis unveiled that inadequate analysis of the risk can annihilate the financial system and repercussions can encompass the whole economy (Kleinow, Horsch & Molina, 2017). The managers of the financial institutions were not able to measure and predict the risk exposure of the financial institutions and the cascade destroyed the whole system. After the global financial crisis, risk assessment in the financial sector has become a prominent topic in the banking literature. Similarly, Avramidis and Pasiouras (2015) posit that in the aftermath of global financial crisis, there is a dire need of efficient measurement and prediction of risk.

The fragility of financial system can be avoided by adequately analyzing the risk exposure of the financial institutions (Billio, Getmansky, Lo & Pelizzon, 2012). The risks faced by the organizations are broadly categorized as systematic and idiosyncratic risk along with the comparatively novel manifestation of systemic risk. Idiosyncratic risk refers to the bank specific volatility and systemic risk is embedded in the system. As far as systemic risk is concerned, there is no consensus definition till date. European Central Bank (ECB, 2010) defines systemic risk as “a risk of financial instability so extensive that it damages the functioning of a financial system to the extent where economic growth and welfare suffer materially”. Systemic risk has three pivotal characteristics namely contagion, externality and universality (Black, Correa, Huang & Zhou, 2016). Contagion effect rises due to inter linkages between financial institutions. The loss of large segment of the market is categorized as universality whereas negative externality refers to the spillover effect from one financial institution to others. Moreover, idiosyncratic risk also becomes significant when a financial institution is important in the network and fall of that institution also generates negative shocks for other institutions in the system during financial crisis (Balla, Ergen & Migueis, 2014).

It is evident from extant literature that contribution of an individual institution to the deficiency of whole financial system is more important than firm specific risk during the period of market stress (Amini, Cont & Minca, 2013; Allen & Gale, 2000). Contrary to that, the financial managers assume the primary responsibility of looking after the interests of the shareholders and are only concerned with the assessment of idiosyncratic risks that can directly jeopardize the profitability and stock value (Strobl, 2016). Moreover, Strobl (2016) highlights that systemic risk has positive effect on valuation and would never be controlled by market discipline, therefore requiring interventions from regulatory authorities. By the same token, Anginer, Demirguc-Kunt and Zhu (2014) postulate that systemic risk of a financial institution should be considered more important as compared to firm specific risk as it contributes to the overall stability of the financial system during the periods of market stress. Similarly, Acharya (2009) also emphasize that regulators and supervisory authorities of financial organizations should be more concerned about the stability and strength of the overall financial system.

As far as systematic and idiosyncratic risk is concerned the existing literature is comparatively mature. Contrary to that, systemic risk became center of attention after the 2008 subprime mortgage crisis which revealed that collapse of individual institution can generate negative shocks for whole system. Since then, studies addressing systemic risk have become ubiquitous in developed countries (Castro & Ferrari, 2014; Balck, Correaz, Huangx & Zhou, 2016; Soedermano and Setorous; 2017) but literature in developing countries appears to be scanty (de Mendonca & da Silva, 2017). This study augments the existing literature by identifying systemically important financial institutions from developing economy[§].

There are 30 baseline measures of systemic risk and their modifications have been proposed (Bisias et al. 2012; Blancher, Mitra, Morsi, Otani, Severo and Valderrama, 2013). These diverse measures approach systemic risk from different angles. One of the widely used measures of systemic risk is conditional value at risk (ΔCoVaR) introduced by Adrian and Brunnermeier (2011). ΔCoVaR is defined as the contribution of an individual institution to systemic risk which is the

[§] State Bank of Pakistan publishes Financial Statement Analysis of Financial Sector. According to the report of State Bank of Pakistan, there is a rapid surge in the total assets, deposits, lending and investments of banking sector from 2009-2016. For more detail on the particulars of banking sector, see Financial Statement Analysis of Financial Sector 2012-2016.

difference between CoVaR conditional on the loss of an institution in crisis and that in a normal situation. Later on Adrian and Brunnermeier (2016) introduced forward CoVaR that can be used to predict realized CoVaR. Furthermore, Acharya, Pedersen, Philippon, and Richardson (2010) propose Marginal Expected shortfall to evaluate the systemic risk sensitivity of individual financial institutions. In the like manner, Brownlees and Engle (2012) propose another measure of MES and present the Systemic Risk index (SRISK) to explicate the systemic risk as a function of the degree of leverage, size and MES of a financial institution. In addition to that, systemic risk is also measured by using credit default swaps, distressed insurance premium and contingent claim analysis etc.

These systemic risk measures are different in the ways in which they view the contribution to the systemic risk by an individual financial institution and response of financial events to the systemic shock. To demonstrate, Laeven, Ratnovski and Tong (2015) use CoVaR and SRISK in their analysis to measure systemic risk and divulged that each measure captures different aspects of systemic risk whereas Lin, Sun and Yu (2016) study the relationship among SRISK, MES, and CoVaR and explicate that these measures identify same institutions as systemically important. Consistent with Acharya et al. (2010) this study uses marginal expected shortfall to measure systemic risk.

The identification of systemically important financial institutions highlights the important players in the financial system. In the like manner, extant literature divulges that the measurement of systemic risk is the first step in the assessment of risk taking behavior of financial institutions (Kleinow & Nell, 2015; Kleinov et al. 2017). The stability of financial system can only be maintained by identifying the factors that build systemic risk (Bessler, Kurmann & Nohel, 2015). The research on the determinants of systemic risk is also confined to developed economies with little attention paid in emerging economies (de Mendonca & da Silva, 2017). This study brings diversity to the existing strand of literature by providing empirical evidence on the determinants of systemic risk from an emerging economy. The results divulge the role of firm and country level variables in shaping up the systemic risk of financial institutions in Pakistan, notably size, market power, deposit ratio, government debt and regulatory quality. In addition to that, the role of high concentration (low competition) is also examined and findings outline positive influence of concentration on systemic risk.

Literature Review

Systemic Risk Measure

Marginal Expected Shortfall

In order to assess the systemic risk sensitivity, Acharya et al. (2010) proposed Marginal Expected shortfall that outlines systemic risk as a function of institution's return dependent upon the overall market being distressed. The financial system is considered in the distress when the daily market returns fall below minus two percent (Brownlees and Engle, 2012). The MES is employed by wide range of studies to estimate systemic risk. For instance, Strobl (2016) used marginal expected shortfall to assess the determinants of systemic risk in US. Suffice to that, Pagano and Sedunov (2016) used MES to analyze the systemic risk of European banks. Furthermore, Yun and Moonb (2015) and Quin and Zhu (2014) apply MES to measure systemic risk of Korean Banking industry and BRICS banks respectively. Concomitantly, Gang and QIAN (2015) applied MES as measure of systemic risk to evaluate the impact of monetary policy on systemic risk in China. Balla et al. (2014) used MES to examine the tail dependence between stock returns of financial institutions. Weib et al. (2014) use MES to elucidate the determinants of systemic risk in Europe. A very useful property of MES is additivity, which implies that overall systemic risk is total of individual institutions risk.

Drivers of Systemic Risk

Bank Characteristics.

Taking the lead from previous studies following bank specific variables are included in the analysis.

Size and Systemic Risk.

The size of the institution is considered as an important determinant of risk taking behavior. Past research suggests that impact of size on systemic risk changes with time. During the crisis larger banks are considered riskier but during the normal times small banks become riskier. Basel Committee on banking supervision highlights that large banks are acutely connected to and within the financial system hence a loss can trigger huge spillovers. Suffice to that, large banks receive sovereign guarantees resulting in increased risk taking because of subsequent bail out. The impact of size on idiosyncratic and systemic risk also varies.

According to Kleinov and Nell (2015) larger banks might have less idiosyncratic risk because of high level of diversification but that argument holds true only for standalone risk. Conversely, Strobl (2016)

argue in favor of negative effect of size on systemic risk. Besides that, Souza et al. (2015) conduct the survey of systemic risk in Brazilian market and argue that in addition to large banks contagion is also generated by small and medium banks and only banks generate contagion. Furthermore, Kleinow et al. (2017) use natural algorithm of bank total assets as proxy of size and divulgethat managers of the banks with sovereign guaranties feel protected and don't pay much attention to market discipline which results in high risk taking. Recently, Teply (2017) also argued in favor of positive effect of size on systemic risk.

Market power and Systemic Risk.

Previous research show market power measured as market to book ratio is an important determinant of systemic risk. Literature presents evidence of both positive and negative effect of market to book ratio on systemic risk. According to Kleinow et al. (2017), high expectations about the earnings of the organization increases the market to book ratio and to get high returns high risk is imperative. In the same vein, Weib et al. (2014) argue that managers are inclined to build large empires as a result they take excessive risk to increase market value and turn the bank into a glamour bank. On the other hand, charter value hypothesis outlines that market power becomes a self-disciplining factor of risk taking. For instance, Soedarmono and Sitorus (2017) report a robust negative impact of market power on systemic risk and relate their results with charter value hypothesis.

In the like manner, Demsetz et al.(1996) also report negative impact of market power on risk taking and argue that financial managers of companies with high market to book ratio restrain themselves from excessive risk taking as they have great deal to lose if the business becomes insolvent. Moreover, Black et al. (2016) use one and two year lags of the market to book ratio to analyze its impact on systemic risk. Interestingly one-year lag has significant negative and two-year lag has significant positive impact on systemic risk. They further discuss that association between market to book ratio is unstable due to volatility in the market prices. Furthermore, Brunnermeier et al. (2012) report insignificant effect of market to book ratio on systemic risk.

Non-Performing Loans and Systemic Risk.

To assess the credit quality of bank loans Non-Performing Loans is used as the next determinant. Non-performing loans shed light on the risk level of banks. One strand of literature outlines the positive impact of non-performing loans on the systemic risk and create negative externality to the overall financial system. For instance, Kleinov et al. (2017) and

Mayordomo, Rodriguez-Moreno and Pena(2014) divulge the positive effect of non-performing loans on systemic risk. Contrary to that Kleinov and Nell (2015) and Quin and Zhou (2014) state insignificant impact of Non-Performing loans on systemic risk. In addition to that Yun and Moon (2014) also report insignificant impact of non-performing loan on systemic risk.

Deposit Ratio

Institutional investors and private creditors provide the funds to the banks. Deposit to total liabilities show the part of total finances that comes from private creditors (Kleinov et al, 2015). According to Strobl (2016), deposit ratio has significant positive impact on systemic risk. Moreover, Strobl (2016) discuss that private creditors impose fewer restrictions on the banks which can result in high risk taking. Contrary to that Kleinow et al. (2017) espouse that high deposit ratio imply that a large chunk of banks finances comes from private creditors and it reduces systemic risk as private depositors and creditors react slowly to the crisis as compared to the financial institutions. As a result, high deposit ratio helps to contain the systemic risk during the times of distress. Deposit ratio reduces the bank dependence on capital markets and institutional investors. Confirming these results, Zeda and Cannas (2017) outline the negative impact of deposit ratio on systemic risk. By the same token Altunbas, Binici and Gambacorta (2017) divulge that increase in deposit ratio reduces systemic risk.

Macro-Economic Factors

The importance of country level variables is highlighted by a large number of studies. Consistent with the previous literature the following country level variables are included in the analysis.

Government Debt Ratio

Government debt ratio refers to gross government debt as a percentage of GDP (World Bank data base computations). High government debt restricts the policymakers to bail out the banks in the financial distress. A number of studies have highlighted the impact of government debt on risk taking. Recently, Kleinov et al. (2017) and Kleinov and Nell (2015) divulge positive influence of government debt on systemic risk. Similarly, Stolbov (2017) also divulge significant positive impact of government debt ratio on systemic risk. In the same vein, Bruyckere, Gerhardt, Schepens and Vennet (2013) divulge government debt ratio as one of the important vehicle of contagion.

Industry Concentration

Industry concentration refers to the level of competitiveness with more concentration referring to less competition and vice versa. Previous literature presents mixed evidence on banking concentration. For instance, Kleinov et al. (2017) measured concentration as the sum of assets of the three largest national commercial banks as a share of total commercial banking assets to analyze the impact of concentration on financial stability. They report that concentration increases stability and reduce systemic risk. Similarly, Beck et al. (2003) postulate that increase in competition can increase the fragility of the financial system. Meanwhile, Jiménez et al. (2013) also divulge that low competition (high concentration) reduces risk taking. Concomitantly, Anringer et al. (2014) use Hirschmann-Herfindahl** Index to measure concentration and report insignificant impact on systemic risk. Conversely a parallel view also exists that posit difficulty of organizations to get value from market in highly concentrated environment and results in higher risk taking (Strobl, 2016)

Regulatory Quality

Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private system development. The estimate extracted from Worldwide Governance Indicators give the country's score on the aggregate indicator in units of a standard normal distribution. Kleinov and Nell (2015) use regulatory requirements in their analysis and divulge interesting results. Regulatory quality has positive influence on contribution measure of systemic risk i.e. CoVaR, whereas negative impact on MES and SRISK. In addition to that, Chen, Wu, Jeon and Wang (2017) divulge significant negative impact of regulatory rules on bank risk.

Data and Methodology

Sources of Data and Sample Population

There are 35 scheduled banks operating in Pakistan. Out of these banks, 20 are listed at Stock Exchange. The sample constitutes of only listed banks as stock prices are required to compute measure of systemic risk. Data is analyzed form 2004-2017. The data on firm level variables is extracted from the financial statement analysis of financial sector published by State Bank of Pakistan. The data on country level variables is extracted from Publications of State Bank of Pakistan, Worldwide

** HHI index is elaborated in Appendix A.

Governance and Development Indicators. Weekly data on share prices of the banks listed at Pakistan Stock Exchange and KSE 100 index are retrieved from Brecorder.com.

Systemic Risk Measures

Marginal Expected Shortfall

The estimation approach applied in this study is Marginal Expected shortfall introduced by Acharya et al. (2010). This approach puts the returns of financial system on the cause side and analyzes the effect of extreme events on institutions return. In a subsequent study Brownlees and Engle (2012) expand the conventional marginal expected shortfall by introducing dynamic conditional correlation structure that is more appropriate in empirical analysis. The MES measure as introduced by Acharya et al. (2010) uses static structural approach whereas, Brownlees and Engle (2012) highlight that correlation between market and security changes with time and are not static. In order to compute marginal expected shortfall it is assumed that there is a panel of individual financial institutions represented by $j = 1, \dots, n$ at times $t = 1, \dots, T$. Furthermore, R_{jt} and R_{mt} represent log return of institution 'j' and market on day 't' respectively. Consistent with Brownlees and Engle (2012) MES of institute 'j' is defined as the tail expectation of the jth firm's return conditional on a crisis event:

$$MES_{jt}(C) \equiv E_{t-1}[R_{jt}|R_{mt} < C] \quad (3.1)$$

In equation (3.12), C is the threshold value that shows a drop in the market return, consequently $\{R_{mt} < C\}$ represents the crisis event. MES of a given firm j can be computed by calculating the log returns of the firm's stock conditional on the days in which the market went through its worst C outcomes. For instance, Acharaya, Engle and Richardson (2012) set the daily loss to be minus two percent. In this study a bivariate daily time series model of the firm and market returns will be applied to compute marginal expected shortfall:

$$\begin{aligned} R_{mt} &= \sigma_{mt}\varepsilon_{mt} \\ R_{jt} &= \sigma_{jt}(\rho_{jt}\varepsilon_{mt} + 1 - \sqrt{\rho_{jt}^2}\varepsilon_{jt}) \\ (\varepsilon_{mt}, \varepsilon_{jt})^T &\sim D \quad (3.2) \end{aligned}$$

In equation (3.2), σ_{jt} and σ_{mt} are conditional standard deviations of the firm j and the market respectively, ρ_{jt} represents the conditional correlation of the firm/market return and the shocks $(\varepsilon_{mt}, \varepsilon_{jt})$ are assumed to be independent and identically distributed with zero mean, unit variance and zero covariance over time. In the above equation

standard deviations are asymmetric GARCH models and correlation is calculated by using Dynamic Conditional correlation model introduced by Engle (2002). Asymmetric GARCH model will be used as positive shock to the stock market has comparatively feeble effect as compared to the negative shock. Using equation (3.12) and (3.13), MES can be expressed as:

$$MES_{jt}(C) = E_{t-1}[R_{jt}|R_{mt} < C] \\ = \sigma_{jt} (\sigma_{jt} E_{t-1} [\varepsilon_{mt} | \varepsilon_{mt} < C/\sigma_{mt}] + 1 - \sqrt{\rho_{jt}^2} E_{t-1} [\varepsilon_{jt} | \varepsilon_{mt} < C/\sigma_{mt}]) \quad (3.3)$$

Estimation of Systemic Risk

Estimation of Systemic Risk, Idiosyncratic Risk and Firm Value

Stationarity of data is checked before applying fixed and random effect models. Augmented Dickey Fuller and Philip Perron tests are applied to gauge the stationarity of data. Hausman specification is used to decide between fixed and random effect. In post estimation, Wooldridge test of autocorrelation and Pesaran's test of cross sectional dependence are applied to ensure robust results. Moreover, Heteroskedasticity-robust Huber-White standard errors are used.

Moreover, endogeneity in the model is controlled by using GMM (Arellano & Bover, 1995). Furthermore, Blundell and Bond (1998) emphasize on the use of system GMM as small and large samples are vulnerable to bias. Consistent with these arguments, the study applies one step and two step system GMM. In addition to that, the results of GMM are reliable in the absence of serial correlation of order 2 or beyond. First and second order test of correlation are performed in the study. Furthermore, Sargan and J-test are performed to analyze the exogeneity of the instruments.

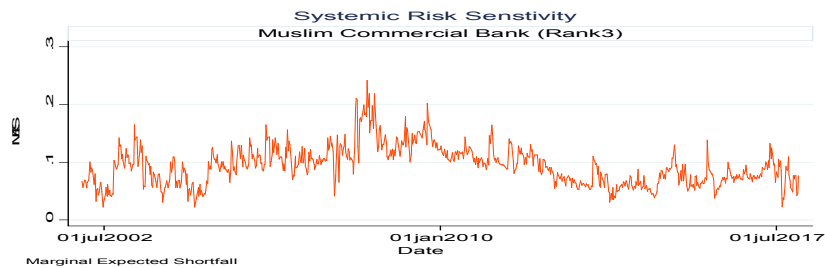
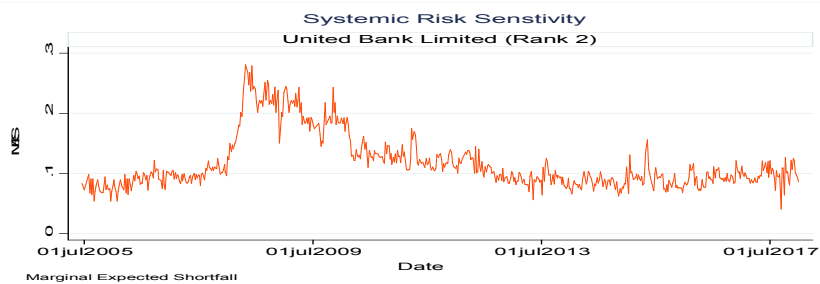
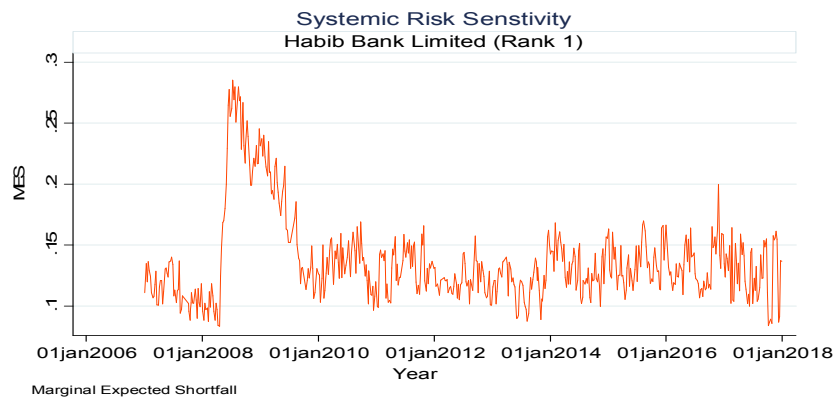
$$\Delta SYS_t = \beta_0 + \beta_1 SYS_{i,t-1} + \beta_2 Size_{i,t} + \beta_3 Market Power_{i,t} + \beta_4 NonPerforming_{i,t} + \beta_5 DepositRatio_{i,t} + \beta_{10} Regulatory Quality + \beta_{12} Gov Debt_t + \varepsilon_{it} \quad (3.4)$$

Systemic risk is the dependent variable in the model. The formulation and empirical evidence on independent variables is provided in Appendix A

Results and Interpretation

Figure 1 shows systemic risk of top five ranked systemically important financial institutions. Habib bank limited (HBL) has highest systemic risk sensitivity followed by United bank limited (UBL), Muslim commercial bank limited (MCB), Bank Alfalah limited and Bank of Punjab limited (BoP). MCB is the largest bank of Pakistan with current market

capitalization of 225.75 billion rupees. UBL is the third largest bank of Pakistan with market capitalization of 177.51 billion rupees whereas, HBL has market capitalization of 209.03 billion rupees. Bank Alfalah and Bank of Punjab have market capitalization of 90.39 billion and 33.42 billion dollars. The results show the financial institutions that respond most to the crisis of the market.



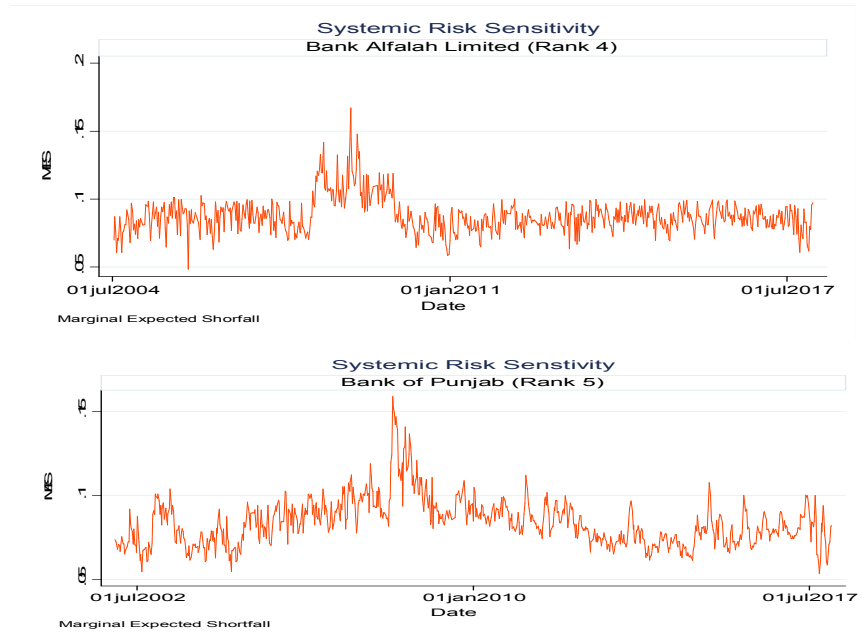


Figure 1

Systemic Risk Sensitivity

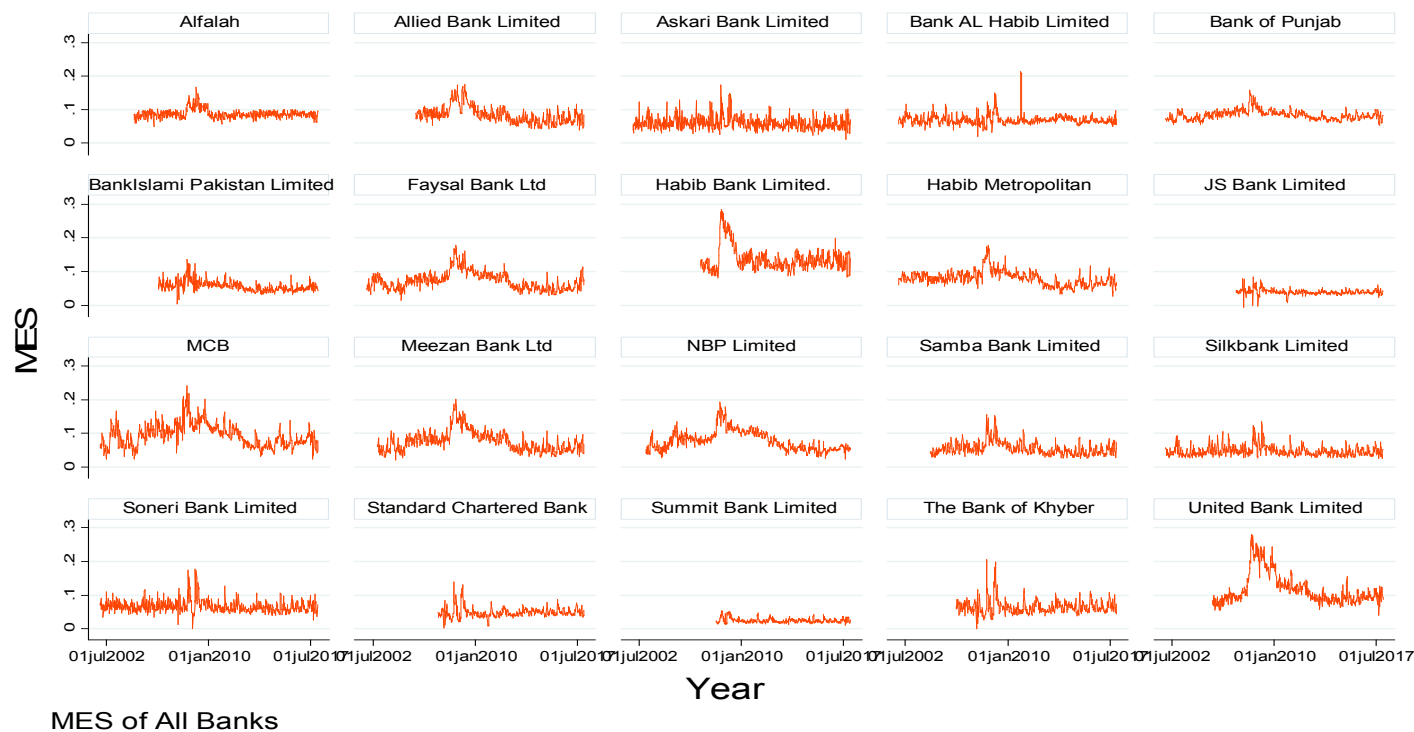


Figure 2

Figure 2 shows systemic risk of all the financial institutions listed at Pakistan Stock Exchange.

Table 1 Fisher Test of Stationarity

	SIZ	MP	NPL	DR	GD	CNC	REG
Inverse chi-squared P	119 (0.00)	183 (0.00)	61.5 (0.015)	104 (0.000)	91.7 (0.000)	372 (0.00)	241 (0.00)
Inverse normal Z	-5.3 (0.00)	-6.76 (0.00)	-1.67 (0.047)	-3.96 (0.046)	-2.50 (0.006)	-14.1 (0.00)	-8.79 (0.00)
Inverse logit L	*-6.4 (0.00)	-10.5 (0.00)	-1.87 (0.032)	-4.79 (0.007)	-2.78 (0.003)	-22.4 (0.00)	-13.4 (0.00)
Modified inv chi-squaredPm	8.8 (0.00)	16.0 (0.00)	2.41 (0.007)	7.20 (0.00)	5.66 (0.000)	37.1 (0.00)	22.5 (0.00)

Where ; SIZ= Size; MP= Market Pow; DR= Deposit Ratio; NPL=Non Performing Loan; CNC= Concentration; GD= Govt Debt; REG= Regulations

Note: The table presents stationarity results with coefficient showing the statistic and probability is shown in parenthesis. Choi (2001) proposed Fisher's test and postulate that the inverse normal Z statistic brings the ultimate trade-off between power size. Furthermore, Choi (2001) suggests modified inverse chi₂ Pm test for large sample. Moreover, inverse chi-square is recommended for both when finite and infinite samples. The table presents all four statistics along with their probability.

Table 1 shows the results of data stationarity. Pesaran and Fisher type test are applied to gauge the stationarity of data. Both tests use augmented Dickey Fuller computations. Due to scarcity of space only results of Fisher test are reported. Fisher test reports four statistics along with the probabilities. All the four statistics and their respective probabilities show that data is stationary at level.

Table 2 Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Firm				
MES	3.7719	1.7108	0.3796	14.8218
Size	8.1347	0.5461	6.5419	9.4087
Market Pow	1.6378	1.7583	-0.7352	21.672
Deposit Ratio	0.7540	0.0839	0.4417	0.8954
Non-Performing	0.0384	0.0370	0.0002	0.2735
Country				
Concentration	1018.952	194.9845	852.59	1730.76
Gov Debt	.6464	.6594	0.567	0.795
Regulatory	-0.6434	0.0950	-0.9052	-0.4835

Note: The table presents descriptive statistics for bank and country specific financial data used in the panel regressions. Bank-specific data are taken from the databases of State Bank of Pakistan. Sector level variables are computed by authors. Political stability and Bank claims is provided by World Wide Governance and development indicators.

Table 2 shows descriptive statistics of dependent and independent variables incorporated in the study. The data set consists of 20 banks ranging across 16 years. The average annual systemic risk is

3.7719. Market to Book ratio has also negative value due to negative equity reported by Bank of Punjab in 2008. Government debt ratio surged to maximum of 79.5%.

Table 3 Correlation Matrix

	SR	SIZ	MP	DR	NPL	CNC	GD	REG
SR	1							
SIZ	0.527	1						
MP	-0.279	-0.162	1					
DR	-0.280	0.067	-0.002	1				
NPL	0.330	0.380	-0.283	0.148	1			
CNC	0.387	-0.640	0.175	-0.043	-0.258	1		
GD	0.488	-0.347	-0.394	0.028	-0.014	0.519	1	
REG	-0.251	-0.171	0.341	0.398	-0.237	-0.355	0.007	1

Where ; SR= Systemic Risk; SIZ= Size; MP= Market Pow; DR= Deposit Ratio; NPL=Non Performing Loan; CNC= Concentration; GD= Govt Debt; REG= Regulations

Table 3 shows the result of correlation among key variables. The highest correlation is between systemic risk and size followed by systemic risk and government debt. Size is negatively correlated while government debt is positively related to systemic risk.

Table 4 Estimation of Systemic Risk

	F.E	SGMM1	SGMM 2
Systemic _{t-1}		0.518*** (0.000)	0.228** (0.0317)
Size	509** (0.029)	0.315* (0.061)	0.337* (0.074)
Market Pow	- 0.403* (0.062)	-0.374** (.031)	-0.447* (0.078)
Deposit Ratio	-1.143** (0.014)	-2.173** (0.011)	-1.85* (0.086)
Non-performing	0176* (0.069)	0.221 (0.118)	0.317* (0.094)
Concentration	0.223* (0.082)	0.173* (0.091)	0.385** (0.027)
Govt Debt	0.421* (.072)	0.556** (0.041)	0.501* (0.053)
Regulations	-0.2.19* (0.077)	-0.305** (0.072)	-0.3.84 (0.152)
Constant	4.33*** (0.000)	5.46*** (0.000)	4.13*** (0.000)
Num of obs	273	256	256
Adj.R ²	0.6381		
F-stat(P-value)	84.20(0.00)	36.58(0.00)	59.76(0.00)
N.Ins/N.Groups	0.80 0.80		
J-stat(p-value)	6.52 (0.163)		
Sargan(p-value)		7.52 (0.111)	3.78(0.451)
AR(1)p-value		- 2.91(0.004)	-1.75(0.080)
AR(2)p-value		0.28(0.778)	0.59(0.555)

Note: Table 4 reports the results of fixed effect along with one step and two step system GMM. (*), (**) and (***) shows significance at 1%, 5% and 10% respectively. P-values are shown in parenthesis. Heteroskedasticity-robust Huber-White standard errors are used. AR (1) and AR(2) present results of first and second order correlation in first differenced results. Sargan and J-stat show if instruments are exogenous.

Table 4 shows result of fixed effect, one step SGMM1 and two step SGMM2. The diagnostic and post estimation tests of fixed effect regression are presented in the Appendix B and Appendix C respectively. The tests include Hausman specification, Woodridge test of autocorrelation and Pasaran's test of cross sectional dependence. In addition to that, Sargan and J-stat confirms the validity of instruments and AR (2) results show the absence of second order autocorrelation. The results show that large financial institutions contribute more to the systemic risk (Laeven et al., 2017; Teply, 2017). Moreover, market power has negative impact on systemic risk and the findings are consistent with charter value hypothesis (Balck et al., 2016). Higher deposit ratio is associated with lower level of systemic risk as private creditors are slow to respond to adverse market movements as compared to individual investors (Kleinow et al., 2017). Increase in Non-Performing loans makes the financial institutions more vulnerable to shocks, hence amplifying systemic risk (Lin et al., 2016). In addition to that, macro-economic variables are also significant in explaining variation in systemic risk. To demonstrate, high concentration builds systemic risk (Stobl, 2016) and same holds true for increased government debt (Bruyckere, 2013; Stolbov, 2017). If government introduces sound policies and ensures implementation of these policies, it can significantly lower the systemic risk. The same is reflected in negative effect of regulatory quality on systemic risk (Kleinow & Nell, 2015).

Conclusion

This study examines systemic risk for the economy of Pakistan for the first time using marginal expected shortfall. According to systemic risk ranking, Habib bank limited is the most systemically important financial institution followed by United bank limited, Muslim commercial bank limited, Bank AlFalah limited and Bank of Punjab limited. In order to ensure the stability of financial system, these systemically important financial institutions should be watched more closely by regulatory authorities. The study reports important relationships and lays down foundation for introducing micro and macro prudential policies. For instance, large financial institutions are prone to infecting others and also sensitive to the stress of the market. Accordingly, higher deposit ratio deters the risk of contagion as private investors are slow to react to stress of the market as compared to institutional investors. Moreover, the State Bank should also have a closer look on the non-performing loans of the banks as they increase the risk of contagion during crisis.

In brief, the State Bank of Pakistan should discourage concentration and encourage competition to dilute the systemic importance of banks. Higher government debt reduces the capacity of government to bail out banks during crisis and lead to higher systemic risk. Furthermore, sound policies introduced by the government and their implementation significantly reduces systemic risk. To epitomize, the stability of financial system is very important for the sound working of whole economy and the fragility of system can be avoided by examining risk exposure of financial institutions and introducing timely micro and macro prudential policies including Pigovian tax^{††}.

^{††}A Pigovian tax (also spelled Pigouvian tax) is a tax on any market activity that generates negative externalities

References

- Acharya, V., V. (2009). A theory of systemic risk and design of prudential bank regulations. *Journal of Financial Stability*, 5(3), 224–255.
- Acharya, V., Pedersen, L. H., Philippon, T., & Richardson, M. P. (2010). *Measuring systemic risk*, AFA 2011 Denver Meeting paper, Available at SSRN, <http://dx.doi.org/10.2139/ssrn.1573171>.
- Acharya, V., Engle, R., & Richardson, M. (2012), Capital shortfall: A new approach to ranking and regulating systemic risks. *American Economic Review*, 102(3), 59–64.
- Adrian, T., & Brunnermeier, M. K. (2011). *CoVaR*, NBER Working Paper 17454. Cambridge, MA: National Bureau of Economic Research, Inc.
- Adrian, T., & Brunnermeier, M. (2016). *CoVaR*. *American Economic Review*, <https://doi.org/10.1108/JRF-11-2016-0141>.
- Allen, F., & Gale, D. (2000). Financial contagion. *The Journal of Political Economy*, 108 (1), 1–33.
- Altunbas, Y., Binici, M., & Gambacorta, L. (2017). Macroprudential policy and Risk. *Journal of International Money and Finance*, doi: <https://doi.org/10.1016/j.jimonfin.2017.11.012>
- Amini, H., Cont, R., & Minca, A. (2013). Resilience to contagion in financial networks. *Mathematical Finance*, 26 (2), 329–365.
- Anginer, D., Demirguc-Kunt, A., & Zhu, M. (2014). How does competition affect bank systemic risk? *Journal of Financial Intermediation*, 23(1), 1–26.
- Anwar, Y. (2012). Long Term Debt Financing - Issues and Challenges for Pakistan. *Institute of Business Management*, 5 March, 2012. Karachi, Pakistan.
- Arellano, M. & Bover, D. (1995). Another look at the instrumental variable estimation of error component models. *Journal of Econometrics*, 68, 29–51
- Avramidis, P., & Pasiouras, F. (2015). Calculating Systemic Risk Capital: A Factor Model Approach. *Journal of Financial Stability*, 16, 138–150.
- Balla, E., Ergen, I., & Migueis, M. (2014). Tail Dependence and Indicators of Systemic Risk for Large US Depositories. *Journal of Financial Stability*, 15, 195–209.
- Basel Committee on Banking Supervision. (2010), *Principles for enhancing corporate governance*. Basel, Switzerland: Bank for International Settlements.

- Beck, T., A. Demircuc-Kunt., & R. Levine, 2006, Bank concentration, competition, and crises: First results. *Journal of Banking and Finance*, 30(5), 1581-1603
- Bessler, W., Kurmann, P., & Nohel, T. (2015). Time-varying systemic and idiosyncratic risk exposures of US bank holding companies. *Journal of international financial markets, institutions and money*, 35, 45–68.
- Billio, M., Getmansky, M., Lo, A. W., & Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics*, 104(3), 535–559.
- Bisias, D., Flood, M., Lo, A. W., & Valavanis, S. (2012). A survey of systemic risk analytics. *Annual Review of Financial Economics*, 4(1), 255–296.
- Black, L., Correa, R., Huang, X., & Zhou, H (2016). The Systemic Risk of European Banks during the Financial and Sovereign Debt Crises, *Journal of Banking and Finance*, doi: <http://dx.doi.org/10.1016/j.jbankfin.2015.09.007>.
- Blancher, N., Mitra S., Morsy H., Otani A., Severo T., & Valderrama, L. (2013), *Systemic risk monitoring toolkit, a user guide*” IMF working paper WP/13/168. International Monetary Fund, Washington
- Blundell, R. & Bond, S. (1998). Initial conditions & moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87, 115-143.
- Brownlees, C. T., & Engle, R. F. (2012). *Volatility, correlation and tails for systemic risk measurement*, SSRN Scholarly Paper ID 1611229. Rochester, New York: Social Science Research Network.
- Brunnermeier, M.K., Dong, G. and Palia, D. (2012). *Banks' non-interest income and systemic risk*, Working Paper, Princeton University, Princeton, New Jersey.
- Bruyckere, D. V., Gerhardt, M., Schepens, G., & Vennet, V, R. (2013). Bank/sovereign risk spillovers in the European debt crisis. *Journal of Banking & Finance*, 37, 4793-4809.
- Castro, C., & Ferrari, S. (2014). Measuring and testing for the systemically important financial institutions. *Journal of Empirical Finance*, 25, 1–14.
- Chen, M., Wu, J., Jeon, N, B., & Wang, R. (2017). Monetary policy and bank risk-taking: Evidence from emerging economies. *Emerging markets Review*, doi: 10.1016/j.ememar.2017.04.001

- Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance*, 20, 249–272.
- Demsetz, R.S., Saidenberg, M., & Strahan, P.E. (1996). Banks with something to lose: the disciplinary role of Franchise value. *Economic Policy Review*, 2(1), 2-14.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74 (366), 427–431. doi:10.1080/01621459.1979.10482531
- Gang, J., & Qian, Z. (2015). China's monetary policy and systemic risk, *Emerging Markets Finance & Trade*, 51, 701–713.
- Hausman, J. A. (1978). Specification tests in econometric, *Econometrica*, 46(6), 1251–1271.
- Im, K. S., & Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115: 53–74.
- Kleinow, J., & Nell, T. (2015). Determinants of systemically important banks: the case of Europe. *Journal of Financial Economic Policy*, 7 (4), 446-476, <https://doi.org/10.1108/>.
- Kleinow, J., Horsch, A., & Molina, M. G. (2017). Factors driving systemic risk of banks in Latin America. *Journal of economics and Finance*, 41, 211–234.
- Laeven, L., Ratnovski, L., & Tong, H. (2015). Bank Size, Capital, and Systemic Risk: Some International Evidence, *Journal of Banking and Finance*, doi: <http://dx.doi.org/10.1016/j.jbankfin.2015.06.022>
- Lin, E., Sun, E., & Yu, M. (2016). Systemic risk, financial markets, and performance of financial institutions. *Financial Economics*, DOI 10.1007/s10479-016-2113-8.
- Mayordomo, S., Rodriguez-Moreno, M., & Pena, J.I. (2014). Derivatives holdings and systemic risk in the US banking sector. *Journal of Banking and Finance*, 45(8), 84-104.
- Pagano, M. S., & Sedunov, J. (2016). A Comprehensive Approach to Measuring the Relation Between Systemic Risk Exposure and Sovereign Debt, *Journal of Financial Stability*, <http://dx.doi.org/10.1016/j.jfs.2016.02.001>
- Phillips, P. C. B., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika*, 75 (2), 335–346. doi:10.1093/biomet/75.2.335
- Pikas, H. P., Lee, B. & Tenpao. (2003). The determinants of capital structure choice using linear models: high technology vs. traditional corporations. *Journal of Academy of Business and Economics*, 1(1), 720-727.

- Qin, X., & Zhu, X. (2015). Too non-traditional to fail? Determinants of systemic risk for BRICs banks, *Applied Economics letters*, 21(4), 261–264.
- Souza, R, S., Tabak, M, B., Silva, C, T., & Guerra, M, S. (2015). Insolvency and contagion in the Brazilian interbank market. *Physica*, 43, 140–151.
- Soedarmono, W., & Sitorus, D. (2017) Abnormal loan growth, credit information sharing and systemic risk in Asian banks. *Research in international business and finance*, DOI: <http://dx.doi.org/doi:10.1016/j.ribaf.2017.07.058>
- Stolbov, M. (2017). Assessing systemic risk and its determinants for advanced and major emerging economies: the case of ΔCoVaR . *International Economic Policy*, 14, 119–152.
- Strobl, S. (2016). Stand-alone vs systemic risk-taking of financial institutions. *The Journal of Risk Finance*, 17 (4), 374-389, <https://doi.org/10.1108/JRF-05-2016-0064>.
- Teplý, P. & Kvapilíková, I. (2017). Measuring Systemic Risk of US Banking Sector in Time-Frequency Domain. *North American Journal of Economics & Finance*, 42, 461-472.
- Weib, G.N., Bostandžić, D., & Neumann, S. (2014). What factors drive systemic risk during international financial crises? *Journal of Banking and Finance*, 41(4), 78-96.
- Yun, J., & Moon, H. (2014). Measuring systemic risk in the Korean banking sector via dynamic conditional correlation models. *Pacific Basin Finance Journal*, 27, 94-114.
- Zedda, S., & Cannas, G. (2017). Analysis of banks systemic risk contribution and contagion determinants through the leave-one-out approach. *Journal of Banking and Finance*, DOI: 10.1016/j.jbankfin.2017.06.008

Appendix A Table 5 Variable Formulation and Empirical Evidence

Variable	Measurements& Source	Empirical Evidence
Bank Level Determinants		
Size	$\frac{\text{Logarithm of Total Assets}}{\text{Bank of Pakistan}}$	Black et al. (2016)
Market Power	$\frac{\text{Market Capitalization}}{\text{Book value of common equity}}$	Weib et al.(2014)
Non-Perf loans	$\frac{\text{Loan Loss Provision}}{\text{Total Assets}}$	Kleinov et al. (2017)
Deposit Ratio	$\frac{\text{Deposit}}{\text{Total Assets}}$	Strobl (2016). State Bank of Pakistan
Country level		
Government Debt Ratio	$\frac{\text{Government Debt}}{\text{GDP}}$	Kleinov & Nell (2015), Kleinov et al. (2017)
Concentration		Anringer et al. (2014) Chen et al. (2017)
Regulatory Quality	Ability of government to develop and implement sound policies (World Wide Governance Indicators).	Kleinov and Nell (2015)

Note: The table provides definition and data sources of Firm, Sector and Country level variables.

Appendix B Table 6 Post estimation of Fixed Effect Regression

Test/ Diagnostic	Systemic
Hausman Specification	chi2= 61.73; p = 0.00
Wooldridge test for autocorrelation in panel data	F= 1.738; p = 0.1294
Pesaran's test of cross sectional dependence	Stat = 1.3916; p = 0.25

Note: The table provides results of post estimation for fixed/ random effect regression. Hausman Specification guides in choosing between fixed and random effect. P-value is less than 0.05, so fixed effect is used. Wooldridge test rejects the presence of serial correlation. Pesaran Test also rejects cross sectional dependence. Heteroskedasticity-robust Huber-White standard errors are used.