MACRO STRESS TESTING: PRELIMINARY EVIDENCE FOR PAKISTAN

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CERTIFICATE

This is to certify that this thesis entitled **"Macro Stress Testing: Preliminary Evidence for Pakistan"** submitted by **Ms. Shahina Ahmed** is accepted in its present form by the Department of Business Studies, Pakistan Institute of Development Economics (PIDE) Islamabad as satisfying the requirements for partial fulfillment of the Degree of Master of Philosophy in Economics and Finance.

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Abstract

This study focuses on macro stress testing in computing Pakistan banking sector's financial sustainability by addressing two important questions. Initially, the prospective measure of vulnerabilities in financial institutions of the country should be identified? Secondly the proper way of calculating vulnerability of the financial institutions especially banks to possible risks .To get the required answers we need to produce a framework that will explain Pakistan's Banks exposure of stress testing credit risk. For this, we will go with the factual analysis which acquires Vector autoregressive (VAR) viewpoint to determine the correlation between certain macroeconomic indicators and from that macroeconomic scenarios are developed. With an intention to evaluate correlation among macroeconomic indicators and forecasting future trends Vector Auto regressive (VAR) model has been applied. Macroeconomic variables utilized here are Industrial production (IP), real effective Exchange rate (REXCH), Discount rate (DR) and Inflation rate (INF). Data for each variable has been taken on monthly basis from 2006 to 2018 from IFS, State bank of Pakistan (SBP), International monetary fund (IMF).For the time series data which is easily deal by Vector autoregressive model unit root test and lag length criteria test check the stationary of the data.

Further, we develop Panel VAR to estimate the relationship between NPL and macroeconomic variables. Data used in this section consists of NPL non-performing loan and four macroeconomic indicators collected yearly from 2006 to 2018. As the available data is fully reported so we create balanced panel data then through capitalization we examined capital adequacy ratio of some banks. Results from the VAR model shows that Exchange rate is among those macroeconomic variable which is not affected by all other macroeconomic indicators but, it has strong impact on all

other variables. These are the approximate results as Pakistan's economy has not suffered from any global financial crisis yet. Therefore we supposed low and medium level risk for viewing the financial capacity of our financial markets and in this our banks. Whereas, Capital adequacy ratio calculated for thirteen banks of Pakistan exhibits that out of these thirteen banks nine banks need to enhance their capital capacity to withstand any shock in the economy.

Keywords:-VAR model, Stress test, NPL, credit risk, PVAR

Table of Contents

List of Tables

List of Figures

Chapter 1

1.1 Introduction

In recent years world has undergone a series of certain substantial changes in the financial sector The financial structure is complex, reasons for its complexity are the vulnerabilities associated with the financial sector, these include; credit risk, liquidity risk, and market risks (Chopra, 2009). On the parallel side, the information inquirers are striving for accurate information for valuing financial instruments, evaluating companies and maintaining soundness on macroeconomic indicators. A better understanding of the vulnerabilities and their measurements is very important to capture susceptibilities which ultimately increases the volatilities in the financial markets. Marco Stress testing has become a popular tool in financial institutions' risk management, an accurate way towards institutional stability in terms of price and monetary against various risks.

The complexity of the financial system results in the evolution of risk management. Stress Testing is a tool witnessed after East Asian Fiasco which gave an important part of risk management. Besides this, the mechanism of Stress Testing is accepted worldwide as the source of identifying risk and vulnerabilities in the financial system. According to the Sorge and Virolainen (2006) IMF and WB in 1999 introduced this technique as a significant component for the Financial Sector Assessment Program (FSAP).

Macro Stress Testing has been defined in the Bank for International Settlements (BIS) in 2000 as:

"*a generic term describing various techniques used by financial institutions to gauge their potential vulnerability to exceptional but plausible events".*

It has been observed that financial institutions adopted this technique to comprehend the behavior of financial risk system for about a couple of decades. Furthermore, in different parts of the world, this process is either done by central banks of that country or financial institutions themselves. The IMF's FSAP reported that multiple Stress testing were carried after various global financial crisis, e.g., the Federal Reserve System or Central Bank (2009a, 2009b) and European Banking supervisors (2010) for restoring confidence in the financial system during the crisis.

Macro Stress Testing can be a significant part of enhanced macro prudential guidelines that evaluate credibility, soundness, and susceptibility of the financial system. According to guidelines, the Basel[1] III[2] accord stressed more on the healthy Stress Testing perspectives than the Basel II[3]. Generally, the Basel accord is a set of prepositions regarding banking rules and regulations. Basel III is a worldwide supervisory agreement that initiated a group of changes for improving regulation and risk mitigations in banking sectors. Whereas Basel II is a worldwide business defined rules which are adopted by financial systems to retain cash requirements in any risk exposure. From the Central bank's viewpoint, Stress Testing is noteworthy since it is

[1]"The Basel Framework is the full set of standards of the Basel Committee on Banking Supervision (BCBS), which is the primary global standard setter for the prudential regulation of banks. In My 2009 this committee published some rules for this technique. As a result of GFC's some stress testing techniques were deduced to overcome the weaknesses. After that significance of this technique has been evolved. www.bis.org/publ/bcbs155.pdf

[2] Basel III is an internationally agreed set of measures developed by the Basel Committee on Banking Supervision in response to the financial crisis of 2007-09. The measures aim to strengthen the regulation, supervision and risk management of banks.

[3] Basel II framework, has an additional element with an aim to upgrade some rules related to capacity of financial institutions regarding various risks prevailing.

manageable and gives a practical point of reference to compute the vulnerability of financial institutions (Bunn et al (2005).

The importance of macro Stress Testing is an effective way of assessing sustainability of banking and financial system (Sorge, 2004). This is significant in case of the banking system where these tests are not only prudent tools rather, conventional supervisory methodologies are also adopted to estimate the vulnerability in different banking institutions (Marcelo et al., (2008). It is evident that banks are engaged in complex and multiple financial activities of the economy which play an intermediary role in the financial system. Therefore, they are the precondition for continuous economic growth, an inconsistency in the banking sector will prove to be too costly for the real economy and lead to multiple global financial crises (Tagkalakis, 2013; Aboody et al., 2014).

By keeping in view, the dominant role of banking in the conventional and country-level financial management system and the consistent risk, macro Stress Testing focuses mainly on the "banking system", in both authoritative terms and individualistic studies.

The study forecasted the following essentials: initially, this becomes clear that Stress Testing is an important component of the banking "risk management" system besides many other financial and non-financial institutions. Secondly, stress testing results are incorporated by creating an association between multiple market shocks and bank responses. Interestingly, Pakistan is at an embryonic stage regarding these tests as Pakistan never faced any drastic financial shocks till now. Therefore this analysis will contribute to understanding the significant market economy.

There are multiple kinds of risks which can be covered under the umbrella of macro stress testing but major part of financial markets especially banks deal in credit. Therefore our main focus in this paper is credit risk as we are taking data of twenty six

different banks of Pakistan. Reason behind taking this number of data is the availability of monthly and yearly data.

As research has done across the globe on application and enhancement of macro stress testing. Instead of the documented application of this testing in computing the robustness and soundness of financial systems and addressing crisis impacts, the practical implication of analysis for the financial system in Pakistan is very limited. This is because till now Pakistan's economy has not undergone any global financial crisis and macro stress testing worldwide has done for major risks. Now to deal small and medium level risks in Pakistan we will be taking approximate results and our results would differ from other researches.

1.2 Problem Statement

Financial Stability Review (FSR) released by the State Bank on 7th July 2017 for the CY2016 shows that Pakistan's banking system remains, in general, in a stable and sound condition. However, some emerging risks in short- to medium-term needs attention and should be closely monitored by the central bank. So we will apply macro stress testing tools to our financial institutions particularly the banking sector of Pakistan to check the robustness of banking sector towards such shocks.

1.3 Research Question

(i) What would be the prospective measure of risk in Pakistan's banking system should be identified?

(ii) Secondly what should be the proper way of calculating the vulnerability of the financial institutions especially banks to possible risk?

(iii) What would be the prospective measure of vulnerabilities associated to credit in the financial institutions especially banks of Pakistan?

1.4 Research Objectives

To find out the number of macroeconomic indicators having the capacity to explain credit vulnerabilities in Pakistan's banks and developing an explanatory quantitative model.

The first objective of this study is to assess stress testing in Pakistan's financial institutions particularly the banking sector. To meet these objective we will estimate the credit risk in the banking system.

1.5 Organization of the Study

Thesis has been organized into five chapters, the first chapter is introduction of the title the scope of the study, problem statement, research question and objectives of the study. The second chapter will discuss the review of the literature on the relevant studies while the third chapter will explain the data and methodology. Fourth chapter discusses the results and fifth concludes thesis work.

Chapter 2

2.1 Literature review

Despite the fact it has been observing that multiples studies are discussing stress testing, and their main focus is on a particular loan portfolio and a structure of credit in different financial institutions .Beside this, the line of dealing this specific stress testing is based on the organizational viewpoint that stresses on a broader scope. International Monetary Fund (IMF) is one of pragmatic example in this case. Stress testing has been originated in the year 1990 as a range of techniques adopted in various financial systems to evaluate vulnerability to maximum hazards. In the past 15 years these tests have transformed into the device used by financial institutions from one of the risk managing tool to become a central element of the policymaking toolbox. However, now in recent years the sensitivity and sophistication of these tests have considerably changed and still there are certain areas where enough space for improvements is needed to support their use in policymaking for micro prudential and macro prudential objectives.

Vector auto regression is a stochastic process used to capture the linear interdependencies among multiple time series. VAR models generalize the univariate autoregressive model by allowing for more than one evolving variable. The methodology proposed by Wilson (1997a, 1997b and 1998) which involves modeling of default probabilities as a nonlinear function of macro-economic variables.

Noticeably, Kimmo Virolainen (2004) identified industrial interaction and macro stress testing which has been done by exploring the transmission of disturbances in various elements of different sectors. We can conclude that stress testing cannot be limited to banking sector rather can be applied to other institutions like insurance and pension

companies.

Elsinger et al., (2002) devise a methodology to estimate the credit risk and market risk on the banking sector particularly for the Austrian Banks. Not only this the particular downturn also effects the other contagion banking system. This model thus decomposes the bank defaults into those indicators that appear directly and those that are a result of contagion. Beside this the combine probability distribution of various indicators like risk premium, currency risk and investment fluctuations determine the relationship between banks' financial positions and the macro economy. As it is evident from the paper that shocks of various nature shocks do effect the Austrian Interbank positions and the stability of the individual banks which decline with a change in a series of macroeconomic factors. Stress testing is contagious in nature it can effect various institutions which are linked according to their line of work.

Macro stress testing itself starts with identifying vulnerabilities, following that comes constructing scenarios, interpreting results and analyzing its impact on Balance sheet Jones et al., (2004). In this paper thorough methodology of the macro stress has been discussed which starts with identifying vulnerabilities ,constructing scenarios and mapping the data on banks' balance sheets and interpreting results. Stress testing follows some procedure starting from identification and ended with its impact.

Pesaran et al., (2004) applied VAR.There are number of variables which can be incorporated in VAR to easily compute effects of macroeconomic variables on different firms (PD) probabilities of default. VAR incorporate many variables, some of them are Gross Domestic Product, consumer prices indexes, monetary resource, stock prices, currency rates and percentage increase in money for approximately some specific countries as the data taken for estimation .Vector Autoregressive model is employed as

a key for various firms' return on equity which is later associated to the per risk annual loss of certain loan portfolio which are corporate in nature. This approach benefits in connecting the non-payments of debts to the whole lender owns portfolios. Through a comprehensive example that authorizes dissimilarities in nations and regions. Commonly VAR is the model used in majority of macro stress testing techniques.

Macro Stress testing has been done by financial institutions to determine susceptibilities in various sectors and analyze specific hazards relevant to financial institutions. It has been done in a top-down approach or bottom-up approach as well. Sorge and Virolainen (2006) supported their literature through an analytical frameworks to test and practically use certain designs in case of Finland banks. Jones et al., (2004) and Sorge (2004) Boss et al., (2006) present a new perspective on this by testing Austrian central banks. The main purpose behind this is thorough explanation of default rates with the help of macroeconomic risk. The two main approaches adopted worldwide for macro stress testing are top sown approach and bottom up approach.

Following that Wong et al., (2006)did a detailed ,comprehensive and advance macro-economic stress testing .Initially a framework is developed to assess vulnerability and later on analyzed the banks' various risk exposures towards mortgages and loan portfolio by using VAR model. Macro stress testing needs a proper framework for its workout.

Study of Van den et al., (2006) showed the results of stress test on Dutch Central Banks by using multivariate scenario analysis which can be both (deterministic and stochastic in nature. Then design logistic functions for computing likelihood that borrower is not able to pay. Later loss of share of an assets when borrower defaults and compute credit

risk or interest rate risk. Some researches follow sensitivity analysis as the tool to capture the vulnerabilities in financial system.

Commonly, it's difficult to find the data of extreme stress events. Novice technological changes in financial markets also bring issues of data limitation. Still, Stress testing outlines compensate hypothetical scenarios. In order to overcome the data availability constraint Cihak (2007) documents various suppositions to test the models, whereas Drehmann (2008) suggests usage of various econometric approaches. Conversely, Ong et al., (2010) recommend a reverse test method to remove data constraints. Stress testing is not always done on the historical data rather some countries also go for hypothetical analysis.

The conventional outcome metrics are losses on the portfolio, capital to risk asset ratio which is called (solvency ST), asset quality and market liquidity indicators. (Sorge and Virolainen, 2006).

Chines banking sector studied by sparser Xu and Liu (2008) analyzed multiple testing perspectives. Their emphasis is on utilizing this technique to compute the robustness and sustainability of the financial scenario through logit model. Ren and Sun (2007) calculated credit risk in the banking industry particularly. While, Chen and Wu (2004) examine risk of Chines s banks in the years 1978-2000. Finally it is proposed that macroeconomic policies played its crucial role in impacting financial institutions like banks resilience through macroeconomic dynamics. Macro stress testing is considered to be a tool to check the robustness of financial institutions.

Elsinger et al, (2006) recommend a model to incorporate important risk sources like (credit risk, market risk, interest rate, liquidity risk,) which combine risk management

technique with a network model of interbank loans. Stress testing can cover more than one risk in its estimations.

One of an important example is Cihak's (2007). This study specifically highlighted various stress testing tools which are modified through various assumptions. Whereas, their structural granularities are used in IMF Financial sector assessment program (FASP) across the world. There are certain procedures and estimations in it which have been followed during this test in financial institutions. Stress testing is one of the technique of IMF under its program financial sector assessment program.

Boss et al ., (2008) gave an extension to this model by combining future income vulnerability and risk from cross border exposure and compensating three year prediction time period. This study highlights one of the aspect of stress testing that it can examine the future income susceptibilities in financial markets.

A detailed literature has estimated the impact of macro stress testing which is done by supervisory bodies in various financial institutions. The emergence of stress test is followed by the financial crisis and financial regulators then assist in designing scenarios and predicting its outcomes and their implementation (BIS (2009); Fed (2009).

Global Financial crisis has displayed severe inadequacies in conventional risk mitigating models. Huang et al., (2009) and Aizenman et al.,(2012) underline the requirements for uncertainty controlling arrangements and rectifications necessary for mitigating dimensions which predict probable risk exposures. Because of this stress tests measure the worse vulnerabilities and scenario analysis which measure multiple risks.

Schimieder et al., (2011) which is a vast, thorough and new academic work to be utilized by Inter monetary fund and many national jurisdictions. Methodology suggested in this study is dynamic in nature because these procedures are considered as a cut off points for further analysis. These cut of points and analysis explain the relationship of financial indicators, various components and vulnerable factors in country wide financial management. For various data granularities this study provides an excel stress testing tool which can be accommodated in banks with huge suppositions. This tool helps in deep and sensitive calculations and used widely by financial sector Assessment program.

Generally, satellite models consist of a credit risk model and its outline includes a broader set of assets groups and vulnerability. Initial models mainly restraint stress testing to "first-round effect "analysis (which ranges from macroeconomic to financial indicator and this methodology is recently adopted by EU (E.B.A., 2011). Now advanced methodology is "second-round effect "which is developed through the endogenous behavior of financial participants. (IMF, 2012a; Drehmann, 2008).This study gives some enhanced models of stress testing which are restricted in previous models of stress testing.

Schmieder et al., (2012) studied liquidity testing which can be a part of stress testing and through this he develops relationship between solvency and liquidity through an excel tool. The paper also gives testing related to liquidity and their implementation in a popular excel tool. Beside this multiple academic work exist with various school of thoughts having common objectives.

Jakubik and Fungaova's (2012) paper is a true explanation for studying, designing of macroeconomic variables and macro stress testing, specifically for top down approach

.This study comprises thorough framework for analysis which is commonly taken for depicting the flexibility mainly in Russian banking industry for different scenarios. So this can be basic in an approach which is called as a top down approach. This procedure is pragmatic beneficial, or motivating. Various countries and financial institutions follows different approaches according to their economy and data availability.

Initially, the macro-economic models computes the influence of exogenous indicator on the overall economy. As this macroeconomic model doesn't consider financial variables therefore, the macro-economic outcome is used as an input in the satellite/auxiliary model. The satellite model creates a link between macro-economic indicators to financial vulnerability estimation (Borio et al, 2012; Foglia, 2009).

Another important study conducted by Schmieder et al., (2011) stated that macro stress testing has great contribution towards current financial stability analysis. Which capture spillover effects and other types of contagion and ultimately determine macro-financial stress at the bank level. This study also shed light on the potential impact of spillover effects on bank-level solvency and liquidity. Spillover effect is one of the major component of stres testing technique.

According to Borio et al., (2012) stress test can be done at micro and macro level and is consist of four elements, Exposure of risk related to stress, scenarios explaining the shocks, models plotting the Shock and estimation of outcome. Main objective of this analysis is to calculate the shock impacts which ultimately effect the economic sustainability. Therefore outcome of this are three fold because it doesn't only contribute in internal control rather deal in risk management which give a base to smoothly cover the methodology and maintaining stability of financial institutions.

Stress testing is not used to inquire about vulnerabilities rather is considered as risk management tool.

On the other side, lengthy-time period can create unpredictability as stress testing is not a prognostication technique, therefore, the decision should be taken according to the dynamics of the circumstance (IMF, 2012a). Usually, the time horizon is taken shorter for a financial system where changes occur rapidly. Like under FSAP one to three-year time horizon is taken for a less mature banking system especially, in emerging markets (IMF, 2012a a).Stress testing is not a procrastination tool.

Borio et al (2012) proposed a basic stress testing structure and an illustrative outline. Conditioned to stress testing a set of risk exposure is also defined. The macroeconomic scenario which elaborates and compute stress events. The model which outline the influence of shocks on results .The measure of outcome which estimate shocks has a great influence on financial institutions' balance sheet.

Iskender (2014) also studied on Turkish Banks and according to him the important part of this analysis is always risk which is related to the failure in the payments of debts. Therefore, his emphasis is on one factor change analysis which is called as sensitivity analysis. Whereas stress testing is the measure of vulnerability occur due to worse or multiple variable change in economy. This paper further explained the rational application and stress testing procedures with complete theory on Credit risk .For estimation, VAR models are used which ultimately depends on macro-economic scenario. At the end outcomes are considered as the effects of capital adequacy ratio. This study is done through sensitivity analysis instead of scenario analysis.

Another paper by Basarir and Toraman (2014) discusses the major tools for financial stability analysis and also declares macro stress testing as an approach for determining

the capital adequacy level of financial institutions in the various developing countries.

Schuermann (2014) explained that stress testing has been brought about changes in monoculture models that institution needs to accommodate in balance sheet to clear the stress testing in various financial institutions.

Ján Klacso (2014) described this testing design for the National Bank of Slovakia to identify the capacity of the bank of Slovakia .Moreover the important risks for this banking sector is credit risk originating from the portfolio of corporate loans. Whereas market risks including FX and equity risk, which play an insignificant role for the sectors so the outcomes disclosed that bank of Slovakia kept its robustness in every sort of stress scenarios. Two key factors playing role in maintaining robustness are the good current capital position of the banks and the capacity to produce interest income even in stressed period. Stress testing plays significant role in maintaining capacity of financial institutions.

Shahhosseini (2015) highlighted various ways of stress testing multiple financial institutions. Especially in US, bank regulators enhanced financial assets either through reorganizing and eliminating bad loans out of their statement of assets to go through this analysis tests smoothly. Further banks adjust balance sheets to respond the stress tests so that these modifications communicates well to the economy. Major outcomes of stress testing are visible on bank balance sheets mostly.

Onder et al .,(2016) studied CAR in various banks of Turkey under various scenarios and carried out stress testing through top down approach and in this framework carried the macro stress testing for banks.

Bird et al., (2016) depicted the actual impact of regulatory biasness on banks behavior for this he developed a model which is Comprehensive Capital Analysis and Review

(CCAR). This model is mostly concerned with stress tests which follow the supervisory capital assessment programs. Moreover, focus of these estimations are on the practical aspect of initial tests against financial crisis. Under stress testing a model id devised which is CCAR.

Moreover, another paper Tijmen et al .,(2017) suggest this test as a technique to quantify financial strength assessments, challenging calculations which financial institutions provide in supervisory stress tests and to support the link between macro risk assessment and micro-prudential actions.

An important study by Izhar Muhammad (2017) highlights the significance of financial stability. He took the data of eighteen biggest banks of Pakistan and India and estimate the stability of all these bank in the period from 1998-2014 .Moreover his findings also encompasses the overall stability of banking sector in the above mentioned time period for both countries. Financial stability in various time period is estimated for various banks of India and Pakistan.

Eber and Minoiu (2017) studied banks in Europe which are undergone through stress testing. They find a framework and discovered that banks decreases their assets for adding capital ratio to their banks .An opposite case is with banks which are weak they shrink their credit supply.

Chapter 3

3.1 Theoretical Framework

Credit risk is a significant part of macro Stress testing. Wilson (1997 a, b) for the first time introduced an approach for credit Risk modelling. This model is amongst the few models which created linkage between macroeconomic indicators and default risk and is based on parsimonious logistic function with a great usage in regression analysis. Logistic function explains the data and relationship between a binary dependent variable and an independent variable. So the empirical evidence showed that the nonlinear logistic function is preferable in the models over linear functions. The perception is to model a linkage between default rate and macroeconomic factors. Ultimately when model is fitted, to imitate the progress of default rates over time by creating various shocks in the financial system.

Boss (2002) and Virolainen (2004) followed the model given by Wilson. Whereas Boss (2002) and Boss et al., (2009) used this model for Austrian financial institution (where they assessed the insolvency rates at corporate, household and industrial level). Sorge and Virolainen (2006) applied this model to compute the liquidation rate at industry level for corporate sector.

In a broader terms, credit risk models follow some steps which are, initially credit risk is assessed then is articulated by defining the dependency of default rate on macro-economic variables. Furthermore, imitating the future losses according to various economic circumstances.

3.2 Specific Model

Drehmann (2005) documented that the various models used in stress testing varies with respect of sophistication and risks involved. Inspite of sound addition to ST we did not find any unanimity on a single tool and any specific method to use. As an outcome of this multiple procedures came into consideration, among these are Wilson (1997a, 1997b), Virolainen (2004) etc. Regardless of all disparities, they proposed a linear linkage between the macroeconomic indicators and the possibility of default on the bank's loan portfolio.

One of the common methodology for estimating credit risk is (top down, reduced form model) methodology which has been derived from the one presented by Wilson (1998).Another framework which has been widely used by international institutions was introduced by Merton (1974).Sorge and Virolainen (2006) document that Wilson (1998) approaches are adaptive and perceptive .Whereas, Merton (1974) model has considered to be of a great benefit for advance way of looking into the risks arises from equity and for credit risk evaluation. Though, there are some firm level theory and stress testing practices which involve some suppositions that this model is not always applicable. Practically this model is used to stress test especially banks for a corporate sector credit portfolio but has limitations in assessing small enterprises portfolio (Mckinsey, 2009).

3.3 Data and Methodology

In this chapter we will explain specific model, model simulation, stress testing, credit risk variables selection and macroeconomic variables selection. We are using some bank specific variables and some macroeconomic variables. Macroeconomic indicators

are Industrial production, real effective exchange rate, Inflation rate and Discount rate. For the first part of VAR analysis data is taken on monthly basis from 2006 to 2018.Sources of data are IFS, State bank Of Pakistan (SBP) and IMF. We take monthly data of four economic indicators which are Industrial production, real effective exchange rate, inflation rate and discount rate. While for the second part Panel VAR estimation we take annual data of the above mentioned macroeconomic variables and one bank specific variable which is Non-performing loan (NPL).Annual data has been taken from 2006 to 2018. As the annual data of macroeconomic variables are same for all the banks therefore we have manipulated this data so that we could perform panel VAR which is otherwise not possible. For Panel VAR 351 observations of each variable are taken for twenty six different banks of Pakistan. Sample banks are the following UBL, HBL.ABL, MBL, Bank of Khyber, Silk Bank, NBP Al Habib Bank, Alfalah, Askari bank, Standard Chartered, MCB, HMB, Citibank, Bank of Punjab, Sindh bank, Dutesche Bank, First women bank, Bank Islami, Albarakah , Samba Bank, Summit bank, Dubai Islamic bank, JS bank, Faysal bank, Soneri Bank, and Meezan Bank. Sources of data is State bank Of Pakistan (SBP) and IMF.

Finally, for stress testing credit risk of Pakistan we take thirteen different banks of Pakistan. Among them are UBL, HBL.ABL, MBL, Bank of Khyber, Silk Bank, NBP Al Habib Bank, Alfalah, Askari bank, Standard Chartered, MCB, and HMB. Capital adequacy ratio of these banks are calculated and compared with the given ratio by State bank of Pakistan for one particular Year of 2018. Sources of data is State bank Of Pakistan (SBP) and IMF.

3.4 Macroeconomic variables selection

The variables we will be using throughout the model with their detail explanation are the following Industrial production, Real Effective exchange rate, Interest rate, and discount rate.

Industrial production is a macroeconomic index which measures industrial output of an economy. It has been calculated on monthly basis which estimate the real output of different sectors. This variable is assumed to have a negative relationship with non-performing loan.

Inflation rate is defined as hike in the prices due to which purchasing capacity of individual's decreases. A positive change in inflation decreases the overall worth of individual and firms and in return repayment capacity of borrowers lowers

Real effective Exchange rate is defined as the measures of change of domestic currency in terms of index of other major foreign currencies by considering the purchasing power of the competing countries' currencies. This estimates the nationwide improvement in competitiveness and assists in increasing credit quality of banks in particular.

Discount rate is defined as charge on banks and financial institutions by central bank against loans they have taken. Positive correlation is assumed because with the increase in interest rate cost of high quality loan will increase. Which in turn will lead the non-performing loans to increase in account for low quality loans.

3.5 Credit risk variable selection

In the above mentioned framework, we opt a macroeconomic scheme to calculate the linkage among economic indicators and the non-performing loan ratio (NPLR) of banking structure integumenting any quarterly period.

By considering three important dependent variables which have been discussed widely in previous research, are probability of default (PD), corporate expected default frequencies (EDF), and NPLR. **NPL** (Non-performing loan) because of its significant importance in the estimation of credit risk and its influence on banks profitability. NPL are loans which remain unsettled for more than 90 days. One of the advantage of these loan is wide usage in the stress testing technique and credit risk studies. Whereas, disadvantage attached with this indicator is its influence by write-offs and are easily affected by the evolution in credit portfolio whether is related to credit risk or not.

There are multiples studies which declared NPL as the most significant indicator which estimate default rate of credit ventures of financial institutions. The studies included are Hoggarth, Sorensen and Zicchino (2005), Vazquez, Tabak and Souto (2012), Festic, Kavkler and Repina (2011) and Mannasoo and Mayes (2009).NPL and lower quality of debt has indirect relationship. By considering these we choose NPL (non-performing loan) as dependent variable of our model.

Second dependent variable will be default rate which is defined as number of borrowers who do not pay their obligations to total number of borrowers. This indicator has an important advantage of the records with the central bank of a country about number of borrowers and loans matured and delayed more than 90 days. While, its disadvantage is it is not easily available.

3.6 Macroeconomic Model

We will be using vector autoregressive model to perform the multivariate shock scenario and the model will be using in the following form

$$macro_t = A1macro_{t-1} + \cdots + A_P macro_{t-p} + CD_t + \upsilon_t \qquad (3.1)$$

Where $macro_t$ = (IP, DR, INF, REXCH) is variable which is determine from within the model.D_T is an inevitable part of equation and υ_t is an unobservable white noise. Then model will be estimated, following that correlation between macroeconomic variables will be established and use in the forecast of macro model.

3.7 Panel VAR

The appropriate model for estimation when using banking specific variable is panel VAR model. This package was first used and presented by love and Zicchino (2002).This approach allows us to get benefit from both the advantages of VAR approach and panel data technique. As VAR address endogeneity in the model by allowing endogenous interaction between variable. The usual form of modeling is the following

$$Y_{i_t} = \alpha_{i_t} + \sum_{p=1}^{m} \beta_{i_t} Y_{i_t-k} + f_i + \mu_{i_t} \qquad (3.2)$$

Y_{i_t} Is a vector of specific variable, time t and μ_{i_t} is a disturbance factor. Whereas, f_i shows the fixed effect to allow the heterogeneity in some of the banks.

$$Y_{i_t} = NPL_{i_t}, IP_{it}, INF_{it}, DR_{it} \qquad (3.3)$$

The empirical model can be specified as

$$NPL_{i_t} = \alpha + \sum_{p=1}^{m} \alpha_{1_p} NPL_{i_{t-p}} + \sum_{p=1}^{m} \alpha_{2_p} IP_{i_{-t}} + \sum_{p=1}^{m} \alpha_{3_p} INF_{it-p} +$$

$$+ \sum_{p=1}^{m} \alpha_{4_p} REXC_{it-p} + \sum_{p=1}^{m} \alpha_{5_p} DR_{it-p} + \mu_{i_t} \qquad (3.4)$$

Where NPL_{i_t}non-performing loan which depends on its own lag, the lag of Industrial production, real effective exchange rate inflation rate and discount rate. In the same manner we model other variables as well

$$IP_{it} = \alpha + \sum_{p=1}^{m} \alpha_{1_p} NPL_{i_t-p} + \sum_{p=1}^{m} \alpha_{2_p} IP_{it-p} + \sum_{p=1}^{m} \alpha_{3_p} INF_{it-p} +$$

$$\sum_{p=1}^{m} \alpha_{4_p} REXC_{it-p} + \sum_{p=1}^{m} \alpha_{5_p} DR_{it-p} + \mu_{i_t} \qquad (3.5)$$

$$INF_{it} = \alpha + \sum_{p=1}^{m} \alpha_{1_p} NPL_{i_{t-p}} + \sum_{p=1}^{m} \alpha_{2_p} IP_{it-p} + \sum_{p=1}^{m} \alpha_{3_p} INF_{it-p} +$$

$$\sum_{p=1}^{m} \alpha_{4_p} REXC_{it-p} + \sum_{p=1}^{m} \alpha_{5_p} DR_{it-p} + \mu_{i_t} \qquad (3.6)$$

$$REXC_{it} = \alpha + \sum_{p=1}^{m} \alpha_{1_p} NPL_{i_{t-p}} + \sum_{p=1}^{m} \alpha_{2_p} IP_{it-p} + \sum_{p=1}^{m} \alpha_{3_p} INF_{it-p} +$$

$$\sum_{p=1}^{m} \alpha_{4_p} REXC_{it-p} + \sum_{p=1}^{m} \alpha_{5_p} DR_{it-p} + \mu_{i_t} \qquad (3.7)$$

$$DR_{it} = \alpha + \sum_{p=1}^{m} \alpha_{1_p} NPL_{i_{t-p}} + \sum_{p=1}^{m} \alpha_{2_p} IP_{it-p} + \sum_{p=1}^{m} \alpha_{3_p} INF_{it-p} +$$

$$\sum_{p=1}^{m} \alpha_{4_p} REXC_{it-p} + \sum_{p=1}^{m} \alpha_{5_p} DR_{it-p} + \mu_{i_t} \qquad (3.8)$$

The properties of the structural PVAR model are typically summarized using impulse response function granger causality test and decomposition of error variance forecasts. Granger causality test uses to predict future values of one variable using the past values of another variable.

The impulse response function explains the reaction of the dependent variable in the VAR system to shocks in the error term μ_{i_t}.The impulse response function is derived from the estimated VAR parameters and their standard errors, so it's necessary to estimate the confidence interval to get the impulse response function.

The forecast error variance decomposition shows how much information each variable contributes to the other variable in the PVAR model. It indicates how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables over time .It determines the severity of the total effect and provides the upcoming trends of variables when there is a shock in the economy.

Chapter 4

4.1 Empirical results and discussions

4.1.1 Macroeconomic Variables and credit risk

Macroeconomic variables have a great influence on credit risk in all commercial banks and this has been under discussion on a wide range. Few macroeconomic indicators listed below have a huge dominance on credit risk.

Inflation rate is an indicator which influence credit risk. Casto (2013) summarizes that inflation impacts positively on credit vulnerability. When inflation rate spikes, RIR which is cost of borrowing decreases by declining the individuals paying capacity which ultimately raises the credit risk. On the other hand when inflation inflates, individuals have to spend more money on their essentials, which influence credit risk negatively (Mkukwana, 2013).

Exchange rate which has direct impact on trade of an economy also effect credit risk. Variations in exchange rate is a significant source of growth and macroeconomic permanence (Zameer & Siddiqi, 2010).Bozovic, Urosevic and Zivkovic (2009) these research indicates that foreign currency escalation opposes to domestic currency enhances the burden on foreign borrowers cost of borrowings and as a result increases credit risk. Hoggarth et al. (2005) finds the effectiveness of REXCH through a change in RIR and INF .He analyzed the foreign currency spikes, importing cost and inflation rate raises which burdened the cost on borrowers and credit risk increases.

Industrial production is a macroeconomic index which estimate the real output of different sectors. This variable is assumed to have a negative relationship with non-performing loan.

Discount rate is charged on banks and financial institutions by central bank against loans they have taken. Positive correlation is assumed because with the increase in interest rate cost of high quality loan will increase. Which in turn will lead the non-performing loans to increase in account for low quality loan.

Table 4. 1: An overview of Macroeconomic indicators used in earlier research

Authors	**Geographical location**	**Macro variables**
Oanh et al. ,(2017)	Vietnam	Real GDP growth rate, INF,REXCH, ITR
Bunn et al., (2005)	United kingdom	ITR, INF, REXCH, GDP
Virolainen (2004)	Finland	GDP growth, ITR, EXCH
Bo Jiang et al.(2014)	China	GDP growth, INF, ITR,EXCH

By keeping in view the credit risk conditions for the case of Pakistan, we are taking four significant factors which are Industrial production a proxy for real GDP growth rate, Inflation rate calculated from consumer price index, real effective exchange rate and Discount rate.

Table 4. 2: List of variables

Macroeconomic variables	**Description**
NPLR	Non-performing loans
IP	Industrial production
REXCH	Real effective exchange rate
INF	Inflation rate
DR	Discount rate

In multiple studies addressing ST technique, different economic variables are taken as independent variable.Figlewski et al., (2012) pointed out three kinds of variables influence the soundness of financial particularly banking system, comprises (1) determinants exhibiting conventional economic state including inflation rate of an economy (ii) determinants showing features of an economy like GDP growth rate (iii) determinants showing financial condition like interest rate

Table 4. 3: Summary Statistics for VAR variables

Variables	**Observations**	**Mean**	**SD**	**Mini**	**Maxi**
IP	138	129.237	1.492388	106.37	184.67
DR	138	10.06884	0.236096	6.25	15
INF	138	3.726083	0.183323	0.571221	9.805385
REXCH	138	106.2569	0.728735	92.4815	124.7919

The above mentioned descriptive statistics describe the various features of data we are using in our model. As we are running simple VAR for macroeconomic variables to check the correlation between the macroeconomic indicators. The total observation for all variables are 138.Beside the sample size descriptive statistics also summarizes the central point which is mean and the variance of the sample which is standard deviation. Furthermore the minimum and maximum values are also explained for the above sample of macroeconomic determinants. Central point for various indicators are 106.2569 for real effective exchange rate, 3.726083 for Inflation rate, 10.06884 for Discount rate and 129.237 for Industrial production. In the same way standard deviation, minima and maxima for all variables is also listed.

4.2 Stress Testing (ST): Empirical Implementation in Pakistan

4.2.1 Economic Variables estimation model

In case of dickey fuller test there may create a problem of autocorrelation .To deal with autocorrelation augmented dickey fuller test (ADF) has been developed.

(i) $\Delta Y_t = B1 + ZY_{t-1} + \partial_i + e_t$ Intercept only

(ii) $\Delta Y_t = B1 + B2_t + ZY_{t-1} + \partial_i + e_t$ Intercept and trend

(iii) $\Delta y_t = \partial_i + e_t$ No intercept and trend

Null hypothesis: Variable is not stationary and got unit root

Alternate hypothesis: Variable is stationary

When p value is less than 0.05 we reject null hypothesis meaning that variable is stationary.

When p value is more than 0.005 we cannot reject null hypothesis meaning that variable is not stationary and got unit root.

Table 4. 4: ADF unit root test

Macroeconomic Variable	t- statistics	Results for unit root test
IP	2.383019	IP~I(0)
REXCH	-8.966605	EXCH~I(1), DEXCH
INF	-6.632778	INF~I(1), DINF
DR	-6.083891	DR~I(1), DDR

Results of augmented Dickey fuller test (ADF) with first difference and intercept for checking stationary suggests that Industrial production (IP) is stationary and is I (0) at level. Whereas EXCH, INF and DR were I (1) at level and become stationary after taking first difference and intercept.

Table 4. 5: Lag length Criteria Tests

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1390.566	NA	24424.80	21.45486	21.54309	21.49071
1	-781.0814	1172.086	2.645800	12.32433	12.76549*	12.50359*
2	-758.2527	42.49664*	2.383692*	12.21927*	13.01336	12.54194
3	-750.3551	14.21554	2.704994	12.34393	13.49094	12.81000
4	-740.3995	17.30753	2.978536	12.43691	13.93686	13.04639
5	-726.561	23.20598	3.095910	12.47017	14.32304	13.22305
6	-711.9063	23.67299	3.185968	12.49087	14.69666	13.38716
7	-705.1556	10.48962	3.714240	12.63316	15.19189	13.67286

Where ***** indicates the best lag order fulfilling the criteria

LR: Sequential lag order selected by the criterion (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-quinn information criterion

Through information criteria computation we select the lag order to check the goodness of fit of our respective model. For this lag order in our VAR model we focused on (AIC), (HQ) and (SC) and we choose that lag where all the tests are pointing and all three criterion suggests lag a two lag period length. In this case all the three criterions suggests lag order 2 as appropriate.

4.2.2 Results from VAR model

With an intention to evaluate correlation among macroeconomic indicators and forecasting future trends Vector Auto regressive (VAR) model has been applied. Macroeconomic variables utilized here are Industrial production (IP), Real Effective Exchange rate (REXCH), Discount rate (DR) and Inflation rate (INF). Data for each variable has been taken on monthly basis from 2006 to 2018 from IFS, State bank of Pakistan (SBP), International monetary fund (IMF).For the time series data which is easily deal by Vector autoregressive model unit root test and lag length criteria test check the stationarity of the data.

The framework we adopted for VAR model is flexible enough. So we assume that banks susceptibility is influenced by common economic occurrences. An effect called feedback effect permit stress testing in banks which on the other hand effect macro economy. In VAR model variable ordering matters a lot and are organized regarding

their reaction speed towards particular innovation or newness. Whereas, this variable arrangement is not necessarily done in simple regression model.

Therefore, variables associated to business cycle are placed after NPL like, Inflation rate, GDP growth and in our case Industrial production IP is related to business cycle. Whereas, Discount rate and REXCH are arranged at the end of the Vector autoregressive model.

Table 4. 6: Results from VAR Model

	IP	INF	DR	EXCH
IP(-1)	0.706589	-0.002936	0.000944	0.001547
	(0.08817)	(0.00509)	(0.00394)	(0.01839)
	[8.01371]	[-0.57725]	[0.23967]	[0.08415]
IP(-2)	0.008639	0.002283	0.000645	0.003195
	(0.08695)	(0.00502)	(0.00388)	(0.01813)
	[0.09935]	[0.45512]	[0.16617]	[0.17618]
INF(-1)	-0.927499	1.181639	0.339526	-0.869125
	(1.49121)	(0.08601)	(0.06659)	(0.31100)
	[-0.62198]	[13.7382]	[5.09876]	[-2.79465]
INF(-2)	0.610857	-0.220971	-0.175640	0.755577
	(1.63176)	(0.09412)	(0.07287)	(0.34031)
	[0.37435]	[-2.34780]	[-2.41043]	[2.22027]
DR(-1)	1.202166	0.139733	0.654058	0.441967
	(1.89275)	(0.10917)	(0.08452)	(0.39474)
	[0.63514]	[1.27993]	[7.73839]	[1.11964]
DR(-2)	-1.745171	-0.194700	0.208405	-0.485778
	(1.70753)	(0.09849)	(0.07625)	(0.35611)
	[-1.02204]	[-1.97688]	[2.73318]	[-1.36412]
EXCH(-1)	-0.011150	-0.006844	-0.007949	1.251526
	(0.40588)	(0.02341)	(0.01812)	(0.08465)
	[-0.02747]	[-0.29234]	[-0.43856]	[14.7853]

EXCH(-2)	0.284750	-0.014455	-0.006460	-0.310745
	(0.42324)	(0.02441)	(0.01890)	(0.08827)
	[0.67278]	[-0.59211]	[-0.34181]	[-3.52046]
C	14.72327	3.048579	2.079723	6.569449
	(18.6073)	(1.07325)	(0.83091)	(3.88062)
	[0.79126]	[2.84050]	[2.50294]	[1.69289]

More precisely, coefficients of the VAR model are interpreted in the same way as simple regression coefficients as simple regression is considered as the partial derivation of any dependent variable against some explanatory variables. While VAR explains the dynamic behavior of all the variables which are endogenous in nature. Therefore our main focus is on Impulse response function because this summarizes the aggregate derivative of all the endogenous variable against exogenous shock in any of the variable.

VAR Model results are contrary to the results of the research Oanh et al. (2017) where the influencing variable was GDP. Contrary to this, from table 6 it is indicated that Exchange rate is among those macroeconomic variable which is not affected by all other macroeconomic indicators but, it has some impact on all other variables. In contrast, Discount rate and Inflation rate are least sensitive to such macroeconomic changes. Meanwhile, Industrial production has no response towards any change in any macro variable. From empirical analysis it has deduced that, Exchange rate is the significant variable having a huge impact on all other macroeconomic determinants in the model.

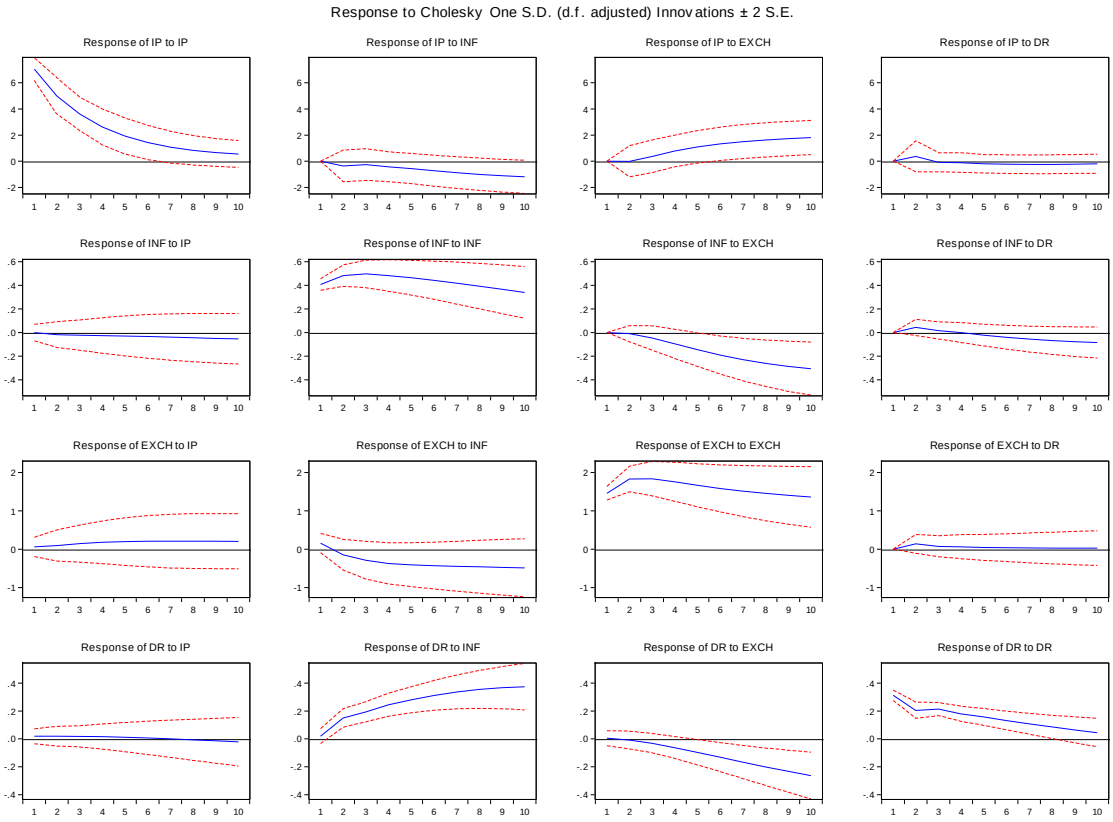

Figure 4. 1: Response of variables in VAR model

VAR approach has an advantage in performing stress test and that is because of carrying out impulse response. As it has been seen that, the dependent variables reaction on policy shocks is easily captured by impulse response. In the above graphs blue lines are impulse response function whereas red lines are the 95% confidence intervals. So the impulse response function will always lie within the 95% confidence intervals. The first graph shows the response of Industrial production against any shock in industrial production and is showing continuous negative trend. While the second response function is reaction of Industrial production against any vulnerable change in Inflation rate and the trend is almost constant. No major change has seen in case of Inflation rate shock. In the same way all the responses of the macro variables are examined by bringing a change in respective variables. From the practical point of view in case of Pakistan no major shocks are seen in the economy therefore the outcome of VAR model

and impulse response functions are not that much significant. But to check whether our financial markets are capable of bearing such shocks or not we take the approximate results. For this reason we take real effective exchange rate as the major variable among all other variables having strong impact on other variables.

Table 4. 7: Descriptive statistics of PVAR variables

Variables	Observations	Mean	SD	Minimum	Maximum
NPL	351	15323.17	1057.183	0	89159
GDP	351	4.515938	0.305515	1.600055	107.7867
INF	351	3.691023	0.100625	1.066754	8.874532
REXCH	351	105.5118	0.440487	95.00134	121.9876
DR	351	10.0563	0.143988	5.98	15.9

From the above results total observations for all variables are estimated. Mean as central values and standard deviation as spread are also calculated for each variable. As the sample is 351 observations for all the variables. Descriptive statistics summarizes information about total observations, mean, standard deviation, Minimum value and maximum values. The 351 observations of each variable are taken for twenty six different banks of Pakistan. Sample banks are the following UBL, HBL.ABL, MBL, Bank of Khyber, Silk Bank, NBP Al Habib Bank, Alfalah, Askari bank, Standard Chartered, MCB, HMB, Citibank, Bank of Punjab, Sindh bank, Dutesche Bank, First

women bank, Bank Islami, Albarakah , Samba Bank, Summit bank, Dubai Islamic bank, JS bank, Faysal bank, Soneri Bank, and Meezan Bank.

4.3 Estimating the relationship between Nonperforming loan and Macroeconomic variables

Data we are using in this model consists of NPL non-performing loan and four macroeconomic indicators collected yearly from 2006 to 2018.As the available data is fully reported so we create balanced panel data. Initially we take five equations but only equation presented is the one where NPL is the dependent variable .Because the aim is to check the reaction of NPL to the shock in other variables. It is obvious from the table that, three out of four variables are significant, like theoretically there should be a positive relationship between Non-performing loan and discount rate. Whereas negative relationship should prevail between non-performing loan and exchange rate and GDP.

4.3.1 Response of variables in PVAR model

In Panel VAR impulse response represents reaction of each indicator to one standard deviation shock in each of them. Impulse response functions are estimated for all variables which are represented in the below figures

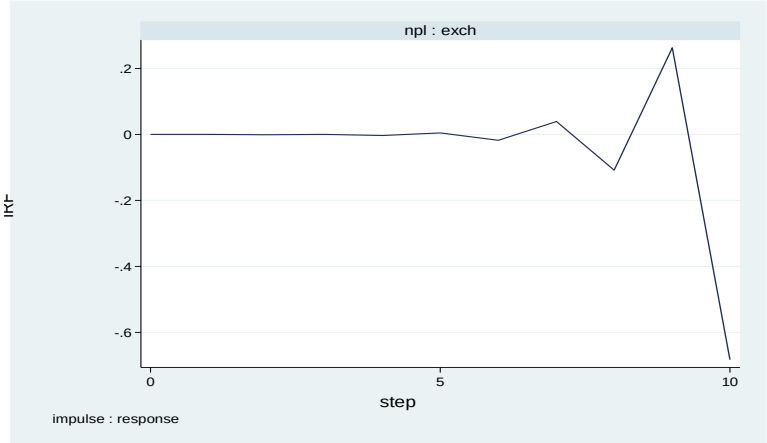

Figure 4. 2: Response of NPL to EXCH shock

Theoretical relationship between non-performing loan and exchange rate is negative which is shown in the above graph from 9th or 10th year. Before this time period no such effect appears**.**

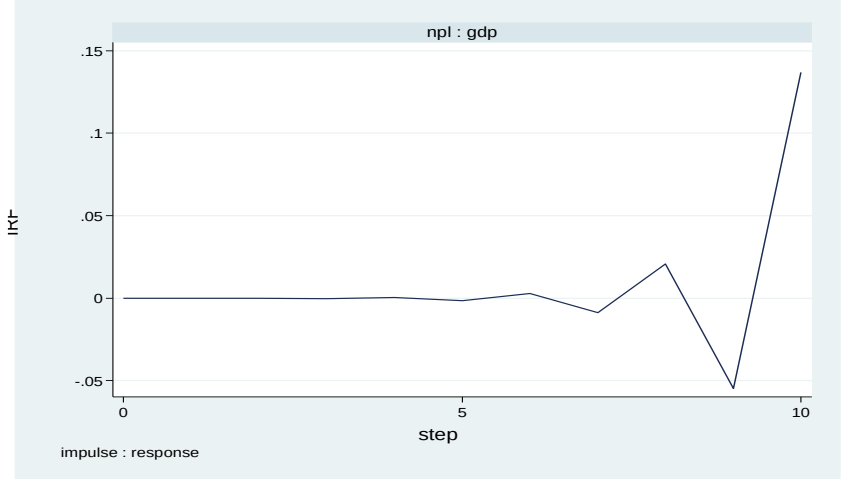

Figure 4. 3: Response of NPL to GDP shock

There should be negative relationship between Nonperforming loan and GDP but, in the below graph only two or three years data is showing this relationship. Otherwise, from 8th year this shows positive relationship.

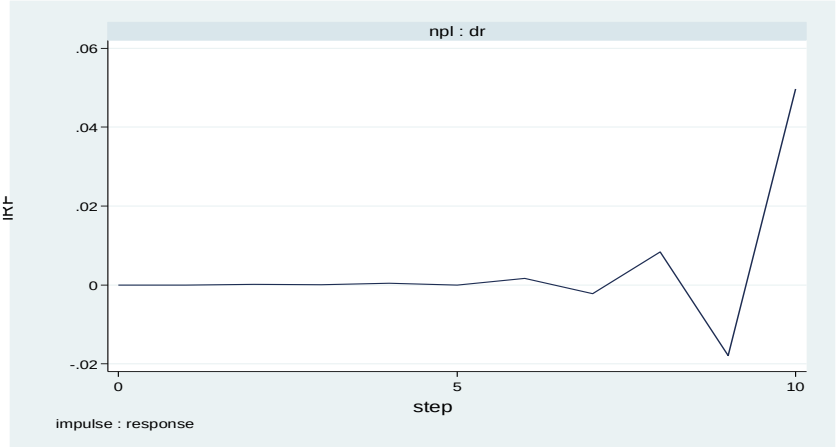

Figure 4. 4: Response of NPL to DR shock

When the shock is done to DR, change in NPL is showing almost trivial variation from year one to seventh year. Whereas, next two years is exhibiting negative relation and from 9th year onward the actual relationship appears which is compatible to theory.

4.4 Macroeconomic scenarios establishment

It is evident from the VAR results that, exchange rate is the significant variable which has the capacity to explain other macroeconomic variables. As Exchange rate estimates the nationwide improvement in competitiveness and assists in increasing credit quality of banks in particular. So we decide to bring shocks in all macroeconomic variables and develop various scenarios for all.

Table 4. 8: Scenarios for stress testing

Variable	One standard deviation shock	Two standard deviation shock	Three standard deviation shock	Last Observation
IP	111.7054	94.17384	76.64225	150.84
REXCH	97.6962	89.1355	80.57481	108.4302
DR	7.29534	4.521839	1.748338	7
INF	1.57252	1.726083	-2.73461	2.206671

We take first June 2018 as our base month before making scenarios. We consider macro scenarios to examine their consequences for next one and half year. Developing scenarios by adding (subtracting) 1, 2 and 3 standard deviation to the forecast generated by the macro VAR system we applied earlier on our macro variables. We consider both univariate scenarios, where only one macro suffers the shock (while the others are simulated conditionally on the former), and multivariate scenarios, in which all macros (but not credit volume) are supposed to jointly suffer.

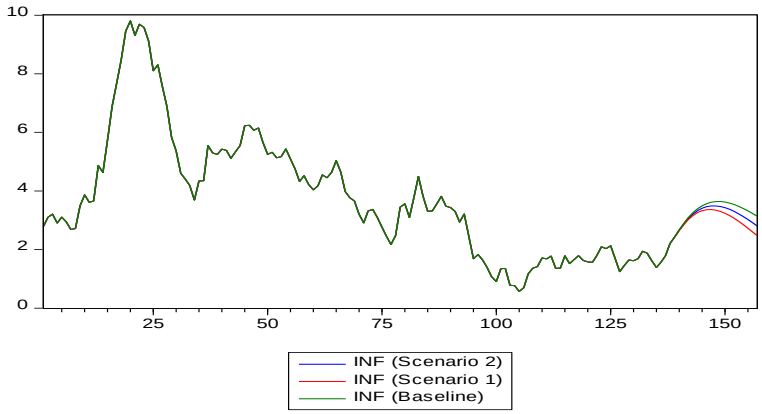

Figure 4. 5: Inflation rate macro stress scenario

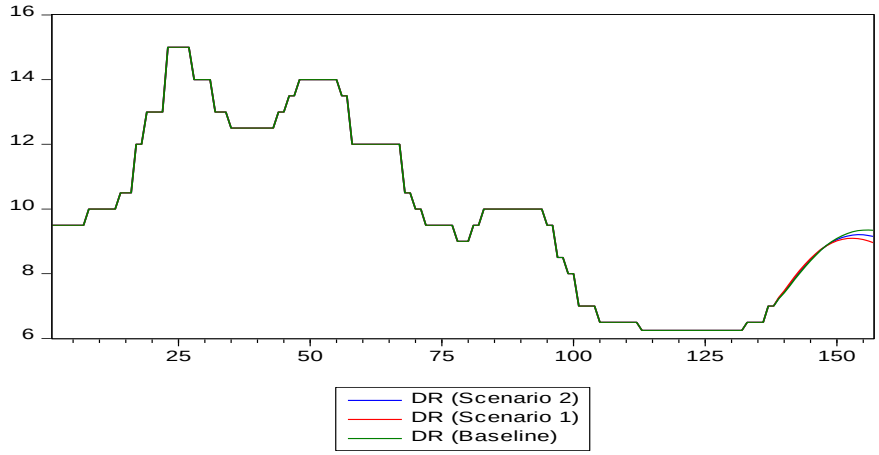

Figure 4. 6: Discount rate macro stress scenario

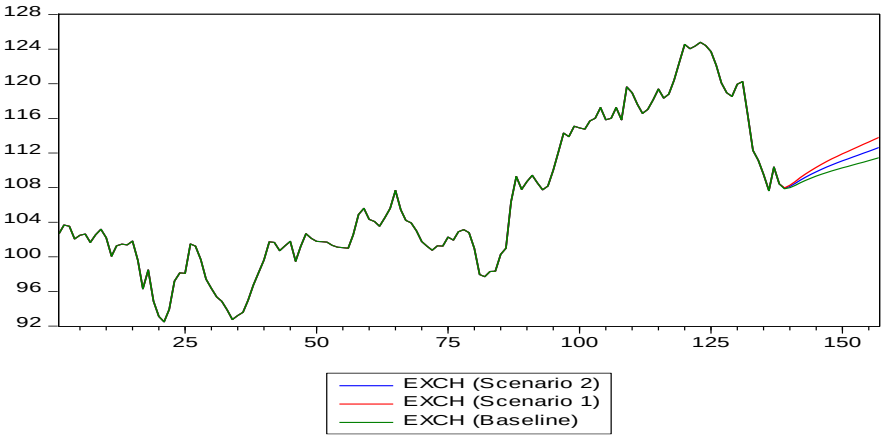

Figure 4. 7: Exchange rate macro stress scenario

Initially, we apply regression function on monthly data of macroeconomic indicators and though deterministic simulation then find forecasted values for Exchange rate, Discount rate and inflation. The graphical representation of forecasted and real values are shown above.

Above graphs shows the various degree of shocks which are baseline, scenario 1 and scenario 2.Inflation at forecasted period is exhibiting negative trend whereas, exchange rate and discount rate is showing positive trend.

4.5 Stress Testing credit risk for Pakistan's Banks

Capital adequacy ratio (CAR) determines the capacity of financial institutions specially banks to bear any shock or stress during business banking venture. CAR (capital adequacy ratio) is generally consider a proxy to estimate the capacity of banks own capital against any risk exposure. Banking regulatory body determine a minimal CAR (capital adequacy ratio) for all banks so that they get cushion to bear any bigger loss before they declared insolvent.

$$CAR = Capital \text{ Adequacy ratio} \qquad (4.1)$$

By keeping in view various assumption and changes in Non-performing loans (NPLs) we calculate CAR (capital adequacy ratio) which is later on compared with the criteria given by the banking regulator or countries. The minimum CAR ratio given by regulators is to find how much financial capacity each individual banks have to face any severe shock in the economy. Beside, to what extent they need to keep a ratio of capital to go through such extreme events in the economy. State bank of Pakistan set a minimum ratio for all other banks which for some years are given below.

There are certain assumptions which are followed during the estimation of Capital adequacy ratio.

Banks have to calculate Capital adequacy ratio from this equation

$$\text{CAR} = \frac{own\ capital}{RWA} x100 \qquad (4.2)$$

We need to calculate Capital adequacy ratio of banks which are based on the consequences of changes in the NPL and other assumptions to compare this CAR to the one specified by State bank of Pakistan.

Where RWA denotes Risk weighted assets and CAR denotes Capital adequacy ratio. So after applying some assumptions CAR is calculated through the following formula

$$\text{CAR} = \frac{own\ capital - \Delta p}{RWA}$$

Where change in p: represents change in NPL when LLP increases and decreases and is named as ΔP.

ΔP is estimated as Δ NPLs (non-performing loan) x LGD. Reasoning of this equation states that the required amount of extra provisions financial institutions is supposed to keep should be equivalent to the loan amount which is expected to default.

Loss given default (LGD) is losses against exposure to default. This is actually the credit risk banks have to bear when borrower's default. Regarding Basel's figures Loss given default is either lower (20-30%) or higher (70-80%) so we took 70 % as our benchmark for calculating CAR (Capital adequacy ratio).

Table 4. 9: Estimated 2019 CAR * for some Banks of Pakistan

Banks of Pakistan	Capital adequacy ratio CAR % 2018	Capital adequacy ratio CAR* %
United Bank limited	16.98	15.63
Habib bank limited	16.18	19.08
Allied bank limited	22.05	23.54
Meezan bank	14.88	15.04
Bank of Khyber	12.28	9.60
Silk bank	10.92	11.08

National bank of Pakistan	16.69	17.31
AL Habib bank	13.20	14.68
Alfalah bank	14.85	14.05
Askari bank	12.52	13.76
Standard chartered	19.09	17.06
Muslim commercial bank	17.02	16.58
Habib metropolitan bank	13.09	10.08

Above empirical results are estimated Capital adequacy ratios for thirteen different banks of Pakistan by keeping in view some assumptions regarding various variables being used in calculations? Reason behind forecasting this Capital adequacy ratio (CAR) is to view how these banks are working under various circumstances like when they encounter any economic shock, are they be able to withstand such innovations during bad times. As Regulatory authority in case of Pakistan is State Bank of Pakistan keep a certain minimum capital requirement for all the banks which for the year of 2019 is 17 %.By considering this given capital adequacy ratio we compare the estimated capital adequacy ratio (CAR) of all banks to the one stated by State Bank of Pakistan. So the results are, out of thirteen banks nine banks are showing slight decrease in their forecasted CAR. However, four banks are having increased CAR ratios. To sum up this by addressing the minimum of 17% CAR as a benchmark from regulatory bodies banks will need to rise their capital capacity because capital adequacy ratios is the capacity of banks to withstand in any case of shock.

Chapter 5

Conclusion

It has been observed that financial institutions started adopting the ST (stress testing) technique to apprehend the behavior of financial risk in economy for about a couple of decades. The importance of macro Stress testing is an effective way of assessing the sustainability of banking and financial system. Therefore, they are the precondition for continuous economic growth, an inconsistency in the banking sector will prove to be too costly for the real economy and lead to multiple global financial crises.

This study focuses on macro stress testing in computing Pakistan banking sector's financial sustainability by addressing two important questions. Initially, the prospective measure of vulnerability in the financial system of the country should be identified? Secondly what should be the proper way of calculating vulnerability of the financial institutions especially banks to possible risks? To get the required answers we need to produce a framework that will cover the macro stress testing of credit exposure in Pakistan's banking system. We developed VAR model and examined four macroeconomic variables and from them pick the most explanatory variable to create macroeconomic shocks. Then estimated Panel VAR (PVAR) to examine the impact of these shocks on the balance sheet of banks. As the banks are impacted by various risks among them we take credit risk and stress test credit risk for Pakistan banks through capitalization. Where we calculate Capital adequacy ratio for thirteen banks and compare estimated CAR to the CAR value suggested by state Bank of Pakistan. The outcome prevails that four banks are having CAR more than the regulatory minimum of 17% but nine banks are exhibiting slight decrease in their values. Therefore, nine

banks are required to increase their capital adequacy ratio to avoid any bad event in banking ventures. As Pakistan has not been effected by any large global financial crisis but has been effected by some small and medium risk so, the results of stress testing suggests that Pakistan's economy needs to be more cautious for the fluctuations in real effective exchange rate because any shock or innovation in real effective exchange rate can impact the banking sector specially the credit side.

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