SYSTEMIC RISK IN BANKING SECTOR

ASSESSMENT AND CONTROL

A Practical Banking Approach

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http://www.worldbank.org/en/topic/financialsector/brief/financial-projection-model

This concept paper along with the sketch of the model presented for **Systemic Risk Assessment & Management** is a very humble attempt on my part to go a few steps ahead of the FPM to establish a more robust and practical framework to assess and manage Systemic Risk in Banking Sector especially in developing economies. I owe a great deal of thanks and gratitude to the World Bank for providing me with the opportunity of working on international assignments with different Central Banks of the world. My special thanks to Mr. Murat Arslaner, Mr. Carlos Vicente and Ms. Yoko Doi with whom I worked in World Bank on this FPM model and learnt a lot. I would also like to thank my dear friends and ex colleagues in State Bank of Pakistan Mr. Faisal Shafaat and Mr. Shakil Paracha for their valuable comments on the model and practical suggestions for improvement. Productive feedback from Mr. Ali Tahir of Techlogix Pakistan, also helped me a lot in making the model more user friendly and practical. I also owe special thanks to Dr. Nadeem Aftab for his priceless feedback and suggestions regarding the default mechanism in the model. However, all the views and opinions expressed in this paper are my personal opinions and in no way can be construed as official policy or opinion of World Bank or State Bank of Pakistan or any of the employees of these two premier organizations. While I am thankful to the people cited above for their help and guidance but all mistakes and errors in the paper and the suggested model may be attributed to me only.

For any query or to provide feedback about any of the points discussed in this paper, please feel free to contact me directly at farrukh710@gmail.com

With Profound Regards and Thanks! **Farrukh Aleem Mirza**

Summary

Countless papers and books have been published on the issue of Systemic Risk in Financial Markets especially in the Banking Sector. By and large all the Central Banks and Banking Regulators of the world have been doing some exercises or studies to assess the degree of systemic risk in their respective banking sector and trying to put in effective checks and controls to minimize this risk. Not only practicing bankers or Central Bankers to be more appropriate, but also academicians in leading universities have been trying to devise a strategy or a model to measure the magnitude of Systemic Risk in financial markets. Instead of referring to all such literature I am just going to start with explaining the philosophy or core methodology of Systemic Risk Assessment employed in this paper. This paper is a humble attempt to devise a simple yet practical and easy to implement methodology for Assessing and Managing Systemic Risk in Banking System. This paper or essay is not a formal academic research paper or study and therefore references or discussion on past academic work on Systemic Risk has been avoided. Instead the only focus is on modeling the Banking Processes and the Behavior expected from rational banks in different possible situations in the market with the ultimate objective of assessing the Systemic Risk in the banking system.

The working engine of the model presented is basically a replica of a typical commercial bank. Or more appropriately, the model has tried to replicate the engine of a conventional bank. As cited in the acknowledgement in the beginning, I borrowed this idea from another model called Financial Projection Model which is owned by World Bank. However, all the opinions about different functions and operations in the framework explained in this paper are all my personal opinions and in no way represent the opinion of any other organization or person. Starting from the FPM I have tried to add more features to make it mimic a typical banking institution to a greater extent. Degree of Systemic Risk is assessed through simulation of the performance of each and every bank under certain constraints together with their respective business objectives. In short this paper endeavors to measure the Systemic Risk in the market by Role Playing Game, in which individual banks have a distinct role to play in the market with their own peculiar constraints and business objectives. Central Bank or the Regulatory Authority is the Apex Bank in the market which sets certain rules and constraints for the banking system. In this set up like all other Role Playing Games, each and every institution or bank tries to meet their respective business objectives through their routine business activities within the framework set by their internal and external constraints. Considering all the participating banks in the system are commercial entities therefore it's safe to assume that each and every bank has an ultimate objective of Profit Maximization and all of them have to adhere to the existing rules and regulations including Regulatory Limits of Cash Reserves Requirement (CRR), Capital Adequacy Ratio (CAR), Minimum Capital Requirements (MCR) and Statutory Liquidity Requirement (SLR). Obviously there can be lot more such ratios which a bank has to follow, but for simplicity let's assume that in current set up, banks are required to adhere

to the above cited limits only and their routine business decisions are affected by the levels of these ratios / limits. Once the business processes and behavior of individual bank is defined, then from the bank's historical data we make certain assumptions for Balance Sheet and Profit & Loss accounts simulations, to kick start the bank's operations i.e. simulate the bank's performance in future period. Having put a single bank in operations cycle, our next logical step is then to set the mechanism of whole market i.e. all the banking institutions operating collectively in the market. To be precise all banks are separate independent business entities but with a strong connection or link with each other. And the **Inter-Bank Borrowing/Lending** is the connecting point for all the banks. Each and every bank will continue to function within its own set of constraints and its own business objectives, however now in the Inter-Bank market every bank is connected with several other banks by either borrowing or lending or both. Generally, all the banks have borrowing and lending from different banks at the same time. Once this Inter-Bank market mechanism is set up, the model can then be used to simulate the operations and growth of the whole banking system under different scenarios with the underlying objective of assessing the Systemic Risk in the market and advising controls and or remedial measures to check and manage the Systemic Risk. Or in other words, in the whole set up each and every bank will try to grow through its business operations and in doing so they will be interacting with each other by borrowing or lending. Our objective is to see how the market or banks react to a bank failure / default and what could be the spillover effects of a bank default on the whole market comprising of many banks. In addition to bank default, we will also try to see how big macro shocks could impact the banking system as a whole.

Model Set Up

Our first step is to construct a model which mimics the operations of an individual bank along with the decision making process in different scenarios to project or simulate the bank's performance in different circumstances or scenarios. Once we have such a mechanism in place i.e. individual bank model for all the banks in the market, then our next step will be to connect all these individual entities / banks through Inter-Bank Borrowing/Lending to have a complete Market Model. Therefore, in this paper we will be working with two simulation / projection tools; one is the Individual Bank Model and the other is the System Wide model which consists of same Individual Bank models connected to each other through Inter-Bank borrowing/lending. And we also have a Central Bank or a Regulatory Authority in this system which sets all the Regulatory Limits to be followed by all the individual banks.

1- **Single Bank Model:** This is a model which mimics the working of an individual bank. We must have all the information how does an individual bank work in the big system.

What are the business objectives of this single unit and how does it attempt to achieve its objectives under different constraints set by its own unique business, market conditions and the regulatory environment? Amount of deposits it can raise, borrow from the market and lend money as loans are some of the internal constraints of the bank. Interest / Profit rates it has to pay on deposits and can receive on loans and other debt instruments and certain market rules of trading are some of the market constraints. And above all the regulatory limits like Cash Reserve Ratio, Statutory Liquidity Requirement, Capital Adequacy Ratio and Advances to Deposits Ratio are the Regulatory Constraints or limits which every bank must comply with.

2- **System Wide Modeling:** Once we have a fully functional model of one bank, our next step is to have a model which consists of multiple units i.e. many banks each having its own business strategy and constraints. Then we need to find the items or economic transactions or activities which connect all these banks. And as already stated that connection point is the “Inter-Bank” borrowing and lending of each bank. Every bank in the system must have borrowed some money from other bank or banks. Similarly, every bank must have lent some money to other bank or banks. Since the Inter-Bank borrowing of one bank is Inter-Bank lending of another bank, therefore at any time for the whole banking system the following relationship must hold:

Total Inter-Bank Borrowing = Total Inter-Bank Lending

Once the stage is set with all the units/banks connected to each other through Inter-Bank Borrowing/Lending, we can then run the model under the regulatory framework set by the Central Bank or Regulatory Authority.

Individual Bank Operations Modeling

As we all know that a bank is an intermediary between depositors and borrowers of money. So what we need is to model the entire process which starts with the accepting of public savings in the form of deposits and then after going through various stages of scrutiny and decision making it is transferred to borrowers in the form of loans or advances. In addition to deposits, there can be other sources of funds as well like bonds, inter-bank borrowing and other borrowings etc. All these sources together form the Cash Inflow for the bank. This pool of cash will then be used in different investments. Initially i.e. when the bank just started operations or came into business, it invests a big portion of the available funds in Fixed Assets like buildings, Technology hardware and software etc. These capital expenditures are imperative to kick start the banking operations. In addition to these investments bank also lends some of the cash as loans or advances to borrowers and these loans/advances are supposed to be the

main source of bank's income under normal market circumstances. The Return which bank pays on Deposits is supposed to be less than that on the Loans and that's how a bank earns profit. In addition to loans, bank also buys other financial assets like Equities and Bonds etc. to keep some portion of its assets liquid enough to be conveniently converted into cash as and when needed. Off and on bank also invests in other assets like Real Estate, Structured Derivatives and Joint Ventures with another financial institution, however for an ordinary commercial bank in a developing country the big chunk of the bank's income is supposed to come from Loans, Equities and Bonds and together all we can call them **Core Banking Activities**. So Banks earn interest / profit from investing in Loans and Other Debt Instruments like Government Bonds and other Non-Government Bonds. Banks also buys equities/stocks and earns dividend income on them. On the liability side bank accepts deposits and issue bonds and have some other borrowings in addition to the paid up capital with which it started its business initially. Now our task is to construct a model or a framework which replicates the engine of a typical commercial bank. We have to define the processes a bank does in its routine activities. Following process flow, a typical commercial bank has in its routine operations and exactly the same we will try to replicate in our model:

1- Bank gets Cash Inflow in the form of Paid Up Capital, Deposits, Borrowings from Financial Institutions, Bonds Issued and Other Borrowings. (sources of funds on the Liability side)
2- The available Cash is used/invested in Fixed Assets like Buildings etc. and Financial Assets like Equities, Bonds and Loans. (uses of funds on the Asset side) Obviously every bank has its own priorities for allocating the Cash Resources to different assets like loans, bonds etc. We will try to use historical data of each bank to define their respective Allocation Strategy.
3- Bank earns interest or profit on its investments and pays interest / profit on its liabilities. At the end of one accounting period the bank has either earned Net Profit or Incurred Loss, which once again becomes part of the Cash Flow. Loss is obviously a negative factor for the Cash Flow. In addition to Net Profit / Loss Non Cash Expenditures and Incomes also impact the value of Net Cash Flow.

   Net Cash Flow = Cash Flow from Financing Activities (Liabilities) + Cash Flow from Investing Activities (Assets) + Cash Flow from Operations (Profit & Loss Account)

   Generally, Cash Flow from Financing Activities is a Positive Flow i.e. Inflow because it's basically raising cash for the bank in different forms. And generally Cash Flow from Investing Activities is a negative flow i.e. outflow as its basically buying of assets for Cash. Cash Flow from Operations depend upon the Net Profit / Loss and Non Cash Income and Expenditures.

4- At the end of the Accounting Period:

- If Net Cash Flow is positive then it is Reinvested in Financial Assets i.e. in Core Banking Assets (Equities, Bonds and Loans) or may be in some other fixed assets & alternative investments as well if decided so. That's how the business cycle continues.
- If Net Cash Flow is negative, then this shortfall has to be covered from either Selling of Securities/assets, more borrowing from market or Roll Over of maturing Loan Liabilities. If after exploiting all the resources the bank still has a negative cash flow, then the only option left is borrowing from Central Bank which is Lender of Last Resort. And then after one more accounting period bank will review its Cash Position and will decide accordingly i.e Reinvestments if it's a Positive Cash flow and Securities' Selling or Borrowing if net cash flow is negative. Banks and Financial Institutions buy and sell securities very often in their routine business activities. However, when it comes to securities' selling to meet immediate liquidity needs then it's a different kind of game. Not necessarily banks make profit on securities' selling in this case and most probably they will incur some loss in it.
  Available options to meet the immediate liquidity needs:
  - Banks can call back loans to bank i.e. Inter-Bank lending obviously after paying some premium/penalty. Or banks can Roll Over the maturing Loans to reduce Cash Outflows. Since we can easily get the data of every bank's inter-bank borrowing and lending, therefore upon loans call back or roll over this can easily be adjusted among the banks. For example, if Bank A calls back loans to meet the emergency liquidity needs, that loan amount can be reduced from the inter-bank borrowing of the banks who borrowed from the Bank A. Doing all these adjustments will make the model more realistic.
  - Banks can sell any of the securities from its Held for Trading (HFT) and or Available for Sale (AFS) portfolios and also Held to Maturity (HTM) portfolio. Though generally HTM portfolio is rarely used for this purpose, but if the bank's survival or repute is at stake, then management can do whatever they can.
  - Though not very common, however in case of very severe liquidity crunch banks can also reduce their cash at bank.
  - Under extreme circumstances banks can even reduce their Cash Reserves (CRR) or Statutory Liquidity Reserves (SLR) with the Central Bank to avoid a default in the market. Obviously in that case bank will have to pay the Prudential Penalty for violating the CRR and or SLR requirement.
  - In the end if still bank has a negative cash flow, then the bank could borrow from the Central Regulatory Authority which can be called Emergency Borrowing. Obviously it will be a Repo Borrowing and bank must have sufficient security to cover the loan amount and the required margin as set by the Regulatory Authority. And in case bank doesn't

have the appropriate security in required quantity to borrow from the Central Regulatory Authority then definitely the bank is in trouble or most probably it will be out of business immediately or very soon. In other words, the bank might default.

- In different countries banks can have a different sequence of securities selling or other options like Calling Back Loans, Reducing Cash at Bank or Cash Reserves, depending upon the market and local laws.

Above cited 4 points define or explain briefly the Business Processes of a Bank. It's a continuous process and that's how banks grow with time. If for any reason any of the above mentioned activities can't be performed for any reason, the whole banking operations would cease to continue and the bank may be termed a Failure or in Default.

Since we are trying to simulate or project a bank's performance in future therefore in addition to defining the business processes, it's also imperative to have a detailed guideline of the bank's investment and financing behavior. That is the model must have a complete set of guidelines for the bank to decide at each time point what to buy or where to invest and how much to buy. Similarly, on the financing side the model must have complete instructions for each time point and in different circumstances which sources of funding bank can go for. All these business processes together with the complete guidelines set will help the model to simulate the bank's performance in future time periods based on certain assumptions and principles laid down.

Investment Behavior

A bank invests in different asset classes to earn profit. In case there were no restrictions from the Regulatory Authority, a bank would always put its money in the asset yielding highest profit. But it's a general rule as well that High Return comes with High Risk. Therefore, due to such associated risks and certain internal & external constraints banks always decide it strategically how much to invest in each of the available investments. From the historical composition of the Bank's Core Banking Activities we can imply an Allocation Strategy for every bank as follows:

Suppose the Total Core Banking Activities are:

1) Lending to Financial Institutions / Inter-Bank Lending
    a) Collateralized Lending / Reverse Repos (Securitized Borrowing/Lending)
    b) Clean Lending (Uncollateralized Borrowing/Lending)

2) Held for Trading Portfolio
    a) Equities
    b) Bonds
        i) Domestic Government Bonds (Risk Free)
        ii) Other Bonds (Risky Securities)

3) Available for Sale Portfolio
    a) Equities
    b) Bonds
        i) Domestic Government Bonds (Risk Free)
        ii) Other Bonds (Risky Securities)

4) Held to Maturity Portfolio
    a) Equities
    b) Bonds
        i) Domestic Government Bonds (Risk Free)
        ii) Other Bonds (Risky Securities)

5) Loans
    a) Sector 1 (Government or Quasi Government Institutions – Less Risk)
    b) Sector 2 (Private Individuals and Other Business Loans – Risky)

Total Core Banking Activities = TCB = 1+2+3+4+5

Share of Each Item in the Total Core Banking Activities can be computed as follows:

Collateralized Lending in Inter-Bank Lending = 1 (a) / TCB = x % of TCB

Equities – Held for Trading = 2 (a) / TCB = y % of TCB

Similarly, we can compute the share of each and every item in the Core Banking Activities this way. In future Projections the same weights/%ages can be used to allocate the Pool of Available Cash among different asset classes. That's the starting point. Suppose we have latest available data of Dec 31, 2015 and we are trying to project or simulate the results for quarter ending Mar 31, 2015. Then out of the total Cash Flow the model can allocate x% to the Collateralized Lending to Financial Institutions and y% to Equities Held for Trading Portfolio. Similarly, model will allocate to other assets as per their respective weights / %ages. However, it's not wise to let the model allocate continuously as per these pre-calculated %ages. Through all these processes bank is investing in Assets which are risky as well as risk free. Depending upon the Profits earned by the banks CAR is also changing periodically. Therefore, if a bank's CAR is deteriorating and if the bank still continues investing in risky assets as per the historical allocation strategy, then obviously CAR will further drop which is not desirable in any banking organization. In view of this constraint a Rationale Bank Management will try to improve the CAR through one of the two ways or both: Add more equity or Reduce the balance of Risk Weighted Assets to improve the CAR. Adding more equity is not an easy option in routine business and therefore wiser and easy way out is to reduce the balance of Risk Weighted Assets or alternatively going forward stop or reduce investment in Risky Assets. Reducing the balance of Risky Assets means shifting the Investment from High Risk to Low Risk items.

This strategy also is not very feasible as it involves Selling the Higher Risk Asset and using the proceeds to buy less risk or risk free asset. Though it's not impossible, however under normal circumstances banks would not resort to such a strategy to improve CAR. Therefore, in routine business activity the most convenient way is to stop or reduce the investment in Risky Investments or Highly Risky investments. ***So with this rationale lets define our first Rule / Investment Behavior and that is: Whenever CAR is less than the Target CAR, Bank will either stop or reduce investment in Risky Assets***. Whether to totally stop allocation or reduce allocation, that can easily be left to the Management or different levels can be set for this decision. An example could be: if

90% of Target CAR < CAR < T CAR, then reduce Future Allocation in Equities by 10%.

80% of Target CAR < CAR < 90% of T CAR then reduce Future Allocation in Equities by 20%

CAR < 80% of T CAR then stop allocation.

This is just one example of controlling the allocation depending upon the level of CAR and Target CAR. Just to remind the readers that all this is basically setting the Investment Behavior of banks. Once we have the historical weights for each asset class, we can still continue allocating exactly as per that historical weights, without any regard to CAR. However as argued earlier a rationale bank management would always adjust their allocation based on Capital Adequacy Ratio so that bank could earn money without violating any prudential regulation like CAR etc. This rule i.e. Reduced or Zero allocation to a particular Risky Asset if CAR is less than the Target CAR will be applied to all the risky assets which can increase the total of Risk Weighted Assets. Following Assets in our model will be subject to this rule:

Lending to Financial Institutions – Collateralized

Lending to Financial Institutions – Clean

Held for Trading Portfolio - Equities and Non-Government Bonds

Available for Sale Portfolio - Equities and Non-Government Bonds

Held to Maturity Portfolio - Equities and Non-Government Bonds

After stopping or reducing allocation to risky assets our next agenda item is what to do with the Unallocated Funds. i.e. What to do with the amount of money which was supposed to be invested in risky assets but wasn't because of low CAR as compared to Target CAR. First option is to let this money sit idle as part of Cash. This seems to be an unrealistic option as banks won't do this. Therefore, such unallocated funds could be diverted to Risk Free Investments to earn something without compromising CAR. Government Debt Securities in HFT, AFS and HTM portfolios are therefore the logical options in this case. So we can have the following general rule / investment behavior:

If CAR is less than the Target CAR then

Stop / Reduce Allocation to Assets	Unallocated Funds to be moved to
Lending to Financial Institutions – Collateralized	Government Debt HFT & AFS (Prorate) Unallocated funds in this case won't be invested in HTM portfolio because investment once done in HTM can't be liquidated easily. Generally, there is a formal process to liquidate investments from HTM. Quite possible bank's CAR's positions will improve soon and then bank might want to take the money out of that safe investment and put it back in some high yielding investment. Therefore unallocated amount in this case will go to HFT and AFS only.
Lending to Financial Institutions - Clean	Government Debt HFT & AFS (Prorate) For the same reason as explained above in case of Collateralized lending, unallocated amount will go to Govt. Debt securities in HFT and AFS portfolios only.
Equities – HFT	Government Debt – HFT Since primarily the investment was supposed to be allocated in HFT Equity portfolio, therefore in case CAR is less than the desirable levels, the unallocated amount will be invested in Govt. Debt securities in the same portfolio i.e. HFT.
Non-Government Debt HFT	Government Debt – HFT Unallocated amount remains in the same HFT portfolio.
Equities – AFS	Government Debt – AFS (same reasons as above)
Non-Government Debt AFS	Government Debt – AFS (same reasons as above)
Equities – HTM	Government Debt – HTM (same reasons as above)
Non-Government Debt HTM	Government Debt – HTM (same reasons above)
Loans Sector 2	Loans Sector 1 (if **ADR** is within limit in the previous period) otherwise Government Debt in HFT and AFS Portfolios. As we stated earlier that Loans in Loans Sector 1 are Govt. or quasi Govt. loans and therefore less risky and Loans sector

	2 is other loans and Risky ones. Therefore, if CAR is less than the target CAR, then loans in sector 2 will get either zero or reduced investment and the unallocated funds could be transferred to Loans sector 1 if ADR is within limits. However if ADR is also above the target level, then that unallocated amount will go to Govt. Debt securities in HFT and AFS but not in HTM.

ADR = Advances to Deposit Ratio : %age of Loans to Deposits. It may or may not be a regulatory limit, however Central Banks do persuade commercial banks not to lend all the deposits money as loans.

We used the terms CAR and Target CAR. Obviously Target CAR > Minimum CAR required. Minimum CAR required is set by the Regulatory Authority and Target CAR is set by the respective commercial bank. Generally, banks try to maintain a little more than the regulatory requirement as a cushion. So with this investment rule whenever CAR falls below the Target CAR bank would either stop or reduce allocation to risky assets in the next projection period.

Rules / Investment Behavior based on the level of Advances to Deposit Ratio (ADR)

As a precautionary measure generally banks are not encouraged or allowed to lend all the Deposits money as loans. Rationale is to keep some amount on hold to meet any unexpected and or heavy withdrawal of deposits. Banks also try to keep their Loan Portfolio within certain limits generally in comparison with the level of Deposits. ADR therefore is the most logical measure which can be used to model the investment behavior of banks in case of Loans and Advances. **So let's define the rule or our 2nd Investment Behavior as follows:**

Whenever ADR is higher than the Target ADR, bank under consideration would either stop giving out more loans or reduce the loans activity.

If ADR > Target ADR then

Stop / Reduce Investment in	**Unallocated Funds to be Diverted to**	
	If CAR > =Target CAR	If CAR < Target CAR
Loans Sector 1	All other Assets excluding Loans Sector 2 (Prorated)	Only Government Debt Securities in HFT and AFS Portfolio
Loans Sector 2	All Other Assets excluding Loans Sector 1 (Prorated)	Only Government Debt Securities in HFT and AFS Portfolio

If we have more loan sectors, each and every sector would be taken care of considering CAR and ADR independently.

In this set up for core banking assets which grow by getting allocation from the Cash Flow our future projection value can be calculated as follows:

Previous Balance + New Allocation – Sold Amounts – Matured Amounts + Revaluations

Sold Amounts are for Securities like Equity and Debt Securities and Loans called back.

Matured Amounts are for Debt Instruments and or Loans including Inter-Bank lending etc.

Revaluation are for securities which are revalued and their book values are adjusted periodically.

Another basic Setting in the Bank's investment behavior relates to the Statutory Liquidity Requirement (SLR) i.e. holding of Government and other approved securities as a %age of total Demand and Time Liabilities. Thinking logically every bank will try to keep SLR equal to or a little more than the target SLR. Whenever SLR is below the target SLR, obviously bank will buy more SLR eligible securities disregarding the preset Asset Allocation Strategy. **Therefore, this constraint is our 3rd rule or Investment Behavior which is whenever bank's SLR < Target SLR, then out of the available cash pool, model first of all buys the appropriate number of such eligible securities to bring the balance up to a level at which the SLR in the previous period is equal to the Target SLR and then with the remaining funds model will do routine allocation of funds to different assets including government bonds.** So if the SLR in current period is less than the Target SLR, the model will try to cover this shortfall in next period first and then will reinvest the available funds in core banking assets as per bank's strategy. Since in that reinvestment model will also buy more SLR eligible securities as part of the Asset Allocation strategy, it is therefore expected that in that stage bank won't have a shortfall in its SLR. This randomness is deliberately left in the model as in real life also banks face this risk of violating SLR requirement due to any unexpected big transaction. If at any time there is a shortfall in any of the Regulatory requirements like CRR, SLR or CAR, bank will have to pay the Prudential Penalty for which a formula as per the regulations can easily be set in the model.

That was all in brief the allocation of Funds to Core Banking Activities with the given historical allocation weights and certain regulatory requirements to be maintained. All these details can be termed as Bank's Investment Behavior within the given framework of opportunities and constraints. In this set up we considered the Target Level of CAR as the only benchmark to decide whether or not to allocate in a risky or risk free security. Obviously if CAR is fine bank might consider to put more money in the risky security which has a high expected return. Therefore, while defining the investment behavior we can also set a higher level of CAR and if the bank's actual CAR is greater than that higher

level then bank might start cutting down on its allocation to the risk free securities and start putting that unallocated amount to risky securities as long as the actual CAR remains above the lower level of Target CAR. Or in other words we can set a band of Target CAR and the bank would always try to remain within that lower and higher level of CAR. Similarly, bands can be defined for SLR and ADR as well. These settings will obviously make the investment behavior more precise and realistic. And there must be a lag between observing the level of actual CAR and the management's reaction i.e. zero or reduced allocation to risky / risk free securities. In this model this lag can be removed by keeping the action and the time of observation at the same time i.e. if the CAR is below the target level then the in the same period asset allocation is adjusted to achieve the desired level of CAR. But this doesn't happen this way in reality. There is always some risk degree of uncertainty in the actual CAR. Also keeping both the observation and action in the same time period would increase the circularity of the model and make calculations more time consuming. Therefore, in view of the cost of calculations and the real market practice it is better to keep that lag. However as stated earlier that no one behavior i.e. set of rules can be used universally and this investment behavior has to be defined in view of the local regulatory laws and the banking practices.

Growth of certain other basic types of assets like Fixed Assets, Intangible Assets can easily be related to Total Assets and in every projection period that particular asset will always be calculated as some percentage of Total Assets and that percentage can be inferred from the available historical data. For example, if we have following data in the last 5 annual balance sheets:

%age of Fixed Assets to Total Assets: 3%, 4%, 5%, 4%, 4.5%. We can take the average of these %age values and use it to project Total Fixed Assets in future projection periods. Similarly, we can do the same calculations for Intangible Assets, and other Assets. Obviously if we have prior knowledge of some big investment in Fixed Assets in future, that we can easily incorporate in our future projections by manually changing the %age in that period or just manually adding an amount in fixed or any other asset.

Calculation of Bad Loans / Probability of Default and Provisioning

Calculation of Probability of Default or Bad Loans rate is the rate at which part of Good Loans turn into Bad Loans in each period. This rate can easily be implied from the historical data as follows:

Good Loans in the Beginning of Period = USD 100 Mill

Amount of Bad Loans created in the Current Period = USD 3 Million

So Rate of Bad Loans / PD = 3 / 100 = 3%

So to project the Bad Loans created in next period we do as follows:

Beginning Balance = USD 150 Mill

Beginning Balance / Ending Balance Last period x Bad Loans Rate

USD 150 Mill X 3% = USD 4.5 Mill.

To calculate PD Good loans at the beginning and end of period could also be used but then in that case model will have more circularity and computations would be quite intensive and time consuming. For practical purposes it's OK to take only Beginning Period balance as this might only increase the Bad Loans rate but the projected amount of Bad loans won't be change significantly than if we used both Beginning and End period. Provisioning Rates for Good and Bad loans and Securities in different portfolios can easily be implied from the Balance Sheet Data of Loans, Securities' Balances and their respective Provisions.

Liability Side Growth

Unlike loans and other Core Banking Assets Liabilities can grow at some constant rate. Rationale is that generally all the banks have a Liability Marketing teams and they are continuously striving to get more and more deposits and other liability side items. Since for advancing Loans there are a lot of internal and external prudential conditions to be satisfied, therefore loans growth has to pass through a process of constructing a Cash Pool and then allocation of funds to loans and other assets. However irrespective of the loans and other available assets banks generally try to grow their deposits base. Having all the stringent KYC (Know your Customer) requirements and Anti Money Laundering / CFT laws in action accepting deposits is no more an easy task for banks, but still for such liability side items we can assume a reasonable growth rate implied from the historical data of the banks. However, more and more disclosure about the bank's equity and CAR in their regulatory and public reports can also have impact on the growth of deposits. It would not be unreasonable to assume that a bank with problems in its equity and low CAR will have trouble in growing its Deposits base and hence not necessarily its deposits and other borrowings can continue grow at the historical growth rates. Therefore, like the assets side we can have same treatment for certain Liability Side items as follows:

If CAR < Target CAR or some %age of T CAR, we can stop the growth or reduce the growth rate of certain liability side items. If the bank's target CAR is well above the minimum CAR, then with actual CAR slightly less than Target CAR won't hurt the public confidence and the growth of liability items won't be affected. In that case we can compare the actual CAR with some %age of Target Car say 90% or 80% or whatever the bank management feel appropriate. Purpose is just to make sure that whenever actual CAR is below a particular threshold level, the market reaction must be incorporated in the growth of liability items. Following liability side items may be affected due to CAR less than the desirable levels:

- Inter-Bank Borrowings: This item for sure will have a reduction its growth rate as the market would definitely react to the problems in CAR of any bank. Banks in the market would either stop or reduce their lending to banks with shortfall or declining CARs.

Further banks can also charge a higher interest / profit rate on lending to such troubled banks.

- Deposits – Current, Savings & Fixed
- Bonds Issuance
- Other Borrowings

These simple settings can easily be incorporated in the projections of Liabilities i.e. reduced growth rates or zero growth rates in case of a shortfall in CAR. And if for some reason Bank Management or Regulators feel that the Bank can still continue grow its liabilities despite of declining CAR, this can easily be done by simply not checking/selecting this condition of reduced / zero growth in liabilities if CAR < T CAR. While setting all these elements of zero or reduced growth of assets or liabilities concerned Regulatory Officers must be consulted as they are the people who know or are supposed to know the investment / financing behaviors of the bank under consideration.

Profit & Loss Account

As mentioned earlier banks might have to pay a higher than normal profit/interest rates in case its CAR has a shortfall and its known to public as well. Therefore, Profit/Interest Rates on Liability side items especially Inter-Bank borrowing must reflect this aspect and will be paying an interest rate plus a spread if CAR is less than the Target CAR or a %age of Target CAR. Profit / Interest rates paid on Deposits and other borrowings can also be adjusted in the same manner. However, if the regulator feels that bank would still continue to pay the normal rates on its financing, this option could be left unselected and there won't be any increase in the rates paid on liabilities.

Interest / Profit rates earned on assets can be implied from the historical data of Profit and Loss Accounts or could be manually input considering the future interest rate scenario.

Calculation of Risk Weights for Different Assets

As we have seen both the Assets and Liability side growth depends upon the level of CAR and other ratios. It is therefore imperative to have a dynamic method of calculating CAR at each stage. For loans banks generally assign a risk weight based on the borrower, collateral security and a few other aspects. However, when we are dealing in a whole bank analysis, it is not wise to go to the loan contract level data to assign a risk weight. Another simple methodology could be as follows:

A) Total Book Value of Loans in Loans Sector 1

B) Total Risk Weighted Value of Loans in Sector 1

B divided by A i.e. B / A gives us the Risk Weights of the Loan Sector 1. This risk weight can be used in future to calculate the Appropriate Risk Weighted Value of Loans Sector 1.

Similarly, model can infer the Risk Weights for each and every asset in the balance sheet.

Securities Selling for Liquidity Needs

In times of liquidity crunch if banks were to sell the securities, they would definitely prefer those securities which could be sold at minimum loss or maximum profit if possible. Therefore, in the model if we could assign loss rates for each security, model could easily start selling from the security with minimum loss rate to meet the liquidity shortfall. Information on loss rates can easily be inferred from the data of market trading in times of liquidity crunch. That loss rate can be manually input in the model.

All these items in Balance Sheet and Profit & Loss Account interact with each other simultaneously. That is Increase in Liabilities in Period 1 is a Cash Inflow for Period 1. Increase in Assets in Period 1 is a Cash Outflow for Period 1. These Cash inflow and Outflow are part of the Cash Flow for Period 1. And the Final Cash Flow from Period 1 is allocated to different core banking assets as explained earlier. All these calculations are happening at the same time i.e. taking values from each other. So in the model there is a Circularity in the Calculations. In our model it will be Iterative Calculations which will solve the equations and simulate the results which are basically projected financial statements of the bank under consideration. All this can easily be done in MS Excel with its Iterative Calculations Turned On.

These were some of the basic and bare minimum settings needed to model the business processes and behavior of an individual bank. With all this information we can project/simulate the Balance Sheet and Profit and Loss Account of any individual bank. Summary of our step by step approach is as follows:

- We make assumptions about the growth rates of Liability items like Deposits, Bonds, Other Borrowings etc. One item on the liability side “Emergency Borrowing” from central bank is not projected and it will have some value only when the bank has a negative Cash Flow and after selling all the available assets, still the balance is negative. That final negative balance short fall will then be covered by borrowing from Central Bank provided the bank has sufficient securities for doing Repo with the Central Bank.
- We define Core Banking Assets as Inter-Bank Lending, HFT, AFS and HTM portfolios and Loans. We define the composition i.e. breakup of total Core Banking Assets into its constituents. i.e. what %age each item holds in the total Core Banking Assets. These %ages will then be used for allocation of funds from Positive Cash Flow to respective asset. However, if Net Cash Flow is a negative amount there won’t be any allocation to any of the assets.

- We set or define the Investment behavior of the bank i.e. Allocation of Available funds to different Core Banking Assets conditional upon Regulatory Limits of CAR, SLR and ADR.
- Projections of certain other assets in the balance sheet are linked to total assets.
- In Profit and Loss accounts assumptions about interest rates to be paid and received are implied form the historical data and these rates can be manually changed to reflect a changing interest rate scenario in future.
- With the latest available data of Balance Sheet, Profit and Loss Account and Other information as our base period we simulate the values for the next period. These simulations can easily be done in Excel with Excel's Iterative Calculations turned On. This set up has a lot of Circularity in its calculations i.e. Many cells are linked to each other for calculations and therefore in ordinary calculation mode without Iterative Calculation our Model won't run. It's a kind of Excel's "Goal Seek" function with whole spread sheet to be calculated instead of just one number in a cell.

Projected or simulated results of the future Balance Sheet and Profit and Loss account give a forward looking view of the financial health of the banking institution under study. Once all this model is established it can be used for normal projections or under stressed scenario to see the impact of negative events on the performance of the bank, not only now but also what could be the bank's positions a few periods from now i.e. one day from now, or one quarter or a year from now. For any bank supervisor/regulator two things are of paramount importance. Whether the bank would be able to survive the stress scenario now. If yes, then what would be bank's performance or position a few periods later. Quite possibly the bank can survive the extreme shock now but in future the after effects won't let bank survive as a profitable institution. Therefore, while doing stress testing regulators must also see the possibility of bank having problems in future due to delayed effects of the stressed scenario under consideration.

We started this project with the objective of assessing Systemic Risk in the market and not just one bank analysis. Therefore, still we have to do a lot more to reach to that point where we are in a position to make some assessment of the Systemic Risk in the market and devise a mechanism to control or manage it prudently.

System Wide Modeling

In system wide modeling as stated earlier we need to take all the banks together working in the market as per their respective business strategies and individual constraints. Few of the constraints however remain same for all the banks. Example of such constraints are Regulatory limits i.e. CRR, CAR, SLR, ADR & MCR etc. Each bank can have a

different Target level of these regulatory requirements. Banks generally keep their target CAR a little more than the minimum required by the Regulatory Authority. So now in System Wide Model we have all the banks in action. They have their own individual growth rates of Liabilities. All of them have their own strategy for allocation of funds to Core Banking Assets. Bad Loans Rate or Probability of Default is different in different banks and so on. In short the individual internal constraints and business styles we fixed in each bank, remain the same. However, the item of Inter-Bank Liabilities i.e. Borrowing from Financial Institutions would be different in this system wide case. In individual bank modeling, that item was allowed to grow at the historical growth rate conditional to satisfactory CAR levels in each period. But when we talk about the System Wide modeling, the growth of Inter-Bank Borrowing is a totally different ball game. In this case we know that Borrowing of one bank is basically the lending of another bank. By and large all the banks have borrowed and lent money in the market at the same time. Some banks are net borrowers and some are net lenders. Because of this fact we have the following parity which holds always:

Total Inter-Bank Borrowing = Total Inter-Bank Lending

In our model we have two types of Inter-Bank borrowing/lending and they are Collateralized and Clean. So we have to make sure that in our System Wide Modeling at any time

Total Inter-Bank Collateralized Lending = Total Inter-Bank Collateralized Borrowing

Total Inter-Bank Clean Lending = Total Inter-Bank Clean Borrowing

In each bank Inter-Bank Lending will continue to grow as was the case in individual bank modeling. i.e. Previous balance plus new allocations etc. However, for Inter-Bank Borrowing we need to design a mechanism or algorithm which not only keeps the Inter-Bank Borrowing growing with the overall growth in the market but also preserves that parity discussed above. Each and every bank will have a growth in its Inter-Bank borrowing depending upon its own circumstances but it is imperative that at any time Total of Inter-Bank Borrowing is exactly equal to the Total of Inter-Bank Lending. And the growth in inter-bank borrowings would still be constrained by the level of CAR i.e. if bank has problems in its CAR i.e. declining or shortfall in comparison with Target CAR, Inter-Bank borrowings can't grow at the normal rates implied from historical data. So to incorporate these constraints we need to do the following things:

- **Calculate the Total Interbank Funds Available in the market:** This is the total of Inter-Bank lending of all the banks which are still solvent. i.e. all the banks which were not in default up to the end of last time period will have their contribution in the total

funds available in the market. Defaulted / Failed banks are no more in the system and therefore they can't contribute anything in the inter-bank market.

- **Distribution of Total Inter-bank funds available among the individual banks:** The total amount calculated above can now be distributed among all the banks which were solvent up to the end of last period. For this distribution the weight of individual bank will be from the previous period's position of Inter-bank borrowing i.e. (inter-bank borrowing of bank 1) / (Total of Inter-bank borrowing of all solvent banks). While doing this distribution the constraints of individual banks in the growth of their Inter-bank borrowing due to shortfall in CAR has to be maintained. Therefore, some of the banks might get an amount of Inter-Bank Borrowing less than their respective weight due to their problems in CAR. And that reduced amount will then be allocated among other banks which do not have any problems/shortfall in their respective CARs.

Systemic Losses

Let's try to understand under what kind of circumstances losses of one bank could be transmitted to other banks directly or indirectly.

The first situation or circumstance in which loss of a bank can be transmitted to another or other banks is a bank default. i.e. close down of a bank. Since banks have inter-bank borrowing and lending therefore in case of a default the banks which have lent money to the defaulted banks will now have to wait for the liquidation process or some other regulatory action before they could get their money back. For sure they won't get their money on the due date in normal business manner. Even if they get their money after some time, the delay in repayment could cost them a fortune. Non repayment of their loans, could land the lending banks in severe liquidity crunch and which could also jeopardize their own survival in the market. So the first situation in which a loss could be transferred to other bank is a bank default. To calculate this loss or exposure of each lending bank having exposure in the defaulted banks, we just need to do a few very simple calculations:

- First information we need is the Positions i.e. Inter-Bank Borrowing and Lending of the Defaulted Banks at the time of default. So at time zero with the latest available data set we can construct two matrices for each bank. One for the Distribution of Inter-Bank Borrowing i.e. details of the breakup of total Inter-Bank borrowing of each bank among other lending banks. Similarly, we can construct a matrix of the distribution of Inter-bank lending of each bank which gives us the details of the breakup of the total Lending of each bank among the borrowing banks. An example can be like this:

  Bank 1 Total Inter-Bank Borrowing Collateralized USD 100 Million distributed as follows:

Bank 2	USD 5.0 Mill	5%

Bank 3	20.0	20%
Bank 4	35.0	35%
Bank 6	25.0	25%
Bank 10	15.0	15%
Total	USD 100 Mill	100%

As long as there is no default in the system the same breakup/ composition of inter-bank liabilities can be used in all the future periods. However, after the default of any one bank or multiple banks, the same %ages can't be used. They have to be readjusted if one of the lending banks has defaulted. i.e If Bank 1 was borrowing from Bank 6 and in the previous period Bank 6 defaulted, then Bank 1 can't continue borrowing from Bank 6. Bank 1 therefore will have to find new sources of funds because Bank 6 is out of the system due to default. In this case we can have two options:

a) If we assume that Bank 1 will not add a new bank in its banking as source of funds, then in future Bank 1 will start borrowing more from other banks from where Bank 1 had been borrowing. This means that after the default of Bank 6 the respective percentages of other banks i.e. Bank2, 3, 4 and 10 will increase. Not necessarily the amount of borrowed funds from other banks will also increase. But for sure the respective percentage will. **b)** Otherwise if the information or Bank 1's credit lines with other banks is available, then this process is very easy to model. However, if that information is not available then the process explained in a) above is a very logical option. Exactly the same way the respective %ages can be computed for the Inter-Bank lending of Bank 1. That is the distribution of assets / Inter-Bank lending of Bank 1 among the banks which have borrowed money from Bank 1.

And in case there is no bank default in the system, then obviously the %ages we set in the beginning will remain same through all the projection periods. As we know that banks have credit lines with other banks and these lines do not change overnight. Therefore, such an assumption is quite sensible.

- Now suppose that at one time point we have a bank default for some reason. We need to see the Net Inter-Bank liability of the defaulted bank. We can do this as follows:

    a. Breakup of Total Inter-Bank Liabilities i.e. amount the defaulted bank owes to each bank. For this we will use the respective percentage of each lending bank as calculated above in point 1.
    b. Breakup of Total Inter-Bank Lending i.e. amount every bank owes to the defaulted bank

Using this information i.e. a & b we can now calculate the Net Inter-Bank liability (a-b) of the defaulted bank towards every other bank in the system. If this amount is a positive value it means the defaulted bank had to pay something to another bank. This amount is

basically a loss to the bank which has a net lending to the defaulted bank at the time of default. If this amount (a-b) is negative it means that defaulted bank had more money lent to a particular bank than what it had borrowed, therefore in this case the other bank had to pay something to the defaulted bank. Therefore, in this situation defaulted bank is not transferring a loss to the other bank. Let's try to understand each and every possible situation:

Suppose Bank A has just defaulted. Suppose Bank A has Inter-Bank borrowing from Bank B and also some Inter-Bank Lending to Bank B. Bank B is solvent now.

Case a: When all the inter-bank borrowing and lending of Bank A with Bank B is Clean i.e. not collateralized

Net Liabilities (NL) of Bank A towards Bank B = Inter-Bank Borrowing – Inter-Bank Lending

If NL > 0, then Bank B has two options. 1) Treat all the NL as Loss. 2) Transfer all the NL to Other Assets 3) Partial Loss and Partial transfer to Other Assets. Bank B can also keep the NL amount in the Inter-Bank lending with a note explaining the default of Bank A.

If NL <0, then Bank A is not transferring a Loss to Bank B, as in this case it was Bank B which had borrowed more amount from Bank A then its lending to Bank A. Therefore, in this case Bank B has two options: 1) Transfer the amount of NL to Other Liabilities or Continue keeping it in Inter-Bank Liabilities with a note explaining the default of Bank A

After doing all these adjustments Bank A is now out of the system and its no more contributing any amount in the inter-bank market. What to do with the assets of the defaulted Bank is beyond the scope of this study.

Case b: When all the inter-bank borrowing and lending of Bank A with Bank B is Collateralized i.e. Repos and Reverse Repos

If NL > 0, then Bank B has two options. 1) Sell all the Collateralized Securities to recover the loan amount. Securities might not be sufficient to cover all the loan amount and in that case the difference of the Loan amount and the Sales' proceeds would be treated as loss. 2) Transfer all the NL to Other Assets 3) Partial Sale of Securities and Partial transfer to Other Assets. Bank B can also keep the NL amount in the Inter-Bank lending with a note explaining the default of Bank A.

If NL <0, then Bank A is not transferring a Loss to Bank B, as in this case it was Bank B which had borrowed more amount from Bank A then its lending to Bank A. Therefore, in this case Bank B has two options: 1) Transfer the amount of NL to Other Liabilities or Continue keeping it in Inter-Bank Liabilities with a note explaining the default of Bank A

When a bank defaults, resulting losses if any will be transferred to the lending banks in the next period. It makes sense because in the model a bank is declared to be in default

at the end of any accounting period. So only after the default of that particular bank, other banks will adjust their exposures and book losses. So transfer of losses and other adjustments in Inter-Bank borrowing or lending will occur in the next accounting period.

After doing all these adjustments Bank A (defaulted bank) is now out of the system and it can no more contribute any amount in the inter-bank market. A government or regulator appointed liquidation board will now decide what to do with the assets of the defaulted bank and how to settle claims of depositors and other borrowers.

That was in brief a working of the Systemic Risk Modeling when complete data about Inter-Bank borrowing or lending is available. That is, we have bank by bank data of interbank borrowing and lending. What if that data is not available for some reason? Though it is very unlikely that a Central Bank doesn't have that data, however if it is so, we can make a simple and reasonable assumption. Instead of distributing the Net Inter-Bank liabilities of the defaulted bank among the actual lending banks, we can distribute that amount among all the surviving banks i.e. banks which are still solvent. Distribution weights for each bank can be related to the inter-bank lending of each surviving bank.

Example: Suppose Bank A has defaulted. Now its Net Inter-Bank borrowing has to be divided among all the surviving banks. We take all the banks which were solvent/surviving up to the end of previous period. Suppose Bank C is one of the surviving banks. %age of Inter-Bank borrowing of Bank A which will go to Bank C as loss will be calculated as follows:

Weight for Bank C = (Total Inter-Bank Lending of Bank C in the previous period) / (Total of Inter-Bank Lending of all surviving banks in the previous period)

Both the values relate to the time when Bank A defaulted i.e. one period earlier than the time when losses are actually being transferred to the surviving banks.

Once all these settings have been done in the model, then it will be a kind of loop structure. i.e. One bank defaults; resulting losses are transferred to lending or surviving banks and quite possibly one or several of the surviving banks also default in the next period and these new defaults could lead to more defaults and so on.

Impact of Defaults on the Market

First and direct impact will be on the lending banks because they have to bear the losses due to bank or banks' defaults. Losses will obviously erode the equity of the lending banks which in turn can further deteriorate other equity related ratios like CAR, Leverage etc. And as explained earlier losses incurred due to bank defaults could lead to more bank defaults and in case of weak equities and strong interconnectedness of the banks, one default could give rise to a series of bank defaults which could be fatal for the whole market.

If the lending banks decide to treat the stuck up Inter-Bank lending amounts with the defaulted banks as Other Assets instead of Losses, still they will have to face liquidity

problems. Because the lending banks won't get the amount / cash on account of maturing Inter-Bank lending to the defaulted banks. i.e. No loan repayments of Inter-Bank lending and the associated interest from borrowing banks which have defaulted. That liquidity crunch could also jeopardize the very survival of the lending banks. Since in this set up we have a properly structured cash/funds flow mechanism, therefore that aspect is appropriately taken care of in this model. In our set up / model all the maturities of loans and Inter-bank lending go directly to the Cash Flow and if a bank defaults, the lending bank won't get that maturity amount due from the defaulted bank and so the Cash Flow will depict the true troubled situation of the Cash Flow for the lending bank.

Another impact on the market due to a bank or several banks' defaults is the squeeze / reduction in the Inter-Bank market size. A defaulted bank automatically is out of the banking system and it is no more capable of giving liquidity in the inter-bank market. Surviving banks have now reduced Cash Resources to utilize or invest in their core banking activities, therefore the size of the total banking books can also be reduced due to default of one bank. For this effect not only default but also only losses in one bank could lead to a reduction in the overall inter-bank market. If a bank has losses or reduced profits obviously it will allocate less cash resources to be invested in the inter-bank lending meaning thereby other banks will have less cash / inter-bank borrowing from that particular bank.

Mass Selling of Securities

As we discussed in the beginning of the System Wide Model that in this case all the banks are part of the system. Each bank has its own unique settings of Target CAR, Target ADR, Strategy of Asset Allocation and other growth rates etc. Therefore, every bank will have different circumstances in the Projected periods and quite possibly many banks face liquidity crunch due to which all of such banks will have to resort to securities' selling. That mass selling of security could also lead to a crash of the securities market with steep decline in securities' prices of the securities being sold in the market to raise liquidity. That crash in the market would not only seriously reduce the liquidity so generated but it would also affect the value of the securities held by the banks in their portfolios and that effect also has to be incorporated. Here in our case for simplicity purpose we have Equity Securities, Government Debt and Other Debt Securities. We can easily set levels of securities sold volume, which if reached could trigger drop in the market prices of securities to model a crash like situation. An easy and practical way could be as follows for **Equity Securities (an example)**

If in a given period total volume of securities sold > 10% of all the securities holdings of all the banks in the previous period, market prices of the securities would drop by 5%. We

can set multiple trigger levels to make it more realistic. Obviously both the percentages mentioned above are just assumed arbitrarily only to understand the concept. Every market will have different %ages for drop in security prices in crises or panic situations.

If in a given period total volume of securities sold > 20% but < 30% of all the securities holdings of all the banks in the previous period, market prices of the securities would drop by 10%. And so on.

Similarly, we can set trigger levels for Government Debt and Other Debt Securities

Broader Aspects of Systemic Risk

Once we have all this set up in place i.e. a model consisting of multiple banks connected to each other through Inter-Bank borrowing and Lending, it becomes very easy to assess the impact of macro shocks on the system. Macro Shocks could be:

Increased Probability of Default / More Bad Loans due to poor economic performance of the country reflected by declining GDP growth rates. This can easily be done by computing the sensitivity of PDs of different loan sectors to the Growth Rates of GDP.

Interest Rate shocks which could impact the valuation of Debt Securities and Interest Payments on Floating Rate Loans and bonds.

When it comes to stress testing of Banks by the Regulatory Authority, customer level testing is not done. However now Central Banks also attempt to see the impact of the bankruptcy of big borrowers on the asset base of all the banks. For example, big borrowers might be considered ones having loans outstanding amount of more than USD 100 (an example) in total from multiple banks in the market. What would happen to banks if one of such big borrowers is declared bankrupt. Obviously banks would have to classify more loans or may have to write down some of them. That kind of testing can also be done with this simple model we have explained. If we assume one such big customers default, we have to see what would be the impact on Probability of Defaults of the loans portfolio. This thing is very easy to model. If every bank knows how sensitive their loan portfolio is to such big customers, then the PDs could be adjusted accordingly upon getting the information of bankruptcy of one such borrowers.

Deposits with Defaulted Banks

Another aspect / issue might also be a point of interest to any central bank. Though it sounds a lose connection however still if it can be quantified in some way, it could also help the Regulatory Authority to assess more accurately the systemic risk in a banking system. Suppose Bank A has a big borrower Mr. Z. Mr. Z has its big deposits in Bank B. Suppose Bank B does not have any inter-bank relationship with Bank A. Therefore, if

Bank B defaults there should not be any direct impact on Bank A. However, if Bank B defaults the deposits money of the customer Mr. Z would be stuck there and Mr. Z obviously couldn't access his funds under normal circumstances of a default. In that case there is a probability that Mr. Z might default on his loan commitments with Bank A. Therefore, after the news of default of Bank B, Bank A might want to revise the classification of the Loans extended to Mr. Z. Or may be Mr. Z just defaults on his loan commitments after the default of Bank B. If the Regulatory Authorities have access to this information i.e. Big Borrowers in a bank who have big deposits in other banks, then this aspect could also be incorporated in doing the Systemic Risk Analysis. Mathematically it is just assigning a little Higher than Normal Probability of Default to the loans of Banks whose' borrowers have deposits in other banks. So to incorporate this aspect in the Systemic Risk modeling what CB needs is the following information:

Suppose we are trying to evaluate the Loan Portfolio of Bank A. What if any other bank or banks in the market default? The borrowers of Bank A, who are maintaining deposits with one of the defaulted banks might have problems in repaying their loans with the Bank A. Therefore, for Bank A, we need the respective additional PD for every other bank in the system if defaults as follows:

Banks	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Add PD	0.5%	1.0%	0.25%	0.12%	0.3%	0.14%	0.16%	0.2%	0.11%

The above table is the additional probability of default in %age to be assigned to the loans of Bank A if any other Banks from B to J defaults. So the interpretation of this information is as follows:

If Bank B defaults, then the Loans in Bank A will have an additional 0.5% chances of going bad. Since PD is basically rate at which Good Loans turn into bad loans, therefore after this default of Bank B, higher portion of Good Loans of Bank A will be turning into Bad Loans. For example, if the PD was 2.5% for loans in Bank A, then after incorporating this effect the PD will be 3% (2.5% + 0.5%). In the same manner we can have information matrix for all the banks in the system and if this aspect/factor is also incorporated in the systemic risk modeling, it could give a reasonable information about how things could go bad in case of multiple defaults in the market.

Provision of a Unique Service to the Market by a Bank

Another aspect which must also be considered while modeling Systemic Risk in the market is the provision of a Unique service by a particular bank or several banks. For example, a bank which is also a Primary Dealer of Securities definitely holds a special

position. A default / close down of that particular bank could seriously hurt the Government's securities business as well as impacting negatively the securities business of a several banks which were in business with that particular defaulted bank. There could be several other unique services like provision of Inter-Bank clearing and or payment services, verification of Credit Cards over telephone and others. For all such services detailed study involving careful analysis of the potential losses needs to be done to track the linkages between each and every small failure of the defaulted bank and the market as a whole.

Summary of Steps in System Wide Modeling

- Set the Investment Behavior of Each and Individual Bank for Balance Sheet and Profit & Loss Account.
- Connect all the banks with each other through Inter-Bank borrowing / Lending
- Develop the Algorithm for the following parity:
    - Inter-Bank Assets = Inter-Bank Liabilities
- Set the Default Triggers e.g. (short fall in CAR, MCR or No Liquidity)
- Define the Process of Loss Transfer if Default occurs
- Incorporate the effects of Additional Bad Loans that might happen due to stuck up deposits of Borrowers in defaulted banks.

  Once we have a fully functional model with all these settings, a central bank can simulate the operations of a complete banking system and will be in a position to ascertain the weak areas which need immediate attention. With this model a central bank could easily see and track the transfer of losses from one bank to other and so on.

Expanding the Model for more Products and Beyond Domestic Economy

The setup explained so far in this model was for a domestic bank having by and large only conventional banking products i.e. Deposits and Bonds on Liability side and Loans and Securities on the Investment side. As banks are now getting into lots of new classes of assets like derivatives and different kind of bonds etc., to account for all such items more set of instructions will have to be included in the Bank's Investment Behavior. The principle or the working methodology will remain same. First the Business Processes are to identified and then for each process Bank's decision making behavior is to be modeled in view of all the possible situations. If a Bank is Internationally Active bank, then in addition to the Inter-Bank market, Bank's connection with the International Banking Community also will be modeled and obviously in that case there will be myriad of more risks which need to be tested in the model. In the framework provided in this paper, Banking Sector was linked to only domestic economy through GDP growth rates.

However, in case of an Internationally active bank a mechanism will have to be put in place which tracks the linkage of the International Markets with the domestic economy and then to the banking system. In short, to have more and more robust and realistic model, each and every linkage between the banking system and the economy must be incorporated in the model framework and the transmission of transactions effects from one bank to other and from one sector to other have to be carefully designed to study the movement of shocks in the system.

Conclusion

This paper is not a comprehensive or universal tool for Systemic Risk Management. Instead this essay may be treated as a concept paper on a simple and practical approach to Systemic Risk Assessment and Management. This paper gives a detailed sketch of a Systemic Risk Assessment model and any Regulatory Authority could develop a more detailed or customized version of this model. In this paper number of Investible Assets were few and so was the financing options for the banks. In real world and especially in developed as well as many developing countries number of investible assets are much more and we will need more logical functions to model the investment and financing behavior of banks in such markets. In short this paper is an attempt to lay solid foundations of a good systemic risk assessment model which gives proper empirical results in monetary terms to form a tenable opinion about a financial institution or the whole banking system in any country.

There is no model or methodology in the world which could accurately project or forecast the future events. However, models based on solid and logical assumptions can help in understanding the mechanics of the events and specially to have a fair idea of how bad things could go. Value at Risk has been in use for many years in financial markets. However, it is never expected that the amount of future losses will be the same as predicted by VAR calculations. This VAR number basically gives an idea of potential losses based on certain plausible assumptions and logical and factual arguments. Analogues to that VAR technology, this model could also help the banking regulators better understand the growth and evolution of a bank and the whole market with the ultimate objective of ascertaining the worst case scenario and might help them to better prepare for such crises like situations.