Asset-Liability Management:
An Empirical Analysis of Selected Banks in India

THESIS

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CERTIFICATE

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ABSTRACT

Banking regulation has undergone many changes since its inception. Due to deregulation, interest rates have become volatile in the past two decades, new complex products are offered to customers, and competition has grown tremendously. All these and many more changes had led to the evolution of Asset-Liability Management (ALM). It comprises of core bank management activities yet manages overall banking risk. Asset Liability Management is planning of balance sheet in such a manner to reduce risk and increase profitability. Allocation of assets, management of liabilities, dealing with uncertainty, business constraints, taxes, changes in policies, etc. are everyday hurdles faced by bank in financial planning. Banking globally is facing challenges to review policies and strategies to reduce risk and maximize revenue.

Every business faces multiple challenges in real world and banking is no different. Bankers make decisions to maximize profits, reduce risk, reduce non-performing assets, increase customer satisfaction, and many more. The complexity of such a problem can be tackled with combining finance with mathematics also known as financial engineering. Financial engineering has become a popular approach for handling financial problems. As the market is volatile, it is necessary to understand the data to derive patterns and valuable information. Financial engineering assists in designing, developing, and implementing innovative financial processes to create a unique solution for financial problems. As ALM and risk management are interrelated, an increase or decrease in risk will impact the value of assets and liabilities. Using financial engineering, the efficiency of banks can be enhanced by

integrating it with ALM. The central problem of ALM revolves around the balance sheet of banks. Therefore, the optimum composition of assets and liabilities can help in achieving higher returns and fulfil objectives of banks. There is a need to determine a balance between risk, liquidity, and profitability.

Taking the above problem into consideration, this study provides a comprehensive discussion of the ALM, risks in banking, strategies to mitigate risk, and techniques in ALM. The approach of bank employees towards ALM and application of ALM policies and strategies in banking is studied with primary survey where structured questionnaire is sent to bank employees. As per the understanding and knowledge of employees and their exposure in ALM, questionnaire responses are gathered. Non-Probability Purposive sampling is used to collect responses. The responses are received from 264 employees of 12 private sector bank and 12 public sector banks. These responses are further analyzed to enhance the understanding of ALM.

Secondly, to overcome the problem of multiple goals of bank management in Asset Liability Management and determine optimal asset liability mix, a mathematical model has been used to achieve banks' objectives while simultaneously undertaking the constraints. Management of the bank plays major role in determining and setting goals. Therefore, with the assistance of banks' managers and other higher officials' goals are defined for the model. The goals are improving liquidity, ensuring capital adequacy, reducing Non-Performing Assets, increasing return on asset and equity, increasing market share of credits and deposits. A

questionnaire based on Analytical Hierarchy Process is used to determine the relative weights of these goals to be used in goal programming.

The mathematical model to maximize profit, manage risk and determine asset liability mix, is built using Linear Goal Programming. The Linear Goal Programming technique aims to achieve multiple objectives with given constraints. The model for Asset Liability Management using Goal Programming is applied in four public banks to analyze the effectiveness of the model. The data used to develop model has been taken from Annual Reports of banks from the year 2010-2019, RBI website, moneycontrol.com, etc.

The findings of the study show that both Public and Private Sector Banks implement ALM policies, strategies, and processes, however the risk mitigation strategies and approach towards ALM is slightly different. Due to advancement of technologies banks are using innovating techniques along with traditional approach to manage ALM and various risks. The findings of the goal programming model implemented in ALM suggests scope for improvement in banks' efficiency and profitability by optimizing asset liability mix. The model suggests different strategy for each bank depending upon the past data and uniqueness of each bank.

There are limited studies in India that used goal programming in ALM, but we have not come across studies on ALM using primary data. The study is unique as it integrates Analytical Hierarchy Process in Goal Programming and CAMEL approach in goals setting. The model is useful for bank management for budgeting, planning, and forecasting. Banks can use the model

to set targets and determine the implications of such targets on the productivity and efficiency of bank. Banks can prioritize their goals and derive deviations from the goal.

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List of Abbreviations

AHP	Analytical Hierarchy Process
ALCO	Asset Liability Management Committee
ALM	Asset-Liability Management
CAR	Capital Adequacy Ratio
CRM	Credit Risk Management
CRR	Cash Reserve Ratio
DeVa	Document Electronic Verification & Archival
DPD	Days Past Due
EWS	Early Warning System
GP	Goal Programming
HQLA	High Quality Liquid Assets
KRI	Key Risk Indicator
LCR	Liquidity Coverage Ratio
NII	Net Interest Income
NPA	Non-Performing Asset
PD	Probability of Default
PSL	Priority Sector Lending

RBI	Reserve Bank of India
RCSA	Risk and Control Self-Assessment
ROA	Return on Asset
ROE	Return on Equity
RSA	Risk Sensitive Asset
RSL	Risk Sensitive Liability
SCBs	Scheduled Commercial Banks
SLR	Statutory Liquidity Ratio
VaR	Value at Risk

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CHAPTER 1: INTRODUCTION

1.1 MOTIVATION OF THE STUDY

In real world, banks face conflicting goals. On one hand banks wants to maximize its profit, and on the other, it wants safety. Banks want their funds to be liquid enough to manage its day-to-day operations without the risk of being insolvent. The risk appetite of banks forces it to trade-off between return and risk. Asset- Liability Management (ALM) is a process where banks focus mainly on Assets and Liabilities of the balance sheet to achieve profit maximization objective and mitigate risk. Under ALM process, banks have to balance between risk and return. When risk is minimized, banks often forgo substantial amount of profit. ALM focuses on allocation of funds in such a manner so as to maximize financial goals and reduce financial risk (Samuel, 2011). ALM is a dynamic process that works in dynamic environment. Banking regulations and policies as well as bank management's plan are subject to change over time therefore, ALM also requires constant monitoring, formulation, updating, implementation, and control. Based on the market condition, banking regulation, and economic condition strategies are revised in ALM to improve the productivity, efficiency and performance of the bank (Romanyuk, 2010).

ALM framework works in coordination of the decisions/targets set by the board of directors related to profit maximization capacity and risk appetite of the bank. The statutory and regulatory policies pertaining to asset quality, liquidity, capital adequacy, allocation of funds to Priority Sector Lending, etc. cannot be overlooked. Therefore, on one hand ALM aims to maintain balance between appropriate allocation of funds and managing liabilities and on

the other hand keep check on the riskiness **(Naderi et al., 2013).** The balance sheet structure of banks is, therefore, the most critical issue in the planning process. Banks' decision to determine the asset mix is mainly affected by competition, economic condition, legal requirements, Reserve bank policies, banker's guidelines, and internal policies. These constraints and factors determine the balance sheet structure in Indian banking.

Financial institutions like banks in India must follow the lending procedures, investment norms, and other guidelines framed by Reserve Bank of India (RBI) related to Statutory Liquidity Ratio (SLR), Cash Reserve Ratio (CRR), liquidity, and capital, etc. into the bank's working operations. The banks are required to disintegrate and allocate their funds in different types of investments such as shares, government bonds, corporate bonds, Subsidiary, etc. Banks are guided to allocate forty percent of Adjusted Net Bank Credit towards Priority sector lending (PSL). The implementation of ALM into the banking working structure is essential to create equilibrium in the inflow and outflow of the bank. Banks need to focus on maintaining balance in the two sides of the balance sheet i.e., assets and liabilities side. The capital and reserve requirements of banks are governed mainly by the RBI and are beyond bank's control. However, a bank can control other assets and liabilities. The SLR and Non-SLR investments in banks depend on factors such as interest rate, maturity, liquidity, marketability, and ratings. These factors also determine the yield of investments. Banks have to trade-off between profit and risk.

The decision related to the size and composition of any asset and liability cannot be made independently. The complexity arises when one component affects other assets & liabilities and yield & cost related to them. The risk management approach has become

enterprise-wide management as interest rate risk, market risk, credit risk, and liquidity risk are interrelated (Jain et al., 2010). Any significant increase in any asset with the given yield and risk will lead to decrease in other assets with different yield and risk. However, banks can increase their spread (yield-cost) by reducing their liquidity. However, reducing short-term liquidity has repercussions in the long term. Banks may be forced to liquidate their investments to meet customers' demands and withdrawals. The reverse is also true. If banks hold higher liquid assets, they will lose a significant amount of earnings to their competitors. The decision of the banks' management regarding ALM affects the current and future stability of banks. Therefore, banks have to make prudent decisions in the present while understanding its severe consequences in the near future. It has to incorporate present scenarios and as well as unprecedented changes in the future.

In banks, the planning process always depends on the availability of information related to interest rate, cost, and yield of various assets and liabilities. In general, forecasting depends on historical data. However, the banking business has become very dynamic. The past data cannot capture the present interaction between assets and liabilities. These complexities in today's banking business have opened itself to integrate mathematics and engineering to seek solutions for its complex problems. Therefore, this thesis first attempts to understand how employees of the banks implement and practice strategies, policies, and procedures related to ALM and risk management techniques. Secondly, with the help of linear goal programming (a mathematical design), the asset-liabilities of banks are allocated to generate better profitability and manage risk.

1.2 RESEARCH BACKGROUND

Banks are financial institutions that secure the savings and deposits of individuals and various institutions to contribute to India's economic growth. Banking Regulation Act, 1949, Section 5(c), defines a bank as "a banking company which transacts the business of banking in India.' Further, Section 5(b) of the BR Act defines banking as 'accepting, for the purpose of lending or investment, of deposits of money from the public, repayable on demand or otherwise, and withdrawable, by cheque, draft, and order or otherwise' ("The Banking Regulation Act," 1949). The banking regulation Act aims to safeguard the interest of customers, minimize the risk related to bank failure, reduce moral hazard, and nourish the financial stability of the economy by controlling the financial system and creating a financial buffer (Srivastava, 2019).

Back in 1935, the Reserve Bank of Indian started its operation. It led to a plethora of events that changed the structure and functioning of banking in India. The summary of significant events relevant to our study is given below:

Table 1.1: Major Events in History of Banking

DATE	EVENTS
1 Apr 1935	Reserve Bank of India commenced its operations under the supervision of Sir Osborne Smith who was the first Governor of the Bank.
5 Jul 1935	Cash Reserve Ratio (CRR) and Statutory Reserve Ratio was required by banks to be maintained by Scheduled banks at 5% of Demand Liability and 2% of Time Liability.
1944	RBI consolidated the government securities laws and public debt management based on Public Debt Act 1944.
1 Jan 1949	Reserve Bank of India was Nationalized.
16 Mar 1949	Banking Companies Act, 1949 came into force, which guided banks in supervision. The Statutory Liquidity Ratio (SLR) was introduced to maintain sufficient liquid assets. Banking companies Act is now known as Banking Regulation Act.
17 May 1956	Selective Credit Controls measures were initiated.
16 Sep 1962	CRR was fixed uniformly at 3 % of their Demand and Time Liabilities providing flexibility between 3 to 15%.
20 Nov 1965	Credit Authorization Scheme (CAS) supported the growth of bank credit with Plan requirements.
1 Mar 1966	Co-operative banking system started its operation under the regulations of RBI banking laws.
19 Jul 1969	Nationalization of 14 scheduled commercial banks having deposit over 50 crores took place 'to serve better the needs of development of the economy in conformity with national policy objectives'.
Jan 1970	Minimum interest rate on advances against sensitive commodities was prescribed by RBI.
14 Jan 1971	Credit Guarantee Corporation of India Ltd. was established to emphasize on priority sectors lending where small borrowers and priority sectors will be given credit.
1973	Oil Shock led to inflation and global recession. In response to inflation banks restricted credit expansion.
08 Sep 1973	Quantitative credit ceiling on non-food bank credit was prescribed for the first time for the busy season of 1973-74.
1979	RBI set up Rural Planning and Credit Cell for effective implementation of the multi-agency approach to credit in rural areas.
1 Jul 1989	CRR raised to 15 % taking statutory pre-emptions of banks' resources in the form of the Statutory Liquidity Ratio (SLR) and the Cash Reserve Ratio (CRR) to over 53%.
Nov 1991	The Narsimahmam Committee Report suggested reforms in the Indian Banking sector. The reforms were mainly to reduce SLR and CRR in phases. Also, accounting standards, income recognition norms and capital adequacy norms were introduced.
Apr 1992	Norms related to income recognition and asset classification were introduced. Moreover, provisioning and Capital adequacy standards were specified.
Oct 1995	Banks were given liberty to fix interest rate on domestic term deposits with two years of maturity.
6 Jun 1997	First auction of 14 days treasury bill was introduced and later in October, auction of 28 days treasury bills was announced by RBI.
Apr 2003	Risk based supervision of Banks introduced.

Source: Reserve bank of India *(Chronology of events, n.d.)*

In the 1956s, the government realized private sector banks were not effectuating the social and developmental goals of banking. It became apparent when private banks lending in the industrial sector doubled from 34% to 68%, whereas agricultural share in loans reduced to less than 2% (Gauba, 2012). In the initial stage of development, government intervention was good for economic growth; however, increasing government interference resulted in unequal distribution of resources and powers in the hand of few banks. Due to these differences in credit policies, the government felt the need for nationalization, and it led 14 banks under government control on 19 July 1969. Later in 1980, six private banks were again nationalized. In 1989, CRR was 15%, and SLR rose to 38%, leaving banks with fewer funds to lend. The interest in government bonds was low, and to satisfy the Statutory liquidity requirement, banks had to invest in government securities mandatorily. It decreased the banking revenue. Apart from these, direct lending/ priority sector lending and administered interest rates reduced banks' incentive to operate effectively.

The Indian economy experienced the hardship of uncertain political situations, continuous fiscal imbalance, double-digit inflation, adverse balance of payment, etc. After nationalization banks came under government sector. Political pressure forced banks to operate unprofessionally and unethically. It resulted in banking inefficiency, increased NPAs and poor profitability. This fiscal imbalance continued from 1980 and reached its critical position by 1989. In 1978-79 fiscal balance was Rupees 21.26 billion which increased all over to 207.70 Billion in the year 1988-89 (*Key Deficit Indicators of the Central Government*, n.d.). Inflation rose from 2.52% in 1978 to 11.35% in 1980 (*India Inflation Rate 1960-2021*, n.d.). The ill-effects of nationalization started showing signs of poor conditions of the financial sector in India, especially the banking industry. Therefore, to drive economic growth to optimized levels, the

Government of India initiated several reforms in the financial system. In 1991, the Narsimahmam committee was set up as the first step towards banking sector reform. The banking sector went through several reforms since its inception, and the major reform that took place in the year 1991 played a significant role in reforming the entire banking sector. The reform was laid down under the leadership and guidance of M. Narsimahmam, who is regarded as an architect of the Indian banking industry (Dash et al., 2011; Kalita, 2008; Kalyan, 2017; Shivagami & Prasad, 2016).

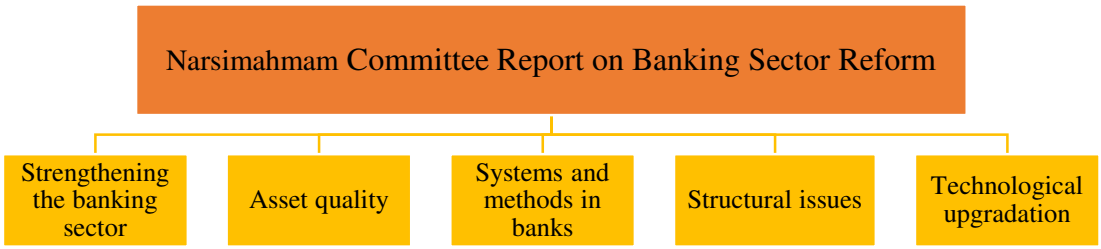


Figure 1.1: Narsimahmam committee report (Kalyan, 2017)

The financial system reform focused on enhancing the efficiency, productivity, and profitability of the financial institution. In banking sector reform, private and foreign banks were welcomed that increased competition and motivated banks to operate efficiently to survive. There was a decrease in CRR and SLR rate, deregulation of interest rate, revisiting priority sector lending, and merging weak banks with strong ones to help them recover. These changes brought positive growth in bank efficiency and effectiveness (Kalita, 2008; Shivagami & Prasad, 2016). The committee constituted banking reforms to look after the rising NPAs and set up an asset reconstruction fund to manage it (Kalita, 2008). The measures led to a reduction in NPAs, which is evident from the table 1.2 and graph 1.2 below. After banking reforms, there

is steady decline in NPAs until 2013. The increase in NPA in year 2013 were mainly due to deterioration in asset quality of SBI Group. SBI Group alone reported 5% of Gross NPA to Gross Advances. Moreover, there was shift of loan assets towards “doubtful” category (RBI, 2013). Rise in NPA and fresh slippages in banking sector was due to inadequate pick up in the global economy as well as in domestic economy, negative spill overs from the global financial markets, reduced market confidence, delay in realization of receivables, and stress in steel, power, and infrastructure projects.

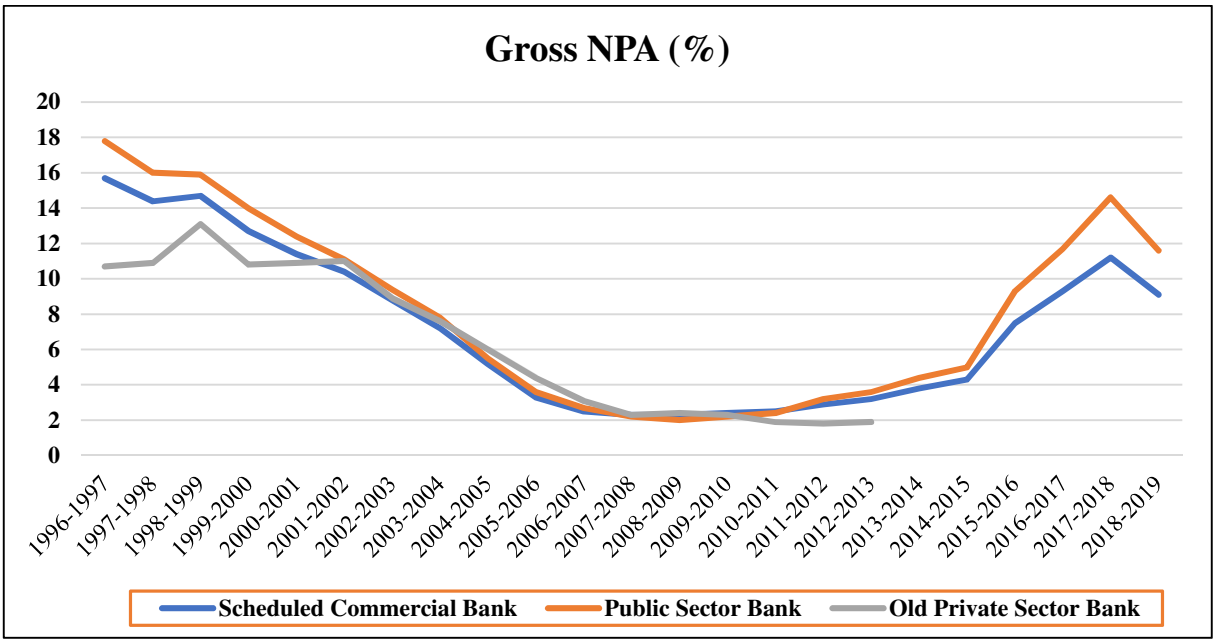


Figure 1.2: Gross NPA of SCBs, PSBs, old private sector bank

(Gross and Net NPAs of SCBs, 2020)

Table 1.2: Gross NPA-Post Liberalization

GROSS NPA AS A PERCENTAGE OF NET ADVANCES					
Year	**Scheduled Commercial Bank**	**Public Sector Bank**	**Old Private Sector Bank**	**New Private Sector Banks**	**Foreign Banks**
1996-1997	15.7	17.8	10.7	2.6	4.3
1997-1998	14.4	16.0	10.9	3.5	6.4
1998-1999	14.7	15.9	13.1	6.2	7.6
1999-2000	12.7	14.0	10.8	4.1	7.0
2000-2001	11.4	12.4	10.9	5.1	6.8
2001-2002	10.4	11.1	11.0	8.9	5.4
2002-2003	8.8	9.4	8.9	7.6	5.2
2003-2004	7.2	7.8	7.6	1.7	4.6
2004-2005	5.2	5.5	6.0	1.9	2.8
2005-2006	3.3	3.6	4.4	0.8	1.9
2006-2007	2.5	2.7	3.1	1	1.8
2007-2008	2.3	2.2	2.3	1.2	1.8
2008-2009	2.3	2.0	2.4	1.4	3.8
2009-2010	2.4	2.2	2.3	1.1	4.3
2010-2011	2.5	2.4	1.9	0.6	2.5
2011-2012	2.9	3.2	1.8	0.5	2.7
2012-2013	3.2	3.6	1.9	0.5	3.0
2013-2014	3.8	4.4	NA	1.8	3.9
2014-2015	4.3	5.0	NA	2.1	3.2
2015-2016	7.5	9.3	NA	2.8	4.2
2016-2017	9.3	11.7	NA	4.1	4.0
2017-2018	11.2	14.6	NA	4.7	3.8
2018-2019	9.1	11.6	NA	5.3	3.0

Source: Reserve Bank of India- Handbook of Statistics on Indian Economy

(Gross and Net NPAs of SCBs, 2020)

TABLE 1.3: Net NPA-Post Liberalization

NET NPA AS A PERCENTAGE OF NET ADVANCES					
Year	**Scheduled Commercial Bank**	**Public Sector Bank**	**Old Private Sector Bank**	**New Private Sector Banks**	**Foreign Banks**
1996-1997	8.1	9.2	6.6	2	1.9
1997-1998	7.3	8.2	6.5	2.6	2.2
1998-1999	7.6	8.1	9	4.5	2.9
1999-2000	6.8	7.4	7.1	2.9	2.4
2000-2001	6.2	6.7	7.3	3.1	1.8
2001-2002	5.5	5.8	7.1	4.9	1.9
2002-2003	4.4	4.5	5.5	4.6	1.8
2003-2004	2.8	3.1	3.8	1.7	1.5
2004-2005	2	2.1	2.7	1.9	0.8
2005-2006	1.2	1.3	1.7	0.8	0.8
2006-2007	1	1.1	1	1	0.7
2007-2008	1	1	0.7	1.2	0.8
2008-2009	1.1	0.9	0.9	1.4	1.8
2009-2010	1.1	1.1	0.8	1.1	1.8
2010-2011	1	1.1	0.5	0.6	0.7
2011-2012	1.3	1.5	0.6	0.5	0.6
2012-2013	1.7	2	0.7	0.5	1
2013-2014	2.1	2.6	NA	0.7	1.1
2014-2015	2.4	2.9	NA	0.9	0.5
2015-2016	4.4	5.7	NA	1.4	0.8
2016-2017	5.3	6.9	NA	2.2	0.6
2017-2018	6	8	NA	2.4	0.4
2018-2019	3.7	4.8	NA	2	0.5

Source: Reserve Bank of India- Handbook of Statistics on Indian Economy

(Gross and Net NPAs of SCBs, 2020)

From 1990 to 1995, the RBI initiated different steps to deregulate the overburden prevailing in the banking sector (Mohan, 2006). Under deregulation, RBI permitted the banks to fix their foreign exchange open position limit. The RBI also provided a New Delivery System for the bank credit and the cash credit component worth 60% (Ranjan & Dhal, 2003).

Significant changes became visible in the critical sector of the economy owing to measures taken under banking reforms. The performance of banks improved the Indian economy (as evident in table 1.4 to 1.8). The reforms look to ameliorate banks' productivity and profitability by reducing CRR and SLR. Reforms also contributed to strengthening the banking system by instigating norms that were in line with the international best practice. These norms were capital adequacy, income recognition, asset classification and provisioning requirements, etc. Banking reform modified the policy framework, enhanced banks' financial structure and credibility, increased competition, and strengthened the financial institutional framework. The measures were elevating competition in the banking sector to enhance the efficiency and productivity of banks by encouraging new banks to enter in the private sector and liberalizing the entry of foreign banks. The effect of competition is visible from the fact that asset concentration ratio of five banks shrink from 0.51 (1991-92) to 0.44 (1995-96) and further lowered down to 0.41 (2000-01). There was also increase in number of new private sector banks and foreign banks (Das & Ghosh, 2001).

Table 1.4: Progress of Scheduled Commercial Banks (SCBs) in India

S.N.	Indicators	June 1980	March 1991	March 2000	March 2005
1	No. of SCBs	75	75	101	88
2	No. of bank offices	34594	60570	67868	68355
	of which Rural & Semi-urban	23227	46550	47693	47485
3	Population per Office ('000)	16	14	15	16
4	Per capita Deposit (Rs.)	738	2368	8542	16091
5	Per capita Credit (Rs.)	457	1434	4555	10440
6	Deposit (% to national income)	36	48.1	53.5	68.3

Source: Reserve Bank of India- Handbook of Statistics on Indian Economy

After bank reforms in the year 1991 bank slowly moved towards profitability (table 1.5, 1.6 and figure 1.3, 1.4). From the year 1995 SCBs became profitable till 2017. The profitability of Public Sector Banks (PSBs) become more sensitive to the market condition. Illustratively, there was sharp increase in the profit after tax of PSBs from 4.6 billion in 1992-93 to Rs. 431 billion in 2015-16. The decline in financial performance of year 2017-18 was due to deteriorating asset quality which led to sharp rise in loan loss provisioning. Treasury losses and increase in NPA provisions impacted non-interest earnings of banks. The decline in yields of G-Sec portfolio and income from off balance sheet operations led to increase in provisions. The surge in provision requirement dropped the non-interest income of banks. The losses from 2017-18 were 324 billion and started to recover in 2018-19 when losses were reported 233.97 billion.

Table 1.5: Net Profit of SCBs

YEAR	NET PROFIT (BILLION)
1994	-43.49
1997	17.0705
2000	73.064
2003	170.77
2006	245.92
2009	527.71
2012	817
2016	431
2019	-233.97

Source: Reserve Bank of India - *(Operation and Performance of Commercial Banks)*

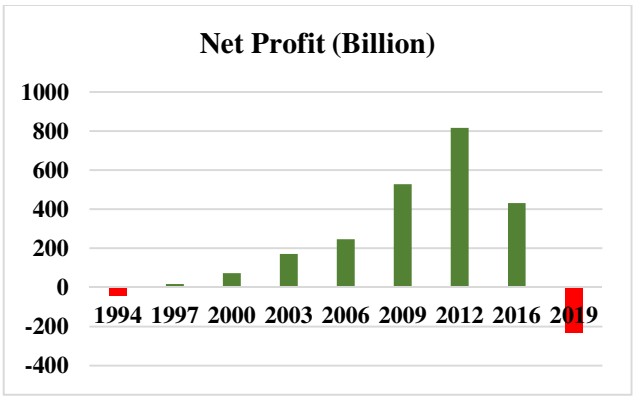


Figure 1.3: Net profit of SCBs (Post Liberalization)

Table 1.6: Return on Asset of SCBs

YEAR	RETURN ON ASSET (%)
1994	-1.15
1997	0.67
2000	0.66
2003	1
2006	0.9
2009	1.01
2012	1.08
2016	0.4
2019	-0.09

Source: Reserve Bank of India - *(Operation and Performance of Commercial Banks)*

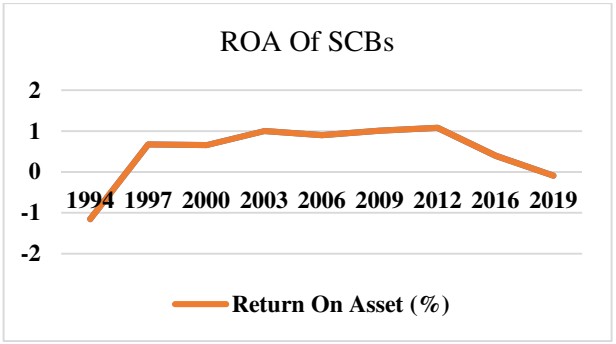


Figure 1.4: Return on asset of SCBs (Post Liberalization)

The reform created an environment for banks to overcome external constraints related to interest rates, reserve requirements (table 1.7), and credit allocation to specific sectors (Kalyan, 2017). Bank rate, CRR and SLR have declined tremendously after the reform. In March 2020, the CRR was 3 per cent and the SLR was 18.25 percent (the legal minimum). The corresponding figures for CRR and SLR as at end March 1991 were 15 percent and 38.5 percent, respectively. The bank rate moved from 12 percent (1991) to 4.65 (2020).

The reforms also focused the social goals of the banks and therefore, RBI directed public sector banks and private sector banks to allocate forty percent of the Adjusted Net Bank Credit to priority sector such as agriculture, small-scale industry, transport operation, small businesses, etc. the priority sector lending limit for foreign banks was set to at least 32%. Direct Credit Lending improved drastically after reforms (table 1.8 and figure 1.5).

Table 1.7: Interest Rate Deregulation

Year	Bank Rate	CRR	SLR
1989-91	11, 12	15	38, 38.5
1992-93	12	15, 14, 14.5	38.5, 38.25, 38, 37.75
1993-94	12	14.5, 14	37.75, 37.5, 37.25, 34.75
1994-95	12	14.5, 14.75, 15	34.75, 34.25, 33.75, 31.5
1995-96	12	14.5, 14	31.5
1996-97	12	13.5, 12, 11.5, 11	31.5
1997-98	11, 10, 9, 11, 10.5	10.5, 10	31.5, 25
1998-99	10, 9, 8	9.75, 9.5, 10, 10.5, 10.25	25
1999-00	8	10, 11, 10.5	25
2000-01	7, 8, 7.5, 7	10, 9.5, 9, 8.5	25
2001-02	6.5	9, 8.5, 8, 8.25, 7.5, 5.75, 5.5	25
2002-03	6.5	5, 4.75	25
2003-04	6	4.5	25
2004-05	6	4.75, 5	25
2005-06	6	5	25
2006-07	6	5.5, 6, 6.5	25
2007-08	6	6.25, 6.5, 7, 7.5	25
2008-09	6	7.75, 8, 8.25, 8.5. 8.75, 9, 6.5, 6. 5.5, 5	24, 25
2009-10	6	5, 5.5, 5.75	25
2010-11	6	5.75, 6	25, 24
2011-12	6, 9.5	6, 5.5, 4.75	24
2012-13	9.5, 9, 8.75, 8.5	4.75, 4.5, 4.25, 4	24, 23
2013-14	8.5, 8.25, 10.25, 9.5, 9, 8.75, 9	4	23
2014-15	9, 8.75, 8.5	4	23, 22.5, 22, 21.5
2015-16	8.5, 8.25, 7.75	4	21.5
2016-17	7.75, 7, 6.75	4	21.5, 21.25, 21, 20.75, 20.5
2017-18	6.75, 6.5, 6.25	4	20.5, 20, 19.5
2018-19	6.25, 6.5, 6.75, 6.5	4	19.5, 19.25
2019-20	6.5, 6.25, 6, 5.65, 5.4, 4.65	3	19.25, 19, 18.75, 18.5, 18.25

Source: Reserve Bank of India- Handbook of Statistics on Indian Economy

Table: 1.8 Direct Credit Lending by SCBs

YEAR	PSL BY SCBS
1980-81	1263
1985-86	2729
1990-91	4676
1995-96	9274
2000-01	16440
2005-06	80599
2010-11	222792
2011-12	312877
2012-13	484499

Source: Reserve Bank of India- Handbook of Statistics on Indian Economy

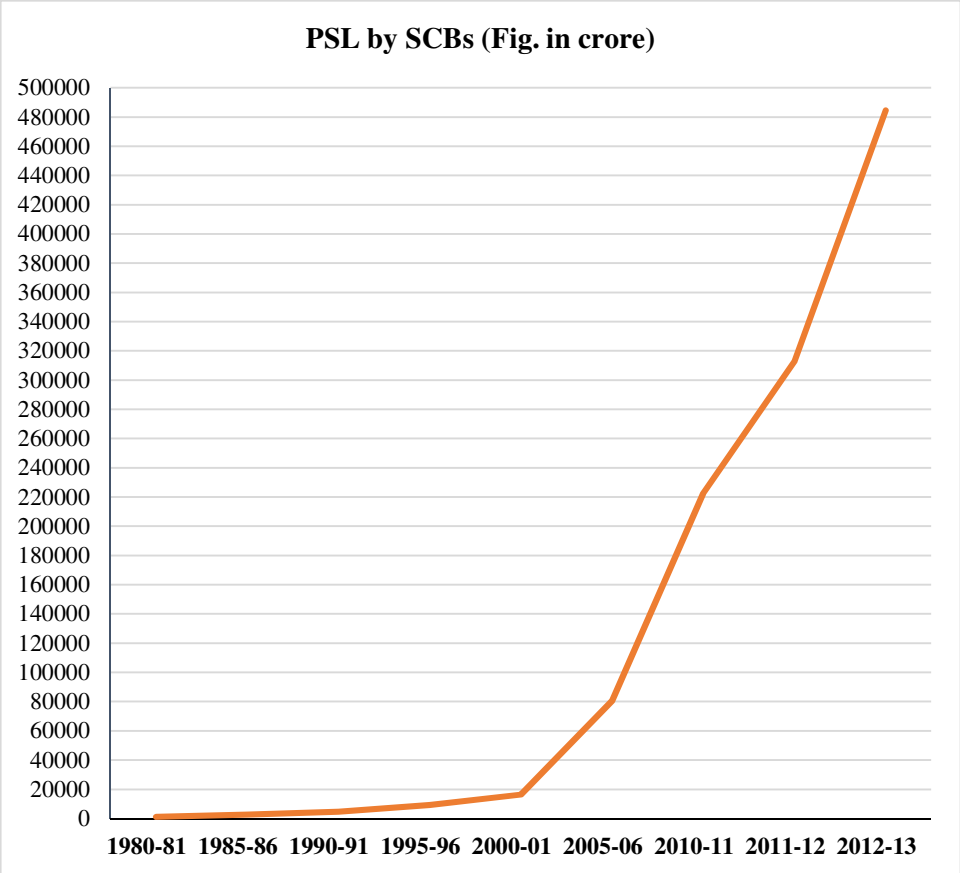


Figure 1.5: Priority sector lending by SCBs (Pre & Post Liberalization)

In earlier years, banks had sufficient funds therefore, banks only focused on asset management. Over a period, fierce competition and volatility in interest rate reduced the availability of low-cost funds which compelled banks to focus on both assets and liabilities management (Chaturvedi, 2014). Banks funds its assets by long-term liabilities and it led to the mismatch between assets and liabilities. The mismatch caused some persistent structural and comprehensive measures and not just provisional. The measures directed banks to concentrate on both assets and liabilities of the balance sheet, thereby originating the concept of ALM. ALM was introduced on 1st April 1999 in Indian Banking System to administer the risk management aspects (RBI, 1999).

ALM is a comprehensive and dynamic framework that concentrate mainly on monitoring, measuring, and managing risk (S. P. Joshi & Sontakay, 2017; Tanwar et al., 2020). The Society of Actuaries Task Force on ALM Principles, Canada, defines ALM as "Asset liability Management is the on-going process of formulating, implementing, monitoring, and revising strategies related to assets and liabilities in an attempt to achieve financial objectives for a given set of risk tolerances and constraints." ("Professional Actuarial Specialty Guide: Asset- Liability Management," 2003). The key function of ALM is to manage various risk, developing strategies for risk management, funding, capital planning, and profit planning with growth projection (Matz & Neu, 2007).

Asset-liability management is a process that facilitates an institution to manage its balance sheet by allowing changes in the interest-rate-sensitive assets and liabilities and liquidity scenario. Asset-liability management provides volatility, product innovation and ensures regulatory and government practices with management recognition (Singh & Tandon, 2012; Van Greuning & Brajovic Bratanovic, 2009). Asset-liability management is considered an appropriate strategy for finance companies, insurance companies, banks, leasing companies, and others as it helps in managing

financial and management risk. It includes formalization and understanding of various risks and identifies the way to quantify and manage those risks. Due to immense changes in the working of the financial institutions around the world, it is essential for the banking organizations dealing in asset and liability, foreign exchanges, and global markets to maintain a good balance in the accounting books so that their long-term viability is maintained. The implementation of ALM is necessary to reduce several risks arising in banking operations like operational, liquidity, interest, and others.

Understanding the ALM concept can help reduce risk and improve the financial soundness of financial institutions (Fabozzi & Konishi, 1991). The ALM process rests on three pillars. The first pillar is known as the ALM information system that includes Management of Information systems and information accessibility so that accounts are maintained accurately and adequately. The second pillar is the ALM organization which consists of structure and responsibilities involving top management for business practices. Finally, the third pillar is the ALM process that undertakes risk identification, risk measurement, and risk management.

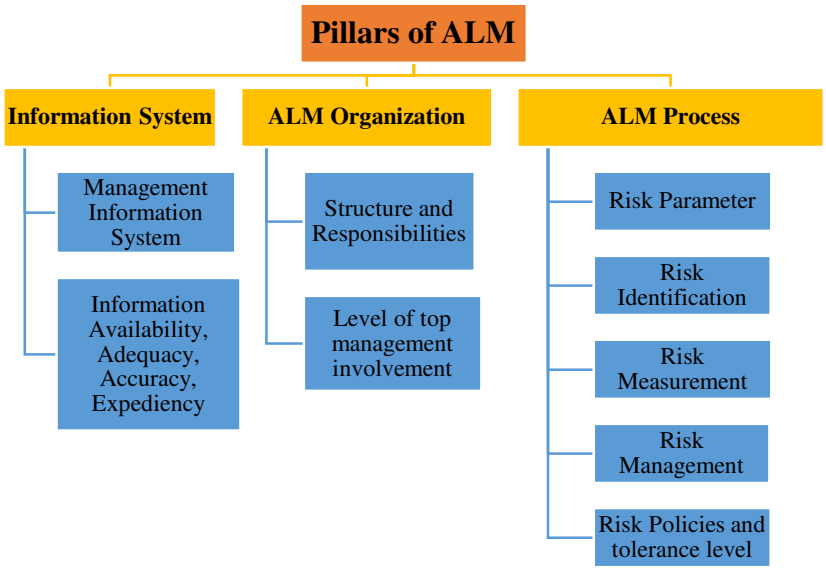


Figure 1.6: Pillars of asset liability management (RBI, 1999)

ALM Information System: The ALM information system is regarded as an essential element of the ALM process. The banking sector in India mainly suffers from connectivity and networking issues, because of which the banks are not able to work together in a well-established coordinated manner. As a result, there is an absence of an adequate system that could be used to gather the relevant information related to ALM. It adversely impacts the residual maturity and working behavioral patterns of the banks, and delays work delivery. Hence, the issues faced at the time of implementation of ALM must be appropriately addressed by adopting the ABC approach, i.e., scrutinizing the accounts of few sample branches for various asset and liability products for significant business and thereafter building assumptions about behavior of assets and liabilities in other branches (RBI, 1999).

This approach synchronizes the foreign exchange, investment portfolio, and activities related to financial market operations to effectively establish an ALM information system. As a result, the banks centralize their operating systems and collect reliable information more easily. It helps to refine the process of data assumption that enables the financial institutions to gain experience regarding commercial activities by using the ALM structure. Moreover, digital technology, computerization, and modernization facilities also help the monetary institutions access the information adequately and efficiently.

ALM Organization*:* ALM organization is further built on the functioning of the Board, Asset - Liability Committee (ALCO), and ALM desk. The first classification of the ALM organization is referred to as the Board, which has the overall responsibility of managing the risks and making decisions related to the risk linked with banking administration policy. It also includes setting

limits for the risks associated with foreign exchange, liquidity, equity price, and interest rate risks (Chaturvedi, 2014; Jayanthi & Umarani, 2014; S. P. Joshi & Sontakay, 2017; K. Singh, 2013).

ALM organization includes the formation of ALCO, which is headed by the senior management officials. The CEO has the prime duty of adhering to the restrictions laid down by the Board and make decisions regarding the business strategies adopted by financial institutions like banks. The Committee is accountable for setting the bank's budget and deciding the objectives related to risk management and performance evaluation. On the other hand, the ALM desk comprises staff that carries out activities related to analyzing, monitoring, and reporting the risk profiles to the ALCO. The team is also responsible for preparing forecasts using simulation and highlighting the effects of possible changes in market conditions on the balance sheet. A future course of action based on the estimates is suggested.

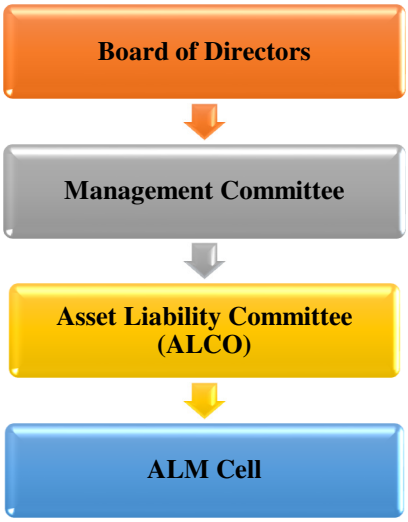


Figure 1.7: ALM Organization (Chaturvedi, 2014; Jayanthi & Umarani, 2014)

The ALCO is regarded as the decision-making unit responsible for balance sheet planning from the risk-return perspectives. It also includes articulating and decision-making related to future business strategies based on current interest rates movement. The decisions regarding the funding policy are based on interest rate movement. All banks have to decide the frequency for holding their ALCO meetings.

The size of ALCO depends on each financial institution's size, organizational complexity, and business mix. All the executives that belong to the top levels of management are included in the committee. It has a CEO, Chiefs of Investment Fund Managers, Treasury (forex and domestic) head, Officials of International Banking and Economic Research, and managers from the Funds Management section that form an integral part of ALCO. It is advisable to include senior officials of the Information Technology Division in the composition of ALCO so that guidance provided by them will support in developing adequate information systems and computerization. Support groups and sub-committees are also formed depending on the organizational size and need.

The Committee of Directors is formed to implement the ALM system and substantiate its successful functioning in the working of banks. In respect to this, the committee known as the Managerial and Supervisory Committee is framed by the banks that consist of expert individuals who have professional learning and expertise in managing and monitoring roles. As a result, due to the efficient working of three to four directors, the reviewing and adoption of ALM functioning are executed periodically.

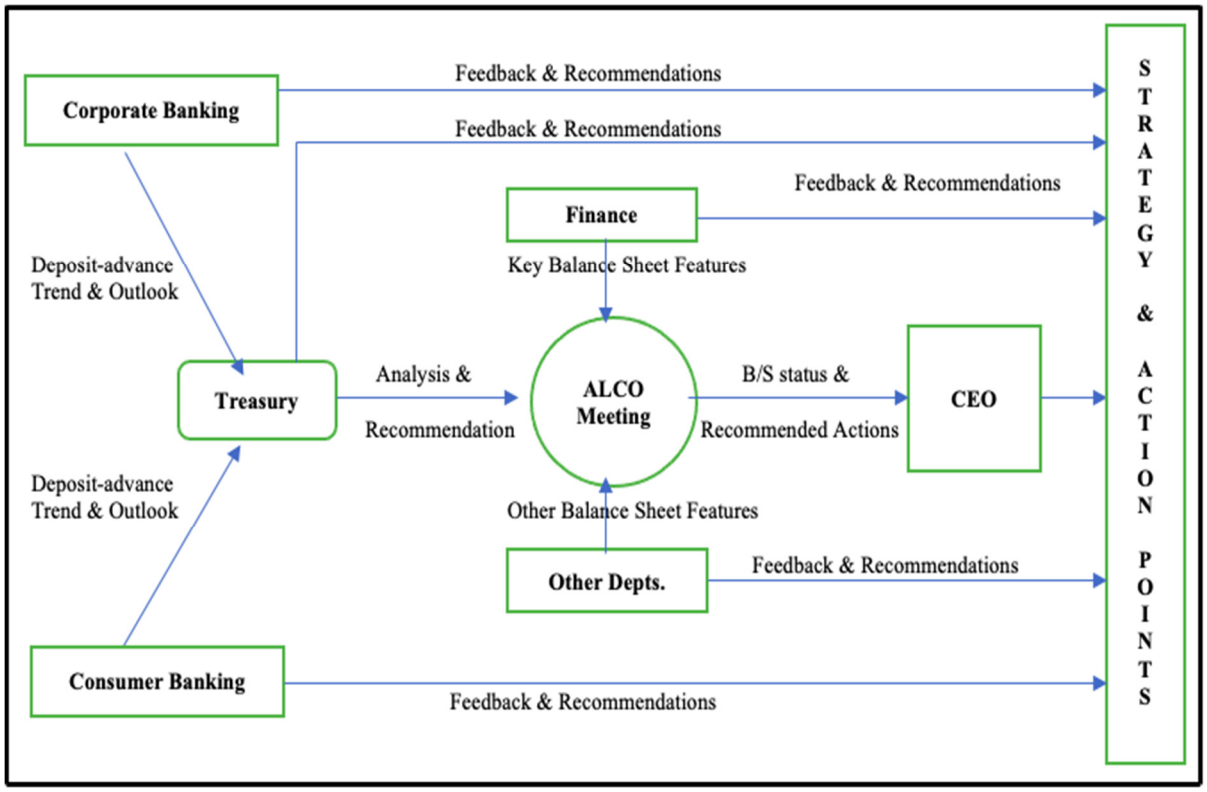


Figure 1.8: Working of ALCO (Chaturvedi, 2014)

ALM Process: The ALM process extends its scope to funding and capital planning, managing liquidity risks, administering trading risks, managing market risks, profit planning, and growth projections. Moreover, the ALM process is also responsible for managing and estimating risks related to liquidity needs that form an essential working operational activity of the commercial banks. The knowledge of liquidity in banks and their management lowers repercussions in the entire organization. The risks related to floating exchange rates are also considered while analyzing the risks associated with the monetary organizations. It defines that the increased flow in the capital always results in deregulation and augments the volume of the financial transactions. It also considers that while dealing with different countries, many opportunities and risks emerge that causes a mismatch of the currency movements. As a result, the implementation of ALM helps in the effective control of the associated risks. For example, ALM analyzes interest rate risks that

help in reducing the operational management of the risks. It is mainly associated with the changes in the current and prospective earnings and assists in meeting the net worth of the financial institutions. It involves the usage of Gap analysis so that assets and liabilities are classified into different buckets as per the time and tenure effectively (Saunders & Cornett, 2008).

The objective of ALM is to manage risk and not to eliminate risk. In finance, risk and rewards go hand in hand. The scope of ALM is related to Liquidity risk, Interest rate risk, and forex risk (Vij, 2001).

Liquidity Risk: "Liquidity risk arises when bank is unable to meet its obligation as they become due without adversely affecting the bank's financial conditions" (Umarani & Jayanthi, 2015). The liquidity risk arises when banks utilize its short-term liabilities to fund its long-term assets. It leads to roll-over or refinance risk (Basel, 2001). It can be measured by the static approach and flow approach. The static approach uses specific ratios to determine the liquidity position of the bank.

The commercial bank needs to properly distribute their outflow and inflow in different residual maturity periods, which is known as a time bucket. For example, asset and liabilities maturing next day, 2-7 days, and so on (Dash et al., 2011; Jayanthi & Umarani, 2014; RBI, 1999, 2007; Anurag Singh & Tandon, 2012). It helps identify mismatches in cash inflow and outflow, which can act as early warning signals of liquidity problems. This approach is commonly known as the flow approach.

Interest Rate Risk: It is change in the Net Interest Income (NII) and change in the value of rate-sensitive assets/liabilities pertaining to change in interest rate. It can be viewed from earning perspective and economic perspective. The techniques used to gauge interest rate risk are Gap

Analysis, Duration gap Analysis, Simulation, and Value at Risk (Dahl et al., 1993; Houpt & Embersit, 1991; Lai & Hassan, 1997; Longstaff & Schwartz, 1992)

The strategies of correcting the mismatch can be applied at both sides of the balance sheet (Seshadri et al., 1999). To explore the effect on the assets side, it mainly focuses on correcting the mismatch, especially in the short-term duration of the portfolio based on financing strategy and securitization. The asset-driven approach primarily focuses on the maturity profile of the asset. On the other hand, a liability-driven strategy mainly focuses on smoothing the maturity profile of the liability. It includes additional equity shares, redeemable preference shares, debenture, and accessing long-term debt such as bank borrowing and term.

The focus of the banking industry is to maximize the return and lower their risk exposure by optimizing the asset-liability mix. RBI has issued several guidelines for Indian Banking System to regulate the asset-liability position and maintain the stability of the financial system. Therefore, ALM is considered an indispensable tool to mitigate risk in the bank and ensure that they work properly while simultaneously increase their performance levels.

1.3 RESEARCH PROBLEM

Banks play a key role in mobilizing the deposit and distribution of credit in different sectors of the economy (Anthony, 2012). An effective banking system help to maintain financial stability and provide the financial strength of the individual bank that is considered a significant participant in the financial system. The reform that began in 1991 transformed the structure of banking industry. As a result banks stepped into the non-traditional area, creating diversified income with diversified activity, and providing core banking services effectively (Pennathur et al., 2012). Even though

banks are performing consistently and follow strong fundamentals, one problem has caged the banking industry, i.e., Asset Liability Management.

In ALM balance sheet is managed in consideration of its size, quality, and components. It helps management make better business decisions by providing information to managers about the current market risk profile and state the impact of business decisions on future risk profiles. ALM has Macro-level objectives and Micro-level objectives. Macro-level objectives deal with the formulation of policies, allocating capital, and innovating products with pricing strategy. At the micro-level, ALM focuses on achieving higher profitability through price matching and maintaining liquidity through matching the liquidity concept. There is a statistically significant relationship between ALM and financial performance (Hester & Zoellner, 1966; Kosmidou et al., 2004; Lai & Hassan, 1997)

Later, more and more banks and financial institutions shifted their focus to Asset-Liability Risk. Banks, asset management companies, and other financial institutions realized that the problem is not that asset value would reduce or value of liability would increase. Instead, they found that its capital might be impacted. The capital might deplete if the difference between assets and liabilities will narrow down. ALM is a leveraged form of risk. As it is seen that financial institutions have small capital as compared to their assets and liabilities; therefore, even the slightest percentage change in assets/liabilities can lead to a relatively more significant percentage change in capital.

The function of ALM is Risk protection and ensuring that the institution's net worth is increasing through opportunistic positioning of the balance sheet. The criticality of the ALM function depends on the leverage. ALM tries to minimize the mismatch between the assets and

liabilities. There is a positive correlation between the firms' ALM processes and financial performance (Anjili, 2014).

As it is evident that the ALM process directly affects the financial performance of financial institutions, it is essential to have an effective ALM process that can closely monitor and manage both assets and liabilities. The complexities in our economy and its increasing size have increased the importance of ALM manifold. It is, therefore, this topic is taken under study (Vossen, 2010). Consequently, it is imperative to explore the interrelation between the asset or liability side of the balance sheet for securing the highest growth effectively (Anurag Singh & Tandon, 2012).

1.4 SIGNIFICANCE OF THE STUDY

Every business needs to ensure capital availability because it is considered a core element for all commercial activity. As a result, the allotment of capital resources is regarded as one of the most critical functions of financial intermediaries like banks and other organizations to conduct economic activity effectively. Asset-liability management is considered an ongoing process that mainly focuses on framing, supervising, implementing, and scrutinizing the strategies related to the maintenance of assets/liabilities of the banks. It also helps to achieve the financial objective by considering the risk and return.

The study pinpoints the significance of ALM in the bank to optimize stakeholders' objectives. It analyses how ALM help in the risk management and achieving higher profit by taking into consideration market share of the deposit, market share of credit, return on asset, return on equity, capital adequacy, liquidity, and other risks in the light of statutory regulations notified by RBI from time to time. The study also discusses the current issues and problems related to the

study area and highlighting the rationale behind pursuing the current topic of the research. It helps in understanding the ALM strategies and procedures implemented by the bank to manage their asset-liability. The study in assets and liabilities of the banks in India encouraged to optimize the assets and liabilities of the bank, achieve set goals, and fulfil the regulatory and management constraints.

1.5 THESIS STRUCTURE

The remaining structure of thesis is as follows:

Chapter 2: Literature Review

This section will focus on the concept of asset-liability management. This chapter covers the history of ALM, its emergence, and its need in India. Literature review is conducted on ALM, risks associated with ALM, basic techniques used in asset-liability management, the strategies to overcome risks, Goal Programming technique, and CAMEL approach. The gaps identify in the literature review will determine the objectives of the thesis.

Chapter 3: Research Methodology

This chapter will determine the sketch of the research conducted. The chapter will discuss the approach to conduct the study objectives. It will determine the rationale behind the selected method and data analysis approach to achieve the objective of the study. The tools and techniques used in the study are also discussed in this chapter.

Chapter 4: Results and Discussions

It will present the models employed for the study and empirically examine the objectives and test the proposed research model. This chapter discusses the result of responses collected from bank officials on ALM strategies and risk management. The results will also show how banks can improve their efficiency and profitability by reallocating the assets and liabilities.

Chapter 5: Findings, Limitations, and Future Scope of Study

This chapter summarizes the most significant findings and key takeaways from the research. The implication of the theory and practice that are usable by academicians, researchers, managers, policymakers are highlighted. The limitation and future scope of the study are discussed for promoting ideas from the study. Lastly in conclusion we summarize the study.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION OF ALM IN THE INDIAN BANKING SECTOR

Most banks in international economies started strategic planning for asset and liabilities management in 1970s (Goodman & Langer, 1983). At that time, Indian banks were free from interest rate risk as it was regulated and governed by Reserve Bank of India (Chatterjee & Dutta, 2016). When other economies were planning for deregulation and Asset-Liability Management (ALM), Indian banks were under the phase of nationalization (in 1969). The restructuring phase that started in 1991 brought a paradigm shift in the banking sector. The purpose of reform was to make banking system sensitive to the changes happening in the market environment. To achieve the purpose, the function of RBI as micromanagement of banks' operation need to be switched to macro governance (Das & Ghosh, 2001).

Before liberalization, banks managed the balance sheet under the instructions of regulatory authorities and government. After liberalization in 1991, there was the deregulation of interest rates, and the banks were given complete freedom to manage their Balance Sheets. Therefore, the ALM guidelines became essential for the banks to help them prevent significant losses by aligning assets and liabilities mismatches. The Reserve Bank of India provided the first directives regarding ALM implementation in February 1999, which came into effect on 1st April 1999 (Anurag Singh & Tandon, 2012).

Banks carried on the ALM process as per the guidelines prescribed by RBI. Information technology and management of information systems were keys for the successful implementation of ALM. Banks were required to redesign their strategies to meet future challenges. ALM developed in three phases over the years to match the increasing volatility of the financial market.

Phase 1: The volatility in the global financial market initiated the first phase in the mid-1970s.

Phase 2: Growth of new financial products provided by financial institutions in the 1980s started this phase.

Phase 3: This phase started with the spread of awareness at the top management level about the risk-taking capacity of banks. An increase in market risk determined the need for ALM as part of strategic planning. In the 1990s, new ALM technologies and software began to develop.

Asset Liability Management (ALM) is known as a monetary arrangement process by which planning, implementing, supervising, and scrutinizing strategies are implemented to maintain the assets and liabilities of the firm. It helps in attaining organizational financial objectives by estimating the risks and constraints (Romanyuk, 2010). ALM is also regarded as an essential tool used by banks to conduct risk management activities such as market risk, financial risk, interest rate risk, and others (Fabozzi & Konishi, 1991). It is responsible for performing economic activities such as risk management of liquidity, project planning, trading, growth projection, capital planning, funding, and market risks. It is also referred to as a process through which an organization manages and maintains its bookkeeping records to analyze interest rate and liquidity risks (S. Chakraborty & Mohapatra, 2008).

As per the ALM guidelines, the asset and liability management has been classified in eight maturity brackets belonging to different days such as 1-14 days, 15-28 days, 29-90 days, 90-180 days, 181-365 days, 1-3 years, 3-5 years and above 5 years. In the accounting procedures, all the assets are considered inflows, and all the liabilities are rendered as outflows that are to be managed and monitored as per the time brackets mentioned in the structural liquidity statement of the banks. Further, to bring significant improvements in the working of the banks regarding the implementation of ALM, the Reserve Bank of India fine-tuned the guidelines related to the liquidity management and term-money market in 2007. As per the new guidelines issued in 2007 by RBI, the 1-14 days maturity bucket has been divided into three brackets, leading to 10 maturity brackets in total. The RBI recommended that the mismatches of the banks must not exceed more than 5%, 10%, 15%, and 20% during the next day, 2-7 days, 8-14 days, and 15-28 days respectively (RBI, 2007; Singh & Tandon, 2012). The objective of RBI is to enforce the deviation within the prescribed limit of tolerance level in banks.

The banks were required to ensure 100% coverage of data to compile a statement of structural liquidity once a month since 1st April 2008. Every month on third Wednesday banks create statement of structural liquidity and submit it to the RBI. Additionally, the banks were guided towards the formation of the Asset–Labiality Committee (ALCO) to look over the ALM practices and their implementation in Indian banks and other financial organizations. It is to be headed by the Executive Director (ED) or Chairman and Managing Director or Chief Executive officer who monitors the risk levels of the banks. The RBI also recommended that the banks implement traditional techniques such as Gap analysis to supervise the liquidity risks and interest rates risk. The application of simulation, duration, and value at risk can also monitor the risks

mentioned above (Singh, 2018). The ALM practices are implemented through a three-tier structure:

- ALM information system,
- ALM organization (structure and responsibilities) and
- ALM process (recognizing risks, estimation, administration, and setting of policies) (Chaturvedi, 2014; Jayanthi & Umarani, 2014; S. P. Joshi & Sontakay, 2017; K. Singh, 2013).

2.2 ASSET LIABILITY MANAGEMENT IN BANKING

Asset Liability Management (ALM) is known as a monetary arrangement process by which planning, implementing, supervising, and scrutinizing strategies are implemented to maintain the assets and liabilities of the firm. It helps in attaining organizational financial objectives by estimating the risks and constraints (Romanyuk, 2010). ALM is also regarded as an essential tool used by banks to conduct risk management activities such as market risk, financial risk, interest rate risk, and others (Fabozzi & Konishi, 1991).

Efficient management of interest rate risk and liquidity risk are two main activities of banks that are managed by ALM. Umarani & Jayanthi (2015) analyzed ALM in SBI & Associate banks. The liquidity position of banks is determined through maturity profiling method and maturity gap was analyzed and compared to measure the liquidity risk in bank. Meena and Dhar (2014) and Vij (2001, 2005) studied few bank in India using traditional gap analysis to measure liquidity risk and interest rate risk . Mismatch in assets and liabilities exposes the balance sheet to liquidity risk. Dash et al. (2011) used maturity gap analysis to determine and compare the liquidity position of

public, private, and foreign sector banks. Chattha et al. (2020) used duration gap analysis to comparative analyze ALM practices in Islamic Commercial Banks (ICBs) and Conventional Commercial Banks (CCBs). The findings report that ICBs have 2.41 times more variation than CCBs and are exposed to liquidity risk.

Prince Paul Antony (2018) studied the impact of ALM on profitability using ratios such as current asset to deposit ratio, credit-deposit ratio, debt-equity ratio, current ratio, and quick ratio. Anjili (2014) studied the effect of ALM on financial performance of bank using CAMEL approach. Chakraborty and Mohapatra (2008) studied ALM in banks and applied canonical correlation to explore the relationship and strength between assets and liabilities. Abou-el-sood and El-ansary (2017) also determined the interdependencies between asset and liability portfolios in Islamic banking using canonical correlation. It was analyzed that decision for funding source depends on asset portfolio. Islamic banking depends less on equity to finance investment during economic boom than in economic turmoil. Kosmidou et al. (2004) applied statistical cost accounting method to investigate the correlation between profitability and asset-liability composition. It was found that high profit banks manage to procure funds at lower cost, which helps in managing losses from lower return on assets. Jain et al. (2010) presented fuzzy programming model for pensioners to control risk of underfunding. It dealt with unusual uncertainty of return on investment and future liabilities.

Black et al. (2003) determined the essential factors for instigating the transformation in ALM i.e., market risk management, amendments in accounting and regulatory rules; and lastly technological advancements. Fiedler et al. (2002) described that due to advancement in software both earnings and value can be supported by single, integrated, and analytical framework to determine earnings sensitivity and future market valuation across dynamically modelled balance sheets.

The restructuring of banking system that began in 1991 combined with varied global developments unveil banks to liquidity risk, foreign exchange risk, credit risk and interest rate risk, etc. and thereby directly affecting the productivity and profitability of banks. As easing the control on interest rate increased volatility in the market, there is need to measure interest rate exposure. Charumathi (2008) (K. Singh, 2013) measured interest rate risk using re-pricing gap analysis and duration analysis. (Seshadri et al., 1999) studied the strategic asset-liability management by developing a simulation model that can generate output in the form of dividend, market value, duration of capital for randomly generated interest rate scenarios. This approach can be used to formulate, test, and refine asset-liability strategies.

2.2 RISKS IN BANKING

The banks face different types of risks such as interest rate risk, liquidity risk, exchange rate risk, operation risk, and credit risk while carrying out the core banking functions (F. Ahmad & Bashir, 2013; Banker et al., 1984; Dash, 2013; Goldstein & Turner, 1996; Kalyan, 2017; Kamarudin et al., 2019; P. Lin et al., 2015; V. R. Singh, 2016; Yannick et al., 2016). Moreover, there are issues related to inadequate and inefficient management practices that create risks associated with asset and liability management (Bace, 2016; Chakraborty & Mohapatra, 2008; Dash, 2013; Dash et al., 2011; Dash & Pathak, 2011; A. K. Meena & Dhar, 2014; Rahul Ranjan & Nallari, 2005; Romanyuk, 2010; Azizi & Neisy, 2017; Sheela, 2015; Vij, 2005; Zenios, 1995; Ziemba & Mulvey, 1998). This section of the chapter focuses on the risk associated with ALM which are considered in the study.

Interest Rate Risk

Administrative restrictions on interest rates have been eased in India after 1993. It led to unparallel system of increased interest rate volatility (Bhattacharyya et al., 1997; Chaturvedi, 2014; Debasish, 2008; Zhou & Zheng, 2017). The interest rate volatility has created an urge to evaluate and control interest rate risk in banks. If interest rates will continue to increase, it would hurt banks who have funded long-maturity assets using short-maturity liabilities (Acharya, 2018; Patnaik & Shah, 2002a). As per Basel committee on Banking Supervision (2004), interest rate risk is mainly segregated into four types i.e., basis risk, yield curve risk, optionality risk and re-pricing risk.

Asset-liability mismatch is a part of asset transformation function that expose banks to interest rate risk (S. Chakraborty & Mohapatra, 2008; Dash et al., 2011; K. Singh, 2013). Interest rate volatility influences the profitability and thereby affecting the stock price of banks (Banz, 1981; Kiwan, 1991; Ngalawa & Ngare, 2014). It can be said interest rate fluctuations highly impact the earnings and economic value of the financial institutions (English et al., 2018). If liabilities are highly responsive to changes in interest rate than assets, a slight rise in interest rate will reduce profits and vice versa (Darshan & Suresh, 2020).

If banks hold long-term assets relative more than long-term liabilities, it certainly increases the refinancing risk. When rolling over cost or cost of reborrowing funds is higher than return earned on investment, it is called refinancing risk (Ballester et al., 2009; Vaidya & Shahi, 2005). However, if banks hold short-term assets relative more than liabilities, it can lead to reinvestment risk. Apart from these risks, banks can also face market value risk pertaining to interest rate volatility. The market value of an asset or liability can also be measured by discounted future cash flows from the asset. The rise in interest rates is positively correlated to discount rate. Increase in discount rate will

reduce the value of cashflow and thereby reduce the market value if asset/liability. (Drehmann et al., 2006; Pitts, 1985; Saunders & Cornett, 2008). Interest rate volatility exposes banks and other financial institutions to the risk of economic loss and insolvency (Charumathi, 2008; Sheela, 2015).

There are several factors that affect interest rate risk. Bank size and loan to total asset ratio are significantly and positively related to interest rate risk. Larger banks have opportunity to undertake riskier strategies pertaining to operating advantages such as better access to capital market and diversification. Capital and non-interest income ratios has no significant influence on the interest rate exposure of bank (Ballester et al., 2009). Fraser et al. (2002) argued banks that uses more equity than deposits to finance large portion of assets have less interest rate risk. Tumwine et al. (2018) studied banks in Uganda. It was observed that interest rate is affected by factors such as liquidity, operational efficiency, capitalization and lending out ratio. However, it is not affected by credit risk.

Saporoschenko (2002) studied that bank stock returns are negatively linked to long-term interest rate. Market return innovations (shocks) have high significance on Japanese bank stock returns and these banks assume more risk. Al-gasaymeh et al. (2021) revealed that systematic risk brings fluctuations in stock price and return. The mixed results of systematic interest rate risk and foreign exchange risk opens up opportunities for hedging and diversification strategies in GCC countries. During financial crisis banks have more liquidity due to diversification opportunities in different regional market. Darshan and Suresh (2020) estimated the elasticity of returns on the stock market after applying 'Augmented Market model'. The interest rates have positive impact on stock returns whereas it has weak predictive power for volatility. There is heterogeneity across Indian banks for interest rate exposure.

Interest Rate Risk is important and so are its hedging strategies. Many companies rely heavily on financial derivative to manage interest rate risk (Dhanani et al., 2008). Au Yong et al. (2009) studied the market perception of interest rate risk and foreign exchange risk on the level of derivative activities in Asia Pacific banks. Interest rate derivatives are positively linked to long-term interest rate (LTIR) exposure however, negatively linked with short-term interest rate exposure. Extensive derivative activities affect the LTIR. Ngalawa and Ngare (2014) discussed those commercial banks are largely exposed to interest rate that can be estimated though income gap. Income gap is also sensitive to market interest rates.

The effects on interest rate uncertainty can be hedged via interest rate swap market. Adverse movement in interest rate slowdowns the economic activity. Financially constrained companies face difficulty due to interest rate uncertainty and as risk management through swaps is risky (Bretscher et al., 2018). Asset-based nature of Islamic banks has potential to reduce systematic risk which may arise from interest-bearing assets (Yuksel, 2017).

Liquidity Risk

Liquidity is potential of banks to increase their funds and meet financial commitment without making any unacceptable losses. The liquidity risks mainly occur when there is a difference between the inflow and outflow of assets and liabilities that creates issues in maintaining the banking accounting procedures. The financial crisis that began in 2007-08 created hardship for financial institutions, especially banks, due to inadequate liquidity risk management (Cucinelli, 2013; Roman & Sargu, 2015). The liquidity crisis that originated in other countries affected Indian banks (Acharya & Kulkarni, 2012; Eichengreen & Gupta, 2013; Shukla, 2014). Liquidity risk is

inherent in the nature of banking. Therefore, it is essential for banks and regulatory authorities to understand liquidity risk and frame policies, regulations, strategies to mitigate the risk.

The liquidity risk is highly affected by the changes occurring in the foreign currency, interest rates, and market changes because of pre-maturity or early withdrawal of the deposits (A. K. Mishra et al., 2012). The maintenance of the liquidity risk is essential so that the banks meet their fiscal obligations and lower down the propensity of any adverse situation in the market (Subramoniam, 2015). The liquidity risk results in financial crises and creates issues in the adequate functioning of the financial markets (Basel-III, 2013). It covers two main aspects: maturity transformation and inherent liquidity, which are subject to market changes (Bace, 2016).

Banks create liquidity on the balance sheet by financing relatively illiquid assets with fairly liquid liabilities (Bryant, 1980; Diamond & Dybvig, 1983). Banks also form liquidity off the balance sheet through loan commitments and similar claims to liquid funds (Berger & Bouwman, 2009; Holmstrom & Tirole, 1998; Kashyap et al., 2002a). It maintains a balance in liquidity risk and liquidity creation by creating equilibrium in demand deposit accounts and undrawn credit lines. Banks capable of supporting this equilibrium performed better than others (Gatev et al., 2004). When a bank faces liquidity risk, it also leads to a downturn in new business. Liquidity risk reduces resource generation and increases the deposit withdrawal that promote recessionary economic conditions. All these financial fluctuations and changes in the financial market negatively impact the entire working of the banking system (Diamond & Rajan, 2003).

Banks with low liquidity are forced to sell their assets to create cash inflow. Illiquidity creates fire sale of securities and investments, credit restrictions, and liquidity hoarding (De Haan & van den End, 2013; Hurd, 2018). In such a situation, highly liquid banks can purchase assets at a high discount and grow in business (Acharya et al., 2009; Vossen, 2010). Bank run shows banks' proneness to liquidity risk and its serious impact on the economy (Calimani et al., 2017; Mirza et al., 2020; Park & Bernardin, 2018).

Several studies on bank liquidity emphasize the factors influencing bank liquidity, i.e., bank size, capital, profitability, cost of fund, ownership, net interest margins, and deposits, etc. (Acharya & Kulkarni, 2012; Bonner et al., 2013; De Haan & van den End, 2013; Dinger, 2009; Distinguin et al., 2013; Kashyap et al., 2002b; G. Kaur & Sharma, 2017). It was asserted that profitability of banks positively impact bank liquidity (Choon et al., 2013; Dzapasi, 2020; Singh & Sharma, 2018; Vodová, 2011). However, Delechat et al. (2012) found that banks' profitability is negatively related to bank liquidity. Banks invest in risky assets to increase profits in the short run. However, such risky investments are prone to a high probability of losses which may have impact on banks' working. Therefore, banks keep more liquid assets to avoid bank runs.

Aspachs et al. (2005) asserted that bank size and profitability have insignificant relation with liquidity. Whereas, Alger and Alger (1999), Bonner et al. (2013), Kashyap et al. (2002), Bunda and Desquilbet (2008), and Singh and Sharma (2018) determined that bank size has a negative effect on bank liquidity. The study of Bhati and Zoysa (2015) argued that size positively impacts bank liquidity.

Liquidity risks also cause impairment of capital base and imbalances the accounting sheets of the financial institutions (Diamond & Rajan, 2001; Falconer, 2001; Goddard et al., 2009). It is essential to introduce corrective regulations so that the financial crises that emerge because of liquidity risks are reduced (Hlatshwayo et al., 2013; Naqvi, 2015). In respect to this, Basel III regulations have been introduced that address the financial crises and strengthen the bank capital and liquidity standards adequately (Hlatshwayo et al., 2013). Banks with high capital increase risk-absorbing magnitude and liquidity creation capacity (Berger & Bouwman, 2009; Munteanu, 2012; Vodová, 2011). During liquidity crunch, capital saves banks from its ill effects by acting as a buffer and provides liquidity to the bank (Bunda & Desquilbet, 2008; Munteanu, 2012; Vodová, 2011). Therefore, banks with high capital take greater risk and generate more profits, thereby maintaining high liquidity (Al-Homaidi et al., 2019). The accuracy of banking practices and holding liquid buffer is vital for banks (Chen & Phuong, 2013; M. Kumar & Yadav, 2013; Ratnovski, 2013).

NPA and Net interest margin (NIM) have a negative effect on liquidity. It shows that bank officials must work on loan recovery and reducing NPAs. Reduction in NPA will enhance the liquidity creation capability and increase profitability for banks (Al-Homaidi et al., 2019; Drakos, 2003; Michael et al., 2006; Anamika Singh & Sharma, 2018).

The banks follow investment norms and comply with the regulations associated with maintaining SLR and CRR to provide a safe monetary environment (Jain et al., 2010). SLR is minimum percentage of the Net Demand and Time liability that a commercial bank has to maintain in the form of cash, gold, or any other liquid asset. It is the reserve requirement that banks are contemplated to set aside before giving credit to customers. SLR can be calculated by dividing liquid asset by Net demand and time liability (Kapparashetty, 2019; Rawat, 2014; K. N. Reddy,

2018; Talreja, 2014). The RBI in 1985 increased this ratio up to 37% so that it can inject money into the economy (*Chronology of events*, n.d.). RBI is also responsible for ensuring steady supply of money and stabilizing prices in the Indian economy. As a result, the statutory liquidity ratio affects different monetary policies and instruments that facilitate the flow of money in the economy.

The statutory liquidity ratio has been recorded to be 40% as an upper limit and 18% as a lower limit that enables commercial banks to increase or decrease the flow of bank credit during the inflation or recession period. If banks are unable to create SLR at required percentage, then such banks shall pay to RBI penalty at 3% per annum on the shortfall for that day. It shall pay penalty at 5% per annum for subsequent days till the default (V. V. R. Kumar & Gupta, 2013; Rani & Rao, 2012; RBI, 2015).

As per Section 24 of the Banking Regulation Act 1949, there is a strong relationship between statutory liquidity ratio (SLR) and bank-based components such as liquid assets, gold, treasury bills, government-approved securities, government bonds, and cash reserves. The main motive of SLR is to secure the commercial bank from liquidity risk. SLR ensures solvency in a commercial bank by making investments in government securities (Acharya, 2018).

On the other hand, the cash reserve ratio (CRR) is a share of the bank's Net Demand and Time liability which is mandatory by the bank to be maintained in the form of liquid cash with RBI. When RBI decides to increase the CRR, the money available in the bank reduces, which helps control the excess flow of money in the Indian economy. The cash reserve ratio is one of the critical components of the RBI monetary policy used to regulate the supply of money, inflation levels, and liquidity (Chaudhury, 2018; Kesavan, 2015; Anamika Singh, 2014). For example, if

the cash reserve ratio is higher, the bank's liquidity will be low and vice versa (M. U. Ahmad, 2014; Kapparashetty, 2019; Rani & Rao, 2012). After complying with CRR, SLR, and daily requirements, the available funds may be invested in assets - loans, advances, investments, and equity to gain maximum returns.

Credit Risk

Credit risk is the inability of the borrower to repay the loan taken by him/her back to the lender and fails in meeting the contractual obligations (Athanasoglou et al., 2006; Bielecki & Rutkowski, 2004; Borio et al., 2020; Rajiv Ranjan & Dhal, 2003; Riyazahmed & Baranwal, 2021). Hence, it is regarded as the risk that is borne by the lender against giving credit or loan to the borrower. The condition of credit failure or non-payment mainly occurs when there is a shortage of income-earning possibilities or a business failure experienced by the borrower (Rodean et al., 2016). The banks provide loans to prospective takers at prevailing interest rates and bear the risk of unpaid loans while doing the business. As a result, when there is a non-payment of credit by the borrowers, it creates a loss in the credit asset value that reduces the current and future earnings of the banks (Gakure et al., 2012; Ibtissem & Bouri, 2013). For example, all the significant banks globally suffered from credit risk losses because of default in the mortgage payments (Borio et al., 2020; "Global Economic Prospects," 2020; Goddard et al., 2009; Mandell, 1973).

Credit risk impacts the performance of banks as few significant defaults by customers on loans can create liquidity problems, increase the cost of recovery, reduce interest income (Bielecki & Rutkowski, 2004; Borio et al., 2020; Kessey, 2015). The Credit Risk Management (CRM) process maximizes the cost-adjusted rate of return of a bank by maintaining exposure to credit risk acceptable

to its shareholders. Banks have to estimate the credit risk of portfolio and external risks pertaining to macroeconomic factors in the economy (N. H. Ahmad & Ariff, 2007; Rehman et al., 2019).

Risk assessment techniques are critical in the management and mitigation of credit risk. Management of loan portfolios depends on knowledge related to the risk posed by the individual borrower and individual credit service (Sabato, 2011). The credit risk assessment of the borrower can be performed by studying, evaluating, and analyzing the qualitative as well as quantitative indicators of the financial condition of the borrower (Beaulieu, 1996; Konovalova et al., 2016; Ngwa, 2010; Strischek, 2017).

Banks assess the risk factors before granting the loan. The comprehensive and systematic analysis of factors affecting credit risk assist banks in preventing such risk and its impact on bank's profitability (Riyazahmed & Baranwal, 2021). The techniques of quantifying credit risk need to be transparent, accurate and robust (Borio et al., 2020; Giesecke, 2004). Transparency is an essential characteristic of credit risk assessment methods. Methodological transparency depends on the accuracy of the mathematical process, reduction in the subjectivity of expert's assessment, clarity in result related to risk assessment and its analysis, understanding of bank employees in the matter of credit risk, and accessibility of methods to regulatory authorities and borrowers.

Banks should assess credit risk factors for further analysis and monitoring risk. The accuracy of risk recognition and assessment influences the banks' decision to grant loans, refuse to provide a loan, the interest rate to be charged, and provisioning of loan default.

Based on literature review it can be concluded that with the use of ALM, the banks ensure that the risks like interest rate risk and liquidity risk that emerge because of mismatch between the asset and liabilities are managed accordingly. ALM also undertakes other risks such as credit risk, foreign exchange risk, legal and regulatory risk etc. while performing balance sheet planning. Hence, the introduction of ALM practices in the working of the banks is necessary to reduce the risks faced by the financial institutions.

2.4 TECHNIQUES USED IN ASSET LIABILITY MANAGEMENT

ALM manages the risks that the banks face in the form of a mismatch of the asset and liabilities (Dash, 2013; Dash et al., 2011; A. K. Meena & Dhar, 2014; Sheela, 2015; Vij, 2005; Zenios, 1995). The appropriate implementation of ALM manages financial risk and interest rate risk, thereby improving profitability (Bogentoft et al., 2001). Financial institutions spend a large number of resources on managing such risk. Different tools are used by the financial institutions, such as Gap analysis, Duration analysis, value-at-risk method, and risk management process implemented by banks.

Gap Analysis: The maturity gap analysis measures the effect of volatility in the interest rate on interest income and interest expense. Gap analysis helps financial institutions to determine the percentage change in net interest income (NII) to percentage change in interest rate.

$$\text{Gap} = \Delta \text{ NII} / \Delta \text{ r},$$

where Δ NII determines a change in net interest income due to a change in interest rate (Δ r).

In the ALM process, gap analysis is highly applied in quantitative aspects like rate-sensitive groups compared to insensitive groups such as float funds, current deposits, and others. It is effectively used to estimate rate sensitivity present in the diversified segments of assets and liabilities concerning identical segments of assets and liabilities (Brown & Swartz, 1989). Gap Analysis is the technique used by banks to measure interest rate risk. The difference between the rate-sensitive asset (RSA) and rate-sensitive liabilities (RSL) is calculated for different time brackets as per their maturity or remaining time (Vij, 2005). It focuses on the change in net interest income with a change in interest rates in different maturity buckets (Singh & Tandon, 2012). If there is a positive Gap, it denotes that RSA is more than RSL and vice versa. With a rise in interest rate, the positive gap will increase, impacting the prospect of earnings. Repricing gaps are also determined for assets and liabilities. Assets are repriced before liabilities if there is positive gap and vice versa. However, if there is a negative gap, an increase in interest rate will decline the earnings. Gap report measure mismatches of interest cash flow of balance sheet items and off-balance sheet items (Singh, 2013).

Table 2.1: Effects of Change in Interest Rates

GAP	CHANGE IN INTEREST RATE	CHANGE IN NET INTEREST INCOME
Positive	Increase	Increase
Positive	Decrease	Decrease
Negative	Increase	Decrease
Negative	Decrease	Increase
Zero	Increase	Zero
Zero	Decrease	Zero

Source: (Jayanthi & Umarani, 2014; S. P. Joshi & Sontakay, 2017)

Duration Analysis: Macaulay (1938) and Hicks (1939) originated the concept of duration. Duration gap analysis examines the sensitivity of the market value of security to change in interest rate. According to Vij (2005), "Duration is the time-weighted average maturity of the present value of the cash flows from assets, liabilities and off-balance sheet items." It examines the relative sensitivity of assets and liabilities to fluctuations in interest rate. it could be stated that duration analysis reviews the impact of changes in interest rate on the banks' economic value i.e., the present value of equity. It measures the average lifetime of securities' stream of payments (Mishkin, 2007). The sensitivity of market value of security to change in interest rate can be determined by:

$$\% \Delta P = - Dur * \Delta i / 1 + i$$

where, $\% \Delta P = (P_{t+1} - P_t)/ P_t$ (percentage change in market value of security)

Dur = Duration

i= interest rate

$DUR_{gap} = DUR_a – [L/A * DUR_l]$

DUR_a = Average duration of asset

DUR_l = Average duration of Liability

L = Market value of liabilities

A= Market Value of Assets

Bank officials can measure the duration of assets and liabilities using the given formula. The responsiveness of market value of assets/liabilities to fluctuations in interest rate can be ascertained

by duration analysis. Later, the impact of change of the market value of assets and liabilities on net worth can be estimated.

Scenario Analysis: Scenario analysis is the process through which the analysis of the anticipated value of the portfolio is determined after a specified duration of time (Darshan & Suresh, 2020). It helps estimate the alterations and modifications that occur in the portfolio's value against the unfavorable events happening in the market (Brzaković et al., 2016). Scenario analysis is a process that helps in the integration of intuitive learning and future judgments by using analyzing models. It initiates the recognition of the issues so that there is a proper assessment of the fundamental problems faced by the firms (Kosmidou & Zopounidis, 2002). The application of scenario analysis is highly beneficial for financial firms like banks. It helps the banks' managers make sound business decisions by considering future possibilities and potential growth opportunities. The financial institutions also use scenario analysis in the development of strategies and to conduct risk management processes. It provides valuable insights on outcomes resulting from a hypothetical change in current situations and systematically analyses future events in the commercial environment (Van De Ven-Glastra et al., 2017).

Deterministic Models and Stochastic models: The deterministic or stochastic models have unique characteristics and distribution functions (Chambers & Charnes, 1961). The deterministic model helps in realizing random events and computing tractable problems. It is known as a pioneer in ALM that frames, investigates, and deduces the actual condition of the financial firms in a mathematical manner (Fielitz & Loeffler, 1979).

Linear programming is used as the deterministic model, which helps coordinate the bank activities as per their objectives (Cohen & Hammer, 1967). It lays constraints on the bank working by developing a comprehensive framework so that sound decision is taken by the managers of the banks regarding the estimation of the substitute strategies. Additionally, using a multi-objective linear programming model helps determine the solvency objectives, assessment, maintenance of banking accounting sheets, and formulation of policies so that managerial constraints are reduced to minimum levels (Eatman & Sealey, 1979).

A multi-period probable linear programming is a simple recourse of assets and liabilities that optimizes production, planning, and making financial design decisions (Kusy & Ziemba, 1986). On the other hand, the linear model of asset-liability evaluation helps in comparing the private and public sector banks concerning liquidity and profit earning capacities (Dash & Pathak, 2011).

Goal Programming (GP) is an extension of linear programming where more than multiple objectives can be solved mathematically. In this model, many objectives can be achieved while seeking an optimal and feasible solution. In this model, goal constraints are set equal to target values that need not be achieved. Goal Programming is a widely used technique in multi-criteria decision-making, where decision-makers can incorporate multiple constraints and goals (Chakroun & Abid, 2013; Zaloom et al., 1986). There is no universal definition of Goal Programming yet can be defined as a tool for decision-making problems having multiple and possible conflicting goals (Zanakis & Gupta, 1985). The Goal Programming technique was first used by Chambers and Charnes (1961) in finance and accounting.

The stochastic model was introduced by Markowitz (1959) through the theory of Portfolio selection, which is also called a static mean-variance method. Several models were developed after the 1970s. For example, the multi-period stochastic linear program helps maintain computational feasibility and administration of assets and liabilities in financial institutions and banks. It optimizes the propositions for the long-term growth of the banking firms by gaining high returns of earnings and income (Ziemba & Mulvey, 1998). Multi-stage Stochastic Linear Programming (MSLP) identifies the issues related to uncertainties and implements different procedures to optimize the future scenarios of the banking firms. It adopts different methods like scenario sampling, fine-tuning, diminution, aggregation, decision-making, and others to identify problems and to resolve such issues effectively. Hence, to improve the working of the banks and reduce the risks in the management process, different techniques like Gap analysis, scenario analysis, and others are used.

2.5 CAMELS ANALYSIS

The full form of CAMELS analysis is Capital Adequacy (C), Asset Quality (A), Management (M), Earnings Quality (E), Liquidity (L), and System controls (S), and the concept of CAMELS came into force since the 1979s (Kiran, 2018; V. Kumar & Malhotra, 2017; G. L. Meena, 2016; Roman & Şargu, 2013). It was first announced by U.S. supervisory authorities who had implemented it into their banking system for carrying out functions related to rating and on-site evaluation of the performed work (Gadhia, 2015). The sixth element, 'S,' was introduced in 1997 as systems and control (Aspal & Dhawan, 2016; Gadhia, 2015). All these component factors ascertain the rating of the organization. CAMELS model helped in rating the performance of the banks. The model provided services like better quality, innovative products, and an improved bargain that was highly beneficial for the banks

to survive in the tough competitions in the market (Mukesh Kumar Jain, 2017; Katarzyna, 2016; Muralidhara & Lingam, 2017; S. Sharma & Chopra, 2018). When the assessment of the performance of financial institutions like banks belonging to the private sector was done based on the CAMELS model, it was found that the different banks performed at different scales and had diversified rates of growth (Kiran, 2018; Panboli & Birda, 2019; Sinha, 2016; Srinivasan & Saminathan, 2016).

Capital adequacy (C) which is an integral part of the CAMELS model, is used for the assessment of the bank losses, conception of the buffer, and safeguarding of bank's stakeholder's interests from banks collapses (Bodla & Verma, 2006; Chaudhuri, 2018; Roman & Şargu, 2013). The unregulated banking procedures in which the banking assets are equal to liabilities create the struggle period, the decline in the value of assets, and bankruptcy. All these dimensions are analyzed so that situations of the financial crisis are averted (H. V. Kaur, 2010; Mahajan & Singh, 2020; A. K. Mishra et al., 2012). For example, the collapse of Lehman Brothers would have been averted if the banking assets and liabilities were estimated before. As a result, Lehman Brothers would not have caused losses or created fiscal instability and crisis worldwide in the 21st century. Hence, capital adequacy helps assess the risk propositions and informs about credit risks, market risks, and operational risks, which are highly essential for enhancing the performance of the banks.

Asset quality (A) ascertains monetary organizations' working by assessing the loss of value in the assets. Financial organizations highly use the asset quality component of the CAMELS model to determine the risk associated with the reliability testing of the capital ratios (Chaudhuri, 2018; A. K. Mishra et al., 2012; Rauf, 2016). It is determined by analyzing the capitalization effects and highly responsible for acquiring capital efficiency parameters. The higher will be capital formation, the greater the performance efficiency (Bodla & Verma, 2006; Kwan & Eisenbeis, 1997; A. K. Mishra et al.,

2012; Sinha, 2016). An organization's assets are regarded to be an essential part of the organization whose impairment causes solvency of the firm, spillover effect, and jeopardizes the revenue generation capacity of the banks. As a result, the profit-earning capabilities of the banks decrease, and there is an increase in the non-performing assets of the banks. Hence, assessing the asset quality helps determine the healthiness of the banks and their working structure (Dao & Thomas, 2014).

Management efficiency (M) is an indispensable part of the CAMELS framework that highlights the different attributes of efficiency and productivity like management competence, leadership, and innovativeness, and others. According to the Uniform Financial Institutions Rating System, Management quality can be ascertained through the managements' ability to recognize, evaluate, and control the risks in bank. It also verify that there is safe, sound, and efficient operation in the bank in adherence to the applicable laws and regulations (FDIC, 1997). It's been said that the right amount of supervision leads to stable and good performance (Risal & Panta, 2019). The indicators for the evaluating soundness of management can be the operating expense to total assets, deposit interest expense to total deposits, non-operating expense to net income, employee cost to average total assets, and cost to income ratio (Avkiran & Cai, 2012; Gunsel, 2007; M. Reddy & Prasad, 2011).

Earning management and quality of earning (E) are the most important terms used to measure earning quality. The earning quality of the firm is responsible for determining the future earning and growth possibilities by evaluating the competencies and lubricity of the financial organizations (Bodla & Verma, 2006; Dang, 2011; S. Sharma & Chopra, 2018). The earning quality is mainly assessed based on interest rate policies and adequacies related to the net income provision by evaluating Return on Assets (ROA) and total asset ratio after deduction of tax. The Cost to Income Ratio is used to ascertain the income generating capacity of the bank to pay operating expenses (Roman & Şargu,

2013). The earning quality determines the revenue-supported sustained earnings and non-revenue-supported earnings so that the actual earning status of the firm is known effectively (Ghosh et al., 2005).

Liquidity (L) is regarded as an essential term in the CAMELS model, which is used to measure the debtor's capability to pay back the loan without creating any new external capital liabilities. It mainly includes the current ratio, quick ratio, and sales outstanding. Liquidity asset holdings are highly impacted by the size of financial firms like banks (Kashyap et al., 2002a). The liquidity holding of banks is positively affected by the profit earning levels. The greater the profitability, the higher the capacity of the bank to retain Liquidity in its workings also increases (Lartey et al., 2013; Vodová, 2014). When the refinancing cost of the bank increases, there is an increase in the investment of liquid assets, which augments the source of Liquidity in banks (S. S. Bhati & Zoysa, 2012). However, other factors like monetary policies lay adverse effects on the bank's Liquidity and decrease its ability to enhance its source of Liquidity (Chen & Phuong, 2013). Resource deployment and raising capacities of the banks also form the vital elements of the Liquidity. The resource-raising ability of the bank is highly dependent upon the fixed asset in comparison to the asset ratio.

Economic development and competition in banking sector have placed management under pressure to meet performance targets and save them from financial and reputation loss. Resources play an essential role in increasing the efficiency of the financial sector and help the economy grow proficiently. It provides a solid base for the resilient function of monetary organizations like banks in India. It reduces the increased deregulations levels in the financial sector that mainly occur because of high competition globally. As a result, the banks are facing immense challenges

related to branch banking, maintaining transparency in work operations, customer service, and others. Banks reevaluate their policies and plans for growth and expansion based on CAMEL approach.

Sharma and Arora (2016) evaluated the performance of public and private sector banks by ranking banks using CAMEL approach. Likewise G. L. Meena (2016) determined the factors affecting the financial performance of public and private banks using CAMEL approach. The factors such as debt-equity ratio, assets-deposits ratio, NPA ratio, and profit per employee are dependent factors affecting performance of banks.

Kaur (2010), Kiran (2018), Kumar and Malhotra (2017), S. Sharma and Chopra (2018), Sinha (2016) and Srinivasan and Saminathan (2016) measured financial soundness of Indian banks based of CAMEL parameters. Composite ranking, average, covariance has been used for comparative analysis to determine that private sector banks are more sound than public sector banks. Jain (2017) used CAMEL approach in comparative study of AXIS and HDFC bank to measure their performance efficiency. Lavanya and Srinivas (2018), studies financial performance of few private sector banks in India using CAMEL approach and ranked them based on performance. Likewise Mahajan and Singh (2020) and Chaudhuri (2018) assess the financial performance of SBI bank and ICICI using CAMEL approach for different time period.

Kandel (2019) analyzed the financial performance of commercial banks situated in Nepal where economic growth is largely dependent on financial sectors. Using CAMEL approach, it was revealed that ROA and ROE are affected mainly by earning quality and moderately affected by bank's capital adequacy ratio (CAR), liquidity ratio, and asset quality. Risal and Panta (2019) studied the effectiveness of CAMELS approach in A class commercial banks in Nepal by

establishing a relationship between supervision and risk management. The riskiness is calculated by downside deviation in ROA and ROE. The findings of the paper shows that reduction in Non-Performing Loan, maintaining sufficient liquidity and effective management supervision can lead to reduction in downside deviations in ROA and ROE. Capital has not created any significant effect on reducing riskiness of bank. All other parameters like asset quality, efficiency of management, earning capacity, liquidity, and market risk sensitivity plays significant role in reducing riskiness of banks.

Rauf (2016) performed comparative study on public and private sector banks in Sri Lanka to analyze the financial performance of banks using CAMEL model. The parameters of CAMEL model were used as independent variable and ROA and ROE were considered dependent variables. The study found that private banks perform better in comparison to public sector banks. Among CAMEL parameters, Capital adequacy, assets quality and earning quality had significant correlation with financial performance whereas, management efficiency and liquidity had insignificant correlation with financial performance of the banks.

Ledhem & Mekidiche (2020) investigated link between financial performance and economic growth. ROE has remarkable effect on the economic growth. Azad et al. (2017) performed comparative analysis of Islamic and conventional banks in Malaysia using Network Date Envelopment Analysis (NDEA) approach. Inputs and outputs were selected based on CAMELS model. The traditional approach of efficiency analysis is replaced with NDEA which provides better benchmark capacity.

Basel-III implementations are adopted by the financial institutions so that new accounting standards, assessment of performance, maintenance of transparent disclosures, and other practices will reduce the issues and challenges faced by the banks effectively. All these significantly impact the bank in the form of capital level, compliance with risk-based net worth requirement practices related to dividend and interest policies, and growth plan. It increases the ability of banks to manage, control, and monitor risk, which ensures an efficient economic environment.

2.6 STRATEGIES TO MITIGATE RISKS

While performing the different functions in the daily work systems, financial institutions like banks face several risks, such as financial or non-financial. The financial risk mainly involves the risks that incur a loss to the firm and lays adverse implications on the internal and external factors of banks. It may pertain to liquidity risk, credit risk, and others (F. Ahmad & Bashir, 2013; Banker et al., 1984; Goldstein & Turner, 1996; Kalyan, 2017; Kamarudin et al., 2019; P. Lin et al., 2015; V. R. Singh, 2016; Yannick et al., 2016).

Non-financial risks include misconduct, challenges related to technology adaptations or operational difficulties, compliance failures, and others (Coleman, 2011; Hassanein et al., 2021; Michael et al., 2006; Mocanu, 2021; Samad-Khan, 2008). All these risks damage and hamper the working of the organization in financial terms and negatively impact the reputation of the firm (Acharya, 2018; Ballester et al., 2009; Charumathi, 2008; Diamond & Rajan, 2001; English et al., 2018; Gatev et al., 2004; Houpt & Embersit, 1991; M. Kumar & Yadav, 2013; N. Kumar & Chatterjee, 2020; Lamanda & Vonek, 2020; Lois et al., 2020; Marozva, 2015; Patnaik & Shah, 2002b, 2002a; Ratnovski, 2013; Shams et al., 2020; Zhou & Zheng, 2017). Moreover, due to misconduct, the working environment also becomes less motivational, and there is a lack of

compliance in the following of law and regulations. Hence, it is necessary to introduce risk mitigating strategies so that the risk faced by the financial institutions will reduce and they will perform more efficiently (Saunders & Cornett, 2008).

Asset-liability management (ALM) is one of the most effective means of managing risk in banks. The Indian banking sector faces several risks like interest rate risk, market risks which are necessary to be assessed with the help of asset-liability management (Bace, 2016; S. Chakraborty & Mohapatra, 2008; Dash & Pathak, 2011; A. K. Meena & Dhar, 2014; Rahul Ranjan & Nallari, 2005; Romanyuk, 2010; S. Mohammad Pourmohammad Azizi & Neisy, 2017; Ziemba & Mulvey, 1998). ALM is well efficient in estimating, supervising, and administering the risk associated with banks. It is a planning function that controls the changes; mixes the assets, liabilities, and capital (Chatterjee & Dutta, 2016; Chaturvedi, 2014; Dash et al., 2011; V. Joshi, 2015; RBI, 2007; K. Singh, 2013; Zenios, 1995).

The introduction of risk measurement techniques like Gap analysis, Duration Model, Value at Risk, and Simulation, etc. also helps in monitoring and reducing risk (Brown & Swartz, 1989; Brzaković et al., 2016; Darshan & Suresh, 2020; Kosmidou & Zopounidis, 2002; Mishkin, 2007; Anurag Singh & Tandon, 2012; K. Singh, 2013; Van De Ven-Glastra et al., 2017; Vij, 2005).

The value at risk helps in evaluating the market risks in response to the long-term risk implications. It also accurately measures the risks within the portfolio of assets/liabilities of the firm. Value at risk states the maximum expected loss that a bank is willing to suffer in a given time. It supports in determining the market risk of investments for which there is a lack of historical data. Bank management can calculate its net worth for a specific time to guide it to make better

decisions in the near future. Banks generally use VaR to measure market risk (Anurag Singh & Tandon, 2012).

Risk management procedures like identifying risk, analyzing, management, controlling monitoring, and risk-return trade-off are practiced while implementing the risk reversion strategies. Moreover, it is also essential to enhance human skills so that the working person will effectively carry out risk management activities. Training must be provided to the credit managers with the help of expert credit analysts. The managers will be able to understand the fiscal and monetary information and implement innovative risk strategies accordingly. Additionally, the revamping strategies related to the performance appraisal structure are also essential to be introduced so that the credit managers in the credit departments establish a link with the business and secure banking systems. It improves the quality of risk assessment and introduces risk mitigation measures so that the banks will develop effective control and effectively deal in the external market scenarios.

The development of reporting risk exposures to the board is executed by involving the stakeholders in the decision-making exercise. The execution of the workforce accountability structure ensures due diligence and enhances the working of banking organizations. As a result, compliance is established between policies and procedures that enable the banks to work as per the company directives and regulations, resulting in effective risk management and performance determination.

The implementation of internal audit systems also helps in reviewing the continuous and systematic evaluation of the risk and performance of the banking firm (Kalyan, 2017; H. Kruger & Hattingh, 2006; Lois et al., 2020). The correct evaluation of the post-sanction procedures and

loan disbursement approaches also helps establish a link between the risks so that the credit managers detect the diversions related to borrowings and expansion effectively. The inclusion of external audits related to the administration of risks and procedures helps in restructuring the departments that are handling risk sections. The development of the operational activities of the banking firms with the help of IT technology will also help in the forecasting of the risks associated with portfolio management (Jayadev, 2013).

2.7 GOAL PROGRAMMING TECHNIQUE IN ASSET-LIABILITY MANAGEMENT

The success of any business rests on its planning process. The management designs the plans and then monitors their implementation. The commercial banks also operate similarly. Planning starts with setting desired goals that are achievable. Bank's assets mainly comprise loans and investments. The bank's management has to wisely choose the investment and loan disbursement to increase its profitability within targeted risk-absorbing capacity. Bank can be compared to manufacturing unit where it has to select the products that can be produced to optimize the production and profitability under a given set of constraints. Likewise, the bank has to deploy its assets to help it attain its desired goals and targets.

Over a while, mathematical and engineering techniques merged with business areas to develop programs that enrich planning tools. Linear programming is one such mathematical tool that is flexible and supports the planning process. As time passes, management has to face new challenges that alter its constraints and objectives. In linear programming, these new constraints and revised objectives can be easily adapted and formulated. Further, this technique helps determine the deviations from the target giving management some time to take corrective actions. However, linear programming allows us to achieve one objective at a time. One can either

maximize or minimize a single objective. The real-world problems are much more complex. In the real world, there are many goals to be achieved simultaneously. The complexity of such a problem can be solved by goal programming (GP) which is an extension of linear programming where more than one objective can be solved mathematically. In this model, many objectives can be achieved while seeking an optimal and feasible solution. In this model, goal constraints are set equal to target values that need not be achieved.

Goal Programming is a extensively used technique in multi-criteria decision-making, where multiple constraints and goals can be incorporated by the decision-maker (Chakroun & Abid, 2013; Zaloom et al., 1986). There is no universal definition of Goal Programming yet can be defined as a tool for decision-making problems having multiple and possible conflicting goals (Zanakis & Gupta, 1985). The Goal Programming technique was first used by Chambers and Charnes, (1961) in finance and accounting. Later, many other authors used the method in portfolio selection, asset management, marketing, capital structure, budgeting, planning, and banking, etc. The GP technique, as mentioned, assists management in the planning process by providing a meaningful framework; however, it does not eliminate the decision-making function of management. The objective of GP is to minimize the deviations from predefined targets. In developing plans, bank management set targets and goals to be achieved. These goals can be profit maximization, risk minimization, increasing the market share, maintaining sufficient liquidity, a balanced portfolio subject to legal requirements imposed by the RBI, and other management constraints. The GP model delivers the most optimum solution for such complex problems to assist bank management in a more efficient planning process.

The survey study of goal programming in finance and accounting has been undertaken by Azmi and Tamiz (2010), Colapinto et al. (2017), Lin and O'Leary (1993), Zanakis and Gupta (1985), and White (1990). D. Giokas and Vassiloglou (1991) developed multi-objective programming for bank assets and liabilities management. They argued that banks have multiple goals. Bank management not only strives to maximize revenue but also puts effort to reduce risk. Apart from revenue/profit, banks try to gain market share of deposits and credits. As linear programming can only handle a single objective function, goal programming is the right approach for multiple goals. Kruger (2011) used a single-period approach and multi-period approach to finds that it is possible to optimize the balance sheet using advanced software. Viswanathan and Balasubramanian (2007) applied the pre-emptive GP model and studied optimal deployment of funds across different asset classes of varying risk and return characteristics to attain the profit goals. The regulatory and other constraints are also satisfied while pursuing objectives. Sedzro et al. (2012) has combined the Analytical Hierarchy process with mean-variance optimization and goal programming models for asset allocation. The authors incorporated the investor's risk profile and future economic scenarios while optimizing asset allocation. Jain et al. (2010) presented the ALM model for pensioners. The study discussed the fuzzy programming approach to control the risk of volatility on investment returns and liabilities.

Viswanathan et al. (2014) used the goal programming model in ALM. Goal programming optimally allocated the assets to achieve the target goals, namely Other Income, Deposits, Investments, and Advances. Halim et al. (2015) applied the GP model to attain six goals: asset accumulation, liability reduction, equity wealth, earning, profitability, and optimum management of a bank in Malaysia. The proposed model is capable of supporting financial decision-making while dealing with diverse economic scenarios. Rezaei et al. (2013), studied assets and liabilities

management by comparing the model value with actual values using Fuzzy AHP and goal programming. Fortson and Dince (1977) developed a model for a country bank using Goal Programming, where the model incorporated profitability, capital adequacy, liquidity, and credit-deposit ratio as multiple goals to be achieved. The model benefited the management by setting goals under different scenarios.

Keown and Martin (1977) applied two-staged, chance constrained lexicographic goal programming in the working capital model. The model deals with a profit goal at the first stage, followed by chance constraints, namely maintaining a cash buffer, maintaining a minimum inventory level, maintaining target current ratio, acid-test ratio, debt to total asset ratio, and fixed charge coverage ratio. Agarwal et al. (2010) investigated capital structure in the Indian industry for 10 years. The capital structure practice of top 500 companies is taken from 19 different sectors. The goal Programming technique is applied to study the relationship between Leverage ratio and market capitalization and reach the target. The responses of CFOs are utilized to determine the goals, priorities, constraints, motivations, and practices.

Tektas et al. (2005) studied bank asset-liability management under financial crisis. Turkey is an emerging economy and therefore highly vulnerable to economic and global market changes. The study proposes goal programming in restructuring the balance sheet under the different risk-taking attitudes of banks. The risk behavior of banks is analyzed for optimistic and pessimistic economic conditions. The results show that banks have a margin for improving the present financial position. However, results also reveal that bank taking more risk and having an optimistic approach have higher profitability.

Chakroun and Abid (2013) presented ALM to help banks develop long-term strategies using their balance sheet. The problems faced in Asset Liability Management have been tackled through the GP technique for Tunisian commercial banks. The tool has been used to optimize the solution for maximizing net interest margin, solvency, improving liquidity, and credit-deposit ratio under the given structural, political, and regulatory constraints. The results of the model outperform the present strategy applied by banks and open scope for improvement. The model is flexible enough to be used by other banks under a similar environment. Zaloom et al. (1986) studied capital and liquidity planning in bank asset management. The study integrated a mathematical model in the banking business to achieve multiple conflicting targets while fulfilling regulatory, legal, and managerial constraints with trade-offs. The implication of goal programming in such a situation is specified as an appropriate technique for banks.

The application of goal programming in banking is proved to be useful as it can handle more than one objective. Unlike linear programming, goal programming estimates deviations from the targets. Application of goal programming with Analytical Hierarchy Process brings experts insight in the goal framing process.

2.8 GOALS FOR GOAL PROGRAMMING MODEL

Goals for goal programming have been selected after the discussion with bank management. The goals are increasing market of credit, increasing market share of deposits, capital adequacy, increasing liquidity, increasing return on asset, increasing return on equity, and reducing NPA. The goals are in line with the CAMEL approach. In this thesis, parameters of CAMEL model are ranked as LCEAM i.e., Liquidity, capital adequacy, earnings, asset quality and management efficiency.

Liquidity: Liquidity is important aspect for banks to avoid situation of bank run. Banking stability depends on asset quality, liquidity, performance, capital adequacy etc. of each individual banks (R. N. Mishra et al., 2013). After the financial crisis of 2008, liquidity risk has gained attention of many researchers and policy makers. The fiscal crisis in 2008 impacted the liquidity flow of several banks and creating liquidity crunch (Choon et al., 2013; Vodová, 2011). Basel III analyzed that liquidity risk in banks is among other risk that need to be addressed along with strengthening capital to create more resilient banking system (de Waal et al., 2013).

RBI (2012) stated that banks' incompetency to satisfy obligation when they arise or become due, without negatively impacting the bank's financial condition is known as liquidity risk. In various studies it has been mentioned that banks' internal factor such as profitability, bank size, availability of deposit, cost of fund, capital adequacy, asset quality, etc. have significant impact on the overall liquidity position of banks (Al-Homaidi et al., 2019; S. Bhati et al., 2019; Choon et al., 2013; Pathi, 2017; Anamika Singh & Sharma, 2018; Sopan & Dutta, 2018). Bourke (1989) and Olagunju et al. (2011) performed a study to determine the relationship between liquidity and profitability. It was revealed that liquidity and profitability are positively related. Banks keep liquid assets above mandatory requirements by RBI for transaction, speculative and precautionary purpose.

Capital Adequacy: The financial crisis of 2008 led Basel to observe the regulations and norms and revise them. Basel III tried to overcome the downsides and weaknesses of Basel II. It highlighted the importance of capital adequacy in banking system. Basel III introduced capital conservation buffer to increase the loss absorbing capacity of banks in difficult times. Indian banking sector also strictly comply with minimum capital requirement norms as per Basel III.

Profitability, credit risk, growth of credit, and leverage are few bank specific variables that affects capital adequacy of banks (Barua, 2018). Capital Adequacy is an essential field for banking regulators. It is one of the critical indicators of stability. Banks focus on maintaining a sound capital adequacy position due to the worldwide increase in the importance of risk- based capital standards (E.Shrieves & DrewDahl, 1992; Gupta & Kamilla, 2016; M. Kaur & Kapoor, 2015; Miah & Sharmeen, 2015; Sarkar et al., 2019). Regulatory pressure has positive effect on capital (Argimon et al., 2012). Banks increase capital to fulfill the regulatory requirements which increases risk for banks that are undercapitalized (Bichsel & Blum, 2002; Das & Ghosh, 2004; Hua, 2011; S. L. Lin et al., 2013). However, having same capital structure does not stimulate better performance nor penalize them. Capital Adequacy reflects loss absorbing capacity but also reflect its inherent risk (Baruah, 2018; Floquet & Biekpe, 2008; Mohanty & Mahakud, 2018)

Earning Efficiency (ROA and ROE): Return on Asset is a ratio that determines the relationship between profit after tax and total asset. It determines the revenue generating capacity of banks given its total assets. ROA measure the overall performance of banks. Return on equity is ratio that indicates the relationship between profit after tax and average shareholder's fund. ROE is evaluated by comparing the earning received after the tax deductions with the total equity value of the firm. It reveals the ability of banks to generate revenue after utilizing the money invested by shareholders (Ekinci & Poyraz, 2019). The banks' financial performance is generally determined using Return on Asset (ROA) and Return on equity (ROE) as proxy for financial indicator. The performance of banks is measured as its capacity to generate profit (Ferrouhi, 2018).

Return on equity (ROE) is the estimation of the monetary proficiency of a firm which is evaluated by comparing net income with equity attained by the shareholders. The value of the equity acquired by the shareholders is evaluated by taking the difference between the asset of the firm and its debt value into account. The status of the ROE is considered to be good or bad depending upon the normal constraints availed by the company in comparison to its peers. It is also used for the estimation of sustainable growth and dividend rates by considering the peer group average ratio with the line of business. It provides information about future estimations related to the growth rates of the stocks and dividends. Return on equity is defined as the ratio that mainly assesses the success of the financial firm like a bank by generating gains for the shareholders of the firm. If the Return of Equity (ROE) is greater than 12% rate of return, it is termed to be good ROE whereas; if it is less than 12% it is termed to be poor ROE (Petro, 2019).

The ROE is highly based on two major factors which are net income and shareholder's equity. To increase the ROE, it is highly essential to augment the profit margins so that the shareholder's earnings will increase. The profit margins are to be increased by raising the increasing interest income on investment and advances, reducing non-operating expenses and operating expenses. The reduction in NPA accumulation also helps in increasing ROE values. Appropriate distribution of idle cash is also regarded as another important way of increasing ROE. Due to the proper allocation of idle cash, the company can leverage its finances and boost ROE. The lowering of taxes is another technique to increase the proportion of ROE in the bank. By reducing the tax payment bracket, the financial firm gains more profit that increases the ROE by balancing the tax rate and profits that are earned by the bank (Liesz, 2002).

Many authors have used ROA and ROE to determine the performance of bank and its relationship with other parameters. Wang and Wang (2015) examined the factors that affect profitability in banking. The relationship between loan to asset, deposit to total liability, NPA to Gross Loan, efficiency, diversification of revenue, and capital has been established with ROA to determine the effect of above factors on financial performance of bank. Jamal et al. (2012) studied the influence of macroeconomic factors on profitability in Malaysian Banks. The factors such as inflation, interest rate and GDP are positively related to banks profitability, whereas stock market development is negatively related to profits, which is measured using ROA as proxy. Likewise, ROA and ROE has been used banks' performance indicators in many other researchers (Ariffin, 2012; Athanasoglou et al., 2006; Molyneux & Thornton, 1992).

Asset Quality (NPA): NPA account is loan asset from which income in the form revenue or principal repayment cannot be generated (S. A. Chakraborty, 2017). Such accounts have ceased to make payment for more than 90 Days. There is plethora of effects that Non-Performing Loans can have on the banks (C S Balasubramaniam, 2011). Banks invest a lot of time, money, and effort to manage NPAs. Management of NPAs increases cost which could otherwise be invested on other revenue generating activities. Banks have credit risk department where they hire financial engineers to deal with NPA accounts. If bank would have invested that money somewhere else, it would have increased revenue and profit. Therefore, it can be said not only NPAs decrease bank income but also its opportunity to earn future income.

Bank's main source of income is interest earned on loan accounts. NPAs reduces this interest income and affect the cash in hand. When bank faces reduction in liquidity it must borrow funds at certain interest rate. Not only financially, increase in NPAs also increases the reputational risk for banks. It limits the credit lending opportunity for banks (Cucinelli, 2015; Vinh, 2017) and affects credit rating. It can be concluded that NPAs affect the income/profitability and stability of banks (Klein, 2013). Due to increased NPAs, bank create provisions for the same (C S Balasubramaniam, 2011). Increasing number of NPA accounts also reflects the credit policy failure on part of banks. NPA can be computed on net and gross basis. NPA is a percentage of Gross Non-performing loans to Gross Advances or Net NPA to Net Advances (Chimkono et al., 2016). There are studies that investigated the relationship of NPA with profit, cost and lending behavior of banks, etc. Studies of Chakraborty (2017), Vinh (2017), Ekinci and Poyraz (2019), Ramesh (2016) and Chimkono et al. (2016) etc. revealed that NPA has inverse relationship with the profitability of banks. NPA depicts low efficiency of bank which is considered as a sign of bad performance of management (F. Ahmad & Bashir, 2013). Therefore, in the light of these implications on the bank's solvency and efficiency, it is critical for banks to lower NPA and maintain high quality asset.

Management efficiency (Market share of credit and deposits): Market share of credit and deposit has strong positive significant relationship with profitability (Ejoh & Sackey, 2014; Genchev, 2012). Banks profit margin increases with increase in market share. Banks can increase its normal profit by gaining market share either through merger or other means (Kurtz & Rhoades, 1992). When banks have higher market share, it focuses on investing in prudent assets and increase returns and minimize risk (Dam et al., 2015). Market share is the most influential determinant of an organization's competitive power (Saravani et al., 2015). The banks can gain market share by

rendering attractive services and interest rates. Banks can also merge together to increase market share and reduce operational and other costs, thereby achieving economies of scale and greater efficiency (Ejoh & Sackey, 2014). A study by Bowyer (1981) examined the change in market share of bank after post-merger and its effect on profitability. It was found that bank's market share rose after merger.

2.9 RESEARCH GAP

Today, banks are facing conflicting goals. One on hand banks wants to maximize its profit, and on the other, it wants safety. The risk appetite of banks force it to trade-off between return and risk. Financial institutions like banks in India must follow the lending procedures, investment norms, specifically the SLR, CRR, CAR and Liquidity coverage ratio (LCR) into the bank's working operations. The banks are required to disintegrate and allocate their funds in different types of investments shares, government bonds, corporate bonds, Subsidiary, etc. Banks have to allocated forty percent of ANBC towards Priority sector lending. Hence, the implementation of ALM into the banking structure is essential to maintain a balance between the inflow and outflow of the bank. Banks need to focus on maintaining balance between assets and liabilities side of the balance sheet. The capital and reserve requirements of banks are governed mainly by the RBI and are beyond the bank's control. However, a bank can control other assets and liabilities. The investments of banks depend on factors such as interest rate, maturity, liquidity, marketability, and ratings. These factors also determine the yield of investments.

Banks have to trade-off between profit and risk. The decision related to the size and composition of any asset and liability cannot be made independently. The complexity arises when one component affects other assets & liabilities and yield & cost related to them. The risk management approach has become enterprise-wide management as interest rate risk, market risk, credit risk, and liquidity risk are interrelated. Any significant increase in any asset with the given yield and risk will lead to decrease in other assets with different yield and risk. However, banks can increase their spread (yield-cost) by reducing their liquidity. However, reducing short-term liquidity has repercussions in the long term. Banks may be forced to liquidate their investments to meet customers' demands and withdrawals. The reverse is also true. If banks hold higher liquid assets, they will lose a significant amount of earnings to their competitors. The decision of the banks' management regarding ALM affects the current and future stability of banks. Therefore, banks have to make prudent decisions in the present while understanding its severe consequences in the near future. It has to incorporate present scenarios and as well as unprecedented changes in the future.

In banks, the planning process always depends on the availability of information related to interest rate, cost, and yield of various assets and liabilities. In general, forecasting depends on historical data. However, the banking business has become very dynamic. The past data cannot capture the present interaction between assets and liabilities. These complexities in today's banking business have opened itself to integrate mathematics and engineering to seek solutions for its complex problems. Therefore, this thesis first attempts to understand the strategies, policies, and procedures incorporated by banks to implement ALM and risk management techniques. Secondly, with the help of linear goal programming (a mathematical design), the asset-liabilities of banks are optimized to generate better profitability and management of risk.

Banks have to make prudent decisions in the present while understanding its severe consequences in the near future. It has to incorporate present scenarios and as well as unprecedented changes in the future. In banks, the planning process always depends on the availability of information related to interest rate, cost, and yield of various assets and liabilities. In general, forecasting depends on historical data. However, the banking business has become very dynamic. The past data cannot capture the present interaction between assets and liabilities. These complexities in today's banking business have opened itself to integrate mathematics and engineering to seek solutions for its complex problems.

- Based on the extensive literature survey we have not came across any study that has conducted primary survey on ALM. The extent of the literature covered poses a need to understand the extent of implementation of strategies and policies by banks related to ALM. Also, we want to study the understanding of the ALM process by bank employees in different departments of the bank which are related to ALM process. All the studies conducted on ALM are based on secondary data.
- After conducting an extensive review of the literature, it is observed that research has been conducted on gap analysis with respect to liquidity risk and interest rate risk. Comparative studies for public and private sector banks are conducted to analyze the structural liquidity position of banks. There is a requirement for determining the asset-liability mix to maximize profit and manage risk within statutory and regulatory limits for banks in India. There are models designed for other countries' banks; however, limited studies were found for Indian banks.

- Significant studies were found using the Goal Programming technique for model development in other countries and India in banking sector. However, studies that combine Goal Programming (GP) and Analytical Hierarchy Process (AHP) are very few in the Indian context.
- Most studies on CAMEL model are based on comparative analysis of banks to determine their financial performance. In this study the CAMEL model is introduced in the Goal Programming model, where its components such as capital adequacy, asset quality, management, earnings, and liquidity have been incorporated as goals/objectives. Studies have been found on the CAMEL model; however, its integration to the GP model is limited.

2.10 RESEARCH QUESTIONS

- Do employees of banks in India have understanding of ALM policies and risk management techniques prescribed by RBI?
- Is there difference between public banks and Private banks related to understanding of ALM strategies, function, and importance?
- Do Public banks and Private banks follow similar risk management techniques?
- Is goal programming model on Asset Liability Management (ALM) used in the study efficient to determine asset liability mix and improve profitability of the banks?
- Is Goal Programming model used in the thesis flexible enough to incorporate modifications and future changes?

2.11 OBJECTIVES OF THE STUDY

The objectives related to the study are as follows:

- To study, understand, and analyze strategies employed by banks to manage their assets and liabilities.
- To determining asset and liabilities mix for Public Sector Banks in India that enable profit maximization and manage risk in compliance with reserve requirements and other statutory conditions.

CHAPTER 3: RESEARCH METHODOLOGY

The current study is intended to analyze the strategies and procedures that the banks have employed to manage their assets and liabilities while complying with the statutory requirements. This study also deals with risks dealt by ALM and techniques implemented by banks to mitigate such risk.

The study also focuses on optimizing the assets and liabilities of few selected public sector banks in India. The model determines the assets and liabilities reported by banks in the balance sheet. The change in the asset-liability mix can change the financial position of banks on liquidity, capital, and profitability. The model is implemented on four public banks of India. However, the same model can be used on scheduled commercial banks in India.

3.1 RESEARCH APPROACH

Research approaches can be referred to as the overall research plans and procedures adopted based on the initial assumptions to fulfil the study objectives. The research approach is primarily of three types- quantitative, qualitative, and mixed research approaches. Ascertaining the ideal research approach dictates the appropriateness of the overall research methodology. **Quantitative research** demonstrates the correlation between the study variables. Such a research approach is implemented when the researcher seeks to gather the respondents' opinions or conduct any statistical evaluation. Thus, numerical and statistical data forms the foundational basis of the quantitative research approach (Apuke, 2017).

On the other hand, **qualitative research** usually poses as the most preferred approach in most of the empirical research that involves reporting new theories and concepts. Such a research approach process is based on the emerging research questions and procedures (Corbin & Strauss, 2015).

The mixed research approach combines both the qualitative and the quantitative methods. It is implemented when the fulfilment of the research objectives calls for both questionnaire-based surveys and experimentation as the necessary research tools. The fundamental basis for the mixed research approach has been to overcome the shortcomings of qualitative and quantitative research approaches, thereby facilitating a complete understanding of the research problem (Brannen, 2005; Schoonenboom & Johnson, 2017).

The current study deals with the study and analysis of the strategies and procedures employed by banks to manage their assets and liabilities while complying with the statutory requirements. This objective of the research undertakes quantitative research approach. However, for second objective of the research, i.e., to develop a mathematical model to optimize the asset-liability mix to maximize profit after undertaking statutory, regulatory, and managerial constraints- the mixed research approach is the most suitable. Qualitative approach is used to determine the goals for the model and there after quantitative approach is used to design the model.

3.2 DEVELOPING A THEORETICAL FRAMEWORK

The study is divided into three sections, namely-

1. Study of the strategies, policies, and procedures applied by Indian commercial banks related to Asset-Liability Management and risk management.

2. Determining the goals/aim/objectives of the bank while applying Asset Liability Management policies.
3. Implementing Goal Programming model to determine the asset-liability mix of a bank that can help banks to achieve the above-said goals subject to regulatory and management constraints.

3.2.1 The research design for first section is:

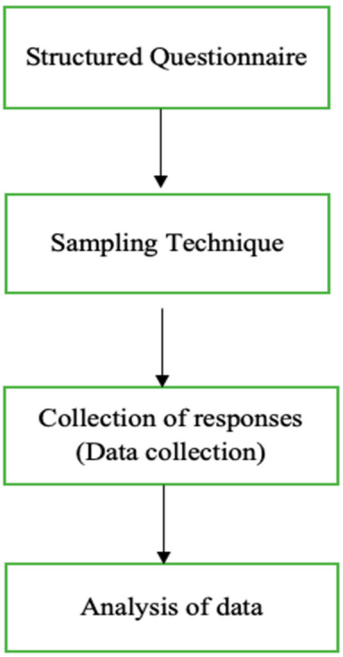


Figure 3.1: Research design for studying strategies in ALM

RBI lays down ALM strategies, policies, and procedures in circular 'Asset Liability Management (ALM) System (1999)' and 'Guidelines on ALM System- Amendments (2007)'. These guidelines provide consistent practice to be followed in banks. However, RBI laid down a basic framework and procedure. Banks have the liberty to improve and extend it depending upon their risk management strategies. Therefore, a questionnaire is sent to banks' risk department, ALM cell,

Treasury department, and Balance Sheet management department to understand what practice public and private banks follow concerning ALM and risk management.

Questionnaire

The most important use of a questionnaire is to extract information from the respondents. Without a questionnaire, it isn't easy to collect data uniformly. Questionnaires are often used in social science, marketing, medical research to collect data from respondents to diagnose a problem related to set objectives. When a questionnaire is appropriately designed, it can be a crucial instrument that helps in analyzing the correlation, differences, and opinions of the group or population (Mathers et al., 2009). However, only a correctly designed questionnaire posing good and necessary questions, rightly scaled, and sequenced questions will reflect respondents' genuine opinions and ideas.

Sir Francis Galton was the inventor of the questionnaire in 1800. He was a British explorer, statistician, and anthropologist. The authenticity of a survey depends on the appropriate design of the questionnaire. It can be said that questionnaire is a critical instrument to collect primary quantitative, qualitative, and descriptive data. It facilitates data collection in a standardized manner, which is internally consistent, reliable, and valid (Roopa & Rani, 2012). While designing a questionnaire, the main aim of research should be known so that straightforward questions are identified, and findings can be accurate. As a questionnaire facilitates the collection of data, it should be carefully planned and designed after considering the following stages:

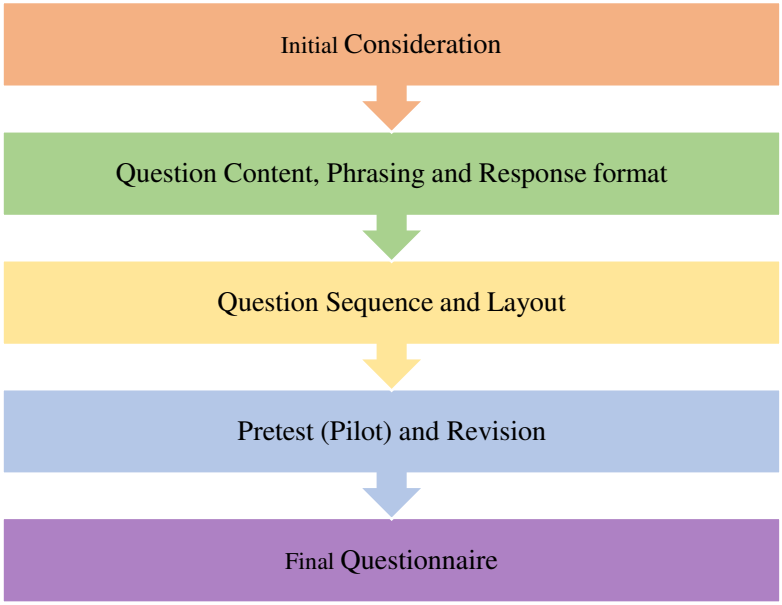


Figure 3.2: Stages of planning a questionnaire (Roopa & Rani, 2012)

There are four different types of questionnaires, i.e., Contingency questions/Cascade format, Matrix questions, Closed-ended questions, and Open-ended questions. The questionnaire designed in the study is closed-ended. In a structured and close-ended questionnaire, respondents' responses are limited to the given options in the questions. The respondent chose a response from the given set of options. The questionnaire used in the study carries Yes/No type questions, multiple-choice questions, checklist questions, scaled questions. In multiple-choice questions, the respondent chooses one response from the given set of options, whereas, in checklist questions, the respondent can choose more than one option. In scaled questions, answers are graded on a continuum, such as the Likert scale.

An ideal questionnaire must be simple and straightforward language. It must allow the respondent to focus on one dimension at a time and yield truthful answers. It must also produce variability in the responses. The questions should be unambiguous and use standard terms. It must have definite, concrete, and predetermined questions.

The questionnaire was tested for Reliability and Validity by pretesting it via a pilot survey. Pretesting helps in determining that the questions are correctly framed in clear language. It specifies that the sequence of questions is appropriate. Pretesting facilitates examining that the questions are understood by the respondent and instructions to fill the questionnaire are adequate. During pretesting, unnecessary and repetitive questions can be eliminated, and additional required questions can be incorporated into the final questionnaire.

Reliability measures the consistency of the responses by respondents. One way of testing reliability is to measure the consistency of responses from one time to another, also known as Test-retest reliability. The Reliability can be tested through kappa statistics. Internal Reliability measures the reliability of the tool by evaluating the consistency of the results for different items of similar construct. A statistical test called Cronbach's- a[alpha] is applied to test internal Reliability. Most literature argues that the acceptable value of Cronbach's- alpha is 0.7. A vale between 0.6-0.7 is acceptable level of Reliability and 0.8 or greater is considered a very good level (Hulin et al., 2001; Ursachi et al., 2015). Hinton et al. (2004) mentioned that alpha value from 0.5 to 0.7 shows moderate Reliability, whereas 0.5 and below is considered low. The Cronbach's-a[alpha] value for Yes/No questions is 0.634, where questions related to ALM, and risk management are covered. The questions about the ALM Significance and ALCO functions have a value of 0.790 and 0.701 respectively. Based on the literature, the questionnaire is internally reliable.

Sampling Technique

Sampling refers to selecting the participants who would be chosen to collect data either through the survey process or via interviews. Sampling is primarily of two types: Probability sampling and

non-probability sampling (Auerbach & Silverstein, 2003). In probability sampling, every item has equal chance of being selected. In random sampling (same as probability sampling) primary quantitative data is gathered to achieve the objectives of the study. The different types of probability sampling are random, systemic, stratified, and cluster sampling. In non-probability sampling, samples are not picked randomly instead, samples are chosen depending on specific parameters formulated as per the research requirement. The different types of non-probability sampling are convenience or accidental, purposive, quota, and snowball sampling (Etikan et al., 2016; Etikan & Bala, 2017).

In the current study setting, judgmental non-probability sampling, also known as the purposive non-probability sampling technique, is employed. Such a sampling method undertakes conscious choice of the candidates as only the relevant opinions/views are required for the research work.

Quota Sampling allows the researcher to decide in advance the critical characteristics on which the sample will be stratified. Interviewers often set sample quotas. For example, with a sample of 100 people, it is pre-decided that 60% should be male and 40% should be female. The difference between stratified sample and quota sample is that the respondents in stratified sampling are selected randomly, whereas, in quota sampling, respondents are not randomly selected. The respondents may be chosen just because they are accessible to the interviewer. Therefore, Quota sampling is used here as samples are grouped in private and public sector banking groups, and banks have been chosen as per the convenience/accessibility of attaining responses. The target banks are selected from both public sector and private sector banks.

Data Collection and Sample

Size Research data is said to be the vital property of research work and is known as the asset of the study. Data collection can be done through primary and secondary approaches. **Primary** research deals with collecting data directly by the researcher utilizing research tools such as questionnaire-based surveys, interviews, and research experiments (Bryman, 2014). Secondary research techniques access data sources such as review articles, journal papers, annual and monthly reports issued by the government or other private organizations, or books to gather relevant data on the subject matter. Such data collection approaches do not necessitate the validation of the data as it remains pre-verified.

The primary methods are exploited for the overall data collection process for analyzing the strategies and policies implemented by private banks and public banks related to ALM and risk management. Primary data collection involves the questionnaire-based survey method as the data collection tool. Primary data has been collected through surveys from respective sources of officials of the Risk Department, Balance Sheet Management department, and other bank departments. The target banks are selected from the public sector and private sector. The questionnaire is sent to Head offices, Regional Offices and branches of the bank. The questionnaire is sent to 400 employees of the public and private sector bank who are engaged either with risk department, balance sheet unit, or treasury department etc. The 264 responses are included in the study. The questionnaire has been sent to 16 public banks before the merger in 2019-2020 and was received from 12 Public banks. The questionnaire is also sent to 17 private banks and response from 14 banks was received. Only 12 private banks are taken in the study as 2 banks declined to answer most of the questions in the questionnaire. A non-probability purposive sampling technique

was employed to collect data of 264 employees for the study. A sample of 264 was adequate considering one item/question to five responses ratio (Hair et al., 2014; Israel, 1992; Ruparel, 2020) for the questionnaires.

The public sector banks included in the study are Allahabad Bank, Bank of India, Bank of Baroda, Canara Bank, Corporation Bank, Indian Bank, Indian Overseas Bank, Oriental Bank of Commerce, Punjab National bank, Punjab and Sind Bank, State Bank of India, and UCO Bank. The private sector banks included in this study are the Federal Bank, HDFC Bank, ICICI Bank, Induslnd Bank, Axis Bank, Yes Bank, Kotak Mahindra Bank, DCB Bank, IndusInd Bank, South Indian Bank, RBL Bank, and IDBI bank. The data collected is then analyzed with the help of IBM SPSS software.

Data Analysis

Data analysis holds vital importance in the overall interpretation of the collected data. Data analysis involves the use of several statistical tools that allows efficient computation of the data. The study is exploratory and descriptive as it attempts to study the strategies and procedures applied by banks for the asset-liability management practice. Herein data analysis would mainly be attempted with the help of a statistical tool like the Mann-Whitney U test, mean, rank, frequency, and others.

Mann-Whitney U Test: The Mann-Whitney U test is applied to compare between two independent sets where dependent variables are generally ordinal or continuous but not normally distributed. The Mann-Whitney U test is a nonparametric test. The test provides opportunity to make conclusions about data based on assumptions about data distribution. It helps in determining

whether there is difference between the two compared groups or not. The shape of the distribution of data determines the results.

The null and two-sided research hypotheses for the *nonparametric test* are stated as follows:

H0: The two populations are equal versus

H1: The two populations are not equal.

Frequency: Descriptive statistics describe the quantitative characteristics of data set. It includes frequency analysis. Frequency is the repetitiveness of an event. Frequency analysis determines the number of occurrences of an item and calculate the central tendency, dispersion, percentile etc.

3.2.2 The research design for second section is

In this section objectives or aims broadly are profit maximization, productivity and efficiency, liquidity, credit risk management, NPAs management of banks will be determined using questionnaire and used in goal programming model of section 3.

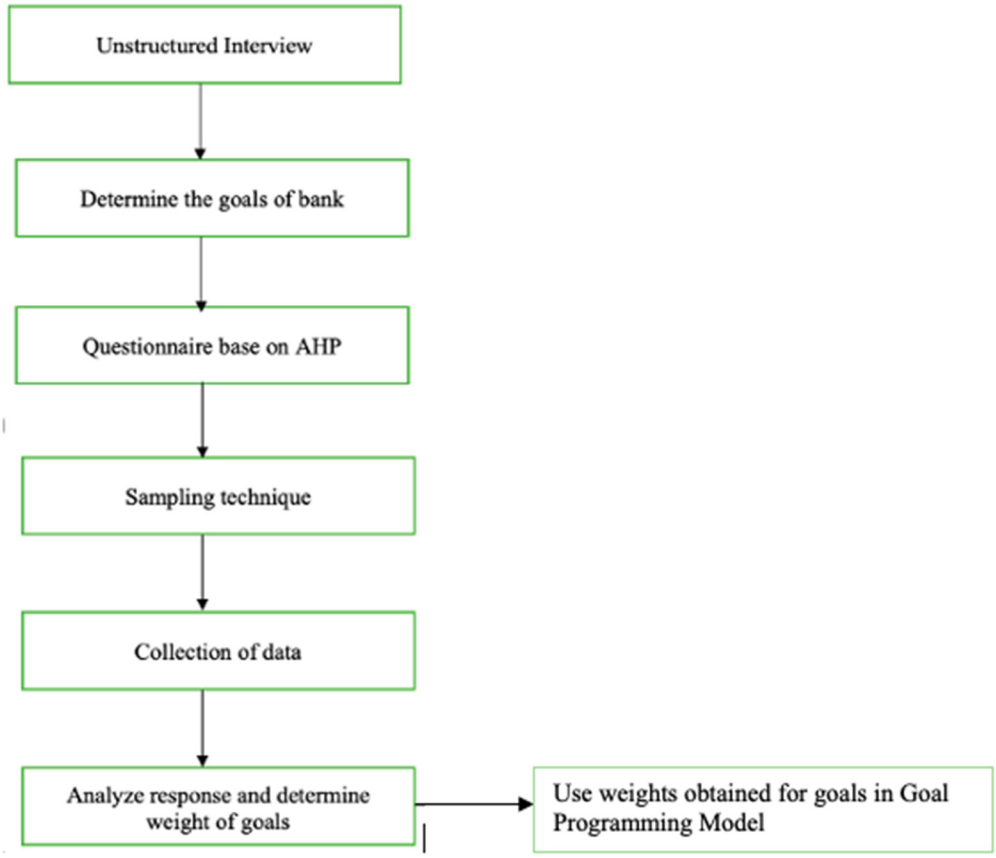


Figure 3.3: Research design for determining goals and its weights

To implement a mathematical model for optimizing the asset and liabilities of banks in India, data has been collected using the primary method. The goals or objectives of the bank are determined using questionnaire based on the Analytical Hierarchy Process (AHP). Unstructured interviews have been conducted with bank officials in the risk department, ALM cell, Treasury department, and Balance Sheet department. After conducting interviews, seven goals are identified, which are further used in the form of a questionnaire to determine the priority weights. The interviews are conducted with Oriental Bank of Commerce, ICICI bank, Punjab & Sind Bank, HDFC Bank, Allahabad Bank, UCO Bank, and Corporation Bank to determine the goals.

A well-structured questionnaire is sent to 24 banks, and only 15 banks responded. Here, purposive non-probability sampling is applied. The response of the two banks came out inconsistent and therefore rejected. The questionnaire reflects a pair-wise matrix comparison of goals based on the Analytical Hierarchy Process developed by Saaty (2008). The questionnaire for the same is attached in the appendix (2). The banks that responded to the AHP questionnaire are Oriental bank of commerce, Punjab & Sind Bank, Corporation Bank, Canara Bank, Allahabad Bank, Indian Bank, Axis Bank, ICICI Bank, HDFC Bank, South Indian Bank, Bank of Baroda, Indian Overseas Bank, and UCO bank.

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is first introduced by Thomas L. Saaty (1994) as the most common multi-criteria decision-making method. AHP break downs complex problem into a hierarchal model for simplicity. AHP allows pair-wise comparison conducted at each level of the hierarchy, integrating a scale of absolute judgments. It develops relative priorities that represent the domination of one element over another. AHP reckon the decision of experts to obtain priority scales. These scales measure the intangibles in relative terms (Saaty, 2008). Inconsistency and biases is always a concern in human judgment. AHP solves the problem of inconsistency by synthesizing the priority scales. According to Saaty (2008), "Using judgements has been considered a questionable practice when objectivity is the norm. But a little reflection shows that even when numbers are obtained from a standard scale and they are considered objective, their interpretation is always, I repeat, always, subjective. We need to validate the idea that we can use judgements to derive tangible values to provide greater credence for using judgements when intangibles are involved" (p. 85).

Over a period, AHP gained popularity in diverse fields, mainly in finance (Bhattarai & Yadav, 2009; Tabar, 2013; Tran, 2019; Yu et al., 2005; Zahedi, 1986). The use of AHP in the banking industry for ranking and assigning weights is extensive (Hunjak & Jakovčević, 2001; Javalgi et al., 1989; Kamil et al., 2013; Mačerinskienė et al., 2004; Srdevic et al., 2011; Srinivasan & Kim, 1987; Tran, 2019; Tummala et al., 1983).

Process of AHP

AHP combines both quantitative and qualitative analysis. Saaty developed steps to be followed for conducting AHP analysis. Those steps are discussed below:

1. The problem should be defined and broken down into a simple hierarchy, and the criteria and sub-criteria of the hierarchy should be defined.
2. A pair-wise matrix should be designed in N*N matrix, and experts should scale each component against another. The scales are between 1 to 9, where 9 depicts extremely important. The table of relative scale is given in table 4.
3. A pair-wise matrix determines the domination of one element/criteria over other.
4. Experts have to fill half of the matrix, and reciprocal is assigned for the remaining table. In other words, experts provide n(n-1)/2 judgments.
5. Eigenvalue and the normalized matrix are calculated in the spreadsheet. Expert choice software or MS excel can also be used for calculations.
6. Next step involves a consistency check of the judgments. Poor judgment or uncertainty of experts is checked here. The consistency is calculated using an eigenvalue, i.e., lamdamax, to determine the consistency index (CI). CR is determined using the Consistency index. To determine Consistency Ratio: **Lambda-max =** Σ (weighted sum value/ criteria weight)/n.

Consistency Index (CI) = (Lambda-max – n) / (n – 1). Consistency Ratio = CI/RI. The table for the Average random consistency index is given in table 5.

7. The value of CR less than or equal to 10% is acceptable.
8. If the value is above 10%, it points out that there is inconsistency in the judgment, and it can be reviewed and improved again.

Table 3.1: Pair-wise Comparison Scale for AHP Preferences

JUDGEMENT OF PREFERENCES	NUMERICAL VALUE
Equally important	1
Moderately important	3
Strongly important	5
Very strongly important	7
Extremely important	9
Intermediate values	
Equally to moderately preferred	2
Moderately to strongly preferred	4
Strongly to very strongly preferred	6
Very strongly to extremely preferred	8

Source: Decision making with Analytical Hierarchy Process (*Saaty, 2008)*

Table 3.2: Average Random Consistency Index (RI)

SIZE OF MATRIX	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Decision making with Analytical Hierarchy Process (*Saaty, 2008)*

AHP and Group Decision Making

AHP allows the decision-makers to obtain the judgment of experts and then encourage them towards consensual decision-making. Combining the judgment of experts in AHP has increased over time. Saaty (2008) recommended that geometric mean is the best way of aggregating individual experts' judgment in group decisions. Experts may not feel comfortable combining their judgment but agree to combine final outcomes. In such a case geometric mean of the final result can be taken to estimate group decision.

Advantages of AHP

1. AHP is one of the most flexible methods in the multi-criteria method. The method can check inconsistency and reduce biases in decision-making (Ramanathan, 2001).
2. It can be used in various fields of study (Karthikeyan et al., 2016).
3. AHP bring the judgment of experts at a common platform and combines their judgment in group decision.
4. It is easy to compute weights and rank due to the advent of software like the expert choice.
5. AHP breaks down the complex problem in a simple hierarchy of criteria. The pair-wise comparison reveals the importance of each criterion clearly (Macharis et al., 2004).
6. AHP captures quantitative and qualitative evaluation measures.

Weakness of AHP

1. Human emotions and preferences can affect the overall ranking and weights.
2. The method becomes complicated when there is a large number of goals, criteria and sub-criteria.

3. The 9-point scale has its limitation. Decision-makers find it confusing to distinguish between nearby scales.

3.2.3 The research design for third section

Since the RBI guidelines issued in 1997, the banks have made severe attempts to minimize the asset-liability mismatch; however, they have not been successful (Chatterjee & Dutta, 2016). Outlook towards asset-liability management significantly varied among the different bank types: the public, private, and foreign banks. While the public and the foreign banks relied upon fixed assets as a part of the asset-liability management approach, the private banks were associated with dynamic strategies that led to active asset-liability management (Dash & Pathak, 2016). Optimizing the asset-liability management strategies that hold true for all banking sectors suggested that profitability standards can be enhanced by monitoring and reducing short-term liquidity. Within the Indian financial market, the prevalence of the liberalized credit policy has pressurized the banks to root for liquidity maintenance, profitability, and long-term viability.

Over a while, mathematical and engineering techniques merged with business areas to develop programs that enrich planning tools. Linear programming is one such mathematical tool that is flexible and supports the planning process. As time passes, management has to face new challenges that alter its constraints and objectives. However, linear programming allows us to achieve one goal at a time. One can either maximize or minimize a single objective. The real-world problems are much more complex. In the real world, there are many goals to be achieved simultaneously. The complexity of such a problem can be solved by goal programming.

Goal Programming

Goal Programming (GP) is an extension of linear programming where more than one objective can be solved mathematically. In this model, multiple objectives can be achieved while seeking an optimal and feasible solution. In this model, goal constraints are set equal to target values that need not be achieved.

Goal Programming is a widely used technique in multi-criteria decision-making, where multiple constraints and goals can be incorporated by decision-maker (Chakroun & Abid, 2013; Zaloom et al., 1986). There is no universal definition of Goal Programming yet can be defined as a tool for decision-making problems having multiple and possible conflicting goals (Zanakis & Gupta, 1985). The Goal Programming technique was first used by Chambers and Charnes (1961) in finance and accounting. Later many other authors used the technique in portfolio selection, asset management, marketing, capital structure, budgeting, planning, and banking, etc. (Agarwal et al., 2010; Azmi & Tamiz, 2010; Chakroun & Abid, 2013; Chambers & Charnes, 1961; Cohen & Hammer, 1967; Colapinto et al., 2017; D. Giokas & Vassiloglou, 1991; Dash & Pathak, 2011; Eatman & Sealey, 1979; Fielitz & Loeffler, 1979; Fortson & Dince, 1977; Halim et al., 2015; Manoj Kumar Jain et al., 2010; Keown & Martin, 1977; M. Kruger, 2011; T. W. Lin & O'Leary, 1993; Markowitz, 1959; Sedzro et al., 2012; Tektas et al., 2005; Viswanathan et al., 2014; Viswanathan & Balasubramanian, 2007; White, 1990; Zaloom et al., 1986; Zanakis & Gupta, 1985; Ziemba & Mulvey, 1998).

The GP technique, as mentioned, assists management in the planning process by providing a meaningful framework; however, it does not eliminate the decision-making function of management. The objective of GP is to minimize the deviations from predefined targets. In

developing plans, bank management set targets and goals to be achieved. The goals can be to maximize profits, reduce risk, increase the market share, maintain sufficient liquidity or balanced portfolio subject to legal constraints imposed by the Reserve Bank of India and other management constraints. The GP model delivers the most optimum solution for such complex problems to assist bank management in a more efficient planning process.

Goal Programming Model

The goal Programming model focuses on the minimization of deviation from the given target. In goal programming, two sets of constraints, namely structural constraints and goal constraints, are identified. Structural constraints have to be fully satisfied whereas, goal constraints are set equal to target value which may or may be achieved. The decision-maker has the liberty to specify the target for each goal. The overachievement or underachievement from a target is called positive deviation and negative deviation, respectively. The objective value derived is the sum of negative and positive deviations. Few steps have to be kept in mind while formulating the goal programming model:

1. Define the decision variables
2. Define the structural constraints and goal constraints
3. Determine the relative weight
4. Define the objective function
5. State the non-negative requirement

There are two types of GP model- Preemptive Goal Programming and Non-Preemptive Goal Programming (Weighted GP model). In this thesis, Weighted Goal Programming has been used.

Weighted Goal Programming

Weighted Goal Programming is known as non-preemptive goal programming, where the weighted sum of deviation from goals is formulated under a single objective function. The objective function is to minimize the weighted sum deviation of the goals. Weighted Goal Programming is solved similarly as a linear programming problem. All the variations are multiplied by weights assigned to represent the importance of each goal.

The weighted Goal Programming as given by Charnes & Cooper (1977) is given below:

Minimize

$$z = \sum_{i=1}^{m} (w_i^- d_i^- + w_i^+ d_i^+) \tag{1}$$

Subject to linear constraints:

Goal Constraints:

$$\sum_{j=1}^{n} a_{ij}\, x_j + d_i^- - d_i^+ = b_i \quad , \quad i = 1,2,\dots,m \tag{2}$$

Structural constraints:

$$\sum_{j=1}^{n} a_{ij} x_j \begin{bmatrix} \leq \\ = \\ \geq \end{bmatrix} b_i \quad , \quad i = m+1,\dots,m+p \tag{3}$$

with $x_j, d_i^-, d_i^+ \geq 0 \quad , \quad i = 1,2,\dots,m \quad , \quad j = 1,2,\dots,n$

where m, p, and n represent goals, structural constraints, and decision variables, respectively.

w_i negative represents weight assigned to negative deviation and w_i positive represent weight assigned to positive deviations.

D_i negative represents the negative deviational variable of the i^{th} goal (underachievement of goal).

D_i positive represents the positive deviational variable of the i^{th} constraints (overachievement of goal).

B_i represents the aspiration level or the target value.

Z = objective function

A_{ij} = The coefficient associated with variable j in the i^{th} goal

X_j = the j^{th} decision variables

Advantages of Goal Programming

Goal Programming is a widely used technique in multi-criteria decision-making problems (Romero et al., 1998). It is a well-defined analytical approach to an ill-defined optimization problem (Rosenthal, 1983). The advantages of goal programming are as follows:

1. It is simple to understand even by managers.
2. Easy to use in complex problems with a wide range of decision variables, objectives and constraints.
3. Capable of handling multiple conflicting goals that cannot be fully satisfied.
4. It can be used in various fields, for example, agriculture, transportation, warehousing, capital budgeting, engineering, portfolio selection, loan management, asset management, finance, economics, etc.

Criticism of Goal Programming

Even though goal programming sounds promising and valuable, yet many authors have criticized it for setting weights or priority for goals. However, few authors suggested the use of Analytical Hierarchy Process (AHP) or other interactive methods for assigning weights and priority (Badri, 2001; Díaz-Balteiro & Romero, 2001; Etemad et al., 2019; Hamurcu & Eren, 2018; Hassan, 2015; Ho, 2007; Jamshidi et al., 2017; Jatuphatwarodom et al., 2018; H. Kruger & Hattingh, 2006; P. Lin et al., 2015; Naderi et al., 2013; Sedzro et al., 2012; Y. M. Wang & Chin, 2008; Wichapa &

Khokhajaikiat, 2017). In pre-emptive goal programming, the model disallows even the slightest trade-off of deviations in higher ranking. It is possible that some loss in higher priority goals may lead to maximization of overall objectives. The construction of the model is time-consuming, especially where there is a high number of variables and constraints.

Data Collection

The goal programming model is implemented to optimize the assets and liabilities of banks in India where data has been collected using both secondary and primary methods. The goals or objectives of the bank are determined using a questionnaire (already discussed in section 2). Later, those results have been incorporated in developing a mathematical model where a secondary research approach is applied for data. The managerial constraints have been used after conducting unstructured interviews with the bank managers of the respective banks taken in the study.

Secondary data is collected from the annual reports of banks, which is used in mathematical model development. The annual reports of banks are downloaded from each bank's website for a period of 10 years, starting from 2010 to 2019. In case the annual report is not available on the bank's website for previous years, then the same is obtained from moneycontrol.com. The annual reports have been used to compile the balance sheets of banks for further analysis. Certain important ratios are also taken from the annual reports to develop the Goal Programming Model for Asset Liability Management.

The information related to regulatory control, capital adequacy norms, liquidity risk, risk-weighted assets, cash reserve ratio, statutory liquidity ratio, priority sector lending, and BASEL III is collected from the RBI website. The model is used for one year at a time. The model can be

reused for subsequent years after redefining the goals and any changes recommended by RBI. The circulars, notifications, and guidelines issued by RBI are used here. The constraints in goal programming have been developed after carefully analyzing the guidelines given by the Reserve Bank of India.

Application of Goal Programming

The Goal Programming model is applied to allocate the assets and liabilities of banks based on regulatory compliances and constraints in such a manner that the goals specified in AHP are achieved either entirely or partially.

Decision Variables

There are two types of variables used in this model. There are decision variables related to the balance sheet of banks, and others are deviation variables that will reveal the positive or negative deviation from the targeted goals.

The decision variables from balance sheet are given below:

Assets

Cash and Bank Balance

YA1 = Cash (including balance with RBI and money at call)

Investments

YA2 = SLR Investment (government securities and approved securities)

YA3 = Non- SLR Investment (shares, debentures, bonds, joint ventures, subsidiary etc.)

HTM = % * (YA2 + YA3)

HFT = % * (YA2 + YA3)

AFS = % * (YA2 + YA3)

Advances

YA4 = Bills Purchased & discounted

YA5 = Cash Credit, Overdrafts, Loans repayable on demand

YA6 = Term Loans

YA7 = Advances to Priority Sector

YA8 = Advances to Banks in India (Interbank borrowings)

FA = Fixed Assets and Intangible assets (Goodwill if any)

OA = Other Assets

Liabilities

Shareholder's fund

XL1 = Equity Capital

XL2 = Reserves & Surplus

Deposits

XL3 = Current Deposits

XL4 = Saving Deposits

XL5 = Term Deposits

Borrowings

Borrowings from India

XL6 = Borrowings from RBI

XL7 = Borrowings from Banks and other institutions & Agencies

Borrowings outside India

XL8 = Borrowings outside India

XL9 = Other Liabilities

XL10 = Others (including provisions)

The deviation variables are presented in the table below:

Table 3.3: Deviations in Goals

Goals	Positive Deviation	Negative Deviation
Market Share of Credit	D^+_1	D^-_1
Market Share of Deposit	D^+_2	D^-_2
Return on Asset	D^+_3	D^-_3
Return on Equity	D^+_4	D^-_4
Capital Adequacy	D^+_5	D^-_5
Liquidity Risk	D^+_6	D^-_6
Non-Performing Asset	D^+_7	D^-_7

The deviations are in percentage for all the goals.

Constraints

The constraints are an essential part of goal programming. Banks follow the guidelines laid down by the RBI from time to time. These regulations become constraints for banks in the free flow of

work. Here, constraints are divided into two sections. There are system constraints and goal constraints. The constraints are given below for the years 2019:

System or structural constraints

1. Total Assets = Total Liabilities

   $\Sigma_{i=1}^{6} YA_i + FA + OA = \Sigma_{j=1}^{10} XL_j$

2. Cash Reserve Ratio = 4%

   $YA_1 \geq 4\%$*(Net demand and Time Liability)

   NDTL = Deposit, Borrowings in India and other liabilities after deducting advances to banks in India

   $NTDL = XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_8$

   $YA_1 \geq 4\%$*(NDTL)

3. Statutory Liquidity Ratio = 19.5%

   Liquid Asset = excess cash and balance with RBI over CRR + investment in govt. securities + Investment in approved securities

   Excess Cash = $YA_1 - 0.04$* NDTL

   Liquid Assets (LA) = $YA_1 - 0.04\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_8) + YA_2$

   Equation for SLR:

   Excess Cash + $(YA_2) \geq 19.5\%\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_8)$

4. Priority Sector Lending = 40% of the Adjusted Net Banking Credit

   $YA_{14} \geq 40\%\ (YA_4 + YA_5 + YA_6)$

5. Investments

   $\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (YA_2 + YA_3)$

   $26\%\ (\Sigma_{i=1}^{13} YA_i + FA + OA)\ TA <= (YA_2 + YA_3)$

6. Investments in Government Securities & approved securities

   $\%\ (YA_2 + YA_3) \leq (YA_2)$

   $84\%^* (YA_2 + YA_3) \leq (YA_2)$

7. Investments in Non-SLR securities

   $\%\ (YA_2 + YA_3) \leq (YA_3)$

   $16\%\ (YA_2 + YA_3) \leq (YA_3)$

8. Held Till Maturity (HTM)

   $\%\ (YA_2 + YA_3) \leq HTM$

9. Held for Trade (HFT)

   $\%\ (YA_2 + YA_3) \leq HFT$

10. Available for Sale (AFS)

    $\%\ (YA_2 + YA_3) \leq AFS$

11. $HTM + HFT + AFS = (YA_2 + YA_3)$

12. Cash, Balance with RBI, Money at call & short notice in India

    $\%(\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (YA_1)$

    $\%^*(\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (YA_1)$

13. Advances

    $\%(\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (YA_4 + YA_5 + YA_6) \leq \%\ (\Sigma_{i=1}^{6} YA_i + FA + OA)$

14. Bills Purchased & discounted

$\%\ (YA_4 + YA_5 + YA_6) \leq (YA_4)$

$5\%\ (YA_4 + YA_5 + YA_6) \leq (YA_4)$

15. Cash Credit, Overdrafts, Loans repayable on demand

$\%\ (YA_4 + YA_5 + YA_6) \leq (YA_5)$

$42\%\ (YA_4 + YA_5 + YA_6) \leq (YA_5)$

16. Term Loans

$\%\ (YA_4 + YA_5 + YA_6) \leq (YA_6)$

$53\%\ (YA_4 + YA_5 + YA_6) \leq (YA_6)$

17. Fixed Assets

$\%\ ((\Sigma_{i=1}^{6} YA_i + FA + OA) \leq FA \leq \%\ (\Sigma_{i=1}^{6} YA_i + FA + OA)$

18. Other Assets

$\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq OA \leq \%\ (\Sigma_{i=1}^{6} YA_i + FA + OA)$

19. Deposits

$\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_3 + XL_4 + XL_5)$

$85\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_3 + XL_4 + XL_5)$

20. Demand Deposit

$6.4\%(\ XL3 + XL4 + XL5) \leq (XL3)$

21. Saving Deposit

$\%(XL_3 + XL_4 + XL_5) \leq (XL_4)$

$16\%(XL_3 + XL_4 + XL_5) \leq (XL_4)$

22. Term Deposit

$\%(XL_3 + XL_4 + XL_5) \leq (XL_5)$

$71\%(XL_3 + XL_4 + XL_5) \leq (XL_5)$

23. Borrowing Limits

$\% (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_6 + XL_7 + XL_8)$

$5\%(\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_6 + XL_7 + XL_8)$

24. Borrowings from RBI

$(XL_6) \geq \% (XL_6 + XL_7 + XL_8)$

$(XL_6) \geq 13\% (XL_6 + XL_7 + XL_8)$

25. Borrowings from Banks and other institutions & Agencies

$\%(XL_6 + XL_7 + XL_8) \leq (XL_7)$

$62\% (XL_6 + XL_7 + XL_8) \leq (XL_7)$

26. Borrowings outside India

$\% (XL_6 + XL_7 + XL_8) \leq (XL_8)$

$24\% (XL_6 + XL_7 + XL_8) \leq (XL_8)$

27. Other liabilities

$$\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_9)$$

$$0.035\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_9) \leq 0.006\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA)$$

28. Provisions

$$\%\ (\Sigma_{i=1}^{6} YA_i + FA + OA) \leq (XL_{10})$$

Goal Constraints

1. Market Share of Credit

   Total Credit of Bank = $YA_4 + YA_5 + YA_6$

   Aggregate Credit in year 2019 = 97674300000

   $YA_4 + YA_5 + YA_6 + d_1^- - d_1^+$ = Share in aggregate Credit of Scheduled commercial bank

   $YA_4 + YA_5 + YA_6 + d_1^- - d_1^+ = \%(97674300000)$

2. Market Share of Deposit

   Total deposit of bank = $XL_3 + XL_4 + XL_5$

   Aggregate Deposit in year 2019= 125725860000

   $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+$ = Aggregate deposit of Scheduled commercial bank

   $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = \%(125725860000)$

3. Return on Asset

   Net Profit / Total Asset + $d_3^- - d_3^+$ = Targeted ROA

4. Return on equity

   Net Profit / (Equity capital + Reserves) + d_4^- - d_4^+ = Targeted ROE

   Income = interest income on excess cash over CRR + Interest income on advance and investment + other income

   Expenses = Interest expense on borrowings and deposits + other expenses + Provisions for the year

   Provisions for the year = 0.25% of Standard Advances (YA4 + YA5 + YA6) + Provision on depreciation on investment + Provision for Non- Performing Assets + Provision for depreciation on fixed assets

   Profit = Income – Expenses – Provisions for the year

   Net Profit = Profit – tax (assumed to be 25%)

5. Capital adequacy ratio

   Capital + reserves ≥11.6 % (risk weighted assets)

   $XL_1 + XL_2 \geq 0.116$*(Risk weighted asset)

   Risk weighted asset = $0*(YA_1 + YA_2) + 1.25*(YA_3) + 0.2*(YA_4 + YA_5) + 1.25*YA_6 +$ 1*(FA)

   Shareholders' fund / Risk weighted Asset+ d_5^- - d_5^+ = 0.116

   $XL_1 + XL_2$ / Risk weighted asset + d_5^- - d_5^+ = 0.116

6. Liquidity risk- (liquidity coverage ratio)

   LCR = HQLA/ Cashflow in 30 days

   LCR>=100%

   HQLA/ Cashflow in 30 days + d_6^- - d_6^+ = 100%

7. Net NPA

   NPA<= % of Net Advances

   NPA/ Net Advance + d_7^- - d_7^+ = Targeted NPA ratio

   NPA + d_7^- - d_7^+ = % (YA_4 + YA_5 + YA_6)

   Net NPA= Gross NPA- Provision on Gross NPA – Recoveries/write off required

The % is the multiplier symbol here, and it is estimated based on the past 10 years data of banks taken under study. The multiplier is calculated for each bank separately based on its past trend, averages, minimum ratios, and maximum ratios. The profitability, return on asset, return on equity, cost ratio, provisions, etc., changes with no specific trend; therefore, either average is used or last year ratios are used to calculate certain multipliers. Moreover, these multipliers are also discussed with bank employees/ managers/ in the risk and balance sheet department who are given targets from the head office. Although managers or AVPs or other senior employees do not set targets, but they are aware of such targets as they have to implement and achieve those targets. After considering the suggestions of bank employees of each bank (balance sheet unit and risk department mainly), the multipliers have been calculated for each bank separately.

Targets/ Goals

The targets of the respective banks are constructed on the performance of benchmarked bank. The banks are categorized based on the slabs for total assets, deposits, and advances (table 3.4 To 3.6). The banks that fall under each slab are grouped together. BOB, BOI, and Canara Bank are grouped together. Likewise, Allahabad Bank, Andhra Bank, Corporation bank, Indian Bank, Indian Overseas bank, OBC, and UCO bank are grouped together. Lastly Punjab & Sind bank and Bank

of Maharashtra are grouped together. Based on the banks' performance in each group, a benchmark bank is determined. The banks under study will be given targets based on the benchmark bank.

Bank in Study	**Benchmark Bank**
OBC	Indian Bank
Allahabad Bank	Andhra Bank
UCO Bank	Andhra Bank
Punjab & Sind	Andhra Bank/ Bank of Maharashtra
Canara Bank	BOB

Table 3.4: Total Assets of the Public Sector Banks

Total Assets of the Banks ('Crore)				
100000-200000	**200001-400000**	**400001-600000**	**600001-800000**	**>800001**
Bank of Maharashtra	Allahabad Bank		BOB	SBI
Punjab & Sind bank	Andhra Bank		BOI	
	Corporation		Canara bank	
	Indian Bank			
	Indian Overseas Bank			
	OBC			
	UCO			

Table 3.5: Deposits of Public Sector Banks

DEPOSITS ('CRORE)				
90000-150000	**150001-350000**	**350001-550000**	**550001-750000**	**>750001**
Bank of Maharashtra	Allahabad Bank	BOI	BOB	SBI
Punjab & Sind bank	Andhra Bank		Canara bank	
	Corporation			
	Indian Bank			
	Indian Overseas Bank			
	OBC			
	UCO			

Table 3.6: Advances of Public Sector Banks

ADVANCES ('CRORE)						
60000-100000	**100001-200000**	**200001-300000**	**300001-400000**	**400001-500000**	**500001-600000**	**>600000**
Bank of Maharashtra	Allahabad Bank		BOI	BOB		SBI
Punjab & Sind bank	Andhra Bank			Canara bank		
UCO	Corporation					
	Indian Bank					
	Indian Overseas Bank					
	OBC					

Target of reduction of NPA is based on the past year NPA ratio. If bank has NPA ratio of more than more than 5%, then targeted NPA ratio will be 5%. If bank has NPA ratio of less than 5%, then targeted NPA ratio will be 1%.

Objective function

Minimize = Z

$$Z = w_1*d^-_1 + w_2*d^-_2 + w_3*d^-_3 + w_4*d^-_4 + w_5*d^-_5 + w_6*d^-_6 + w_7*d^+_7$$

$$Z = 0.035*d^-_1 + 0.038*d^-_2 + 0.119*d^-_3 + 0.116*d^-_4 + 0.244*d^-_5 + 0.284*d^-_6 + 0.101*d^+_7$$

The goals for banks under study are developed as per the 2018 performance of benchmark bank. Each bank is unique, and it is necessary to incorporate the uniqueness of each bank in the model by analyzing each bank individually. Therefore, targets for each bank are set after analyzing its past records. The targets of banks will be shown for each bank separately during analysis. The goal constraints will be set individually for each bank. The model developed here is computed using LINGO software version 17.0 for optimizing the problem. The software is easy to use and read. The software also tells the solution is feasible or infeasible. Infeasible solution refers to output that has input errors based on constraints.

CHAPTER 4: RESULTS AND ANALYSIS

This chapter focuses on the results and analysis. The work is divided into three sections. First section focuses on studying the strategies, producers, and practices used in bank with respect to ALM and risk management. This is achieved by analyzing the primary data collected from bank officials. Second section investigate the goals of bank with respect to ALM after conducting unstructured interviews with bank officials. Later in this section weight are calculated for each goal as per Analytical Hierarch Process (AHP). The goals and their weight are later used in section three for framing objective in goal programming model. Section three uses Linear Goal Programming technique to frame objectives, goal constraints and decision constraints for banks. The model is then run in LINGO software to simulate and derive optimum asset liability mix of four Public Banks.

This chapter will provide detailed analysis of the results obtained for each objective.

4.1 STUDYING THE STRATEGIES, POLICIES AND PROCEDURES OF ALM IN BANKS IN INDIA

The current study aims to study and analyze strategies employed by banks to manage their assets and liabilities while complying with statutory requirements. In this section, risk assessment techniques used in the Indian banking sector and techniques used in Asset liability management are also studied. To achieve the objectives, the study has used a quantitative data approach. The primary data is collected through a survey from respective sources of officials of the Risk Management department, balance sheet department and other departments of the banks.

4.1.1 Respondents' Profile

The respondents are both male and female bank employees. Male respondents are 66.7% and female respondents are 33.3% of total sample size i.e 264. Most of the respondents are of age 31-40 years (52.7%) followed by 41-50 years (30.7%). Most respondents have master's degree as highest education. Few respondents also have professional qualification i.e., Chartered Accountants, CAIIBs etc. The respondents are well qualified and experienced in their field of banking. At present given the educational level, employees are even eligible for higher position at age of 31-40 years. The data for the study has been collected from various top managerial employees of the banks. Most of the respondents are Assistant General Manager, Assistant Vice President and Managers. Other than that, employees holding positions such as Chief Manager, Branch Manager, Senior Trader, Regional Manager are also considered for the survey. The respondents have been selected from various profiles to understand from the policy perspective to implementation stage. Most respondents have completed 5 years tenure in their current bank. The tenure of respondents also varies from 1 year to 15 years. Respondents are selected from 12 Public Sector Bank and 12 Private Sector Bank.

4.1.2 PART A: Structure and Resources

Questions a. to f. are introductory in nature and used to start dialogue with the respondents

a. A separate risk management function

Table 4.1: Frequency table of Separate Risk Management Function

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Yes	264	100	100
No	0	0	0
Total	264	100	

As per RBI guidelines, it is mandatory for banks to have separate risk management function which is supervised by board of directors. They conduct meeting with other committees at executive level to ensure that the bank has adopted the principle and requirements of managing risk. Table 4.1 shows that all banks selected for survey have their separate risk management function constituted of Board of Directors.

b. Availability of chief risk officer

Table 4.2: Frequency table for Availability of Chief Risk Officer

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Yes	264	100	100
No	0	0	0
Total	264	100	

According to RBI circular, all scheduled commercial banks (except Local Area Bank and Regional Rural Bank) are required to frame board approved policy that should state the roles and responsibilities of Chief Risk Officer (CRO). CROs' have professional qualification or experience in the area of risk management. Table 4.2 shows that 100% of the respondents said their bank has a chief risk officer.

c. Independent ALM function

Table 4.3: Frequency table of Independent ALM Function

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Yes	264	100	100
No	0	0	0
Total	264	100	

As a mandatory requirement from RBI, all Scheduled Commercial banks are advised to have independent ALM function. ALM function of bank keep check on whether ALCO adhere to the limits set by the Board, design the business strategy of the bank (on the assets and liabilities sides)

after incorporating the bank's budget and risk management objectives. Table 4.3 exhibits that 100% of the respondents said their bank had a separate asset-liability management function.

d. Reporting of independent asset-liability management

Table 4.4: Frequency table for Reporting of Independent Asset-Liability Management

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Balance sheet management unit	11	4.17	4.17
Risk department or ALM cell in Risk department	187	70.83	75
Treasury and Risk department	11	4.16	79.16
Treasury department, Treasury operations	55	20.84	100
Total	264	100	

From the table 4.4 it is evident that all the respondents are engaged in ALM related work. However, as the question is open ended and responses are captured from their replies, many of the respondents might be handling multiple tasks and all of them are well aware of ALM process. 70.83% of the respondents said their bank's independent asset-liability management reporting area is the Risk Management Department or ALM cell in Risk Management Department. Then 20.84% of the respondents said it is the treasury department or treasury operations, where they work on ALM-related issues. The rest of the respondents said it was the Balance Sheet Management Unit, Treasury and Risk department, that looked after the independent asset-liability management.

e. Formal committee for asset-liability management

Table 4.5: Frequency table for Formal Committee for Asset-Liability Management

RESPONSE	FREQUENCY	PERCENT
Yes	264	100
Total	264	100.0

As per RBI guidelines, all commercial banks have to form Asset Liability Management Committee comprising of senior management. The ALCO in banks is responsible for balance sheet planning from risk-return perspective that undertakes interest rate risk management and liquidity risk management. Board of Directors decide the role and responsibilities of ALCO. ALCO is responsible for the decisions taken by it. ALCO ensures that it incorporate the risk management practices and parameters set by the board while taking decisions. ALCO works on product pricing of deposits and advances, and maturity profile of assets and liabilities, etc. ALCO also reviews the work of ALM desk related to the progress and results of the implementation of decisions made in the previous meetings. The committee is headed by either Managing Director or Chief Executive officer. The Chiefs of other departments such as Investment, Credit, Funds, International Banking, Economic Research and Information Technology Department are also members of the committee. Depending upon the complexity of the bank hierarchy, some banks also have sub-committees to assist ALCO.

Table 4.5 exhibits that 100 percent of the respondents said they have a formal committee for asset-liability management.

f. Statement of principles and objectives concerning asset-liability management

Table 4.6: Frequency table of Statement of Principles and Objectives

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Yes	264	100.0	100.0

The objectives and principles are framed by member of Risk Management Committee comprising of Board of Directors of the banks. These objectives, principles, limits, targets are then intimated to other committees at executive level. ALCO is also one such committee which follow the

objectives and targets set by board of directors and incorporate them in its own planning. Based on the analysis, monitoring and reporting of the risk profiles by ALM cell, the ALCO recommend the action required to adhere to bank's internal limits.

Table 4.6 exhibits that 100% of the respondents said their banks had statements of principles and objectives concerning asset liability management.

g. Frequency of asset-liability management committee meet

Table 4.7: Frequency table for Meeting of ALM Committee

RESPONSE	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Quarterly	132	50.0	50.0
Monthly	88	33.3	83.3
Annually	0	0	83.3
Other*	44	16.7	100.0
Total	264	100.0	

Other* - more than 4 times a year

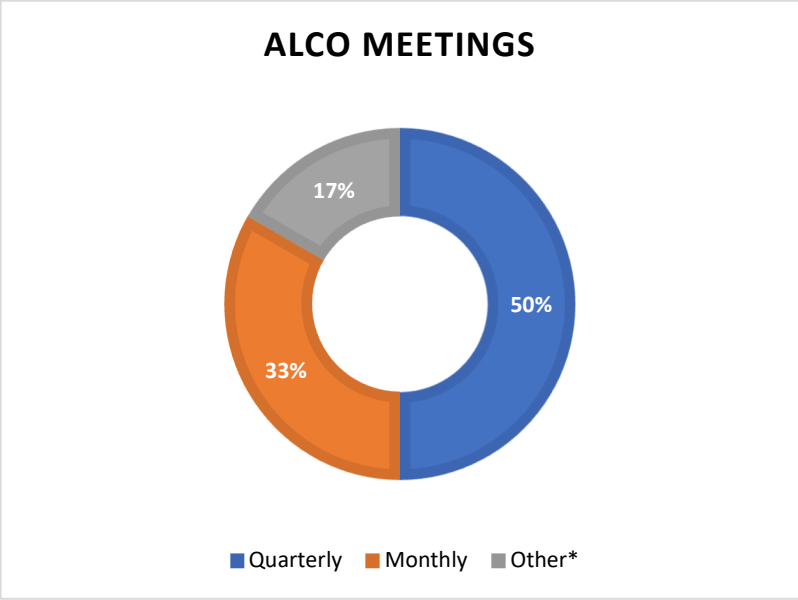


Figure 4.1: ALCO Meeting

Table 4.7 depicts the frequency and percentage of how often the asset-liability management committee meets. 50% of the respondents said ALM committee members meet every quarter for an asset-liability management meeting, whereas 33.3% of the banks have monthly meetings. Further, only 16.7% of respondents ticked others which shows that these banks comply the minimum requirements of 4 meetings in a year. However, such banks also conduct meetings as and when required to discuss important matters.

It is also noted that regular meetings are conducted by all banks to discuss monitoring, progress and implementation of decisions taken by ALCO.).

h. Indicate the measure that the ALM financial objectives are based on-

Table 4.8: Measurement of ALM Financial Objectives

		RESPONSES		PERCENT OF CASES
		Frequency	Percent	
Financial objectives are based on	Economic Value	209	51.4%	79.2%
	Accounting Earnings	187	45.9%	70.8%
	Other	11	2.7%	4.2%
Total		407	100.0%	154.2%

Economic Value is the profit earned by bank minus the cost of financing the company's capital. It is a well-accepted tool for management to evaluate bank's performance. Economic value is based on principles such as increasing the return from existing assets, investing in portfolio where return is more than cost of capital, free up cash flows. In banks economic value is expressed as free cash flow and their present value. Economic value can be calculated by deducting mark-to-market value of liabilities from the assets. Funding cost does include risk premium.

Respondents were allowed to choose more than one option. In questionnaire survey, 79.2% of the respondents said their bank considered economic value to measure financial objectives of asset-liability management (table 4.8).

Accounting profit is net income derived after deducting all explicit costs. 70.8% of respondents said their banks had accounting earnings as a measure of financial objectives of asset-liability management. 4.2% respondents were specific in their response and suggested that risk limit, ratio, and regulatory norms are also considered to measure ALM financial objectives.

i. Level at which ALM is performed

Table 4.9: Frequency table for Level at which ALM Is Performed

		RESPONSES		PERCENT OF CASES
		Frequency	**Percent**	
Indicate level at which ALM is performed	For each financial product/asset segment separately	187	60.7%	70.8%
	At the divisional level	33	10.7%	12.5%
	at the total organization company /business unit level	88	28.6%	33.3%
Total		308	100.0%	116.6%

Before analyzing the responses given in table 4.9, we need to understand organizational structure of private and public sector banks. Private sector banks function on vertical system. Each vertical system related to either product or a function. For example, vertical can be capital market or wholesale banking operations etc. Whereas Public Sector banks operate on pyramid structure (Figure 4.2).

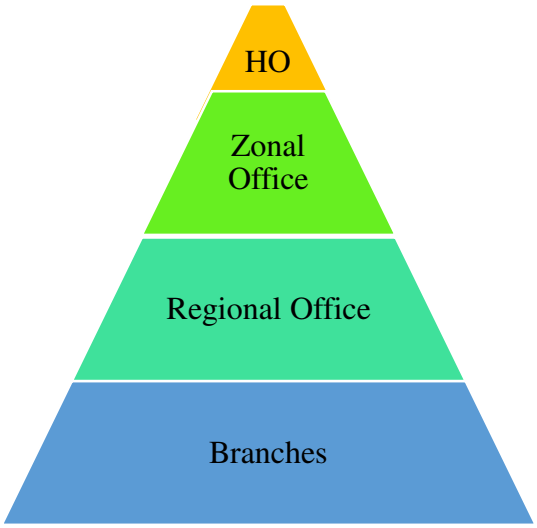


Figure 4.2: Structure of public sector banks

ALCO is an apex committee and based on recommendations of ALCO, Treasury and funds department, product-wise (whether asset or liability) targets at HO level are decided and then disaggregated through top-down or Bottom-up approach. Within the boundaries, targets are disaggregated up to lowest level i.e., branch office. Once boundaries/parameters/targets are set by HO, all other units are directed to achieve those targets. Deviations are taken care by each controlling level. However, branch office /regional office/ Zonal Office has hardly any roles in deciding ALM.

Table 4.9 also provides similar outcome, where it presents that 70.8% respondents said that ALM is performed for each product/asset separately. 28.6% respondents claim that ALM is performed at organizational level/ business unit level and only 10.7% respondents said that ALM is performed at divisional level.

j. significance of asset-liability management in the banking system

Table 4.10: Frequency table showing Significance of ALM in Banking

	FREQUENCY	PERCENT	CUMULATIVE PERCENT
To minimize the volatility in Interest Income and Economic value	44	16.7	16.7
It provides a framework for banks to tackle the risks.	22	8.3	25.0
All of the above	198	75.0	100.0
Total	264	100.0	

Statistics acquired regarding the significance of asset-liability management in the banking system reveals, 75% of the respondents felt that all the reasons given in the questionnaire are significant for having ALM in banking and RBI rigorously monitor it. These reasons are:-

1. to minimize the volatility in interest income and economic value
2. the reason for the growing importance of ALM is the rapid innovation taking place in the financial products of the bank,
3. it provides a framework for banks to tackle the market risks that may arise due to rate fluctuations and excessive credit risk,
4. recognizes the vision of the management

Whereas 16.7% felt that minimizing the volatility in interest income and economic value is the most significant reason for having asset-liability management in the banking system. Further, 8.3% of respondents said it provides a framework for banks to tackle the market risks that may arise due to rate fluctuations and excessive credit risk.

k. Department responsible for the Asset-Liability Management

Table 4.11: Frequency table showing the Department Responsible for The Asset Liability Management

	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Treasury	88	33.3	33.3
Risk	176	66.7	100.0
Total	264	100.0	

ALM is interrelated to all other departments of the bank, be it credit department, loan department, funds department etc. ALCO is executive level committee framed under Risk Management department. Table 4.11 shows that 66.7% of the respondents said the risk department in their bank is responsible for Asset-Liability Management. Further, 33.3% of the respondents said that treasury department which deals with market risk is responsible for ALM in their banks.

l. Key driver for change in strategic asset allocation

Table 4.12: Frequency table showing Key Driver for Change in Strategic Asset Allocation

	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Lowering risk	77	29.2	29.2
Increasing return	11	4.2	33.3
Matching liabilities	176	66.7	100.0
Total	264	100.0	

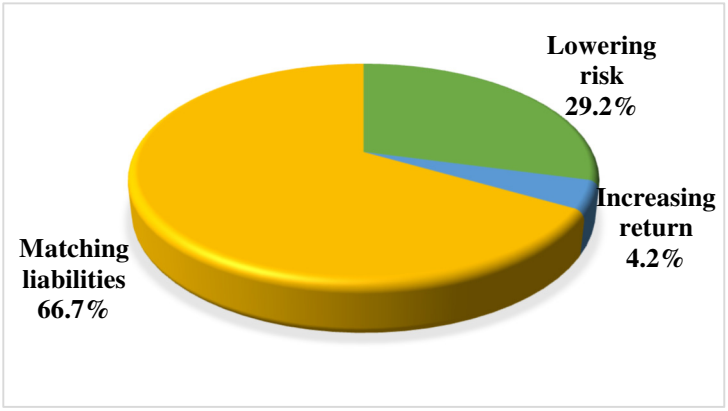


Figure 4.3: Key driver for change in asset allocation

Asset allocation depends on goal factors, risk tolerance, age-based asset allocation etc. Based on aforementioned factors, 66.7% of the respondents said it was the matching liabilities with assets that acted as the most critical driver for change in strategic asset allocation. Whereas 29.2% of the respondents said, the change in strategic asset allocation was for lowering the risk. Further, 4.2% of the respondents said it was increasing the return that led to a shift in asset allocation.

m. Other drivers to be considered while changing asset allocation

Table 4.13: Frequency table showing other Drivers for Change in Asset Allocation

	RESPONSES		PERCENT OF CASES
	Frequency	Percent	
Lowering risk	176	28.1%	66.7%
Increasing return	220	35.1%	83.3%
Matching liabilities	99	15.7%	37.5%
Changes in perception of the market	33	5.3%	12.5%
Changes caused by variations in market values	44	7.0%	16.7%
Availability of new asset classes	55	8.8%	20.8%
Total	627	100.0%	237.5%

Respondents were allowed to choose more than one option if they wish. 83.3% of the respondents considered increasing returns as other drivers for changing asset allocation. 66.7% of the respondents said it was for lowering the rate of risk. Further, 37.5% of the respondents said it was for matching the liabilities. After that, 20.8% of the respondents believed that asset allocation change is triggered to avail new asset classes. On the other hand, 16.7% of respondents said it was due to changes caused by variations in market values, and 12.5% said it was due to changes in perception of the market.

n. The basic motive for change in asset allocation strategy in the bank

Table 4.14: Frequency table for the Basic Motive for Change in Asset Allocation Strategy in The Bank

		RESPONSES		PERCENT OF CASES
		Frequency	Percent	
Basic motive for change in asset allocation strategy	Actuarial valuation to be done for employee benefits	22	5.3%	8.3%
	Asset liability matching study	242	57.9%	91.7%
	It was the decision based on the board's knowledge and research	121	28.9%	45.8%
	The change in asset allocation strategy was due to corporate influence	33	7.9%	12.5%
Total		418	100.0%	158.3%

As given in table 4.14, 91.7% of the respondents believed that the motive for strategic asset allocation was asset-liability matching study. Whereas 45.8% of the respondents argued, the decision was based on the board's knowledge and research. However, 12.5% and 8.3% of the respondents said the change in asset allocation strategy was due to corporate influence or due to actuarial valuation for employee benefits.

4.1.3 PART B: Asset-Liability Management

The statements given in the questionnaire related to ALM are all important and mandatory for the bank. The respondents were asked about their perspective on the significance of ALM based on their own experience and practice. This part of the questionnaire reveals that respondents' practice of ALM in their department determine their opinion and thereby their responses.

The statement that best describes the asset liability management and its significance is ranked by bank officials using Likert scale.

Table 4.15: Significance of ALM

STATEMENTS RELATED TO THE ASSET LIABILITY MANAGEMENT Responses		Count	Percentage %
a. Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet	Neutral	46	17.4%
	Agree	127	48.1%
	Strongly Agree	91	34.5%
b. Asset liability management comprises of managing liquidity risk and market risks in an effective manner	Neutral	57	21.6%
	Agree	112	42.4%
	Strongly Agree	95	36.0%
c. Asset liability management consists of managing maturity gaps and mismatches	Neutral	57	21.6%
	Agree	113	42.8%
	Strongly Agree	94	35.6%
d. Asset liability management involves managing structural, static and dynamic gap	Neutral	46	17.4%
	Agree	115	43.6%
	Strongly Agree	103	39.0%
e. Management of overall liquidity of the bank	Neutral	29	11.0%
	Agree	87	33.0%
	Strongly Agree	148	56.1%
f. Facilitates, coordinates, communicates and control balance sheet risk planning	Neutral	44	16.7%
	Agree	109	41.3%
	Strongly Agree	111	42.0%
g. Ensures bank's risk lies within parameters set by the Board	Neutral	50	18.9%
	Agree	118	44.7%
	Strongly Agree	96	36.4%
h. Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps	Neutral	42	15.9%
	Agree	101	38.3%
	Strongly Agree	121	45.8%

Out of the total respondents of the study, 34.5% of the respondents strongly agreed that asset-liability management comprises effectively managing both the assets and liabilities sides of the bank balance sheet, whereas 48.1% of the respondents only agreed to it. It has already been indicated earlier in the literature review.

When asked about whether asset-liability management comprises managing liquidity risk and market risks effectively, 36% of the respondents strongly agreed to it, whereas 42.4% only agreed to it. 35.6% of the respondents strongly agreed that asset-liability management consists of managing maturity gaps and mismatches, whereas 42.8% of the respondents agreed to it. ALM is used to manage the risks that are faced by the banks in the form of a mismatch of the asset and liabilities, as proved by Zenios (1995).

Further, 39% of the respondents strongly agreed that asset-liability management involves managing structural, static, and dynamic gaps. The rest, 43.6% and 17.4%, either agreed to it or were just neutral. When asked, is ALM manages the bank's overall liquidity, 56.1% strongly agreed, while 33% only agreed to it. 42% of the respondents strongly agreed that asset-liability management facilitates, coordinates, communicates and controls the balance sheet planning whereas, 41.3% of the respondents agreed to it. 16.7% of respondents were neutral, i.e., they neither agree nor disagree.

36.4% of the respondents strongly agreed that asset-liability management ensures that the bank's risk lies within the board's parameters, 44.7% of the respondents agree to it. In contrast, the rest 18.9% of the respondents, neither agree nor disagree. Further, 45.8% of the respondents strongly agreed that ALM undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps, whereas 38.3% only agreed to it.

Sum and mean are calculated to determine ranks for the significance of ALM that mostly define ALM. The significance that is ranked 1 describes ALM as management of the overall liquidity of the bank. According to respondents, ALM also undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps.

Table 4.16: Mann Whitney Test Results - Significance of ALM

TEST STATISTICS[a]								
	a	b	c	d	e	f	g	h
Mann-Whitney U	7939.5	8533.5	8688.0	8577.0	8216.0	8504.0	8200.0	7117.5
Wilcoxon W	16717.5	17311.5	17466	17355	16994	17282	16978	15895.5
Z	-1.357	-.309	-.042	-.236	-.902	-.364	-.892	-2.798
Asymp. Sig. (2-tailed)	.175	.757	.967	.814	.367	.716	.372	.005
a.Grouping Variable: bank								

Ho: There is no difference between public banks and private banks regarding the understanding and implementation of ALM.

H1: There is difference between public banks and private banks regarding the understanding and implementation of ALM.

In table 4.16 the p-value is not less than 0.05 indicating that both public and private bank have similar understanding and implementation of ALM and follows similar approach to ALM. However, the p-value is less than 0.05 for last statement on ALM. Therefore, based on the responses it can be said that Public Banks and Private Banks have different opinion on the fact that ALM undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps. According to Private sector bank, Asset Liability Management is useful beyond maturity analysis. It is not limited to maturity analysis only.

4.1.4 Part C: Asset Liability Management Committee Functions

The functions of ALCO are decided by board of directors. All the functions are determined as per the directives given by RBI. Though all the functions of ALCO are important and useful for the balance sheet planning, yet responses of the respondents are evaluated here. The responses are based on the opinion of respondents pertaining to their practice, knowledge and experience.

Table 4.17: Frequency table of ALCO Function

ASSET LIABILITY COMMITTEE FUNCTION	RESPONSES		BANK	
			PUBLIC	PRIVATE
a. ALCO is responsible for the management of the overall liquidity of the bank	Neutral	Count	15	20
		Table N %	5.7%	7.6%
	Agree	Count	55	59
		Table N %	20.8%	22.3%
	Strongly Agree	Count	62	53
		Table N %	23.5%	20.1%
b. ALCO facilitates, coordinates, communicates and control balance sheet planning with regards to risks inherent in managing liquidity and convergences in interest rates	Neutral	Count	17	22
		Table N %	6.4%	8.3%
	Agree	Count	44	49
		Table N %	16.7%	18.6%
	Strongly Agree	Count	71	61
		Table N %	26.9%	23.1%
c. ALCO is responsible for ensuring that the bank's operational risk lies within the parameters set by its Board of Directors	Neutral	Count	30	43
		Table N %	11.4%	16.3%
	Agree	Count	60	46
		Table N %	22.7%	17.4%
	Strongly Agree	Count	42	43
		Table N %	15.9%	16.3%
d. ALCO regularly undertakes maturity analysis of Assets and Liabilities to identify liquidity gaps	Neutral	Count	9	23
		Table N %	3.4%	8.7%
	Agree	Count	53	44
		Table N %	20.1%	16.7%
	Strongly Agree	Count	70	65
		Table N %	26.5%	24.6%

A percentage frequency distribution is a display of data that specifies the percentage of observations for each data point or grouping of data points. It is a beneficial method of expressing the relative frequency of survey responses. The respondents were required to use a Likert scale of 1 to 5, i.e., strongly disagree to strongly agree to rank the ALCO functions.

Most of the respondents (43.56%) strongly agree that the asset-liability committee was responsible for the bank's overall liquidity; out of this, 62% of respondents were from public banks, and 53% were from private banks. The rest of the respondents who agreed (43.18%) were 20.8% from public sector banks and 22.3% from private sector banks.

Further, when asked whether the asset-liability committee facilitates, coordinates, communicates, and controls balance sheet planning regarding risks inherent in managing liquidity and converges in interest rates, out of 50% of the respondents who strongly agreed, 71% were from public companies and 61% from private companies.

40.2% of the respondents agreed that the asset-liability committee is responsible for ensuring that the bank's operational risk lies within the parameters set by its Board of Directors. Out of the total respondents, 22.7% were from public banks, and 17.4% were from private banks. Whereas 32.2% of respondents strongly agreed to this.

The respondents (51.13%) strongly agreed that the asset-liability committee regularly undertakes a maturity analysis of Assets and liabilities to identify liquidity gaps. 26.5% of the respondents were from public sector banks, and 24.6% were from private sector banks. This is in line with the findings of Saunders and Cornett, 2008 who stated that the asset-liability committee

makes reports regarding the interest rate and places sensitive assets and liabilities in different brackets as per maturity and repricing duration.

As per Sum and Mean analysis, according to Bank officials, the primary function of the ALM committee is to undertake maturity analysis of Assets and Liabilities to identify liquidity gaps. Moreover, ALCO facilitates, coordinates, communicates, and controls balance sheet planning regarding risks inherent in managing liquidity and convergences in interest rates.

From the analysis, it is clear that there is still need for the higher management to allow employees of the bank from every department to understand the functions, benefits, and implementation of ALM process. Effective functioning of ALM depends on the contribution of other departments towards achieving their targets.

Table 4.18: Mann Whitney Test Results - ALCO Function

Test Statistics [a]				
	a	**b**	**c**	**d**
Mann-Whitney U	8010.500	7984.500	8178.000	7970.500
Wilcoxon W	16788.500	16762.500	16956.000	16748.500
Z	-1.238	-1.289	-.917	-1.324
Asymp. Sig. (2-tailed)	.216	.197	.359	.185
a. Grouping Variable: bank				

H0: There is no significance difference between the functions of ALCO in private and public banks.

H1: There is significance difference between the functions of ALCO in private and public banks.

In the above table 4.18 p-value is not less than 0.05 so we conclude that there is no significant difference between the asset liability committee functions performed by public banks and private banks. Both types of banks have framed alike functions to be performed by ALCO.

4.1.5 PART D: Risks Associated with the ALM Process

Table 4.19: Risks Associated with The ALM Process

RISKS ASSOCIATED WITH ALM PROCESS	Response	Count	Percentage %
a. Interest Rate risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	264	100.0%
b. **Foreign exchange risk**: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	198	75.0%
	No	66	25.0%
c. Credit risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	11	4.2%
	No	253	95.8%
d. Sovereign risk: Is this a material risk for your bank?	Yes	231	87.5%
	No	33	12.5%
Does your bank have a formal process to manage this risk?	Yes	231	87.5%
	No	33	12.5%
Is this risk considered a part of ALM in your bank?	Yes	22	8.3%
	No	242	91.7%
e. Equity market risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	246	93.2%
	No	18	6.8%
f. Liquidity risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	264	100.0%

RISKS ASSOCIATED WITH ALM PROCESS	Response	Count	Percentage %
g. Operational risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	22	8.3%
	No	242	91.7%
h. Legal and regulatory risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	264	100.0%
i. Strategic Risk: Is this a material risk for your bank?	Yes	264	100.0%
Does your bank have a formal process to manage this risk?	Yes	264	100.0%
Is this risk considered a part of ALM in your bank?	Yes	198	75.0%
	No	66	25.0%

For the questions related to risk associated with ALM process and responses thereof, we have discussed and explained the underline assumptions hereunder: -

The risk mainly – interest rate risk, liquidity risk, and legal & regulatory risk have been accepted by all respondents as part of ALM process as these risks are directly related to ALM and are present in the banking sector since the beginning of the formal banking sector. These risks are well understood by every rank of employees in the bank.

Foreign exchange risk, strategic risk, sovereign risk, credit risk, counter party risk, equity market and operational risk are part of risk management, and these risks are generally dealt separately. However, their impact and implications are factored in pricing of financial products, setting day/overnight limits. Risk such as operational risk are quantified to gauge the monetary impact on Profit & Loss and accordingly provided for in capital. These risks are accessed and mitigated/ diversified to the extent possible by the banks. However, these risks as a part of ALM processes

are viewed differently by different respondents. Those banks who have integrated treasury and risk management along with ALM process, the respondents of such banks viewed these risks as part of ALM, while others have not. Difference in opinion also comes from respondents' role in the ALM process.

Table 4.19 gives the frequency and percentage of yes and no for the corresponding levels of the variable where interest rate risk, liquidity risk, legal and regulatory and equity risk has more significant effect on ALM. Interest risk, liquidity risk, market risk and foreign exchange risk, legal and regulatory risk, and strategic risk are considered part of ALM risk mitigation process.

a) Interest Rate Risk

All the respondents of the study i.e.,100%, said that they see interest rate risk as a material risk to their bank and they also admitted that their bank did have a formal process to manage this risk. In their study, Fabozzi and Konishi (1991) had proved that asset-liability management is also regarded as an important tool that is used by banks to conduct risk management activities such as market risk, financial risk, interest rate risk, and others. The banks also considered interest rate risk as a part of asset-liability management. This research is in line with Jain et al. (2010) where they said that ALM helps in managing interest rate risks.

b) Foreign Exchange Risk

100% of the respondents saw foreign exchange risk as a material risk to their bank and agreed that their bank has a formal process to manage this risk. But when asked whether their banks consider this as a part of asset-liability management, only 75% of the respondents said yes and the rest 25% said no to it. The banks that deal less in foreign exchange transactions are most that replied foreign

exchange risk is not part of ALM process. Samy and Raman (2018) in their study had noticed that new work systems need to be implemented which can tackle issues like foreign exchange, and ALM was found to be an excellent tool to do so.

c) Credit Risk

When asked whether credit risk is seen as a material risk for their banks, all the respondents agreed, and they even agreed that their banks have a formal process in place to manage such risks. When asked whether it is considered as a part of asset-liability management in their bank then, 95.8% of the respondents declined and said credit risk is monitored separately in credit risk department instead of forming it part of asset liability management, whereas 4.2% of the respondents said their banks did see it as part of ALM function. However, they all agreed that credit risk is considered while framing decisions related to balance sheet planning.

d) Sovereign Risk

Sovereign risk is the associated with the probability that a national government's treasury or central bank may default on their sovereign debt, or else it may implement foreign exchange rules or such restrictions that will either significantly reduce or negate the worth of its forex contracts. 87.5% of the respondents said their banks considered a sovereign risk as a material risk and only 12.5% didn't consider it as a material risk. Further, only 87.5% of the respondents agreed that their bank has a formal process to manage this risk, the rest 12.5% said their bank did not have a formal procedure in place for this risk. 91.7% of the respondents said their bank did not consider this as a part of asset-liability management, while 8.3% of the respondents said their banks did consider it a part of their asset-liability management.

e) Equity Market Risk

Equity risk is involved with the change in price of stock. Increase or decrease in price of stock affect the gain/loss on it. 100% of the respondents agreed that equity market risk was a material risk for their bank, and they also said that their bank had a formal procedure in place to manage this risk. Whereas, when asked whether they consider being a part of the asset-liability management then 93.2% of the respondents said yes and 6.8% said they did not consider it. The respondents that said no also replied that market risk is mitigated separately in either treasury department/operations or market risk department.

f) Liquidity Risk

100% of the respondents agreed that liquidity risk was a material risk for their bank, and they also said that their bank had a formal procedure in place to manage this risk. Further, 100% of the respondents also agreed that liquidity risk was considered as a part of asset-liability management in their banks. This research is in line with Jain et al. (2010) where they said that ALM helps in managing liquidity risks.

g) Operational Risk

100% of the respondents agreed that operational risk was a material risk for their bank, and they also said that their bank had a formal procedure in place to manage this risk. Further, 91.7% of the respondents said their banks did not consider this as a part of their asset-liability management, whereas 8.3% of respondents said their banks did consider. Operational risk department is responsible for managing operational risk. Every bank has operational risk department to manage such risk.

h) Legal and Regulatory Risk

100% of the respondents agreed that legal and regulatory risk was a material risk for their bank, and they also said that their bank had a formal procedure in place to manage this risk. Further, 100% of the respondents also agree that legal and regulatory risk was considered as a part of asset-liability management in their banks. The policies, regulations, and guidelines of RBI are followed by banks in their ALM process and practices.

i) Strategic Risk

100% of the respondents agreed that strategic risk was a material risk for their bank, and they also said that their bank had a formal procedure in place to manage this risk. Further, 75% of the respondents said their banks consider strategic risk as integral part of asset-liability management, whereas 25% of respondents said their banks did not consider it as part of ALM. The ALCO strategically plan the balance sheet of the bank; however, ALCO also follows the policies, targets and parameters set by board of directors.

Table 4.20: Mann Whitney Test Results - Risks associated with The ALM Process

TEST STATISTICS [A]									
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
Mann-Whitney U	8712	8712	7986	8046.50	8184.00	8712.00	7260.00	8712.00	8712
Wilcoxon W	17490.00	17490.00	16764.00	16824.500	16962.000	17490.000	16038.000	17490.000	17490.000
Z	.000	.000	-3.38	-1.515	-1.950	.000	-4.890	.000	.000
Asymp. Sig. (2-tailed)	1.000	1.000	<.001	1.000	.051	1.000	.000	1.000	1.000

Hypothesis

H0: There is no significant difference in treatment of risks in public and private banks

H1: There is significant difference in treatment of risks in public and private banks

In the above table 4.20, p-value is less than 0.05 for credit risk (c). More Private banks treat credit risk as part of ALM than public banks. In contrast, more public banks treat operational risk (g) as part of ALM than private banks. The p-value for all other risk such as interest rate risk, foreign exchange risk, sovereign risk, equity marker risk, liquidity risk, legal & regulatory risk and strategic risk is greater than 0.05, thereby null hypothesis is accepted which says that there is no significant difference in the way public and private banks treat these risks. Public and Private banks deal with all other risk in ALM alike.

4.1.6 PART E: The Risk Mitigation Practices Followed in Banks

Table 4.21: Risk Mitigation Practices

Risk Mitigation Practices followed in banks			Banks= 264		
			Public	Private	Total
Maturity Gap Analysis	Yes	Count	132	121	253
		Percentage %	50%	45.8%	95.80%
	No	Count	0	11	11
		Percentage %	0.0%	4.2%	4.2%
Duration Gap Analysis	Yes	Count	132	132	264
		Percentage %	50.0%	50.0%	100%
Maturity Profile (Liquidity Gap) Preparation	Yes	Count	132	132	264
		Percentage %	50.0%	50.0%	100%
Liquidity Planning Under Alternative Scenario	Yes	Count	132	132	264
		Percentage %	50.0%	50.0%	100%
Currency Swaps	Yes	Count	110	110	220
		Percentage %	41.7%	41.7%	83.40%
	No	Count	22	22	44
		Percentage %	8.3%	8.3%	16.60%
Setting Up of Appropriate limits for open position and gaps	Yes	Count	110	66	176
		Percentage %	41.7%	25.0%	66.70%
	No	Count	22	66	88
		Percentage %	8.3%	25.0%	33.30%
Loan Review Mechanism	Yes	Count	132	132	264
		Percentage %	50.0%	50.0%	100%
Usage of Credit Derivatives	Yes	Count	88	66	154
		Percentage %	33.3%	25.0%	58.30%
	No	Count	44	66	110
		Percentage %	16.7%	25.0%	41.70%
Setting Operational Risk Limits	Yes	Count	132	132	264
		Percentage %	50.0%	50.0%	100%
Risk Education	Yes	Count	121	99	220
		Percentage %	45.8%	37.5%	83.30%
	No	Count	11	33	44
		Percentage %	4.2%	12.5%	16.70%

The table 4.21 shows the comparison between public and private banks for risk mitigation practices.

Interest Rate Risk

100% of the respondents from the public banks said their banks used maturity gap analysis for interest rate risk mitigation practices, whereas in the private banks 91.67% of the respondents said their bank uses the same analysis for interest risk mitigation. In short, 95.8% of the total respondents agreed that maturity gap analysis is used as a tool for analyzing and recoding interest rate risk. This result is in line with the Brown and Swartz (1989), Singh and Tandon (2012), Singh (2013) and Vij (2005). When asked about duration gap analysis as a practice for interest rate risk mitigation, the private bans, as well as the public bank respondents, said they do use it as interest rate mitigation practice.

Liquidity Risk

All of the respondents from the private banks and public banks admitted that their bank used the liquidity gap as a practice to mitigate liquidity risk. On the other hand, they also admitted that their banks also used liquidity planning under alternative scenarios i.e., 100% of private and public bank. Scenario analysis is widely used technique in banks through which the analysis of the anticipated value of the portfolio is determined after a specified duration of time (Brzaković et al., 2016; Kosmidou & Zopounidis, 2002). Samy and Raman (2018) in their study had noticed that new work systems need to be implemented which can tackle issues like liquidity risk, and ALM was found to be an excellent tool to do so.

Currency Risk

In response to the practice for currency risk mitigation, most of the respondents said their bank did use currency swaps for currency risk mitigation, this was agreed by 83.3% of total respondents from which, 50% respondents were of private bank and 50% of were public bank respondents. Whereas few respondents i.e., 16.67% said their banks did not use currency swaps for mitigation of currency risk, in this 50% of respondents were of public and private banks each. Many respondents also suggested that their banks have set up an appropriate limit for an open position and gaps to mitigate the risk associated with currency risk. Out of the 66.67% of total respondents, 41.7% of public bank respondents, and 25.0% of the private bank respondents agreed to it. Around 33.3% respondents said their banks do not set up an appropriate limit for an open position and gaps to mitigate the currency risk. 16.67% respondents from public banks while 50% were from private banks answered no to setting up of Appropriate limits for open position and gaps.

For Credit Risk

Loan Review Mechanism is a widely used tool in bank that cover the entire portfolio of credit. The credit cycle that starts with processing of documentation for loan, granting loan, disbursement of loan money, grading, monitoring and recovery problems, is handled by loan review. Bank officials should have good understanding of the Basel norms and guidelines issued by RBI on credit risk and administering loan review mechanism. This process identifies and assess the quality of credit and grade loan portfolio that determines the soundness and financial health of banks. According to Chilukuri and Rao (2014), “Loan Review Mechanism (LRM) is an effective tool for constantly evaluating the quality of loan book and to bring about qualitative improvements in credit administration.” The aim purpose of LRM is to identify problem accounts as early as possible to

minimize the probability of loss. The problem accounts are tackled either through restructuring or the termination of poor-quality loans.

All the respondents in the study said that their banks did consider loan review mechanisms as a practice for mitigating risk related to credit. On the other hand, when asked about the usage of credit derivatives 58.3% respondents said their bank used it as a practice to mitigate credit risk. Out of the ones who agreed 57.1% belonged to public sector banks and 42.9% belonged to private sector banks. The rest of the 41.67% respondents who said their banks did not use credit derivatives to mitigate credit risk, 40% belonged to public banks while 60% belonged to private banks. This is information that has emerged in this study when compared to the previous studies done in this regard.

For Operational Risk

All of the respondents said that their banks have set up an operational risk limit while considering measures for mitigating the operational risk. Samad-Khan (2008) said that operational risks are mainly associated with the uncertainties and hazards that occur in the working of the organization. Many of the respondents also said that risk education was also a practice adopted by their banks for mitigating the risk associated with operations. 83.3% respondents answered positively where, 45.8% of the public bank respondents agreed to it whereas, 37.5% belonged to private banks. Of the few respondents (16.67%) who said their bank did not use risk education as a measure to mitigate operational risk, 4.2% of them belonged to public sector banks and 12.5% of them belonged to private sector banks.

Table 4.22: Mann Whitney Test Results - Risks Mitigation Practice

	FOR INTEREST RATE RISK	FOR LIQUIDITY RISK	FOR CURRENCY RISK	FOR CREDIT RISK	FOR OPERATIONAL RISK
Mann-Whitney U	7986.000	8712.000	6776.000	7260.000	7260.000
Wilcoxon W	16764.000	17490.000	15554.000	16038.000	16038.000
Z	-3.382	.000	-3.571	-2.741	-3.626
Asymp. Sig. (2-tailed)	.001	1.000	.000	.006	.000

Ho: There is no significance between Public and Private banks with respect to techniques used to mitigate risk.

H1: There is significance between Public and Private banks with respect to techniques used to mitigate risk.

Table 4.22 reveals that there is significant difference between Public and Privates bank for interest rate risk techniques, currency risk techniques, credit risk techniques and operational risk techniques to mitigate aforesaid risk. As the p-value is less than 0.05, null hypothesis is rejected, and alternative hypothesis is accepted. Banks use risk mitigation techniques based on the size, asset classification, volatility in market, control mechanism, availability of information etc. Risk mitigation techniques also depends upon technological advancement and use of such technologies in banks. Therefore, banks differ in their approach to mitigate risk, but they all have some mechanism to reduce or manage risk. As p-value is more than 0.05 in case of liquidity risk, it can be concluded that Public and Private sector banks implement same techniques to mitigate liquidity risk.

4.1.7 Analysis of ALM and Risk Management Based on Unstructured Interviews/Discussion

Banks' risk management policies are in line with the RBI standards and guidelines. Banks also follow the industry's best practices depending upon the complexity and scale of operations. The risk management policies are undertaken to alleviate returns by creating a balance between risk and return on assets. It also enhances the market share to improve shareholder's wealth, improves asset quality, and ensure capital adequacy. Banks have a risk governance structure to measure, monitor, and control risk. Banks have techniques implemented to handle individual risk.

Liquidity and Market Risk

The market risk management division has specialized employees that look into interest rate risk, foreign exchange risk, and liquidity risk. Market risk is controlled through Net Overnight Open Position, Stop Loss, VaR, Modified Durations, and PV01, etc. Banks also maintain contingency fund plans for an unforeseen liquidity crisis. The foreign exchange risk is monitored by Net overnight open position, VaR limits, Aggregate Gap Limits, Individual Gap Limits on a daily basis.

Banks monitor liquidity profiles on a dynamic and static basis with gap analysis techniques. Various liquidity ratios and stress testing are also considered a part of monitoring liquidity risk. Periodically, liquidity positions and liquidity stress output are discussed by ALCO and the risk management committee of the banks.

Policies related to investment, ALM, and derivatives are first approved by the board and then govern treasury activities. The policies have a limit structure to handle risk. ALCO reviews

business profiles regularly to determine the impact on ALM. Market Risk Management group also does periodic monitoring to recommend necessary changes in processes, policies, and methods.

Credit Risk Management

Banks have Credit Risk Management (CRM) to develop credit risk rating models and scorecards for corporate and retail clients. The credit risk rating model is a scientific method of calculating credit risk. The model is periodically validated to maintain its efficiency and validity. The probability of default (PD) for portfolios is assessed regularly to act as a basis of estimation of Expected credit loss.

In most banks Document Electronic Verification & Archival (DeVA) is used as a tool for pre -disbursement, checking and verifying documentation. It also removes irregularities to improve credit quality and documentation. LAMP is another tool for managing credit risk by capturing data on credit monitoring parameters and rate accounts. It facilitates precise and accurate monitoring of credit. LAMP acts as an Early Warning Signals (EWS) to manage risk and take corrective measures timely.

Banks are pushing harder to manage NPA with daily dashboards like Days Past Due (DPD) Report, NPA Movement Chart, and Mock Runs to forecast degradations and improvement in collections.

Operational Risk

The operational Risk Management division manages overall operational risk within a well-defined framework of operational risk management. The operational risk is identified, measured,

monitored, and controlled through root cause analysis of operational loss data, Risk and Control Self-Assessment (RCSA), Key Risk Indicators (KRI), etc.

Banks need an internal controls system, ways to observe transactions, key backup plan, and contingency procedures. The governance and framework for managing operational risks are defined in the Operational Risk Management Policy.

Based on the responses of questionnaire and direct interview with bank officials, it can be concluded that banks implement the guidelines framed by RBI. ALM is important and useful tool for banks to plan diversification in assets and liabilities after considering various risks associated with banking. Decisions of ALCO are monitored and revised time to time depending upon the feedback by ALM desk on analysis of risk profiles, reporting of sensitivity of assets and liabilities, and forecasts of possible changes in market conditions that might impact balance sheet.

It is also to be noted that there is knowledge gap in employees of the bank with respect to ALM. Employees from all the department must be aware of the ALM process and contribute to risk mitigation process.

4.2 RESULTS AND ANALYSIS OF ANALYTICAL HIERARCHY MODEL APPLICATION

The goals used in developing the conceptual model are decided after an unstructured interview conducted with bank officials. Banks desire to increase return on investment, create deposit mix where cost is low, increase market share of credit and deposits, increase return on equity etc. Based on that total seven goals are identified after unstructured interview: market share of credit, market share of the deposit, return on asset, return on equity, managing capital adequacy, liquidity, and

Non-Performing Asset (NPA). The banks want to increase the market share of credit, market share of the deposit, return on asset, and liquidity. Bank intends to maintain a capital adequacy ratio as per regulatory norms. However, they don't want capital to fall below the capital adequacy ratio as determined by the Reserve Bank of India. Banks intend to reduce liquidity risk by maintaining sufficient liquidity. Banks also want to reduce their NPA over time. Other than these goals are framed part of constraints.

Table 4.23: Goals for Banks

Goals	Definition
Liquidity	Liquidity risk is the inability of a bank to meet its obligation when it arises. Banks manage their liquidity risk through ALM.
Capital Adequacy	Capital Adequacy Ratio determines the extent of capital a bank requires against its risk-weighted credit exposure to protect it against losses before the risk of insolvency.
Market share of the Deposit	It shows the bank's share of customer deposits in an aggregate deposit of scheduled commercial banks in India.
Market Share of Credit	It shows the credit available to banks from the aggregate credit facility available to all scheduled commercial banks in India.
Return on Asset	Return on Asset (ROA) is a profitability ratio which indicates the net profit generated on total assets. It is computed by dividing net profit after tax by average total assets (RBI, n.d.-a).
Return on Equity	Return on Equity (ROE) is a ratio relating net profit (net income) to shareholders' equity. Here the equity refers to share capital reserves and surplus of the bank (RBI, n.d.-a).
Non-Performing Asset (NPA)	An asset, including a leased asset, becomes nonperforming when it ceases to generate income for the bank. The banks want to reduce their nonperforming asset. It is calculated by dividing Gross NPA with Gross Advances. The lower the ratio, the better it is for the bank.

As discussed earlier, AHP helps make a pair-wise comparison that reduces inconsistency and allows experts to focus on the dominance of one element over others. It makes the entire process more meaningful and free from extraneous influences. The judgment of experts in banks is collected and analyzed using MS excel. The decisions are checked for any inconsistency. The consistency ratio must be below 0.1 (10%); otherwise, the judgments must be revised. When data is collected from experts, out of 15 only 2 turns out to be inconsistent. Therefore, data from 13 questionnaires have been used for analysis. After analyzing each questionnaire, we finally used a geometric mean, as suggested by Saaty (2008), to arrive at a group decision. The decision of each expert is combined by taking a **geometric mean** after analyzing the data. The priority weights of the goals are mentioned in table 4.24 below:

Table 4.24: Weights of Goal as per AHP

GOALS	WEIGHTS (USING AHP)
Market share of credit	0.035
Market share of deposits	0.038
Return on assets	0.119
Return on equity	0.116
Capital adequacy ratio	0.244
Liquidity risk	0.284
Non-Performing Asset	0.101

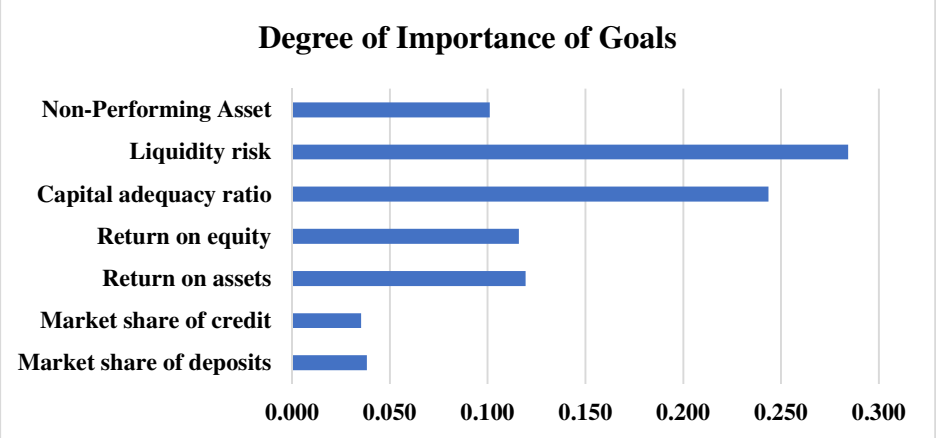


Figure 4.4: Degree of importance of each goal

Figure 4.8 above reveals that banks give more importance to liquidity risk. Liquidity holds 28.4% importance among other goals. The second weighted goal is capital adequacy of banks. Capital adequacy is 24.4% relatively important than rest of the goals. Return on asset (ROA) is ranked third important goal of banks and return on equity ROE) is fourth important. Experts have given 11.9% and 11.6% weight to ROA and ROE respectively. According to AHP analysis, NPA has 10.1% weight in goals of banks. Market share or deposit and market share of credit holds 3.8% and 3.5% importance respectively.

4.3 RESULTS AND ANALYSIS OF GOAL PROGRAMMING MODEL USED TO OPTIMIZE THE ASSET AND LIABILITY MIX IN PUBLIC SECTOR BANKS IN INDIA

In this chapter, the results of model run in Lingo software are analyzed. The results present the allocation of each element of balance sheet of banks in most optimum manner depending upon the goals and constraints. The results incorporate the weights as determined by bank experts using AHP and therefore, includes the experience and wisdom of banking experts in the model. The model is used to analyze Indian scheduled commercial banks, but goals are defined for each bank separately. The results present the most optimum allocation of assets and liabilities in the balance sheet. After simulating the model, the most optimum solution is presented for each bank.

The model has statutory constraints such as Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), Priority Sector Lending (PSL), and Capital Adequacy Ratio (CAR). In 2019, CRR was 4%, SLR was 19.5%, PSL was 40% and CAR was 11.5% (however, 11.6% is used for most banks).

Oriental Bank of Commerce

The model analyzed the asset and liabilities of Oriental Bank of Commerce (OBC) for 2019. The targets are set in constraints after simulating the model. The target value shows the most optimum level of the bank.

- In the market share of the credit (OBC Bank), the target is set as 1.815% of the aggregate market share of the credit of all scheduled commercial banks.
- Likewise, the market shares of deposits (OBC Bank) is set at 1.86% of the aggregate market share of deposits of scheduled commercial banks.
- Targeted Return on asset and Return on Equity (ROE) is set based on the ROA and ROE of Indian bank for year 2018 i.e., 0.49% and 7.95% respectively.
- Capital adequacy ratio is targeted at 11.6% based on RBI guidelines (RBI, n.d.-b)
- Cashflow for 30 days has been taken from the 2019 annual report as Rs. 374319700.
- As Net NPA in 2018 is 10.48%, therefore Targeted Net NPA ratio is 5%.
- The total assets have been taken from the balance sheet of 2019 as Rs. 2719095661, and Equity capital is taken as Rs. 13702093.
- The interest income on investments and advances is taken 8.57%% after considering the average yield of OBC from 2010-2018.
- The interest expense on deposits and borrowing is 5.8%, taken from the average cost of the fund from the year 2010 to 2018 annual report of OBC.
- Liquidity coverage ratio (LCR) should be 100% of the cashflow for 30 days as per RBI and same is targeted to achieve.

Other multipliers

- Provision for depreciation is created at 15% of fixed assets, provision for depreciation of investment is created at 0.44% and provision for NPA is created at 22.5% after taking the averages for the year 2010-2018.
- Other income is calculated at 0.11% of total assets and non-operating expenses are calculated at 0.14% after considering the average for the years 2010-2018.
- Other multipliers and lower-upper bounds are based on trends, minimum and maximum values, and averages for the bank for the year 2010 to 2018.

It is to be noted that all the figures are in '000.

Therefore, the goal constraints for OBC banks are as follows:

1. **Market Share of Credit**

   $YA_4 + YA_5 + YA_6 + d_1^- - d_1^+ = 0.01815 *(97674300000)$

2. **Market Share of Deposit**

   $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = 0.0186 *(125725860000)$

3. **Return on Asset**

   Net profit / $(\Sigma_{i=1}^{6} YA_i + FA + OA) + d_3^- - d_3^+ = 0.49\%$

4. **Return on equity**

   Net Profit / $(XL_1 + XL_2) + d_4^- - d_4^+ = 7.95\%$

5. **Capital adequacy ratio**

$XL_1 + XL_2 + d_5^- - d_5^+ = 0.116*(0*(YA_1 + YA_2) + 1.25*(YA_3) + 1*(YA_8 + YA_9 + YA_{10}) + 0.2*(YA_4 + YA_5) + 1.25*YA_6 + 1*FA)$

6. **Liquidity risk- (liquidity coverage ratio)**

HQLA / cashflow for 30 days + $d_6^- - d_6^+ = 100\%$

7. **Net NPA**

Net NPA / $(YA_4\ YA_5 + YA_6) + d_7^- - d_7^+ = 5\%$

The model is then run-on Lingo software, and the results are given in table 4.25:

Table 4.25: Real and Model Values of OBC bank

OBC 2019		REAL	MODEL	DEVIATION
ASSETS				
Cash and Bank	YA1	164760868	135954800	28806068
SLR Investment	YA2	583275898	593850500	-10574602
Non SLR Investment	YA3	209402321	113114400	96287921
Advances	YA4, YA5, YA6	1592848135	1772850420	-180002285
Bills Purchased and Discounted	YA4	31570620	88642520	-57071900
Cash Credits, Overdrafts and Loans repayable on demand	YA5	756933270	744597200	12336070
Term Loans	YA6	804344245	939610700	-135266455
Fixed asset	FA	25892722	21752770	4139952
Other assets	OA	142915717	81572771	61342946
Total Asset		**2719095661**	**2719095661**	**0**
LIABILITIES				
Capital & Reserves	XL1 & XL2	189012435	174499590	14512845
Current deposit	XL3	142610850	150063500	-7452650
Saving deposit	XL4	541258880	375158800	166100080
Term Deposit	XL5	1642584046	1819520000	-176935954
Borrowing in India	XL6, XL7	141193671	103325630	37868041
Borrowing outside India	XL8	0	32629150	-32629150
Other liabilities	XL9	16850484	9517081	7333403
Provisions	XL10	45585295	54381910	-8796615
Total Liabilities		**2719095661**	**2719095661**	**0**

The analysis made from above model value is given in table 4.26:

Table 4.26: Analysis of OBC Bank

	MODEL
NTDL	2439856000
HQLA	400424700
Priority lending	709140100
Net Profit	955251.7
Liquid asset	632211000
Risk Weighted Asset	1504307000
Return on Asset %	0.0378
Return On equity %	0.654
CRR %	4
SLR %	25.9
Market Share of deposit %	0.01815
Market Share of credit %	0.01865
Capital Adequacy ratio %	11.6
CD Ratio %	75.61
Liquidity coverage ratio %	106.9
Priority lending ratio %	40
NPA %	5
Liquid Asset to Total Asset Ratio %	23.25
Investments Held till Maturity (HTM)	498410200
Investments Held for Trade (HFT)	4241789
Investments Available for Sale (AFS)	204312800
Cash in hand and Money at call to Total Asset %	1.14

Table 4.27: The Deviation from The Targets

GOALS	NEGATIVE DEVIATION %	POSITIVE DEVIATION %
Market Share of credit	0	0
Market Share of deposit	0	0
Return on Asset	0	0.45
Return On equity	0	7.3
Capital Adequacy ratio	0	
Liquidity coverage ratio %	0	6.97
NPA	0	0

The results of the model are compared with actual figures of the balance sheet for the year 2019. Table 4.25 highlights any deviation in model value from an actual value. Optimized assets and liabilities of OBC bank have been calculated, which shows that the bank can reallocate its assets and liabilities and achieve more than its current position. As already mentioned, after testing the model for sensitivity, the targets at which bank is most optimal are used.

The above table 4.26 shows that the model has satisfied all the statutory constraints and decision constraints. The analysis derived from the model values are:

- The CRR achieved here is 4% and SLR is 25.9%. Bank has excess cash over CRR, which is 1.14% of total assets. Bank keep excess cash over CRR to manage day to day expenses and maintain liquidity.
- The credit in priority sector lending is 40%.
- The model has successfully achieved all seven goals, although there are few deviations recorded. There is no infeasibility in the solution when the model is run in Lingo software.
- The objective is to minimize the deviations that negatively affect the bank's performance.
- The actual market share of the credit of OBC bank is 1.63% in 2019, whereas the model has achieved 1.815%. It shows that the bank can increase its market share of credit to increase profitability and interest income.
- The actual market share of deposits for OBC bank is 1.85%, and in the model, the market share of the deposit is 1.865% as against the target of 1.86%. It shows that the bank can slightly increase its deposits at low cost to fund its assets.
- The credit-deposit (CD ratio) achieved is 75.6% as against 68.5%.

- The bank generates a 0.0378% ROA in the model, which is better than the actual ROA in 2019 i.e., 0.02%. However, the targeted return on assets is 0.49%. The model reports a positive deviation of Rs. 11423460 to achieve a 0.49% return on the assets.
- The targeted ROE is 7.95% however, the model has achieved 0.654%. The ROE for OBC bank in the year 2019 is reported as 0.3%. there is deviation of 7.3% from the target.
- In the year 2019 bank has earned a profit of Rs. 5,49,938 whereas, as per the model, the net profit is Rs. 9,55,251.
- Capital Adequacy Ratio of 11.6% is achieved in the model.
- The liquidity coverage ratio (LCR) is 106.97%, which shows that the bank has sufficient high-quality liquid assets to match the cash outflows for 30 days. In year 2019, OBC bank recorded LCR as 119.13%.
- The model also shows that the liquidity asset to total asset ratio is 23.25%. The model has allocated more funds in SLR investments and cash and balances with RBI to improve the bank's liquidity. The model values show that the bank has enough liquid assets to protect itself from a liquidity crisis.
- Over a period of time, NPAs have increased tremendously for all banks. NPAs can be decreased by management's effort to screen loan applications and secure loans against physical property. NPA can also be reduced by recovery mechanism. The model aims to reduce the NPA ratio to 5%. The NPA ratio is computed by dividing net NPAs by Net Advances. The OBC bank has recorded a 5.93% of NPA ratio in the year 2019. The model suggests that after creating 22.5% of provision on Gross NPA and initiating recoveries of Rs. 79800730 bank can achieve 5% Net NPA ratio.

- As per model bank holds 70% of its total investment till maturity whereas it has 30% investment available for sale and held for trade, therefore increasing the liquidity of the bank.
- In model indicated that banks could shift their portion of assets towards investments and advances. An increase in deposits at low cost will increase the fund for investment and credit.
- As the objective was to minimize the deviations, the objective value as per the model is 0.68 as there is negative deviation of Rs. 18.95 in market share of deposit which is almost negligible.

Table 4.27 shows the under and overachievement of targets. The negative deviation and positive deviation are recorded. The model wants to minimize the underachievement of targets, and it has been achieved. In Goal Programming, when underachievement of any goal is minimized, the objective function undertakes a negative deviation (D minus). On the other hand, if overachievement of goal is to be minimized, then positive deviation is undertaken in the objective function. In this model, we want to reduce underachievement of market share of credit, market share of the deposit, return on asset, return on equity, capital adequacy ratio, and liquidity risk. In contrast, we want to minimize the overachievement of NPA, i.e., we don't want to increase NPA. According to optimal solution generated with the model, bank has deviation in ROA of 0.45%. Increase in net profit by Rs. 11423460, bank can achieve target of 0.49% of ROA. Similarly, there is deviation in ROE of 7.3%, which indicate that by bank is underachieving its target of 7.95% by Rs. 106,66,340. In Model solution, bank is overachieving liquidity coverage ratio by 6.97%.

The ability to test the sensitivity of the model is the best advantage of goal programming. The variables can be changed to test the effect on the optimal solution. The model has tested sensitivity to arrive at the optimal solution where the deviation is minimized to 0. Any change in the constraint may lead to a solution where deviations from the target may arise. It is an integral part of the solution to test the effect of parameters for sensitivity. There are high chances of frequent change in goals, priorities, and available resources in the real world. Any change will result in the alteration of the optimum solution (Holzman, 1981).

The sensitivity of net profit with change in the interest rate of advances & investment and change in the interest rate of deposits and borrowing is shown in table 4.28. Sensitivity analysis reflects the effect of one or more input variable on the output variable. In this case the effect of change of average yield on investment/advances and average cost of funds on Net Profit is determined assuming that all other income and expenses do not change. The sensitivity test reveals that the bank is profitable if spread (Average yield on investment/advances – average cost of fund) is 2.8% or above. As interest rate on deposits and borrowing increases bank generates losses. With the increase in the interest expense, the bank has to increase its interest income to remain profitable.

Table 4.28: Sensitivity Analysis of Interest Rate on Net Profit of OBC Bank (fig. in crores)

INTEREST ON DEPOSIT AND BORROWING	INTEREST ON ADVANCES AND INVESTMENT							
		8.40%	**8.60%**	**8.70%**	**8.80%**	**9.00%**	**9.20%**	**9.40%**
	5.60%	151	523	709	895	1267	1639	2011
	5.70%	-35	337	523	709	1081	1453	1825
	5.80%	-221	151	337	523	895	1267	1639
	5.90%	-407	-35	151	337	709	1081	1453
	6.00%	-593	-221	-35	151	523	895	1267
	6.10%	-779	-407	-221	-35	337	709	1081
	6.20%	-965	-593	-407	-221	151	523	895
	6.30%	-1151	-779	-593	-407	-35	337	709
	6.40%	-1337	-965	-779	-593	-221	151	523
	6.50%	-1523	-1151	-965	-779	-407	-35	337
	6.60%	-1709	-1337	-1151	-965	-593	-221	151
	6.70%	-1895	-1523	-1337	-1151	-779	-407	-35
	6.80%	-2081	-1709	-1523	-1337	-965	-593	-221
	6.90%	-2267	-1895	-1709	-1523	-1151	-779	-407
	7.00%	-2453	-2081	-1895	-1709	-1337	-965	-593

Punjab & Sind Bank

The model analyzed the asset and liabilities of Punjab & Sind Bank (P&S Bank) for 2019. The targets are set in constraints after simulating the model. The target value shows the most optimum level of the bank.

- In the market share of the credit (P&S Bank), the target is set as 0.705% of the aggregate market share of the credit of scheduled commercial banks. It is the most optimum level of credit a bank can achieve given its total assets and other constraints.
- Likewise, the market shares of deposits (P&S Bank) is set at 0.771% of the aggregate market share of deposits of scheduled commercial banks.
- Targeted Return on Asset and Return on Equity is set based on the ROA and ROE of Andhra bank for year 2017 i.e., 0.08% and 1.53% respectively. In year 2018, Andhra Bank suffered losses.
- Capital adequacy ratio is targeted at 11.6% based on RBI guidelines (RBI, n.d.-b)
- Cashflow for 30 days has been taken from the 2019 annual report as Rs. 111675724.
- As Net NPA in 2018 is 6.93%, therefore Targeted Net NPA ratio is 5%.
- The total assets have been taken from the balance sheet of 2019 as Rs. 1089820458, and Equity capital is taken as Rs. 5649123.
- The interest income on investments and advances is taken 7.42 %% after considering the average yield of P&S Bank for year 2019.
- The interest expense on deposits and borrowing is 4.84%, taken from the average cost of the fund for the year 2019 annual report of P&S Bank.

- Liquidity coverage ratio (LCR) should be 100% of the cashflow for 30 days as per RBI and same is targeted to achieve.

Other multipliers

- Provision for depreciation is created at 15% of fixed assets, provision for depreciation of investment is created at 0.44% and provision for NPA is created at 11.48%.
- Other income is calculated at 0.54% of total assets and non-operating expenses are calculated at 1.4% after considering the average for the years 2010-2018.
- Other multipliers and lower-upper bounds are based on trends, minimum and maximum values, and averages for the bank for the year 2010 to 2018.

It is to be noted that all the figures are in '000.

Therefore, the goal constraints for PSB banks are as follows:

1. **Market Share of Credit**

   $YA_{11} + YA_{12} + YA_{13} + d_1^- - d_1^+ = 0.705\%*(97674300000)$

2. **Market Share of Deposit**

   $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = 0.771\%*(125725860000)$

3. **Return on Asset**

   $\text{Net Profit} / (\Sigma_{i=1}^{6} YA_i + FA + OA) + d_3^- - d_3^+ = 0.08\%$

4. **Return on equity**

   $\text{Net Profit} / (XL_1 + XL_2) + d_4^- - d_4^+ = 1.53\%$

5. **Capital adequacy ratio**

$XL_1 + XL_2 + d_5^- - d_5^+ = 0.116*(0*(YA_1 + YA_2) + 1.25*(YA_3) + 1*(YA_8 + YA_9 + YA_{10}) + 0.2*(YA_4 + YA_5) + 1.25*YA_6 + 1*FA)$

6. **Liquidity risk- (liquidity coverage ratio)**

HQLA / cashflow for 30 days + $d_6^- - d_6^+ = 100\%$

7. **Net NPA**

Net NPA / (YA_4 YA_5 + YA_6)+ $d_7^- - d_7^+ = 5\%$

The model is then run-on Lingo software, and the results are given below in the table 4.29.

Table 4.29: Real and Model Values of Punjab & Sind Bank

PUNJAB & SIND BANK 2019		REAL	MODEL	DEVIATION
ASSETS				
Cash and Bank	YA1	66182236	63209590	2972646
SLR Investment	YA2	206390608	238016800	-31626192
Non SLR Investment	YA3	55338670	45336530	10002140
Advances	YA4, YA5, YA6	691755333	688766530	2988803
Bills Purchased and Discounted	YA4	4389918	34438330	-30048412
Cash Credits, Overdrafts and Loans Repayable On Demand	YA5	304788136	289281900	15506236
Term Loans	YA6	382577279	365046300	17530979
Fixed Asset	FA	12303845	10898190	1405655
Other Assets	OA	57849766	43592818	14256948
Total Asset		**1089820458**	**1089820458**	0
LIABILITIES				
Capital & Reserves	XL1 & XL2	57014023	68280003	-11265980
Demand Deposit	XL3	49759635	67922320	-18162685

Saving Deposit	XL4	214311187	213470200	840987
Term Deposit	XL5	721505223	688926400	32578823
Borrowing in India	XL6, XL7	27140000	32204172.8	-5064173
Borrowing Outside India	XL8	0	490419.2	-490419
Other Liabilities	XL9	12441214	10898200	1543014
Provisions	XL10	7649176	7628743	20433
Total Liabilities		**1089820458**	**1089820458**	0

The analysis made from the above model value is given 4.30:

Table 4.30: Analysis of Punjab & Sind Bank

	MODEL
NTDL	1006534000
HQLA	165344300
Priority lending	275506600
Net Profit	4068.863
Liquid asset	260965000
Risk Weighted Asset	588620700
Return on Asset %	0.00037
Return On equity %	0.00596
CRR %	4
SLR %	25.92
Market Share of credit %	0.705
Market Share of deposit %	0.77
Capital Adequacy ratio %	11.6
CD Ratio %	70.98
Liquidity coverage ratio %	148.06
Priority lending ratio %	40
NPA %	5
Liquid Asset to Total Asset Ratio %	23.95
Cash in hand and Money at call to Total Asset %	2.1

Table 4.31: The Deviation from The Targets

GOALS	NEGATIVE DEVIATION %	POSITIVE DEVIATION %
Market Share of credit	0	0
Market Share of deposit	0	0
Return on Asset	0	0.0796
Return On equity	0	1.524
Capital Adequacy ratio	0	0
Liquidity coverage ratio %	0	48.05
NPA	0	0

The results of the model are compared with actual figures of the balance sheet for the year 2019. Table 4.29 highlights any deviation in model value from the actual value. The optimized assets and liabilities of Punjab & Sind Bank have been calculated, which shows that the bank can reallocate its assets and liabilities and achieve more than its current position.

The above table 4.30 shows that the model has satisfied all the statutory constraints and decision constraints. The model values reveal the following analysis:

- The CRR achieved here is 4% and SLR is 25.92%. Bank has excess cash over CRR, which is 2.1% of total assets. Bank keep excess cash over CRR to manage day to day expenses and maintain liquidity.
- The credit in priority sector lending is 40%.
- The model has successfully achieved all seven goals, although there are few deviations recorded. There is no infeasibility in the solution when the model is run in Lingo software.
- The objective is to minimize the deviations that negatively affect the bank's performance.
- The actual market share of the credit of P&S bank is 0.708% in 2019, whereas the model has achieved 0.705. It shows that the bank can decrease its market share of credit to increase

profitability and interest income. It is not always true that increase in credit will increase in profit. Profitability also depends on the cost of fund and return on investment and advances.

- The actual market share of deposits for P&S bank is 0.78%, and in the model, the market share of the deposit is 0.771%. It shows that the bank needs to decrease its deposits to reduce its operating cost.
- The credit-deposit (CD ratio) achieved is 70.98% as against 70.18%.
- The bank generates a 0.00037% ROA in the model, which is better than the actual ROA in 2019 i.e., -0.5%. However, the targeted return on assets is 0.08%. The model reports a deviation of 867787 to achieve a 0.08% return on the assets.
- The targeted ROE is 1.53% however, the model has achieved 0.00596%. The ROE for P&S bank in the year 2019 is reported as -9.53%. there is deviation of 1.524% from the target.
- In the year 2019 bank has suffered loss of Rs. 5434779 while, as per the model, the net profit is Rs. 4068.
- Capital Adequacy Ratio of 11.6% is achieved in the model.
- The liquidity coverage ratio is 148.05%, which shows that the bank has sufficient high-quality liquid assets to match the cash outflows for 30 days. In year 2019, Punjab & Sind Bank recorded LCR as 164.02%.
- The model also shows that the liquidity asset to total asset ratio is 23.95%. The model has allocated more funds in SLR investments to improve the bank's liquidity. The model values show that the bank has enough liquid assets to protect itself from a liquidity crisis. There is shift of cash to advances as cash at bank has negligible return.

- Over a period, NPAs have increased tremendously for all banks. NPAs can be decreased by management's effort to screen loan applications and secure loans against physical property. NPA can also be reduced by recovery mechanism. The model aims to reduce the NPA ratio to 5%. The NPA ratio is computed by dividing Net NPAs by Net Advances. The P&B bank has recorded a 7.22% of NPA ratio in the year 2019. The model suggests that after creating 11.48% of provision on Gross NPA and initiating recoveries of Rs. 41740830 the bank can achieve 5% Net NPA ratio.
- The model suggests that it is better for P&S bank to decrease it advances and increase its investments that has high return.

Table 4.31 shows the under and overachievement of targets. The negative deviation and positive deviation are recorded. The model wants to minimize the underachievement of targets, and it has been achieved. In Goal Programming, when underachievement of any goal is minimized, the objective function undertakes a negative deviation (D minus). On the other hand, if overachievement of goal is to be minimized, then positive deviation is undertaken in the objective function. In this model, we want to reduce underachievement of market share of credit, market share of the deposit, return on asset, return on equity, capital adequacy ratio, and liquidity risk. In contrast, we want to minimize the overachievement of NPA, i.e., we don't want to increase NPA. In P&S bank model, there are deviations of 0.0796% and 1.524% in ROA and ROE respectively, which indicates that bank need to increase its net profit to achieve the targets.

The sensitivity of net profit with change in the interest rate of advances & investment and change in the interest rate of deposits and borrowing is shown in table 4.32 below. Sensitivity analysis reflects the effect of one or more input variable on the output variable. In this case the effect of change of average yield on investment/advances and average cost of funds on Net Profit

is determined assuming that all other income and expenses do not change. The sensitivity test reveals that the bank is profitable if spread (Average yield on investment/advances – average cost of fund) is 2.6% or above. As interest rate on deposits and borrowing increases bank generates losses. With the increase in the interest expense, the bank has to increase its interest income to remain profitable.

Table 4.32: Sensitivity Analysis of Interest on Net Profit of P&S Bank (fig. in crores)

INTEREST ON DEPOSIT AND BORROWING	INTEREST ON ADVANCES AND INVESTMENT						
	7.00%	**7.20%**	**7.40%**	**7.60%**	**7.80%**	**8.00%**	**8.20%**
4.80%	-276	-130	16	162	308	453	599
4.90%	-351	-205	-59	87	232	378	524
5.00%	-426	-280	-135	11	157	303	449
5.10%	-501	-356	-210	-64	82	228	374
5.20%	-577	-431	-285	-139	7	152	298
5.30%	-652	-506	-360	-214	-69	77	223
5.40%	-727	-581	-435	-290	-144	2	148
5.50%	-802	-656	-511	-365	-219	-73	73
5.60%	-878	-732	-586	-440	-294	-148	-3
5.70%	-953	-807	-661	-515	-369	-224	-78
5.80%	-1028	-882	-736	-591	-445	-299	-153
5.90%	-1103	-957	-812	-666	-520	-374	-228
6.00%	-1178	-1033	-887	-741	-595	-449	-304
5.70%	-953	-807	-661	-515	-369	-224	-78
5.80%	-1028	-882	-736	-591	-445	-299	-153

Allahabad Bank

The model analyzed the asset and liabilities of Allahabad for 2019. The targets are set in constraints after simulating the model. The target value shows the most optimum level of the bank.

- In the market share of the credit (Allahabad Bank), the target is set as 1.60% of the aggregate market share of the credit of scheduled commercial banks. It is the most optimum level of credit a bank can achieve given its total assets and other constraints.
- Likewise, the market share of deposits (Allahabad Bank) is set at 1.71% of the aggregate market share of deposits of scheduled commercial banks.
- Targeted Return on Asset and Return on Equity is set based on the ROA and ROE of Andhra bank for year 2017 i.e., 0.08% and 1.53% respectively.
- Capital adequacy ratio is targeted at 11.6% based on RBI guidelines (RBI, n.d.-b)
- Cashflow for 30 days has been taken from the 2019 annual report as Rs. 374319700.
- As Net NPA in 2018 is 10.48%, therefore Targeted Net NPA ratio is 5%.
- The total assets have been taken from the balance sheet of 2019 as Rs. 2719095661, and Equity capital is taken as Rs. 224670000.
- The interest income on investments and advances is taken 7.61%% after considering the average yield of Allahabad for the year 2019.
- The interest expense on deposits and borrowing is 5.03%, taken from the average cost of the fund for the year 2019 from annual report of Allahabad.
- Liquidity coverage ratio (LCR) should be 100% of the cashflow for 30 days as per RBI and same is targeted to achieve.

<u>Other multipliers</u>

- Provision for depreciation is created at 15% of fixed assets, provision for depreciation of investment is created at 0.31% and provision for NPA is created at 11.13%.
- Other income is calculated at 0.93% of total assets and non-operating expenses are calculated at 1.5% after considering the average for the years 2010-2018.
- Other multipliers and lower-upper bounds are based on trends, minimum and maximum values, and averages for the bank for the year 2010 to 2018.

It is to be noted that all the figures are in '000.

Therefore, the goal constraints for ALLAHABAD banks are as follows:

1. Market Share of Credit

$YA_4 + YA_5 + YA_6 + d_1^- - d_1^+ = 0.016 *(97674300000)$

2. Market Share of Deposit

$XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = 0.0171 *(125725860000)$

3. Return on Asset

Net profit / Average Total Asset + $d_3^- - d_3^+ = 0.08\%$

4. Return on equity

Net Profit / Average shareholders fund + $d_4^- - d_4^+ = 1.53\%$

3.2.1 Capital adequacy ratio

$XL_1 + XL_2 + d_5^- - d_5^+ = 0.116*(0*(YA_1 + YA_2) + 1.25*(YA_3) + 1*(YA_8 + YA_9 + YA_{10}) + 0.2*(YA_4 + YA_5) + 1.25*YA_6 + 1*FA)$

3.2.2 Liquidity risk- (liquidity coverage ratio)

HQLA / cash flow for 30 days + $d_6^- - d_6^+ = 100\%$

3.2.3 Net NPA

Net NPA / (YA_4 YA_5 + YA_6) + $d_7^- - d_7^+ = 5\%$

The model is then run-on Lingo software, and the results are given in table 4.33:

Table 4.33: Real and Model Values of Allahabad Bank

ALLAHABAD BANK 2019		REAL	MODEL	DEVIATION
ASSETS				
Cash and Bank	YA1	142335158	186431800	-44096642
SLR Investment	YA2	690923162	553702500	137220662
Non SLR Investment	YA3	104655971	117452100	-12796129
Advances	YA4, YA5, YA6	1422121630	1562788780	-140667150
Bills Purchased and Discounted	YA4	5238163	31255780	-26017617
Cash Credits, Overdrafts and Loans Repayable On Demand	YA5	652786810	711068900	-58282090
Term Loans	YA6	764096657	820464100	-56367443
Fixed Asset	FA	35382578	22371820	13010758
Other Assets	OA	90339210	43010680	47328530
Total Asset		2485757709	2485757680	29
LIABILITIES				
Capital & Reserves & Share Application	XL1 & XL2	160263177	155815307	4447870
Demand Deposit	XL3	119864594	129052900	-9188306
Saving Deposit	XL4	940837537	946387600	-5550063
Term Deposit	XL5	1082638544	1075440000	7198544

Borrowing in India	XL6, XL7	93769660	62187602	31582058
Borrowing Outside India	XL8	31119750	62187600	-31067850
Other Liabilities	XL9	9529382	9943031	-413649
Provisions	XL10	47735065	44743640	2991425
Total Liabilities		2485757709	2485757680	29

The analysis made from above model value is given in table 4.34:

Table 4.34: Analysis of Allahabad Bank

	MODEL
NTDL	2223012000
HQLA	440027800
Priority lending	625115500
Net Profit	18285.02
Liquid asset	651213900
Risk Weighted Asset	1343232000
Return on Asset %	0.00075
Return On equity %	0.012
CRR %	4
SLR %	29.29
Market Share of credit %	1.59
Market Share of deposit %	1.71
Capital Adequacy ratio %	11.6
CD Ratio %	72.65
Liquidity coverage ratio %	195.85
Priority lending ratio %	40
NPA %	5
Liquid Asset to Total Asset Ratio %	26.2
Cash in hand and Money at call to Total Asset %	3.9

Table 4.35: The Deviation from The Targets

GOALS	NEGATIVE DEVIATION %	POSITIVE DEVIATION %
Market Share of credit	0	0
Market Share of deposit	0	0
Return on Asset	0	0.079
Return On equity	0	1.518
Capital Adequacy ratio	0	0
Liquidity coverage ratio %	0	95.85
NPA	0	0

The results of the model are compared with actual figures of the balance sheet for the year 2019. Table 4.33 highlights any deviation in model value from an actual value. Optimized assets and liabilities of Allahabad bank have been calculated, which shows that the bank can reallocate its assets and liabilities and achieve more than its current position. As already mentioned, after testing the model for sensitivity, the targets at which bank is most optimal are used.

The above table 4.34 shows that the model has satisfied all the statutory constraints and decision constraints. The analysis derived from the model values are:

- The CRR achieved here is 4% and SLR is 29.29%. Bank has excess cash over CRR, which is 3.9% of total assets. Bank keep excess cash over CRR to manage day to day expenses and maintain liquidity.
- The credit in priority sector lending is 40%.
- The model has successfully achieved all seven goals, although there are few deviations recorded. There is no infeasibility in the solution when the model is run in Lingo software.
- The objective is to minimize the deviations that negatively affect the bank's performance.

- The actual market share of the credit of Allahabad bank is 1.45% in 2019, whereas the model has achieved 1.60%. It shows that the bank can increase its market share of credit to increase profitability and interest income.
- The actual market share of deposits for Allahabad bank is 1.704%, and in the model, the market share of the deposit is 1.71%. It shows that the bank can increase its deposits at low cost to slightly to fund its assets.
- The credit-deposit (CD ratio) achieved is 72.65% as against 66.3%.
- The bank generates a 0.00075% ROA in the model, which is better than the actual ROA in 2019 i.e., -3.35%. However, the targeted return on assets is 0.08%. The model reports a positive deviation of Rs. 1986875 which reflects that the amount of profit bank needs to generate to achieve a 0.08% return on the assets.
- The targeted ROE is 1.53% however, the model has achieved 0.012%. The ROE for Allahabad bank in the year 2019 is reported as -91.28%. There is deviation of 1.517% from the target.
- The model has generated profit of Rs. 18285 while, in year 2019, the net loss suffered by bank is Rs. 83339612.
- Capital Adequacy Ratio of 11.6% is achieved in the model.
- The liquidity coverage ratio (LCR) is 195%, which shows that the bank has sufficient high-quality liquid assets to match the cash outflows for 30 days. LCR of Allahabad bank in 2019 is 210%.
- The model also shows that the liquidity asset to total asset ratio is 26.19%. The model has allocated more funds in cash and balances with RBI to improve the bank's liquidity. The model values show that the bank has enough liquid assets to protect itself from a liquidity crisis.

- Over a period, NPAs have increased tremendously for all banks. NPAs can be decreased by management's effort to screen loan applications and secure loans against physical property. NPA can also be reduced by recovery mechanism. The model aims to reduce the NPA ratio to 5%. The NPA ratio is computed by dividing net NPAs by Net Advances. The Allahabad bank has recorded a 5.22% of NPA ratio in the year 2019. The model suggests that after creating 11.13% of provision on Gross NPA and initiating recoveries of Rs. 176960100 the bank can achieve 5% Net NPA ratio. In year 2019, Allahabad bank has created higher provisions for NPA
- In model indicated that banks could shift their portion of assets towards investments and advances. An increase in deposits at low cost will increase the fund for investment and credit.

Table 4.35 shows the under and overachievement of targets. The negative deviation and positive deviation are recorded. The model wants to minimize the underachievement of targets, and it has been achieved. In Goal Programming, when underachievement of any goal is minimized, the objective function undertakes a negative deviation (D minus). On the other hand, if overachievement of goal is to be minimized, then positive deviation is undertaken in the objective function. In this model, we want to reduce underachievement of market share of credit, market share of the deposit, return on asset, return on equity, capital adequacy ratio, and liquidity risk. In contrast, we want to minimize the overachievement of NPA, i.e., we don't want to increase NPA. According to optimal solution generated with the model, bank has positive deviation in ROA of 0.079%. Increase in net profit by Rs. 1986875, bank can achieve target of 0.08% of ROA. Similarly, there is deviation in ROE of 1.516%, which indicate that by bank is underachieving its target of 1.53% by net profit of Rs. 2073981. In Model solution, bank is overachieving liquidity coverage ratio by 95.85%.

The sensitivity of net profit with change in the interest rate of advances & investment and change in the interest rate of deposits and borrowing is shown in table 4.36 below. Sensitivity analysis reflects the effect of one or more input variable on the output variable. In this case the effect of change of average yield on investment/advances and average cost of funds on Net Profit is determined assuming that all other income and expenses do not change. The sensitivity test reveals that the bank is profitable if spread (Average yield on investment/advances – average cost of fund) is 2.6% or above. As interest rate on deposits and borrowing increases bank generates losses. With the increase in the interest expense, the bank has to increase its interest income to remain profitable.

Table 4.36: Sensitivity Analysis of Interest on Net Profit of Allahabad Bank (fig. in crores)

INTEREST ON DEPOSIT AND BORROWING	INTEREST ON ADVANCES AND INVESTMENT								
		7.00%	7.20%	7.40%	7.60%	7.80%	8.00%	8.20%	8.40%
	4.60%	-286	49	384	719	1054	1389	1724	2059
	4.70%	-457	-122	213	548	883	1218	1553	1889
	4.80%	-628	-293	42	378	713	1048	1383	1718
	4.90%	-798	-463	-128	207	542	877	1212	1547
	5.00%	-969	-634	-299	36	371	706	1042	1377
	5.10%	-1140	-805	-469	-134	201	536	871	1206
	5.20%	-1310	-975	-640	-305	30	365	700	1035
	5.30%	-1481	-1146	-811	-476	-141	195	530	865
	5.40%	-1652	-1316	-981	-646	-311	24	359	694
	5.50%	-1822	-1487	-1152	-817	-482	-147	188	523
	5.60%	-1993	-1658	-1323	-988	-653	-317	18	353
	5.70%	-2164	-1828	-1493	-1158	-823	-488	-153	182
	5.80%	-2334	-1999	-1664	-1329	-994	-659	-324	11
	5.90%	-2505	-2170	-1835	-1500	-1164	-829	-494	-159
	6.00%	-2675	-2340	-2005	-1670	-1335	-1000	-665	-330

CANARA BANK

The model analyzed the asset and liabilities of Canara for 2019. The targets are set in constraints after simulating the model. The target value shows the most optimum level of the bank.

- In the market share of the credit (Canara Bank), the target is set as 4.38% of the aggregate market share of the credit of scheduled commercial banks. It is the most optimum level of credit a bank can achieve given its total assets and other constraints.
- Likewise, the market shares of deposits (Canara Bank) is set at 4.76% of the aggregate market share of deposits of scheduled commercial banks.
- Targeted Return on asset and Return on Equity (ROE) is set based on the ROA and ROE of Bank of Baroda bank for year 2019 i.e., 0.07% and 1.0% respectively.
- Capital adequacy ratio is targeted at 11.6% based on RBI guidelines (RBI, n.d.-b)
- Cashflow for 30 days has been taken from the 2019 annual report as Rs. 927613800.
- As Net NPA in 2018 is 7.48%, therefore Targeted Net NPA ratio is 5%.
- The total assets have been taken from the balance sheet of 2019 as Rs. 6947666905, and Equity capital is taken as Rs. 7532448.
- The interest income on investments and advances is taken 7.59%% after considering the average yield of Canara for the year 2019.
- The interest expense on deposits and borrowing is 5.24%, taken from the average cost of the fund for the year 2019 from annual report of Canara.
- Liquidity coverage ratio (LCR) should be 100% of the cashflow for 30 days as per RBI and same is targeted to achieve.

Other multipliers

- Provision for depreciation is created at 15% of fixed assets, provision for depreciation of investment is created at 0.2% and provision for NPA is created at 18.05%.
- Other income is calculated at 0.84% of total assets and non-operating expenses are calculated at 1.3% after considering the average for the years 2010-2018.
- Other multipliers and lower-upper bounds are based on trends, minimum and maximum values, and averages for the bank for the year 2010 to 2018.

It is to be noted that all the figures are in '000.

Therefore, the goal constraints for CANARA banks are as follows:

1. Market Share of Credit

$YA_4 + YA_5 + YA_6 + d_1^- - d_1^+ = 0.0438 *(97674300000)$

2. Market Share of Deposit

$XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = 0.0476 *(125725860000)$

3. Return on Asset

Net profit / Average Total Asset + $d_3^- - d_3^+ = 0.07\%$

4. Return on equity

Net Profit / Average shareholders fund + $d_4^- - d_4^+ = 0.1\%$

5. Capital adequacy ratio

$XL_1 + XL_2 + d_5^- - d_5^+ = 0.116*(0*(YA_1 + YA_2) + 1.25*(YA_3) + 1*(YA_8 + YA_9 + YA_{10}) + 0.2*(YA_4 + YA_5) + 1.25*YA_6 + 1*FA)$

1. **Liquidity risk- (liquidity coverage ratio)**

   HQLA / cash flow for 30 days + $d_6^- - d_6^+ = 100\%$

2. **Net NPA**

   Net NPA / (YA_4 YA_5 + YA_6) + $d_7^- - d_7^+ = 5\%$

The model is then run-on Lingo software, and the results are given in table 4.37:

Table 4.37: Real and Model Values of Canara Bank

CANARA BANK 2019		REAL	MODEL	DEVIATION
ASSETS				
Cash and Bank	YA1	661526888	382121700	279405188
SLR Investment	YA2	1353777773	1547593215	-193815442
Non SLR Investment	YA3	176075187	328277300	-152202113
Advances	YA4, YA5, YA6	4277272684	4293337500	-16064816
Bills Purchased and Discounted	YA4	183837878	171733500	12104378
Cash Credits, Overdrafts and Loans Repayable on Demand	YA5	1789893619	1846135000	-56241381
Term Loans	YA6	2303541187	2275469000	28072187
Fixed Asset	FA	84102336	85305690	-1203354
Other Assets	OA	394912037	311031500	83880537
Total Asset		6947666905	6947666905	0
LIABILITIES				
Capital & Reserves & Share Application	XL1 & XL2	361772319	434253005	-72480686
Demand Deposit	XL3	232739260	299616900	-66877640

CANARA BANK 2019		REAL	MODEL	DEVIATION
Saving Deposit	XL4	1515348737	1498085000	17263737
Term Deposit	XL5	4242244751	4194637000	47607751
Borrowing in India	XL6, XL7	253629300	210514300	43115000
Borrowing Outside India	XL8	156293644	136869000	19424644
Other Liabilities	XL9	60874896	41686000	19188896
Provisions	XL10	124763998	132005700	-7241702
Total Liabilities		6947666905	6947666905	0

The analysis made from above model value is given in table 4.38:

Table 4.38: Analysis of Canara Bank

	MODEL VALUES
NTDL	6188726000
HQLA	1094237000
Priority lending	1717335000
Net Profit	3947557
Liquid asset	1682165000
Risk Weighted Asset	3743562000
Return on Asset %	0.06
Return On equity %	1.00
CRR %	4
SLR %	27.18
Market Share of credit	4.396
Market Share of deposit	4.766
Capital Adequacy ratio %	11.59%
CD Ratio %	71.65
Liquidity coverage ratio %	117.96
Priority lending ratio %	40
NPA	5
Liquid Asset to Total Asset Ratio	24.21
Cash in hand and Money at call to Total Asset %	1.93

Table 4.39: The Deviation from The Targets

GOALS	NEGATIVE DEVIATION %	POSITIVE DEVIATION %
Market Share of credit		
Market Share of deposit		
Return on Asset		0.01
Return On equity		
Capital Adequacy ratio		
Liquidity coverage ratio %		17.963
NPA		

The results of the model are compared with actual figures of the balance sheet for the year 2019. Table 4.37 highlights any deviation in model value from an actual value. Optimized assets and liabilities of Canara bank have been calculated, which shows that the bank can reallocate its assets and liabilities and achieve more than its current position. As already mentioned, after testing the model for sensitivity, the targets at which bank is most optimal are used.

The above table 4.38 shows that the model has satisfied all the statutory constraints and decision constraints. The analysis derived from the model values are:

- The CRR achieved here is 4% and SLR is 27.18%. Bank has excess cash over CRR, which is 1.93% of total assets. Bank keep excess cash over CRR to manage day to day expenses and maintain liquidity.
- The credit in priority sector lending is 40%.
- The model has successfully achieved all seven goals, although there are few deviations recorded. There is no infeasibility in the solution when the model is run in Lingo software.
- The objective is to minimize the deviations that negatively affect the bank's performance.

- The actual market share of the credit of Canara bank is 4.379% in 2019, whereas the model has achieved 4.39%. It shows that the bank can slightly increase its market share of credit to increase profitability and interest income.
- The actual market share of deposits for Canara bank is 4.764%, and in the model, the market share of the deposit is 4.766%. It shows that the bank can slightly increase its deposits at low cost to fund its assets.
- The credit-deposit (CD ratio) achieved is 71.54% as against 71.65%.
- The bank generates a 0.06% ROA in the model, which is equal to the actual ROA in 2019 i.e., 0.052%. However, the targeted return on assets is 0.07%. The model reports a positive deviation of Rs. 643228 to achieve a 0.07% return on the assets.
- The targeted ROE is 1% and model has also achieved ROE at 1%. There is no deviation in targeted ROE and achieved ROE.
- In the year 2019 bank has earned a profit of Rs. 347015 while, as per the model, the net profit of the bank is Rs. 3947557.
- Capital Adequacy Ratio of 11.6% is achieved in the model.
- The liquidity coverage ratio (LCR) is 117.96%, which shows that the bank has sufficient high-quality liquid assets to match the cash outflows for 30 days.
- The model also shows that the liquidity asset to total asset ratio is 24.21%. The model has allocated more funds in cash and balances with RBI to improve the bank's liquidity. The model values show that the bank has enough liquid assets to protect itself from a liquidity crisis.
- Over a period of time, NPAs have increased tremendously for all banks. NPAs can be decreased by management's effort to screen loan applications and secure loans against

physical property. NPA can also be reduced by recovery mechanism. The model aims to reduce the NPA ratio to 5%. The NPA ratio is computed by dividing net NPAs by Net Advances. The Canara bank has recorded a 5.37% of NPA ratio in the year 2019. Canara bank has created huge provision and written off provision in 2019 to reduce its NPAs. The model suggests that after creating 18.05% of provision on Gross NPA and initiating recoveries of Rs. 107106100 the bank can achieve 5% Net NPA ratio.

- In model indicated that banks could slightly shift their portion of assets towards investments and advances. An increase in deposits at low cost will increase the fund for investment and credit.

Table 4.39 shows the under and overachievement of targets. According to optimal solution generated with the model, bank has positive deviation in ROA of 0.0096%. After increasing the net profit by Rs. 643228, bank can achieve target of 0.07% of ROA. In Model solution, bank is overachieving liquidity coverage ratio by 17.96%.

The sensitivity of net profit with change in the interest rate of advances & investment and change in the interest rate of deposits and borrowing is shown in table 4.40 below. Sensitivity analysis reflects the effect of one or more input variable on the output variable. In this case the effect of change of average yield on investment/advances and average cost of funds on Net Profit is determined assuming that all other income and expenses do not change. The sensitivity test reveals that the bank is profitable if spread (Average yield on investment/advances – average cost of fund) is 2.3% or above. As interest rate on deposits and borrowing increases bank generates losses. With the increase in the interest expense, the bank has to increase its interest income to remain profitable.

Table 4.40: Sensitivity Analysis of Interest on Net Profit of Canara Bank (fig. in crores)

INTEREST ON DEPOSIT AND BORROWING	INTEREST ON ADVANCES AND INVESTMENT									
		7.00%	7.20%	7.40%	7.60%	7.80%	8.00%	8.20%	8.40%	8.60%
	4.60%	714	1639	2565	3490	4416	5341	6266	7192	8117
	4.70%	239	1164	2089	3015	3940	4866	5791	6716	7642
	4.80%	-237	689	1614	2539	3465	4390	5315	6241	7166
	4.90%	-712	213	1138	2064	2989	3915	4840	5765	6691
	5.00%	-1188	-262	663	1588	2514	3439	4364	5290	6215
	5.10%	-1663	-738	187	1113	2038	2964	3889	4814	5740
	5.20%	-2139	-1213	-288	637	1563	2488	3414	4339	5264
	5.30%	-2614	-1689	-763	162	1087	2013	2938	3863	4789
	5.40%	-3090	-2164	-1239	-314	612	1537	2463	3388	4313
	5.50%	-3565	-2640	-1714	-789	136	1062	1987	2912	3838
	5.60%	-4041	-3115	-2190	-1265	-339	586	1512	2437	3362
	5.70%	-4516	-3591	-2665	-1740	-815	111	1036	1961	2887
	5.80%	-4992	-4066	-3141	-2216	-1290	-365	561	1486	2411
	5.90%	-5467	-4542	-3616	-2691	-1766	-840	85	1011	1936
	6.00%	-5943	-5017	-4092	-3166	-2241	-1316	-390	535	1460

Efficiency and productivity analysis of banks bring insight in the areas where a bank can focus to increase its profitability and reduce cost. The critical analysis has gained importance mainly due to the dynamic environment where banks are facing heavy competition and survival has become became difficult. The soundness and effectiveness of a bank is often measured by efficiency, profitability, increasing volume of funds, risk mitigation strategies, etc. Asset Liability Management has gained popularity in banking as it assists in planning balance sheet after embracing risk factors, profitability, and targets, etc. set by board of directors.

In current study an attempt has been made to optimize assets and liabilities mix to improve profitability, manage risk, and undertake statutory and regulatory guidelines of RBI. The mathematical goal programming model has allowed to set multiple goals. The advantage of goal programming is that it helps in determining the underachievement and overachievement of objectives. The deviations in the results from the target reveals the area of improvement.

In the given section, four Banks have been analyzed using goal programming model. The results of bank vary from other banks. In OBC bank, bank is underachieving its target related to ROA and ROE while overachieving the liquidity coverage ratio. It is suggested that increasing low-cost funds and investing in assets that can generate better return will benefit bank in improving profitability. Management can develop strategies to increase its market share of credit and deposit. OBC bank has created heavy provisions for NPAs in year 2019 to reduce its NPA. Model also suggests that bank either create provisions or implement effective recovery mechanism to reduce its NPAs.

The results of Punjab & Sind Bank reveal that profitability is not always associated with increase in market share of credit and deposits. P&S bank has higher market share in credit and deposits during 2019 and was still incurring losses. The model suggests that reducing market share of credit and deposit can also improve profitability. When funds are procured at high cost and return on investment and advances is low, then profitability of banks tend to decline. Non-operating income and expenses are although less but has significant impact on the overall profitability of the bank. Although Punjab & Sind Bank in the model is unable to achieve all its goal yet the position is better than actual in the year 2019. The losses incurred by bank is mainly due to increase in NPA. NPA has three side effects on the profitability. Bank must create provisions for NPA, thereby declining the profits and secondly the fund blocked in NPA cannot be used for generating future income. Also, bank has to incur cost to recover such NPA Accounts. It is therefore important for banks to reduce its NPAs by

actively monitoring recovery mechanism, by securitization of NPA, and analyzing the credit score, background, mortgage asset of the customer before sanctioning loans/advances.

In Allahabad bank it is suggested that increasing market share of credit and deposit will help bank to decrease its losses. Although bank is unable to achieve all the goals, yet the profitability of the bank has improved. Canara bank is profitable in year 2019. The model suggests slight increase in market share of credits and deposits. Increasing CD ratio can help bank to improve profitability further. It is also analyzed that banks that can secure low-cost funds have chances of improving their profitability. As technological advancement is growing rapidly, the increasing cost of running multiple branches can be reduced substantially. Operational efficiency in bank can improve by reducing employee cost per customer. Reducing the customers' visit to branches by making user-friendly webpage that contains all the necessary features that customers might need, will help in reducing infrastructure cost and fixed cost of the bank.

The current model has fulfilled all the statutory and regulatory constraints related to CRR, SLR, Liquidity coverage ratio, and capital adequacy, etc. In all the banks, Liquidity Coverage Ratio has declined from the actual value. It shows that by reducing liquidity bank can increase its profitability by investing the liquid asset in high income generating assets. Therefore, it can be concluded that it is possible to improve banks' profitability by judiciously allocating assets and liabilities.

As per CAMEL approach the analysis of the model reveals those banks following CAMEL approach are more profitable.

Capital Adequacy: The financial crisis of 2008 led Basel to observe the regulations and norms and revise them. Basel III tried to overcome the downsides and weaknesses of Basel II. It highlighted the importance of capital adequacy in banking system. Basel III introduced capital conservation buffer to

increase the loss absorbing capacity of banks in difficult times. Indian banking sector also strictly comply with minimum capital requirement norms as per Basel III. Capital Adequacy is one of the critical indicators of stability. Banks focus on maintaining a sound capital adequacy position due to the worldwide increase in the importance of risk- based capital standards (E.Shrieves & DrewDahl, 1992; Gupta & Kamilla, 2016; M. Kaur & Kapoor, 2015; Miah & Sharmeen, 2015; Sarkar et al., 2019). Regulatory pressure has positive effect on capital (Argimon et al., 2012). Banks increase capital to fulfill the regulatory requirements which increases risk for banks that are undercapitalized (Bichsel & Blum, 2002; Das & Ghosh, 2004; Hua, 2011; S. L. Lin et al., 2013). However, having same capital structure does not stimulate better performance nor penalize them. Capital Adequacy reflects loss absorbing capacity but also reflect its inherent risk (Baruah, 2018; Floquet & Biekpe, 2008; Mohanty & Mahakud, 2018). The model satisfies the capital adequacy norm where capital adequacy ratio is maintained at 11.6%.

Asset Quality (NPA): NPA account is loan asset from which income in the form revenue or principal repayment cannot be generated (S. A. Chakraborty, 2017). Such accounts have ceased to make payment for more than 90 Days. Banks invest a lot of time, money, and effort to manage NPAs. Management of NPAs increases cost which could otherwise be invested on other revenue generating activities. If bank would have invested that money somewhere else, it would have increased revenue and profit. Therefore, it can be said not only NPAs decrease bank income but also its opportunity to earn future income.

Bank's main source of income is interest earned on loan accounts. NPAs reduces this interest income and affect the cash in hand (Klein, 2013). Due to increased NPAs, bank create provisions for the same (C S Balasubramaniam, 2011). Increasing number of NPA accounts also reflects the credit policy failure on part of banks (Chimkono et al., 2016). There are studies that investigated the

relationship of NPA with profit, cost, and lending behavior of banks, etc. The studies reflects that NPA has inverse relationship with the profitability of banks which is in line with other studies such as Chakraborty (2017), Vinh (2017), Ekinci and Poyraz (2019), Ramesh (2016) and Chimkono et al. (2016). NPA depicts low efficiency of bank which is considered as a sign of bad performance of management (F. Ahmad & Bashir, 2013). Therefore, in the light of these implications on the bank's solvency and efficiency, it is critical for banks to lower NPA and maintain high quality asset.

Management efficiency (Market share of credit and deposits): Market share of credit and deposit has strong positive significant relationship with profitability in this study as suggested by Ejoh and Sackey (2014) and Genchev (2012). Banks profit margin increases with increase in market share (Kurtz & Rhoades, 1992). Banks can increase its normal profit by gaining market share either through merger or other means (Kurtz & Rhoades, 1992). When banks have higher market share, it focuses on investing in prudent assets and increase returns and minimize risk (Dam et al., 2015). Market share is the most influential determinant of an organization's competitive power (Ejoh & Sackey, 2014; Saravani et al., 2015).

Earning Efficiency (ROA and ROE): The banks' financial performance is generally determined using Return on Asset (ROA) and Return on Equity (ROE) as proxy for financial indicator. The performance of banks is measured as its capacity to generate profit (Ferrouhi, 2018).

Return on equity (ROE) is the estimation of the monetary proficiency of a firm which is evaluated by comparing net income with equity attained by the shareholders. The status of the ROE is good or bad depending upon the normal constraints availed by the company in comparison to its peers. It is also used for the estimation of sustainable growth and dividend rates by considering the peer group average ratio with the line of business. It provides information about future estimations related to the

growth rates of the stocks and dividends. The study shows as the ROE and ROA of banks are less than targeted ROE and ROA as per benchmarked bank. However, the ROE and ROA of bank calculated by model is higher than the actual ROE and ROA of the bank for the year 2019.

To increase the ROE and ROA, it is highly essential to augment the profit margins. The profit margins are to be increased by raising the increasing interest income on investment and advances, reducing non-operating expenses and operating expenses. The reduction in NPA accumulation also helps in increasing ROE and ROA values. Appropriate distribution of idle cash is also regarded as another important way of increasing ROE and ROA (Liesz, 2002).

Liquidity: Liquidity is important aspect for banks to avoid situation of bank run. Banking stability depends on asset quality, liquidity, performance, capital adequacy etc. of each individual banks (Choon et al., 2013; R. N. Mishra et al., 2013; Vodová, 2011). Basel III analyzed that liquidity risk in banks is among other risk that need to be addressed along with strengthening capital to create more resilient banking system (de Waal et al., 2013).

RBI (2012) stated that banks' incompetency to satisfy obligation when they arise or become due, without negatively impacting the bank's financial condition is known as liquidity risk. In this study it has been analyzed that banks' internal factor such as profitability, bank size, availability of deposit, cost of fund, capital adequacy, asset quality, etc. have significant impact on the overall liquidity position of banks as suggested by many other authors such as Al-Homaidi et al. (2019), Bhati et al. (2019), Choon et al. (2013), Pathi (2017), Singh and Sharma (2018), Sopan and Dutta (2018). It can be stated that liquidity and profitability are positively related (Bourke, 1989; Olagunju et al., 2011). Banks keep liquid assets above mandatory requirements by RBI for transaction, speculative and precautionary purpose.

CHAPTER 5: FINDINGS, LIMITATIONS, AND FUTURE SCOPE OF THE STUDY

A detailed discussion of the findings of the two objectives are presented in this chapter. Thereafter, the applicability of the study for the bank management and policy makers is discussed. At last, the limitations and future scope of the study are presented.

5.1 SUMMARY OF FINDINGS

5.1.1 ALM Practices and Policies in Banks

The findings of the research on ALM practice in banks in India are:

- All the mandatory requirements issued by RBI are followed by both public banks and Private Banks. All the banks selected in the study have well-documented ALM policies, separate risk management functions, independent ALM functions, separate objective for ALM, and formal ALM committee to monitor, manage and control risk. The banks have appointed chief risk officer to manage risk.
- Bank employees report to either ALM Cell, Risk Management Department, Treasury Department, Market Risk Department, or Balance Sheet Management Unit with ALM related issues.
- ALM committee of all banks meets at least once every quarter to discuss policy related to ALM, investment policy, derivatives policy, etc. However, the market risk management group conduct routine meetings every month to recommend changes in policies, processes, and methodologies.

- For most banks, ALM financial objectives are measured by economic value. BIS II stated that banks need to have interest rate measurement systems to examine the repercussions of changes in rate on economic values and earnings.
- For most banks, ALM is performed for each product/asset segment separately.
- The significance of ALM is to minimize the volatility in Interest Income and Economic value. Rapid innovation in the bank's financial products create need for ALM. ALM lay out a foundation for banks to manage the market risks arising out of fluctuations in rates and excessive credit risk. It also recognizes the management's vision.
- Most banks make changes in the strategic allocation of an asset to match liabilities and increase returns.
- The Asset-Liability matching concept is the primary motive for change in asset allocation strategy in the bank.
- Interest rate risk, liquidity risk, market risk, and foreign exchange risk are considered part of ALM in most banks.

There is no significant difference between employees of private and public banks concerning the fundamental understanding of ALM and its functions.

5.1.2 Risk Mitigation Practice in Banks

- All Public Sector banks and Private Sector banks use standard risk mitigation practices such as maturity gap analysis and duration gap analysis to mitigate interest rate risk, maintaining liquidity profile to identify gap, perform liquidity planning in alternative scenarios. Banks have loan review mechanism to minimize risk of NPAs.
- 83.3% of Public and Private banks use currency swaps to minimize currency risk.

- 62.5% and 37.5% Public and Private banks set up limits for an open position and gaps to mitigate currency risk.
- 66.7% and 50% of Public and Private banks respectively use credit derivates to reduce credit risk.
- All the banks in the study set an operational limit to minimize operational risk. However, 83% of banks in the survey follow a risk education approach.
- There is a significant difference between Public and Private Banks in the application of risk mitigation techniques. Banks use a different approach to mitigate risks depending on the size of the bank, industry standards, innovation, information availability, etc.
- The market risk management division has specialized employees that look into interest rate risk, foreign exchange risk, and liquidity risk. Market risk is controlled through Net Overnight Open Position, Stop Loss, VaR, Modified Durations, and PV01, etc. Banks also maintain contingency fund plans for an unforeseen liquidity crisis. The foreign exchange risk is monitored by Net overnight open position, VaR limits, Aggregate Gap Limits, Individual Gap Limits on a daily basis.
- Banks monitor liquidity profiles on a dynamic and static basis with gap analysis techniques. Various liquidity ratios and stress testing are also considered a part of monitoring liquidity risk. Periodically, liquidity positions and liquidity stress output are discussed by ALCO and the risk management committee of the banks.
- Policies related to investment, ALM, and derivatives are first approved by the board and then govern treasury activities. The policies have a limit structure to handle risk. ALCO reviews business profiles regularly to determine the impact on ALM. Market Risk

Management group also does periodic monitoring to recommend necessary changes in processes, policies, and methods.

- Banks have Credit Risk Management (CRM) to develop credit risk rating models and scorecards for corporate and retail clients. The credit risk rating model is a scientific method of calculating credit risk. The model is periodically validated to maintain its efficiency and validity. The probability of default (PD) for portfolios is assessed regularly to act as a basis of estimation of Expected credit loss.
- In most banks DeVA is used as a tool for pre -disbursement, checking and verifying documentation. It also removes irregularities to improve credit quality and documentation. LAMP is another tool for managing credit risk by capturing data on credit monitoring parameters and rate accounts. It facilitates precise and accurate monitoring of credit. LAMP acts as an Early Warning Signals (EWS) to manage risk and take corrective measures timely.
- Banks are pushing harder to manage NPA with daily dashboards like Days Past Due (DPD) Report, NPA Movement Chart, and Mock Runs to forecast degradations and improvement in collections.
- The operational risk is identified, measured, monitored, and controlled through root cause analysis of operational loss data, Risk and Control Self-Assessment (RCSA), Key Risk Indicators (KRI), etc.
- Banks need an internal controls system, ways to observe transactions, key backup plan, and contingency procedures for operational risk management.

5.1.3 ALM Function and Approach

- According to Public and Private banks, ALM manages the overall liquidity of the bank.
- It undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps.
- ALCO facilitates, coordinates, communicates, and controls balance sheet planning regarding risks inherent in managing liquidity and convergences in interest rates.
- ALCO is responsible for ensuring that its operational risk lies within the parameters set by its Board of Directors.

5.1.4 Optimizing Asset-Liability for Public banks

- It is possible to design a quantitative model for optimizing the assets and liabilities of banks.
- Goal Programming is a mathematical tool that can help achieve goals. When the risk is under control, returns can be increased (M. Kruger, 2011; Viswanathan et al., 2014; Viswanathan & Balasubramanian, 2007).
- AHP can assist in determining the relative importance of goals.
- The analysis of the model values shows that banks can increase their market share of credit and deposit to generate more profit. An increase in market share of credit and deposit reduces operational costs, improves competitive power and economies of scale, and efficiency of the bank (Bowyer, 1981; Dam et al., 2015; Ejoh & Sackey, 2014; Genchev, 2012; Kurtz & Rhoades, 1992; Saravani et al., 2015).
- Banks can allocate its funds in assets that generate high yield. However, it must also take into consideration the liquidity of the bank. Therefore, bank has to allocate its funds in less risk assets to minimize the liquidity risk and high paying assets to improve profitability

(Dash, 2013; Halim et al., 2015; Kosmidou & Zopounidis, 2002; Prince Paul Antony, 2018; Samuel, 2011; Sheela, 2015; Tee, 2017).

- The model can satisfy all the constraints that are related to RBI guidelines. The goal programming model is fulfilling the capital adequacy requirement of 11.5%, CRR at 4%, SLR at 19.5%, LCR at 100% etc. On the one hand, less capital can affect the liquidity and loss-absorbing capacity of banks. On the other hand, increasing capital is costly, which leads to customer borrowings and a fall in investments (Jochen et al., 2011).
- Reduction in NPAs has a positive effect on profitability and liquidity. NPA leads to creation of provisions that decreases the profits and block funds that can generate future income (Cucinelli, 2015; Karunakar et al., 2008; Klein, 2013; Michael et al., 2006; Mohan, 2006; Ramesh, 2016; Rajiv Ranjan & Dhal, 2003; R. K. Singh, 2018; V. R. Singh, 2016; Vinh, 2017).
- Decrease in liquidity increases the profitability of banks. Banks have more funds at its disposal to invest in higher income generating assets (Bace, 2016; S. Bhati et al., 2019; De Haan & van den End, 2013; Diamond & Rajan, 2001, 2003; Distinguin et al., 2013; Lartey et al., 2013; Marozva, 2015; A. K. Meena & Dhar, 2014; Olagunju et al., 2011; Sathyamoorthi et al., 2020; Vodová, 2011; Williamson, 1988).
- Banks can increase their efficiency by reducing costs. Reducing bank branches and increasing technological, digital, and online support to customers can reduce such costs.
- Interest rate sensitivity of assets and liabilities affects the net interest income of banks and thereby their profitability (C. Prabhavathi, 2011; Chattha et al., 2020; Dash et al., 2011; Sheela, 2015; Umarani & Jayanthi, 2015; Vij, 2005).

- Bank can increase its market share of credit and deposits by focusing on marketing strategies and building public relations. Private banks are more efficient and successful due to their customer relations, public relations, and progressive environment in the bank where public sector banks lack.
- Public sector banks can also increase dealing in non-core activities to enhance its non-interest income (Kobler et al., 2015; Kohlscheen et al., 2018; Menon & Pillai, 2018; Saunders et al., 2018).

5.2 CONCLUSION AND RECOMMENDATION

The Goal Programming model is flexible enough to be used by any bank for any period. Banks' managers can use it for forecasting. The goals/targets can be set, and based on constraints, it can be determined to what extent such targets can be achieved, overachieved, or underachieved. Management can use it as a tool for planning, forecasting, and budgeting. The results can be used for changing strategies and developing policies within the bank for a better financial position in the future. Not only scheduled commercial banks but regional rural banks, cooperative banks, and NBFC can also use the model with some modifications as per their assets, liabilities, and constraints. Bank can also analyze its targets in different scenarios such as conservative, moderate, and aggressive. It will guide banks to take appropriate risks and increase their profitability.

The GP model exhibited in the thesis would guide bank officials in planning the outcome of the following years. The best quality of this model is that one can work on multiple goals, prioritize goals, or weight goals as per their preference. The model doesn't have to achieve all the goals; instead, it informs about the deviation from the set target. As regulatory policy changes, the constraints can be modified accordingly. Like in 2019, CRR and SLR was 4% and 19.5% which

declined to 3% and 18% respectively in the year 2020. These changes can be incorporated into the model very easily. Sensitivity analysis can guide banks towards the effect of changes on profit. It shows how a change in one element affects the profitability of a bank and by what percentage. Banks can set the minimum or maximum limit for CD ratio, Net interest income, and other factors which should not be crossed to minimize the losses.

In this thesis, four public scheduled commercial banks have been analyzed for the year 2019, where the model allocated assets and liabilities of the banks to achieve the goals set in the model. When model values are compared with actual values in the balance sheet, it gives guidance on where the bank needs to divert its funds for better returns and profitability. Banks can also state new goals if they want to test new targets.

When conducted a primary survey, it was analyzed that both public and private banks follow the guidelines established by the RBI. All the bank irrespective of their type and nature tries to maximize return but at the same time focus of their risk appetite. Concerning ALM, private and public banks have established a formal ALCO committee that looks over the issues related to mismatch in asset and liabilities, rate-sensitive assets and liabilities, and other risks that can affect the bank's solvency. Bank management conducts formal and timely meetings to discuss any issues in ALM. Banks conduct at least four formal meetings in a year, and other meetings take place whenever required. It was found that banks have a proper channel of communication, standard procedure, and written objectives for ALM. Banks have formal policies and departments to tackle different types of risk, be it liquidity risk, market risk, foreign exchange risk, credit risk, interest rate risk, legal risk, etc. However, interest rate risk and liquidity risk are two categories of risk that

are part of ALM in every bank under study. It shows that banks' ALM cells focus mainly on interest rate risk and liquidity risk.

Risk mitigation procedures and techniques such as gap analysis, duration analysis, VaR, stress testing, Currency swaps, interest rate swaps, and hedging, etc. are intact in banks. All the banks in the study follow one or other method to mitigate risk. Most importantly, banks educate their employees with the guidelines, techniques, and norms to follow standardized procedures. Educating employees reduces the chance of error. It was fascinating to see that banks are cautious about the potential risk. Nowadays, banks don't want to take an unnecessary risk that can reduce their profitability and liquidity. Banks use various models and simulation techniques to study the potential risk and its effect on solvency and liquidity. Awareness has been developed in banks' employees about ALM and the need to document the policy related ALM.

5.3 FUTURE SCOPE OF THE STUDY

1. Comparative analysis of private and public banks can see which sector banks are running more efficiently and effectively. If the model's deviation and actual output are less, it shows that the bank is efficient.
2. Ratio analysis can be incorporated in the model so that banks can also target to achieve better performance ratios, liquidity ratios, and operating ratios, etc.
3. Instead of using yearly data, the study can be conducted using fortnightly, monthly, quarterly, and semi-annual data. It will help banks in taking corrective measures timely.
4. New and improved techniques can be used for deriving the relative importance of key drivers and goals. Fuzzy AHP can be used to determine relative weights more accurately.
5. The model can be extended to optimize the maturity buckets of assets and liabilities.

6. Off-balance sheet items can also be added in decision variables to study their effect on the bank's goals.

5.4 LIMITATIONS

The model results will not hold value if there are changes in RBI policies, government policies, and unexpected events that impact the bank's functioning drastically. As during Covid-19, the functioning of the bank changed. People started using online and mobile banking. Credit and deposit growth are impacted severely, affecting the income-generating capacity. Banks allowed customers to delay in interest payment which also directly affect the operating profit of banks. Therefore, if there is an extreme change in the economy and banking policies, and the model has not incorporated such changes, then the results are difficult to use. The relationship between risk and return is very dynamic and challenging to incorporate entirely. The study also does not undertake inter-period concept however; the multipliers are determined based on past data. There is also lack of implementation of inter-period relations with endogenous effects which determines the linking of variables pertaining to different time-period and expressing the effect of initial conditions and present decisions on the future position of the bank.

Interest rates are very volatile, and it is challenging to collect daily interest rates on different assets and liabilities. Interest rate affects the net interest margins of the bank. However, the effect of interest rate on profitability is tried to capture in the thesis however, it has not been achieved entirely. The model did not undertake the maturity buckets of assets and liabilities. It can be pursued in future study.

REFERENCES

Abou-el-sood, H., & El-ansary, O. (2017). Asset-liability management in Islamic banks : evidence from emerging markets. *Pacific Accounting Review*, *29*(1), 55–78. https://doi.org/10.1108/PAR-04-2016-0050

Acharya, V. V. (2018). Understanding and Managing Interest Rate Risk at Banks. *Fixed Incoem Money Market and Derivatives Association of India*, 1–15.

Acharya, V. V., & Kulkarni, N. (2012). What Saved the Indian Banking System: State Ownership or State Guarantees? *The World Economy*, *35*(1), 19–31.

Acharya, V. V., Shin, H. S., & Yorulmazer, T. (2009). *Crisis Resolution and Bank Liquidity* (Working paper 15567; NBER Working Paper). http://www.nber.org/papers/w15567

Agarwal, Y., Iyer, K. C., & Yadav, S. S. (2010). Multi Objective Capital Structure Modelling: A Goal Programming Approach. *SSRN Electronic Journal*. https://doi.org/http://dx.doi.org/10.2139/ssrn.1572689

Ahmad, F., & Bashir, T. (2013). Explanatory power of bank specific variables as determinants of non-performing loans: Evidence form Pakistan banking sector. *World Applied Sciences Journal*, *22*(9), 1220–1231. https://doi.org/10.5829/idosi.wasj.2013.22.09.1908

Ahmad, M. U. (2014). An Analysis of the Effectiveness of Monetary Policy Changes. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2474594

Ahmad, N. H., & Ariff, M. (2007). Multi-country study of bank credit risk determinants. *The International Journal of Banking and Finance*, *5*(1), 135–152.

Al-gasaymeh, A. S., Kaddumi, T. A., & Qasaimeh, G. M. (2021). Measuring risk exposure in the banking sectors : evidence from Gulf Cooperation countries. *Journal of Financial Economic*, *13*(4), 491–501. https://doi.org/10.1108/JFEP-01-2020-0008

Al-Homaidi, E. A., Tabash, M. I., Farhan, N. H., & Almaqtari, F. A. (2019). The determinants of liquidity of Indian listed commercial banks: A panel data approach. *Cogent Economics and Finance*, *7*(1), 1–20. https://doi.org/10.1080/23322039.2019.1616521

Alger, G., & Alger, I. (1999). *Liquid Assets in Banks: Theory and Practice* (No. 446; Boston College Working Papers in Economics).

Anjili, A. D. (2014). *Effects of Asset and Liability Management on the Financial Performance of Commercial Banks in Kenya*. http://erepository.uonbi.ac.ke/bitstream/handle/11295/95398/Anjichi_Effects Of Asset And Liability Management On The Financial Performance Of Commercial Banks In Kenya.pdf?sequence=1

Anthony, O. (2012). Bank Savings and Bank Credits in Nigeria : *International Journal of Economics and Financial Issues*, *2*(3), 357–372.

Apuke, O. D. (2017). Quantitative Research Methods : A Synopsis Approach. *Arabian Journal of Business and Management Review*, *6*(10), 40–47. https://doi.org/10.12816/0040336

Argimon, I., Castells, G. A., & Tous, F. R. (2012). Does the intensity of prudential regulation affect banks? Evidence from the 2007-2009 crises. *Journal of Governance and Regulation*, *1*(3), 14–26. https://doi.org/10.22495/jgr_v1_i3_p2

Ariffin, N. M. (2012). Liquidity risk management and financial performance in Malaysia: empirical evidence from Islamic banks. *Aceh International Journal of Social Sciences*, *1*(2), 77–84. https://doi.org/10.12345/AIJSS.1.2.1530

Aspachs, O., Nier, E., & Tiesset, M. (2005). Liquidity, Banking Regulation and the macroeconomics: evidence on bank liquidity holdings from a panel of UK-resident banks. In *BIS Economic Papers*.

Aspal, P. K., & Dhawan, S. (2016). Camels Rating Model For Evaluating Financial Performance of Banking Sector: A Theoretical Perspective. *International Journal of System Modeling and Simulation*, *1*(3), 10–15.

Athanasoglou, P., Delis, M., & Staikouras, C. (2006). Determinants of bank profitability in the South Eastern European region. *Journal Of Financial Decision Making*, *2*(2), 1–17. http://mpra.ub.uni-muenchen.de/10274

Au Yong, H. H., Faff, R., & Chalmers, K. (2009). Derivative activities and Asia-Pacific banks' interest rate and exchange rate exposures. *Journal of International Financial Markets, Institutions and Money*, *19*(1), 16–32. https://doi.org/10.1016/j.intfin.2007.08.002

Auerbach, C. F., & Silverstein, L. B. (2003). *Qualitative Data: An Introduction to Coding and Analysis*. New York University Press.

Avkiran, N. K., & Cai, L. (Cynthia). (2012). Predicting bank financial distress prior to crises. In *New Zealand Finance Colloquium* (Issue January). http://www.nzfc.ac.nz/archives/2012/papers/updated/24.pdf

Azad, A. K., Kian-Teng, K., & Talib, M. A. (2017). Unveiling black-box of bank efficiency: An adaptive network data envelopment analysis approach. *International Journal of Islamic and Middle Eastern Finance and Management*, *10*(2), 149–169. https://doi.org/10.1108/IMEFM-12-2016-0184

Azmi, R., & Tamiz, M. (2010). A Review of Goal Programming for Portfolio Selection. In *New Developments in Multiple Objective and Goal Programming* (Issue 638, pp. 15–33). Springer. https://doi.org/10.1007/978-3-642-10354-4

Bace, E. (2016). Bank profitability: Liquidity, capital and asset quality. *Journal of Risk Management in Financial Institutions*, *9*(4), 327–331.

Badri, M. A. (2001). A combined AHP-GP model for quality control systems. *International Journal of Production Economics*, *72*(1), 27–40. https://doi.org/10.1016/S0925-5273(00)00077-3

Ballester, L., Ferrer, R., & González, C. (2009). Interest rate risk and bank-specific characteristics. In *New Frontiers in Insurance and Bank Risk Management* (Issue March, pp. 1–3). Mc Graw Hill.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, *30*(9), 1078–1092. https://doi.org/10.1287/mnsc.30.9.1078

Banz, R. W. (1981). The relationship between return and market value of common stocks. *Journal of Financial Economics*, *9*(1), 3–18.

Barua, R. (2018). Capital Adequacy of Indian Commercial Banks under Basel Regime - An Empirical Study. *Prajnan*, *XLVII*(3), 283–306.

Baruah, A. (2018). Dynamic Capital Adequacy Ratio for Bringing Equilibrium in Lending in the Banking Industry : A Study of the Five Largest Banks in India. *Prajnan*, *XLVII*(1), 89–107.

Basel-III. (2013). Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools. In *Basel Committee on Banking Supervision* (Issue January).

Basel. (2001). Risk Management Practices and Regulatory Capital: Cross-Sectional Comparison. *BIS Review*, *November*, 1–120. https://www.bis.org/publ/joint04.pdf

Beaulieu, P. R. (1996). A note on the role of memory in commercial loan officers' use of accounting and character information. *Accounting, Organizations and Society*, *21*(6), 515–528. https://doi.org/10.1016/0361-3682(96)00004-9

Berger, A. N., & Bouwman, C. H. S. (2009). Bank liquidity creation. *The Review of Financial Studies*, *22*(9), 3779–3837. https://doi.org/10.1093/rfs/hhn104

Bhati, S., De Zoysa, A., & Jitaree, W. (2019). Factors affecting the liquidity of commercial banks in India: A longitudinal analysis. *Banks and Bank Systems*, *14*(4), 78–88. https://doi.org/10.21511/bbs.14(4).2019.08

Bhati, S. S., & Zoysa, A. De. (2012). An examination of factors affecting liquidity management in Indian financial system. *Sixth Annual International Conference on Business and Society in a Global Economy*.

Bhati, S. S., & Zoysa, A. De. (2015). Determinants of liquidity in nationalised banks of India. *World Finance & Banking Symposium*, 1–11.

Bhattacharyya, A., Lovell, C. A. K., & Sahay, P. (1997). The impact of liberalization on the productive efficiency of Indian commercial banks. *European Journal of Operational Research*, *7*.

Bhattarai, S., & Yadav, S. R. (2009). AHP APPLICATION IN BANKING : UNFOLDING UTILITY IN A SITUATION 2 . 0 Review of Application AHP in Banking. *Proceedings of International Symposium on Analytic Hierarchy Process*. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.558.3062&rep=rep1&type=pdf

Bichsel, R., & Blum, J. (2002). *The Relationship Between Risk And Capital In Swiss Commercial Banks : A Panel Study* (02.04).

Bielecki, T. R., & Rutkowski, M. (2004). Introduction to Credit Risk. In *Credit Risk: Modeling, Valuation and Hedging* (pp. 3–30). Springer Finance. https://doi.org/https://doi.org/10.1007/978-3-662-04821-4_1

Black, R., Brown, K., & Moloney, J. (2003). Asset and liability management : what does the future have in store ? *Balance Sheet*, *11*(2), 32–38. https://doi.org/10.1108/09657960310480651

Bodla, B. S., & Verma, R. (2006). Determinants of Profitability of Banks in India: a Multivariate Analysis. *Journal of Services Research*, *6*(2), 1–19.

Bogentoft, E., Romeijn, H. E., & Uryasev, S. (2001). Asset/liability management for pension funds using CVaR constraints. *Journal of Risk Finance*, *3*(1), 57–71. https://doi.org/10.1108/eb043483

Bonner, C., Lelyveld, I. Van, & Zymek, R. (2013). Banks' Liquidity Buffers and the Role of Liquidity Regulation. In *DNB Working Paper* (No. 393). https://doi.org/10.1007/s10693-014-0207-5

Borio, C., Contreras, J., & Zampolli, F. (2020). Assessing the fiscal implications of banking crises. In *BIS Working Papers* (No. 893; BIS Working Papers).

Bourke, P. (1989). Concentration and other determinants of bank profitability in Europe, North America and Australia. *Journal of Banking & Finance*, *13*(1), 65–79.

Bowyer, L. E. (1981). *The effect of bank mergers on a bank's market share*. Iowa State University.

Brannen, J. (2005). Mixed Methods Research: A Discussion Paper. In *NCRM Methods Review Papers* (NCRM/005; Issue January 2005).

Bretscher, L., Schmid, L., & Vedolin, A. (2018). Interest rate risk management in uncertain times. *Review of Financial Studies*, *31*(8), 3019–3060. https://doi.org/10.1093/rfs/hhy039

Brown, S. W., & Swartz, T. A. (1989). A Gap Analysis of Professional Service Quality. *Journal of Marketing*, *53*(2), 92–98. https://doi.org/10.2307/1251416

Bryant, J. (1980). A model of reserves, bank runs, and deposit insurance. *Journal of Banking & Finance*, *4*(4), 335–344.

Bryman, A. (2014). *Social Research Methods* (Fourth). Oxford University Press.

Brzaković, T., Brzaković, A., & Petrović, J. (2016). Application of Scenario Analysis in the Investment Projects Evaluation. *Economics of Agriculture*, *63*(2), 501–513.

Bunda, I., & Desquilbet, J. B. (2008). The bank liquidity smile across exchange rate regimes. *International Economic Journal*, *22*(3), 361–386. https://doi.org/10.1080/10168730802287952

C. Prabhavathi, C. P. (2011). Impact of Interest Rate Risk In Banking System. *Indian Journal of Applied Research*, *3*(6), 314–316. https://doi.org/10.15373/2249555x/june2013/105

C S Balasubramaniam. (2011). Non-Performing Assets and Profitability of Commercial Banks in India : Assessment and Emerging Issues. *Abhinav*, *1*(7), 41–52.

Calimani, S., Hałaj, G., & Żochowski, D. (2017). Simulating fire-sales in a banking and shadow banking system. In *ESRB: Working Paper Series* (No. 46; ESRB Working Paper Series). https://doi.org/10.2849/487392

Chakraborty, S. A. (2017). Effect of NPA on Banks Profitability. *International Journal of Engineering Technology, Management and Applied Sciences*, *5*(5), 201–210.

Chakraborty, S., & Mohapatra, S. (2008). An Empirical Study of Asset Liability Management Approach by the Indian Banks. *Journal of Bank Management*, 7–14.

Chakroun, F., & Abid, F. (2013). A Multiobjective Model for Bank Asset Liability Management: The Case of a Tunisian Bank. *The IUP Journal of Financial Risk Management*, *10*(4), 35–56. https://doi.org/10.2139/ssrn.2246972

Chambers, D., & Charnes, A. (1961). Inter-Temporal Analysis and Optimization of Bank Portfolios. *Management Science*, *7*(4), 393–410. https://doi.org/10.1287/mnsc.7.4.393

Charnes, A., & Cooper, W. W. (1977). Goal programming and multiple objective optimizations: Part 1. *European Journal of Operational Research*, *1*(1), 39–54. https://doi.org/https://doi.org/10.1016/S0377-2217(77)81007-2

Charumathi, B. (2008). Asset Liability Management in Indian Banking Industry - with special reference to Interest Rate Risk Management in ICICI Bank. *Proceeding of the World Congress on Engineering*, *II*(September).

Chatterjee, C., & Dutta, P. (2016). Exploring the Linkage between Profits and Asset–Liability Management: Evidence from Indian Commercial Banks. *Paradigm*, *20*(2), 131–142. https://doi.org/10.1177/0971890716670707

Chattha, J. A., Alhabshi, S. M., & Meera, A. K. M. (2020). Risk management with a duration gap approach. *Journal of Islamic Accounting and Business Research*, *11*(6), 1257–1300. https://doi.org/10.1108/JIABR-10-2017-0152

Chaturvedi, V. (2014). Asset Liability Management in Banks. *International Journal of Engineering Technology, Management and Applied Sciences*, *1*(2), 2349–4476. http://www.ijetmas.com/admin/resources/project/paper/f201406281403951723.pdf

Chaudhuri, B. (2018). A comparative analysis of SBI and ICICI: Camel Approach. *International Journal of Research in Management, Economics and Commerce*, *08*(1), 151–156. http://indusedu.org

Chaudhury, N. J. (2018). Impact of Liquidity on Profitability: A Study on the Commercial Banks in Bangladesh. *IIUC Studies*, *15*, 59–71. https://doi.org/10.47260/amae/1114

Chen, I.-J., & Phuong, N. L. (2013). The Determinants of Bank Liquidity Buffer. *SSRN Electronic Journal*, 1–51. https://doi.org/10.2139/ssrn.2313541

Chilukuri, S., & Rao, K. S. (2014). Effective Credit Approval and Appraisal System : Loan Review Mechanism of Commercial Banks. *International Journal of Innovative Research & Development*, *3*(12), 267–274.

Chimkono, E. E., Muturi, W., & Njeru, A. (2016). Effect On Non-Performing Loans And Other Factors On Performance Of Commercial Banks In Malawi. *International Journal of Economics, Commerce and Management*, *IV*(2), 549–563.

Choon, L. K., Hooi, L. Y., Murthi, L., Yi, T. S., & Shven, T. Y. (2013). *The Determinants Influencing Liquidity of Malaysia Commercial Banks, and Its Implication for Relevant Bodies: Evidence From 15 Malaysia Commercial Banks* (Issue August). Universiti Tunku Adbul Rahman.

Chronology of events. (n.d.). Reserve Bank of India. https://www.rbi.org.in/Scripts/chro_1968.aspx

Cohen, K. J., & Hammer, F. S. (1967). Linear Programming and Optimal Bank Asset Management Decisions. *The Journal of Finance*, *22*(2), 147–165. https://doi.org/10.2307/2325551

Colapinto, C., Jayaraman, R., & Marsiglio, S. (2017). Multi-Criteria Decision Analysis with Goal Programming in Engineering, Management and Social Sciences: A State-Of-The Art Review. *Annals of Operations Research*, *251*(1–2), 7–40. https://doi.org/10.1007/s10479-015-1829-1

Coleman, R. (2011). Operational Risk. In J. J. Cochran (Ed.), *Wiley Encyclopedia of Operations Research and Management Science*. https://doi.org/10.1002/9780470400531.eorms0591

Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: techniques and procedures for developing grounded theory* (Fourth). Sage Publication.

Cucinelli, D. (2013). The Determinants of Bank Liquidity Risk within the Context of Euro Area. *Interdisciplinary Journal of Research in Business*, *2*(10), 51–64.

Cucinelli, D. (2015). The Impact of Non-performing Loans on Bank Lending Behavior: Evidence from the Italian Banking Sector. *Eurasian Journal of Business and Economics*, *8*(16), 59–71. https://doi.org/10.17015/ejbe.2015.016.04

D. Giokas, & Vassiloglou, M. (1991). A goal programming model for bank assets and liabilities management. *European Journal of Operational Research*, *50*(1), 48–60. https://doi.org/ https://doi.org/10.1016/0377-2217(91)90038-W

Dahl, H., Meeraus, A., & Zenios, S. A. (1993). Some financial optimization models: 1 Risk management. In S. A. Zenios (Ed.), *Financial Optimization* (pp. 3–36). Cambridge University Press. https://doi.org/10.1017/CBO9780511522130.003

Dam, K., Escrihuela-Villar, M., & Sanchez-Pages, S. (2015). On the relationship between market power and bank risk taking. *Journal of Economics*, *114*(2), 177–204.

Dang, U. (2011). *The CAMEL Rating System in Banking Supervision: A Case Study*. Arcada University of Applied Sciences.

Dao, B. T., & Thomas, A. (2014). Capital Adequacy & Banking Risk An Empirical Study on Vietnamese Banks. *SSRN Electronic Journal*, 1–21. https://doi.org/10.2139/ssrn.2524233

Darshan, G., & Suresh, N. (2020). A Study on Interest Rate Risk of Commercial Banks. *Journal of Engineering and Applied Sciences*, *15*(2), 380–383. https://doi.org/10.36478/jeasci.2020.380.383

Das, A., & Ghosh, S. (2001). The Relationship Between Risk and Capital: Evidence from Indian Public Sector Banks. *Reserve Bank of India Occasional Papers*, *22*(1, 2 and 3), 1–20. https://doi.org/10.1111/j.1813-6982.1961.tb02383.x

Das, A., & Ghosh, S. (2004). The Relationship Between Risk and Capital: Evidence From the Indian Public Sector Banks. *Reasearch Gate*. https://www.researchgate.net/publication/23745875_The_Relationship_Between_Risk_and_Capital_Evidence_from_Indian_Public_Sector_Banks

Dash, M. (2013). A Study of the Impact of Asset-Liability Management on the Profitability of Banks in India. *Journal of Applied Management and Investments*, *2*(4), 230–234. https://doi.org/10.1017/CBO9781107415324.004

Dash, M., & Pathak, R. (2011). A Linear Programming Model for Assessing Asset- Liability Management in Banks. *The IUP Journal of Financial Risk Management : IJFRM*, *8*(1), 50–67.

Dash, M., & Pathak, R. (2016). Canonical Correlation Analysis of Asset-Liability Management of Indian Banks. *Journal of Applied Management and Investments*, *5*(2), 75–81.

Dash, M., Venkatesh, K. A., & Bhargav, B. (2011). An Analysis of Asset-Liability Management in Indian Banks. *SSRN Electronic Journal*, 1–13. https://doi.org/10.2139/ssrn.1760786

De Haan, L., & van den End, J. W. (2013). Bank liquidity, the maturity ladder, and regulation. *Journal of Banking and Finance*, *37*(10), 3930–3950. https://doi.org/10.1016/j.jbankfin.2013.07.008

de Waal, B., Petersen, M. A., Hlatshwayo, L. N. P., & Mukuddem-Petersen, J. (2013). A note on Basel III and liquidity. *Applied Economics Letters*, *20*(8), 777–780. https://doi.org/10.1080/13504851.2012.744130

Debasish, S. S. (2008). Foreign exchange risk management practices- A study in Indian scenario. *BRAC University Journal*, *5*(2), 81–91. http://dspace.bracu.ac.bd:8080/handle/10361/447

Delechat, C., Henao, C., Muthoora, P., & Vtyurina, S. (2012). The Determinants of Banks' Liquidity Buffers in Central America. In *IMF Working Papers* (WP/12/301 The).

Dhanani, A., Fifield, S., Helliar, C., & Stevenson, L. (2008). The management of interest rate risk: Evidence from UK companies. *Journal of Applied Accounting Research*, *9*(1), 52–70. https://doi.org/10.1108/09675420810886123

Diamond, D. W. ., & Dybvig, P. H. . (1983). Bank Runs , Deposit Insurance , and Liquidity. *Journal of Political Economy*, *91*(3), 401–419.

Diamond, D. W., & Rajan, R. G. (2001). Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of Political Economy*, *109*(2), 287–327. https://doi.org/10.1086/319552

Diamond, D. W., & Rajan, R. G. (2003). Liquidity Shortages And Banking Crises. In *NBER Working Paper Series* (No. 10071).

Díaz-Balteiro, L., & Romero, C. (2001). Combined Use of Goal Programming and the Analytic Hierarchy Process in Forest Management. In *The Analytical Hierarchy Process in Natural Resource and Environmental Decision Making* (pp. 81–95). Kluwer Academic Publishers. https://doi.org/10.1007/978-94-015-9799-9_6

Dinger, V. (2009). Do foreign-owned banks affect banking system liquidity risk? *Journal of Comparative Economics*, *37*(4), 647–657. https://doi.org/10.1016/j.jce.2009.04.003

Distinguin, I., Roulet, C., & Tarazi, A. (2013). Bank regulatory capital and liquidity: Evidence from US and European publicly traded banks. *Journal of Banking and Finance*, *37*(9), 3295–3317. https://doi.org/10.1016/j.jbankfin.2013.04.027

Drakos, K. (2003). Assessing the success of reform in transition banking 10 years later: An interest margins analysis. *Journal of Policy Modeling*, *25*, 309–317. https://doi.org/10.1016/S0161-8938(03)00027-9

Drehmann, M., Sorensen, S., & Stringa, M. (2006). Integrating credit and interest rate risk : A theoretical framework and an application to banks' balance sheets. *Bank for International Settlements*, 1–33. https://www.bis.org/bcbs/events/rtf06stringa_etc.pdf

Dzapasi, F. D. (2020). The impact of liquidity management on bank financial performance in subdued economic environment: A case of the Zimbabwean Banking Industry. *PM World Journal*, *9*(1), 1–20.

E.Shrieves, R., & DrewDahl. (1992). The relationship between risk and capital in commercial banks. *Journal of Banking & Finance*, *12*(2), 439–457.

Eatman, J., & Sealey, C. (1979). A multiobjective linear programming model for commercial bank balance sheet management. *Journal of Bank Research*, *9*, 227–236.

Eichengreen, B., & Gupta, P. (2013). The financial crisis and Indian banks: Survival of the fittest? *Journal of International Money and Finance*, *39*(December), 138–152. https://doi.org/10.1016/j.jimonfin.2013.06.022

Ejoh, N. O., & Sackey, J. A. (2014). The Impact of Capital Adequacy on Deposit Money Banks' Profitability in Nigeria. *European Journal of Business and Management*, *6*(19), 81–89.

Ekinci, R., & Poyraz, G. (2019). The Effect of Credit Risk on Financial Performance of Deposit Banks in Turkey. *Procedia Computer Science*, *158*, 979–987. https://doi.org/10.1016/j.procs.2019.09.139

English, W. B., Van den Heuvel, S. J., & Zakrajšek, E. (2018). Interest rate risk and bank equity valuations. *Journal of Monetary Economics*, *98*, 80–97. https://doi.org/10.1016/j.jmoneco.2018.04.010

Etemad, S. S., Limaei, S. M., Olsson, L., & Yousefpour, R. (2019). Forest management decision-making using goal programming and fuzzy analytic hierarchy process approaches (case study: Hyrcanian forests of Iran). *Journal for Forest Science*, *65*(9), 368–379. https://doi.org/https://doi.org/10.17221/46/2019-JFS

Etikan, I., & Bala, K. (2017). Sampling and Sampling Methods. *Biometrics & Biostatistics International Journal*, *5*(6), 1–3. https://doi.org/10.15406/bbij.2017.05.00149

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, *5*(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Fabozzi, F. J., & Konishi, A. (1991). *Asset/liability Management: Investment Strategies, Liquidity Requirements, and Risk Controls for Banks and Thrifts*. Probus Publishing Company.

Falconer, B. (2001). Structural liquidity: the worry beneath the surface. *Journal of Risk Finance*, *9*(3), 13–19.

FDIC. (1997). *UNIFORM FINANCIAL INSTITUTIONS RATING SYSTEM*. FDIC Law, Regulations, Related Acts.

Ferrouhi, E. M. (2018). Determinants of banks' profitability and performance: an overview. *Munich Personal RePEc Archive (MPRA)*, 1–15. https://mpra.ub.uni-muenchen.de/id/eprint/89470

Fiedler, R., Brown, K., & Moloney, J. (2002). The dynamically projected balance sheet : implications for earnings , value and funds transfer pricing. *Balance Sheet*, *10*(2), 17–21.

Fielitz, B. D., & Loeffler, T. A. (1979). A Linear Programming Model for Commercial Bank Liquidity Management. *Financial Management*, *8*(3), 41–50. https://doi.org/DOI: 10.2307/3665037

Floquet, K., & Biekpe, N. (2008). The Relationship Between Capital Structure and Risk in Emerging Market Banks. *Banks and Bank Systems*, *3*(1), 63–74.

Fortson, J. C., & Dince, R. R. (1977). An Application of Goal Programming to Management of a Country Bank. *Journal of Bank Research*, *Winter*, 311–319.

Fraser, D. R., Madura, J., & Weigand, R. A. (2002). Sources of bank interest rate risk. *Financial Review*, *37*(3), 351–368. https://doi.org/10.1111/0732-8516.00002

Gadhia, N. M. (2015). "CAMEL" Model, A conceptual framework for financial performance evaluation of Banks in India. *International Journal of Scientific Research*, *4*(1), 45–47.

Gakure, R. ., Ngugi, J. K., Ndwiga, P. M., & Waithaka, S. M. (2012). Effect of Credit Risk Management Techniques on the Performance of Unsecured Bank Loans Employed Commercial Banks In Kenya. *International Journal of Business and Social Research*, *2*(4), 221–236. https://doi.org/10.18533/ijbsr.v2i4.164

Gatev, E., Schuermann, T., & Strahan, P. E. (2004). How do banks manage liquidity risk? Evidence from equity and deposit markets in the fall of 1998. In *Risks of Financial Institutions* (Working paper 10982). http://www.nber.org/papers/w10982%0ANATIONAL

Gauba, R. (2012). Banking & its Evolution The Indian Banking Industry : Evolution, Transformation & The Road Ahead. *Pacific Business Review International*, *5*(1), 85–97.

Genchev, E. (2012). Effects of Market Share on the Bank's Profitability. *Review of Applied Socio-Economic Research*, *3*(1), 87–94.

Ghosh, A., Gu, Z., & Jain, P. C. (2005). Sustained Earnings and Revenue Growth, Earnings Quality, and Earnings Response Coefficients. *Review of Accounting Studies*, *10*, 33–57.

Giesecke, K. (2004). Credit Risk Modeling and Valuation: An Introduction. In D. Shimko (Ed.), *Credit Risk: Models and Management* (Vol. 2, pp. 1–67). https://doi.org/10.2139/ssrn.479323

Global Economic Prospects. (2020). In *The World Bank* (Issue June). https://doi.org/10.1596/978-1-4648-1553-9

Goddard, J., Molyneux, P., & Wilson, J. O. S. (2009). The financial crisis in Europe: Evolution, policy responses and lessons for the future. *Journal of Financial Regulation and Compliance*, *17*(4), 362–380. https://doi.org/10.1108/13581980911004352

Goldstein, M., & Turner, P. (1996). Banking Crises in Emerging Economies: Origins and Policy Options. In *BIS Economic Papers* (No. 46). https://doi.org/10.1142/9789814749589_0008

Goodman, L. S., & Langer, M. J. (1983). Accounting for Interest Rate Futures in Bank Asset-Liability Management. *The Journal of Futures Markets*, *3*(4), 415–427. https://doi.org/10.1002/fut.3990030407

Gross and Net NPAs of SCBs. (2020). Reserve Bank of India.

Gunsel, N. (2007). Financial Ratios and the Probabilistic Prediction of Bank Failure in North Cyprus. *European Journal of Scientific Research*, *18*(2), 191–200.

Gupta, D., & Kamilla, U. (2016). Measuring Bank Competition in Changing Indian Loan Markets: A Modern Empirical Approach. *Prajnan*, *45*(3), 201–221.

Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, *26*(2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Halim, B. A., Karim, H. A., Fahami, N. A., Mahad, N. F., Nordin, S. K. S., & Hassan, N. (2015). Bank Financial Statement Management Using A Goal Programming Model. *Procedia - Social and Behavioral Sciences*, *211*(November), 498–504. https://doi.org/10.1016/j.sbspro.2015.11.066

Hamurcu, M., & Eren, T. (2018). Transportation Planning with Analytic Hierarchy Process and Goal Programming. *International Advanced Researches and Engineering Journal*, *02*(02), 92–97.

Hassan, A. G. (2015). *Designing a Mathematical Model for Optimal Assets and Liabilities Management Using Goal Programming Model (Case Study: The Bank of Palestine 2013-2014).*

Hassanein, M., Bouaddi, M., & Karim, T. (2021). Measurement of operational risk regulatory capital in the banking sector: developed countries versus emerging markets. *Journal of Operational Risk*, *16*(1), 13–43.

Hester, D. D., & Zoellner, J. F. (1966). The Relation Between Bank Portfolios and Earnings : An Econometric Analysis. *The Review of Economics and Statistics*, *48*(4), 372–386.

Hicks, J. R. (1939). *Value and Capital* (First). Oxford University Press.

Hinton, P. R., Brownlow, C., McMurray, I., & Cozens, B. (2004). *SPSS Explained* (first). Taylor & Francis.

Hlatshwayo, L. N. P., Petersen, M. A., Mukuddem-Petersen, J., & Meniago, C. (2013). Basel III liquidity risk measures and bank failure. *Discrete Dynamics in Nature and Society*, *2013*(Stochastic Modeling and Financial Applications). https://doi.org/10.1155/2013/172648

Ho, W. (2007). Combining analytic hierarchy process and goal programming for logistics distribution network design. *IEEE International Conference on Systems, Man and Cybernetics*, 714–719. https://doi.org/10.1109/ICSMC.2007.4413642

Holmstrom, B., & Tirole, J. (1998). Private and Public Supply of Liquidity. *Journal of Political Economy*, *106*(1), 1–40.

Houpt, J. V, & Embersit, J. A. (1991). A Method for Evaluating Interest Rate Risk in US Commercial Banks. *Federal Reserve Bulletin*, *1*(August), 625–637.

Hua, W. (2011). The Capital and Risk Adjustment Under Regulatory Pressure of Chinese Commercial Banks. *Management Science and Engineering*, *5*(4), 41–44.

Hulin, C., Netermeyer, R., & Cudeck, R. (2001). Can a Reliability Coefficient Be Too High? *Journal of Consumer Psychology*, *10*(1), 55–58.

Hunjak, T., & Jakovčević, D. (2001). AHP Based Model for Bank Performance Evaluation and Rating. *Proceedings of 6th International Symposium on Analytic Hierarchy Process (ISAHP 2001)*, 149–158.

Hurd, T. R. (2018). Bank panics and fire sales, insolvency and illiquidity. *International Journal of Theoretical and Applied Finance*, *21*(6), 1–30. https://doi.org/10.1142/S0219024918500401

Ibtissem, B., & Bouri, A. (2013). Credit Risk Management in Microfinance: The Conceptual Framework. *ACRN Journal of Finance and Risk Perspectives*, *2*(1), 9–24. http://www.acrn.eu/resources/Journals/jfrp201301b.pdf

India Inflation Rate 1960-2021. (n.d.). Macro Trends. https://www.macrotrends.net/countries/IND/india/inflation-rate-cpi

Israel, G. D. (1992). Determination of sample size. In *Program Evaluation and Organizational Development* (Vol. 6).

Jain, Manoj Kumar, Dalela, A. K., & Tiwari, S. K. (2010). Application of Fuzzy Mathematical Model in Assets-Liabilities. *International Journal of Trade, Economics and Finance*, *1*(3), 247–253. https://doi.org/10.7763/ijtef.2010.v1.45

Jain, Mukesh Kumar. (2017). Comparative Analysis of Private Sector Banks: An Application of Camel Model. *International Journal of Trade & Commerce*, *6*(2), 341–354. www.sgsrjournals.co.in

Jamal, A. A. A., Karim, M. R. A., & Hamidi, M. (2012). Determinants of Commercial Banks ' Return on Asset : Panel Evidence from Malaysia. *Nternational Journal of Commerce , Business and Management*, *1*(3), 55–62.

Jamshidi, H., McDaniel, L., & Harris, D. (2017). An Empirical Application of Goal Programming and AHP in Real Estate Assessment. *Journal of Management Research*, *9*(3), 1–11. https://doi.org/10.5296/jmr.v9i3.11074

Jatuphatwarodom, N., Jones, D. F., & Ouelhadj, D. (2018). A mixed-model multi-objective analysis of strategic supply chain decision support in the Thai silk industry. *Annals of Operations Research*, *267*(1–2), 221–247. https://doi.org/10.1007/s10479-018-2774-6

Javalgi, R. G., Armacost, R. L., & Hosseini, J. C. (1989). Using the analytic hierarchy process for bank management: Analysis of consumer bank selection decisions. *Journal of Business Research*, *19*(1), 33–49. https://doi.org/10.1016/0148-2963(89)90039-8

Jayadev, M. (2013). Basel III implementation: Issues and challenges for Indian banks. *IIMB Management Review*, *25*(2), 115–130. https://doi.org/10.1016/j.iimb.2013.03.010

Jayanthi, M., & Umarani, R. (2014). Asset-Liability Management in Banks. *CKPIM Business Review*, *9*(2), 10–25.

Jochen, S., Aikman, D., Collazos, P., Farag, M., Gregory, D., & Kapadia, S. (2011). The long-term economic impact of higher capital levels. In *BIS Papers* (No. 60; BIS Papers). http://www.bis.org/publ/bppdf/bispap60j.pdf

Joshi, S. P., & Sontakay, R. V. (2017). Review Paper on Asset Liability Management in Banking System. *Imperial Journal of Interdisciplinary Research*, *3*(6), 670–678.

Joshi, V. (2015). *A Study of Financial Management in Regional Rural Banks in Madhya Pradesh* [P.M.B. Gujarati Commerce College]. http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf

Kalita, B. (2008). Post 1991 Banking Sector Reforms in India: Policies and Impacts. *SSRN Electronic Journal*.

Kalyan, N. B. (2017). Banking Sector Reforms in India. *International Journal of Management and Humanities*, *4*(4), 13–18. https://doi.org/10.2139/ssrn.2303731

Kamarudin, F., Sufian, F., Nassir, A. M., Anwar, N. A. M., & Hussain, H. I. (2019). Bank Efficiency in Malaysia a DEA Approach. *Journal of Central Banking Theory and Practice*, *8*(1), 133–162. https://doi.org/10.2478/jcbtp-2019-0007

Kamil, K. H., Ismail, A. G., & Shahimi, S. S. (2013). Use of the Analytic Hierarchy Process (AHP) to Derive Priorities in the Management of Assets and liabilities in Accordance with Islamic Banking Objectives. *Malaysian Management Review*, *July-December*, 39–51.

Kandel, S. (2019). Analysis of financial performance of commercial banks of Nepal using CAMEL approach. *Ieee-Sem*, *10*(6), 210–237.

Kapparashetty, B. V. (2019). RBI Control on CRR and SLR to Private Sector Banks – A Study. *International Journal of Research and Analytical Reviews*, *6*(4), 396–403.

Karthikeyan, R., Venkatesan, K. G. S., & Chandrasekar, A. (2016). A Comparison of strength and weakness for analytical hierarchy process. *Journal of Chemical and Pharmaceutical Sciences*, *9*(3), 12–15.

Karunakar, M., Vasuki, K., & Saravanan, S. (2008). Are Non -Performing Assets Gloomy or Greedy from Indian Perspective? *Research Journal of Social Sciences*, *3*, 4–12.

Kashyap, A. K., Rajan, R., & Stein, J. C. (2002a). Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking. *The Journal of Finance*, *LVII*(1), 33–73. https://doi.org/10.1111/1540-6261.00415

Kashyap, A. K., Rajan, R., & Stein, J. C. (2002b). Banks as Liquidity Providers: An Explanation for the Coexistence of Lending and Deposit-Taking. *Journal of Finance*, *57*(1), 33–73. https://doi.org/10.1111/1540-6261.00415

Katarzyna, K. (2016). The Assessment Of The Situation In Banking Sectors In Selected European Countries. *Economics and Law*, *15*(2), 193–208.

Kaur, G., & Sharma, R. (2017). Study of Determinants of Liquidity Risk in Context to Indian Banking Industry. *International Journal of Applied Business and Economic Research*, *15*(22), 153–163.

Kaur, H. V. (2010). Analysis of banks in India-a CAMEL approach. *Global Business Review*, *11*(2), 257–280. https://doi.org/10.1177/097215091001100209

Kaur, M., & Kapoor, S. (2015). Risk-Based Capital Regulation and Bank Behaviour: A Critical Review of Literature from 1990 to 2013. *Prajnan*, *XLIV*(1), 29–52.

Keown, A. J., & Martin, J. D. (1977). A Chance Constrained Goal Programming Model for Working Capital Management. *Engineering Economist*, *22*(3), 153–174. https://doi.org/10.1080/00137917708965174

Kesavan, V. (2015). A Study on Rbi ' s Interest Rate Cuts and its Aftermath Effects in its Economy with Specific Reference to India. *International Journal of Engineering and Management Research*, *5*(5), 20–24.

Kessey, K. D. (2015). Assessing credit risk management practices in the banking industry of Ghana: Processes and challenges. *Global Journal of Management and Business Research: C Finance*, *15*(6), 1–11.

Key Deficit Indicators of the Central Government. (n.d.). RBI Publications. https://www.rbi.org.in/Scripts/PublicationsView.aspx?id=17874

Kiran, K. (2018). A camel model of analysis of selected public and private sector banks in India. *International Journal of Management, IT & Engineering*, *8*(8), 257–271.

Kiwan, S. H. (1991). Re-examination of interest rate sensitivity of commercial bank stock returns using a random coefficient model. *Journal of Financial Services Research*, *5*, 61–76. https://doi.org/https://doi.org/10.1007/BF00127084

Klein, N. (2013). Non-Performing Loans in CESEE: Determinants and Impact on Macroeconomic Performance. In *IMF Working Papers* (WP/13/72, Vol. 13, Issue 72). https://doi.org/10.5089/9781484318522.001

Kobler, D., Grampp, M., Hauber, F., Witt, J., Brandes, D., Schlotmann, J., & Fischer, N. (2015). Growth in Banking – unlocking the full potential. In *Deloitte Consulting Switzerland White Paper*. https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/financial-services/ch-en-fs-growth-in-banking.pdf

Kohlscheen, E., Pabón, A. M., & Contreras, J. (2018). *Determinants of bank profitability in emerging markets* (No. 686; BIS Working Papers). https://www.bis.org/publ/work686.pdf

Konovalova, N., Kristovska, I., & Kudinska, M. (2016). Credit risk management in commercial banks. *Polish Journal of Management Studies*, *13*(2), 90–100. https://doi.org/10.17512/pjms.2016.13.2.09

Kosmidou, K., Pasiouras, F., & Floropoulos, J. (2004). Linking profits to asset-liability management of domestic and foreign banks in the UK. *Applied Financial Economics*, *14*(18), 1319–1324. https://doi.org/10.1080/0960310042000293146

Kosmidou, K., & Zopounidis, C. (2002). An optimization scenario methodology for bank asset liability management. *Operational Research*, *2*(2), 279–287. https://doi.org/http://dx.doi.org/10.1007/BF02936331

Kruger, H., & Hattingh, J. (2006). A combined AHP-GP model to allocate internal auditing time to projects. *ORiON*, *22*(1), 59–76. https://doi.org/10.5784/22-1-33

Kruger, M. (2011). A Goal Programming Approach to Strategic Bank Balance Sheet Management. *SAS Global Forum 2011 Banking, Financal Services and Insurance*, 1–11.

Kumar, M., & Yadav, G. C. (2013). Liquidity Risk Management in Bank: A Conceptual Framework. *AIMA Journal of Management and Research*, *7*(2/4), 20–35.

Kumar, N., & Chatterjee, P. (2020). Quantification of regulatory capital for management of operational risk in banks: study from an emerging market economy. *Journal of Operational Risk*, *15*(3), 97–121.

Kumar, V., & Malhotra, B. (2017). A Camel Model Analysis of of Private Banks in India. *EPRA International Journal of Economic and Business Review*, *5*(7), 87–93.

Kumar, V. V. R., & Gupta, N. (2013). A study on Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR) Management at The Jammu and Kashmir Bank Ltd. *Journal of Contemporary Management Research*, *7*(1), 58–77.

Kurtz, R. D., & Rhoades, S. A. (1992). A note on the market share-profitability relationship. *Review of Industrial Organization*, *7*(1), 39–50. https://doi.org/10.1007/BF00354845

Kusy, M. I., & Ziemba, W. (1986). A Bank Asset and Liability Management. *Operation Research*, *34*(3), 356–376.

Kwan, S., & Eisenbeis, R. A. (1997). Bank Risk, Capitalization, and Operating Efficiency. *Journal of Financial Services Research*, *12*, 117–131.

Lai, V. S., & Hassan, M. K. (1997). An empirical investigation of asset-liability management of small US commercial banks. *Applied Financial Economics*, *7*(5), 525–536. https://doi.org/10.1080/096031097333394

Lamanda, G., & Vonek, Z. T. (2020). What do risk disclosures reveal about banking operational risk processes? Content analysis of banks' risk disclosures in the Visegrad Four countries. *Journal of Operational Risk*, *15*(1), 27–48.

Lartey, V. C., Antwi, S., & Boadi, E. K. (2013). The Relationship between Liquidity and Profitability of Listed Banks in Ghana. *International Journal of Business and Social Science*, *4*(3), 48–56.

Lavanya, B., & Srinivas, T. (2018). Performance Analysis Using Camel Model- a Study of Select Private. *Journal of Emerging Technologies and Innovative Research (JETIR)*, *5*(6), 214–223.

Ledhem, M. A., & Mekidiche, M. (2020). Economic growth and financial performance of Islamic banks: a CAMELS approach. *Islamic Economic Studies*, *28*(1), 47–62. https://doi.org/10.1108/IES-05-2020-0016

Liesz, T. J. (2002). *Really Modified DuPont Analysis: Five Ways to Improve Return on Equity*. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.610.5026

Lin, P., Pourmohammadi, H., & Sarfaraz, A. R. (2015). A combined AHP-GP model for selecting and awarding design-build construction contracts. *Business Management Dynamics*, *5*(4), 30–42.

Lin, S. L., Hwang, D.-Y., Wang, K. L., & Xie, Z. W. (2013). Banking Capital and Risk-Taking Adjustment under Capital Regulation: The Role of Financial Freedom, Concentration and Governance Control. *International Journal of Management, Economics and Social Sciences*, *2*(2), 99–128. https://doi.org/10.2139/ssrn.2280481

Lin, T. W., & O'Leary, D. E. (1993). Goal Programming Applications in Financial Management. *Advances in Mathematical Programming and Financial Planning*, *3*(June), 211–229.

Lois, P., Drogalas, G., Petridis, K., & Doulgeridis, K. (2020). Critical variables in the implementation of a risk-based internal audit: a theoretical and empirical investigation of Greek companies. *Journal of Operational Risk*, *15*(4), 15–36.

Longstaff, F. A., & Schwartz, E. S. (1992). Interest Rate Volatility and the Term Structure: A Two-Factor General Equilibrium Model. *Journal of Finance*, *47*(4), 1259–1282.

Macaulay, F. R. (1938). *The Movements of Interest Rates, Bond Yields and Stock Prices in the United States since 1856*. London: Macmillan.

Mačerinskienė, I., Ivaškevičiūtė, L., & Babarskas, J. (2004). Multicriteria in Bank Loan Portfolio Management. *Ekonomika*, *67*, 79–90. https://doi.org/10.15388/ekon.2004.17371

Macharis, C., Springael, J., De Brucker, K., & Verbeke, A. (2004). PROMETHEE and AHP: The design of operational synergies in multicriteria analysis - Strengthening PROMETHEE with ideas of AHP. *European Journal of Operational Research*, *153*(2), 307–317. https://doi.org/10.1016/S0377-2217(03)00153-X

Mahajan, R., & Singh, P. (2020). Application Of Camel Model To Assess The Performance of Banking Sector : An Empirical Study. *International Journal of Disaster Recovery and Business Continuity*, *11*(3), 3320–3328.

Mandell, L. (1973). Consumer Knowledge and Understanding of Consumer. *The Journal of Consumer Affairs*, *7*(1), 23–36.

Markowitz, H. M. (1959). *Portfolio Selection: Efficient Diversification of Investments*. John Wiley & Sons.

Marozva, G. (2015). Liquidity And Bank Performance. *International Business & Economics Research Journal*, *14*(3), 453–462. https://doi.org/10.19030/iber.v14i3.9218

Mathers, N., Fox, N., & Hunn, A. (2009). Surveys and questionnaires. *National Institute of Health Research*, 4–51. https://doi.org/10.4324/9780203154281-35

Matz, L., & Neu, P. (Eds.). (2007). *Liquidity Risk Measurement and Management: A practitioner's guide to global best practices*. John Wliey & Sons Pte Ltd.

Meena, A. K., & Dhar, J. (2014). An Empirical Analysis and Comparative Study of Liquidity Ratios and Asset-Liability Management of Banks Operating in India. *International Journal of Social, Human Science and Engineering*, *8*(1), 4968–4974. www.waset.org

Meena, G. L. (2016). Financial Analysis of Select Banks Using Camel Approach a Study with Reference to Indian Banking Industry. *International Journal of Reserach and Scientific Innovation*, *III*(X), 30–35.

Menon, D. G., & Pillai, S. G. (2018). Impact of Non-Core Income on the Profitability of Banks in India : An Econometric Analysis. *International Journal of Pure and Applied Mathematics*, *119*(12), 2559–2567.

Miah, M. D., & Sharmeen, K. (2015). Relationship between capital, risk and efficiency: A comparative study between Islamic and conventional banks of Bangladesh. *International Journal of Islamic and Middle Eastern Finance and Management*, *8*(2), 203–221.

Michael, J. N., Vasanthi, G., & Selvaraju, R. (2006). Effect of Non-Performing Assets on Operational Efficiency of Central Co-Operative Banks. *Indian Economic Panorama*, *16*(3), 33–39. http://ssrn.com/abstract=1735329%0Ahttps://www.researchgate.net/publication/321049932

Mirza, H., Moccero, D., Palligkinis, S., & Pancaro, C. (2020). Fire sales by euro area banks and funds: What is their asset price impact? In *Economic Modelling* (Vol. 93, pp. 430–444). https://doi.org/10.1016/j.econmod.2020.07.020

Mishkin, F. S. (2007). Duration Gap Analysis. In *The Economics of Money, Banking and Financial Markets* (Eighth, pp. 32–33). Pearson Addison Wesley.

Mishra, A. K., Harsha, G. S., Anand, S., & Dhruva, N. R. (2012). Analyzing Soundness in Indian Banking: A CAMEL Approach. *Research Journal of Management Sciences*, *1*(3), 9–14.

Mishra, R. N., Majumdar, S., & Bhandia, D. (2013). *Banking Stability - A Precursor to Financial Stability* (RBI WPS (DEPR): 01/2013; RBI Working Paper Series No. 01).

Mocanu, M. (2021). The impact of culture upon operational risk management guidelines in the banking sector of selected Asian countries. *Journal of Operational Risk*, *16*(1), 55–72.

Mohan, R. (2006). Reforms, productivity, and efficiency in banking: The Indian experience. *Bank of International Settlement Review*, *15*, 505–532. https://doi.org/10.30541/v44i4ipp.505-538

Mohanty, S., & Mahakud, J. (2018). Commercial Bank Capital and Risk in India: Does Financial Crisis Matter? *Cogent Economics and Finance*, *6*(1), 1–23. https://doi.org/10.1080/23322039.2018.1520424

Molyneux, P., & Thornton, J. (1992). Determinants of European bank profitability: A note. *Journal of Banking & Finance*, *16*(6), 1173–1178.

Munteanu, I. (2012). Bank Liquidity and its Determinants in Romania. *Procedia Economics and Finance*, *3*, 993–998. https://doi.org/10.1016/s2212-5671(12)00263-8

Muralidhara, P., & Lingam, C. (2017). Camel Model As An Effective Measure of Financial Performance of Nationalised Banks. *International Journal of Pure and Applied Mathematics*, *117*(7), 255–262.

Naderi, S., Minouei, M., & Gashti, H. P. (2013). Asset and Liability Optimal Management Mathematical Modeling for Bank. *Journal of Basic and Applied Scientific Research*, *3*(1), 484–493.

Naqvi, H. (2015). Banking crises and the lender of last resort: How crucial is the role of information? *Journal of Banking and Finance*, *54*, 20–29. https://doi.org/10.1016/j.jbankfin.2015.01.004

Ngalawa, J., & Ngare, P. (2014). Interest Rate Risk Management for Commercial Banks in Kenya. *IOSR Journal of Economics and Finance*, *4*(1), 11–21. https://doi.org/10.9790/5933-0411121

Ngwa, E. (2010). *Credit Risk Management In Banks As Participants in the Financial Markets*. Umea School of Business.

Olagunju, A., David, A. O., & Samuel, O. O. (2011). Liquidity Management and Commercial Banks' Profitability in Nigeria. *Research Journal of Finance and Accounting*, *2*(7–8), 24–38. https://core.ac.uk/download/pdf/234629226.pdf

Panboli, S., & Birda, K. (2019). Camel research of selected private and public sector banks in India. *International Journal of Innovative Technology and Exploring Engineering*, *8*(12), 1237–1248. https://doi.org/10.35940/ijitee.L3979.1081219

Park, H. W., & Bernardin, T. (2018). Liquidity, bank runs, and fire sales under local thinking. *North American Journal of Economics and Finance*, *46*(May), 89–102. https://doi.org/10.1016/j.najef.2018.04.001

Pathi, R. (2017). MEASURING LIQUIDITY RISK IN A BANKING MANAGEMENT FRAMEWORK. *ELK Asia Pacific Journal of Finance and Risk Management*, *8*(2), 1–14. https://doi.org/10.16962/EAPJFRM/issn

Patnaik, I., & Shah, A. (2002a). Interest-Rate Risk in the Indian Banking System. In *Working paper No. 92* (Issue December).

Patnaik, I., & Shah, A. (2002b). Interest-Rate Risk in the Indian Banking System. *Working Paper No. 92*.

Pennathur, A. K., Subrahmanyam, V., & Vishwasrao, S. (2012). Income diversification and risk: Does ownership matter? An empirical examination of Indian banks. *Journal of Banking and Finance*, *36*(8), 2203–2215. https://doi.org/10.1016/j.jbankfin.2012.03.021

Petro, S. (2019). *Business and Financial Analysis of Tesla Inc.* [Tallinn University of Technology]. https://digikogu.taltech.ee/et/Download/df65bad2-55e9-4636-8547-30810a3d4338/TeslaIncrijafinantsanals.pdf

Pitts, M. (1985). The management of interest rate risk. *The Journal of Portfolio Management*, *11*(4), 67–69. https://doi.org/https://doi.org/10.3905/jpm.1985.409022

Prince Paul Antony, K. (2018). A Study on Asset Liability Management in Indian Bank. *International Journal of Business Administration and Management*, *8*(1), 1–9. http://www.ripublication.com

Professional Actuarial Specialty Guide: Asset- Liability Management. (2003). *Society of Actuaries (SOA)*. www.soa.org/library/professional-actuarial-specialty- guides/professional-actuarial-specialty-guides/2003/september/spg0308alm.pdf

Ramanathan, R. (2001). A note on the use of the analytic hierarchy process for environmental impact assessment. *Journal of Environmental Management*, *63*(1), 27–35. https://doi.org/10.1006/jema.2001.0455

Ramesh, K. (2016). Analysis of Priority and Non-Priority Sector NPAs of Indian Public Sectors Banks. *ISOR Journal of Business and Management*, *April*, 56–61.

Rani, V., & Rao, K. B. (2012). Study on CRR & SLR Ratio and Impact of These Ratios on Interest Rates. *Journal of Advances and Scholarly Researches in Allied Education*, *3*(6), 1–6.

Ranjan, Rahul, & Nallari, R. (2005). Study of Asset Liability Management in Indian Banks : Canonical Correlation Analysis Period 1992-2004. *Spandan*.

Ranjan, Rajiv, & Dhal, S. C. (2003). Non-Performing Loans and Terms of Credit of Public Sector Banks in India: An Empirical Assessment. *Reserve Bank of India Occasional Papers*, *24*(3), 81–121.

Ratnovski, L. (2013). Liquidity and transparency in bank risk management. *Journal of Financial Intermediation*, *22*(3), 422–439. https://doi.org/10.1016/j.jfi.2013.01.002

Rauf, A. L. A. (2016). Towards Increasing the Financial Performance: An Application of CAMEL Model in Banking Sector in the Context of Sri Lanka. *Research Journal of Finance and Accounting*, *7*(5), 66–71.

Rawat, R. (2014). Impact of Crr & SLR and Investment on Loans and Advances of Sbi. *IOSR Journal of Economics and Finance*, *4*(5), 40–44. https://doi.org/10.9790/5933-0454044

RBI. (n.d.-a). *GLOSSARY*. https://www.rbi.org.in/scripts/Glossary.aspx#Earnings

RBI. (n.d.-b). *Master Circular on BAsel III Capital Regulations*. 2–327.

RBI. (1999). Asset - Liability Management (ALM) System. *Reserve Bank of India Notifications*, 1–23. https://rbidocs.rbi.org.in/rdocs/notification/PDFs/5212.pdf

RBI. (2007). *Guidelines on Asset-Liability Management (ALM) system - Amendments*. Resereve Bank of India Guidelines. https://rbidocs.rbi.org.in/rdocs/notification/PDFs/80878.pdf

RBI. (2012). *Liquidity Risk Management by Banks*. https://doi.org/RBI No 2012-13/285 DBOD.BP.No.56/21.04.098/ 2012-13

RBI. (2013). *Operation and Performance of Commercial Banks*. Trend and Progress of Banking in India. https://www.rbi.org.in/scripts/PublicationsView.aspx?id=15440

RBI. (2015). *Master Circular - Cash Reserve Ratio (CRR) and Statutory Liquidity Ratio (SLR)*. Master Circular of RBI.

Reddy, K. N. (2018). Impact of Banking Sector Reforms on CRR and SLR in Indian Banks. *International Journal of Latest Engineering and Management Research (IJLEMR)*, *3*(12), 1–4.

Reddy, M., & Prasad, K. (2011). Evaluating Performance of Regional Rural Banks : An Application of CAMEL Model. *Indian Journal of Commerce & Management Studies*, *2*(6), 124–128.

Rehman, Z. U., Muhammad, N., Sarwar, B., & Raz, M. A. (2019). Impact of risk management strategies on the credit risk faced by commercial banks of Balochistan. *Financial Innovation*, *5*, 1–13. https://doi.org/10.1186/s40854-019-0159-8

Rezaei, S. T., Ameleh, K. N., Ghalmegh, K., & Ramezanzadeh, A. (2013). *Management of Balance Sheet Bank Using Goal Programming Model (GP) and Fuzzy Analytic Hierarchy Process (FAHP)*. Semantic Scholar.

Risal, H. G., & Panta, S. B. (2019). CAMELS-Based Supervision and Risk Management: What Works and What Does Not. *FIIB Business Review*, *8*(3), 194–204. https://doi.org/10.1177/2319714519873747

Riyazahmed, K., & Baranwal, G. (2021). Determinants of Credit Risk. *International Journal of Accounting & Finance Review*, *6*(1), 53–71. https://doi.org/10.46281/ijafr.v6i1.1005

Rodean, M.-D., Grigoroi, L., & Minculete, G. D. (2016). Study on Credit Risk Management in Commercial Banks. *Revista Economica*, *68*(4), 163–176.

Roman, A., & Sargu, A. C. (2015). The Impact of Bank-specific Factors on the Commercial Banks Liquidity: Empirical Evidence from CEE Countries. *Procedia Economics and Finance*, *20*, 571–579. https://doi.org/10.1016/s2212-5671(15)00110-0

Roman, A., & Şargu, A. C. (2013). Analysing the Financial Soundness of the Commercial Banks in Romania: An Approach based on the Camels Framework. *Procedia Economics and Finance*, *6*, 703–712. https://doi.org/10.1016/s2212-5671(13)00192-5

Romanyuk, Y. (2010). Asset-Liability Management : An Overview. In *Bank of Canada Discussion Paper*.

Romero, C., Tamiz, M., & Jones, D. (1998). Goal programming, compromise programming and reference point method formulations: Linkages and utility interpretations. *Journal of the Operational Research Society*, *49*(9), 986–991.

Roopa, S., & Rani, M. (2012). Questionnaire Designing for a Survey. *Journal of Indian Orthodontic Society*, *46*(4_suppl1), 273–277. https://doi.org/10.1177/0974909820120509s

Rosenthal, R. (1983). Goal programming- A Critique. *Nz Oper.Res.*, *11*(1), 1–8. https://www.researchgate.net/publication/256502481_A_Preemptive_Goal_Programming_Model_for_the_Sustainability_of_Growth_in_Engineering_Colleges

Ruparel, N. (2020). *(Re) Thinking Positive Workplace /s : A Multisectoral Cross-Sectional Investigation*. Birla Institute of Technology & Sciences- Pilani.

S. Mohammad Pourmohammad Azizi, & Neisy, A. (2017). Mathematic Modelling and Optimization of Bank Asset and Liability by Using Fractional Goal Programing Approach. *International Journal of Modeling and Optimization*, *7*(2), 85–91. https://doi.org/10.7763/ijmo.2017.v7.564

Saaty, T. L. (2008). Decision making with the Analytic Hierarchy Process. *International Journal of Services Sciences*, *1*(1), 83–98. https://doi.org/10.1504/ijssci.2008.017590

Saaty, Thomas L. (1994). How to make a decision: The Analytic Hierarchy Process. *Interfaces*, *24*(6), 19–43. https://doi.org/10.1016/0377-2217(90)90057-I

Sabato, G. (2011). Credit Risk Scoring Models. *SSRN Electronic Journal*, 1–15. https://doi.org/10.2139/ssrn.1546347

Samad-Khan, A. (2008). Modern Operational Risk Management. *Emphasis*, *2*, 26–29.

Samuel, G. (2011). *The effect of Asset liability management on profitability of National Investment Bank in the New Jyabeng municipality*. The Institute of Distance Learning, Kwame Nkrumah University Of Science And Technology.

Samy, A., & Raman, P. (2018). A Study on The Perception of Commercial Banks Towards Priority Sector Lending with Reference To Education Loan In Tamil Nadu. *Arabian Journal of Business and Management Review*, *34*(6109), 1–8.

Saporoschenko, A. (2002). The sensitivity of Japanese bank stock returns to economic factors: An examination of asset/liability differences and main bank status. *Global Finance Journal*, *13*(2), 253–270. https://doi.org/10.1016/S1044-0283(02)00043-1

Saravani, Z., Tash, M. N. S., & Mahmodpour, K. (2015). Evaluation of Bank Market Share and Its Affective Determinants : Sepah Bank. *International Research Journal of Applied and Basic Sciences*, *9*(7), 1003–1009. https://doi.org/10.12816/0018865

Sarkar, S., Sensarma, R., & Sharma, D. (2019). The relationship between risk, capital and efficiency in Indian banking: Does ownership matter? *Journal of Financial Economic Policy*, *11*(2), 218–231.

Sathyamoorthi, C. R., Mapharing, M., & Dzimiri, M. (2020). Liquidity Management and Financial Performance: Evidence From Commercial Banks in Botswana. *International Journal of Financial Research*, *11*(5), 399–413. https://doi.org/10.5430/ijfr.v11n5p399

Saunders, A., & Cornett, M. M. (2008). Financial Institutions Management: A Risk Managemeng Approach. In *Financial Institutions Management* (Sixth). McGraw-Hills.

Saunders, A., Schmid, M., & Walter, I. (2018). *Non-Core Banking, Performance, and Risk* (WORKING PAPERS ON FINANCE NO. 2014/17 SWISS; S/BF – HSG).

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *Kolner Zeitschrift Fur Soziologie Und Sozialpsychologie*, *69*, 107–131. https://doi.org/10.1007/s11577-017-0454-1

Sedzro, K., Marouane, A., & Assogbavi, T. (2012). Analytical Hierarchy Process and Goal Programming Approach for Asset Allocation. *Journal of Mathematical Finance*, *02*(01), 96–104. https://doi.org/10.4236/jmf.2012.21012

Seshadri, S., Khanna, A., Harche, F., & Wyle, R. (1999). Method for strategic asset-liability management with an application to the Federal Home Loan Bank of New York. *Operations Research*, *47*(3), 345–360. https://doi.org/10.1287/opre.47.3.345

Shams, S. M. R., Sobhan, A., Vrontis, D., Belyaeva, Z., & Vukovic, D. (2020). Detection of financial fraud risk: implications for financial stability. *Journal of Operational Risk*, *15*(4), 1–13.

Sharma, G., & Arora, A. K. (2016). Study of performance of Indian banks : A camel model approach. *International Journal of Commerce and Management Research*, *2*(6), 14–18.

Sharma, S., & Chopra, I. P. (2018). A Comparative Study of Public and Private Banks in India Using CAMEL Model. *International Journal of Creative Research Thoughts*, *6*(1), 704–717.

Sheela, P. (2015). Asset-Liability-Management – A Comparative Study of a Public and Private Sector Bank. *International Research Journal of Business and Management*, 34–43.

Shivagami, G., & Prasad, T. R. (2016). Impact of Banking Sector Reforms - An Analysis. *Shanlax International Journal of Economics*, *4*(3), 1–8.

Shukla, S. (2014). Analysis of Banking System Performance of Select Global Economies with that of India – During and After the Global Financial. *Procedia Economics and Finance*, *11*, 383–395. https://doi.org/10.1016/s2212-5671(14)00206-8

Singh, Anamika. (2014). A Study of Monetary Policy Impact on Stock Market Returns. *IRJA - Indian Research Journal*, *1*(5), 1–12.

Singh, Anamika, & Sharma, A. K. (2018). Study on liquidity of Indian banks: An empirical analysis of scheduled commercial banks. *International Journal of Business Excellence*, *15*(1), 18–39. https://doi.org/10.1504/IJBEX.2018.091279

Singh, Anurag, & Tandon, P. (2012). Asset - Liabilty Management in Indian Banking Industry. *Asia Pacific Journalof Marketing & Management Review*, *1*(3), 121–132.

Singh, K. (2013). Asset-Liability Management in Banks: A Dynamic Approach. *AIMA Journal of Management & Research*, *7*(2), 1–14.

Singh, R. K. (2018). *Comparative Analysis of Non- Performing Assets of Public Sector Bank Vs Private Sector Bank with Special Reference to Bank of Maharashtra and Yes Bank* [Shri Jagdish Prasad Jhabarmal Tibrewala University]. http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf

Singh, V. R. (2016). A Study of Non-Performing Assets of Commercial Banks and it's recovery in India. *Annual Research Journal of Symbiosis Centre for Management Studies, Pune*, *4*(March), 110–125.

Sinha, R. (2016). A CAMEL Approach Using Financial Accuracy of Public and Private Sector Banks in India. *International Journal of Applied Sciences and Management*, *2*(1), 192–201.

Sopan, J., & Dutta, A. (2018). Determinants of Liquidity Risk in Indian Banks: A Panel Data Analysis. *Asian Journal of Research in Banking and Finance*, *8*(6), 47–59. https://doi.org/10.5958/2249-7323.2018.00043.3

Srdevic, Z., Blagojevic, B., & Srdevic, B. (2011). AHP based group decision making in ranking loan applicants for purchasing irrigation equipment: A case study. *Bulgarian Journal of Agricultural Science*, *17*(4), 531–543.

Srinivasan, & Saminathan, Y. P. (2016). A Camel Model Analysis of Public, Private and Forein Sector Banks in India. *Journal on Banking Financial Services & Insurance Research*, *8*(9), 45–57.

Srinivasan, V., & Kim, Y. H. . (1987). Credit Granting : A Comparative Analysis of Classification Procedures. *The Journal of Finance , 42*(3), 665–681.

Srivastava, A. (2019). The Effectiveness of Prudential Regulations for Banks : Global Perspective and Indian Context. *Prajnan*, *XLVIII*(2), 89–106.

Strischek, D. (2017). Fundamentals of Assessing and Controlling Bank Lending Risk. *The SEACEN Financial Stability Journal*, *8*, 41–54. http://www.seacen.org/products/702003-100419-PDF.pdf

Subramoniam, K. (2015). Basel III Framework on Liquidity Standards: The Challenges Before the Indian Banks on Liquidity Risk Management. *The IUP Journal of Bank Management*, *XIV*(3), 40–54.

Tabar, M. J. . (2013). *Analysis of Decisions Made Using The Analytic Hierarchy Process* (Issue September). Naval Postgraduate School.

Talreja, P. (2014). Policy rate changes and the movement of stock market (With special reference to nifty). *Asian Journal of Management Research*, *5*(1), 91–100.

Tanwar, J., Vaish, A. K., & Rao, N. V. M. (2020). Mathematical Modeling of Asset Liability Management in Banks Using Goal Programming and Ahp. *Indian Journal of Finance and Banking*, *4*(4), 1–19. https://doi.org/10.46281/ijfb.v4i4.899

Tee, E. (2017). Asset Liability Management and the Profitability of Listed Banks in Ghana. *SSRN Electronic Journal*, *8*(3), 9–14. https://doi.org/10.2139/ssrn.2987875

Tektas, A., Nur Ozkan-Gunay, E., & Gunay, G. (2005). Asset and liability management in financial crisis. *Journal of Risk Finance*, *6*(2), 135–149. https://doi.org/10.1108/15265940510585806

The Banking Regulation Act. (1949). In *Reserve Bank of India*. https://rbidocs.rbi.org.in/rdocs/Publications/PDFs/BANKI15122014.pdf

Tran, T.-T. (2019). An Empirical Study by Applying Multi - Criteria Expertise Analytic Hierarchy Process Model in Evaluation. *Advances in Management & Applied Economics*, *9*(2), 51–68.

Tummala, V. M. R., Smith, J. R., & Uppuluri, V. R. R. (1983). Evaulating Commercial Credit Decisions by Analytical Hierarchy Process. *ASCI Journal of Management*, *12*(1 & 2), 48–56.

Tumwine, S., Sejjaaka, S., Bbaale, E., & Kamukama, N. (2018). An empirical analysis of bank specific factors affecting interest rate of Ugandan banking financial institutions. *World Journal of Entrepreneurship, Management and Sustainable Development*, *14*(2), 153–167. https://doi.org/10.1108/WJEMSD-07-2017-0046

Umarani, R., & Jayanthi, M. (2015). An Analysis of Asset-Liability Management in Indian Banks. *International Journal of Business and Administration Research Review*, *1*(11), 179–183. https://doi.org/10.2139/ssrn.1760786

Ursachi, G., Horodnic, I. A., & Zait, A. (2015). How Reliable are Measurement Scales? External Factors with Indirect Influence on Reliability Estimators. *Procedia Economics and Finance*, *20*(15), 679–686. https://doi.org/10.1016/s2212-5671(15)00123-9

Vaidya, P., & Shahi, A. (2005). Asset Liability Management in Indian Banks. In *Asset Liability Management in Banks: Emerging Challenges* (pp. 1–64). Spandan.

Van De Ven-Glastra, M. J., Verberk, J. Q. J. C., Sonke, R., Dominicus, J., & Bindt, A. (2017). Strategic scenario analysis of long-term asset management planning. *Water Practice and Technology*, *12*(1), 48–54. https://doi.org/10.2166/wpt.2017.009

Van Greuning, H., & Brajovic Bratanovic, S. (2009). Analyzing Banking Risk: A framework for assessing corporate governance and finacial risk management. In *Analyzing Banking Risk A framework for assessing corporate governance and finacial risk management* (Third). The World Bank. http://books.google.com/books?id=73CX8O8akZ4C&pgis=1

Vij, M. (2001). Asset Liability Management in Banks and Financial Institutions: A case study of IDBI. *Journal of Management Research*, *1*(1), 111–120. http://www.businessworld.in/article/Asset-Liability-Management-In-Financial-Institutions/04-11-2018-163493/

Vij, M. (2005). Managing Gap: A Case Study Approach to Asset-Liability Management of Banks. *Vision: The Journal of Business Perspective*, *9*(1), 49–58. https://doi.org/10.1177/097226290500900106

Vinh, N. T. H. (2017). The impact of non-performing loans on bank profitability and lending behavior:Evidence from Vietnam. *Journal of Economic Development*, *24*(3), 27–44. https://doi.org/10.24311/jabes/2017.24.3.06

Viswanathan, P. K., & Balasubramanian, G. (2007). Modelling asset allocation for banks- A goal programming approach. *Journal of National Institute of Bank Management-Prajnan*, *XXXVI*(1), 135–145.

Viswanathan, P. K., Ranganatham, M., & Balasubramanian, G. (2014). Modeling asset allocation and liability composition for Indian banks. *Managerial Finance*, *40*(7), 700–723. https://doi.org/10.1108/MF-10-2013-0276

Vodová, P. (2011). Liquidity of Czech commercial banks and its determinants. *International Journal of Mathematical Models and Methods in Applied Sciences*, *5*(6), 1060–1067.

Vodová, P. (2014). Determinants Of Commercial Bank Liquidity In Hungary. *Institute of Financial Research and Analysis*, *9*(3), 64–71.

Vossen, B. van der. (2010). *Bank Liquidity Management*. https://doi.org/10.1007/978-0-230-37048-7_8

Wang, R., & Wang, X. (2015). *What Determines the Profitability of Banks? Evidence From the Us* (Issue Master thesis). SIMON FRASER UNIVERSITY.

Wang, Y. M., & Chin, K. S. (2008). A linear goal programming priority method for fuzzy analytic hierarchy process and its applications in new product screening. *International Journal of Approximate Reasoning*, *49*(2), 451–465. https://doi.org/10.1016/j.ijar.2008.04.004

White, D. J. (1990). A Bibliography on the Applications of Mathematical Programming Multiple-Objective Methods. *The Journal of the Operational Research Society*, *41*(8), 669–691. https://www.jstor.org/stable/2583473

Wichapa, N., & Khokhajaikiat, P. (2017). Solving multi-objective facility location problem using the fuzzy analytical hierarchy process and goal programming: a case study on infectious waste disposal centers. *Operations Research Perspectives*, *4*, 39–48. https://doi.org/10.1016/j.orp.2017.03.002

Williamson, S. D. (1988). Liquidity, Banking, and Bank Failures. *International Economic Review*, *29*(1), 25–43.

Yannick, G. Z. S., Hongzhong, Z., & Thierry, B. (2016). Technical Efficiency Assessment Using Data Envelopment Analysis: An Application to the Banking Sector of Côte D'Ivoire. *Procedia - Social and Behavioral Sciences*, *235*, 198–207. https://doi.org/10.1016/j.sbspro.2016.11.015

Yu, H.-C., Lee, Z.-Y., & Chang, S.-C. (2005). Using a fuzzy multi-criteria decision making approach to evaluate alternative licensing mechanisms. *Information & Management*, *42*, 517–531. https://doi.org/10.1016/j.im.2002.12.001

Yuksel, S. (2017). The causality between returns of interest-based banks and Islamic banks : the case of Turkey. *International Journal of Islamic and Middle Eastern Finance and Management*, *10*(4), 519–535. https://doi.org/10.1108/IMEFM-12-2013-0133

Zahedi, F. (1986). The Analytic Hierarchy Process—A Survey of the Method and its Applications. *Interfaces*, *16*(4), 96–108. https://doi.org/10.1287/inte.16.4.96

Zaloom, V., Tolga, A., & Chu, H. (1986). Bank Fund Management By Goal Programming. *Computers & Industrial Engineering*, *11*(1–4), 132–135. https://doi.org/https://doi.org/10.1016/0360-8352(86)90064-1

Zanakis, S. H., & Gupta, S. K. (1985). A Categorized Bibliographic Survey of Goal Programming. *Omega*, *13*(3), 211–222. https://doi.org/https://doi.org/10.1016/0305-0483(85)90059-3

Zenios, S. A. (1995). Asset/liability management under uncertainty for fixed-income securities. *Annals of Operations Research*, *59*, 77–97.

Zhou, Y., & Zheng, X. (2017). A Study of Commercial Banks Interest Rate Risk Management under Interest Rates Liberalization. *Advances in Economics, Business and Management Research*, *37*, 522–531. https://doi.org/10.2991/ictim-17.2017.70

Ziemba, W. T., & Mulvey, J. M. (1998). *Worldwide Asset and Liability Modeling*. Publications of the Newton Institute.

APPEXDIX TABLE

1. Questionnaire on ALM Practices and Strategies
2. Questionnaire on ALM Using AHP Technique
3. Certificate of Data Collection
4. Respondents' Profile/Characteristics
5. Statement on ALM- Public and Private Bank Response
6. Statement on ALM - Mean and Rank Table of Mann Whitney U Test
7. Statement on ALM- Mann Whitney U Test Results
8. ALCO Functions- Mean and Rank Table of Mann Whitney U Test
9. Risks associated with ALM process- Mean and Rank Table of Mann Whitney U Test
10. Risk Mitigation Techniques- Mean and Rank Table of Mann Whitney U Test
11. Reliability test of Part C- Asset Liability Management
12. Reliability Test for Part D: ALCO functions

1. QUESTIONNAIRE ON ALM PRACTICES AND STRATEGIES

Respondents' characteristics

1. Gender

1. Male
2. Female

2. Which age group are you in?

1. 21-30
2. 31-40
3. 41-50
4. 51-60
5. >60

3. Your highest level of education?

1. Diploma
2. Bachelor's Degree
3. Master's Degree
4. Professional degree
5. Ph.D.

4. Name of the bank : _____

5. Designation : _____

6. Tenure in the bank : _____

Part A: Structure and Resources

Q.1 Does your bank has a separate risk management function?

1. Yes
2. No

Q.2 Does your bank has a Chief Risk Officer?

1. Yes
2. No

Q.3 Does your bank has an independent ALM function?

1. Yes
2. No

Q.4 If there is an independent ALM area, where does that group report to (e.g., Corporate Actuarial, Investment Department, other)?

_____

Q.5 Does your bank has a formal ALM Committee?

1. Yes
2. No

Q.6 Does your bank has a statement of principles and objectives with respect to ALM?

1. Yes
2. No

Q.7 How frequently does the ALM Committee meet?

1. Annually
2. Quarterly
3. Monthly
4. Weekly
5. Ad hoc
6. N/A

Q.8. Indicate the measure that the ALM financial objectives are based on (tick more than one if applicable):

1. Economic value
2. Accounting earnings
3. Other (please specify)

Q.9 Indicate the level at which ALM is performed:

1. For each financial product separately
2. At the divisional level
3. At the total organizational unit level
4. Other

Q.10 What is the significance of ALM in banking sector?

1. To minimize the volatility in interest income and economic values
2. The reason for growing importance of ALM is the rapid innovations taking place in the financial products of bank.
3. It provides a framework for banks to tackle the market risks that may arise due to rate fluctuations and excessive credit risk
4. Recognize the vision of management
5. All the above

Q.11 Which department is responsible for the Asset liability management in your bank?

1. Treasury
2. Finance
3. Risk

Q.12 Which key driver justified the change in strategic asset allocation (choose one only)?

1. Lowering risk
2. Increasing return
3. Matching liabilities
4. Changes in perception of the market
5. Changes caused by variations in market values
6. Availability of new asset classes

Q.13 What other drivers do you consider when changing asset allocation (choose more than one if applicable)?

1. Lowering risk
2. Increasing return
3. Matching liabilities
4. Changes in perception of the market
5. Changes caused by variations in market values
6. Availability of new asset classes

Q.14 What are the basic motive for change in asset allocation strategy in bank (if relevant, please select more than one)?

1. Actuarial valuation to be done for employees' benefit
2. Asset liability matching study
3. Advising consultants or internal staff recommendation
4. It was the Decision based on boards own knowledge and research
5. The change in asset allocation strategy was due to corporate influence

Part B. Asset Liability Management (ALM)

The table below consists of certain statements that describes the Asset Liability Management. On a scale of 1-5, please indicate the degree to which you agree to the statements given below based on your experience. (5=Strongly Agree, 4=Agree, 3= Neither Agree nor Disagree, 2=Disagree, 1=Strongly Disagree).

Statements	**1**	**2**	**3**	**4**	**5**
1.Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet					
2. Asset liability management comprises of managing liquidity risk and market risks in an effective manner					
3. Asset liability management consists of managing maturity gaps and mismatches					
4. Asset liability management involves managing structural , static and dynamic gap					
5.Management of overall liquidity of the bank					
6.Facilitates, coordinates, communicates and control balance sheet risk planning					
7.Ensures bank's risk lies within parameters set by the Board					
8.Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps					

Part C. Asset Liability Committee Function

The table below consists of certain statements related to the Asset Liability Committee Function. On a scale of 1-5, please indicate the degree to which you agree to the statements given below based on your experience. (5=Strongly Agree, 4=Agree, 3= Neither Agree nor Disagree, 2=Disagree, 1=Strongly Disagree)

Statements	**1**	**2**	**3**	**4**	**5**
1.ALCO is responsible for the management of the overall liquidity of the bank					
2. ALCO facilitates, coordinates, communicates and control balance sheet planning with regards to risks inherent in managing liquidity and convergences in interest rates					
3. ALCO is responsible for ensuring that the bank's operational risk lies within the parameters set by its Board of Directors					
4. ALCO regularly undertakes maturity analysis of Assets and Liabilities to identify liquidity gaps					

Part D. Risks associated with ALM process

ALM is the ongoing process of formulating, implementing, monitoring, and revising strategies related to assets and liabilities in an attempt to achieve financial objective for a given set of risk tolerances and constraints.

Within the context of the definition provided above, indicated the risks that are included as part of ALM process.

Risks	Is this a material risk for your bank?	Does your bank have a formal process to manage this risk?	Is this risk considered a part of ALM in your bank?
1. Interest rate risk			
2. Foreign exchange risk			
3. Credit risk			
4.Sovereign risk			
5.Equity market risk			
6. Liquidity risk			
7. Operational risk			
8.. Legal and regulatory risk			
9.Strategic Risk			

Part E: Please specify the Risk Mitigation Practices followed in your bank

A. For Interest rate risk

1. Maturity Gap Analysis Yes No

2. Duration Analysis Yes No

B. For Liquidity Risk

1. Maturity Profile (Liquidity Gap) Yes No

Preparation

2. Liquidity Planning Under Yes No

Alternative Scenarios

C. For Currency Risk

1. Currency Swaps	Yes	No
2. Setting Up of Appropriate		
Limits for Open Position and Gaps	Yes	No

D. For Credit Risk

1. Loan Review Mechanism	Yes	No
2. Usage of credit derivatives	Yes	No

E. For Equity Price Risk

1. Stock/Index Options and	Yes	No
2. Future Contracts	Yes	No

F. For Operational Risk

1. Setting Operational Risk Limits	Yes	No
2. Risk Education	Yes	No

2. QUESTIONNAIRE ON ALM USING AHP TECHNIQUE

The aim of this questionnaire is to make the pair wise comparisons of major criteria and their importance in the process of prioritizing and determining the importance degree of goals using Analytic Hierarchy Process.

This questionnaire is the first step in constructing a model to manage the optimal assets and liabilities in banks using the Analytic Hierarchy Process and Goal programming.

The research will help toward improved evaluation process to arrive at successful management of assets and liabilities in banks.

All data collected from you will be used only for academic research purpose.

Part 1

General Information

Please fill the following information:

- **Place of work**
- **Experience**

  ☐ 1- 4 years ☐ More than 10 years

  ☐ 5 -10 years
- **Education**

  ☐ Bachelors ☐ Doctorate

  ☐ Masters
- **Designation**

Part 2

The numbers from (1 – 9) are used for showing the preference or the importance in the comparison as shown in the following table:

Number Description

Equally important	1
Moderately important	3
Strongly important	5
Very strongly important	7
Extremely important	9
Intermediate values	
Equally to moderately preferred	2
Moderately to strongly preferred	4
Strongly to very strongly preferred	6
Very strongly to extremely preferred	8

1	The criterion (x) is of the same importance of criterion (y)
3	The importance of criterion (x) is 3 times the importance of criterion (y)
5	The importance of criterion (x) is 5 times the importance of criterion (y)
7	The importance of criterion (x) is 7 times the importance of criterion (y)
9	The importance of criterion (x) is 9 times the importance of criterion (y)
2,4,6,8	The importance of criterion (x) is 2, 4, 6, 8 times the importance of criterion (y)

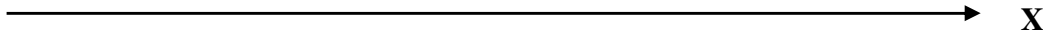
Example:

Goal	Capital adequacy	Liquidity risk	The growth of total assets
Capital adequacy		**3**	**1**
Liquidity risk			**1/5**
The growth of total assets			

3 **Means that the importance of "Capital adequacy" is 3 times the importance of "Liquidity risk"**

1 **Means that the importance of "Capital adequacy" is the same as the importance of "The growth of total assets"**

1/5 **Means that the importance of "The growth of total assets" is 5 times the importance of "Liquidity risk"**



Criteria	Market share of credit	Market share of deposits	Return on assets	Return on equity	Capital adequacy ratio	Liquidity risk	NPA
Market share of credit	1						
Market share of deposits		1					
Return on assets			1				
Return on equity				1			
Capital adequacy ratio					1		
Liquidity risk						1	
Non-Performing Asset							1

3. CERTIFICATE OF DATA COLLECTION

Birla Institute of Technology and Science, Pilani
Pilani Campus
Arun Kumar Vaish, Ph.D.
Assistant Professor
Department of Economics and Finance
Phone No. 01596-515667

4th January 2020

To whom so ever it may concern

This is to certify that Ms. Jyoti Tanwar is pursuing her PhD. under the supervision of Dr. Arun Kumar Vaish, Assistant Professor, Department of Economics & Finance, Birla Institute of Technology & Science – Pilani (Pilani Campus). The topic of her research is "Development of a conceptual model for Optimum Asset and Liability Management for Indian Banking system".
In this regard, she is conducting surveys and interviews for data collection among the top management of a few banks in India. The objective of the research is to study and analyze strategies employed by banks to manage their assets and liabilities while complying with statutory requirements. Moreover, to develop a conceptual model for optimum Asset Liability Management, data is required with respect to bank's investment strategy and profitability goals.
Therefore, I request you to kindly allow her to conduct surveys in your bank to collect data through focus group interviews/ semi-structure/ structured questionnaire. We hereby assure you that data collected will be used for academic purpose only.

Thanking you
Yours' sincerely,

(Arun Kumar Vaish)
Supervisor
(Assistant Professor)
PH – 01596 515667 (landline), +91-9314915550 (mobile)
Email: akvaish@pilani.bits-pilani.ac.in

4. RESPONSENTS' PROFILE

Gender

	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
Male	176	66.7	66.7	66.7
Female	88	33.3	33.3	100.0
Total	264	100	100	

Age of the respondents

	FREQUENCY	PERCENT	CUMULATIVE PERCENT
21-30	22	8.3	8.3
31-40	139	52.7	61
41-50	81	30.7	91.7
51-60	22	8.3	100
Total	264	100	

Education of the respondents

	FREQUENCY	PERCENTAGE	CUMULATIVE PERCENTAGE
Master's degree	176	66.7	66.7
Professional degree	88	33.3	100
Total	264	100	

Public or private bank

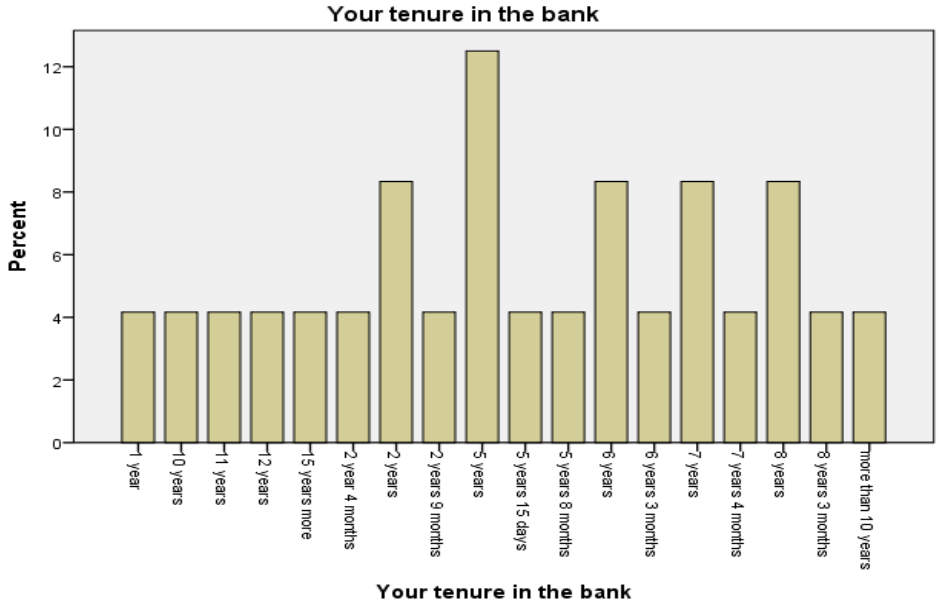
	FREQUENCY	PERCENT	CUMULATIVE PERCENT
Public	12	50	50
Private	12	50	100
Total	24	100	

Designation of respondents

The data for the study was collected from various top managerial level employees. The analysis depicted that the maximum respondents were the assistant general manager and assistant vice presidents with 12.5% each and the rest of the respondents like the manager, chief manager, branch manager, etc., are at 4.2% each. Respondents holding position of chief manager, senior trader, regional manager are 8.3% each in the survey.

Tenure in the bank

In the current study, 12.5% of the respondents had the tenure of 5 years at their respective banks. Then the respondents with tenure of 1, 7, 10, 11, 12 and 15 years, etc. years in respective banks are 4.2% each. Figure 11 shows that respondents have different tenure period in banks.



5. SIGNIFICANCE OF ALM: PUBLIC AND PRIVATE SECTOR BANKS' RESPONSES

Significance of ALM			Bank	
			Public	Private
Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet	Neutral	Count	21	25
		Table N %	8.0%	9.5%
	Agree	Count	60	67
		Table N %	22.7%	25.4%
	Strongly Agree	Count	51	40
		Table N %	19.3%	15.2%
Asset liability management comprises of managing liquidity risk and market risks in an effective manner	Neutral	Count	27	30
		Table N %	10.2%	11.4%
	Agree	Count	57	55
		Table N %	21.6%	20.8%
	Strongly Agree	Count	48	47
		Table N %	18.2%	17.8%
Asset liability management consists of managing maturity gaps and mismatches	Neutral	Count	27	30
		Table N %	10.2%	11.4%
	Agree	Count	59	54
		Table N %	22.3%	20.5%
	Strongly Agree	Count	46	48
		Table N %	17.4%	18.2%
Asset liability management involves managing structural, static and dynamic gap	Neutral	Count	22	24
		Table N %	8.3%	9.1%
	Agree	Count	58	57
		Table N %	22.0%	21.6%
	Strongly Agree	Count	52	51
		Table N %	19.7%	19.3%
Management of overall liquidity of the bank	Neutral	Count	10	19
		Table N %	3.8%	7.2%
	Agree	Count	46	41
		Table N %	17.4%	15.5%
	Strongly Agree	Count	76	72
		Table N %	28.8%	27.3%

Significance of ALM			Bank	
			Public	Private
Facilitates, coordinates, communicates and control balance sheet risk planning	Neutral	Count	20	24
		Table N %	7.6%	9.1%
	Agree	Count	56	53
		Table N %	21.2%	20.1%
	Strongly Agree	Count	56	55
		Table N %	21.2%	20.8%
Ensures bank's risk lies within parameters set by the Board	Neutral	Count	24	26
		Table N %	9.1%	9.8%
	Agree	Count	56	62
		Table N %	21.2%	23.5%
	Strongly Agree	Count	52	44
		Table N %	19.7%	16.7%
Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps	Neutral	Count	15	27
		Table N %	5.7%	10.2%
	Agree	Count	46	55
		Table N %	17.4%	20.8%
	Strongly Agree	Count	71	50
		Table N %	26.9%	18.9%

6. SIGNIFICANCE ON ALM - MEAN AND RANK TABLE OF MANN WHITNEY U TEST

	Bank	N	Mean Rank	Sum of Ranks
1 Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet	Public	132	138.35	18262.50
	Private	132	126.65	16717.50
	Total	264		
2 Asset liability management comprises of managing liquidity risk and market risks in an effective manner	Public	132	133.85	17668.50
	Private	132	131.15	17311.50
	Total	264		
3 Asset liability management consists of managing maturity gaps and mismatches	Public	132	132.68	17514.00
	Private	132	132.32	17466.00
	Total	264		
4 Asset liability management involves managing structural, static and dynamic gap	Public	132	133.52	17625.00
	Private	132	131.48	17355.00
	Total	264		
5 Management of overall liquidity of the bank	Public	132	136.26	17986.00
	Private	132	128.74	16994.00
	Total	264		
6 Facilitates, coordinates, communicates and control balance sheet risk planning	Public	132	134.08	17698.00
	Private	132	130.92	17282.00
	Total	264		
7 Ensures bank's risk lies within parameters set by the Board	Public	132	136.38	18002.00
	Private	132	128.62	16978.00
	Total	264		
8 Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps	Public	132	144.58	19084.50
	Private	132	120.42	15895.50
	Total	264		

7. SIGNIFICANCE OF ALM- MANN WHITNEY U TEST RESULTS

	Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet	Asset liability management comprises of managing liquidity risk and market risks in an effective manner	Asset liability management consists of managing maturity gaps and mismatches	Asset liability management involves managing structural, static and dynamic gap	Management of overall liquidity of the bank	Facilitate, coordinates, communicates and control balance sheet risk planning	Ensures bank's risk lies within parameters set by the Board	Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps
Mann-Whitney U	7939.500	8533.500	8688.000	8577.000	8216.000	8504.000	8200.000	7117.500
Wilcoxon W	16717.500	17311.500	17466.000	17355.000	16994.000	17282.000	16978.000	15895.500
Z	-1.357	-.309	-.042	-.236	-.902	-.364	-.892	-2.798
Asymp. Sig. (2-tailed)	.175	.757	.967	.814	.367	.716	.372	.005

8. ALCO FUNCTIONS- MEAN AND RANK TABLE OF MANN WHITNEY U TEST

	BANK	N	MEAN RANK	SUM OF RANKS
1. ALCO is responsible for the management of the overall liquidity of the bank	Public	132	137.81	18191.50
	Private	132	127.19	16788.50
	Total	264		
2. ALCO facilitates, coordinates, communicates and control balance sheet planning with regards to risks inherent in managing liquidity and convergences in interest rates	Public	132	138.01	18217.50
	Private	132	126.99	16762.50
	Total	264		
3. ALCO is responsible for ensuring that the bank's operational risk lies within the parameters set by its Board of Directors	Public	132	136.55	18024.00
	Private	132	128.45	16956.00
	Total	264		
4. ALCO regularly undertakes maturity analysis of Assets and Liabilities to identify liquidity gaps	Public	132	138.12	18231.50
	Private	132	126.88	16748.50
	Total	264		

9. RISKS ASSOCIATED WITH ALM PROCESS- MEAN AND RANK TABLE OF MANN WHITNEY U TEST

Ranks				
	Bank	N	Mean Rank	Sum of Ranks
1. Interest rate risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
2. Foreign exchange risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
3. Credit risk	Public	132	127.00	16764.00
	Private	132	138.00	18216.00
	Total	264		
4. Counterparty credit risk	Public	132	127.00	16764.00
	Private	132	138.00	18216.00
	Total	264		
5.Sovereign risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
6.Equity market risk	Public	132	128.50	16962.00
	Private	132	136.50	18018.00
	Total	264		
7. Liquidity risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
8. Operational risk	Public	132	143.50	18942.00
	Private	132	121.50	16038.00
	Total	264		
9.. Legal and regulatory risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
10.Strategic Risk	Public	132	127.00	16764.00
	Private	132	138.00	18216.00
	Total	264		

10. RISK MITIGATION TECHNIQUES- MEAN AND RANK TABLE OF MANN WHITNEY U TEST

	BANK	N	MEAN RANK	SUM OF RANKS
A. For Interest rate risk	Public	132	127.00	16764.00
	Private	132	138.00	18216.00
	Total	264		
B. For Liquidity Risk	Public	132	132.50	17490.00
	Private	132	132.50	17490.00
	Total	264		
C. For Currency Risk	Public	132	117.83	15554.00
	Private	132	147.17	19426.00
	Total	264		
D. For Credit Risk	Public	132	121.50	16038.00
	Private	132	143.50	18942.00
	Total	264		
E. For operational Risk	Public	132	121.50	16038.00
	Private	132	143.50	18942.00
	Total	264		

11. RELIABILITY TEST OF PART B- ASSET LIABILITY MANAGEMENT

Reliability Statistics	
Cronbach's Alpha	N of Items
.790	8

Cronbach's Alpha is *above* 0.7 which means *reliable data*

The table above gives the overall reliability of Part C where the Cronbach alpha value is 0.790 indicating that data is reliable for the analysis. Furthermore, it indicates *high* level of internal consistency with respect to the variables for decision making.

	Cronbach's Alpha if Item Deleted
Asset liability management comprises of managing effectively both the assets and liabilities sides of the bank balance sheet	.779
Asset liability management comprises of managing liquidity risk and market risks in an effective manner	.773
Asset liability management consists of managing maturity gaps and mismatches	.761
Asset liability management involves managing structural, static and dynamic gap	.761
Management of overall liquidity of the bank	.753
Facilitates, coordinates, communicates and control balance sheet risk planning	.756
Ensures bank's risk lies within parameters set by the Board	.779
Undertakes regular maturity analysis of assets and liabilities to identify liquidity gaps	.772

12. RELIABILITY TEST FOR PART C: ALCO FUNCTIONS

Reliability Statistics	
Cronbach's Alpha	N of Items
.701	4

Cronbach's Alpha is *above* 0.7 which means *reliable data*

The table above gives the overall reliability of Part E where the Cronbach alpha value is 0.701 indicating that data is reliable for the analysis. Furthermore, it indicates *high* level of internal consistency with respect to the variables for decision making.

	Cronbach's Alpha if Item Deleted
ALCO is responsible for the management of the overall liquidity of the bank	.646
ALCO facilitates, coordinates, communicates and control balance sheet planning with regards to risks inherent in managing liquidity and convergences in interest rates	.564
ALCO is responsible for ensuring that the bank's operational risk lies within the parameters set by its Board of Directors	.730
ALCO regularly undertakes maturity analysis of Assets and Liabilities to identify liquidity gaps	.596

Journal Papers

- Tanwar, J., Vaish, A. K., & Rao, N. V. M. (2020). Comparative Analysis of Employees' Perspective on Asset-Liability Management in Banks. Indian Journal of Finance and Banking, 9(1), 47-64. https://doi.org/10.46281/ijfb.v9i1.1552

- Tanwar, J., Vaish, A. K., & Rao, N. (2021). Optimizing Balance Sheet for Banks in India Using Goal Programming. *International Journal of Accounting & Finance Review*, *6*(2), 81-101. https://doi.org/10.46281/ijafr.v6i2.1082 (ABDC-C indexing, ISSN - 2576-1285, ISSN Online - 2576-1293)

- Tanwar, J., Vaish, A. K., & Rao, N. V. M. (2020). Mathematical Modeling of Asset Liability Management in Banks Using Goal Programming and Ahp. *Indian Journal of Finance and Banking*, *4*(4), 1-19. https://doi.org/10.46281/ijfb.v4i4.899 (ABDC-C indexing, ISSN - 2574-6081, ISSN Online - 2574-609X)

- Tanwar, J., Seth, H., Vaish, A. K., & Rao, N. V. M. (2020). Revisiting the Efficiency of Indian Banking Sector: An Analysis of Comparative Models Through Data Envelopment Analysis. *Indian Journal of Finance and Banking*, *4*(1), 92–108. https://doi.org/10.46281/ijfb.v4i1.585 (ABDC-C indexing, ISSN - 2574-6081, ISSN Online - 2574-609X).

- Tanwar, J., Vaish, A. K., & Rao, N. V. M. (2018). Contribution of Corporate Social Responsibility Towards India in Achieving Inclusive Growth. *IASSI Quarterly: Contributions to Indian Social Science*, *37*(3 & 4), 509–521. (UGC CARE LISTED)

Conferences

- Participated and presented research paper 'Revisiting the Efficiency of Indian Banking Sector: An Analysis of Comparative Models Through Data Envelopment Analysis' in International Conference on Measurement of Efficiency and Productivity in Emerging Economies held during December 18-19, 2019, at Faculty of Economics, South Asian University.
- Participated in ICBESD 2018 conference held on 22-23 February 2018 and presented paper titled 'Sustainable Development- NGO Intervention in Corporate Social Responsibility**'.**
- Participated in 18th IASSI conference held on 3-5 December 2017 in Guntur and presented paper 'Contribution of Corporate Social Responsibility towards India in achieving Inclusive Growth'

Brief Biography of Candidate

Jyoti Tanwar is a senior research scholar in the Department of Economics and Finance, Birla Institute of Technology & Science, Pilani - Pilani Campus. She has published five research papers during her PhD and participated in two International and 1 National Conference. She was also awarded with Best Paper Award under Research Scholar category by ICBESD 2018. She qualified NET and JRF in 2016 in Commerce. During Ph.D., she also acted as teaching assistant for subjects such as Derivate and Risk Management, Financial Risk and Management, Financial Accounting, and Principles of Economics. She also pursued Chartered Accountants from Institute of Chartered Accountants of India. She has completed her graduation from Shaheed Bhagat Singh College - Delhi University in 2009 and completed her Master's in Business Administration – International Business from ICFAI University in 2013. Before joining Ph.D., she worked with RNB Global University as Assistant Professor where she taught undergraduate and graduate students. She took teaching courses such as Banking Theory and Practice, Cost Accounting and Management, Financial Accounting, Corporate Accounting, Entrepreneurship, and Corporate Governance and Ethics. She also worked in various Chartered Accountants firm as Audit Assistant and Senior Audit Assistant for seven years where she performed statutory audit, internal audits, concurrent audits for various banks and companies. Currently, she is working as Senior Financial Planning and Analyst in a Biotech company named 'Stemexpress'.

Brief Biography of Supervisor

Dr. Arun Kumar Vaish is Assistant Professor (Finance) at Birla Institute of Technology & Science, Pilani - Pilani Campus. He completed his B.E. (Hons.) in 1989 from BITS Pilani. Out of his total experience of 30 years, he has served more than 13 years in banking in various domains like credit, retail, branch banking, corresponding banking, capital market, and treasury. During his tenure as rural branch manager, he has managed to reduce non-performing asset of the branch drastically and his efforts towards micro-credit, especially government sponsored schemes, was recognized by administrative authorities. Since 2006, he is teaching at BITS Pilani. His research interest areas are micro-finance, credit risk, structure finance, financial engineering, and Asset Liability Management. He has delivered several guest lectures and conducted MDPs. He worked on consultancy project on financial inclusion and involved with Government of India on study of implementation of National Good Security Act 2013. He has published more than thirteen research papers and participated in various conferences. He is also working with Technology Business Incubator at BITS Pilani and started a company named FinQuant that supports incubation.