A LINEAR PROGRAMMING MODEL FOR ASSESSING ASSET-LIABILITY MANAGEMENT IN BANKS

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INTRODUCTION:

Bank asset-liability management (ALM) may be defined as the simultaneous planning of all asset and liability positions on the bank's balance sheet under consideration of the different bank management objectives and legal, managerial and market constraints, for the purpose of enhancing the value of the bank, providing liquidity, and mitigating interest rate risk (Gup and Brooks, 1993). An efficient asset-liability management system aims to manage the volume, mix, maturity, rate sensitivity, quality and liquidity of the assets and liabilities as a whole, so as to earn a predetermined, acceptable risk/reward ratio.

The framework of asset-liability management broadly covers area of interest rate risk, liquidity risk, exchange risk and credit risk. ALM can be defined as an operation for assessing the above mentioned risks, actively altering the asset-liability portfolio, and for strategically taking actions and managing risks with the objective of maximizing profits. ALM is not limited to on balance sheet assets and liabilities such as deposits and lending's only, but also includes off-balance sheet activities such as swaps, futures and options. The objective of ALM is to make banks fully prepared to face the emerging challenges.

The present study proposes a linear programming model for asset-liability management, with profitability as the objective, and constraints based on liquidity and statutory requirements. The model was applied to a sample of banks operating in India, resulting in a recommended optimal asset-liability mix of the banks in the sample. Using these results, the study assessed the nature of asset-liability management of different bank groups, in terms of its implications on profitability, liquidity, and interest rate sensitivity.

LITERATURE REVIEW:

There is a considerable literature addressing asset-liability management in banks. One of the key motivators of asset-liability management worldwide was the Basel Committee. The Basel Committee on Banking Supervision (2001) formulated broad supervisory standards and guidelines and recommended statements of best practice in banking supervision. The purpose of the committee was to encourage global convergence toward common approaches and standards. In particular, the Basel II norms (2004) were proposed as an international standard for the amount of capital that banks need to set aside to guard against the types financial and operational risks they face. Basel II proposed setting up rigorous risk and capital management requirements designed to ensure that a bank holds capital reserves appropriate to the risk the bank exposes itself to through its lending and investment practices. Generally speaking, these rules mean that the greater risk to which the bank is exposed, the greater the amount of capital the bank needs to hold to safeguard its solvency and overall economic stability. This would ultimately help protect the international financial system from the types of problems that might arise should a major bank or a series of banks collapse.

Gardner and Mills (1991) discussed the principles of asset-liability management as a part of banks' strategic planning and as a response to the changing environment in prudential

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supervision, e-commerce and new taxation treaties. Their text provided the foundation of subsequent discussion on asset-liability management.

Haslem et al (1999) used canonical analysis and the interpretive framework of asset/liability management in order to identify and interpret the foreign and domestic balance sheet strategies of large U.S. banks in the context of the "crisis in lending to LDCs." Their study found that the least profitable very large banks have the largest proportions of foreign loans, yet they emphasize domestic balance sheet (asset/liability) matching strategies. Conversely, the most profitable very large banks have the smallest proportions of foreign loans, but, nonetheless, they emphasize foreign balance sheet matching strategies.

Vaidyanathan (1999) discussed issues in asset-liability management and elaborates on various categories of risk that require to be managed in the Indian context. In the past Indian banks were primarily concerned about adhering to statutory liquidity ratio norms; but in the changed situation, namely moving away from administered interest rate structure to market determined rates, it became important for banks to equip themselves with some of these techniques, in order to immunize themselves against interest rate risk. Vaidyanathan argues that the problem gets accentuated in the context of change in the main liability structure of the banks, namely the maturity period for term deposits. For instance, in 1986, nearly 50% of term deposits had a maturity period of more than five years and only 20%, less than two years for all commercial banks, while in 1992, only 17% of term deposits were more than five years whereas 38% were less than two years (Vaidyanathan, 1995). He found that several banks had inadequate and inefficient management systems. Also, he argued that Indian banks were more exposed to international markets, especially with respect to FOREX transactions, so that asset-liability management was essential, as it would enable the bank to maintain its exposure to foreign currency fluctuations given the level of risk it can handle. He also found that an increasing proportion of investments by banks was being recorded on a marked-to-market basis, thus being exposed to market risks. He also suggested that, as bank profitability focus has increased over the years, there is an increasing possibility that the risk arising out of exposure to interest rate volatility would be built into the capital adequacy norms specified by the regulatory authorities, thus in turn requiring efficient asset-liability management practices.

Vaidya and Shahi (2001) studied asset-liability management in Indian banks. They suggested in particular that interest rate risk and liquidity risk are two key inputs in business planning process of banks.

Ranjan and Nallari (2004) used canonical analysis to examine asset-liability management in Indian banks in the period 1992-2004. They found that SBI and associates had the best asset-liability management in the period 1992-2004. They also found that, other than foreign banks, all other banks could be said to be liability-managed; i.e. they all borrowed from the money market to meet their maturing obligations. Private sector banks were found to be aggressive in profit generation, while nationalized banks were found to be excessively concerned about liquidity.

There have been several applications of mathematical models in the field of bank management. The deterministic linear programming model of Chambers and Charnes (1961) was the first of its kind in ALM. Cohen and Hammer (1967), Robertson (1972) have realized successful applications of Chambers and Charnes' model. Even though these models have differed in their treatment of disaggregation, uncertainty and dynamic considerations, they all have in common the fact that they are specified to optimize a single objective profit function subject to the relevant linear constraints.

Giokas and Vassiloglou (1991) developed a goal-programming model for bank asset and liability management. They supported the idea that apart from attempting to maximize revenues, management tries to minimize risks involved in the allocation of the bank's capital,

as well as to fulfill other goals of the bank, such as retaining its market share, increasing the size of its deposits and loans, etc.

Apart from the deterministic models, several stochastic models have been proposed since the 1970s. These models, including the use of chance-constrained programming (Charnes and Thore, 1966; Charnes and Littlechild, 1968; Pogue and Bussard, 1972), dynamic programming (Samuelson, 1969; Merton, 1969,1990; Eppen and Fama, 1971), sequential decision theory (Wolf, 1969; Bradley and Crane, 1972) and stochastic linear programming under uncertainty (Cohen and Thore, 1970; Booth, 1972; Crane, 1971; Kallberg et al. 1982), presented computational difficulties.

An alternative approach in considering stochastic models is the stochastic linear programming with simple recourse. Kusy and Ziemba (1986) employed a multi-period stochastic linear program with simple recourse to model the management of assets and liabilities in banking while maintaining computational feasibility. Their results indicate that the proposed ALM model is theoretically and operationally superior to a corresponding deterministic linear programming model and that the computational effort required for its implementation is comparable to that of the deterministic model. Another application of the multistage stochastic programming is the Russell-Yasuda Kasai model (Carino et al., 1994), which aims at maximizing the long term wealth of the firm while producing high income returns.

The present study analyses asset-liability management in Indian banks using a linear programming model developed according to the asset-liability guidelines provided by the Reserve Bank of India. The study covers all scheduled commercial banks except regional rural banks (RRBs), for the year 2007-08. The banks are grouped on the basis of ownership structure: viz. public sector banks (including SBI & associates), private sector banks, and foreign banks.

MODEL DEVELOPMENT:

THE DECISION VARIABLES

The decision variables used in the model were the assets and liabilities of the banks, classified into the following time periods/buckets, based on the guidelines given by the Reserve Bank of India, constrained by the totals as obtained from the balance sheets of the banks: bucket 1 (1 - 14 days); bucket 2 (15 - 30 days); bucket 3 (1 - 3 months); bucket 4 (3-6 months); bucket 5 (6 months - 1 year); bucket 6 (1 - 3 years); bucket 7 (3 - 5 years); and bucket 8 (5+ years).

The variables used in the specification of the model were based on the assets and liability categories reported by banks in their balance sheets, for each time bucket (i = 1 to 8), including: DD_i (demand deposits in the i^{th} bucket), SD_i (savings deposits in the i^{th} bucket), TD_i (term deposits in the i^{th} bucket), B_i (borrowings in the i^{th} bucket), OLP_i (other liabilities & provisions in the i^{th} bucket), $CBRBI_i$ (cash balances with RBI in the i^{th} bucket), BOB_i (balances with other banks in the i^{th} bucket), GS_i (investment in government securities in the i^{th} bucket), DB_i (investment in debentures & bonds in the i^{th} bucket), E_i (investment in equity shares in the i^{th} bucket), OI_i (other investments in the i^{th} bucket), and A_i (advances in the i^{th} bucket). In all, ninety-six variables were used, of which fifty-six corresponded to assets and forty to liabilities, as detailed above.

THE OBJECTIVE FUNCTION

The objective function for the model was the net operating profit, expressed as the total revenue from assets (balances with RBI, balances with other banks, investments, and

advances) less the total cost of funds (deposits and borrowings). The expected rates of return and the expected costs of funds of different assets and liabilities were estimated based on historical data, and are shown in the tables below.

EXPECTED COSTS OF FUNDS

	demand deposits	savings deposits	term deposits	borrowings
upto 14 days	0.00%	3.50%	3.50%	3.50%
upto 30 days	0.00%	3.50%	4.25%	3.50%
upto 3 months	0.00%	3.50%	5.75%	5.50%
upto 6 months	0.00%	3.50%	6.25%	5.50%
upto 1 year	0.00%	3.50%	8.50%	5.50%
upto three years	0.00%	3.50%	8.75%	8.50%
upto five years	0.00%	3.50%	9.50%	9.00%
overall	0.00%	3.50%	10.00%	9.50%

EXPECTED RATES OF RETURN

	RBI rates	bank rates	government securities	debt securities	equity securities	other investments	advances
upto 14 days	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	5.00%
upto 30 days	3.50%	4.25%	3.50%	3.50%	3.50%	3.50%	5.00%
upto 3 months	5.50%	5.75%	5.50%	5.50%	5.50%	5.50%	6.50%
upto 6 months	5.50%	6.25%	5.50%	5.50%	5.50%	5.50%	6.50%
upto 1 year	5.50%	8.50%	5.50%	5.50%	5.50%	5.50%	8.00%
upto three years	6.00%	8.75%	8.50%	8.50%	8.50%	8.50%	9.00%
upto five years	6.50%	9.50%	9.00%	9.00%	9.00%	9.00%	9.50%
overall	7.00%	10.00%	9.50%	9.50%	9.50%	9.50%	10.00%

THE CONSTRAINTS

Liquidity constraints (as per RBI guidelines):

Certain short-term liquidity constraints are imposed by the Reserve Bank India guidelines on particular categories of accounts.

For example, savings deposits and current/demand deposits may be classified into volatile and core portions, with 10% of savings deposits and 15% of current deposits generally treated as withdrawable on demand. This portion may be treated as volatile, and is placed in the day 1, 2-7 days and 8-14 days time buckets, depending upon the experience and estimates of banks, while the core portion is placed in over 1- 3 years bucket. This is modeled by the following constraints: $SD_1 = 0.1 * SD$ and $DD_1 = 0.15 * DD$.

Similarly, the following constraints regarding cash are based on the guidelines that the cash should be placed in the 'Day 1' bucket. While the excess balance over the required CRR/SLR (assuming CRR = 5% & SLR = 24%) may be shown under the 'Day 1' bucket, the statutory balances may be distributed amongst various time buckets corresponding to the maturity profile of DTL with a time-lag of 14 days. The non-withdrawable portion on account of stipulations of minimum balances may be shown under 'Over 1-3 years' bucket and the remaining balances may be shown under 'Day 1' bucket. Finally, money at call and short notice, term deposits and other placements should be placed in respective maturity buckets. The corresponding constraints are: $CBRBI_1 \geq CBH/O$ (cash balances in hand or others), $CBRBI_8 \geq 0.05 * CBRBI$, and $BOB_1 \geq 0.05 BB \& MC$ (balances with other banks and money at call).

Demand-based constraints:

Certain constraints are suggested by the Reserve Bank India guidelines on particular categories of accounts to reflect demand patterns for the corresponding assets/liabilities.

For example, the following constraints regarding term deposits are based on the guidelines that banks which are better equipped to estimate the behavioural pattern, roll-in and roll-out, embedded options, etc. on the basis of past data/empirical studies could classify the retail deposits in the appropriate buckets on the basis of behavioural maturity rather than residual maturity: $\sum_{i=1}^{4} TD_i \geq O.5 * TD$, $TD_1 \geq 0.05 * TD$, $TD_2 \geq 0.05 * TD$, $TD_3 \geq 0.05 * TD$, $TD_4 \geq 0.05 * TD$, $TD_5 \geq 0.05 * TD$, $TD_6 \geq 0.05 * TD$, $TD_7 \geq 0.05 * TD$, and $TD_8 \geq 0.05 * TD$.

Similarly, the following constraints are imposed relating to demand patterns for borrowings: $B_1 \geq 0.85 * B$, $B_6 \geq 0.05 * B$, $B_7 \geq 0.05 * B$, and $B_8 \geq 0.05 * B$.

The following constraints regarding other liabilities and provisions are based on the guidelines that the core component which could reasonably be estimated on the basis of past data and behavioural pattern may be shown in the 'Over 1-3 years' time bucket. The balance amount may be placed in Day 1, 2-7 days and 8-14 days buckets, as per behavioural pattern. Also, provisions should be placed in respective buckets depending on the purpose. Thus, $OLP_1 \geq 0.75 * OLP$ (excluding provisions), $OLP_2 \geq 0.25 * OLP$ (excluding provisions), $OLP_3 \geq 0.05 * OLP$, $OLP_4 \geq 0.05 * OLP$, $OLP_5 \geq 0.05 * OLP$, $OLP_6 \geq 0.05 * OLP$, $OLP_7 \geq 0.05 * OLP$, and $OLP_8 \geq 0.05 * OLP$.

Similarly, the following constraints regarding advances are based on the guidelines that the banks should undertake a study of behavioural and seasonal pattern of availments based on outstandings and the core and volatile portion should be identified. While the volatile portion could be shown in the near-term maturity buckets, the core portion may be shown in the 'Over 1-3 years' bucket, giving the constraints $A_1 \geq 0.05 * A$, $A_2 \geq 0.05 * A$, $A_3 \geq 0.05 * A$, $A_4 \geq 0.05 * A$, and $A_5 \geq 0.05 * A$.

Illiquidity constraints (as per RBI guidelines):

Certain long-term illiquidity constraints are imposed by the Reserve Bank India guidelines on particular categories of accounts.

As discussed before for savings deposits and current/demand deposits, $SD_6 = 0.9 * SD$, and $DD_6 = 0.85 * DD$.

The following constraints regarding approved government securities, corporate debentures and bonds, PSU bonds, CDs and CPs, and redeemable preference shares are based on the guidelines that the cash should be placed in respective maturity buckets. Investments classified as NPIs should be shown under 'Over 3-5 years' bucket (sub-standard) or 'Over 5 years' bucket (doubtful). The corresponding constraints are: $GS_8 \geq 0.5 * GS$, $DB_8 \geq 0.5 * DB$, and $OI_8 \geq 0.5 * (GS + Units + Subsdiaries / JV + OI)$.

Similarly, the following constraints regarding listed shares (except strategic investments) are based on the guidelines that the cash should be placed in the '2-7days' bucket, with a haircut of 50%, and other shares fall in the 'Over 5 years' bucket; i.e. $E_8 \geq E$ (equity shares).

Statutory liquidity ratio (SLR) constraint:

This constraint reflects the Reserve Bank of India guideline that investment in approved securities should be placed in respective maturity buckets, excluding the amount required to be

reinvested to maintain SLR corresponding to the DTL profile in various time buckets. The constraint is expressed as follows: $-0.24\sum_{i=1}^{8} DD_i - 0.24\sum_{i=1}^{8} SD_i - 0.24\sum_{i=1}^{8} TD_i + \sum_{i=1}^{8} GS_i \geq 0$.

Aggregation constraints:

These constraints reflect aggregation of the subcomponents of assets and liabilities:

$$\sum_{i=1}^{8} SD_i = SD,\ \sum_{i=1}^{8} DD_i = DD,\ \sum_{i=1}^{8} TD_i = TD,\ \sum_{i=1}^{8} B_i = B,\ \sum_{i=1}^{8} OLP_i = OLP,$$

$$\sum_{i=1}^{8} GS_i = GS,\ \sum_{i=1}^{8} DB_i = DB,\ \sum_{i=1}^{8} E_i = E,\ \sum_{i=1}^{8} OI_i = (GS + Units + Subsdiaries / JV + OI),$$

$$\sum_{i=1}^{8} CBRBI_i = CBRBI,\ \sum_{i=1}^{8} BOB_i = BOB,\ \sum_{i=1}^{8} A_i = A.$$

Asset-Liability matching constraints:

These constraints reflect the asset-liability matching conditions, cumulatively for the different time periods.

The cumulative net inflow/outflow for the '1 -14 days' time bucket:

$$-DD_1 - SD_1 - TD_1 - B_1 - OLP_1 + CBRBI_1 + BOB_1 + GS_1 + DB_1 + E_1 + OI_1 + A_1 \geq 0$$

The cumulative net inflow/outflow for the 'Upto 30 days' time bucket:

$$-\sum_{i=1}^{2} DD_i - \sum_{i=1}^{2} SD_i - \sum_{i=1}^{2} TD_i - \sum_{i=1}^{2} B_i - \sum_{i=1}^{2} OLP_i + \sum_{i=1}^{2} CBRBI_i + \sum_{i=1}^{2} BOB_i + \sum_{i=1}^{2} GS_i$$
$$+\sum_{i=1}^{2} DB_i + \sum_{i=1}^{2} E_i + \sum_{i=1}^{2} OI_i + \sum_{i=1}^{2} A_i \geq 0$$

The cumulative net inflow/outflow for the 'Upto 3 months' time bucket:

$$-\sum_{i=1}^{3} DD_i - \sum_{i=1}^{3} SD_i - \sum_{i=1}^{3} TD_i - \sum_{i=1}^{3} B_i - \sum_{i=1}^{3} OLP_i + \sum_{i=1}^{3} CBRBI_i + \sum_{i=1}^{3} BOB_i + \sum_{i=1}^{3} GS_i$$
$$+\sum_{i=1}^{3} DB_i + \sum_{i=1}^{3} E_i + \sum_{i=1}^{3} OI_i + \sum_{i=1}^{3} A_i \geq 0$$

The cumulative net inflow/outflow for the 'Upto 6 months' time bucket:

$$-\sum_{i=1}^{4} DD_i - \sum_{i=1}^{4} SD_i - \sum_{i=1}^{4} TD_i - \sum_{i=1}^{4} B_i - \sum_{i=1}^{4} OLP_i + \sum_{i=1}^{4} CBRBI_i + \sum_{i=1}^{4} BOB_i + \sum_{i=1}^{4} GS_i$$
$$+\sum_{i=1}^{4} DB_i + \sum_{i=1}^{4} E_i + \sum_{i=1}^{4} OI_i + \sum_{i=1}^{4} A_i \geq 0$$

The cumulative net inflow/outflow for the 'Upto 1 year' time bucket:

$$-\sum_{i=1}^{5} DD_i - \sum_{i=1}^{5} SD_i - \sum_{i=1}^{5} TD_i - \sum_{i=1}^{5} B_i - \sum_{i=1}^{5} OLP_i + \sum_{i=1}^{5} CBRBI_i + \sum_{i=1}^{5} BOB_i + \sum_{i=1}^{5} GS_i$$
$$+\sum_{i=1}^{5} DB_i + \sum_{i=1}^{5} E_i + \sum_{i=1}^{5} OI_i + \sum_{i=1}^{5} A_i \geq 0$$

The cumulative net inflow/outflow for the 'Upto 3 years' time bucket:

$$-\sum_{i=1}^{6} DD_i - \sum_{i=1}^{6} SD_i - \sum_{i=1}^{6} TD_i - \sum_{i=1}^{6} B_i - \sum_{i=1}^{6} OLP_i + \sum_{i=1}^{6} CBRBI_i + \sum_{i=1}^{6} BOB_i + \sum_{i=1}^{6} GS_i$$
$$+\sum_{i=1}^{6} DB_i + \sum_{i=1}^{6} E_i + \sum_{i=1}^{6} OI_i + \sum_{i=1}^{6} A_i \geq 0$$

The cumulative net inflow/outflow for the 'Upto 5 years' time bucket:

$$-\sum_{i=1}^{7} DD_i - \sum_{i=1}^{7} SD_i - \sum_{i=1}^{7} TD_i - \sum_{i=1}^{7} B_i - \sum_{i=1}^{7} OLP_i + \sum_{i=1}^{7} CBRBI_i + \sum_{i=1}^{7} BOB_i + \sum_{i=1}^{7} GS_i$$
$$+\sum_{i=1}^{7} DB_i + \sum_{i=1}^{7} E_i + \sum_{i=1}^{7} OI_i + \sum_{i=1}^{7} A_i \geq 0$$

Finally, the overall cumulative net inflow/outflow:

$$-\sum_{i=1}^{8} DD_i - \sum_{i=1}^{8} SD_i - \sum_{i=1}^{8} TD_i - \sum_{i=1}^{8} B_i - \sum_{i=1}^{8} OLP_i + \sum_{i=1}^{8} CBRBI_i + \sum_{i=1}^{8} BOB_i + \sum_{i=1}^{8} GS_i$$
$$+\sum_{i=1}^{8} DB_i + \sum_{i=1}^{8} E_i + \sum_{i=1}^{8} OI_i + \sum_{i=1}^{8} A_i \geq 0$$

Non-negativity constraints:

These constraints reflect non-negativity of the decision variables: viz. DD_i, SD_i, TD_i, B_i, OLP_i, $CBRBI_i$, BOB_i, GS_i, DB_i, E_i, OI_i, and $A_i \geq 0$, (i = 1 to 8).

DATA AND METHODOLOGY:

The data for the present study consists of the assets and liabilities (from the balance sheets) of a sample of fifty-one banks with India-wide operations in the study period 2007-08 from the Capitaline database.[2] The sample banks included twenty-seven public sector banks, fourteen private sector banks, and ten foreign banks.

The linear programming model as developed in the previous section was run for each bank using data from the balance sheet. The results of the LPP were then analysed to assess the asset-liability management of the banks. As an example, application of the model to the data of SBI Bank, one of the leading public sector banks in India, is given in Tables 1-6 below.

The outcome of applying the linear programming model is explained by two statements, the Structural Liquidity Statement and the Interest Rate Sensitivity Statement.

The Structural Liquidity Statement estimates the maturity profiles of various assets and liabilities and its consequential impact on liquidity. The Structural Liquidity Statement is basically meant for evaluation of the liquidity risk the bank is exposed to. Liquidity risk is the potential inability of a bank to generate enough cash to cope with the decline in deposits or increase in assets. The gap between the inflows and outflows in each bucket reveals the mismatch between assets and liabilities, and helps the bank to estimate and manage its liquidity position. The gap analysis (cumulative mismatch) shows whether the liquidity position of the bank is comfortable or not in all the time buckets.

The Interest Rate Sensitivity Statement gives the classification of various rate sensitive assets and rate sensitive liabilities of the bank. The phased deregulation of interest rates and the operational flexibility given to banks have exposed the banks to interest rate risks wherein changes in market interest rate might have a direct bearing on the bank's net interest margin. Interest rate risk is the gain/loss that arises due to sensitivity of the interest income/ interest expenditure or values of assets/liabilities to the interest rate fluctuations. The gap indicates whether the bank is in a position to benefit from rising interest rates (RSA >RSL) or from declining interest rates (RSL > RSA). The gap can therefore be used as a measure of interest rate sensitivity. A study of the interest rate sensitivity table would give an indication as to the rate sensitive maturity buckets which after careful scrutiny may be repriced.

[2] www.capitaline.com

Table 1: Structural Liquidity (outflows)

0UTFLOWS	1-14days	15-28 days	29days-3months	3-6 months	6-12 months	1yr-3yrs	3-5yrs	over 5yrs	Total
1. CAPITAL	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**631.47**	**631.47**
2. RESERVES & SURPLUS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**48401.19**	**48401.19**
3.DEPOSITS	**83352.57**	**14252.06**	**58418.54**	**16640.36**	**16640.36**	**250942.92**	**14252.06**	**82905.09**	**537403.94**
1)Demand Deposits	14720.03	0.00	0.00	0.00	0.00	83413.50	0.00	0.00	**98133.53**
2)Savings Bank Deposits	15422.93	0.00	0.00	0.00	0.00	138806.36	0.00	0.00	**154229.29**
3)Term Deposits	53209.61	14252.06	58418.54	16640.36	16640.36	28723.06	14252.06	82905.09	**285041.12**
4.BORROWINGS	**43968.30**	**0.00**	**0.00**	**0.00**	**0.00**	**2586.37**	**2586.37**	**2586.37**	**51727.41**
5. OTHER LIABILITIES & PROVISIONS	**35623.42**	**11874.47**	**4198.05**	**4198.05**	**4198.05**	**4198.05**	**4198.05**	**15472.91**	**83961.07**
TOTAL OUTFLOWS	**162944.28**	**26126.53**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**149997.03**	**722125.08**

Table 2: Structural Liquidity (inflows)

INFLOWS	1-14days	15-28 days	29 days-3months	3-6 months	6-12 months	1yr-3yrs	3-5yrs	over 5yrs	Total
1.CASH	**3220.31**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3220.31**
2.BALANCES WITH RBI	**45898.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2415.72**	**48314.30**
3.BALANCES WITH OTHER BANKS	**7965.86**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7965.86**	**0.00**	**15931.72**
3.INVESTMENTS	**85021.12**	**5288.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**99192.03**	**189501.27**
1)Government Securities	70564.14	0.00	0.00	0.00	0.00	0.00	0.00	70564.13	**141128.27**
2)Debentures & Bonds	8814.39	0.00	0.00	0.00	0.00	0.00	0.00	8814.39	**17628.78**
3)Shares	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4502.54	**4502.54**
4)Others Investments	5642.59	5288.12	0.00	0.00	0.00	0.00	0.00	15310.97	**26241.68**
5.ADVANCES	**20838.41**	**20838.41**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**13070.62**	**0.00**	**416768.20**
6.FIXED ASSETS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3373.48**	**3373.48**
7.OTHER ASSETS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**45015.80**	**45015.80**
TOTAL INFLOWS	**162944.28**	**26126.53**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**149997.03**	**722125.08**

Table 3: Statement of Structural Liquidity

Particulars	1-14days	15-28 days	29 days-3months	3-6 months	6-12 months	1yr-3yrs	3-5yrs	over 5yrs	Total
A.Total Outflows	**162944.28**	**26126.53**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**149997.03**	**722125.08**
B.Total Inflows	**162944.28**	**26126.53**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**149997.03**	**722125.08**
C.GAP (B-A)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
D.Other Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
E.Net GAP	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
F.Cumulative GAP	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
G.(E)as a % to (B)	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	

Table 4: Interest Rate Sensitivity (liabilities)

LIABILITIES	1-28days	29 days-3months	3-6 months	6-12 months	1yr-3yrs	3-5 yrs	over 5yrs	Non-sensitive	Total
1. CAPITAL	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**631.47**	**631.47**
2. RESERVES & SURPLUS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**48401.19**	**48401.19**
3.DEPOSITS	**67461.66**	**58418.54**	**16640.36**	**16640.36**	**167529.42**	**14252.06**	**82905.09**	**113556.46**	**537403.94**
1)Current Deposits	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98133.53	**98133.53**
2)Savings Bank Deposits	0.00	0.00	0.00	0.00	138806.36	0.00	0.00	15422.93	**154229.29**
3)Term Deposits	67461.66	58418.54	16640.36	16640.36	28723.06	14252.06	82905.09	0.00	**285041.12**
4.BORROWINGS	**43968.30**	**0.00**	**0.00**	**0.00**	**2586.37**	**2586.37**	**2586.37**	**0.00**	**51727.41**
5. OTHER LIABILITIES & PROVISIONS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**83961.07**	**83961.07**
TOTAL LIABILITIES	**111429.96**	**58418.54**	**16640.36**	**16640.36**	**170115.79**	**16838.43**	**85491.46**	**246550.19**	**722125.08**

Table 5: Interest Rate Sensitivity (assets)

ASSETS	1-28days	29 days-3months	3-6 months	6-12 months	1yr-3yrs	3-5yrs	over 5 yrs	Non-sensitive	Total
1.CASH	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3220.31**	**3220.31**
2.BALANCES WITH RBI	**45898.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2415.72**	**0.00**	**48314.30**
3.BALANCES WITH OTHER BANKS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**7965.86**	**0.00**	**7965.86**	**15931.72**
3.INVESTMENTS	**90309.24**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**94689.49**	**4502.54**	**189501.27**
1)Government Securities	70564.14	0.00	0.00	0.00	0.00	0.00	70564.13	0.00	**141128.27**
2)Debentures & Bonds	8814.39	0.00	0.00	0.00	0.00	0.00	8814.39	0.00	**17628.78**
3)Shares	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4502.54	**4502.54**
4)Others Investments	10930.71	0.00	0.00	0.00	0.00	0.00	15310.97	0.00	**26241.68**
5.ADVANCES	**41676.82**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**13070.62**	**0.00**	**0.00**	**416768.20**
6.FIXED ASSETS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3373.48**	**3373.48**
7.OTHER ASSETS	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**45015.80**	**45015.80**
TOTAL ASSETS	**177884.64**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**97105.21**	**64077.99**	**722125.08**

Table 6: Statement of Interest Rate Sensitivity

Particulars	1-28days	29 days-3months	3-6 months	6-12 months	1yr-3yrs	3-5yrs	over 5 yrs	Non-sensitive	Total
Duration	**0**	**30**	**90**	**180**	**360**	**1080**	**1800**		
A.Total Liabilities	**111429.96**	**58418.54**	**16640.36**	**16640.36**	**170115.79**	**16838.43**	**85491.46**	**246550.19**	**722125.08**
B.Total Assets	**177884.64**	**62616.59**	**20838.41**	**20838.41**	**257727.35**	**21036.48**	**97105.21**	**64077.99**	**722125.08**
C.GAP (B-A)	**66454.68**	**4198.05**	**4198.05**	**4198.05**	**87611.55**	**4198.05**	**11613.75**	**-182472.20**	**0.00**
D.Other Products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
E.Net GAP	**66454.68**	**4198.05**	**4198.05**	**4198.05**	**87611.55**	**4198.05**	**11613.75**	**-182472.20**	**0.00**
F.Cumulative GAP	**66454.68**	**70652.73**	**74850.79**	**79048.84**	**166660.39**	**170858.45**	**182472.20**	**0.00**	
G.(E)as a % to (B)	**37.36%**	**6.70%**	**20.15%**	**20.15%**	**33.99%**	**19.96%**	**11.96%**	**284.77%**	

Duration (Rate-sensitive Assets)	**452.54**
Duration (Rate-sensitive Liabilities)	**503.72**

FINDINGS:

(a) PUBLIC SECTOR BANKS

Analysis of the results of the linear programming model showed that twenty-five of the twenty-seven public sector banks in the sample yielded profitability and could simultaneously satisfy all the liquidity constraints. The sample banks with this property were: Allahabad Bank, Andhra Bank, Bank of India, Bank of Maharashtra, Canara Bank, Central Bank of India, Corporation Bank, Dena Bank, IDBI Bank, Indian Bank, Indian Overseas Bank, Oriental Bank of Commerce, Punjab National Bank, Punjab and Sind Bank, State Bank of Indore, State Bank of Mysore, State Bank of Patiala, State Bank of Bikaner and Jaipur, State Bank of Hyderabad, State Bank of India, Syndicate Bank, UCO Bank, Union Bank of India, United bank of India, and Vijaya Bank. Two of the sample public sector banks, viz. Bank of Baroda and State Bank of Travancore, were found to fail the liquidity constraints (specifically the SLR constraint), thus were subject to liquidity risk.

Further analysis showed that nine of the twenty-seven sample public sector banks were exposed to interest rate risk, as the duration of their rate-sensitive assets was greater than the duration of their rate-sensitive liabilities. These banks were: Allahabad Bank, Andhra Bank, Bank of India, Corporation Bank, Indian Bank, Indian Overseas Bank, Punjab National Bank, Union Bank of India, and Bank of Baroda. On the other hand, eighteen of the twenty-seven sample public sector banks were found not to be exposed to interest rate risk, as the duration of their rate-sensitive assets was less than the duration of their rate-sensitive liabilities. These banks were: Bank of Maharashtra, Canara Bank, Central Bank of India, Dena Bank, IDBI Bank, Oriental Bank of Commerce, Punjab and Sind Bank, State Bank of Indore, state Bank of Mysore, State Bank of Patiala, State Bank of Bikaner and Jaipur, State Bank of Hyderabad, State Bank of India, Syndicate Bank, UCO Bank, United Bank of India, Vijaya Bank, and State Bank of Travancore.

(b) PRIVATE BANKS

Analysis of the results of the linear programming model showed that nine of the thirteen private sector banks in the sample yielded profitability and could simultaneously satisfy all the liquidity constraints. The sample banks with this property were: Federal Bank, HDFC Bank, ICICI Bank, IndusInd Bank, Jammu and Kashmir Bank, Karnataka Bank, Karur Vysya Bank, Yes Bank, and Kotak Mahindra Bank. Four of the sample private sector banks, viz. Axis Bank, City Union Bank, ING Vysya, and South India Bank, were found to fail the liquidity constraints (specifically the SLR constraint), thus were subject to liquidity risk.

Further analysis showed that seven of the thirteen sample private sector banks were exposed to interest rate risk, as the duration of their rate-sensitive assets was greater than the duration of their rate-sensitive liabilities. These banks were: City Union Bank, Jammu and Kashmir Bank, Karnataka Bank, Karur Vysya Bank, South Indian Bank, Yes Bank, and Kotak Mahindra Bank. On the other hand, six of the thirteen sample private sector banks were found not to be exposed to interest rate risk, as the duration of their rate-sensitive assets was less than the duration of their rate-sensitive liabilities. These banks were: Axis Bank, Federal Bank, HDFC Bank, ICICI Bank, IndusInd Bank, and ING Vysya Bank.

(c) FOREIGN BANKS

Analysis of the results of the linear programming model showed that seven of the ten foreign banks in the sample yielded profitability and could simultaneously

satisfy all the liquidity constraints. The sample banks with this property were: Abu Dhabi Commercial Bank, Barclays Bank, BNP Paribas, Citibank N.A., HSBC Bank, Standard Chartered Bank, and State Bank of Mauritius. Three of the sample foreign banks, viz. ABN Amro Bank N.V., DBS Bank, and Deutsche Bank, were found to fail the liquidity constraints (specifically the asset-liability matching constraints), thus were subject to liquidity risk.

Further analysis showed that seven of the ten sample foreign banks were exposed to interest rate risk, as the duration of their rate-sensitive assets was greater than the duration of their rate-sensitive liabilities. These banks were: DBS Bank, Deutsche Bank, Abu Dhabi Commercial Bank, Barclays Bank, BNP Paribas, Citibank N.A., and State Bank of Mauritius. On the other hand, three of the ten sample foreign banks were found not to be exposed to interest rate risk, as the duration of their rate-sensitive assets was less than the duration of their rate-sensitive liabilities. These banks were: Standard Chartered Bank, ABN Amro Bank N.V., and HSBC Bank.

CONCLUSIONS AND RECOMMENDATIONS:

The model developed in the study is a normative model, describing the optimal asset-liability matching pattern that a bank should follow in order to maximize its profitability and maintain its liquidity position. The actual asset-liability positions of the banks may be quite different from that proposed by the model. Thus, the results of the study describe possibilities of asset-liability management in the sample banks.

The results of the study show that ownership and structure of the banks do affect their ALM procedure. According to the linear programming model for asset-liability management developed in the study, among all the groups, public sector banks have best asset-liability management positions, as 92.59% of the sample public sector banks were found to satisfy the liquidity constraints, and, further, 59.26% of them were found not to be exposed to interest rate risk.

The general recommendations of the study are that banks must carefully maintain and monitor their asset-liability positions, balancing profitability, liquidity, and interest rate risk. Banks which were found to satisfy all the liquidity constraints can focus on profit maximization; on the other hand, banks which were found not to satisfy all the liquidity constraints should identify which particular constraints they fail, and should subsequently pursue strategies to satisfy these constraints. Also, banks such as HSBC Bank and Standard Chartered Bank, which were found to satisfy all liquidity constraints, but at the cost of profitability, should pursue the strategy of profit maximization, ensuring that they satisfy all the guidelines of RBI. Finally, banks which are exposed to interest rate risk should focus on improving the duration of rate sensitive assets/liabilities, as far as possible.

The present study suffers from some mild limitations. The sample size used for the study was relatively small; a larger sample would have given better results. Also, the objective function coefficients in the model were estimated from past data, and some of them were relatively conservative and inaccurate, and the demand patterns of the assets and liabilities were not known. Further, the proposed model does not take the multi-objective and stochastic nature of the asset-liability management problem into consideration. Thus, there is great scope for further refinements and extensions of the model.

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