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Asset-Liability and Liquidity Management

POOYA FARAHVASH

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To my parents: Mahin and Ahmad

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About the Author

Pooya Farahvash is vice president of Treasury Modeling and Analytics at American Express Company, overseeing the development of models used in ALM, liquidity risk management, stress testing, and deposit products. He previously worked at investment bank Jefferies in liquidity risk management and at CIT Group in asset-liability and capital management. His experience in the banking industry is focused in treasury department activities, specifically in the areas of interest rate risk, liquidity risk, asset-liability management, deposit modeling, and economic capital. Dr. Farahvash is also an adjunct instructor at New York University, teaching analytical courses. He received both his PhD degree in Industrial and Systems Engineering and MS degree in Statistics from Rutgers University, New Jersey. He currently lives in New York City.

Preface

In recent years, use of quantitative methods in asset-liability management (ALM) has increased significantly, particularly among medium- to large-size banks and insurance companies. This partly reflects the importance of effective balance sheet planning and managing related risks in achieving earnings and equity valuation targets. Traditionally and in the past, balance sheet management efforts were mainly focused on funding activities to ensure that the bank's assets are properly funded at the lowest cost possible. Lack of risk awareness, however, was always a major weakness in this approach and recent history has shown that poorly managed balance sheets can lead to catastrophic events for banks. In one view, the failures of several banks and investment banks during the financial crisis of 2007–2009 were partially due to ineffective balance sheet management practices. Newer banking strategies rely on ALM techniques that are based on accurate and precise calculations to evaluate the impact of various risk factors on earnings and value of the firm. These metrics are designed to assess the efficiency of the balance sheet management efforts while taking various risks, such as interest rate risk, into consideration.

This book presents the fundamentals of asset-liability management in banking. During my years of practice as an ALM analyst in various banks, I generally felt that there was a need for a book that provides a comprehensive view of ALM as it is exercised in practice. The goal of this book is to present the fundamentals and methodologies that are commonly used by banks in their ALM analysis. The book is written for professionals who are active in asset-liability management, financial risk management, and treasury analytics. This book can also be used as the main textbook for a graduate-level course in the aforementioned areas.

The main materials in the book are organized in three parts. The first part, consisting of Chapters 1 through 7, is focused on the interest rate concept and related topics, interest rate modeling methods, and valuation of financial instruments. Many ALM analyses require valuation of positions on the balance sheet of a bank, as well as valuation of off-balance-sheet exposures, such as derivative contracts. Materials in this part provide the fundamentals for valuation of common financial instruments, including fixed- and

floating-rate loans, fixed-income securities such as bonds, equity securities, mortgage-backed and asset-backed securities, and callable or putable bonds. Valuations of common derivative products such as stock options, future options, interest rate swaps, interest rate forwards, interest rate caps and floors, and swaptions are also discussed. Since some topics reviewed in the interest rate models chapter require knowledge of valuation methods, that chapter is placed after the fundamentals of valuation are explained.

The second part of the book, consisting of Chapters 8, 9, and 10, is focused on two fundamental ALM metrics: economic value of equity and net interest income, and their related scenario analysis. The topics discussed in this part rely on the materials explained in Part One.

The third part of the book, consisting of Chapters 11 and 12, covers two topics that are closely related to ALM: liquidity risk and funds transfer pricing. Liquidity risk is the risk factor behind one of the gap measurements that the ALM process aims to optimize and funds transfer pricing is an internal allocation method of the net interest income. There are some practitioners who view liquidity risk management and funds transfer pricing as separate and independent topics from ALM. Recent trends, however, indicate that banks are moving toward a holistic view in managing the interest rate risk and the liquidity risk by combining the resources and required analysis of the two risk types. Particularly, there are many commonalities between data required for ALM and liquidity risk management. Funds transfer pricing, if done properly, internalizes the interest rate risk and liquidity risk among business units of a bank, and hence plays an important role in balance sheet management.

Asset-liability management studies are part of quantitative finance. In ALM, mathematical modeling and statistical concepts are mixed with high-level business decision making on how to run a bank. For the quantitative techniques discussed and used in this text, the general approach is to focus on applications and outcomes rather than providing deep discussions on supporting theories and proof of equations. For readers who are interested in theoretical background, each chapter provides a list of references for the origins of methods and further discussions. Since several subjects introduced in this book rely on statistical concepts, an appendix is added to cover the basic elements of probability and statistics in a concise form. These materials should help a reader who is not proficient in statistics to gain an understanding of the subjects that are needed in other parts of the book.

Methods discussed in this text when applied to the entire balance sheet of a bank require extensive computations. For the most part, examples provided are simple enough so the reader can follow and understand the topics. In practice, software packages are available that can perform the analysis explained here for balance sheets with a large number of positions. The book is not written with any particular software in mind, however, as the

concepts discussed here are applicable to any ALM analysis, regardless of the software used.

In some of the examples and illustrations throughout the book I occasionally use a LIBOR–swap curve for coupon calculation of floating-rate instruments or for discounting. The principles discussed, however, are applicable if any other interest rate, such as SOFR or OIS, was used instead. In some of the examples presented in the book, the reader may notice some minor differences between the results shown here and results if calculations are performed using a spreadsheet software. This is due to rounding errors that may occur at a calculation step and those errors generally make no difference in the final outcomes.

I would like to thank those individuals who commented on the manuscript, and those who were involved in the production process of the book.

Pooya Farahvash
New York
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Abbreviations

ABCP:	asset-backed commercial paper
ABS:	asset-backed security
ACT:	Actual (used in day count conventions)
ADR:	annual default rate
AFC:	available funds cap
ALLL:	allowance for loan and lease losses
APR:	annual prepayment rate
APS:	absolute prepayment speed
BAU:	business as usual
BBA:	British Bankers' Association
BCBS:	Basel Committee on Banking Supervision
BHC:	bank holding company
BIS:	Bank for International Settlements
bps:	basis points (0.01%)
CB:	coupon-bearing bond
CD:	certificate of deposit
CDF:	cumulative distribution function
CDO:	collateralized debt obligation
CDR:	constant default rate
CDS:	credit default swap
CFP:	contingency funding plan
CMBS:	commercial mortgage-backed security
CME:	Chicago Mercantile Exchange
CMO:	collateralized mortgage obligation
CP:	commercial paper
CPI:	Consumer Price Index
CPR:	constant prepayment rate
CVaR:	conditional value-at-risk

DCF:	discounted cash flow
DF:	discount factor
DR:	default rate (periodic)
DV01:	dollar value of a basis point
DVP:	delivery versus payment
EaR:	earnings-at-risk
EBIT:	earnings before interest and taxes
EBITDA:	earnings before interest, taxes, depreciation, and amortization
ECB:	European Central Bank
EMTN:	Europe medium-term note
EONIA:	Euro Overnight Index Average
EPS:	earnings per share
EVE:	economic value of equity
EWI:	early waning indicator
FASB:	Financial Accounting Standards Board
FCFE:	free cash flow to equity
FCFF:	free cash flow to firm
FDIC:	Federal Deposit Insurance Corporation
Fed:	Federal Reserve System
FOMC:	Federal Open Market Committee
FRA:	forward rate agreement
FRBNY:	Federal Reserve Bank of New York
FSA:	Financial Services Authority
FTP:	funds transfer pricing
FX:	foreign exchange
GDP:	gross domestic product
GMRA:	global master repurchase agreement
HELOC:	home equity line of credit
HIC:	hold in custody
HQLA:	high quality liquid asset
IBF:	international banking facility
IBR:	income-based repayment
ICAAP:	internal capital adequacy assessment process
ICE:	Intercontinental Exchange
IID:	independent and identically distributed
IRRBB:	interest rate risk in the banking book
ISDA:	International Swaps and Derivatives Association
LCR:	liquidity coverage ratio
LGD:	loss given default
LIBOR:	London Interbank Offered Rate

LR:	loss rate
LRNVR:	locally risk-neutral valuation relationship
LTV:	loan to value
MBS:	mortgage-backed security
MDR:	monthly default rate
MMDA:	money market deposit account
MPR:	monthly payment rate
MSRP:	manufacturer's suggested retail price
MTL:	month to liquidation
MTN:	medium-term note
NAS:	non-accelerated senior
NII:	net interest income
NOW:	negotiable order of withdrawal
NSFR:	net stable funding ratio
NWCI:	net working capital investment
OAS:	option-adjusted spread
OIS:	overnight index swap
OTS:	Office of Thrift Supervision
PAC:	planned amortization class
PB:	price-to-book value
PCA:	principal component analysis
PD:	probability of default
PDF:	probability density function
PE:	price-to-earnings
PFE:	potential future exposure
PLUS:	Parent Loan for Undergraduate Students
PMF:	probability mass function
PPC:	prospectus prepayment curve
PR:	prepayment rate (periodic)
PS:	price-to-sales
PSA:	Public Securities Association
PV:	present value
PV01:	present value of a basis point
QRM:	qualified residential mortgage
Repo:	repurchase agreement
Reverse repo:	reverse repurchase agreement
RMBS:	residential mortgage-backed security
ROE:	return on equity
SDA:	standard default assumption
SIV:	structured investment vehicle

SLABS:	student loan asset-backed security
SMM:	single monthly mortality
SOFR:	Secured Overnight Financing Rate
SONIA:	Sterling Overnight Index Average
SPE:	special purpose entity
SPV:	special purpose vehicle
VaR:	value-at-risk
WAC:	weighted average coupon
WACC:	weighted average cost of capital
WAM:	weighted average maturity
ZB:	zero-coupon bond

Introduction

A bank at its core is a financial intermediary institution that collects funds from those individuals or entities who do not have immediate use for them and lends to those who can use the capital to generate economic benefits. Depositors with excess cash can benefit from the interest earned on their deposits while borrowers can benefit from the borrowed funds for their personal needs, such as purchasing real properties, or business needs, such as investing in their small business ventures. As the facilitators of such fund transfers, banks earn the difference between the interest paid to the depositors and the interest earned from the borrowers. A bank with an asset-driven business model seeks to originate assets through lending activities and simultaneously pursue funding methods to fund those assets, whereas a bank with a liability-driven business model primarily focuses on collecting deposits and then attempts to lend or invest the proceeds from the deposits. While traditionally deposits are the main *source of funds* in the banking industry, nowadays banks use a variety of methods to raise funds, including the issuance of short-term and long-term notes, securitization, and collateralized borrowings. *Use of funds* is also evolved from traditional lending in the form of loans to individuals and businesses, in investment in securities, and even in speculation using derivatives. The net revenue a bank makes is the difference between the costs associated with its sources of funds and earnings from the instruments where available funds are invested and used.

A bank manages its sources and uses of funds by trying to match them based on different criteria. One such criterion is based on the principal cash flows. The status of a bank as a financial intermediary, which is often supported by the central bank of the country, allows it to have a lower cost of funds compared to other entities. In particular, the bank's short-term borrowings are usually significantly cheaper compared to long-term alternatives. This allows the bank to fund long-term assets that are more profitable by cheaper short-term liabilities. While economically this seems like a sound business model, it potentially increases the risk for banks of not being able to fulfill their obligations when they are due. When the return of the principal amount borrowed by the bank is due before the principal lent is returned, this may

lead to the bank's failure, should it not have any alternative source to replace the needed funds. A prudent banking practice is to align or overlap the terms of asset and liability positions such that there are always available funds to cover short- to medium-term liability maturities. However, in practice this is hard to achieve for individual asset or liability positions. Except in rare cases in which a particular debt position is raised to fund a large asset portfolio or a particular investment project, individual asset positions, such as loans and investment in securities, are not funded by distinct liability positions. Banks raise funds in micro form through deposits or in bulk form by issuing bonds. This makes the principal matching between assets and liability difficult, if not impossible. Due to this, banks may attempt to match the principal cash flows on a portfolio level. But even this approach has its limitations, since non-maturing products such as credit card accounts or savings accounts do not have contractual maturity dates. To overcome this, existing balances of non-maturing products are assumed to follow some modeled *runoff profiles* that act as amortization schedules for them. This allows the bank to estimate principal cash flows related to these products and to create *principal cash flow schedules* at an aggregated level, for example, for the bank as a whole or at a subsidiary level. Such schedules provide an overview of amounts and timings of expected principal cash flows and help in the planning and coordination of asset originations and debt issuances. This approach, however, does not incorporate planned changes in the assets and the liabilities. For example, if the bank is planning to grow a certain asset portfolio or to issue new debt securities in the near future, they are not reflected in a *static cash flow schedule*. Particularly, expected changes in balances of non-maturing products due to macroeconomic factors are not included. A *dynamic cash flow schedule* incorporates planned and expected changes in the asset and liability portfolios. A more sophisticated version of such a schedule considers all principal and interest payments to create a comprehensive view of cash flows a bank can experience in a short- to medium-term time horizon in the future. *Cash flow gap*, sometimes referred to as *maturity gap*, is the net value of cash flows generated by assets and liabilities in a specific time period. Minimizing cash flow gap is one way to reduce the risk of adverse events due to the mismatch between asset and liability cash flows, particularly their principal flows.

A bank may manage its uses of funds based on the reliability and persistency of the sources of funds. Funding sources being unavailable when they are needed may lead to the bank's failure. To assess their readiness, banks often perform scenario analysis to evaluate the impact of unavailability of one or more funding sources on their cash flow schedules and ultimately on their balance sheets. This enables them to obtain a view of the potential *liquidity gap* they may face in the future.