Christian Schmaltz

A Quantitative Liquidity Model for Banks

GABLER RESEARCH

Christian Schmaltz

A Quantitative Liquidity Model for Banks

With a foreword by Prof. Dr. Thomas Heidorn

GABLER

RESEARCH

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at http://dnb.d-nb.de.

Dissertation Frankfurt School of Finance and Management, 2009

1st Edition 2009

Editorial Office: Claudia Jeske | Anita Wilke

Gabler is part of the specialist publishing group Springer Science+Business Media.
www.gabler.de

Umschlaggestaltung: KünkelLopka Medienentwicklung, Heidelberg
Printed on acid-free paper
Printed in Germany

ISBN 978-3-8349-1822-2

Para mi princesa

Foreword

Liquidity is a core resource and its management is a core activity of banks. Nevertheless, liquidity management has not received much attention during the last decades, as liquidity has not been perceived as scarce. This perception has clearly changed during the financial crisis 2007/2009. Facing dried interbank markets, many banks were desperately looking for liquidity. Despite its crucial role, the modeling techniques for bank liquidity are so far rather simple, which sharply contrasts the sophisticated techniques used for other risks as credit or market. Furthermore, German regulators now allow banks to use internal liquidity models for regulatory reporting. This leads to the need to develop a liquidity model for banks that uses advanced stochastic techniques, incorporates all liquidity key variables, discusses internal liquidity allocation and optimization. The work of Christian Schmaltz closes this gap in the literature.

There are three major contributions:

1. Key liquidity variables are derived.
2. An innovative way to internally allocate liquidity is developed.
3. Transfer prices of liquidity are calculated.

The key variables are derived from the liquidity condition of banks and the channels to generate additional cash flows. Customer deposits and credit, funding spread and funding capacity, haircuts and short term interest rates are identified as key liquidity variables. Liquidity risk is the consequence of the non-deterministic nature of these variables, which may take large adverse values (liquidity crisis). Having identified the key variables, a liquidity model is set up by assuming a particular stochastic process for each variable. The focus lies on the customer cash flows which are modeled by a jump-diffusion process. With this general type of process it is possible to describe stochastic objects that have an expected component and two unexpected components. One unexpected component accounts for small and the second for sudden large deviations. Customer cash flows can be modeled this way. The expected component can be interpreted as contractual or expected cash flows, the small deviations come from the liquidity option banks provide for their customers and the large deviations are confidence-driven (individual or systematic liquidity crisis). In contrast to previous authors, Christian Schmaltz models cash flows on the product level instead of using an aggregate. This allows him to discuss the interdependence between products and to analytically describe the aggregation and disaggregation of liquidity risk.

The model is applied to internal liquidity allocation and optimization. The thesis proposes to separate the cash flow components and to allocate them to different departments. In particular, the expected cash flow is allocated to the asset liability management, the unexpected component to the money market and the confidence-driven part to the risk controlling department. The asset liability management manages long-term cash flows facing funding spread uncertainty. The money market department manages the short-term unexpected component using money market loans and deposits. This department has to maintain a (central) reserve. The risk controlling department pools the confidence-driven component. It balances the risk with a decentral reserve. The departments are connected by a new liquidity transfer price system that reflects the cost of a passive strategy. This system ensures that the liquidity allocation is adequately accounted for in the profit and loss calculations. Transfer prices are of practical importance as they are an integral component of recent regulatory initiatives in liquidity management.

The addressees of this work are numerous: the model could inspire liquidity managers and controllers in banks for their own internal models. Furthermore, it might serve regulators for their assessment of these models. Finally, it invites researchers to generalize many assumptions that have been made during the development of this particular approach.

Being convinced of the promising solutions and their practical relevance, I hope that Christian Schmaltz' approach to liquidity risk will find a wide acceptance in the industry and research community.

Prof. Dr. Thomas Heidorn

Acknowledgements

This thesis is a joint effort of my brain and fingers, but it benefited from many other people intellectually, financially, and personally.

Intellectually, I am very grateful to my supervisor Prof. Dr. Thomas Heidorn for having given me the opportunity and freedom to focus on the exciting subject of liquidity management for the past three years. When we seemed to hit a wall, we brainstormed and found a way out. I thank Prof. Dr. Ursula Walther for interesting insights into the behavioural aspects of liquidity and her acceptance of my co-supervision. Furthermore, I am also grateful to Prof. Stephan Dieckmann who accepted the external supervision despite his recent move to a new town and university. My special thanks go to Prof. Dr. Wolfgang Schmidt for his altruistic help and impulses with respect to stochastic optimization.

Furthermore, I want to express my gratitude to HSH Nordbank AG for raising a topic of practical relevance, providing a network of liquidity practitioners, and for sponsoring this thesis. It is true that while contracts are made between institutions, contacts are made between people – therefore, my thanks to HSH are equally shared between Dr. Carl Heinz Daube, Prof. Dr. Dr. Marcus Porembski, Armin Schneider, and Dirk Schröter. Furthermore, I thank TriSolutions' Dr. Peter Bartetzky, Dr. Holger Thomae, and Dr. Tobias Ihde for their suggestions and valuable comments during my first liquidity project.

Not only am I grateful to my office, but to the colleagues in its vicinity. I highly appreciate the inspiring conversations about filtrations, processes and beyond with colleagues and my friends Christoph Becker, Natalie Packham, and Carlos Veiga.

I am further indebted to Mildred Fehlberg and my friend Stefan Hirth for proof-reading and questioning all the points that seem to be self-explanatory while they are not.

Personally, I am grateful to my friend and training partner Dierk Dennig for setting the pace in both marathons and research. Furthermore, I thank Matthias Hilgert for nice runs, nice conversations, and nice venues.

I thank my parents for teaching me that life is a pool of options rather than of obligations. I chose the option to pursue a PhD in full consciousness of the fact that any other option would have found their full support as well. Finally, I am grateful to my future wife Maria, for her sunshine on rainy days – but this is beyond words anyway.

Christian Schmaltz

Contents

List of Figures

List of Tables

Symbols

Notation	Description
$1-\alpha$	Origination, Fraction of Roll-Over Volume
$B_{t_{k+1}}$	Money Market, Cumulated Cash Flow Balance
β	Origination, Long-term Funding Capacity
$C(.)$	Jump Transfer Price, Required Collateral
CF_t^+	Incoming Cash Flow at t
CF_t^-	Outgoing Cash Flow at t
$c^R()$	Brownian Transfer Price, Cost Function
$c(t_1,t_2)$	Credit Spread for period [t_1,t_2]
$d_t^{+/-}$	Money Market, Interbank Loan (-)/ Deposit (+)
$\delta(t_1,t_2)$	Market Illiquidity Premium for period [t_1,t_2]
η	Liquidation Model, Market Resiliency
$FC(.)$	Brownian Transfer Price, Required Funding Capacity
FC_t	Available Funding Capacity at t
γ	Brownian Transfer Price, Diversification Systematic/ Non-Systematic
γ^p	Brownian Transfer Prices, Diversification Product i/ Product j
$H(i)$	Liquidation Model, Characteristics of Asset i
HC	Haircut
HC^{ON}	Liquidation Model, Market Depth
$J_{t_k}^i$	Product Cash Flow, Compound Poisson Process
l	Brownian Transfer Price, Secured Fraction
λ^i	Product Cash Flow, Jump Intensity

Notation	Description
LC_t	Liquidation Capacity at t
L_t^a	Liquidation Value of Asset a at t
MMD	Money Market Department
$\mu_{t_k}^A$	Aggregated Cash Flow, Drift
$\mu_{t_k}^i$	Product Cash Flow, Drift
$N(t_k)$	Counting Model for Compound Poisson Process.
n_1	Transfer Prices, Time Without Exercises
n_2	Transfer Prices, Number of Exercises
OD	Origination Department
p	Brownian Transfer Price, Confidence Level
p^c	Money Market, Probability of Distressed Funding
p^{CF}	Money Market, Probability of Inflowing Cash Flow
$\Phi()$	Standard Normal Distribution
PV_t	Present Value at t
P&L	Profit & Loss
q_k	Time Index for Quarterly Variables
$r(t_1,t_2)$	Gross Funding Rate for $[t_1,t_2]$
$r_f(t_1,t_2)$	Risk-free interest rate for $[t_1,t_2]$
RC	Risk Controlling
s	Origination, Penalty Spread
s^A	Aggregated Cash Flow, Jump Component
s^{bas}	Bid-ask spread
s^i	Product Cash Flow, Jump Scaling Factor
σ^A	Aggregated Cash Flow, Brownian Component
σ^i	Product Cash Flow, Brownian Volatility
σ^M	Systematic Brownian Risk across all Products
σ^P	Unsystematic Brownian Risk across all Products
T	Transfer Prices, Product Maturity
t_k	Time Index for Daily Variables
ϑ_1^i	Confidence Model, Expected Jump Size
ϑ_2^i	Confidence Model, Jump Size Variance
$TP^B()$	Brownian Transfer Price
$TP^D()$	Drift Transfer Price
$TP^J()$	Jump Transfer Price

Notation	**Description**
V	Liquidation Model, Transaction Volume
v_{t_k}	Liquidation Model, Volume liquidated at t_k
W_{t_k}	Wiener Process
$\Delta W_{t_k}^{i,p}$	Product Cash Flow, Product-specific Liquidity Shock
$\Delta W_{t_k}^{m}$	Product Cash Flow, Systematic Liquidity Shock
$X_{t_k}^{i}$	Inventory of product i at t_k
Y_j	Jump Size Model for Compound Poisson Process