

Christian Schmaltz

A Quantitative Liquidity Model for Banks

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With a foreword by Prof. Dr. Thomas Heidorn



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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 Schmalz 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 Schmalz 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 Schmalz' approach to liquidity risk will find a wide acceptance in the industry and research community.

Prof. Dr. Thomas Heidorn

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Christian Schmaltz

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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
$C(\cdot)$	Jump Transfer Price, Required Collateral
CF_t^+	Incoming Cash Flow at t
CF_t^-	Outgoing Cash Flow at t
$c^R(\cdot)$	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
$FC(\cdot)$	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
μ_k^A	Aggregated Cash Flow, Drift
μ_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_k	Wiener Process
$\Delta W_k^{i,P}$	Product Cash Flow, Product-specific Liquidity Shock
ΔW_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