Institute for Operations Research
and Computational Finance

University of St.Gallen

Modeling Client Rate and Volumes of Non-maturing Accounts

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Agenda

- Problem statement: Non-maturing Accounts (NMA)
- Motivation: Multistage Stochastic Programming Model/Dynamic replicating portfolio approach
- Client rate model specification and results
- Volumes model specification and results
- Case study
- Conclusion

Simplified bank balance. Non-maturing accounts

A	L
Non-maturing accounts • overdraft facilities • non-fixed mortgages • other variable loans	Non-maturing accounts • savings accounts • sight deposits
Fixed-income positions: • credits • fix-rate mortgages • bonds	Fixed-income positions: • savings certificates • issued bonds
	Other liabilities
Other assets	*Equity capital*

Non-maturing accounts:

- Contractual maturity not specified
- Two options:
  - Clients: option to withdraw liquidity or prepay credits/mortgages
  - Bank: option to adjust client rate
- Volume may fluctuate significantly, often depending on the level of observed interest rates
- Future cash flows are uncertain

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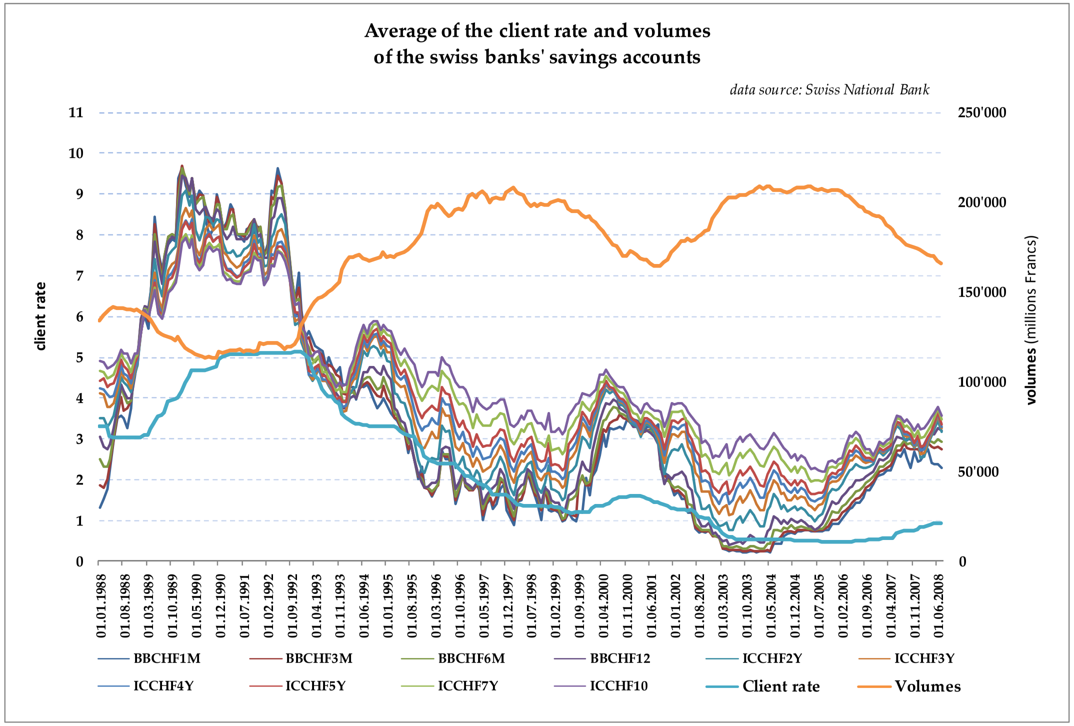
Modeling NMA: Margin Optimizer

- Dynamic modeling and optimization of NMA
- Multistage stochastic programming model that determines an optimal replicating portfolio from scenarios for future outcomes of the relevant risk factors:
  - market rates
  - client rates
  - volumes
- Realistic client rate and volumes models are required

Client rate and volumes of the savings accounts



- Client rate:
  - asymmetric adjustment to the market rates
  - rigidity (delay in the client rate's adjustment to market rates)
- Volumes: negative correlation with the market rates

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Asymmetry in the Literature

- *Hannan and Berger (1991), Ausubel (1992):* difficulties in explaining asymmetric model for deposit rents based on consumer search costs
- *Kahn, Pennacchi, Sopranzetti* (1999): explain the temporal and quantitative discreteness in deposit rates adjustments, but there's no explanation for the asymmetry
- *Dueker* (2000): explanations for asymmetric adjustment in the context of loan rates
- *O'Brien* (2000): first who derives an interesting property of the asymmetry:

$$E\left[R_t\right] = E_{rt}\left[R_t^e\right] - \left(1 - \frac{\lambda^+}{\lambda^-}\right) E_{rt,R_{t-1},}\left[\max\left\{R_t^e - R_{t-1}, 0\right\}\right]$$

  - equilibrium deposit rate conditional on a market rate

$$R_t^e = br_t - g$$

Equilibrium deposit rates

- Common practice: relate the deposit rates to a short term interest rate, assuming depositors were concerned with opportunity costs

against empirical evidence

- We relate the idea of equilibrium to the common trend of deposit rates and market rates (including also a longer maturity)

study cointegration

Johansen cointegration test results

System	Vector	Eigen value	Trace statistic	Lags
Client rate	1.000	0.158	58.477	4
Libor 3m	-0.295 (0.085)			
Swap 5y	-0.695 (0.123)			
Constant	1.378 (0.237)			

Threshold model in error correction form

- In deriving the client rate model, we take into account its deviations from the equilibrium level (error correction term derived from the cointegrating vector)
- We check for the asymmetry by allowing the parameter for the market rates to differ when they are above or below some estimating threshold

$$\Delta R_t = \alpha + \beta_1 \Delta R_{t-1} + \beta_2 \Delta r_{t-1}^{short} + \beta_3 \Delta r_{t-1}^{long} + \delta EC_{t-1} + \lambda \varpi_{t-1} + \varepsilon_t$$

  - ΔR_t change in the deposit rate
  - Δr_{t-1} lagged change in the market rate
  - EC_{t-1} lagged error-correction term
  - ε_t random i.i.d. disturbance

- The variable $\varpi_{t-1} = \omega_{t-1} I[\omega_{t-1} \le \tau]$ captures the threshold effect, where ω is the threshold variable, τ is the unknown threshold variable and the indicator function is defined as:

$$I[\omega_{t-1} \le \tau] = \begin{Bmatrix} 0 \text{ for } \omega_{t-1} > \tau \\ 1 \text{ for } \omega_{t-1} \le \tau \end{Bmatrix}$$

Threshold estimation

- We apply Hansen's grid search (1996) to locate the most likely threshold value in the market rates or error correction term
  - Model parameters are estimated by MLE ($S_n(\beta,\delta,\tau)$)

$$\hat{\tau} = \operatorname{argmin}\left(S_n(\tau)\right)$$

  - We apply the likelihood ratio statistic to test $H_0 : \tau = \tau_0$

$$LR_n(\tau) = n\frac{S_n(\tau) - S_n(\hat{\tau})}{S_n(\hat{\tau})}$$

  - *p*-values are derived:

$$p_n = 1 - \left(1 - \exp\left(-\frac{1}{2}LR_n(\tau_0)^2\right)\right)^2$$

	Short rate $(\omega = r_{t-1}^{short})$	Long rate $(\omega = r_{t-1}^{long})$	EC term $(\omega = EC)$
Threshold value	0.468	-0.520	1.027
p-value	0.262	0.048	0.016

Estimation results

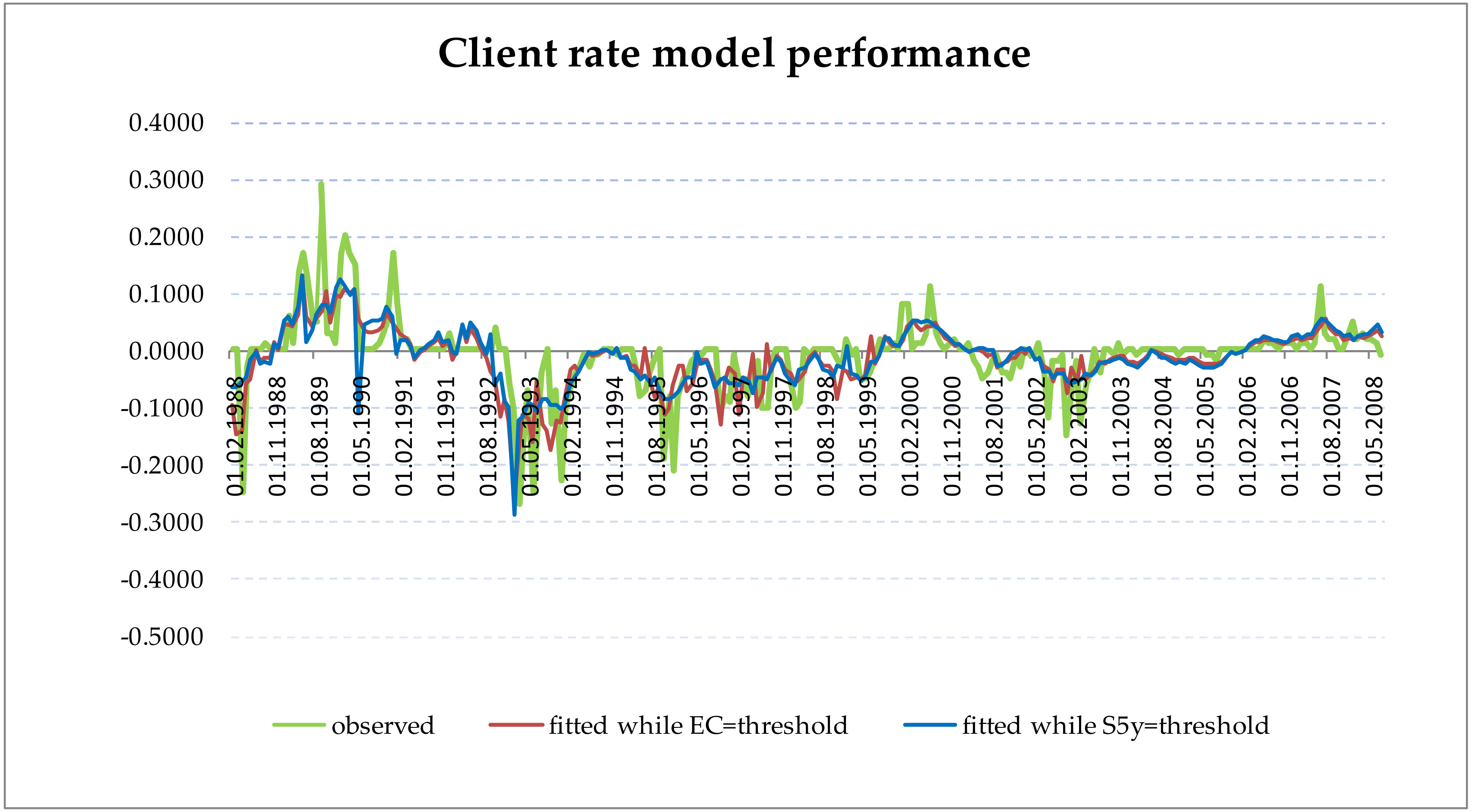
$$\Delta R_t = \alpha + \beta_1 \Delta R_{t-1} + \beta_2 \Delta r_{t-1}^{short} + \beta_3 \Delta r_{t-1}^{long} + \delta EC_{t-1} + \lambda \varpi_{t-1} + \varepsilon_t$$

Parameters	**Libor 3m threshold**	**Swap 5Y threshold**	**Error-correction threshold**
α	**0.056** (2.41)	**0.0008** (0.275)	**-0.027** (-3.028)
β_1	**0.098** (1.245)	**0.101** (1.287)	**0.070** (0.887)
β_2	**-0.062** (1.216)	**0.020** (1.679)	**0.020** (1.785)
β_3	**-0.043** (-3.35)	**0.034** (2.27)	**0.042** (3.328)
δ	**-0.053** (-7.35)	**-0.053** (-6.799)	**-0.140** (2.592)
λ	**0.057** (3.47)	**0.756** (7.63)	**0.101** (1.983)
$\bar{R}^2$	**0.592**	**0.551**	**0.563**
Durbin-Watson stat.	2.01	1.98	2.0005
Threshold	**0.468**	**-0.520**	**1.027**
Sup-LM	10.53	8.958	13.78
p-value	**0.262**	**0.048**	**0.016**

t Statistics are in parenthesis. *Threshold* is the value of the nuisance parameter associated with the *sup-LM* statistic to locate the most likely threshold. the P value associated with sup-LM is also presented, and is obtained by simulating the asymptotic distribution (1000 replications) of the test statistic using the method proposed by Hansen (1996).

Model performance

- Best fit to the observed data is obtained by the model with EC term as threshold variable:



Interpretation of results

- There is a strong asymmetric relationship between the client rate and the changes in the long rate maturity:
  - a significant threshold exists at -52 b.p. change in the Swap 5 years rate;
  - for every negative shock of 100 b.p. below -52 b.p. in the Swap 5 years rate, the client rate will be adjusted, on average, by a 79 b.p. drop per month;
  - for every 100 b.p. change in the Swap rate above -52 b.p. level, the client rate will change, on average, with only 3.4 b.p. per month.

- The greater the magnitude of the disequilibrium, the greater the speed of adjustment towards equilibrium:
  - a significant threshold exists when the client rate is 1.027% (102.7 b.p.) above its equilibrium level;
  - for every 100 b.p. above this departure from equilibrium, we expect the convergence back to equilibrium to be of 14 b.p. drop in the client rate per month;
  - below the disequilibrium threshold, the convergence to equilibrium only occurs with 3.9 b.p. drop.

Modeling volumes of NMA. Literature overview

Common practice:

- formulation of volume models as autoregressive distributed lag models: Selvaggio (1996), O'Brien (2000), de Jong and Wielhouver (2001), Dewachter, Lyrio and Maes (2006)
- explaining the volumes by a proxy for the market rates (level or spread between client rate and market rates): Hutchison and Penacchi (1996), Bardenhewer (2007), O'Brien (2000), de Jong and Wielhouwer (2007)

Modeling NMA volumes

- dependent variables:
  - time trend as proxy for the unspecific macro variables
  - lagged value of deposit volumes
  - spread between client rate and market rates

$$D_t = \beta_1 + \beta_2 t + \beta_3 D_{t-1} + \beta_4 \left[R_{t-3} - \left\{ \delta r_{t-3}^{short} + (1-\delta) r_{t-3}^{long} \right\} \right] + \varepsilon_t$$

- as proxy for the market rates we include a mix of a shorter and a longer maturity
- when significant changes in the less volatile market rates (in our case 5 years Swap) occur, depositors become more sensitive and we expect changes in the volumes dynamics ($\delta = 33\%$)

Estimation results

$$D_t = \beta_1 + \beta_2 t + \beta_3 D_{t-1} + \beta_4 \left[R_{t-3} - \left\{ \delta r_{t-3}^{short} + (1-\delta) r_{t-3}^{long} \right\} \right] + \varepsilon_t$$

Table 3: Step one: OLS covariance matrix obtained with Newey West estimator

Variable	Coefficient	t-statistic	p-values
β_1	8850	5.00	0.0000
β_2	4.60	1.20	0.2311*
β_3	0.96	100.12	0.0000
β_4	1486	5.81	0.0000
$\bar{R}^2$	0.9971		
Durbin-Watson	1.1740		

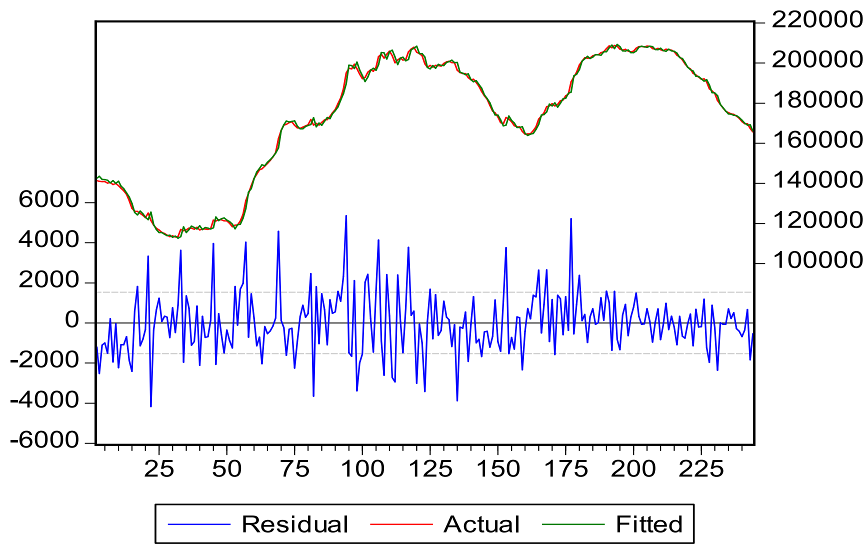
!! not significant

Table 4: *Results estimating the volumes model in AR(1) form excluding the time trend from the estimation:*

Variable	Coefficient	t-statistic	p-values
β_1	7884	4.179615	0.0000
β_3	0.96	115.3435	0.0000
β_4	1360	4.895730	0.0000
AR(1)	0.42	7.016911	0.0000
$\bar{R}^2$	0.99		
Durbin-Watson	2.04		

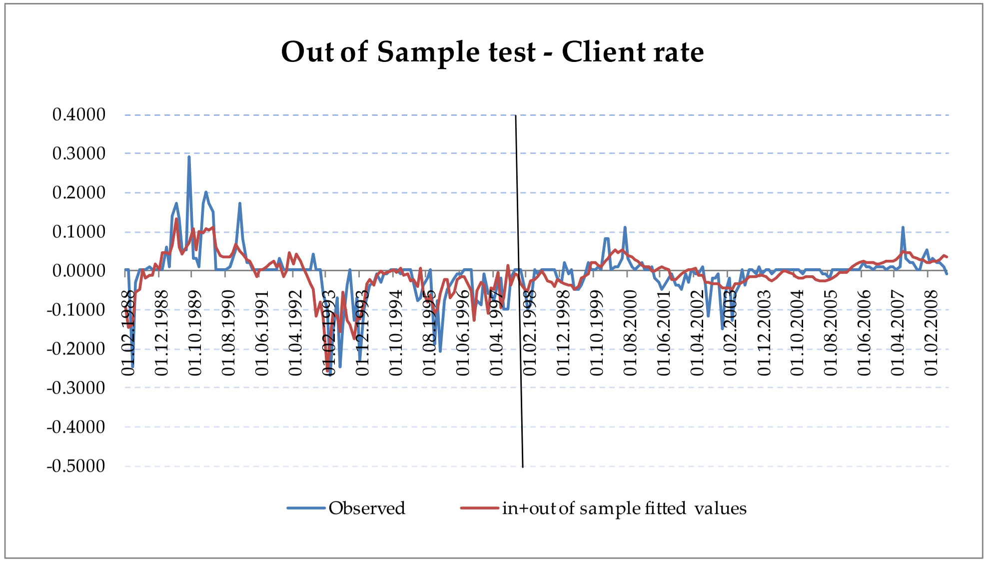
Interpretation of results

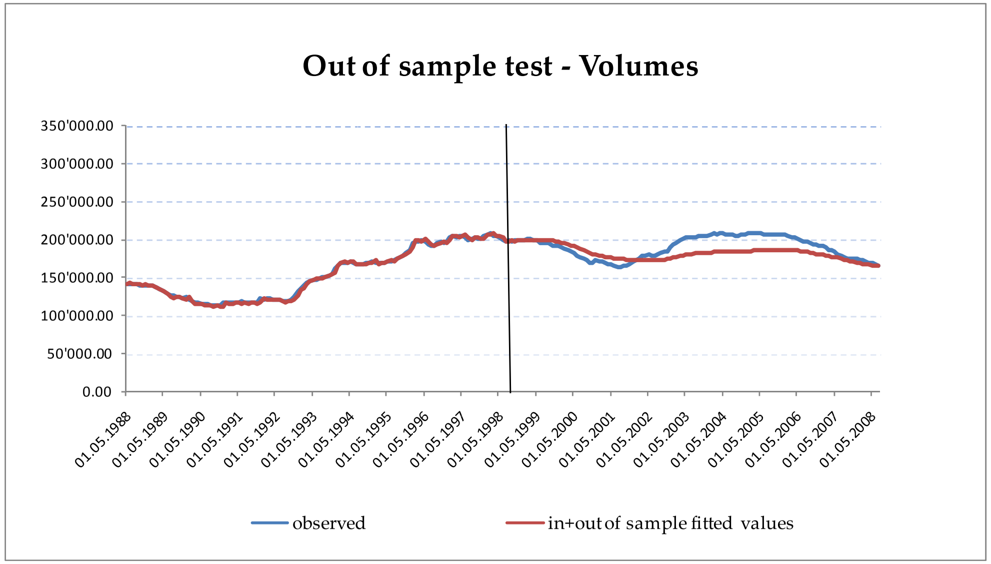
- The lagged deposits and the spread between deposits and market rates have important explanatory power for deposit balances
- Depositors are sensitive to market rates increase: If market rates are 100 b.p. above client rate, this would determine 1360 millions CHF drop in the volumes value.



Case study – client rate model

We reestimate the coefficients of the client rate model using data from the beginning of the data sample up to January 1998 and we calculate the out of sample fitted value (for the rest of the data sample)





Conclusion

- Changes in the deposit rates respond to changes in the 5 year Swap rate in an asymmetric manner
- Adjustment of the client rate to a disequilibrium is more pronounced when the disequilibrium widens noticeably: large disequilibria caused by shocks to money market rates will imply proportionally more rapid responses from client rates
- The client rate and volumes models prove a realistic out-of-sample fit and they could be integrated in the general framework of NMA optimization tools