Liquidity-Saving Mechanisms: Quantifying the Benefits in TARGET2

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Importance of LSM in RTGS

- **Increased use of RTGS in LVPS**
- **rising liquidity needs**
- **introduction of liquidity saving mechanism to alleviate liquidity needs**
- **Example: Queuing arrangements**
- **Problem:**
  - strategic incentives (using incoming liquidity) may counteract the supposed efficiency effects of LSM
  - costs of programming LSM
- **Hitherto:**
  - models of advantages of LSM for pure RTGS
  - recently: quantification of LSM in Fedwire
- **Here: using applied models of LSM to quantify the welfare benefits of LSM in TARGET2**

Recent Literature on LSM

- **Martin, Antoine and James McAndrews**
  - 2008: Liquidity-saving mechanisms. Journal of Monetary Economics 55, 554 – 567.
    - studies the incentives of participants in a RTGS system with and without LSM
    - shows mixed welfare implications for a fee-based RTGS
  - 2007: Liquidity-saving mechanisms. Federal Reserve Bank of New York Staff Reports No. 282.
    - provides for the proofs of details not listed in Martin and McAndrews 2008
- **Jurgilas, Marius and Antoine Martin**
  - 2010: Liquidity-Saving Mechanisms in Collateral-Based RTGS Payment Systems. Bank of England Working Paper No. 389 and Federal Reserve Bank of New York Staff Reports No. 438.
    - extends model of Martin and McAndrews to collateral-based RTGS system
    - proves that introduction of LSM always increases welfare

Recent Literature on LSM (2)

- **Atalay, Enghin; Martin, Antoine, and James McAndrews**
  - 2008: The Welfare Effects of a Liquidity-Saving Mechanism.
    Federal Reserve Bank of New York Staff Report No. 331, revised January 2010
    - provides LSM-model for fee-based RTGS
  - 2010: Quantifying the Benefits of a Liquidity-Saving Mechanism. Federal Reserve Bank of New York Staff Report No. 447:
    - quantifies the benefit of a LSM for FEDWIRE
      at more than 500.000 USD a day

Our approach

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- **Martin / McAndrews, 2008:**
  - „Future research in this area can usefully focus on the question of the empirical magnitudes of the parameters of interest. The important parameters in the model are
    - the cost of delay,
    - the cost of borrowing intraday funds from the CB,
    - the relative size of the payments made to the settlement system versus other payments, and
    - the proportion of time-critical payments. […]
    - the probability that queued payments offset.“

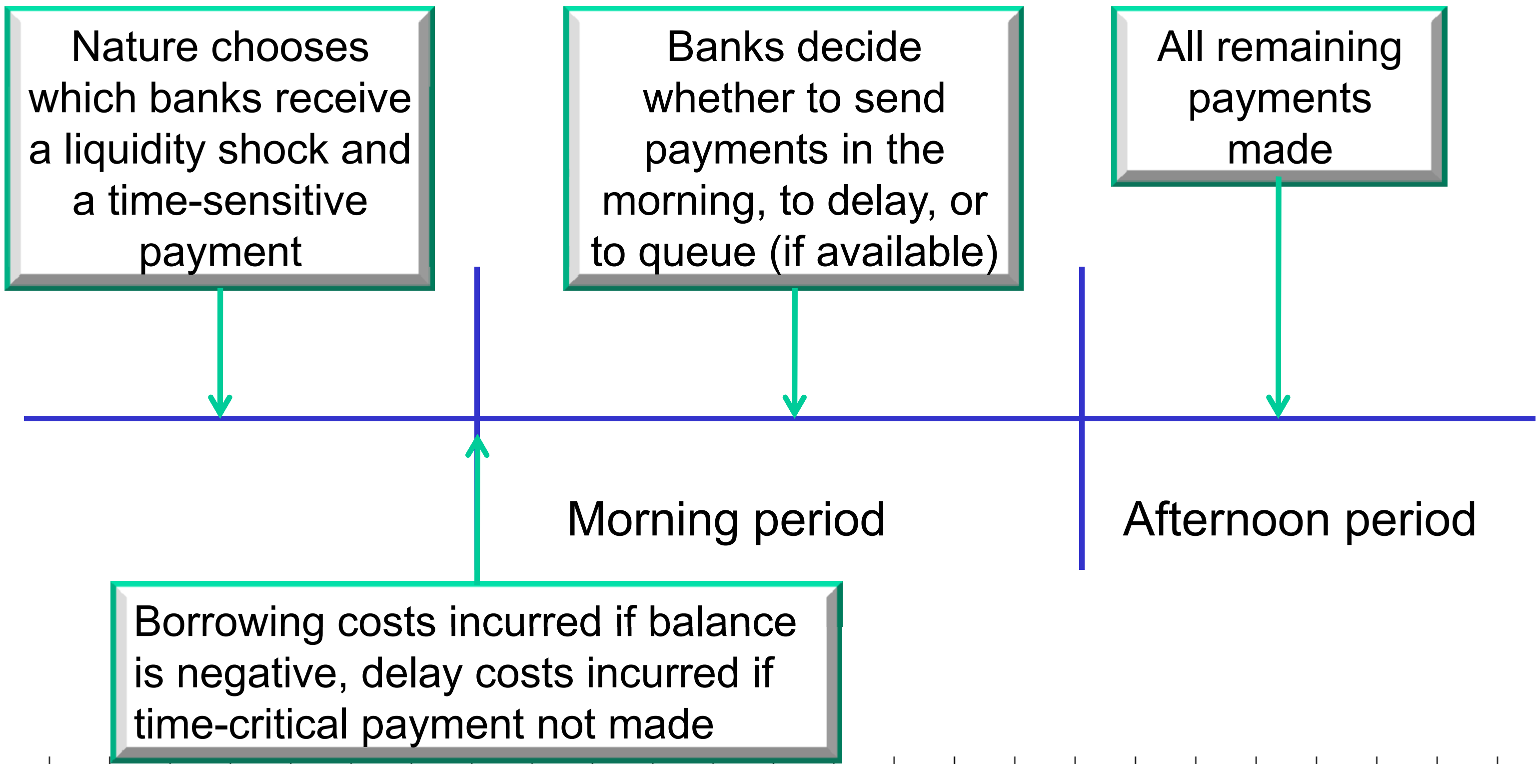
- **That‘s our focus**
  - use the existing models largely unchanged
  - quantify and calibrate with TARGET2 data

Model of Atalay et alii: fee-based (1/5)

- **Set-up**
  - two periods, morning and afternoon
  - unit mass of banks of equal size
  - payments
    - each bank must make and receive one payment a day
    - a fraction of θ of the banks must make a time-critical payment
    - delay costs for delayed time-critical payments of γ
  - liquidity shock = payment to settlement systems
    - a fraction σ receive a positive liquidity shock of size $1-\mu$
    - a fraction σ receive a negative liquidity shock of size $1-\mu$
    - a fraction $1-2\sigma$ receive no liquidity shock
  - banks that have a negative balance at the end of the morning must pay an overdraft fee R

Model of Atalay et alii: fee-based (2/5)

Timeline



Model of Atalay et alii: fee-based (3/5)

Rationale:

- **With LSM banks receive third option**
  - Queuing
  - queue will release payment provided it does not cause the bank to incur overdraft
- **fraction of banks that delay may increase with ratio γ/R (cost of delay / cost of overdraft)**
- **However, strategy is not so simple:**
  - banks form a belief about the probability of receiving a payment in the morning
  - equilibrium depends on probability of liquidity-shock and of time-critical payments
  - for some parameter constellations multiple equilibria coexist
- **six different type of banks**
  - banks with or without time-sensivite payments (s or r)
  - banks with positive, negative or no liquidity shock (s_+, s_-, s_0, r_+, r_-, r_0)

Model of Atalay et alii: fee-based (4/5)

Actions for different banks (equilibrium or social planner) without LSM

Type	s+	s0	s-	r+	r0	r-
1-Equilibrium	E	E	E	D	D	D
2-Equilibrium	E	E	D	D	D	D
3-Equilibrium	E	D	D	D	D	D
4-Equilibrium	D	D	D	D	D	D
1-Planner	E	E	E	E	E	E
2-Planner	E	E	E	E	E	D
3-Planner	E	E	D	E	E	D

Actions for different banks (equilibrium or social planner) with LSM

Type	s+	s0	s-	r+	r0	r-
1-Equilibrium	E	E	E	E	E	E
2-Equilibrium	E	E	E	Q	Q	D
3-Equilibrium	E	Q	Q	Q	Q	D
4-Equilibrium	E	Q	D	Q	Q	D
1-Planner	E	E	E	E	E	E
2-Planner	E	E	E	E	Q	D
3-Planner	E	Q	Q	E	Q	D
4-Planner	E	Q	D	E	Q	D

Model of Atalay et alii: fee-based (5/5)

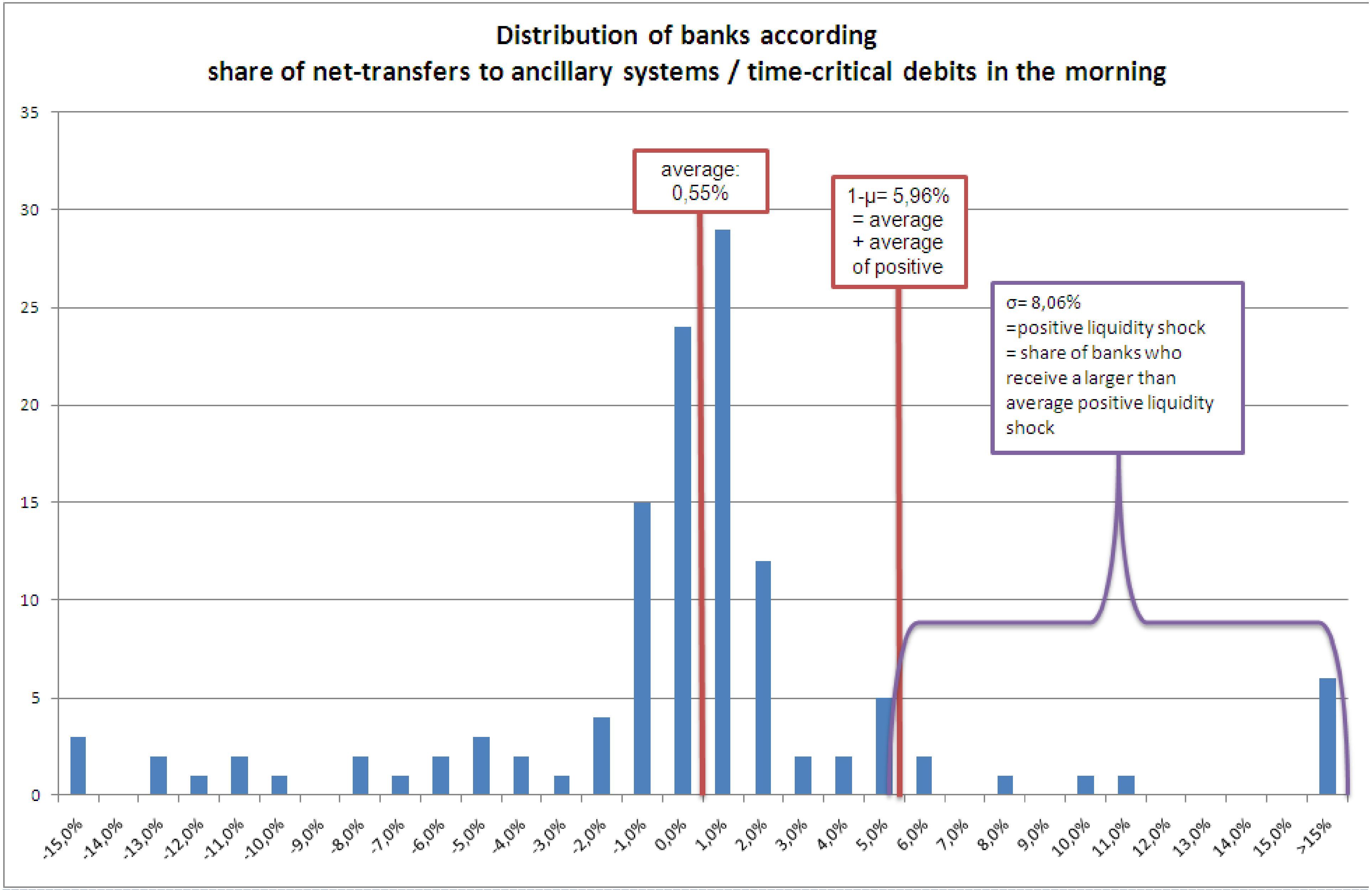
W =	Welfare costs
$-\sigma[(\theta\Lambda^{e}_{s+}+(1-\theta)\Lambda^{e}_{r+})(1-\pi^{0})(2\mu-1)R]$	overdraft costs of banks with positive liquidity shock and who pay early, but did not receive a payment in the morning
$-\sigma\theta\Lambda^{q}_{s+}(1-\pi^{q})\gamma$	costs of delaying a time-critical payment of banks who queued, received a positive liquidity shock and did not receive a payment in the morning
$-\sigma\theta\Lambda^{d}_{s+}\gamma$	costs of delaying a time-critical payment of banks who delayed and received positive liquidity shock
$-(1-2\sigma)[(\theta\Lambda^{e}_{s0}+(1-\theta)\Lambda^{e}_{r0})(1-\pi^{0})\mu R]$	overdraft costs of banks without liquidity shock who payed early
$-(1-2\sigma)\theta\Lambda^{q}_{s0}(1-\pi^{q})\gamma$	delay costs of banks without liquidity shock who queued
$-(1-2\sigma)\theta\Lambda^{d}_{s0}\gamma$	delay costs of banks without liquidity shock who delayed
$-\sigma[(\theta\Lambda^{e}_{s-}+(1-\theta)\Lambda^{e}_{r-})(1-\mu\pi^{0})R]$	overdraft costs of banks with negative liquidity shock who payed early
$-\sigma[\theta\Lambda^{q}_{s-}(1-\pi^{q})\gamma+(\theta\Lambda^{q}_{s-}+(1-\theta)\Lambda^{q}_{r-})(1-\mu)R]$	overdraft costs of banks with negative liquidity shock who queued
$-\sigma[\theta\Lambda^{d}_{s-}\gamma+(\theta\Lambda^{d}_{s-}+(1-\theta)\Lambda^{d}_{r-})(1-\pi^{0})(1-\mu)R]$	overdraft costs of banks with negative liquidity shock who delayed

Quantifying the variables

- **1-μ: size of liquidity shock**

$$1-\mu = \frac{net\ position\ with\ ancillary\ systems}{time-critical\ payments}$$

- **σ= fraction of banks with positive/negative liquity shock**
  - definition of Atalay et alii:
    fraction of banks with larger than average positive/negative liquidity shock
  - in model: assumed to be symmetric
  - in T2-reality: not symmetric
  - yielding two cases
    - start with positive liquidity shocks
    - start with negative liquidity shocks


Distribution of banks according
share of net-transfers to ancillary systems / time-critical debits in the morning
average:
0,55%
1-μ= 5,96%
= average
+ average
of positive
σ= 8,06%
=positive liquidity shock
= share of banks who
receive a larger than
average positive liquidity
shock
0
5
10
15
20
25
30
35
-15,0%
-14,0%
-13,0%
-12,0%
-11,0%
-10,0%
-9,0%
-8,0%
-7,0%
-6,0%
-5,0%
-4,0%
-3,0%
-2,0%
-1,0%
0,0%
1,0%
2,0%
3,0%
4,0%
5,0%
6,0%
7,0%
8,0%
9,0%
10,0%
11,0%
12,0%
13,0%
14,0%
15,0%
>15%

Quantifying the variables (2)

- **θ=fraction of banks with time critical payments**
  - method
    - either bottom-up: questioning banks and concluding from payment behaviour
    - or top-down: according to various payment types
  - Atalay et alii vote for top-down, two cases
    - classify only deliveries of money-market loans as non-time critical (θ=0,4)
    - classify all third-party transactions as non-time critical (θ=0,6)
  - approach with T2
    - banks classify various payments as urgent: cit-company payments, securities settlement, money leg of other trades, exceptional third-party transfers etc.
    - banks‘ quantity estimation yields very low number: θ≤0,07
    - submitted „urgent“ and „highly urgent“ is inconclusive with data
    - following Atalay et alii we classify only customer payments as non-time critical (and delete all technical payments) and receive **θ=0,5**

Quantifying the variables (3)

- **γ=delay costs; R=overdraft fees**
  - Atalay et alii: derive from model
    - if only banks with a positive liquidity shock make payments early, the model implicates: $(1\text{-}\sigma\theta)\mu > \gamma/R \geq (1\text{-}\sigma\theta)(2\mu\text{-}1)$
    - FEDWIRE: R = 0,06 BP
    - therefore Atalay et alii get a range of $0{,}83 > \gamma/R \geq 0{,}738$
    - judging from the payed overdraft fees they conclude R = six basis points and
  - countercheck
    - FBE guidelines: EONIA + 0,25 BP + 100 Euro => in 2010: 0,9377 %
    - Clearstream

Delay costs (in Euro)

minutes	First delay	Second delay	Third and further delay
30 - 60	100.00	200.00	400.00
60 - 90	2,500.00	5,000.00	10,000.00
>90	5,000.00	10,000.00	20,000.00

Quantifying the variables (4)

- **R=overdraft fees**
  - not available in T2
  - or applying the range for γ/R (as Atalay et alii did)
    - yields for the variables in T2 a range $1{,}03\% < R < 1{,}11\ \%$
    - 10 times higher than collateral costs and therefore not applicable
  - approximation : substitute R by κ=cost of collateral
- **κ=cost of collateral**
  - three parts of costs of collateral
    - transaction costs: mostly fix costs
    - depository costs: see e.g. Clearstream
    - opportunity costs: not applied in many banks
  - data from banks: $\kappa \leq 8$ BP
  - costs from Bundesbank: $\kappa \leq 0{,}54$ BP
  - approximation (including fix costs and part of opportunity costs): 1 BP

Results for fee-based model

- **Atalay et alii:**
  - multiplying w=welfare costs with 4,31 trillion USD (total transaction of FEDWIRE Funds and Fedwire Securities)
  - minimum saving of 500.000 USD per day after introduction of LSM
- **T2**
  - comparing the equilibria (Nash-equilibria) by multiplying w with 2,5 trillion Euro (daily turnover of T2)
  - for $1-\mu=0{,}96$ and $\sigma=0{,}14$: **minimum** saving of 45.000 Euro per day
  - for $1-\mu=0{,}94$ and $\sigma=0{,}08$: minimum saving of 58.000 Euro per day
- **Comparison**
  - lack of overdraft fees leads to lower costs
  - LSM => less collateral needs
- **Caveats**
  - model quite sensitive to parameters
  - absolute cost figures not always plausible

Model of Jurgilas and Martin (collateral-based)

- **Main assumptions**
  - heterogenous participants
  - Liquidity shocks (1-μ)
    - net payments to settlement systems which cannot be delayed
    - negative and positive liquidity shocks occur with probability π
  - time-sensitive payments
    - occur with probability θ
    - incur delay costs (γ) if delayed
  - non time-sensitive payments (probality: 1-θ)
  - reputational costs (R) if a payment submitted for settlement does not settle
  - initial collateral (L_0)
    - cost of posting collateral early (κ) is cheaper
    - than cost of additional collateral during the day (ψ)

Model of J&M (collateral-based) (2)

- **sequence**
  - choose amount of initial collateral: L_0
  - observe liquidity shock λ and liquidity in the morning: $L_1=L_0+\lambda(1-\mu)$
  - observe type of payment to be made (time critical or non-time critical)
    - share of time critical payments: θ
    - delay costs for time critical payments: γ
  - submit a payment (P=1) or delay (P=0) until afternoon
  - with LSM decide if to queue (Q=1) or not (Q=0)
  - observe incoming payments
  - post additional collateral at the end of day if needed at costs ψ
- **strategy**
  - minimize sum of delay and collateral costs
  - dependend on liquidity shock, time criticality of payments and on belief about probality to receive a(nother) payment in the morning (ω)

Model of J&M (collateral-based) (3)

- **solution for RTGS without LSM**

$$\min_{L_0} \mathop{\mathrm{E}}_{\lambda,\gamma}\left[\min_{P} \mathop{\mathrm{E}}_{\phi(\omega)}(C_1 + C_2)\right]$$

$$C_1 = \kappa L_0 + PI(L_1 < \mu)\left(1 - \omega^i\right)(R + \gamma) + (1 - P)\gamma$$

$$C_2 = \left[(1 - P)\left(1 - \omega^i\right) + PI(L_1 < \mu)\left(1 - \omega^i\right)\right] \max\{\mu - L_1, 0\}\, \Gamma$$

$$\Gamma = \frac{(1 - \tau_s)^{n-1}}{n}\psi < \psi$$

- **strategy as a symmetric subgame perfect Nash equilibrium strategy:**
- **stable beliefs about ω^s, ω^i**

Model of J&M (collateral-based) (4)

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- **optimal collateral choice for RTGS without LSM**
  - (i) if (1-μ)κ<γθ(1-π) and (2μ-1)κ<γθ(1-π)
    L0=μ, ωi=1-π, P*=1 für λ=0,1 und 0 für λ=-1
  - (ii) if (1-μ)κ>γθ(1-π) and (3μ-2)κ<γθπ
    L0=2μ-1, ωi=1-π, P*=1 für λ=1 und 0 für λ=-1,0
  - (iii) if (3μ-2)κ>γθπ and (2μ-1)κ>γθ(1-π)
    L0=1-μ, ωi=0, P*=0

- **social planner solution for RTGS without LSM**

$$L_0 = 1 - \mu, \qquad P(\lambda, \gamma, L_0) = 0, \qquad \omega^i = 0 \ \forall \lambda, \gamma$$

$$if\ (3\mu - 2)\kappa > \gamma\theta$$

  - otherwise:

$$L_0 = 2\mu - 1, \qquad P(\lambda, \gamma, L_0) = 1, \qquad \omega^i = 1 \ \forall \lambda, \gamma$$

Model of J&M (collateral-based) (4)

- **with LSM**

$$\min_{L_0} \underset{\lambda,0}{\mathrm{E}} \left[\min_{P,Q} \underset{\phi(\omega)}{\mathrm{E}} (C_1 + C_2) \right]$$

$$C_1 = (1-Q)\left[PI(L_1 < \mu)\left(1-\omega^i\right)(R+\gamma) + (1-P)\gamma\right] + Q(1-P)(1-\omega^q)\gamma + \kappa L_0$$

$$C_2 = \left\{(1-Q)\left(1-\omega^i\right)[(1-P) + PI(L_1 < \mu)] + Q(1-P)(1-\omega^q)\right\} x \max(\mu - L_1, 0)\Gamma$$

- **optimal collateral choice with LSM (equilibrium and social planner):**

$$\boldsymbol{L_0 = 1 - \mu, \qquad P(\lambda, \gamma, L_0) = 0, \qquad Q(\lambda, \gamma, L_0) = 1\ \forall \lambda, \gamma \ \ \omega^q = 1}$$

Quantifying the model of J&M (1)

- **calibration of CHAPS**
  - J&M calculate that the current level of collateral could be reduced by 50% after introduction of LSM
  - using the following variables
    - size of liquidity shock: $1-\mu = 0{,}062$
    - probality of liquidity shock: $\pi = 0{,}24$
    - current level of collateral $L_0 = 0{,}14$
- **calibration of T2**
  - using the following variables
    - size of liquidity shock: $1-\mu = 0{,}0596$
    - probality of liquidity shock: $\pi = 0{,}0806$
    - actual collateral used is only 90 per cent of minimum result for model (case of RTGS + LSM)
    - explanation: T2 uses already LSM and more features

Quantifying the model of J&M (2)

- **welfare effects were not quantified by J&M**
- **quantifying the model with T2-data:**

Variables		
γ (case iii)	delay cost	0,0001
γ (case i)	delay cost	0,0005
μ	size of payment to banks	0,9404
1-μ	size of a payment to the settlement systems	0,0596
λ	bank's liquidity shock	
π	probability of λ=1 and λ=-1	0,0806
θ	probability that payment to another bank is urgent	0,5
κ	cost per unit of initial collateral level	0,00009999
ψ	cost of additional collateral during the day	0,0001
R	resubmission or reputational cost for submitted payment inspite of insufficient reserves	0,0001
n	number of banks	186
T	relevant turnover for German banks	6,08896E+11

Quantifying the model of J&M (3)

- **welfare effects of LSM in T2**

	Daily savings (in Euro) after introducing LSM	
	vs. RTGS (Nash-Equilibrium)	vs. RTGS (social planner)
case (i)	292.326,53	138.882,05
case (iii)	169.943,10	169.943,10

- **discussion of welfare effects of LSM in T2**
  - **range is comparable to quantification of Atalay et alii given the lower turnover (only DE)**
  - **effects of LSM quite significant**
  - **model seems more applicable to T2**

Discussion

- **Idea**
  - to use another ones‘ model and calibrate with T2-data
  - sticking as close to the model as possible
  - using similar methods for quantifying the variables
- **problems**
  - quantification is not always free of doubts
    - e.g. liquidity shock and share of time critical payments
  - comparability of different LVPS is hampered
- **useful model extensions**
  - enhance heterogeneity of banks: apply different costs for collateral
  - widen rationale for banks: tracking bilateral balances (see use of bilateral limits)