Risk-focused Approach to Oversight

Harry Leinonen
24 November 2010

The views expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.
Area of oversight

Macro-prudential supervision
- Impact of general economic conditions on financial sector

Oversight of
- Payment systems
- Securities settlement systems
- Basic Financial Infrastructures

(Micro) supervision
- Supervising and assessing individual financial institutions

Relationships with other types of supervision and some areas of overlapping interests
Oversight
risks versus efficiency focus

Stability
- trust
- failures
- losses
- reliability

Efficiency
- general service benefits
- costs & precautions
- service/development speed
- competition force

Oversight has two different focuses
between which there often exist a tradeoff
Oversight balance between stability and efficiency

**Business developments**
- Increasing globalisation
- Increasing inter-dependence
- 24/7 business continuity

**Stability oversight developments**
- International cooperation
- New robustness criteria
- Continuous monitoring and reaction speed

**Too-slow business developments**
- Improved standardisation
- Increased harmonisation
- Changing customer needs

**Efficiency oversight developments**
- Coordination support
- Assessment of alternatives
- Research on public needs

**Oversight needs to react on favorable, unfavorable and non-existent business developments**
Oversight policies, stances, methods and tools need to be continuously updated according to the changing needs.

Global issues will require global solutions and cooperation.
BIS/G-10 Core Principles for systemically important payment systems

I. Wellfounded legal basis
II. Clear understanding of financial risks of participants
III. Procedures for managing financial risks
IV. Prompt (at least by end of day) final settlement
V. Multilateral netting systems should be able to make daily settlement even when its largest participant fails.

VI. Settlement asset CB-money or very low-risk asset
VII. High degree of security and reliability
VIII. The system should be efficient for its users and the economy
IX. Fair and public access criteria
X. Efficient and transparent governance

The Core Principles have become a general norm for payment system oversight
Central Bank responsibilities in applying Core Principles

A. To define its payment system objectives and publicly disclose its role and major policies

B. To ensure own systems operate according to CP

C. To oversee that systems operated by others comply with CP

D. To cooperate with other central banks and authorities to promote system safety and efficiency

The Core Principles are widely employed
CPSS-IOSCO recommendations for securities settlement systems

1. Well-founded, transparent legal basis
2. Trade confirmation asap not later than T+0, for indirect no later than T+1
3. Rolling settlement no later than T+3
4. Evaluation of well-controlled CCP
5. Encouragement of securities lending
6. Immobilised and dematerialised book-entry in CSDs
7. Delivery versus payment required
8. Finality no later than end of settlement day
9. CSD risk controls and timely settlement even when largest particip. fails
10. CB-money or low risk settlement asset
11. Operational reliability and contingency plans
12. Protection of customers’ securities
13. Proper governance
14. Fair, open and public access criteria
15. Systems should be cost-efficient and meet user requirements
16. International communication procedures and standards
17. Risk and cost transparency
18. Systems should be subject to transparent and efficient regulation and oversight
19. Reduction of cross-border risks

These recommendations are quite widely employed
Authority/oversight challenges

- **Increased globalisation**
  - How to oversee multinational and foreign service providers?

- **Higher speed/shorter reaction times**
  - Do we need real-time oversight?

- **More consolidation**
  - How to ensure competition and efficiency in mono/oligopolies?

- **Deeper integration among participants**
  - How to ensure integration works correctly in exceptional situations?

- **Increased interdependence**
  - How to control critical components and ensure effective back-ups?

- **Larger risks of wider contagion**
  - How to identify critical relationships and ensure proper risk controls?

- **Greater complexity of markets and infrastructures**
  - How to understand/test market reactions to exceptional situations and authority actions in those?

*Need for in-depth studies, preparations and simulations*
Risks are part of financial systems they cannot be completely avoided.

They need to be recognized in order to design risk mitigation procedures and contingency/backup solutions.

Risks need to be reduced to acceptable levels.
Figure 1. Classification of payment system risks

- Credit risks
  - Bank credit risks
  - Customer credit risks

- Liquidity risks
  - Variation risks
  - Availability risks

- Operational risks
  - Information technology system risks
  - Administrative risks
  - Crime risks
  - Risks of changes in legislation or market practices
  - Loss-of-confidence risks
  - Technological change risks
  - Catastrophe risks

- Environmental risks
  - System risks
  - Collateral risks
  - Settlement cancellation risks

- Clearing and settlement risks
  - Bank risks
  - Market risks
  - Technology risks

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### Table 3.

**Risk classification of payment services/products**

<table>
<thead>
<tr>
<th>Realisation loss</th>
<th>Negligible</th>
<th>Very small</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td></td>
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</table>

**Realisation probability**
Risk concepts

- Bank-specific risks, affect individual banks
- System-specific risks, affect a given payment system or segment of it
- Systemic risks, affect the whole financial system

Please, note the difference between system-specific and systemic risks
### Table 2. Risk grading of credit transfer system

<table>
<thead>
<tr>
<th>Risk level/ Risk type</th>
<th>System-specific</th>
<th>Bank-specific</th>
<th>Systemic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credit risks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank credit risks</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Customer credit risks</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Liquidity risks</strong></td>
<td>None</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td><strong>Operational risks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information system risks</td>
<td>Minor</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Administrative risks</td>
<td>None</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Crime risks</td>
<td>Minor</td>
<td>Minor</td>
<td>None</td>
</tr>
<tr>
<td><strong>Environmental risks</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risks of changes in legislation or market practices</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Loss-of-confidence risks</td>
<td>Minor</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Technological change risks</td>
<td>Minor</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Catastrophe risks</td>
<td>Minor</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td><strong>Clearing and settlement risks</strong></td>
<td>Ei</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>System risks</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Collateral risks</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Settlement cancellation risks</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Systemic risk</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Stress testing

♦ Systems can be tested for shock resistance
♦ Backup systems can be tested
♦ Participants’ shock readiness can be tested
♦ Personnel can be trained using testing models

♦ Different techniques available
  – Risk scenarios
  – Analytic calculations
  – Process/procedure simulations
  – Numeric simulations

The financial crisis made stress testing topical
Advantages of simulation studies in payment systems

- system complexity
- network structure and interdependencies
- hidden risks and other characteristics
- what if – testing of internal/external shocks
- pretesting changes in system parameters/policies
- general applicability

Simulation studies assist in understanding the structures and dependencies in payment systems
System complexity

- Large systems often with several thousand participants
- Large volumes (often > 100,000 transactions/day)
- Each participant can have different behavioural patterns and processing limits towards other participants
- The system community can define market rules
- The settlement agent/bank stipulates different account rules on the settlement accounts and provide incentives for given types of processing
- The system contains processing rules for different kinds of situations
- The authorities can regulate payment and settlement processing

*Models based on simulation are closer to reality than models based on calculus*
Network structure and interdependencies

♦ Payment = debit on one and credit on another account
♦ Processed payments create an intraday transaction flow
♦ An interbank payment requires updating of interbank positions at a settlement bank (generally central bank)
♦ Interbank settlement requires liquidity (funds to transfer)
♦ Banks are dependent on the liquidity
  – available on the settlement account,
  – the incoming liquidity from other banks and
  – the outgoing liquidity from their transactions
♦ Banks operate in several parallel payment systems with liquidity effects on each other
♦ Transactions can have transaction level dependencies
  – in the form of PVP (payment-versus-payment) and
  – DVP (delivery-versus-payment) rules

Compared to other transaction flows, payments must also transfer the money value between all participants
Payment systems and their participants are dependent on an even and predictable transaction flow.

Some nodes (banks) and relationships (links) are more critical than others.
Hidden risks and other characteristics

Generally payment systems work without problems, but …

♦ Hidden single point of failures may stop the physical flow
♦ Liquidity drainage can stop the settlement flow
♦ Some systems build up credit risk exposures during the day, which can generate domino-effects in crises
♦ The interdependencies between systems and their participants can transmit problems throughout the system

Simulations can be used to disclose the hidden characteristics of real systems
Robustness towards shocks

- Small external shocks can affect the whole system
- What if
  - a central participant experiences operational problems?
  - the largest participant fails to settle?
  - one ancillary system is delayed or stops running?
  - the liquidity market and other liquidity sources function abnormally?

Checking impact with simulations improve readiness for external and internal shocks
Pretesting policy changes/decisions

♦ Small changes in system designs and rules can have a big impact

♦ What if
  – liquidity supply rules changed?
  – queuing options are changed?
  – new kinds of liquidity saving mechanisms/algorithms are introduced?
  – risk mitigation features are changed?
  – opening hours are changed?
  – new participants are accepted or old excluded?

*Checking impact with simulations improve policy decisions and readiness for change*
General applicability

♦ Central banks can use payment simulations in
  – The payment and settlement system oversight work
  – Preparing payment and settlement system policies
  – Managing operational services
♦ Clearing centres and other service providers the tools for
  – Developing system rules and practices
  – Improving the efficiency of the system
  – Assessing the risks in the provided services
♦ Academics have increased their interest in
  – Payment system research on efficiency & risks
  – Modelling systems and participant behavior

The application area of simulations seem to grow rapidly
Three pure types of payment systems

- Deferred net settlement systems (=DNS) collect all transactions to a given, mostly, end-of-day settlement
  - Only net liquidity needed, all payments are delayed, no credit risked when payments are stopped due to insufficient liquidity
- Continuous net settlement systems (=CNS) process continuously payments and updates settlement positions which will be settled only later (mostly at end-of-day)
  - Payments are credited to customers before interbank settlement, which results in credit risks supporting rapid delivery
- Real-time gross settlement systems (=RTGS) process payments continuously by also making final settlements
  - Payments can be credited directly to customers as these are settled directly, but this will require more intraday liquidity

Most of the real systems are some kind of hybrid systems containing a mix of features
System type and cost structures

**Settlement-delay costs**

- Pure DNS system in which settlement and processing is delayed until e-o-d
- Mixed/hybrid system A
- Mixed/hybrid system B
- Credit-risk costs

**Liquidity-usage costs**

- Pure RTGS system with sufficient liquidity and collateral
- Pure CNS-system with no credit limits and no collateral

All dimensions carry direct or indirect costs and risks

- Intraday liquidity used in payment systems carry costs in the form of an interest rate or a collateral (alternative) cost.
- Extended credits carry always a risk and thereby a cost, which can partly be reduced by collateral, but collateral carries also costs for its provider.
- Delays can have costs in the form of penalties or other delay charges, but also in the form of "bad will" or reduced trust.
- An inefficiently functioning system will have higher costs than necessary.

Minimising system costs requires thorough analysis of the cost factors.
Mixed/hybrid systems balance cost factors
RTGS can speed up processing

RTGS benefit over DNS when same liquidity is used during the day

Upper bound
= everything settles immediately

Lower bound
= everything settles at least by e-o-d

Gridlock algorithms can decrease liquidity needs and settlement delays

Participants’ decisions affect the others, some participants may be free-riders in RTGS

- Participants select generally their liquidity levels
- Reducing liquidity towards lower bound, will delay outgoing payments
- Reduced outgoing payments, will decrease incoming payments, which could trigger new outgoing payments
- Some "free-riding" participants may reduce their liquidity anticipating that others will send off payments as before, providing them (=free-riders) with incoming liquidity

Simulation studies can be used to discover efficient liquidity level, assess liquidity risks and possible free-riders
Risk mitigation and liquidity drainage limits

♦ In CNS systems participants use multilateral on bilateral debit caps to reduce credit risks
♦ In RTGS systems this corresponds to bilateral or multilateral net sending limits which reduces ”liquidity drainage” risks
♦ Liquidity drainage can occur eg when central participant experiences operational problems hindering its outgoing payment flow = it becomes a “liquidity sink”
♦ Debit caps and net sending limits can both be used too little, fairly and too protectively

The market, system owner or authorities may prescribe suitable or minimum limits to be used
System linkages and liquidity bridges

- Most payment systems are integrated and interlinked due to ICT-developments.
- Typically ancillary systems such as retail DNS systems and real-time securities settlement systems use the central bank accounts in RTGS systems for settlement.
- There are several types of system linkages:
  - End-of-day or settlement cycle net settlement transfers.
  - Liquidity bridges for transferring liquidity between systems.
  - DVP- or PVP-based transfers with the different legs (money or security) in two interconnected systems.
- Systems linkages make systems dependent on each other.

_The linked systems create large networks by themselves in the global financial markets._
Possible multisystem structures

Domestic currency

- RTGS-1

Foreign currencies

- RTGS_j
- RTGS_k

Security currencies

- RTGS_m
- RTGS_n

bonds

shares

PVP-condition

DVP-condition

Intraday liquidity injections

CNS-level

- CNS_p

End-of-period RTGS settlement

DNS-level

- DNS_r
- DNS_s

End-of-period RTGS settlement

End-of-period RTGS settlement

Growing financial and ICT integration increase the number of system linkages


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Back-up facilities

- Payment and settlement systems form the backbone of modern economies
- Without these economic activities would be difficult to settle
- High reliability is required from all kind of systems
- Payment and settlement systems therefore need to have well-designed back-up systems
- When payments are of different urgencies, the top back-up facilities can be designed for highly urgent payments only

Simulation models can be used to check the functioning and capacity of back-up solutions
How true to nature?

- Real payment systems contain a multitude of detailed processing rules and conventions
- Behavioural patterns can be stable but also random with unanticipated changes
- Participant numbers and transaction volumes can be huge in large systems
- Simulation technology gives the possibility to design models that are true to nature

The complexity of the simulation models should be designed according to research needs
Input data close to production data would include ...

- System level data describing the processing conventions of the system
- Transaction data with or without DVP/PVP-linkages
- Basic participant data
- Beginning of day liquidity (settlement account) balances
- Intraday credit provisions
- Bilateral or multilateral debit caps and/or sending limits
- Behavioural patterns of participants

The “real and hard” data is generally available, however the “soft behavioural” data is seldom available and it is difficult to describe:

How do markets react to new types of shocks?
**Transaction driven simulations**

*Basically same events occur in the same sequence in simulations as in real-systems.*

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**Source:** Harry Leinonen (ed) Liquidity, risks and speed in payment and settlement systems - A simulation approach, Bank of Finland Studies E:31. 2005 / Leinonen& Soramäki Introduction p29
A typical simulation project structure

- Define and obtain input data
  - Participants/accounts, transactions, system data
  - Historic data can be difficult to obtain
  - Behavioural parameters for agent-based models are difficult to define
- Build the simulator for simulations
  - Ready made or using programming or modelling tools
- Execute simulations
  - Different background data, different parameters
  - Good preplanning helps in massive simulations
- Analyse results
  - Find suitable comparison points
  - Possibilities for international comparisons are growing
- Reiterate
  - Simulations are often learn-by-doing processes

*Large simulations are time-consuming*
Simulations are only simulations

♦ Historic data is history, not the future
♦ In historic data abnormal situations are rare
♦ Treasurers’ payment behaviour and preferences are mainly unknown and especially in new circumstances
♦ Behaviour in stress situations can be surprisingly different
♦ The results take mostly the form of probability outcomes

*Despite its weaknesses simulations provide important insights to the complex payment processes*
## Available payment and settlement simulation studies

<table>
<thead>
<tr>
<th>Network analysis *</th>
<th>Liquidity analysis</th>
<th>Credit risk analysis</th>
<th>Delay/queuing analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oversight</td>
<td></td>
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<tr>
<td>2 USA, UK</td>
<td>23 FIN, UK, SWE, CAN, AUT, JPN, SUI, HOL, HUN, DEN, POL, NOR, ROM, BIS</td>
<td>16 ISL, UK, CAN, FIN, AUT, JAP, SUI, HOL, DEN, POL, BIS</td>
<td>14 DEN, FIN, UK, SWE, CAN, AUT, JAP, HOL, HUN, POL</td>
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<td>Operational development issues</td>
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<td>4 ISL, CAN, UK, FIN</td>
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<td>4 USA, FIN, JAP, BIS</td>
<td>5 USA, DEN, FIN, UK</td>
</tr>
</tbody>
</table>

**Source:** Bank of Finland Payment and Settlement Simulation seminars 2003-2009

[see www.bof.fi/sc/bof-pss]
Typical oversight studies

♦ Network analysis
  – Which are the most important participants and connections?
  – Do connections vary during the day and from day to day?
  – What are the end-of-day and overnight patterns?
  – How would the network change during outages?

♦ Liquidity analysis
  – What are the current liquidity levels and effects of general drainage?
  – What is the impact of large participants’ liquidity problems or stoppage?
  – Are some participants working with too low liquidity levels?
  – How large shocks can the current liquidity supply sustain?

♦ Credit risk analysis
  – How large are the current credit risk levels and systemic risk probabilities?
  – By how much will credit risks grow in crisis situations?
  – To what extent can participants sustain current credit limits?
  – What impact will more stringent credit risk requirement have?

♦ Delay/queuing analysis
  – What effect will large participants’ and system stop have on delays?
  – Do some participants delay payments more than others?
**Example 1: Liquidity effects of a participant-level operational disruption in the Swiss Interbank Clearing**

- Simulations with May 2004 data: 13 million payments worth SFR 3 bn
- 1 or 2 major participants’ payment submissions are disrupted at ”worst” point
- Results:

<table>
<thead>
<tr>
<th></th>
<th>Number of transactions</th>
<th>Value of transactions in million CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily</td>
<td>% (minimum to maximum)</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td></td>
</tr>
<tr>
<td>May 2004</td>
<td></td>
<td></td>
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<tr>
<td>Settled transactions</td>
<td>661'000</td>
<td>92 (85 to 98)</td>
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<tr>
<td>Unsettled transactions -</td>
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<tr>
<td>direct effect</td>
<td>32'000</td>
<td>4 (1 to 7)</td>
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<td>Unsettled transactions -</td>
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<tr>
<td>systemic effect</td>
<td>26'000</td>
<td>4 (0 to 9)</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>719'000</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: M. Glaser – P. Haene in Bank of Finland publication E:42
Typical policy studies

♦ Network analysis
   – What would be the impact of new participant access criteria?
   – What is the current level of tiering and the impact of possible changes?
   – What is the network characteristic of prioritised transactions?

♦ Liquidity analysis
   – What is the impact of new liquidity regimes
   – What would be the effects of new liquidity pricing schemes?
   – What would be the impact of different prioritising regimes?
   – What would be the most efficient liquidity/delay levels?

♦ Credit risk analysis
   – What would be the impact of new credit risk rules?
   – What would be the most efficient credit risk/delay levels?

♦ Delay/queuing analysis
   – What could be the effects of new rush-hour pricing policies?
   – Which gridlock resolution algorithms would be most efficient for given payment flows?
   – What are the effects of bypassing FIFO or other processing order rules?
   – What are the effects of new opening hour rules?
Example 2: Risks and efficiency gains of the tiered structure in CHAPS (UK)

- Simulations with June 2005 data: 2.5 million payments worth GPB 4.2 trillion
- Increasing tiering by reducing number of direct participants i.e. moving small banks to become indirect participants of major banks
- Results: Substantial liquidity savings, but increased node and credit risks

Source: A. Lasaosa – M. Tudela in Bank of Finland publication E:39
Typical operational studies

♦ Network analysis
  – What are the current capacity profiles and bottlenecks?
  – How would different shocks change the capacity profiles?
  – How much capacity do different prioritising schemes for different system outage scenarios require

♦ Liquidity analysis
  – What effects would different kinds of marked-based synchronisation and timing rules have?
  – What impact would shifting volumes between different systems have?
  – What are the effects of different types of liquidity bridges?
  – How fast should liquidity expansion operations be?

♦ Credit risk analysis
  – How fast do credit limit change procedures need to be?

♦ Delay/queuing analysis
  – What would be the effects of introducing prioritising, queuing and gridlock resolution features?
  – How efficiently are current prioritising, queuing and gridlock resolution features used?
  – How would algorithms’ parameter changes affect overall queuing?
Example 3: Effects of gridlock resolution mechanisms in Danish and Finnish RTGS systems

- Simulations for last 64 days/1999 in Denmark (daily average EUR 9.4 bn and 925 transactions) and last 100 days/2000 in Finland (daily average EUR 15 bn and 1428 transactions)

- A partial net-settlement gridlock solution algorithm is tested

Results:

**Trade-off between liquidity and delay**

Typical basic research studies

♦ Network analysis
  – What are current network structures in different systems?
  – Are there typical trends in network structure changes?
  – Are there differences in marked-driven and society-optimal network structures?

♦ Liquidity analysis
  – Do liquidity levels vary across systems and countries?
  – Are there typical trends in liquidity provision regime changes?
  – What are the differences between public and private liquidity regimes?

♦ Credit risk analysis
  – Are there general warning signals for increased systemic risk?
  – How could systemic risk probabilities be best measured?
  – What are the historic correlations between systemic risks and participants credit risks?
  – What are the efficiency and risk concerns of private vs public credit risks?

♦ Delay/queuing analysis
  – Can general optimality among gridlock algorithms be established?
  – Are there differences among service providers’ and customers’ preferences?
Example 4: Simulating the impact of a hybrid receipt reactive processing convention in CHAPS

- Simulations using artificial and CHAPS (UK) data
- Testing the impact of introducing a receipt reactive processing convention

Results: RRGS (receipt reactive) processing can achieve a level of welfare that weakly dominates that achievable under RTGS

Source: K. Ercevik – J. Jackson in Bank of Finland publication E:42
Understanding payment processes better

- Payment systems have often been seen as "black boxes"
- Only critical situations have generated more focus on these important parts of the economies
- Payment research has been growing since early 1990s
- Deeper understanding have resulted in core principles (BIS/CPSS), recommendations and standards for efficient payment and settlement systems
- System requirements seem to become harmonised globally
- International cooperation regarding multinational and multicurrency systems will become necessary

Understanding the “hard facts” of payment systems have increased and it seems know be the time to focus on the “soft parts” of payment processing
Improved behavioural modelling

♦ Which factors steer banks payment submission behaviour?
♦ Which factors steer banks counterparty reactions in different situations?
♦ What affect banks behaviour in crisis situations?
♦ How can the payment behaviour of large institutional investors and large companies etc be modelled?

*We will need more basic research on the underlying behavioural factors*
Deeper knowledge of critical risks

♦ Financial turmoil has brought back focus on financial risks and the need to secure sufficient liquidity
♦ Payment systems have often embedded risk factors and authorities have need to penetrate deeper into critical risk factors
♦ Global real-time payment processing will require fast response times in problem situations both by participants and authorities

*The development speed seems to accelerate and all concerned parties need to update their information on critical risk issues*
Expanded simulation models

- From payment systems to general market stability simulations
- From interbank system simulations to customer-level models
- From very simple behavioural models to more complex models

Today, computer capacity is no limitation for building even comprehensive “economy-level” simulation models, but we lack sufficiently reliable behavioural information
Summary of development visions

♦ The research on payment and settlement systems has steadily grown since the 1990s
♦ Systems have become more standardised and harmonised
♦ The topic of payment behaviour will need more research
♦ ICT developments will provide improved high-capacity tools

Simulation models of payments systems will still improve and become more versatile (from second generation to third generation models)
Thank you for your interest.

Q & A

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Section VI: Further reading


You can find more information on the web-site www.bof.fi/sc/bof-pss and in the list of published studies after the last slide
Oversight studies with publically available results I

**Finnish BoF-RTGS** - assess liquidity effects of introduction of TARGET and the shift to a greater use of RTGS settlement – results published 1997 in BoF E:14

**Iceland’s Sedlabanki** - netting vs. real-time gross settlement - setting credit limits for the system, 1999

**Bech and Soramäki (2002)** ‘Liquidity, Gridlocks and Bank Failures in Large Value Payment systems’, E-Money and Payment systems Review (Bech-Soramäki)

**Paul Bedford - Stephen Millard - Jing Yang, BoE**: Analysing the impact of operational incidents in large-value payment systems: A simulation approach, 2005

**Johan Pettersson, Sveriges Riksbank**: Liquidity levels and delays in RIX, 2005

**Darcey McVanel, Bank of Canada**: The impacts of unanticipated failures in Canada's Large Value Transfer System, 2007

**Matti Hellqvist, Bank of Finland**: Stress testing securities settlement systems using simulations, 2007

**Claus Puhr, Stefan W. Schmitz / Oesterreichische Nationalbank**: Risk Concentration and Operational Risk in Payment Systems – A Simulation Approach, 2007

**Kei Imakubo, Yutaka Soejima / Bank of Japan**: Intraday Settlement Activities in the BOJ-NET RTGS, 2007
Oversight studies with publically available results II


Matti Hellqvist / Bank of Finland: Stress testing liquidity needs in Finnish retail securities settlement system, 2007

Martina Glaser, Philipp Haene / Swiss National Bank: Simulation of participant-level operational disruption in Swiss Interbank Clearing, 2009

Ronald Heijimans / De Nederlandsche Bank: Stress simulations: A Dutch case, 2009

Ágnes Lublóy, Eszter Tanai / Magyar Nemzeti Bank: Operational Disruption and the Hungarian RTGS system VIBER, 2009

Neville Arjani and Lana Embree, Bank of Canada: Consolidation in Canada's LVTS: A Simulation Study

Kristian Sparre Andersen and Irene Madsen, Danmarks Nationalbank: A quantitative assessment of international best practices in relation to business continuity arrangements in payment systems, 2009

Matti Hellqvist, Bank of Finland: Implicit intraday counterparty limits in large value payment systems, 2009
Oversight studies with publically available results III

Jenni Koskinen, Bank of Finland: The liquidity impact of merging bond and equity settlement systems, 2007

Agnieszka Grat-Osinska - Miroslaw Pawliszyn: Liquidity Levels and Settlement Delays in the Sorbnet System-Simulation-Based Approach With the Application of the BOF-PSS2 Payment, 2007


Policy studies with publically available results I

**Finnish BoF-RTGS** - assess liquidity effects of introduction of TARGET and the shift to a greater use of RTGS settlement – results published 1997 in BoF E:14

**Iceland’s Sedlabanki** - netting vs. real-time gross settlement - setting credit limits for the system, 1999


**Bank of Korea** – alternative liquidity provision, optimisation methods, 2002

**Leinonen and Soramäki (1999)** ‘Optimizing Liquidity and Settlement Speed in Payment Systems’, Discussion Paper, Bank of Finland


**Bech and Soramäki (2002)** ‘Liquidity, Gridlocks and Bank Failures in Large Value Payment systems’, E-Money and Payment systems Review (Bech-Soramäki)

**Johan Pettersson, Sveriges Riksbank**: Liquidity levels and delays in RIX, 2005

**Neville Arjani, Bank of Canada**: Examining the Balance between Risk and Efficiency in Canada’s LVTS: A Simulation Approach, 2007
Policy studies with publically available results II

Matti Hellqvist, Bank of Finland: Stress testing securities settlement systems using simulations, 2009

Morten Bech and Kurt Johnson, Federal Reserve Bank of New York: BoF-PSS 2.0.0 A tool for policy analysis

Kemal Ercevik, John Jackson / Bank of England: Simulating the impact of hybrid functionality on CHAPS banks, 2009

Kristian Sparre Andersen and Irene Madsen, Danmarks Nationalbank: A quantitative assessment of international best practices in relation to business continuity arrangements in payment systems, 2009

Jenni Koskinen, Bank of Finland: The liquidity impact of merging bond and equity settlement systems, 2007

Agnieszka Grat-Osinska - Miroslaw Pawliszyn: Liquidity Levels and Settlement Delays in the Sorbnet System-Simulation-Based Approach With the Application of the BOF-PSS2 Payment System Simulator (SSRN, Financial Markets and institutions, May 2007)


Operational studies with publically available results I

Iceland’s Sedlabanki - netting vs. real-time gross settlement - setting credit limits for the system, 1999


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Research studies with publically available results I


**Leinonen and Soramäki (1999)** ‘Optimizing Liquidity and Settlement Speed in Payment Systems’, Discussion Paper, Bank of Finland

**Morten L. Bech, FED NY. - Kurt Johnson, FED NY. - Kimmo Soramäki, ECB**: System Simulating the Fedwire ® Securities Service

**Elisabeth Ledrut / Bank for International Settlements**: Tit for Tat in Payment Systems, 2007

**Kei Imakubo, Yutaka Soejima / Bank of Japan**: Intraday Settlement Activities in the BOJ-NET RTGS, 2007