Congestion and Cascades in Coupled Payment Systems

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Joint Bank of England / ECB Conference on “Payments and monetary and financial stability”
Frankfurt 12 November 2007

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Speaker: Fabien
Overview

- Motivation
- Single RTGS model
- Coupled RTGS model
- Correlation between the 2 RTGS systems
- FX settlement risk under non-PvP
- Queuing under non-PvP and PvP
- Conclusion

Speaker: Fabien
Motivation

- The 2001 Group of Ten "Report on Consolidation in the Financial Sector" (the Ferguson report) noted a possible increased interdependence between the different systems due to:
  - The emergence of global institutions that participate to many systems
  - The emergence of global service providers offering services to many systems
  - The development of DvP procedures linking RTGS and SSS
  - The development of CLS

- The report suggested that these trends might accentuate the role of payment and settlement systems in the transmission of disruptions across the financial system.

- To complement this previous work, the CPSS (Committee on Payment and Settlement Systems) commissioned a working group to:
  - describe the different interdependencies existing among the payment and settlement systems of CPSS countries
  - analyze the risk implications of the different interdependencies

Speaker: Fabien
Motivation

- Could a modeling approach provide any useful additional information to the regulators?
- So far, payment and settlement system modeling has been mainly limited to a single system, with a few exceptions.
- We model the interactions between 2 RTGSs.
- Our model include two forms of interdependencies, as observed by the Working Group.

- Real data will not be available at individual level... need for generated data.

Speaker: Fabien
Single RTGS model
Model description

- RTGS$^5$ is a “virtual” RTGS
- The value of all payments is taken equal to 1
- Many participating banks of different sizes (initial balance at the CR, volumes emitted and received, number of counterparties...)
- The structure of the network (scale-free with an average of 12 counterparties per bank) was chosen in order to mimic the structure of the core of FedWire
- Payments are generated randomly between a bank and one of its counterparties, according to an intensity varying Poisson process
- Payments are settled immediately if the paying bank has sufficient liquidity, else they are queued until the paying bank receives some liquidity

Speaker: Fabien
Lowering liquidity couples processing across banks. Payments loose correlation with input because their timing becomes determined by internal dynamics of the system.

NOTE: we would see increasing correlation of payment activity between neighboring banks as correlation with instructions declines. This is akin to reaction function.
Coupled RTGS model

Model description

- RTGS³ and RTGS⁶ are two distinct RTGSs with two different currencies: $ and €
- RTGS³ and RTGS⁶ are similar in structure
- 6 “global banks”:
  - The 3 top banks in RTGS³: A₁, A₂ and A₃ which are also in the top 20 of RTGS⁶
  - The 3 top banks in RTGS⁶: E₁, E₂ and E₃ which are also in the top 20 of RTGS³
- The 6 “global banks” make FX trades (at constant exchange rate) between themselves
- FX trades are generated randomly between the global banks according to a model similar to the local payments generation model

Speaker: Fabien
• Each RTGS processes:
  - “Local” payments
  - Their respective leg of FX trades
• Those 2 RTGSs are linked:
  - Via the dual participation of some global banks that can make FX trades (institution-based interdependency)
  - Via a possible PvP (Payment versus Payment) constraint on the FX trades (system-based interdependency), the alternative being a non-PvP settlement

Speaker: Fabien
Speaker: Walter

This is the settlement rate for the entire system, not just FX
We’re showing settlement rates in the two systems measured over 1000 small time windows using different networks in each system
The systems are correlated only because their response is correlated to the input which is identical in each system...
Correlation between the two RTGS sum-up

High liquidity non-PvP
- Local $ payment orders
- $ legs of FX trades
- \( \text{Correlation: 0.22} \)
  (institution-based interdependency)

Low liquidity non-PvP
- Local $ payment orders
- \( \text{Correlation: - 0.02} \)
  (none)
Speaker: Walter

Note scale change from 25000 for FoP up to 35000 for PvP here
We’re showing settlement rates in the two systems measured over 1000 small time windows using different networks in each system
Red arrows points out the correlated high settlement rates (cascades) in each system triggered by PvP payments, there are also corresponding periods of correlated low settlement rates
Correlation between the two RTGS sum-up

**High liquidity (PvP or non-PvP)**
- Local $ payment orders
- $ leg of FX trades
- € leg of FX trades
- Correlation: 0.22 (institution-based interdependency)

**Low liquidity non-PvP**
- Local $ payment orders
- $ leg of FX trades
- € leg of FX trades
- Correlation: -0.02 (none)

**Low liquidity PvP**
- Local $ payment orders
- $ leg of FX trades
- € leg of FX trades
- Correlation: 0.83 (system-based interdependency)
Exposure of Banks in case of non-PvP

Non-PvP Creates Exposure due to Differences in Settlement Times

Settlement times may differ due to:
- structural differences (e.g. time zone differences or topology).
- Liquidity differences

Speaker: Walter
Speaker: Morten

We here show exposures between the € selling banks and the $ selling banks, when both RTGSs have the same level of liquidity and with no priority for FX payments.

As expected the aggregate exposures increase as liquidity decrease.

Whether the euro selling banks or the dollar selling banks are
Speaker: Morten

We here show exposures between the € selling banks and the $ selling banks, when both RTGSs have the same level of liquidity and with a priority for FX payments.

In this particular case the priority for FX payments is sufficient to eliminate most of the exposure. Obviously all other types of payments are queued to a higher degree.
Speaker: Morten

Here we show exposures between the € selling and the $ selling banks, when euro liquidity is at the highest level and dollar liquidity varies.

The less liquid the dollar system is the higher is the exposure for the banks selling euros because euros are settled quicker than dollars.

Whether the euro selling banks or the dollar selling banks are
**Speaker: Morten**

PvP eliminates the FX related exposures but introduces queuing

Here, we show the average

There are more queuing in the two systems when there is a PvP mechanism except when both systems are super liquid.
Queues: PVP

Average queue in dollar RTGS
Speaker: Morten

In the case of non-PvP the degree of cascades and Congestion here measured as the variability of the settlement rate is

1) Decreasing in the liquidity of the system

2) Does not depend on the liquidity of the other system
Speaker: Morten

In the case of PvP the degree of cascades and Congestion is higher than non-PvP and the level depends on the liquidity of the other system.
Conclusions

- At high liquidity the common FX drive creates discernable correlation in settlement
- At low liquidity
  - Congestion destroys instruction/settlement correlation in each system,
  - Coupling via PvP amplifies the settlement/settlement correlation by coordinating the settlement cascades in the two systems
- Queuing in systems increases and becomes interdependent with PvP
- Congestion and cascades becomes more prevalent with PvP
- Exposure among banks in the two systems
  - Is inversely related to liquidity available.
  - Is reduced by prioritizing FX
- Banks selling the most liquid currency are exposed
Upcoming Investigations

- **Effect of settling FX trades through a net funding mechanism**
  - Decrease of the interdependency?
  - However, the time critical payments would force the banks to set some liquidity aside...
- **Reaction of the global system to shocks**
  - Contagion of a local shock from one RTGS to another
    - Default of a local player (will the crisis spread out to the other currency zone?)
  - Effects of global shocks
    - Default of a global player
    - Total shut-down of a RTGS
    - Operational problems affecting the FX link
- **Influence of an intraday FX swap market**
  - Reduced queueing in normal operation
  - As a mitigation of a local shock affecting one RTGS (beneficial interdependency)
- **Additional market infrastructures (SSSs, CCPs, ICSDs, DNSs, markets...)**

**Speaker: Fabien**