Disruptions in large value payment systems: an experimental approach

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Road map

- Motivation of this research
- Why an experiment?
- Model used
- Experimental set up
- Results
- Heuristic models
- Conclusion

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Motivation

- Operational disruptions constitute a real risk (i.e. attacks WTC in 2001)
- Problems in large value payment systems may spill over to other parts of the financial system => systemic risk
- Disruptions affect the behavior of participants (liq. crisis)

  →Understanding how participants react to shocks (disruptions) is crucial for regulators and operators

Why an experiment?

- Disruptions are typically tail events, real life data are limited.
- Computer simulations offer the opportunity to study stress situations, but assumptions about behavior under extreme circumstances must be made.
- An experiment generates such behavior endogenously under controlled conditions.
- However, an experiment is not a substitute for simulations but should be seen as a complement.
- There has not been any experimental study on large value payment systems yet!

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Model used

- Based on theoretical work by Bech & Garratt (2006)
- Simple model:
  - n banks have to pay one unit to each other
  - two periods: morning and afternoon
  - either pay in the morning or delay to the afternoon
- Delaying a payment involves a cost D
- Paying in the morning involves a cost F which depend on how many other banks delay their payment

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Experimental model with n=5 banks

- Payoff player$_i$ (bank$_i$) choosing option Y (paying in the afternoon) = 2
- Payoff player$_i$ choosing option X (paying in the morning) = depends on number of players choose Y

Number of other players choosing Y	Your earnings from choosing X	Your earnings from choosing Y
0	5	2
1	3	2
2	1	2
3	−1	2
4	−3	2

- If 0 or 1 players choose Y then the best response is to choose X => efficient equilibrium
- If two or more players choose Y, then the best response is to choose Y as well => inefficient equilibrium

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Experimental model

- Each bank has to trade off the cost of delaying against the cost of paying early
- Suppose each bank believes that the other banks are paying late, then the (expected) cost of paying early increases and banks might pay late
- However, if banks believe that the other banks pay early, then paying early becomes less costly and every bank might pay in the morning
- Interesting case is where there are two equilibria:
  - every bank pays in the morning, which is efficient
  - every bank pays in the afternoon, which is inefficient

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Experimental set up: (1/2)

- With probability *p* there is a disruption at each individual player
- Disruption: one cannot choose *X* and is forced to go for *Y*
- Players cannot observe forced *Y* of other players
- Outcome of choices of others are observed only
- Theoretically, disruption does not change the equilibria as such
- But, behaviorally, disruption may affect the equilibrium 'chosen' => move to inefficient equilibrium?

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Experimental set up (2/2)

- Each group has 5 players (partners during whole experiment)
- 3 blocks of 30 rounds; the probability of disruption is constant in each block
- Disruption probabilities used: 15%, 30% or 45%
- Path dependency investigated
- Extension : Heterogeneous market case (3 small players, 1 large player)

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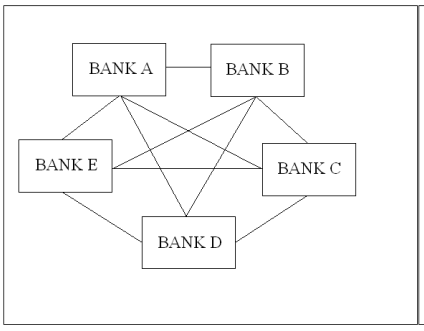
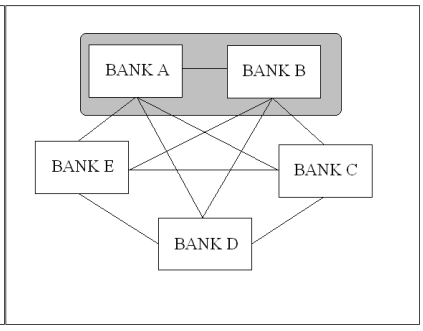
Extension : heterogeneous market

Homogeneous



Heterogeneous



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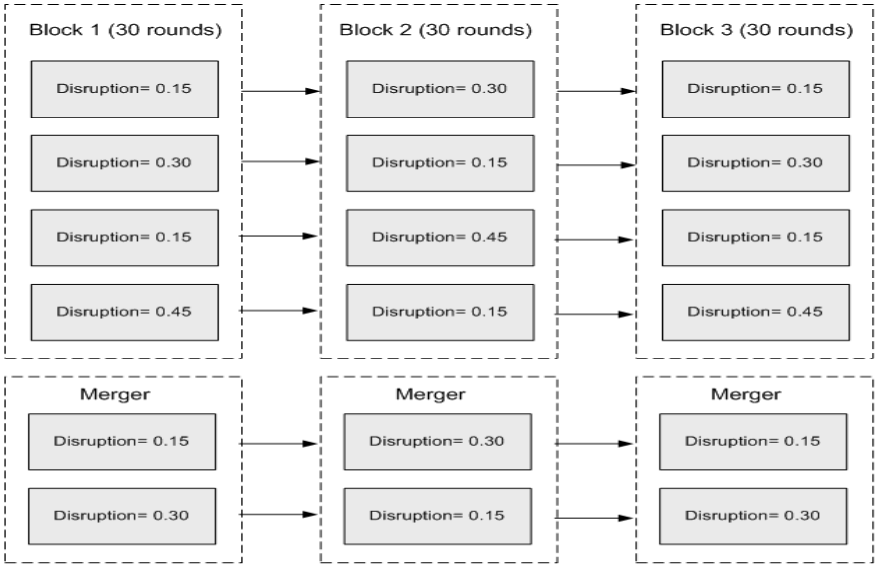
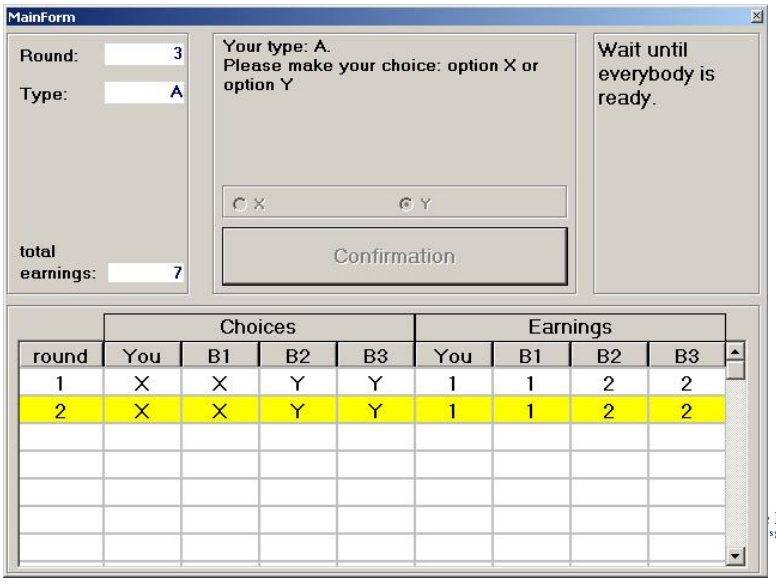
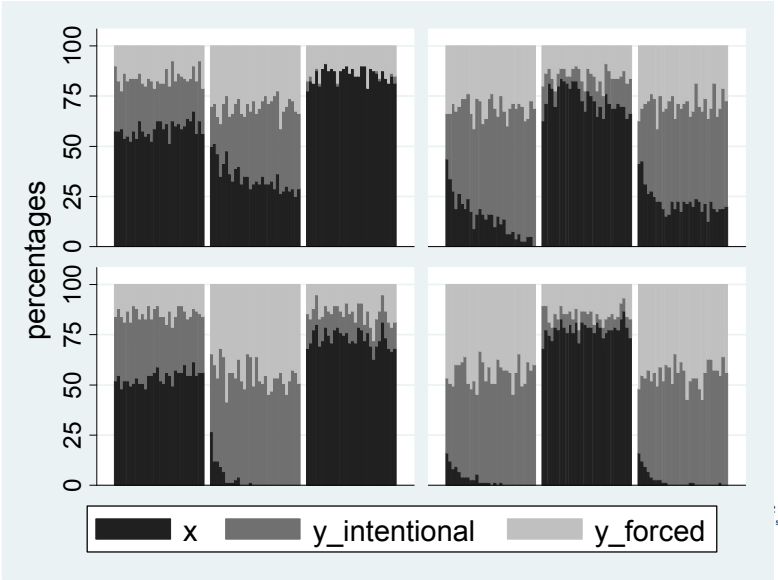
Experimental treatments



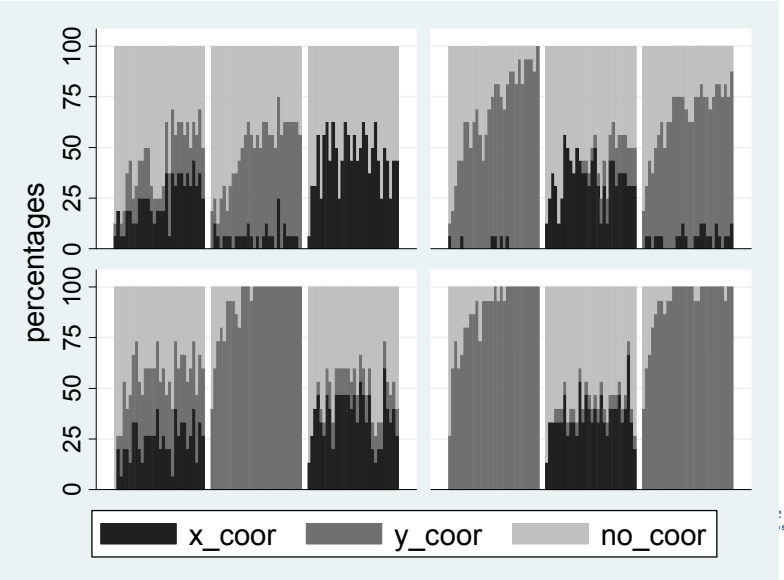
Screenshot of the merger case



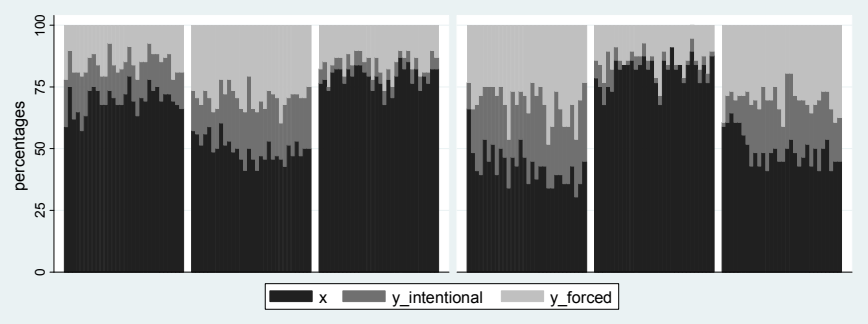
Choice frequencies homogeneous market



Full coordination homogeneous market



Choice frequencies heterogeneous market



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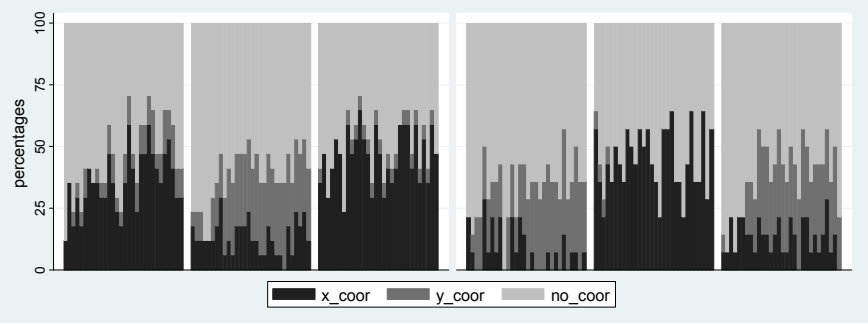
Full coordination heterogeneous market



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Full coordination on X

Treatment					Block		
					1	2	3
1	Hom	15	30	15	0.56 (0.14)	0.40 (0.05)	0.97 (0.06)
2	Hom	30	15	30	0.11 (0.08)	0.76 (0.12)	0.24 (0.05)
3	Hom	15	45	15	0.53 (0.14)	0.01 (0.04)	0.80 (0.06)
4	Hom	45	15	45	0.01 (0.03)	0.86 (0.12)	0.01 (0.03)
5	Het	15	30	15	0.73 (0.10)	0.64 (0.05)	0.93 (0.03)
6	Het	30	15	30	0.44 (0.08)	0.87 (0.08)	0.60 (0.10)

Notes:
-Average over all rounds; st. dev.in parentheses
-Hom: homogeneous market
-Het: heterogenous market

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Leadership effect (1/3)

Choice large bank	Choice small = x if choice large = x		Choice small = x if choice large = y	
	p=15%	p=30%	p=15%	p=30%
once in a row same choice	90%	88%	87%	80%
twice in a row same choice	95%	89%	65%	67%
3 times in a row same choice	97%	90%	37%	39%
4 times in a row same choice	96%	86%	19%	20%

→ Conclusion: if large banks chooses ‘y’ → the number of small banks choosing ‘x’ decreases rapidly.

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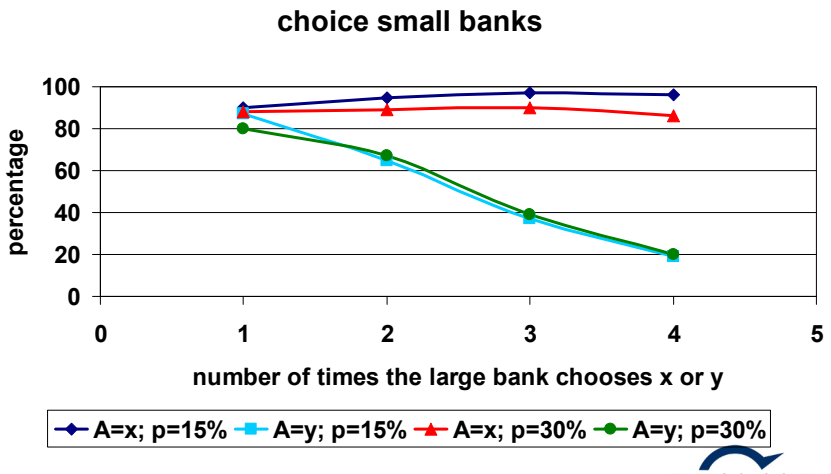
Leadership effect (2/3)



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Leadership effect (3/3)

- There is significant more coordination on X in the het-market compared to hom-market in 5 out of 7 cases

Block 1:
- Treatment 1 vs 5: significantly different
- Treatment 2 vs 6: significantly different
- Treatment 3 vs 5: significantly different

Block 2:
- Treatment 2 vs 6: not significantly different
- Treatment 1 vs 5: significantly different

Block 3:
- Treatment 2 vs 6: significantly different
- Treatment 1 vs 5: not significantly different

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Heuristic models (1/5)

1. Myopic best response model
   - Given the outcome of other players in round N-1, what would have been the best choice. That is the choice in round N

2. Imitation model
   - Choice in round N is based on the outcome of round N-1

3. Adjusted model

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Heuristic models (2/5)

MYOPIC																						
	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t
B1	X	X	Y	X	X	X	Y	X	X	Y	Y	Y	X	Y	Y	Y	X	Y	Y	Y	Y	Y
B2	X		X		X		X		X		X		X		X		Y		Y		Y	
B3	X		X		X		X		X		X		Y		Y		Y		Y		Y	
B4	X		X		X		X		Y		Y		Y		Y		Y		Y		Y	
B5	X		X		Y		Y		Y		Y		Y		Y		Y		Y		Y	
payoff if X	5		3		3		1		1		-1		-1		-3		-3		na			
payoff if Y	na		2		2		2		2		2		2		2		2		2			

IMITATION																						
	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t	t-1	B1 at t
B1	X	X	Y	X	X	X	Y	X	Y	Y	Y	Y	X	Y	Y	Y	X	Y	Y	Y	Y	Y
B2	X		X		X		X		X		X		X		X		Y		Y		Y	
B3	X		X		X		X		X		X		Y		Y		Y		Y		Y	
B4	X		X		X		X		Y		Y		Y		Y		Y		Y		Y	
B5	X		X		Y		Y		Y		Y		Y		Y		Y		Y		Y	
payoff if X	5		3		3		1		1		-1		-1		-3		-3		na			
payoff if Y	na		2		2		2		2		2		2		2		2		2			

na = not applicable

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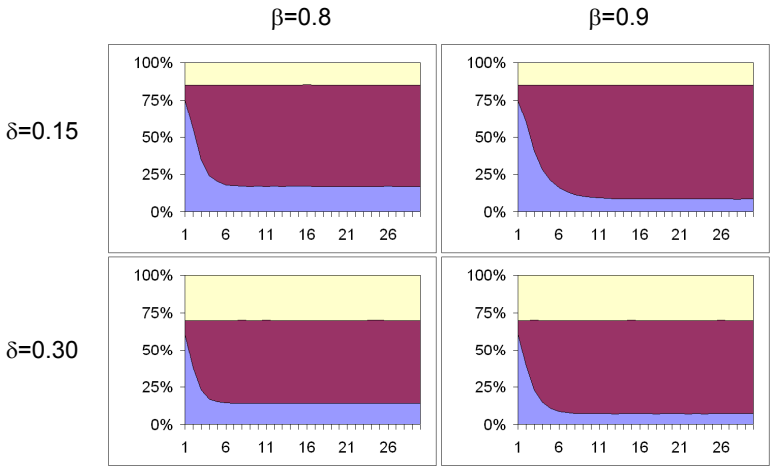
Heuristic models (3/5)

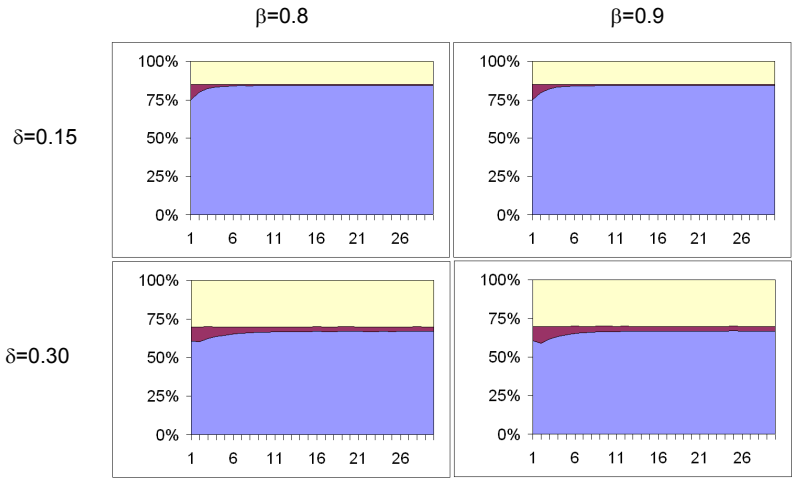


Myopic best response
δ: disruption probability
β: probability that player will follow the best choice that it can make in round N-1

Heuristic models (4/5)

- Reality shows less Y than models
  - Due to Y_forced
- Prob. to deviate from X = Prob. to deviate form Y
  - This is not appropriate for our game
- B1 chooses X in t=1 with initial propensity α and Y with propensity 1-α
- t=t+1: determine whether choice X would have a positive yield
  - If yes: choose X with probability β and choose Y 1-β
  - If no: choose Y with probability γ and choose X with 1-γ

Heuristic models (5/5)



Adjusted model

δ: disruption probability

β: probability that player will follow the best choice that it can make in round N-1

Conclusion Heuristics

- None of simple dynamics succeeds to fit data completely
- Imitation an myopic best response massively over predict Y (inefficient equilibrium)
- Adjusted model follows data much better but over predicts choice X

conclusions

- There is a learning effect:

→ 1st block less coordination on *X* than 3rd block, disruption has the same probability

- Heterogeneous market improves coordination on *X*

→ Large bank shows leadership

- Long term disruptions of large bank has effect on whole market
- Disruption history has effect on coordination in current block
- Full coordination on *X* in 3rd block larger after a smaller disruption in 2nd block

Policy recommendation:

- Extra requirements on technical infrastructure of critical participants are justified form a financial stability point of view

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