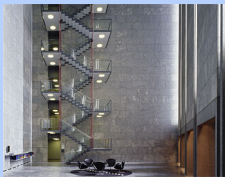




A quantitative assessment of international best practices in relation to business continuity arrangements in payment systems



Kristian Sparre Andersen & Irene Madsen,
Danmarks Nationalbank, Payment Systems

6th Payment and Settlement Simulation Seminar,
Bank of Finland, Helsinki, 26 August 2008



Outline

- ◆ Over-all objective
- ◆ Operational risk and business continuity in payment systems
- ◆ Simulation of business continuity in payment systems
- ◆ Payment settlement in Danmarks Nationalbank
- ◆ Incidents on system level
- ◆ Incidents on participant level
 - ◆ Critical participants
 - ◆ Duration and timing
 - ◆ Capacity in contingency mode
 - ◆ “Stop sending” rules
- ◆ Concluding remarks



Over-all objective

- ◆ Assess by simulations whether international best practices on business continuity in payment systems are adequate for Danmarks Nationalbank's RTGS-system, Kronos, i.e.:
 - ◆ Time limit for resumption of settlement
 - ◆ Best practice: 2 hours
 - ◆ Capacity for settlement in contingency mode
 - ◆ Target2 objective: 750 payments per hour
 - ◆ Definition of critical participants
 - ◆ Target2 definition: 2 per cent of gross turnover
 - ◆ Stop-sending rules (prevent liquidity sinks)
 - ◆ Target2 rule: Critical participant shall notify about incident within 30 minutes

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Operational risk and business continuity in payment system

- ◆ Oversight and supervisory standards:
 - ◆ Core Principles for Systemically important Payment Systems (BIS, 2001)
 - ◆ Interagency Paper on Sound Practices to strengthen the resilience of the US Financial System (Fed/OCC/SEC, 2003)
 - ◆ Do we need new statutory powers? (BoE/FSA/Treasury, 2003)
 - ◆ Business Continuity Expectations for Systemically Important Payment Systems (Eurosystem, 2006)
 - ◆ High-level Principles for Business Continuity (Joint Forum, 2006)
 - ◆ Principles for Sound Liquidity Risk Management and Supervision (BIS, 2008)

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Operational risk and business continuity in payment system

- ◆ Definition of operational Risk:
 - ◆ Risk of loss resulting from inadequate or failed internal processes and systems, human errors, or external events such as natural disasters, terrorism, etc.
- ◆ Operational risk is a function of:
 - ◆ Probability of incidents happening
 - ◆ Impact of incidents when they happen
- ◆ Measurement of operational risk:
 - ◆ Gross risk: Exclude effect of countermeasures
 - ◆ Net risk: Include effect of countermeasures
- ◆ Business Continuity
 - ◆ Relates primarily to incidents that cause major operational disruption, i.e. incidents that have a *widespread economic impact* or threaten *financial stability*

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Simulation of business continuity in payment systems

- ◆ Previous studies
 - ◆ Liquidity effects of the events of September 11, 2001 (McAndrews and Potter, 2002)
 - ◆ Assessing operational risk in CHAPS Sterling; A simulation approach (Bedford et al., 2004)
 - ◆ Operational risk and contagion in the Austrian large-value payment system (Schmitz et al., 2006)
 - ◆ Operational disruptions and the Hungarian RTGS system VIBER (Lublóy and Tanai, 2007)
 - ◆ Liquidity effects of a participant-level operational disruption in SIC (Glaeser & Haene, 2008)

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Simulation of business continuity in payment systems

- ◆ Output data (basis for decision making)
 - ◆ Gross liquidity distributed in the system
 - ◆ Participants' in-going payments
 - ◆ Results interpreted against participants' liquid assets on their balance sheet
 - ◆ Net liquidity distributed in the system
 - ◆ Participants' in-going less out-going payments
 - ◆ Results interpreted against the size of the Danish money market
 - ◆ Participants' balances on current accounts end-of-day
 - ◆ Liquid holdings in Danmarks Nationalbank
 - ◆ Results interpreted against assets pledged to DN
- ◆ Simulations structured according to
 - ◆ With/without incident and contingency measures
 - ◆ Incidents in busiest 2 hours, end-day and whole day
 - ◆ Incidents on system level and participant level

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Simulation of business continuity in payment systems

- ◆ Input data
 - ◆ Interbank transactions and CLS pay-ins/pay-outs
 - ◆ Intraday credit granted by Danmarks Nationalbank based on pledging of collateral at start-of-day
 - ◆ Sample of 22 banking days (January 2008)

	Volume	DKK billion
Total turnover	63.467	3.348
- Of which CLS pay-ins/pay-outs	2.144	391
Daily turnover		
- Average	2.885	152
- Minimum	2.605	64
- Maximum	3.905	213
Settlement assets (average start-of-day)		286
- Of which balances on current accounts		6
- Of which intraday credit limits		280
Participants (active in January 2008)	117	

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Simulation of business continuity in payment systems

◆ Input data (cont.)

- ◆ Payments and settlement assets for 10 large participants for which we simulate incidents (daily averages, January 2008)

	Average value submitted pr. day	Average value recieved pr. day	Average Beginning-of-day balance	Average credit limit
Bank 1	48,8	47,3	-5,1	48,2
Bank 2	38,9	40,7	12,9	17,4
Bank 3	9,2	9,0	-3,1	24,9
Bank 10	8,9	8,9	0,0	0,0
Bank 6	6,1	6,0	-5,6	35,2
Bank 5	5,6	5,5	3,3	10,8
Bank 4	5,0	5,7	4,8	3,5
Bank 8	2,3	2,3	-0,1	3,7
Bank 7	2,3	2,2	0,0	4,8
Bank 9	0,6	0,7	-0,2	2,0

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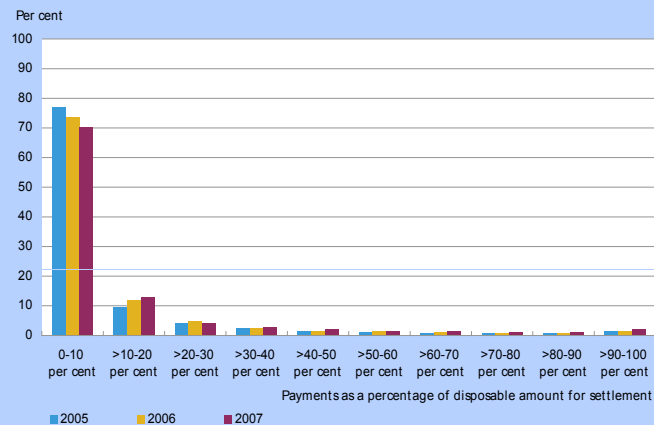
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Payments in Danmarks Nationalbank

- ◆ Participants' utilisation of disposable amounts for settlement of interbank payments



Note: In the compilation payments have been weighted by size. Payments of less than Kr. 1 million have been excluded.
Source: Danmarks Nationalbank.

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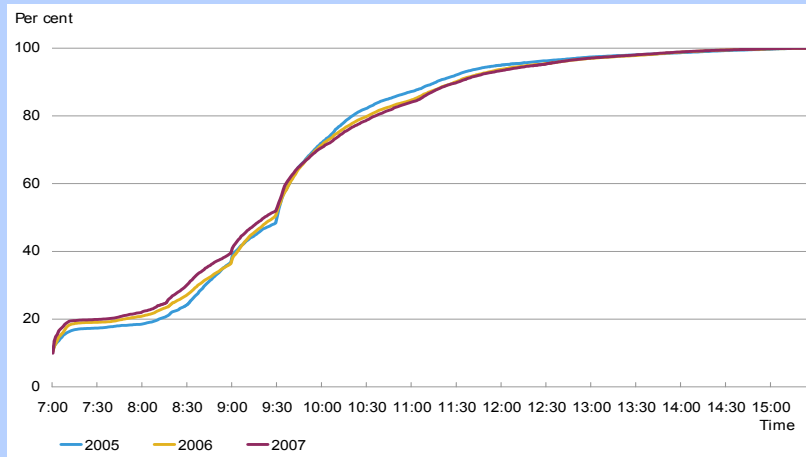
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Payments in Danmarks Nationalbank

Time profile for interbank payments in Kronos



Note: Accumulation of interbank payments over Kronos' opening hours (7:00 a.m. to 3:30 p.m.).
Source: Danmarks Nationalbank.

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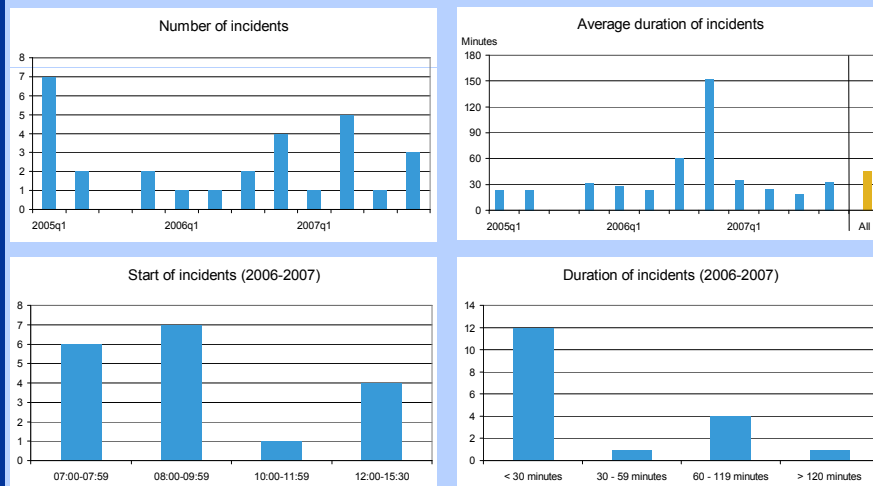
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Payments in Danmarks Nationalbank

Incidents in Kronos (system level), 2005-2007



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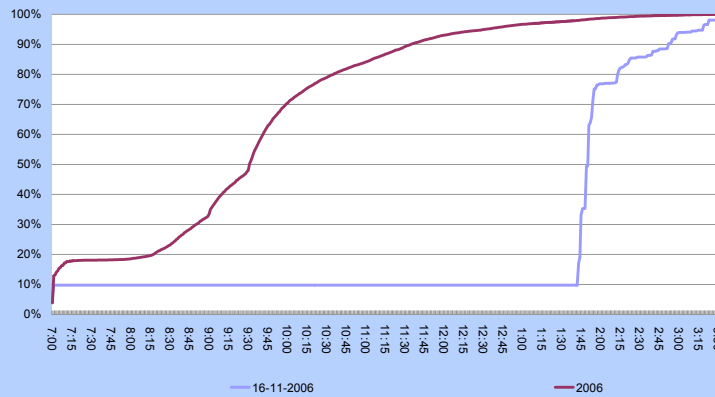
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Payments in Danmarks Nationalbank

Incident in Kronos, 16 November 2006



Note: Accumulation of interbank payments over Kronos' opening hours (7:00 a.m. to 3:30 p.m.).
 Source: Danmarks Nationalbank.

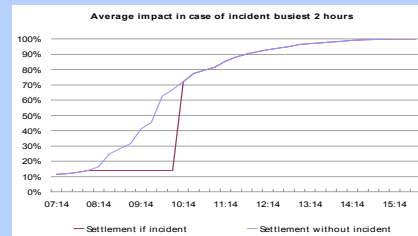
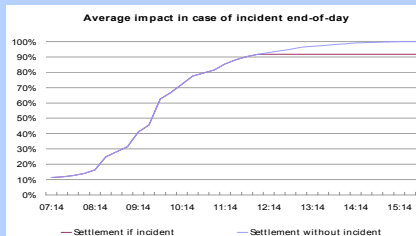
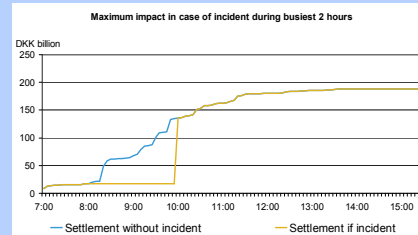
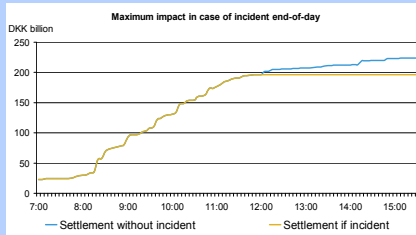
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Incidents on system level



- Time profile of end-of-day and busiest 2 hour incidents in Kronos
 - Experience show that pending transactions are settled quickly when normal operations starts again (system capacity at least 5.000 transactions per hour)
 - In case of end-of-day incidents the values to be settled in contingency mode typically rather limited (both in values and volumes)

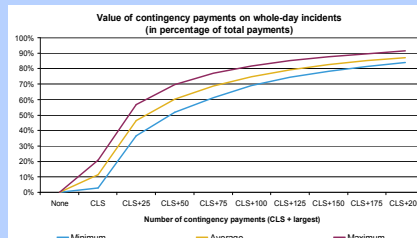
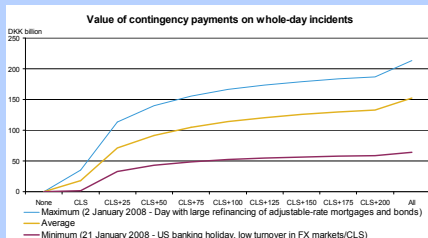
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Incidents on system level



- ◆ Settlement of CLS and 200 largest payments in contingency mode in case of whole-day incident
 - ◆ Account for significant share of daily gross liquidity settled in Kronos Irrespective of day of incident
 - ◆ Payments not settled (in case of contingency settlement) only a limited share of
 - ◆ Participants' liquid assets (DKK 917 billion on 31 December 2007)
 - ◆ Intraday-credit limits and current account balances at Danmarks Nationalbank (DKK 286 billion on average during January 2008)

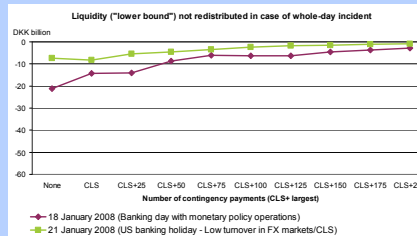
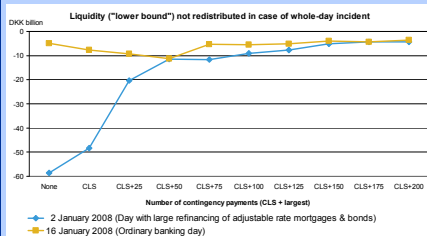
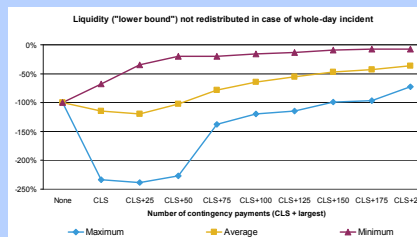
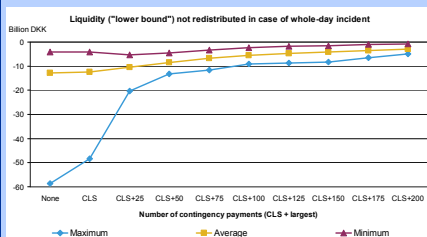
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Incidents on system level



- ◆ Contingency payments would reduce the impact of whole-day incidents on the liquidity not redistributed (unexpected net liquidity exposures) to a modest level
 - ◆ Compared with the size of the Danish short-term money market with an average daily turnover in January 2008 on DKK 50 billion (maximum DKK 71 billion)
 - ◆ On some days, with modest turnover however, this is not the case if only few contingency payments are transacted!

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Incidents on participant level Critical participants

- ◆ Total impact on settlement in Kronos due to whole day incident (unexpected gross liquidity exposure)

Kr billion	Average value				Worst case			
	Direct effect	Indirect effect	Submitted to the system	Direct+indirect effect/submitted value	Direct effect	Indirect effect	Submitted to the system	Direct+indirect effect/submitted value
Bank 1	48,8	7,8	103,4	54,8%	72,8	13,7	134,3	64,4%
Bank 2	38,9	4,5	113,3	38,3%	62,7	7,5	139,7	50,3%
Bank 3	9,2	1,6	142,9	7,6%	16,7	3,8	190,4	10,8%
Bank 6	5,8	0,7	146,4	4,5%	12,2	0,3	152,7	8,2%
Bank 4	4,9	0,7	147,3	3,8%	21,0	8,0	137,0	21,2%
Bank 7	2,3	0,5	149,9	1,9%	3,8	2,3	209,7	2,9%
Bank 5	5,6	0,4	146,6	4,1%	12,7	0,1	184,4	6,9%
Bank 10	8,9	0,3	143,3	6,4%	17,5	0,7	196,0	9,3%
Bank 8	2,0	0,2	150,2	1,5%	2,0	2,8	151,3	3,2%
Bank 9	0,5	0,0	151,7	0,3%	1,2	-	146,3	0,8%
Normal	-	-	152,2	-	-	-	213,5	-

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Incidents on participant level Critical participants

- ◆ Total impact on settlement in Kronos due to whole day incident (unexpected gross liquidity exposure)
 - ◆ Payments not submitted to other participants due to direct and indirect impact of incident

Kr. billion	Whole day incident in Bank 1		Kr. billion	Whole day incident in Bank 2	
	Average	Worst case (Jan 11)		Counterpart	Average
Bank 2	28,5	37,7	Bank 1	27,9	53,2
Bank 3	5,0	5,2	Bank 10	3,3	7,2
Bank 10	4,6	8,1	Bank 3	2,0	4,4
Bank 4	3,7	19,3	Bank 5	1,8	1,3
Bank 5	1,5	2,0	Bank 4	1,6	0,3
Bank 6	1,3	0,5	Bank 6	1,4	0,3
Bank 8	0,7	0,6	Bank 7	0,5	0,8
Bank 7	0,7	1,8	Bank 8	0,3	0,2
Bank 9	0,1	0,0	Bank 9	0,2	0,0
Rest	10,5	11,4	Rest	4,4	2,4
Total	56,6	86,5	Total	43,4	70,2

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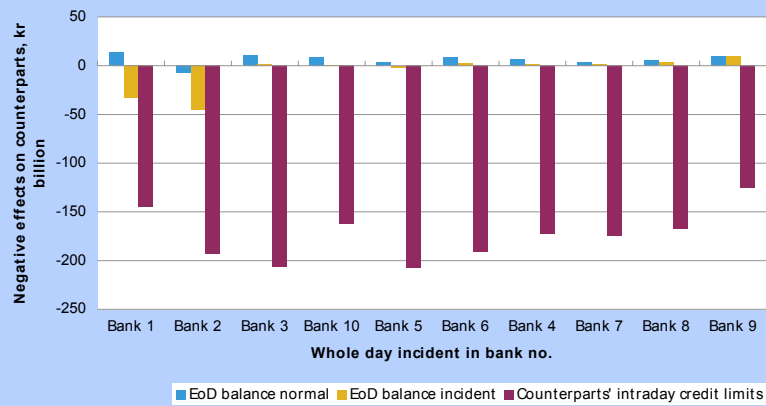
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Incidents on participant level Critical partipants

- ◆ Balances on current accounts end-of-day due to whole day incident

Average values



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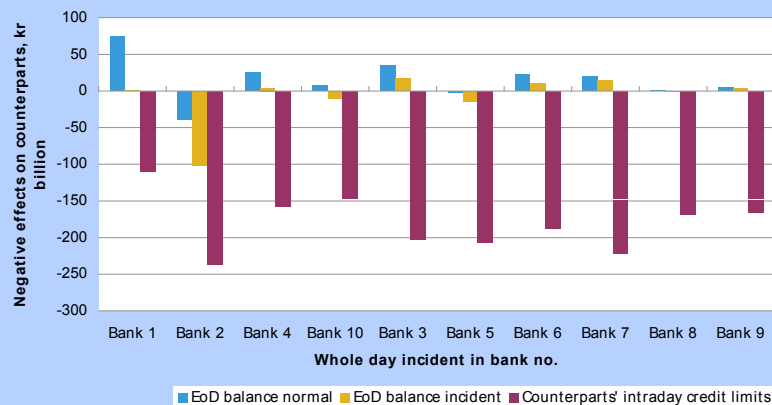
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Incidents on participant level Critical partipants

- ◆ Balances on current accounts end-of-day due to whole day incident

Worst case



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Incidents on participant level Critical participants

- ◆ Liquidity not redistributed in case of whole day incident (Unexpected net liquidity exposure)

Incident in bank	Average values		Worst case	
	System lower bound	Danish money market compared to system lower bound	System lower bound	Danish money market compared to system lower bound
Normal	12,9	392%	55,7	91%
Bank 1	48,4	104%	72,0	70%
Bank 2	44,7	113%	86,7	58%
Bank 3	18,8	268%	59,0	86%
Bank 4	14,9	339%	56,3	90%
Bank 5	16,1	313%	56,0	90%
Bank 6	15,3	329%	58,1	87%
Bank 7	13,8	366%	57,7	87%
Bank 8	13,8	367%	57,3	88%
Bank 9	13,1	386%	55,5	91%
Bank 10	17,8	284%	55,7	91%

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Incidents on participant level Duration and timing



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Incidents on participant level

Duration and timing

- ◆ Total impact on settlement in Kronos due to end-of-day incident (Unexpected gross liquidity exposure)
 - ◆ Payments not submitted to other participants due to direct and indirect impact of incident

Kr. billion	End of day incident Bank 1		Kr. billion	End of day incident Bank 2	
	Average	Worst case (Jan 14)		Counterpart	Average
Bank 2	1,2	6,3	Bank 1	2,0	7,1
Bank 8	0,4	2,4	Bank 5	0,4	1,5
Bank 5	0,3	0,4	Bank 6	0,4	0,4
Bank 6	0,2	-	Bank 3	0,1	-
Bank 4	0,1	-	Bank 8	0,1	-
Bank 3	0,1	0,3	Bank 7	0,1	0,0
Bank 7	0,0	0,0	Bank 9	0,0	0,3
Bank 9	0,0	-	Bank 4	0,0	-
Rest	0,7	0,0	Rest	1,6	0,5
Total	2,9	9,4	Total	4,8	9,7

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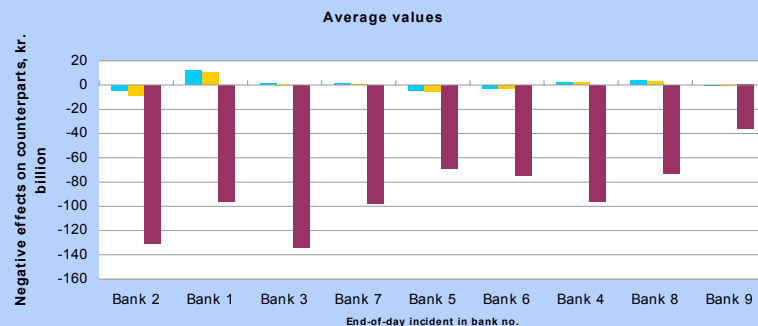
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Incidents on participant level

Duration and timing

- ◆ Balances on current accounts end-of-day due to end-of-day incident



■ EoD Balance normal ■ EoD balance incident ■ Counterparts' intraday credit limits

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Incidents on participant level Duration and timing

- ◆ Liquidity not redistributed in case of end-of-day incident (Unexpected net liquidity exposure)

Kr. billion	Average values		Worst case	
	System lower bound	Danish money market compared to system lower bound	System lower bound	Danish money market compared to system lower bound
Normal	12,9	392%	55,7	91%
Bank 1	13,1	385%	51,3	98%
Bank 2	14,2	355%	57,8	87%
Bank 3	13,4	377%	55,7	91%
Bank 4	13,0	388%	55,6	91%
Bank 5	13,2	382%	55,7	91%
Bank 6	12,9	392%	56,5	89%
Bank 7	13,1	385%	55,7	91%
Bank 8	13,0	389%	55,8	90%
Bank 9	12,9	392%	55,7	91%

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Incidents on participant level Capacity in contingency mode

- ◆ Contingency plans' impact on settlement in Kronos in case of whole day incident in Bank 1 (reduction in unexpected gross liquidity exposure)

	Kr. billion	Average values			Reduction in direct effect	Reduction in indirect effect
		Direct effect	Indirect effect	Value submitted		
Contingency plan	Without contingency plan	48,8	7,8	103,4	-	-
	CLS	44,2	4,1	107,9	9%	48%
	CLS+25	12,9	1,3	139,3	74%	83%
	CLS+50	6,2	1,2	145,9	87%	85%
	CLS+75	3,5	1,0	148,7	93%	87%

	Kr. billion	Worst case			Reduction in direct effect	Reduction in indirect effect
		Direct effect	Indirect effect	Value submitted		
Contingency plan	Without contingency plan	72,8	13,7	134,3	0%	0%
	CLS	64,7	6,7	142,5	11%	51%
	CLS+25	17,6	6,2	178,6	76%	55%
	CLS+50	8,4	5,4	193,9	88%	61%
	CLS+75	4,9	5,3	197,4	93%	62%

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Incidents on participant level Capacity in contingency mode

- Contingency plans' impact on settlement in Kronos in case of whole day incident in Bank 1 (reduction in unexpected gross liquidity exposure)
 - Payments not submitted to other participants due to direct and indirect impact of incident

Kf. billion	Without contingency plan		CLS		Kf. billion	CLS+25		Kf. billion	CLS+50		Kf. billion	CLS+75	
	Average	Worst case (Jan 11)	Average	Worst case (11-1)		Counterpart	Average		Worst case (18-1)	Counterpart		Average	Worst case (18-1)
Bank 2	28,5	37,7	26,8	36,3	Bank 2	7,8	13,7	Bank 2	4,1	8,6	Bank 2	2,6	6,4
Bank 3	5,0	5,2	4,8	5,2	Bank 3	1,5	2,4	Bank 3	0,7	0,9	Bank 3	0,4	0,6
Bank 4	3,7	19,3	3,0	13,8	Bank 5	0,7	0,5	Bank 5	0,2	0,3	Bank 6	0,1	0,3
Bank 5	1,5	2,0	1,5	2,0	Bank 6	0,5	1,2	Bank 6	0,2	0,0	Bank 5	0,1	0,0
Bank 6	1,3	0,5	1,3	0,5	Bank 7	0,2	0,4	Bank 7	0,1	-	Bank 7	0,1	-
Bank 8	0,7	0,6	0,7	0,6	Bank 4	0,2	0,2	Bank 9	0,1	0,0	Bank 9	0,0	0,0
Bank 7	0,7	1,8	0,7	1,8	Bank 8	0,1	0,0	Bank 8	0,0	0,0	Bank 8	0,0	0,0
Bank 9	0,1	0,0	0,1	0,0	Bank 9	0,1	0,0	Bank 4	0,0	0,2	Bank 4	0,0	0,0
Rest	10,5	11,4	9,4	11,2	Rest	3,1	5,5	Rest	1,9	3,9	Rest	1,1	2,9
Total	56,6	86,5	48,3	71,4	Total	14,2	23,8	Total	7,4	13,8	Total	4,5	10,2

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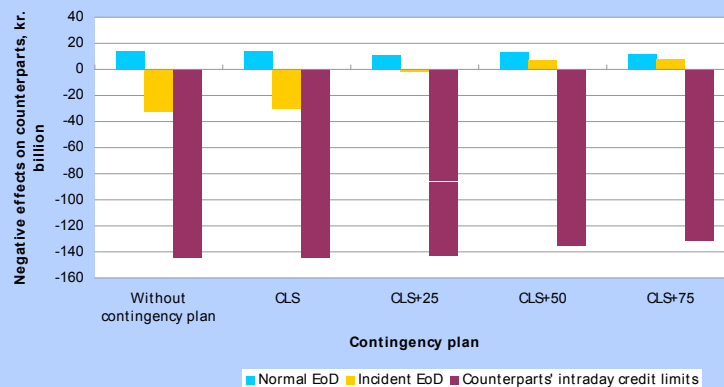
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Incidents on participant level Capacity in contingency mode

- Contingency plans' impact on other participants' balances on current accounts end-of-day in case of whole day incident in Bank 1 (reduction in overdrafts)

Average values



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Incidents on participant level Capacity in contingency mode

- Contingency plans' impact on liquidity not redistributed in case of whole day incident in Bank 1 (reduction in unexpected net liquidity exposure)

Kr.billion	Average		Worst case	
	System lower bound	Danish money market compared to system lower bound	System lower bound	Danish money market compared to system lower bound
Without contingency plan	48,4	104%	72,0	70%
CLS	46,0	110%	72,0	70%
CLS+25	19,3	262%	46,3	109%
CLS+50	14,8	342%	50,4	100%
CLS+75	13,4	378%	52,4	96%

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Incidents on participant level Stop sending rules

- Stop-sending rules' impact on settlement in Kronos in case of whole day incident in Bank 1

Average values

Reaction scheme	Kr. billion	Direct effect		Value submitted	Indirect effect	Reduction in indirect effect	Reduction in submitted value due to "stop-sending rule"
		Participant with incident	"Stop-sending" rule				
No reaction	48,8	-	-	103,4	7,8	-	-
120 min	48,8	36,8	-	66,6	5,8	26%	36%
60 min	48,8	41,6	-	61,8	4,1	47%	40%
30min	48,8	42,9	-	60,5	3,6	54%	41%

2 January 2008

Reaction scheme	Kr. billion	Direct effect		Value submitted	Indirect effect	Reduction in indirect effect	Reduction in submitted value due to stop-sending rule
		Participant with incident	"Stop-sending" rule				
No reaction	70,4	-	-	143,1	14,4	-	-
120 min	70,4	37,8	-	105,3	11,41	21,0%	26%
60 min	70,4	43,3	-	99,8	11,36	21,3%	30%
30min	70,4	43,3	-	99,8	11,36	21,3%	30%

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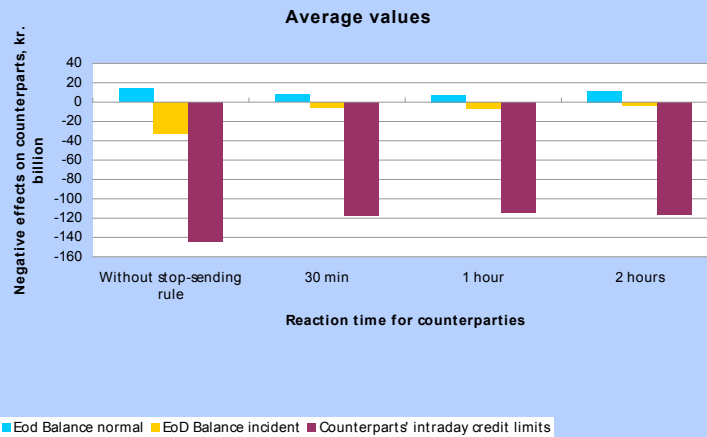
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Incidents on participant level Stop sending rules

- ◆ Stop sending rules' impact on other participants' balances on current accounts end-of-day in case of whole day incident in Bank 1 (reduction in overdrafts)



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Incidents on participant level Stop sending rules

- ◆ Stop sending rules' impact on liquidity not redistributed in case of whole day incident in Bank 1 (reduction in unexpected net liquidity exposure)

Kr.billion	Average values		2 January 2008	
Stop-sending rule	System lower bound	Danish money market compared to system lower bound	System lower bound	Danish money market compared to system lower bound
Without stop-sending rule	48,4	104%	56,8	89%
120 min	17,2	293%	38,2	132%
60 min	15,2	331%	35,6	142%
30 min	15,1	334%	35,6	142%

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Concluding remarks

- ◆ Preliminary results:
 - ◆ Defining major disruptions in Kronos:
 - ◆ Whole-day incident will cause a major disruption, both on system level and for critical participants if no contingency measures
 - ◆ Contingency measures seem to be able to mitigate the gross impact significantly but will still leave many transactions unsettled (some days more than DKK 25 billion)
 - ◆ On some days contingency measures will not reduce unexpected net liquidity exposure efficiently
 - ◆ 2 hour incident during the busiest hours seems not to create problems in the Danish RTGS-system, Kronos
 - ◆ when taking account of contingency measures
 - ◆ and assuming quick settlement of pending transactions after normal operations starts again
 - ◆ End-of-day incident seems in most circumstances not to create a major disruption
 - ◆ but only if contingency measures can ensure proper closing of the system (as well as opening next day)

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Concluding remarks

- ◆ Preliminary results (cont.):
 - ◆ Defining major disruptions in Kronos (cont.):
 - ◆ Therefore seems the present 4 hour limit for resumption of normal operations imposed on Danmarks Nationalbank's service provider adequate
 - ◆ This applies for critical participants, too
 - ◆ Setting requirements for settling payments in contingency mode
 - ◆ To mitigate effects of disruptions Kronos operators should be able to settle a certain number of payments manually
 - ◆ All urgent payments for ancillary systems like CLS
 - ◆ + 25-50 large payments per hour
 - ◆ NB! Has to be accompanied with rules requiring participants to forward large out-going payments for settlement in contingency mode

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Concluding remarks

- ◆ Preliminary results (cont.):
 - ◆ Defining critical participants in Kronos:
(without taking account of contingency measures)
 - ◆ Bank 1 and 2 are critical participants in all circumstances
 - ◆ Judged on average direct and indirect impact
 - ◆ Bank 10 (CLS) critical in all circumstances, too
 - ◆ Bank 3 and 4 are a critical participants on some days
 - ◆ Judged on direct and indirect impact in worst case
 - ◆ Bank 5 and 6 are maybe critical participants on some days, too, but not during January 2008
 - ◆ Bank 7, 8 and 9 probably not critical participants at all
 - ◆ Bank 1-6 all have a market shares > 3 per cent in Kronos while Bank 7-9 have markets shares < 2 per cent

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Concluding remarks

- ◆ Preliminary results (cont.):
 - ◆ Defining critical participants in Kronos (cont.):
(taking account of contingency measures)
 - ◆ Payments settled in contingency mode will improve the system's resilience against incidents at critical participants
 - ◆ Both direct and indirect impact reduced significantly if CLS and largest out-going payments are settled manually
 - ◆ However, unexpected net liquidity exposure not reduced efficiently on all days
 - ◆ Stop-sending rule can prevent critical participants to become liquidity sinks and, thereby, protect other participants' liquidity positions
 - ◆ Stop-sending after 30 minutes reduces submitted payments with 60 per cent in a whole-day incident on average
 - ◆ Note: Stop-sending reduce gross turnover significantly and this can have a negative impact on banks' operations
 - ◆ However, unexpected net liquidity exposure not reduced efficiently on all days (but better than contingency payments)
 - ◆ Identification of critical participants dominated by participants' presence in the Danish money market

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Concluding remarks

- ◆ Further work need to be done:
 - ◆ Stabilise results by expanding simulations to cover:
 - ◆ either all banking days in one calendar year
 - ◆ or adequate numbers of all types of banking days
 - ◆ Simulations on one month of data probably insufficient
- ◆ Improve results by:
 - ◆ Elaborating on existing scenarios
 - ◆ E.g. Changes in contingency measures
 - ◆ Expand input data by including additional transactions
 - ◆ E.g. transactions for ancillary systems
 - ◆ Include additional scenarios
 - ◆ E.g. incidents lasting more than one day (3-5 days)