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EUROPEAN CENTRAL BANK
EUROSYSTEM

ESTIMATING THE EURO AREA MONEY MARKET EXCHANGES

APPLYING THE FURFINE ALGORITHM TO TARGET2

CPSS workshop on payment monitoring indicators
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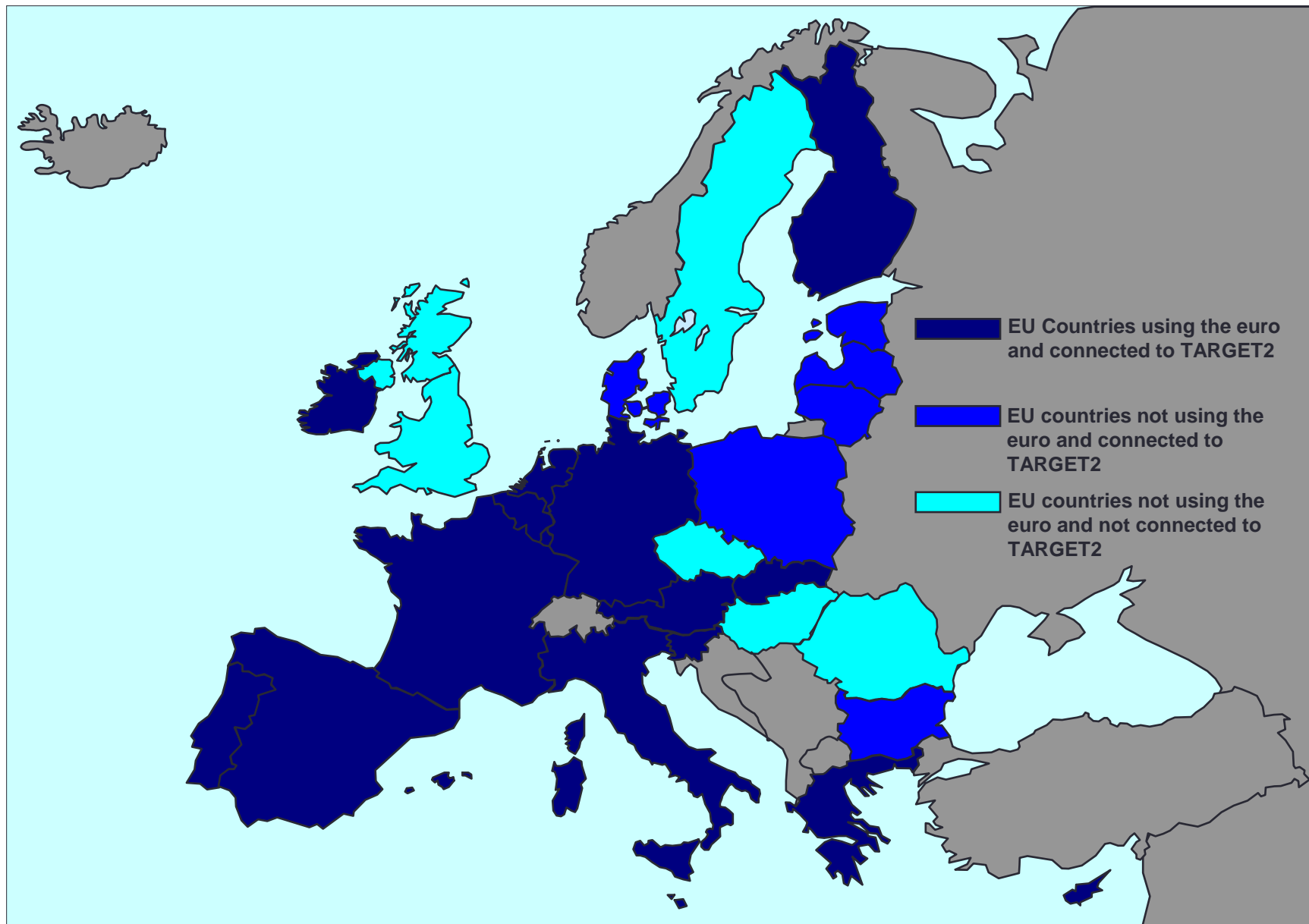
Outline

- The TARGET2 payment system
- Why identify interbank lending transactions?
- How to identify a money market payment?
- Literature review
- TARGET2 implementation (Corridor approach)
- Validation
- First results

TARGET2 payment system in a nutshell

- PAN European Large Value Payment System (RTGS)
- Daily turnover \pm EUR 2,300 billion
- Daily number of transactions \pm 350,000
- Average transaction value: EUR 6.6 million

Countries connected to TARGET2



Why identify interbank lending transactions?

Payment systems perspective

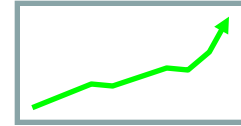
- They are highest in value
- When preparing for simulations:
 - primary goal for money market is reserve requirement
 - first leave out money market transactions
 - then bring in generated transactions based on rules

Other perspectives

- Link with monetary policy
- Interbank money market is crucial for funding of banks
- First signs of difficulties / exclusions

Example of a transaction (1/2)

Date: Thursday, 9th October



Fred



Lara

Lara speaking

Hi, it's Fred
I need a 100 mills overnight..

OK, that's possible Fred,
I'm asking 1.05

Hmm, EONIA is 1.00
I'll ask for 1.05

$$\begin{aligned} &100 \text{ mln} \\ &\quad * 1.05 \\ &\quad * (1 / 360) \\ &= 2,916.67 \end{aligned}$$

Agreed
Rate amount is 2,916.67

One moment Lara,
can we agree on Monday ?

Well, he sure is in need...
Let me rise to 1.10

That's a bit difficult...
then I'm asking 1.10

$$\begin{aligned} &100 \text{ mln} \\ &\quad * 1.10 \\ &\quad * (4 / 360) \\ &= 12,222.22 \end{aligned}$$

Agreed !
Rate amount is 12,222.22
Thanks, see you

Hmmm that was VERY
quickly agreed
Next time I will start
negotiations at Eonia + 10

Bye bye Fred

Example of a transaction (2/2)

- Resulting payments are:
 - Thursday: Lara to Fred – 100,000,000.00
 - Monday: Fred to Lara – 100,012,222.22
- Loan amount, year rate and maturity lead to accrued amount
- Rates lie around EONIA
- Reputation of a bank is the result of a delicate process

How to identify a money market payment ?

The “Furfine algorithm”

Methodology introduced by Craig Furfine, 1999, BIS



- Payment on day t
- from participant **A** to **B**
- amount **X**
(rounded to 1 mln euro)

- Payment on day $t+1$
- from participant **B** to **A**
- amount **X**
plus
plausible
interest rate

Literature review 1/3

- Furfine (1999) was the first to develop an algorithm
 - US overnight market
 - Corridor 50 bp above and below the federal funds rate
 - Minimum loan size USD 1 million and increment 100,000
- Demerrialp et al. (2004)
 - US overnight market
 - Based on Furfine
 - Corridor 100 bp above and below the federal funds rate
 - Minimum loan size USD 50,000 and increment 50,000
 - Interest rate rounded to 1/32

Literature review 2/3

- Guggenheim et al. (2010)
 - Swiss market
 - Corridor 15 bp above and below respective Libor rate. On days of high volatility this corridor is set larger.
 - Minimum loan size CHF 500,000 and increment 100,000
 - Maturities up to 3 months
- Heijmans et al. (2010)
 - Dutch market (in euro)
 - Corridor 50 bp above and below EONIA/EURIBOR. Temporarily increased lower bound to 100 bp.
 - Minimum loan size EUR 100,000 and increment 100,000
 - Minimum interest rate: 5bp
 - Maturities up to 3 months

Literature review 3/3

- Hendry and Kamhi (2007): Canadian market
- Akram and Christophersen (2010): Norwegian market
- Whetherilt et al. (2010): British market
- ...

Matching is never 100% perfect

- Type 1 error (false positive)
 - Payment transaction wrongly classified as bank loan
- Type 2 error (false negative)
 - True bank loan wrongly rejected
- Type A error
 - Wrongly assigned to a duration

The added value of the paper

- Our algorithm is suitable for the whole euro area
 - Domestic
 - Cross border
- Maturities up to three months reliably estimated (with a high degree of uncertainty also maturities from three months to one year)
- Validation of the “Furfine” algorithm for the first time with subsections of the whole euro area money market data (e-MID and EONIA)

TARGET2 implementation - Corridor approach (1/7)

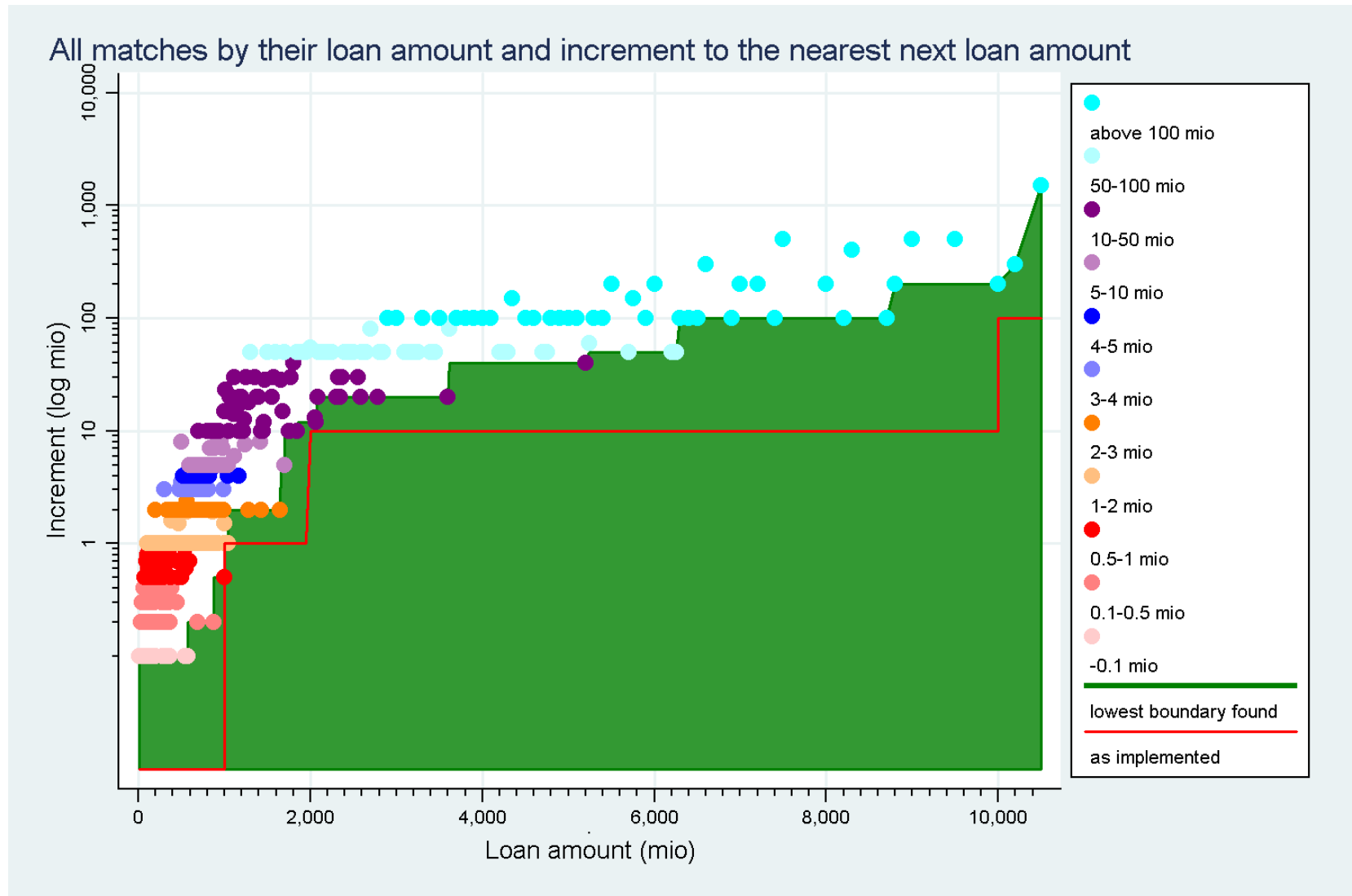
- Data

- Transaction type:
 - Bank-to-bank transactions
 - At later stage also customer payments
- Aggregation of BICs: BIC11 (at later stage improvement/research)
- Removing intra-group transaction using Group BIC consolidation based on SWIFT directory
- Limitation due to the missing ordering and beneficiary information:
 - Some extra-group transactions could be intra-group and vice-versa

- Loan and increment

- Minimum loan value: EUR 1 million (may be decreased to 100 thd - performance problem!)
- Increment: EUR 10,000: (larger increment e.g. for loans > 1 bln (research). **Based on unique matches statistics** (see next slide)

TARGET2 implementation - Corridor approach (2/7)



TARGET2 implementation - Corridor approach (3/7)

- Different corridors investigated
 - ECB corridor (OverNight Deposit and Marginal Lending)
 - ECB corridor ± 25 bps (OND-25 bps and ML+25 bps)
 - EONIA/EURIBOR ± 25 bps
 - EONIA/EURIBOR ± 50 bps
 - EONIA/EURIBOR ± 100 bps

→ One of these corridors still has to be chosen to be the most optimal

- Plausible interest rates
 - Must be within corridor
 - Only interest rates rounded to nearest $\frac{1}{2}$ bp are considered plausible

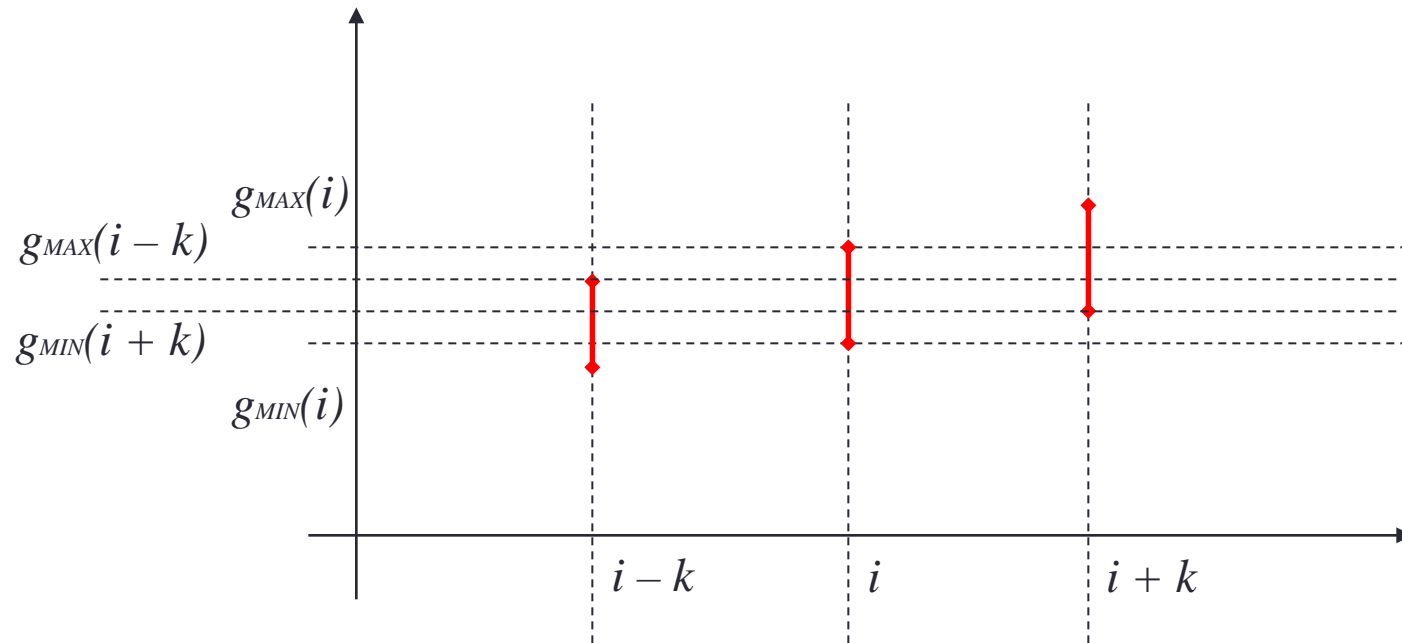
TARGET2 implementation - Corridor approach (4/7)

- Multiple matches
 - Multiple matches possible (matched loan not taken out)
 - Most plausible duration will be chosen on number of unique matches per duration (see next slides)
 - Information on choice is kept in final datasets
- Maximum duration of stable assignment
 - ongoing research (see next slides)

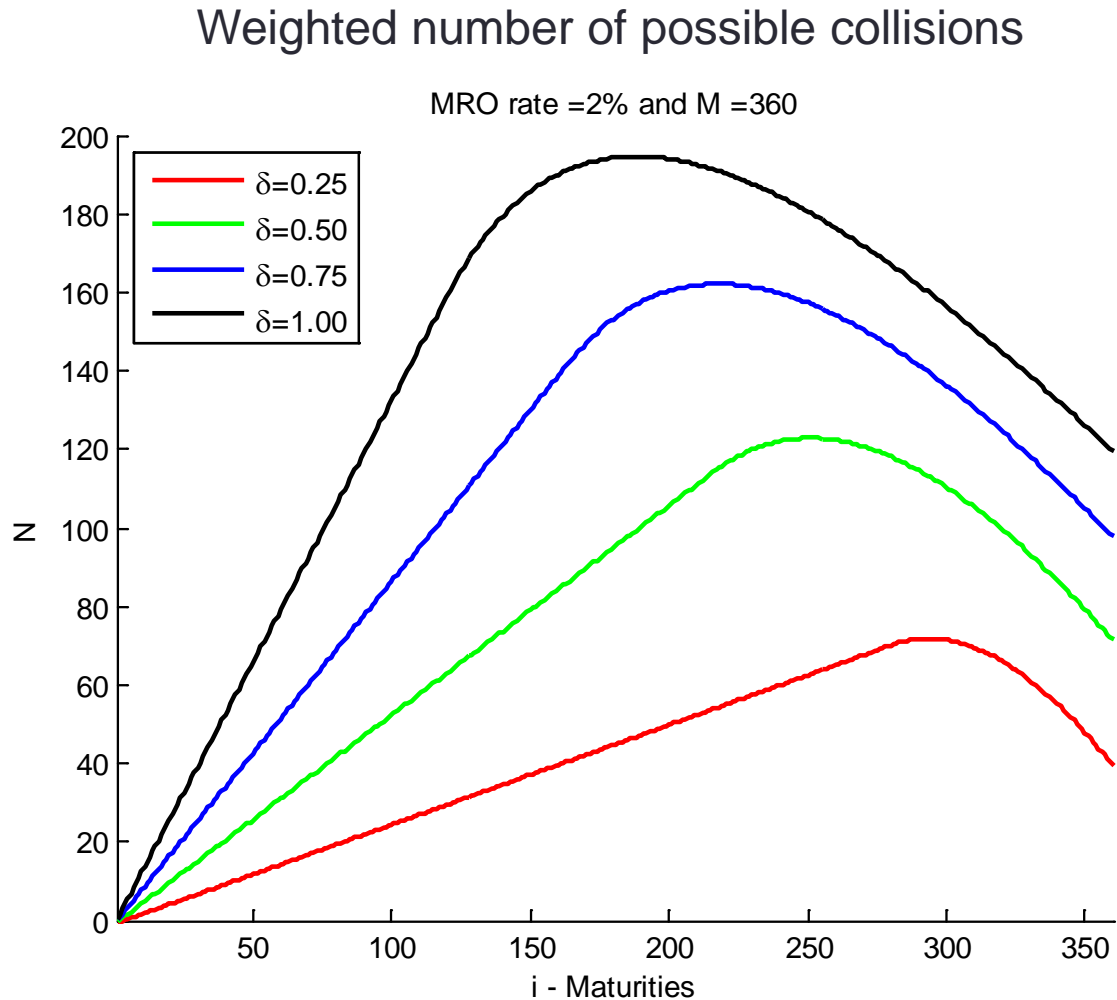
TARGET2 implementation - Corridor approach (5/7)

There is intra-maturity ambiguity between i days duration loan and $i + k$ and $i - k$ for a given amount x if the interest corridors overlaps

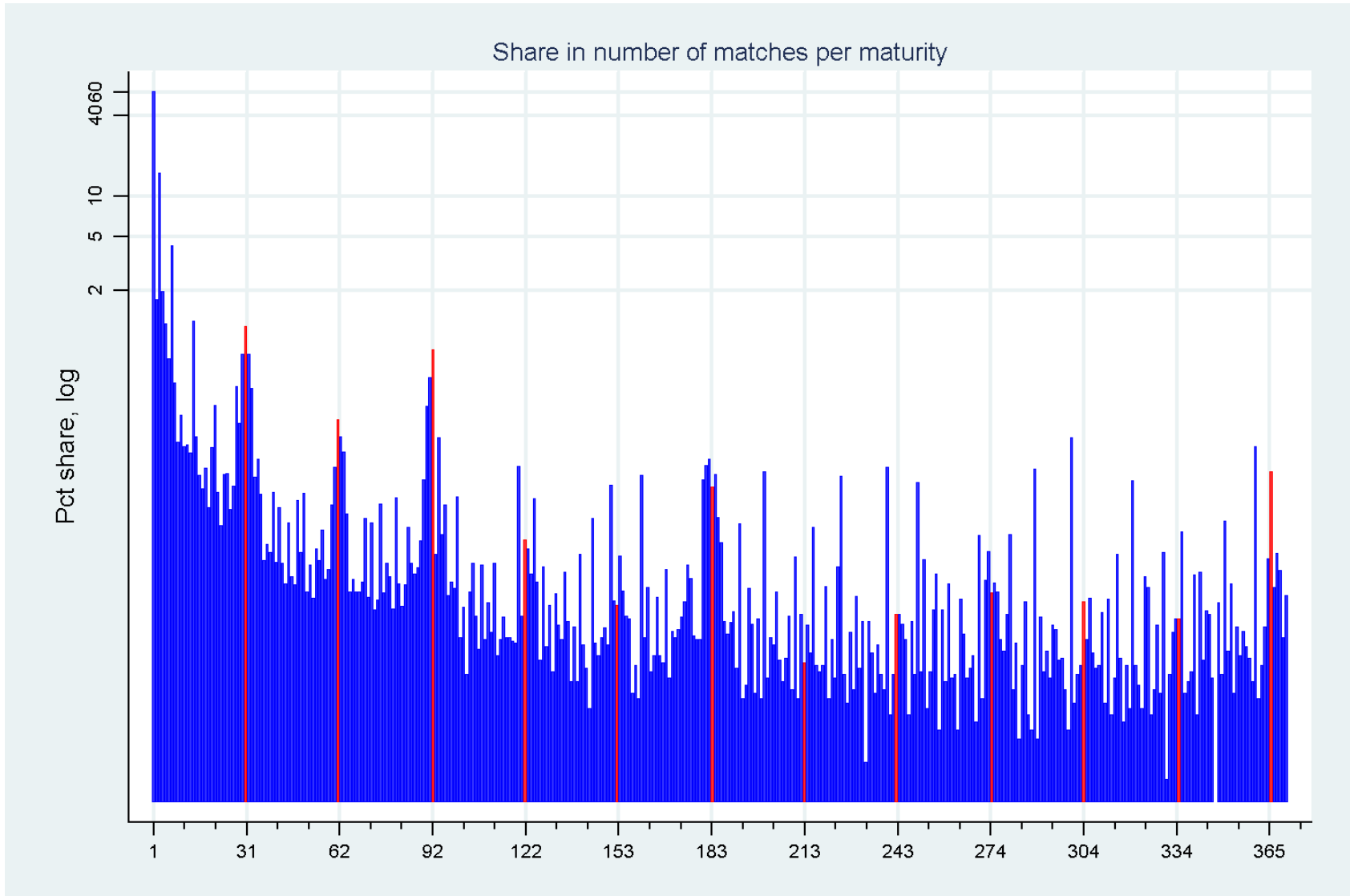
$$\begin{cases} g_{MIN}(i+k) < g_{MAX}(i) \\ g_{MAX}(i-k) > g_{MIN}(i) \end{cases} \quad \text{for } k < i$$



TARGET2 implementation - Corridor approach (6/7)



TARGET2 implementation - Corridor approach (7/7)



Validation – e-MID (1/7)

- Italian electronic money market system for all maturities
- Participation of foreign banks and sizeable market share until end 2009
 - Significant euro-area benchmark
- Three trading possibilities
 - Multilateral segment
 - Request for quote
 - Direct order
- Two settlement options (and two validation strategies)
 - Automatic
 - Manual

Validation – e-MID (2/7)

Corridor	Monetary policy corridor		EONIA/EURIBOR		
	0 p.b.	+/-25p.b.	+/-25p.b.	+/-50p.b.	+/-100p.b.
	ECB0	ECB25	EONIA25	EONIA50	EONIA100
Transactions with correct quantities and counterparties but with wrong interest rate or maturity (E11)	49	72	20	29	60
False positive (E12)	512	534	1485	746	460
False negative (E21) due to interest rate not enclosed within the corridor	4.230	371	117	46	2
False negative (E22) due to reasons other than interest rate not enclosed within the corridor	2.956	633	19.139	3.864	1.318
Total money market transactions estimated with the Furfine algorithm	183.569	189.796	172.443	187.059	189.394
Total e-MID transactions with automatic settlement	190.194	190.194	190.194	190.194	190.194
Total correctly estimated transactions	183.008	189.190	170.938	186.284	188.874
Total type 1 errors	561	606	1505	775	520
Total type 2 errors	7186	1004	19.256	3.910	1.320
Type 2 errors (percentage of the total e-MID transactions with automatic settlement)	3,78%	0,53%	10,12%	2,06%	0,69%
Type 1 and Type 2 errors (percentage of the total e-MID transactions with automatic settlement)	4.07%	0.85%	10.92%	2.46%	0.97%

Validation – e-MID (3/7)

- First validation strategy possible when using the automated settlement facility
 - Almost exclusively adopted by Italian counterparties
- Corridors $ECB \pm 25$ and $EONIA \pm 100$ provide best results
 - Error rate 0.85% and 0.97%

Validation – e-MID (4/7)

maturities	ctype	delta	E11	E12	E21	E22	TOTFURF	TOTEMID	TOTGOOD	E1	E2	Error Rate
1-94	ECB	0bps	49	512	4.230	2.956	183.569	190.194	183.008	561	7.186	3,78%
		25bps	72	534	371	633	189.796	190.194	189.190	606	1.004	0,53%
		100bps	116	642	20	788	190.144	190.194	189.386	758	808	0,42%
	Eoniap	25bps	20	1.485	117	19.139	172.443	190.194	170.938	1.505	19.256	10,12%
		50bps	29	746	46	3.864	187.059	190.194	186.284	775	3.910	2,06%
		100bps	60	460	2	1.318	189.394	190.194	188.874	520	1.320	0,69%
	200bps	99	644	-	952	189.985	190.194	189.242	743	952	0,50%	
1	ECB	0bps	11	4	2.780	2.001	135.720	140.486	135.705	15	4.781	3,40%
		25bps	13	6	10	61	140.434	140.486	140.415	19	71	0,05%
		100bps	28	18	-	63	140.469	140.486	140.423	46	63	0,04%
	Eoniap	25bps	1	-	10	13.331	127.146	140.486	127.145	1	13.341	9,50%
		50bps	2	2	1	2.027	138.462	140.486	138.458	4	2.028	1,44%
		100bps	9	4	-	427	140.072	140.486	140.059	13	427	0,30%
	200bps	19	7	-	52	140.460	140.486	140.434	26	52	0,04%	
2-10	ECB	0bps	31	230	852	698	42.668	43.957	42.407	261	1.550	3,53%
		25bps	51	249	20	296	43.941	43.957	43.641	300	316	0,72%
		100bps	77	300	-	375	43.959	43.957	43.582	377	375	0,85%
	Eoniap	25bps	11	851	4	4.504	40.311	43.957	39.449	862	4.508	10,26%
		50bps	14	258	2	1.033	43.194	43.957	42.922	272	1.035	2,35%
		100bps	45	217	-	511	43.708	43.957	43.446	262	511	1,16%
	200bps	70	312	-	547	43.792	43.957	43.410	382	547	1,24%	
11-33	ECB	0bps	4	113	306	196	3.979	4.364	3.862	117	502	11,50%
		25bps	5	143	136	211	4.165	4.364	4.017	148	347	7,95%
		100bps	8	196	2	254	4.312	4.364	4.108	204	256	5,87%
	Eoniap	25bps	6	357	32	1.078	3.617	4.364	3.254	363	1.110	25,44%
		50bps	10	243	11	630	3.976	4.364	3.723	253	641	14,69%
		100bps	4	127	-	250	4.245	4.364	4.114	131	250	5,73%
	200bps	7	183	-	250	4.304	4.364	4.114	190	250	5,73%	
34-94	ECB	0bps	3	165	292	61	1.202	1.387	1.034	168	353	25,45%
		25bps	3	136	205	65	1.256	1.387	1.117	139	270	19,47%
		100bps	3	128	18	96	1.404	1.387	1.273	131	114	8,22%
	Eoniap	25bps	2	277	71	226	1.369	1.387	1.090	279	297	21,41%
		50bps	3	243	32	174	1.427	1.387	1.181	246	206	14,85%
		100bps	2	112	2	130	1.369	1.387	1.255	114	132	9,52%
	200bps	3	142	-	103	1.429	1.387	1.284	145	103	7,43%	

Validation – e-MID (5/7)

- The higher the maturity, the higher the error rate
 - Maturities >10 days have an error rate >5%
 - ECB corridors better for shorter maturities whereas EONIA corridors for longer maturities

Validation – e-MID (6/7)

	Maturity	Total e-MID trades	Total e-MID trades (size > 1000E)	Total e-MID trades (size >1000E - not on-us)	Totally correctly matched transactions	False positives - assignment to wrong maturity	False negatives - interest rate outside of the corridor	False negatives - due to other reasons	Correctly matched	Type 2 error	
ecb 25	All	216,039	215,782	209,000	195,105	7	758	13,137	93%	7%	
	1	159,098	158,886	154,333	144,656	1	584	9,093	94%	6%	
	Italian	2 - 10	50,109	50,071	48,235	45,135	3	174	2,926	94%	6%
	Domestic	11 - 33	5,237	5,231	4914	4,199	2	0	715	85%	15%
		34 - 94	1,595	1,594	1518	1,115	1	0	403	73%	27%
	All	11,316	11,315	11,277	10,367	5	1	909	92%	8%	
	1	8,769	8,768	8,752	8,069	1	1	682	92%	8%	
	Foreign	2 - 10	2,363	2,363	2,352	2,158	4	0	194	92%	8%
		11 - 33	163	163	161	133	0	0	28	83%	17%
		34 - 94	21	21	12	7	0	0	5	58%	42%
eonia 100	All	216,039	215,782	209,000	192,721	12	3,368	12,911	92%	8%	
	1	159,098	158,886	154,333	142,821	1	2,690	8,822	93%	7%	
	Italian	2 - 10	50,109	50,071	48,235	44,382	3	678	3,175	92%	8%
	Domestic	11 - 33	5,237	5,231	4914	4,245	5	0	669	86%	14%
		34 - 94	1,595	1,594	1518	1,273	3	0	245	84%	16%
	All	11,316	11,315	11,277	10,356	2	16	905	92%	8%	
	1	8,769	8,768	8,752	8,074	0	16	662	92%	8%	
	2 - 10	2,363	2,363	2,352	2,141	4	0	211	91%	9%	
	Foreign	11 - 33	163	163	161	134	0	0	27	83%	17%
		34 - 94	21	21	12	7	0	0	5	58%	42%

Validation – e-MID (7/7)

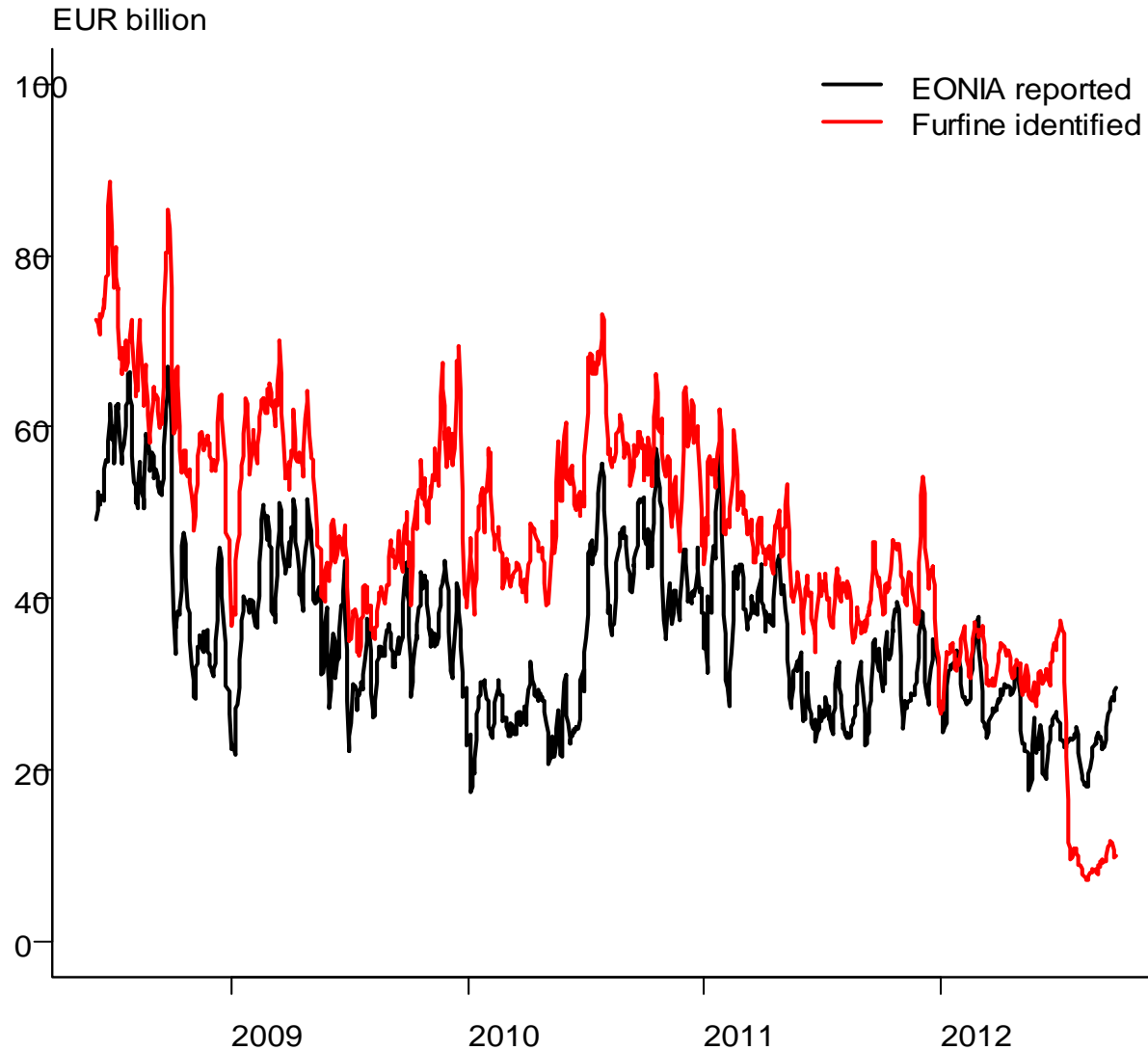
- Second validation strategy used when trades are
 - Settled through the same settlement bank; or
 - When involving at least one participant not using the automated settlement facility
- Not directly comparable with the first validation strategy
- Error rates
 - Lower for trades between Italian counterparties
 - <10% for short maturities but very large for longer maturities
- Low incidence of correspondent banking arrangements

Validation – EONIA (1/3)

- Effective Overnight Interest rate for all lending transactions
- Based on a dynamic panel of representative banks reporting turnover and weighted rate
 - Euro-area benchmark
- Two validation strategies
 - Aggregate level
 - Individual level

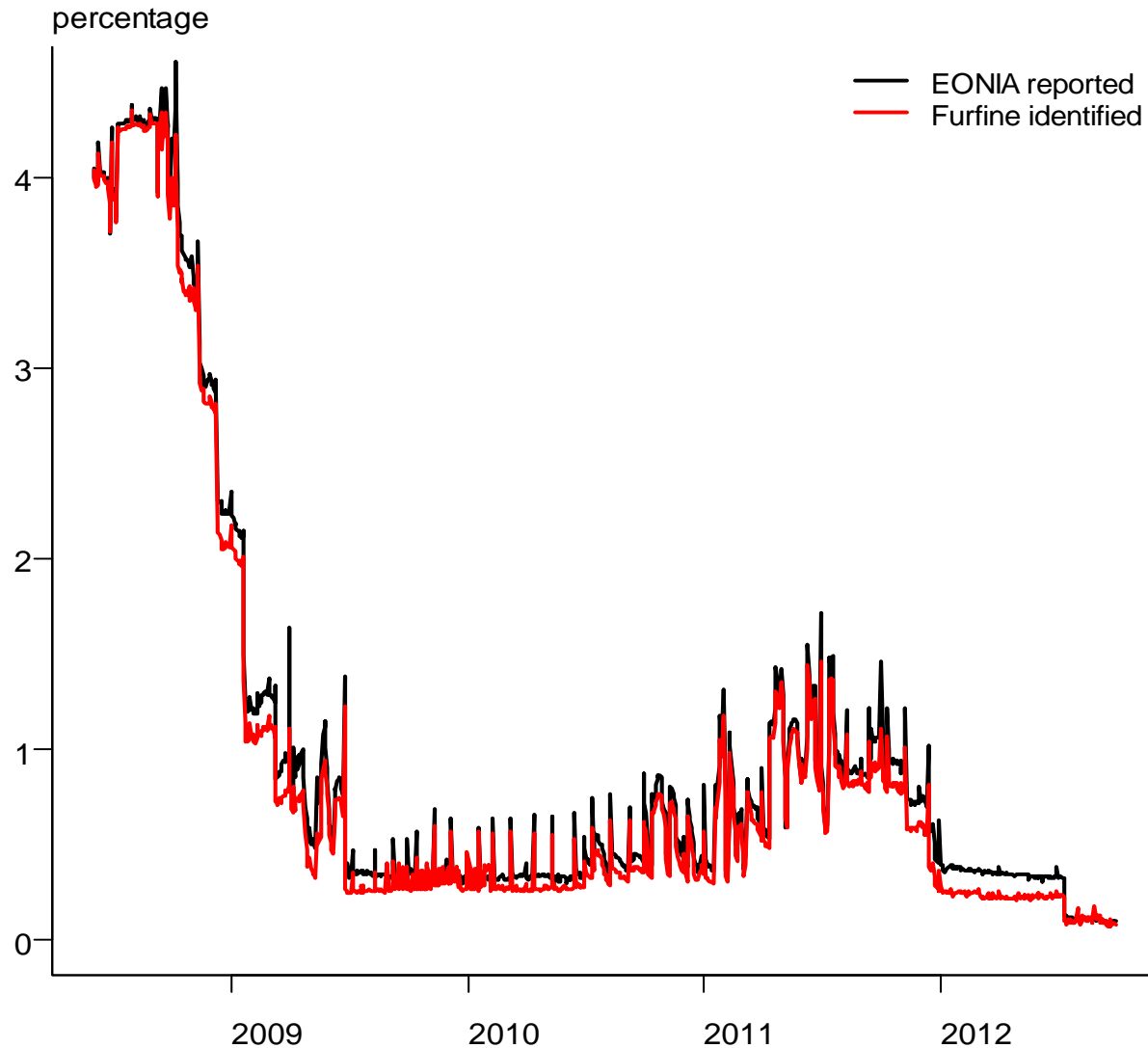
Validation – EONIA (2/3)

- Identified loans larger than reported ones can be due to
 - tom e spot next transactions
 - transactions on behalf of other banks
 - intragroup transactions
- Effect of the last ECB interest rate decision



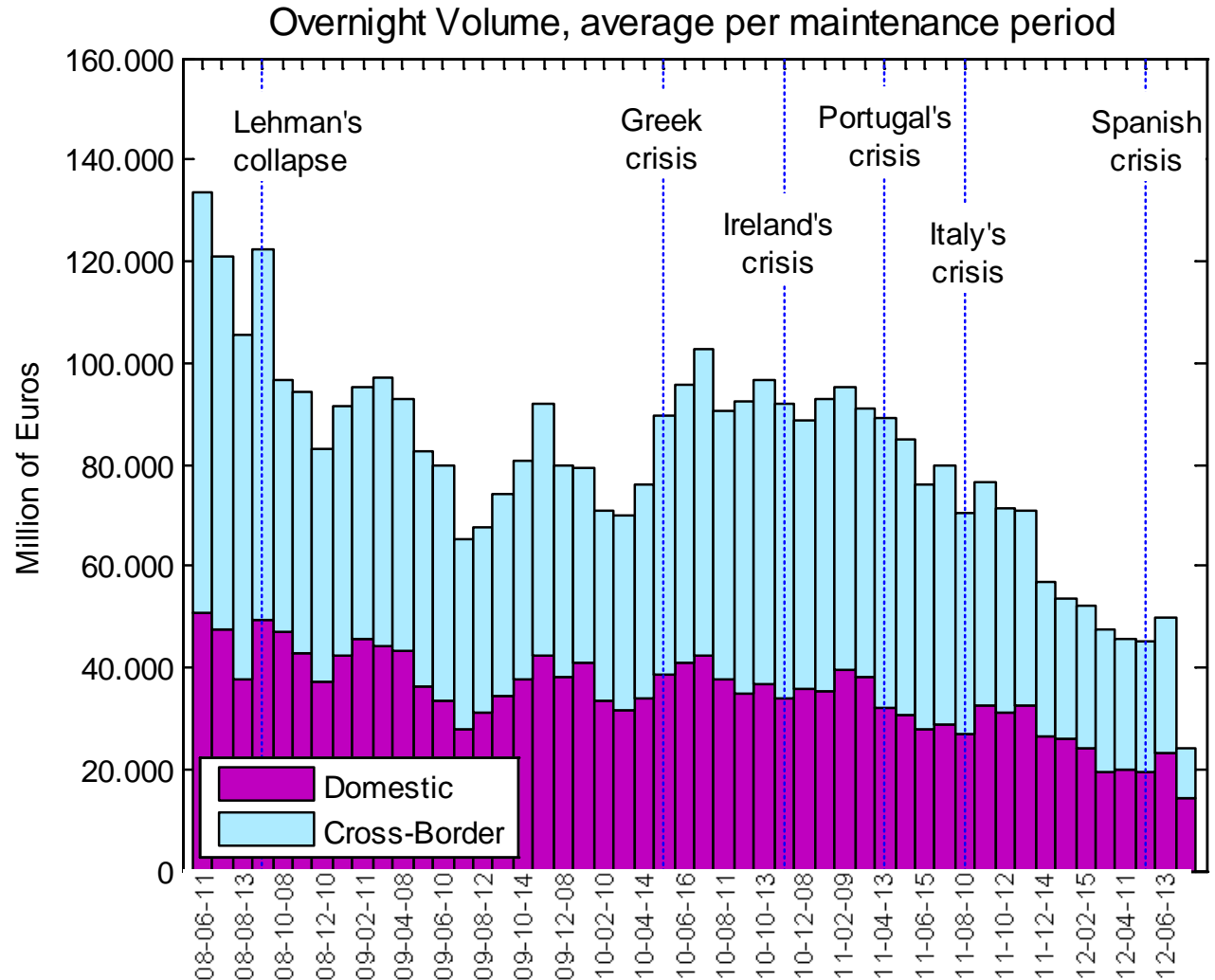
Validation – EONIA (3/3)

- Identified rate closely matches EONIA
- Peaks at the end of the maintenance period matched
- Lower dispersion with lower interest rate levels



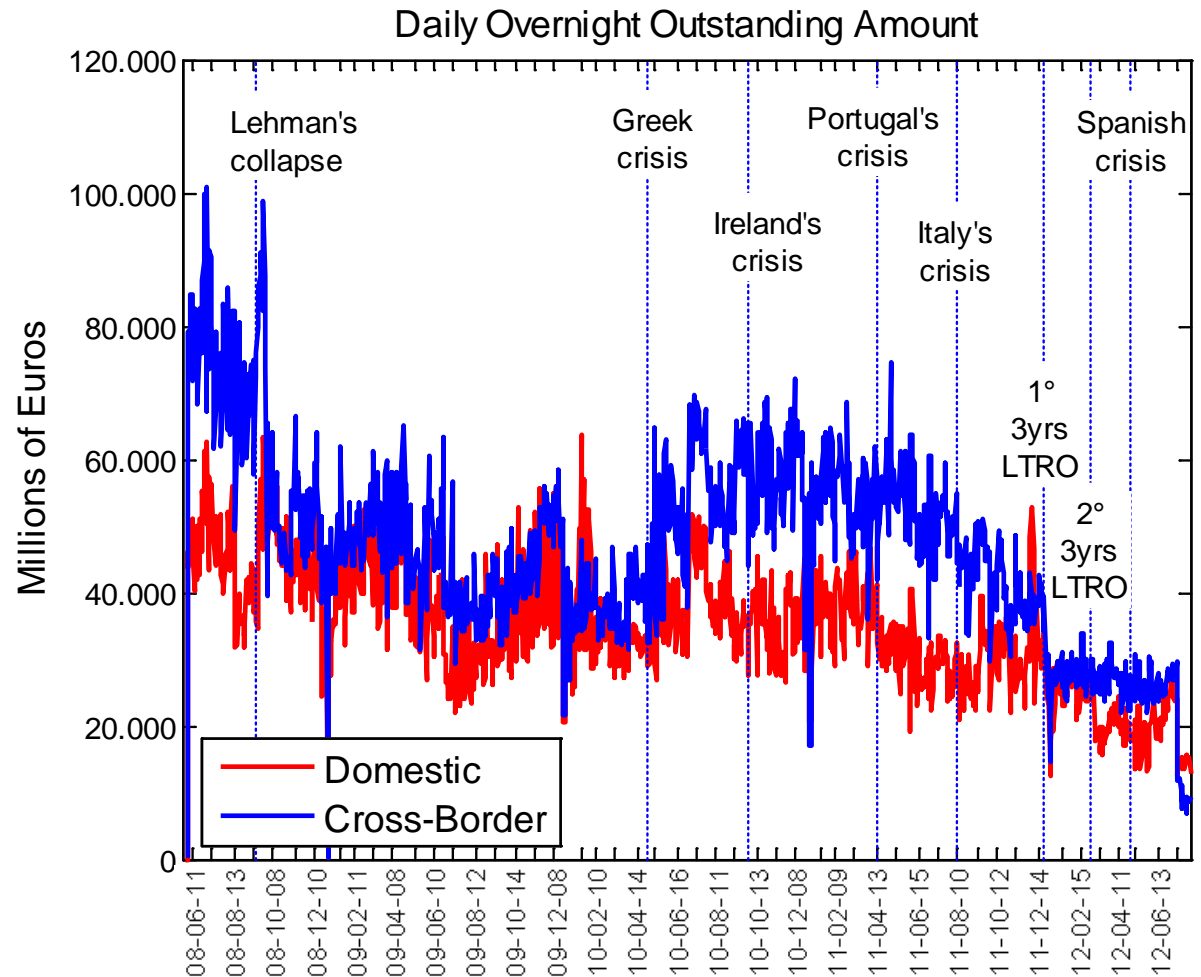
Overnight money market volume

- Drop after Lehman's default
- Stabilisation between July 2009 and the outbreak of the Greek crisis (May 2010)
- Partial recovery
- Renewed drop after the Portugal's request of financial assistance and the two 3-yrs LTRO



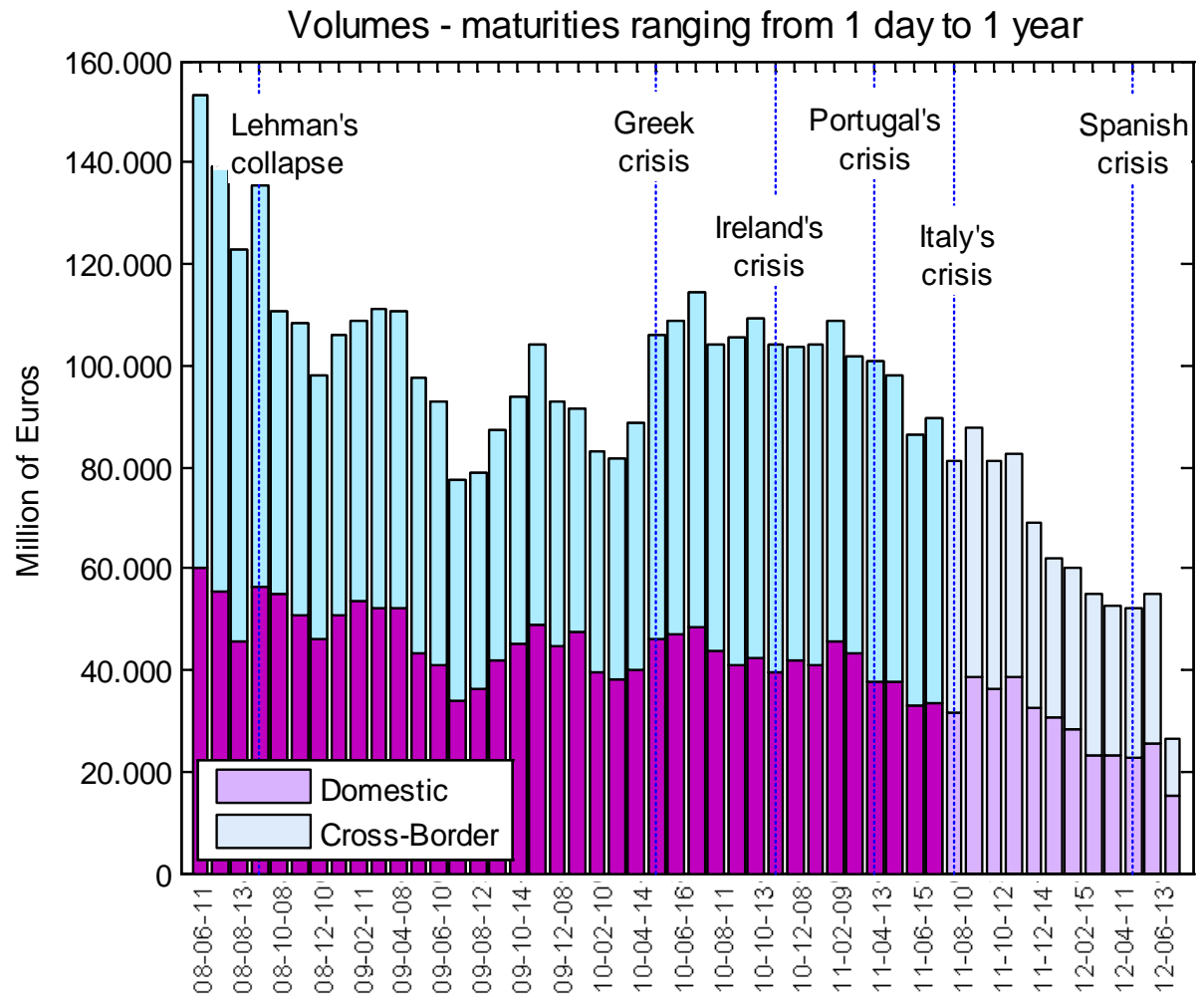
Cross-border overnight money market volumes

- More pronounced decreasing pattern than the domestic share
- More stable than the domestic share following the ECB's second 3yrs-LTRO
- Drop dramatically after the last ECB rate cut



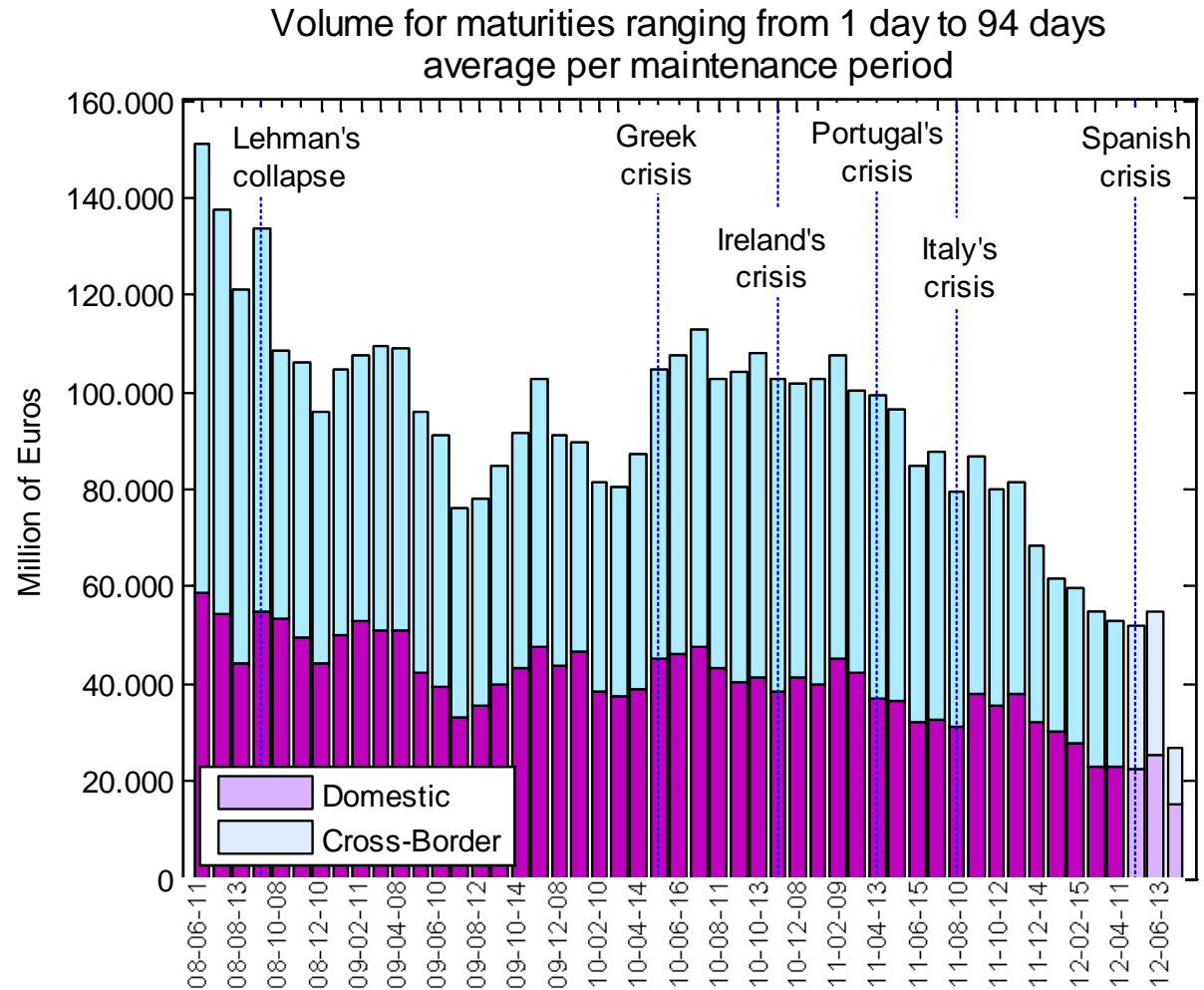
Maturities from 1 day to 1 year (volumes)

- Represent the biggest value added of the methodology
- Not fully reliable on the last 12 months of the sample
- Therefore focus on maturities up to 3 months



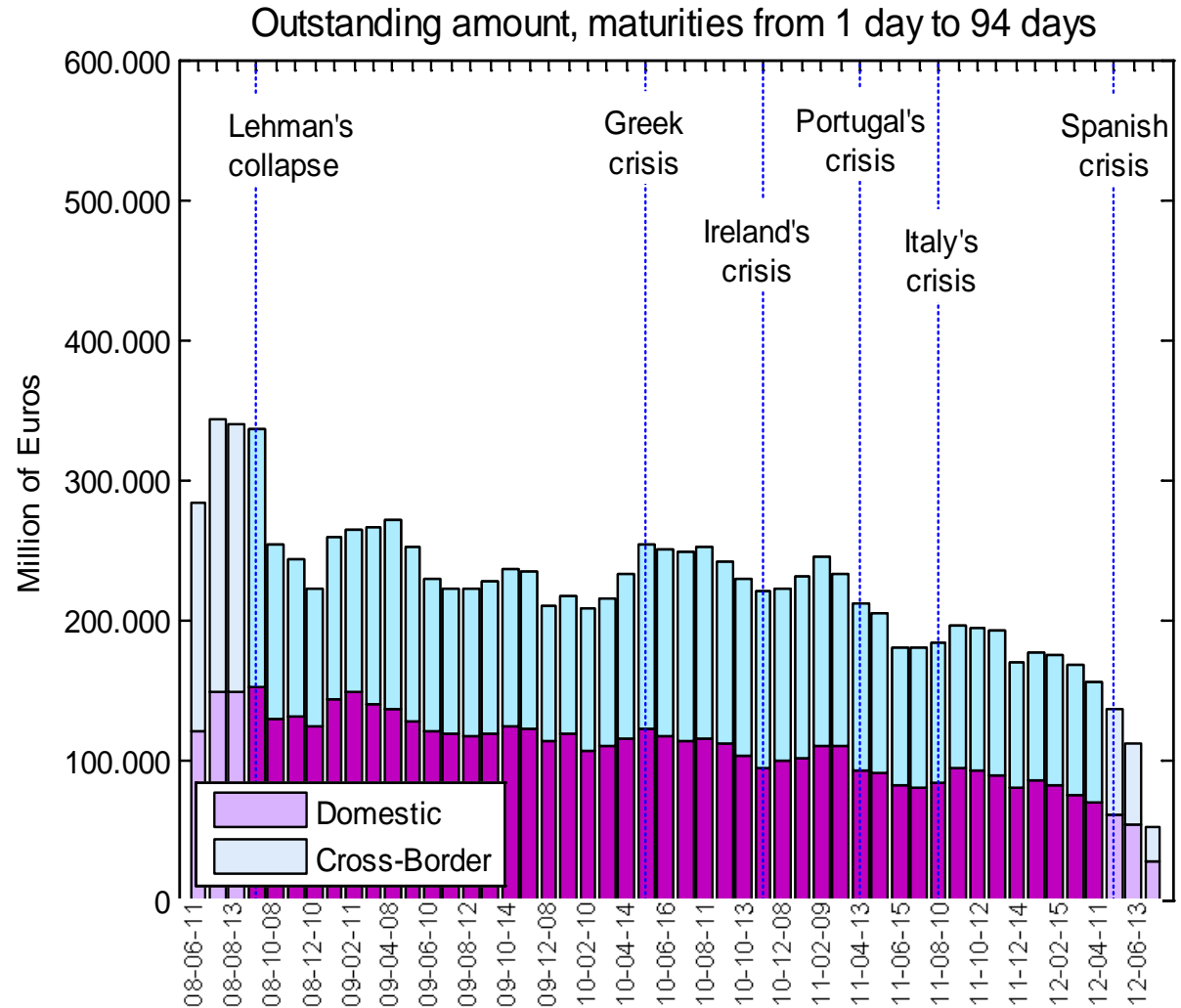
Maturities from 1 day to 3 months (volume)

- Reflect the same pattern as the one of the overnight market



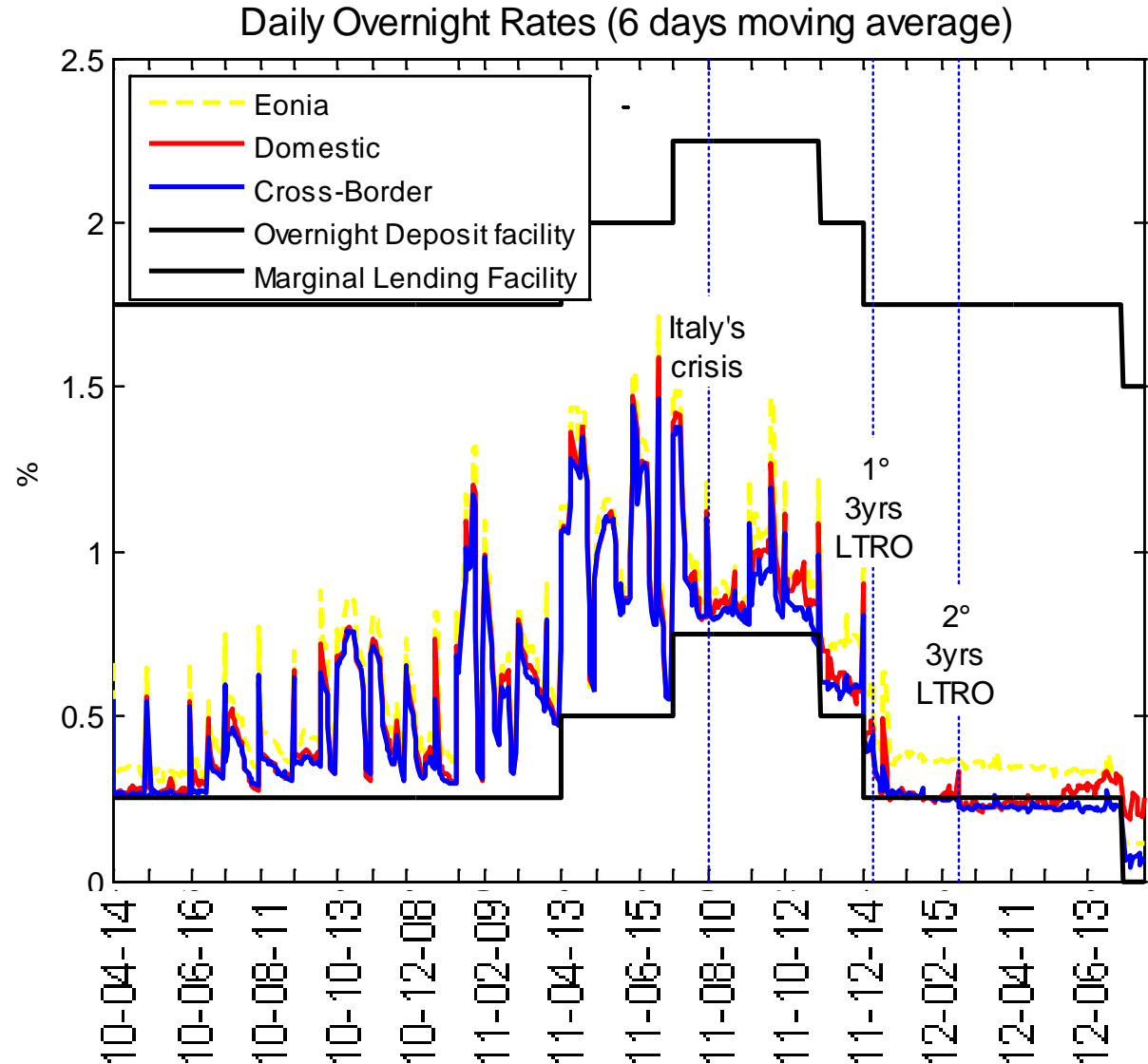
Maturities from 1 day to 3 months (out. amounts)

- Drop after Lehman's default
- Drop after Portugal's crisis



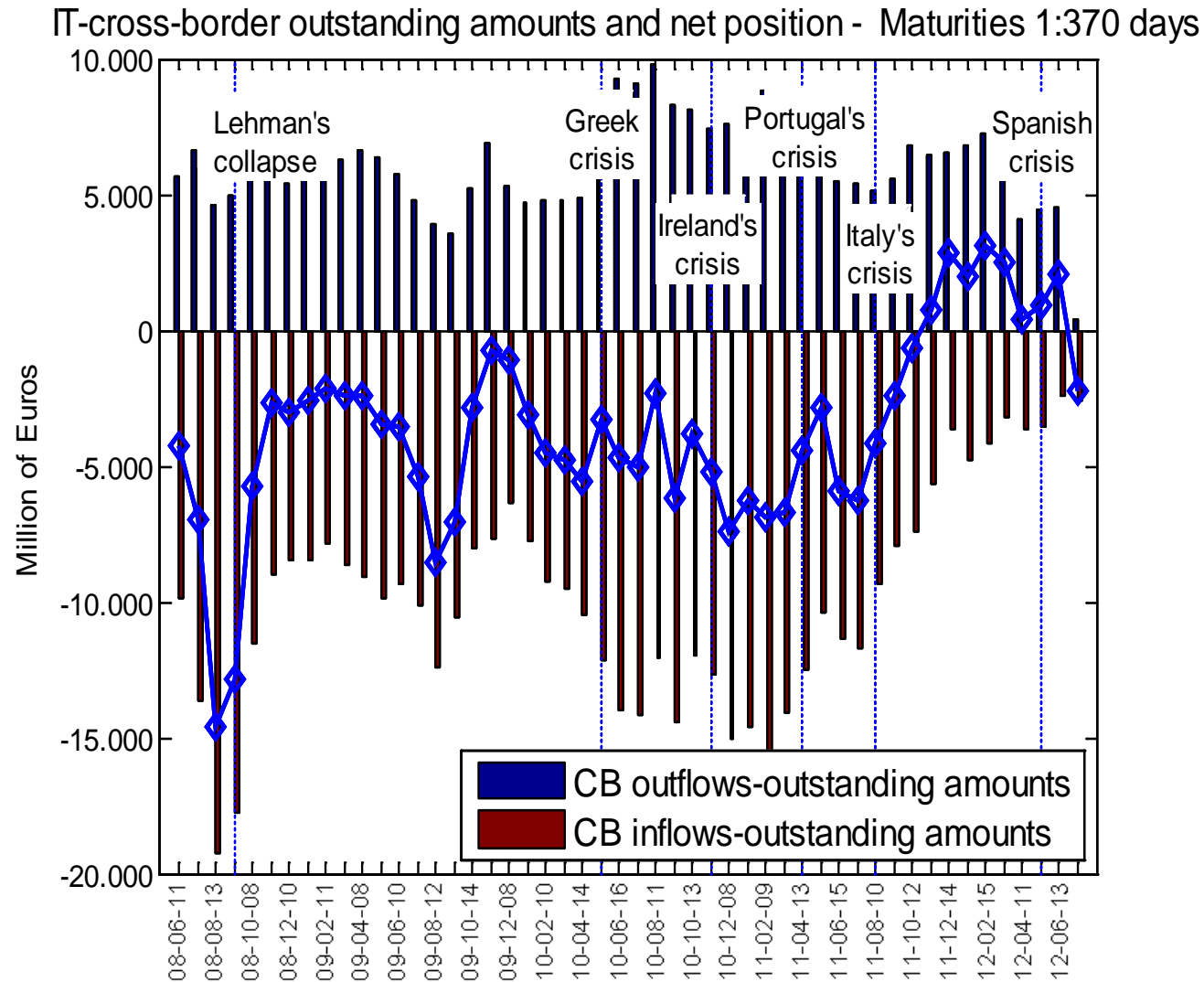
Overnight rates

- Usually lower than EONIA in the last day of maintenance periods
- Following the second 3-years LTRO it is aligned with the deposit facility rate
- Cross-border rates are lower than since mid 2011



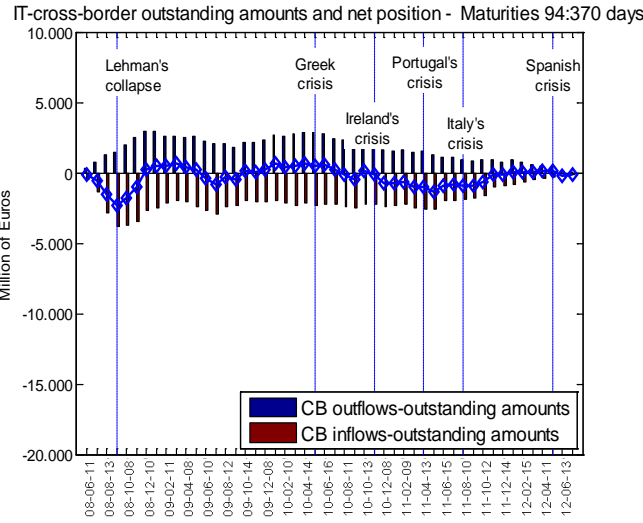
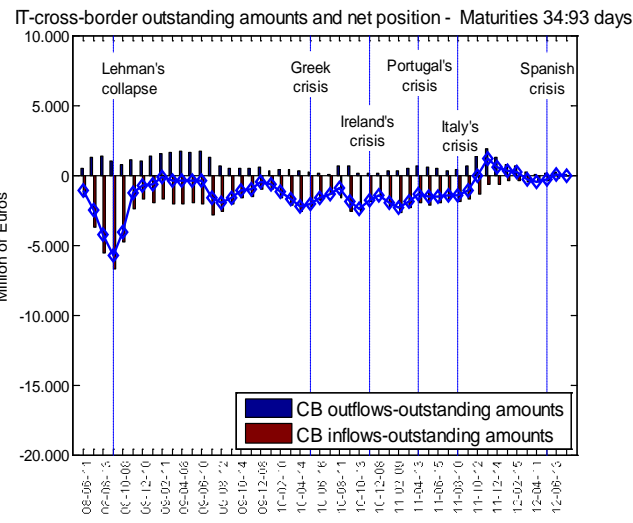
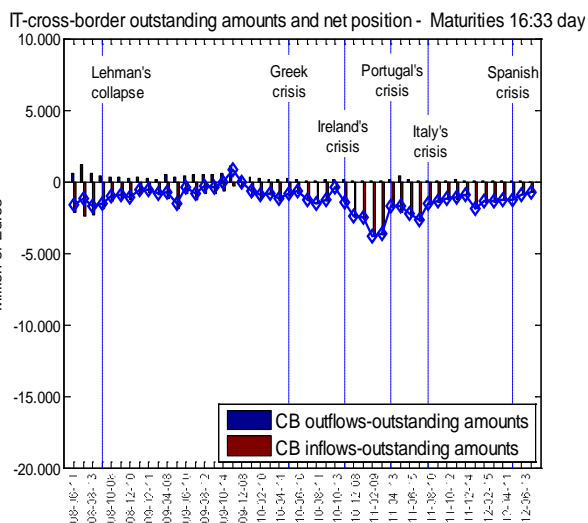
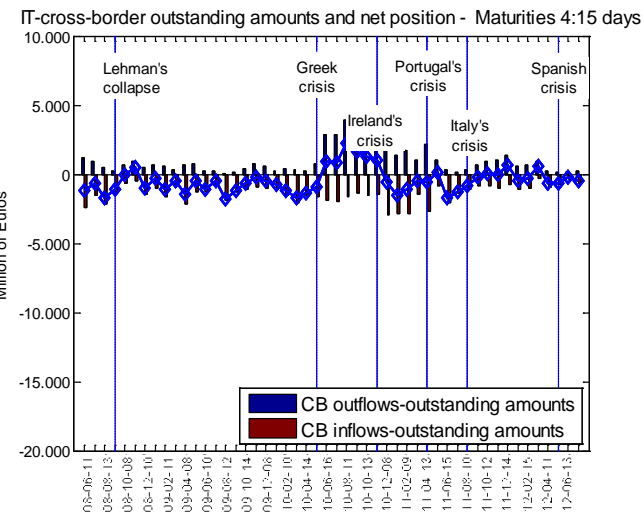
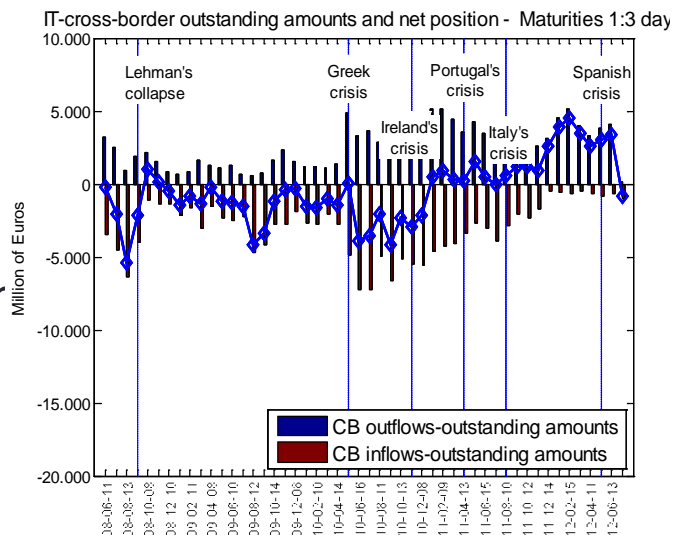
The Italian cross-border net position

- Negative cross-border net position until the first 3-years LTRO (December 2011)
- Reversal in June 2012



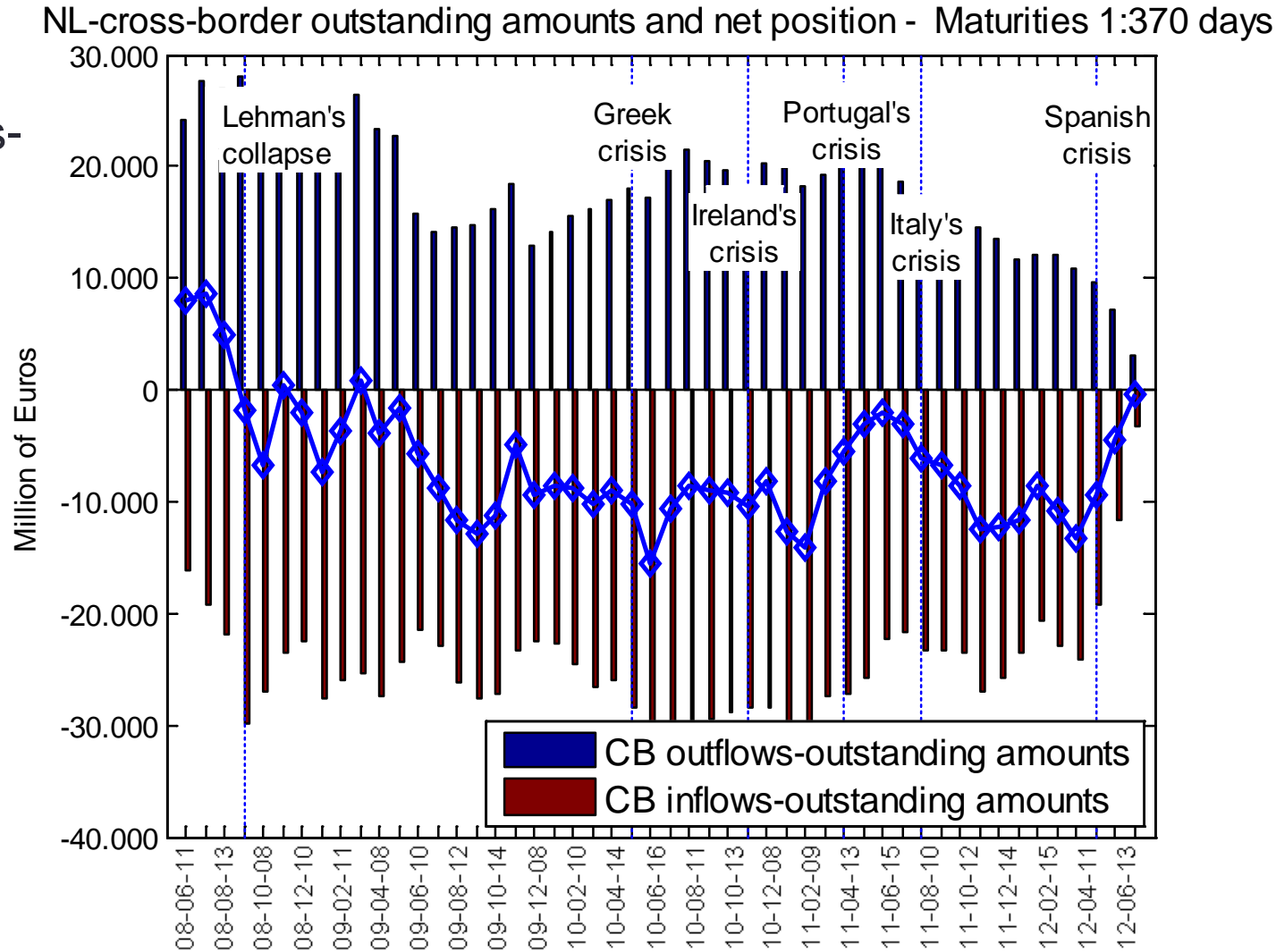
The Italian cross-border net position: decomposition for maturity buckets

Already since June 2009 on very short maturities positive cross-border net position + negative on the longer maturities



The Dutch cross-border net position

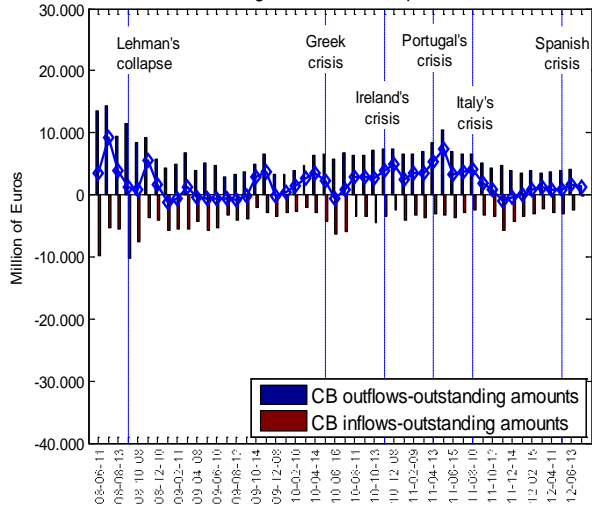
- Negative cross-border net position



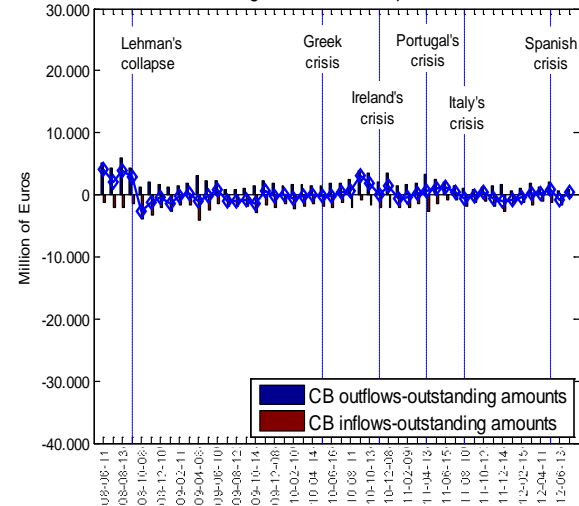
The Dutch cross-border net position: decomposition for maturity buckets

Positive cross-border net position on very short maturities + negative on the longer maturities (exceeding one month)

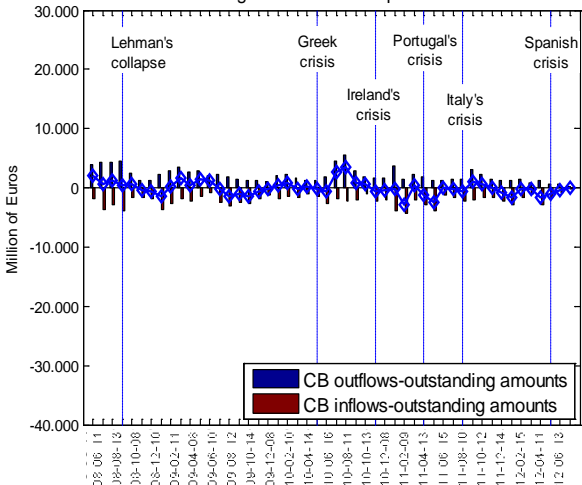
NL-cross-border outstanding amounts and net position - Maturities 1:3 days



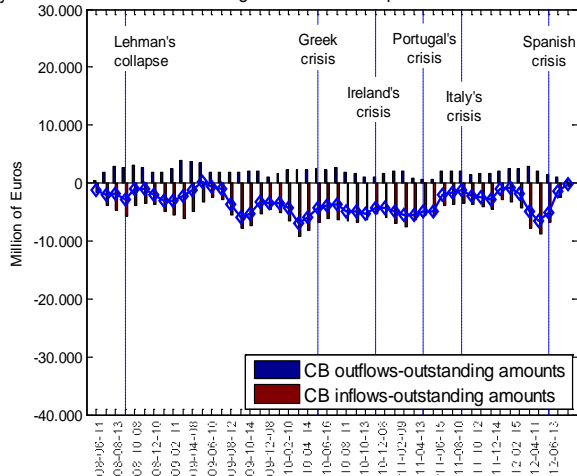
NL-cross-border outstanding amounts and net position - Maturities 4:15 days



NL-cross-border outstanding amounts and net position - Maturities 16:33 day



NL-cross-border outstanding amounts and net position - Maturities 34:93 days



NL-cross-border outstanding amounts and net position - Maturities 94:370 days

