Internet Appendix for "The Euro Interbank Repo Market"

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Abstract

This supplemental appendix extends the main paper by presenting additional analyses and robustness checks. It also describes the procedure to construct proxies for representative volume-weighted average haircuts that are used in our measure for differences in eligibility criteria at the ECB and at the CCP (HCR).

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Appendix A. Computation of average haircuts

This section describes the procedure to compute our proxies for the representative weighted average haircuts at Eurex Repo and at the ECB that we discuss in Section 3 of the main paper and use to compute the state variable HCR, measuring differences in eligibility criteria at the ECB and at the CCP in Section 4. To compute the haircuts we rely on the list of securities that are eligible for ECB refinancing operations as our main data set. This list is available on a daily basis since April 8, 2010 from the ECB website (`www.ecb.europa.eu/paym/coll/assets/html/list.en.html`.). For each eligible security, the list contains various information, including the ISIN code, detailed properties of the security as well as the issuer, and the haircut applied by the ECB.

The first step in computing our haircut proxies is to reconstruct the universe of assets that could be eligible as collateral at the ECB. We only consider securities that were eligible at the ECB at least during part of the sample to be included in this universe of eligible securities. Between October 30, 2008 and December 31, 2010 we let the universe of assets simply be equal to the list of eligible securities at the ECB. During this time period the ECB accepted the broadest range of securities to support financial markets during the crisis. For the sample prior to April 8, 2010 we use the universe of assets on April 8, 2010, assuming that the properties of the securities that are included in the universe are constant over time. On December 31, 2010 some of the unconventional measures from the financial crisis expired and the number of eligible securities was reduced significantly, e.g., excluding marketable debt instruments denominated in currencies other than the euro and subordinated debt instruments.[1] To reconstruct the universe after December 31, 2010, we add the securities that were excluded on December 31, 2010 to the list of eligible

[1]See `www.ecb.int/press/pr/date/2010/html/pr100408_1.en.html`. Some the measures were reintroduced on December 31, 2011; see `www.ecb.int/press/pr/date/2012/html/pr120906_2.en.html`

securities on each day after December 31, 2010. For days after December 31, 2011 we only add securities from the exclusion list that are not denominated in USD, GBP, and JPY, because securities denominated in those currencies became eligible again on December 31, 2011 and they are thus already included on the list of eligible securities that we downloaded from the ECB's website after that day. We account for the exclusion of securities on December 31, 2012, and the addition of securities on May 30, 2012, and November 8, 2012, in a similar fashion.

The second step is to determine the haircuts applied at the ECB for each individual security in the universe of potentially eligible assets on each day. For the ECB we apply the haircuts from the daily list of eligible assets. Assets that are not eligible receive a haircut of 100%. Thus we take the view of a hypothetical bank that holds various securities and wants to obtain funding by posting these securities as collateral.

Third, we apply the haircut rules applicable at Eurex Repo for each security in the universe. As a starting point we use the haircuts applied by the ECB including 100% for securities that are not eligible at the ECB. Next we exclude further securities that are ineligible at Eurex. One important piece of information for the haircut assignment is the rating of the security. Although it would be most accurate to use the prevailing rating of the issuer or of the guarantor for each security and day in the sample, this information is not available. Therefore, we assign ratings to each security based on the issuer's or guarantor's country of residence, depending on which is better rated. More precisely, each security receives the better Fitch rating of the country corresponding to the residence of the issuer or the guarantor. The history of Fitch sovereign ratings is available on the Fitch website (`www.fitchratings.com/web_content/ratings/sovereign_ratings_history.xls`). Combining these ratings with the properties of the securities specified in the ECB list of eligible assets allows us to exclude securities that are not eligible in the two GC Pooling baskets according to the

criteria applied by Eurex Repo. We account for the changes in the eligibility criteria specified in Table IA.1. The eligibility rules at the end of our sample period are given in Eurex Repo (2013).

Finally, we compute the average haircuts of the securities eligible at the ECB and of those included in the GCP ECB basket and the ECB EXTended basket. We take the outstanding volume of different securities into account which yields a more relevant haircut proxy from the point of view of a bank. Since, we do not have information about the outstanding volume for each security in the universe of potentially eligible assets, we use the aggregate outstanding volume for different security types in 2012 as weights. The weights, which we obtained from the ECB, are shown in Table IA.2. For instance, all haircuts of central government securities receive a much higher weight (45.6%) than haircuts of asset-backed securities (7.2%) that have a much smaller outstanding volume. The resulting value weighted average haircuts are plotted in Figure IA.1.

Table IA.1. Main changes in collateral policy taken by Eurex Repo AG

Date	Basket	Change
May 17, 2010	ECB EXTended basket	Exclusion of bonds with Issuer Residence IRGR (Greece)
January 27, 2012	ECB EXTended basket	Exclusion of bonds with Issuer Residence IRPT (Portugal)
January 27, 2012	ECB basket	Exclusion of bonds with Issuer Residence IRIT (Italy)
July 5, 2012	ECB & ECB EXTended basket	Exclusion of bonds with Issuer Group IG4, IG5, and IG9 in combination with Issuer Residence IRES (Spain)
July 30, 2012	ECB & ECB EXTended basket	Exclusion of bonds with Issuer Group IG4, IG5, and IG9 in combination with Issuer Residence IRIE (Ireland) and IRIT (Italy)

Table IA.2. Weights for different security types

Security type	Outstanding volume in EURbn	Outstanding volume in percent
Central government securities	5,225	45.6%
Regional government securities	348	3.0%
Uncovered bank bonds	2,029	17.2%
Covered bank bonds	1,420	12.5%
Corporate bonds	1,097	9.4%
ABS	856	7.2%
Other	614	5.1%

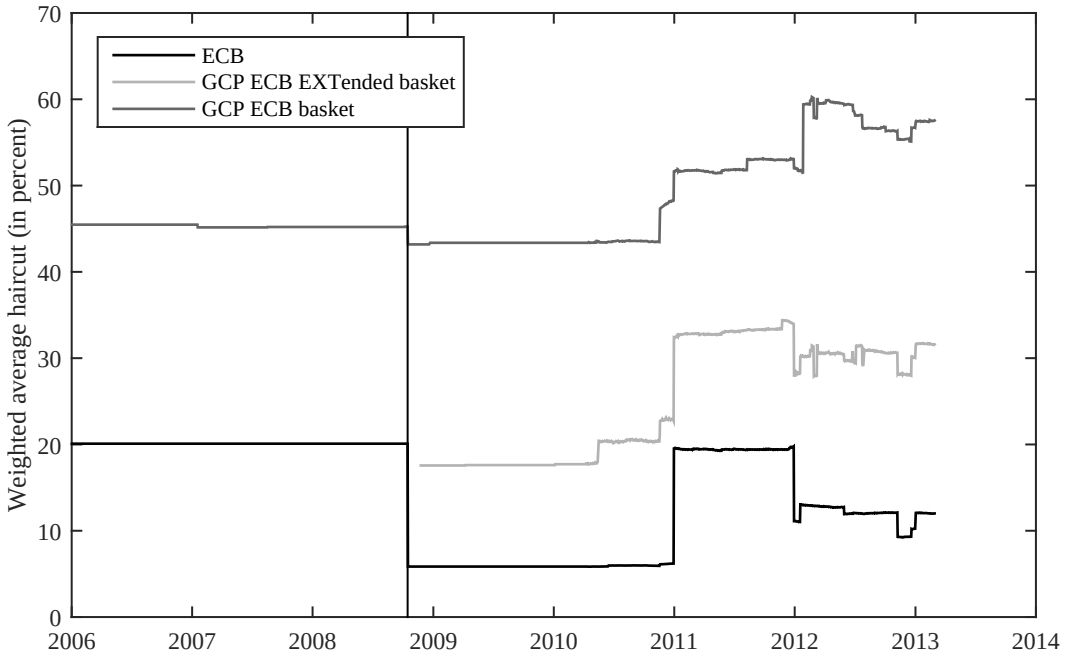


Figure IA.1. Weighted average haircuts. This figure depicts weighted average haircuts at the ECB and at Eurex GCP for all securities in the asset universe. Assets that are not eligible enter the computation with a haircut of 100%. The weights are determined by the outstanding volume for each security type (data from the ECB). The figure is based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

Appendix B. Correlations between repo market activity and the state variables

Panels A and B of Table IA.3 show correlations between repo market activity and the state variables prior to October 2008 and in the FRFA regime, respectively. Given the much larger variation in the variables, correlations in the FRFA period are most interesting. Risk as measured by the CISS is positively related to repo volume, whereas there is no significant correlation to repo spreads or the average term. HCR is positively related to the repo spread and repo volume; that is, if the number of accepted securities at the ECB and at Eurex diverges, the repo spread and the volume decrease. This reflects the Eurex GCP basket becoming smaller, but safer, relative to the portfolio of securities accepted at the ECB. Both repo volume and Eonia volume are strongly negatively related to ECB excess liquidity.

Table IA.3
Correlations between repo market activity and the state variables

This table shows correlations between repo spread, detrended repo volume, average repo term, and the state variables. The results are based on weekly data from January 2006 to February 2013. Panel A shows results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Panel B presents results for the sample period after this date. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Prior to full allotment

	S_t^{1d}	$\widetilde{VOL}_t^{1d}$	AT_t	$CISS_t$	VOL_t^{EONIA}	HCR_t	EMC_t	EL_t
S_t^{1d}	1							
VOL_t^{1d}	−0.022	1						
AT_t	0.200 **	−0.016	1					
$CISS_t$	0.000	0.626 ***	0.248 ***	1				
VOL_t^{EONIA}	−0.171 **	0.118	0.023	0.437 ***	1			
HCR_t	−0.142*	0.373 ***	−0.032	0.534 ***	0.410 ***	1		
EMC_t	−0.588 ***	−0.266 ***	−0.248 ***	−0.430 ***	−0.071	−0.271 ***	1	
EL_t	0.077	0.216 ***	0.220 ***	0.319 ***	−0.043	0.110	−0.241 ***	1

Panel B: After full allotment

	S_t^{1d}	$\widetilde{VOL}_t^{1d}$	AT_t	$CISS_t$	VOL_t^{EONIA}	HCR_t	EMC_t	EL_t
S_t^{1d}	1							
VOL_t^{1d}	0.419 ***	1						
AT_t	−0.317 ***	−0.531 ***	1					
$CISS_t$	−0.064	0.292 ***	−0.101	1				
VOL_t^{EONIA}	0.481 ***	0.394 ***	−0.299 ***	0.297 ***	1			
HCR_t	0.391 ***	0.317 ***	−0.150 **	−0.265 ***	−0.092	1		
EMC_t	−0.046	−0.060	−0.023	−0.571 ***	−0.006	0.123*	1	
EL_t	−0.585 ***	−0.632 ***	0.440 ***	−0.191 ***	−0.648 ***	−0.060	−0.102	1

Appendix C. Analysis of the term spread

Our results in the main paper indicate that interest rates for short-term GC Pooling repos do not increase in times of stress. To further corroborate this result, we analyze the term spread. Figure IA.2 shows the repo term spreads between long-term (one month or one year, $r_t^{GCP,LT}$) and short-term repo rates,

$$TS_t = r_t^{GCP,LT} - r_t^{GCP,1d}.$$

We compute the one-month term spread using the one-month repo rate, which is the volume-weighted average of all GCP repos with a maturity longer than one week and up to one month.[2] The one-year term spread is constructed similarly. The term spread appears to respond to ECB monetary policy closely. It becomes small or even negative in response to the ECB's monetary policy after October 2008, suggesting that repo traders did not increase term premiums significantly during the crisis.

[2]Because such longer-term repos are not traded during a few weeks, particularly in the beginning of our sample, we fill missing values with fitted values from a regression of one-month GCP rates on one-month Eurepo rates from the European Banking Federation that we obtained from Datastream.

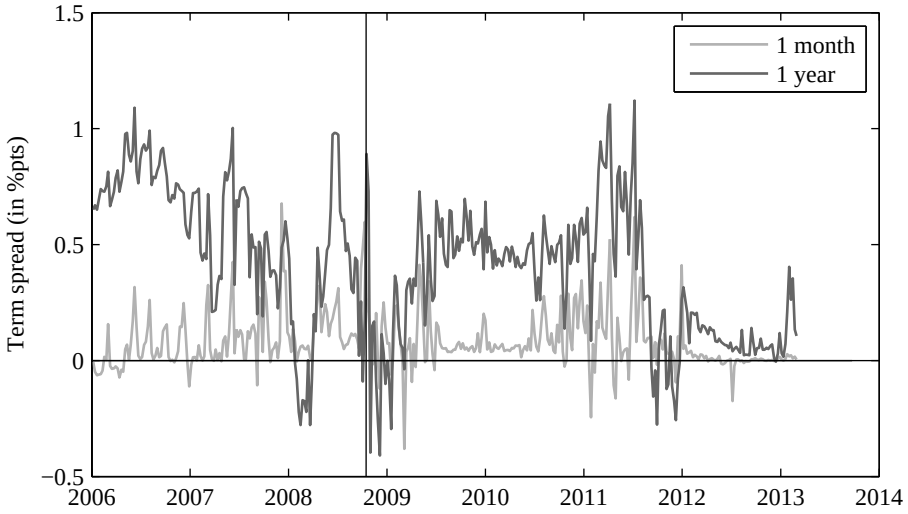


Figure IA.2. Term spread. This figure shows the term spread, that is, the spread between longer-term repo rates and the rate for short-term (o/n, t/n, and s/n) repos. The dark gray line depicts the spread based on longer-term repos with a maturity between six months and one year, whereas the light gray line shows the spread for medium term repos with a maturity between nine days and one month. Missing observations are filled with fitted values from a regression of Eurex GCP rates on Eurepo rates from the European Banking Federation obtained via Datastream. The figure is based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

To investigate the behavior of longer-term repos traded on the Eurex Repo platform (GCP ECB basket) we repeat the regression analysis from the main paper, but using the term spread as dependent variable (c.f. Figure IA.2). Table IA.4 presents the results of regressing the one-year term spread on the state variables. We find a negative relation between risk ($CISS$) and the term spread, suggesting that it becomes relatively cheaper to obtain longer-term financing when risk increases. Expected policy rate changes (EMC) are positively related to the term spread; that is, an expected increase in the policy rate makes long-term repo borrowing more expensive. Finally, we find a negative impact of excess liquidity on the term spread. This effect prevails even in times of high excess liquidity or when we include LTRO volume as separate explanatory variable.

Table IA.4
Drivers of the term spread

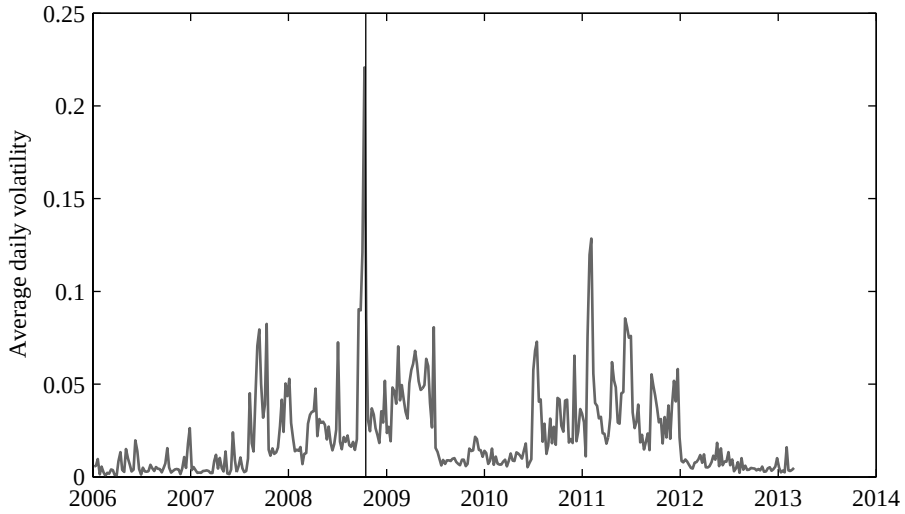
This table shows the results of regressing the one-year repo term spread on various state variables. The term spread is the spread between the repo rates of repos with a maturity of one year and repos with a term of one day (o/n, t/n, and s/n). The state variables are explained in Section 4 of the main paper. Regressions are based on weekly data from January 2006 to February 2013. Column 2 shows results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Column 3 presents regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment	After full allotment
const.	-0.518	$0.696**$
	(0.535)	(0.096)
S^{1d}_{t-1}	$2.307**$	0.306
	(0.918)	(0.231)
AT_{t-1}	0.007	0.006
	(0.016)	(0.005)
VOL^{1d}_{t-1}	-0.189	$-0.079**$
	(0.119)	(0.033)
$VOL^{1d}_{t-1} * DUM^{EL>300}_{t-1}$		0.009
		(0.031)
$CISS_{t-1}$	$-0.549*$	$-0.279**$
	(0.295)	(0.112)
EL_{t-1}	3.846	$-0.704*$
	(2.854)	(0.359)
$EL_{t-1} * DUM^{EL>300}_{t-1}$		0.088
		(0.290)
HCR_{t-1}		-0.118
		(0.294)
EMC_{t-1}	$1.002**$	$0.617**$
	(0.397)	(0.146)
Adj. - R^2	0.462	0.599

Appendix D. Volatility and illiquidty of Eurex GC Pooling repos

In addition to the risk mitigation channels discussed in the main paper, the financial crisis may have affected proxies for market quality (O'Hara and Ye, 2011) of the repo market; that is, volatility and illiquidity might have increased. The realized volatility of repo rates and the bid-ask spread implied by Roll's (1984) measure are shown in Figure IA.3 for each week in our sample. We observe similar patterns when using the intraday range instead of realized volatility as a measure of price dispersion and the illiquidity measures of Amihud (2002) and Corwin and Schultz (2012). These measures are shown in Figures IA.4 and IA.5. Both volatility and illiquidity tend to be higher in distressed market conditions, but fluctuate within a fairly narrow range, suggesting that market quality for the CCP-based euro interbank repo market was not impaired. For instance, the average volatility is only 5.2% (6.2%) before (during) the FRFA period.

Panel A. Average daily volatility per week



Panel B. Illiquidity

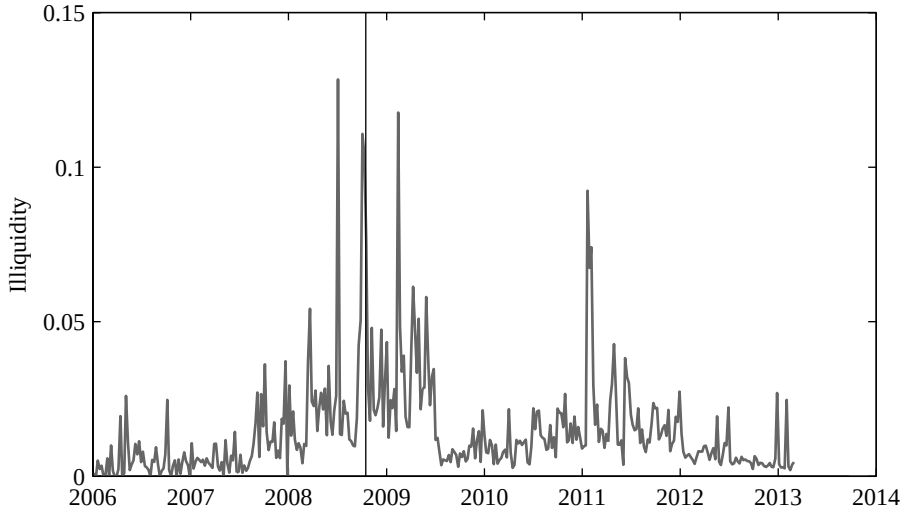


Figure IA.3. Volatility and illiquidity. Panel A shows the annualized average daily volatility per week computed as the realized volatility of intraday trades. Panel B depicts Roll's (1984) measure of the bid-ask spread as a proxy for market illiquidity. For each day d with intraday trades indexed by i, we compute $Roll_d = 2\sqrt{min(0, -Cov(\Delta r_{GCP,i}, \Delta r_{GCP,i-1}))}$. Then we average $Roll_d$ over all trading days of each week to obtain the illiquidity measure. The figures are based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

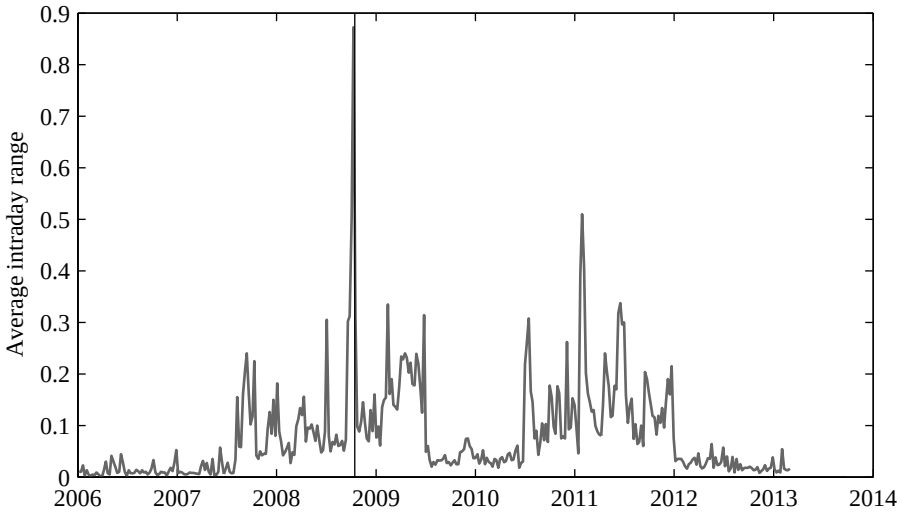
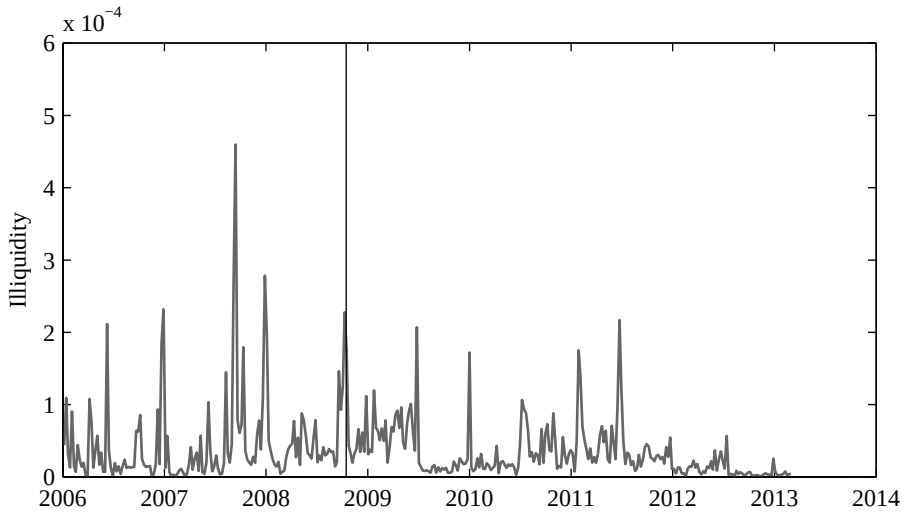


Figure IA.4. Average intraday range. This figure shows the average intraday range (IDR) as a measure of market quality. The IDR for day d is computed as the difference between the daily maximum and minimum (annualized) repo rates. We then average IDR over all trading days of each week to obtain the measure of price dispersion. The figure is based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

Panel A. Illiquidity (Amihud (2002))



Panel B. Illiquidity (Corwin and Schultz (2012))

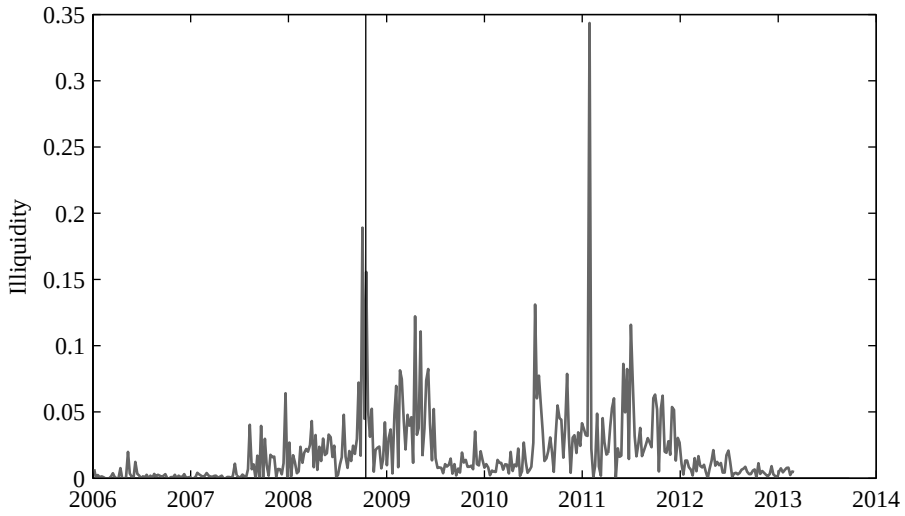


Figure IA.5. Alternative measures of market illiquidity. Panel A shows the Amihud (2002) measure of the price impact of a trade as proxy for illiquidity. For each day d with intraday trades indexed by $i = 1, \ldots, I$, we compute $Amihud_d = |log(r_{GCP,I}) - log(r_{GCP,1})|/VOL_t^{GC}$. Then, we average $Amihud_d$ over all trading days of each week to obtain the illiquidity measure. Panel B depicts the Corwin and Schultz (2012) measure of the bid-ask spread as an additional proxy for market illiquidity. The measure is based on the high and low repo rates for two consecutive days; see Equation (14) in Corwin and Schultz (2012). We multiply both measures with the volume-weighted average repo rate to obtain estimates for the absolute price impact and bid-ask spread rather than relative values. The figures are based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

Appendix E. Robustness checks

Table IA.5
Regression results for term-adjusted trading volume

This table shows the results of regressing the term-adjusted repo volume on various state variables. The term-adjusted trading volume is constructed by multiplying trading volume for each repo transaction by the corresponding repo maturity in days. Regressions are based on weekly data from January 2006 to February 2013. Column 2 shows results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Column 3 presents regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment	After full allotment
const.	4.525	0.921
	(5.125)	(3.176)
trend	0.003	$0.034 * **$
	(0.005)	(0.009)
S_{t-1}^{1d}	−3.403	$-6.960 * *$
	(7.950)	(3.109)
AT_{t-1}	−0.073	$0.802 * **$
	(0.165)	(0.281)
$VOL_{t-1}^{GC,ta}$	−0.013	$-0.259 * *$
	(0.234)	(0.124)
VOL_{t-1}^{EONIA}	−0.574	$-0.740 * *$
	(0.363)	(0.321)
$CISS_{t-1}$	$10.459 * **$	$7.396 * **$
	(3.356)	(2.236)
EL_{t-1}	−20.468	$-18.513 * **$
	(18.426)	(6.280)
$EL_{t-1} * DUM_{t-1}^{EL>300}$		$10.348 * *$
		(4.734)
HCR_{t-1}		4.474
		(3.800)
EMC_{t-1}	0.584	−0.708
	(1.772)	(2.267)
Adj. - R^2	0.469	0.183

Table IA.6
Regression results for different risk measures

This table shows the estimated coefficients of different risk measures when regressing the repo spread (S_t), repo trading volume (VOL_t^{1d}), and the average repo term (AT_t) on various state variables. Each column corresponds to a regression with the dependent variable shown in the first row. The regressions are the same as in Equations (1) to (3) in the main paper, but in each row a different proxy for risk is used, which is indicated in the first column. The interest rate spreads ($LIBOIS$, $10ySpread^{ESP-GER}$, and $10ySpread^{ITA-GER}$) are measured in percentage points. CDS spreads and volatility ($iTraxx$ and $VSTOXX$) are measured in percent. Absolute values of target balances ($TARGET^{Germany}$ and $TARGET^{GIIPS}$) are measured in EUR trillion. Regressions are based on weekly data from January 2006 to February 2013. Columns 2 to 4 show results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Columns 5 to 7 present regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment			After full allotment		
	S_t^{1d}	VOL_t^{1d}	AT_t	S_t^{1d}	VOL_t^{1d}	AT_t
$CISS_{t-1}$	0.046	0.558 **	4.569 ***	0.043	0.708 ***	−0.055
	(0.075)	(0.224)	(1.675)	(0.038)	(0.180)	(0.897)
$LIBOIS_{t-1}$	−0.037*	−0.047	1.134	0.030	0.362 ***	−0.615
	(0.022)	(0.123)	(0.843)	(0.021)	(0.134)	(0.506)
$iTraxx_{t-1}$	0.055	0.236 **	2.138 ***	0.006	0.118 **	0.264
	(0.035)	(0.100)	(0.559)	(0.010)	(0.057)	(0.287)
$TARGET_{t-1}^{Germany}$	0.014	3.004 ***	9.515 **	−0.041	1.533*	2.065
	(0.198)	(0.934)	(4.385)	(0.073)	(0.814)	(1.785)
$TARGET_{t-1}^{GIIPS}$	0.297	0.203	25.561 ***	0.024	1.078 **	1.283
	(0.331)	(0.979)	(6.608)	(0.051)	(0.512)	(1.355)
$VSTOXX_{t-1}$	0.000	0.016 ***	0.070	0.000	0.009 **	−0.016
	(0.001)	(0.004)	(0.056)	(0.001)	(0.004)	(0.016)
$10ySpread_{t-1}^{ESP-GER}$	0.100	0.179	5.038 ***	−0.003	0.070 **	0.124
	(0.070)	(0.234)	(1.435)	(0.007)	(0.035)	(0.171)
$10ySpread_{t-1}^{ITA-GER}$	0.088	0.295	5.713 ***	0.001	0.073	0.071
	(0.094)	(0.372)	(1.554)	(0.007)	(0.045)	(0.177)

Table IA.7
Regression results for the hypothetical case in which traders could forecast interest rates perfectly

This table shows the results of regressing the repo spread, repo trading volume, and the average repo term on various state variables. Compared to Table 2 of the main paper, the variable EMC is replaced by $EMC^{perfect}$, which is computed as the difference between the Eonia rate one month in the future and today's Eonia rate, capturing the hypothetical case in which traders could forecast interest rates perfectly. Each column corresponds to a regression with the dependent variable shown in the first row, whereas the explanatory variables are shown in the first column. Regressions are based on weekly data from January 2006 to February 2013. Columns 2 to 4 show results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Columns 5 to 7 present regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment			After full allotment		
	S_t^{1d}	VOL_t^{1d}	AT_t	S_t^{1d}	VOL_t^{1d}	AT_t
const.	0.644 * **	0.366	3.440*	0.075 * *	0.188	4.898 * **
	(0.147)	(0.418)	(1.971)	(0.030)	(0.223)	(0.696)
trend		0.002 * **			0.005 * **	
		(0.001)			(0.001)	
S_{t-1}^{1d}	−0.157	−0.057	−1.429	0.574 * **	0.258	−3.813 * **
	(0.250)	(0.655)	(3.723)	(0.070)	(0.272)	(1.063)
AT_{t-1}	−0.002	−0.032 * **	0.020	−0.001	−0.031 * **	0.309 * **
	(0.003)	(0.011)	(0.079)	(0.002)	(0.011)	(0.059)
$VOL_{t-1}^{GC,1d}$	−0.031	0.447 * **	−1.191*	0.003	0.267 * **	−0.894 * **
	(0.026)	(0.109)	(0.654)	(0.015)	(0.068)	(0.325)
$VOL_{t-1}^{GC,1d} * DUM_{t-1}^{EL>300}$				−0.038 * *		
				(0.017)		
VOL_{t-1}^{EONIA}		−0.033			−0.088 * **	
		(0.022)			(0.032)	
$CISS_{t-1}$	0.009	0.514 * *	4.207 * *	−0.010	0.642 * **	−0.174
	(0.052)	(0.212)	(1.623)	(0.033)	(0.169)	(0.828)
EL_{t-1}	−0.806	0.268	−14.361	−0.394 * **	−0.835 * *	−3.305
	(0.750)	(1.567)	(12.180)	(0.114)	(0.411)	(2.606)
$EL_{t-1} * DUM_{t-1}^{EL>300}$				0.318 * **	−0.312	3.770*
				(0.091)	(0.301)	(2.246)
HCR_{t-1}				0.155*	0.405	2.124
				(0.088)	(0.494)	(1.471)
$EMC_{t-1}^{perfect}$	−0.083*	−0.079	−1.038	−0.049	−0.283*	−0.654
	(0.042)	(0.094)	(0.892)	(0.034)	(0.144)	(1.055)
Adj.- R^2	0.133	0.772	0.078	0.713	0.548	0.321

Table IA.8
Regression results for first differences

This table shows the results of regressing changes in the repo spread, changes in the repo trading volume, and changes in the average repo term on lagged changes in various state variables. Each column corresponds to a regression with the dependent variable shown in the first row, whereas the explanatory variables are shown in the first column. Regressions are based on weekly data from January 2006 to February 2013. Columns 2 to 4 show results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Columns 5 to 7 present regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment			After full allotment		
	ΔS_t^{1d}	$\Delta VOL_t^{GC,1d}$	ΔAT_t	ΔS_t^{1d}	$\Delta VOL_t^{GC,1d}$	ΔAT_t
const.	−0.001	0.009	0.023	0.000	0.006	0.025
	(0.003)	(0.011)	(0.087)	(0.004)	(0.016)	(0.087)
ΔS_{t-1}^{1d}	−0.748 * **	0.945	−1.914	−0.078	0.085	−4.928 * *
	(0.242)	(0.740)	(5.072)	(0.135)	(0.338)	(1.972)
ΔAT_{t-1}	−0.002	−0.021 * **	−0.486 * **	0.001	−0.014	−0.265 * **
	(0.002)	(0.007)	(0.053)	(0.001)	(0.010)	(0.049)
$\Delta VOL_{t-1}^{GC,1d}$	−0.083*	−0.110	−0.225	−0.011	−0.390 * **	0.277
	(0.046)	(0.117)	(0.970)	(0.016)	(0.062)	(0.354)
$\Delta VOL_{t-1}^{GC,1d} * DUM_{t-1}^{EL>300}$				0.022		
				(0.018)		
ΔVOL_{t-1}^{EONIA}		−0.048			−0.141 * *	
		(0.033)			(0.058)	
$\Delta CISS_{t-1}$	0.139	0.354	7.360*	0.132	0.644	5.637 * **
	(0.096)	(0.401)	(4.203)	(0.082)	(0.462)	(1.773)
ΔEL_{t-1}	−0.665	0.150	−26.514 * *	−0.525 * *	0.099	−10.385*
	(0.659)	(1.700)	(10.932)	(0.206)	(1.157)	(5.462)
$\Delta EL_{t-1} * DUM_{t-1}^{EL>300}$				0.361	−1.438	9.074
				(0.233)	(1.841)	(7.805)
ΔHCR_{t-1}				0.060	0.517	7.883
				(0.180)	(0.704)	(6.451)
ΔEMC_{t-1}	−0.010	0.497*	3.648	0.022	0.129	−1.581
	(0.046)	(0.281)	(2.599)	(0.099)	(0.300)	(1.201)
Adj. - R^2	0.358	0.114	0.360	0.044	0.193	0.128

Table IA.9
Regression results for vector autoregression model

This table shows the results of regressing the repo spread, repo trading volume, and the average repo term on various state variables. Compared to Table 2 in the main paper, all state variables are included for each dependent variable. Each column corresponds to a regression with the dependent variable shown in the first row, whereas the explanatory variables are shown in the first column. Regressions are based on weekly data from January 2006 to February 2013. Columns 2 to 4 show results for the sample prior to the introduction of fixed-rate full allotment refinancing operations at the ECB on October 15, 2008. Columns 5 to 7 present regression results for the sample period after this date. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Prior to full allotment			After full allotment		
	S_t^{1d}	VOL_t^{1d}	AT_t	S_t^{1d}	VOL_t^{1d}	AT_t
const.	0.607 * **	0.042	5.584*	0.027	0.202	4.778 * **
	(0.084)	(0.350)	(2.928)	(0.057)	(0.273)	(1.554)
trend	0.000	0.003 * **	−0.003	0.000	0.005 * **	0.004
	(0.000)	(0.001)	(0.006)	(0.000)	(0.001)	(0.006)
S_{t-1}^{1d}	−0.058	0.465	−2.820	0.603 * **	0.195	−4.254 * *
	(0.141)	(0.587)	(4.907)	(0.064)	(0.309)	(1.761)
AT_{t-1}	−0.003	−0.032 * **	0.003	−0.001	−0.032 * **	0.298 * **
	(0.003)	(0.011)	(0.088)	(0.002)	(0.012)	(0.066)
$VOL_{t-1}^{GC,1d}$	−0.039 * *	0.446 * **	−1.278 * *	0.003	0.276 * **	−0.825 * *
	(0.019)	(0.077)	(0.646)	(0.015)	(0.071)	(0.406)
$VOL_{t-1}^{GC,1d} * DUM_{t-1}^{EL>300}$				−0.032*	−0.044	−0.642
				(0.017)	(0.083)	(0.473)
VOL_{t-1}^{EONIA}	−0.007	−0.033	−0.335*	0.009	−0.085 * *	−0.123
	(0.005)	(0.021)	(0.174)	(0.007)	(0.035)	(0.201)
$CISS_{t-1}$	0.056	0.558 * **	5.983 * **	0.019	0.702 * **	0.412
	(0.044)	(0.182)	(1.525)	(0.044)	(0.211)	(1.202)
EL_{t-1}	−0.777 * **	0.508	−18.002*	−0.276 * **	−0.826*	−5.054*
	(0.294)	(1.222)	(10.209)	(0.103)	(0.495)	(2.823)
$EL_{t-1} * DUM_{t-1}^{EL>300}$				0.241 * **	−0.215	5.600 * *
				(0.092)	(0.440)	(2.511)
HCR_{t-1}				0.174 * *	0.424	0.654
				(0.086)	(0.415)	(2.367)
EMC_{t-1}	0.044	0.234	−0.157	0.042	−0.110	−0.638
	(0.044)	(0.184)	(1.535)	(0.039)	(0.186)	(1.063)
Adj.- R^2	0.080	0.774	0.089	0.711	0.542	0.318

Table IA.10
Regression results with LTRO volume

This table shows the results of regressing the repo spread, repo trading volume, and the average repo term on various state variables. The regressions are the same as in Table 2 of the main paper, but allowing for a separate effect of the 3-year LTROs by including VOL^{LTRO} and $\widetilde{EL}$, which corresponds to excess liquidity minus the outstanding volume of the 3-year LTROs, rather than EL as explanatory variables. Each column corresponds to a regression with the dependent variable shown in the first row, whereas the explanatory variables are shown in the first column. Regressions are based on weekly data from October 2008 to February 2013, that is, the sample after the introduction of fixed-rate full allotment refinancing operations at the ECB. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Regression results		
	S_t^{1d}	VOL_t^{1d}	AT_t
const.	0.027	0.255	4.555 * **
	(0.033)	(0.250)	(0.752)
trend		0.005 * **	
		(0.001)	
S_{t-1}^{1d}	0.660 * **	0.168	−3.402 * **
	(0.074)	(0.262)	(1.040)
AT_{t-1}	0.000	−0.032 * **	0.315 * **
	(0.002)	(0.011)	(0.059)
VOL_{t-1}^{1d}	−0.005	0.263 * **	−0.911 * **
	(0.015)	(0.068)	(0.334)
$VOL_{t-1}^{1d} * DUM_{t-1}^{EL>300}$	−0.012		
	(0.017)		
$VOL_{t-1}^{EONIA,1d}$		−0.088 * **	
		(0.032)	
$CISS_{t-1}$	0.062	0.697 * **	0.228
	(0.040)	(0.178)	(0.971)
$\widetilde{EL}_{t-1}$	−0.227 * *	−0.960 * **	−1.870
	(0.092)	(0.334)	(1.989)
HCR_{t-1}	0.164*	0.462	2.177
	(0.091)	(0.506)	(1.490)
EMC_{t-1}	0.074	−0.136	0.022
	(0.057)	(0.193)	(0.888)
VOL_{t-1}^{LTRO}	−0.117 * *	−1.098 * **	0.035
	(0.053)	(0.236)	(0.973)
Adj. - R^2	0.709	0.542	0.316

Table IA.11
Regression results with LTRO dummy variable

This table shows the results of regressing the repo spread, repo trading volume, and the average repo term on various state variables. The regressions are the same as in Table 2 of the main paper, but replaces the dummy variable $DUM^{EL>300}$ with DUM^{LTRO}. Moreover, we allow for a separate effect of the 3-year LTROs by including a dummy variable DUM^{LTRO} that equals one after the first three year LTRO on December 21, 2011 and zero otherwise. Moreover, we interact this variable with risk. Each column corresponds to a regression with the dependent variable shown in the first row, whereas the explanatory variables are shown in the first column. Regressions are based on weekly data from October 2008 to February 2013, that is, the sample after the introduction of fixed-rate full allotment refinancing operations at the ECB. HAC standard errors are shown in parentheses. The stars ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Regression results		
	S_t^{1d}	VOL_t^{1d}	AT_t
const.	0.027	0.185	5.833 ∗ ∗
	(0.040)	(0.266)	(0.800)
trend		0.005 ∗ ∗	
		(0.001)	
DUM^{LTRO}	0.043	−0.139	−0.326
	(0.040)	(0.201)	(0.957)
S_{t-1}^{1d}	0.646 ∗ ∗	0.174	−4.586 ∗ ∗
	(0.086)	(0.252)	(1.117)
AT_{t-1}	0.000	−0.032 ∗ ∗	0.274 ∗ ∗
	(0.002)	(0.011)	(0.059)
VOL_{t-1}^{1d}	0.000	0.270 ∗ ∗	−0.906 ∗ ∗
	(0.014)	(0.071)	(0.326)
$VOL_{t-1}^{1d} * DUM_{t-1}^{LTRO}$	−0.038		
	(0.023)		
$VOL_{t-1}^{EONIA,1d}$		−0.085 ∗ ∗	
		(0.032)	
$CISS_{t-1}$	0.059	0.718 ∗ ∗	−0.992
	(0.046)	(0.189)	(0.957)
$CISS_{t-1} * DUM_{t-1}^{LTRO}$	−0.112 ∗ ∗	0.015	5.291 ∗ ∗
	(0.055)	(0.417)	(2.389)
EL_{t-1}	−0.254 ∗ ∗	−0.901 ∗ ∗	−4.316∗
	(0.122)	(0.369)	(2.315)
$EL_{t-1} * DUM_{t-1}^{LTRO}$	0.205 ∗ ∗	−0.065	2.660
	(0.101)	(0.336)	(2.281)
HCR_{t-1}	0.151	0.438	1.347
	(0.093)	(0.533)	(1.401)
EMC_{t-1}	0.068	−0.132	−0.990
	(0.064)	(0.203)	(0.946)
Adj.- R^2	0.710	0.539	0.344

Appendix F. Additional figures and tables

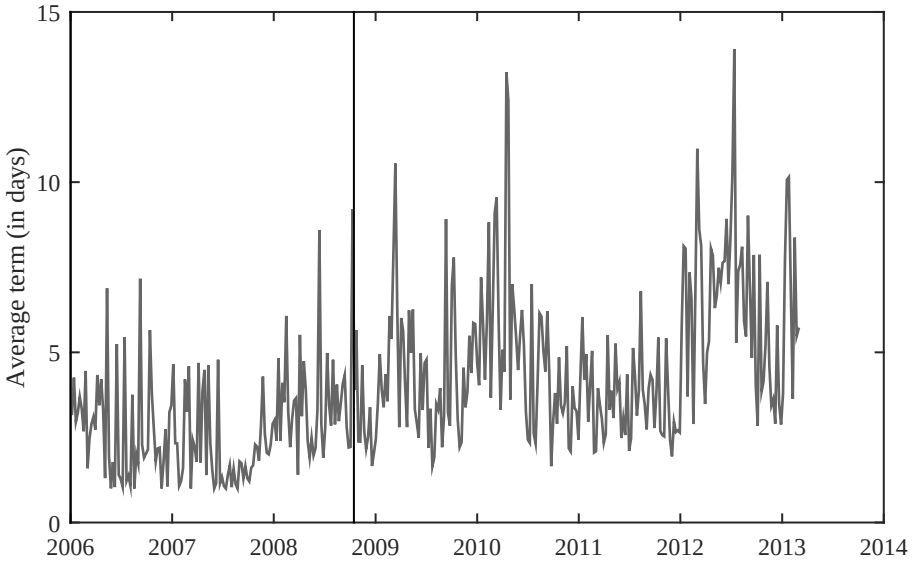
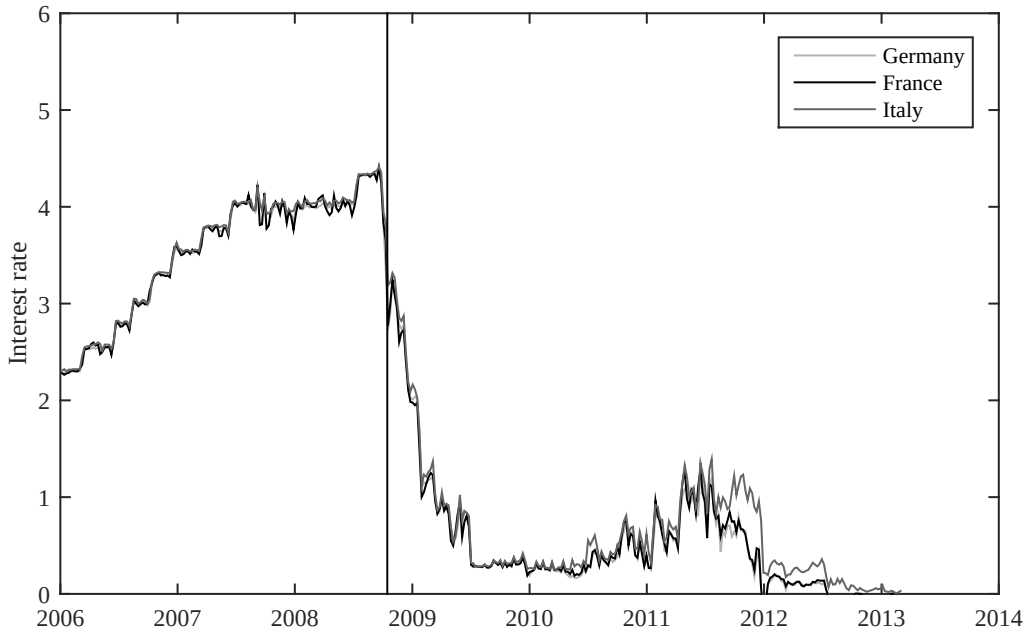


Figure IA.6. Average repo term. This figure shows the volume-weighted average GCP term (in days) for the ECB basket. The figure is based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

Panel A. Interest rates



Panel B. Spread over rate for GCP ECB basket

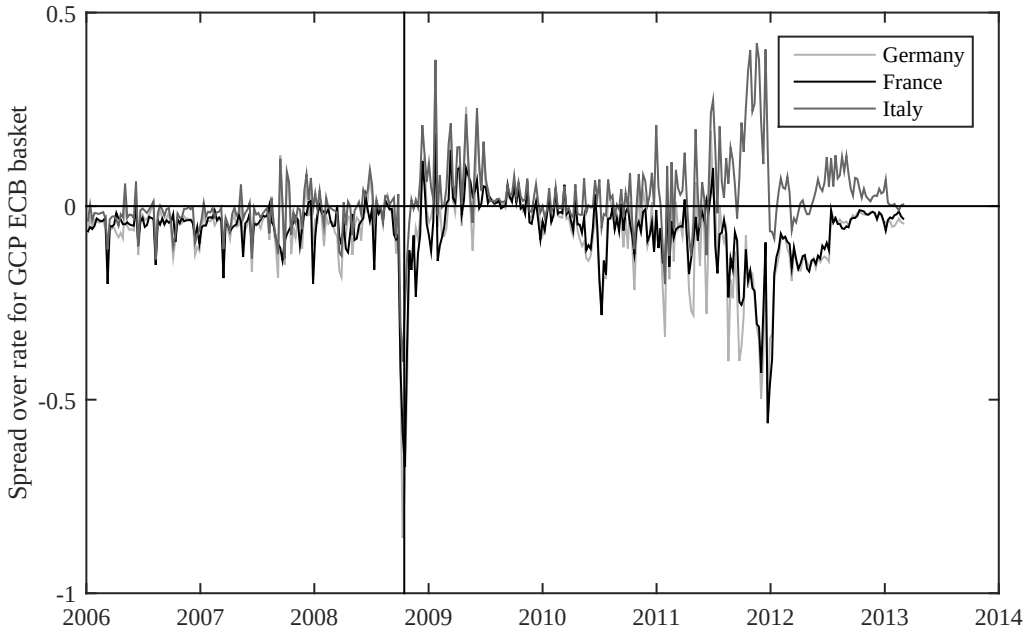
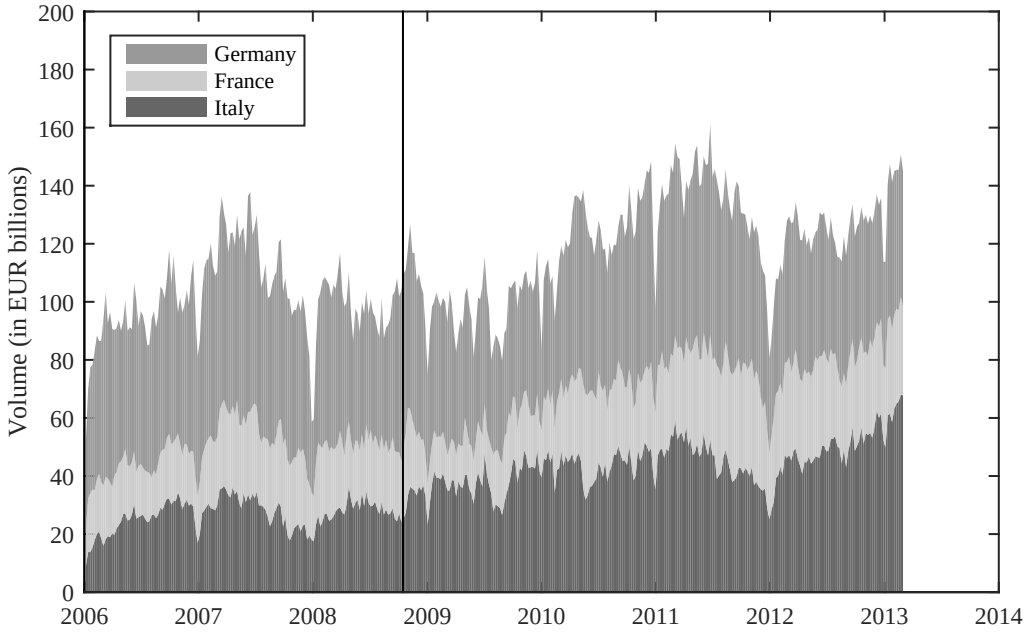


Figure IA.7. Volume-weighted average repo rate for BrokerTec and MTS data. Panel A shows the volume-weighted average repo rate for repos with German, French, and Italian government securities as collateral that are traded on BrokerTec or MTS. Panel B shows the difference between the interest rate for the RFR indices and the GCP ECB basket. A positive spread indicates that the RFR rate is higher than the GCP rate. The figures are based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

Panel A. Volume



Panel B. Share of different countries

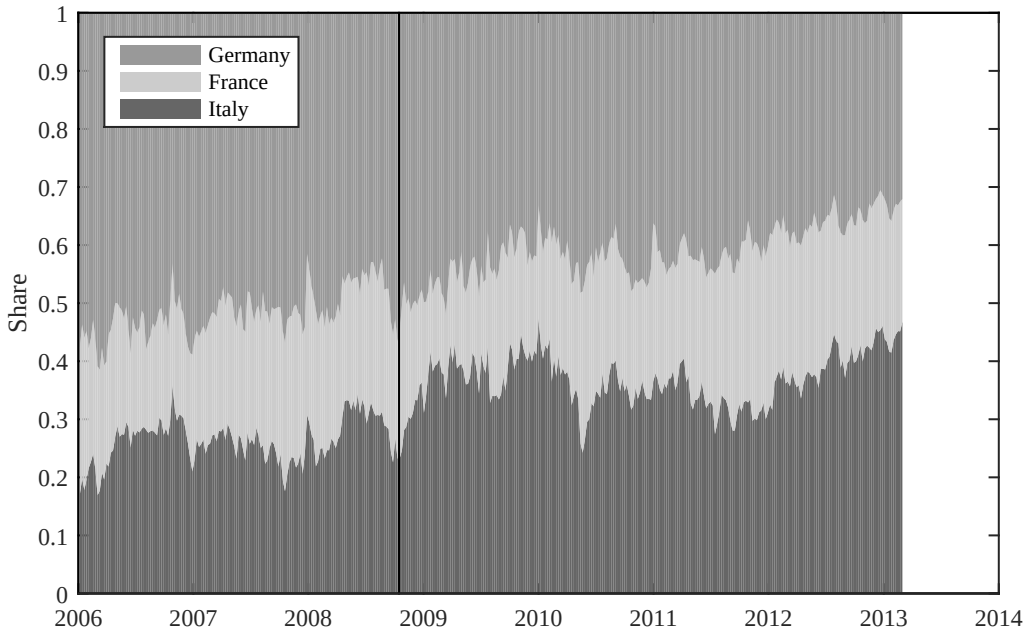


Figure IA.8. Volume on BrokerTec and MTS. Panel A presents the average daily trading volume for repos trading on BrokerTec and MTS that are part of the RFR indices. The corresponding shares of total trading volume are plotted in Panel B. The figures are based on weekly data from January 2006 to February 2013. The vertical line represents the ECB's switch to fixed-rate full allotment refinancing operations on October 15, 2008.

References

Amihud, Yakov (2002), Illiquidity and Stock Returns: Cross-section and Time-series Effects, *Journal of Financial Markets* 5, 31–56.

Corwin, Shane A., and Paul Schultz (2012), A Simple Way to Estimate Bid-Ask Spreads from Daily High and Low Prices, *Journal of Finance* 67, 719–760.

Eurex Repo (2013), GC Pooling Basket Definition, February 2013, Eurex Repo, `http://www.eurexrepo.com/repo-en/products/gcpooling/`.

O'Hara, Maureen, and Mao Ye (2011), Is Market Fragmentation Harming Market Quality?, *Journal of Financial Economics* 100, 459–474.

Roll, Richard (1984), A Simple Implicit Measure of the Effective Bid-Ask Spread in an Efficient Market, *Journal of Finance* 39, 1127–1139.