Internet Appendix
Sovereign Credit Risk, Liquidity, and ECB Intervention: *Deus ex Machina*?

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Int.1. Instrumental Variable Analysis

In Section 6, we focused on the bid-ask spread equation of the VAR system, augmenting it with the contemporaneous changes in the CDS spread. In order to test whether the causality runs one way or both ways, i.e., whether the variables suffer from contemporaneity, we re-estimate Equation (5) and test for the endogeneity of ΔCDS_t by instrumenting it with several cohorts of variables.

Conditional on the instruments being valid—i.e., strong, exogenous, and relevant—if the Hausman-Wu test cannot reject the null hypothesis of the ordinary least squares (OLS) and IV estimators being the same (under the null hypothesis both are consistent), we can conclude that the OLS estimate is to be preferred in virtue of having a smaller estimator variance. On the other hand, if the Hausman-Wu test rejects the null hypothesis, only the IV estimator is consistent and hence preferred, regardless of its larger estimator variance. In this appendix, we will describe our cohorts of instruments, establish their exogeneity, show that they are strong and relevant, and finally present the IV results, together with the Hausman-Wu test results.

We have three cohorts of instruments:

- Other European sovereign CDS/bond yields:
  - Germany: The German 10-year yield is likely to be correlated with the Italian CDS, presuming that the German sovereign has very little credit risk. In the case of a flight-to-quality, as the Italian CDS rises, the German yield could plummet due to investors switching from holding Italian bonds to German bonds. If the change in German yield were perfectly correlated with the change in Italian CDS, however, the German yield should not be correlated with the residuals from Equation (5), since the CDS is on the right-hand side, and hence, it would constitute a good instrument. If, however, a flight to liquidity depended also on the relative change in the CDS compared to the yield and the two were not perfectly correlated, then the instrument would not be exogenous. Nevertheless, we repeat the analysis using the lagged value of the change in the German bond yield, in order to account for this possible endogeneity.
  - Finland: The flight-to-quality argument applies less stringently for a relatively safer country with a small bond market. The Finnish sovereign debt amounted to €90 billion during the period of our study, a small fraction of both the Italian and German outstanding sovereign debt. **?** report that the Finnish bond market has a similar bid-ask spread to the German and Italian ones, while the trading volume is an order of magnitude smaller. Moreover, in our sample, the changes in Italian and Finnish CDS spreads are correlated at the 70% level, while those of Germany and Italy are correlated at -57%. Hence, the data hardly support a flight-to-quality from Italian to Finnish bonds. Hence, the change in the Finnish CDS spread qualifies as a valid instrument.
- The CDS of Italian-government-owned/controlled companies significantly comove with the sovereign CDS (with correlations above 56% in the changes), and moreover, would not constitute a safer security,

since a government-owned company would be hit hard if the central government were to fail, thus disqualifying it from a flight-to-quality or other asset substitution perspective. We consider all government-owned companies that had a traded CDS spread during our sample period, namely

- ENI: the national oil and gas company,
- ENEL: the national electricity company,
- Finmeccanica: a large industrial group, specializing in aerospace, defence, and security.

- The European stock market index Euro50 is highly correlated with the Italian CDS spread (-61%); so, when the crisis mounted for the sovereign, it also pushed the stock market down, partially due to the presence of some Italian companies in the index. In order for Euro50 to be correlated with the regression residuals – that is partially correlated with bond-market liquidity, after controlling for the overall worsening of the crisis through the Italian CDS, for investor sentiment with the VIX, and for the funding liquidity with the CCBSS, there should be a substitution effect between Italian bonds and Euro50-included companies. We are not aware of any academic study showing this phenomenon.

Table Int.1 presents the results from the IV estimation, for both the first and the second-stage regression, in Panels A and B, respectively. First of all, all our instruments are strong, with F-test results well above 10, the level recommended in **?**, among others. The F-test IV row presents the F-test results regarding whether the added exogenous variables are contemporaneously zero. As one might expect, the weakest instrument is the lagged German yield change. However, even for Model 3, the F-statistic is 29.09 (although only 6.44 for the instrument alone). The adjusted R^2 of all the models is very high, supporting our claims of strong instruments.

As shown in Panel B, which presents the results of the second-stage estimations, the Hausmann-Wu test is not statistically significant for any of the specifications (only marginally so for model 6), thus supporting the exogeneity of ΔCDS_t in Equation (5). Indeed, the parameter estimates are very similar to those in Table 4 Panel A. The specification with the highest difference in the ΔCDS_t parameter (and thus one of the highest Hausman-Wu tests) is that using only $\Delta Yield_{t-1}^{DE}$ as an additional instrument, which we attribute to the poor predictive power provided by the additional instrument in the first-stage regression.

Using different sets of IVs, we have shown that ΔCDS_t is not endogenous (implying contemporaneous feedback effects) in Equation (5). Therefore, we have justified the use of a single equation in explaining the dynamics of the CDS/bid-ask spread system in the remainder of the paper.

Table Int.1: **Results for the Instrumental Variable Analysis.** This table presents the results for the instrumental variable (IV) analysis. The first-stage regressions are presented in Panel A, where ΔCDS_t is regressed on the second-stage right-hand-side variables and several combinations of variables exogenous to Equation (5). The significance of the parameters refers to heteroskedasticity-robust t-tests. The F-test row reports the (standard) F-test for the hypothesis that all regression parameters are contemporaneously 0, while F Test IV reports the F-test for the hypothesis that only the parameters of the exogenous variables added to the second-stage variables are contemporaneously equal to 0. Panel B reports the IV estimators of Equation (5) when using different combinations of exogenous variables in the first stage. The Hausmann-Wu test verifies whether the OLS and the IV estimates are significantly different under the assumption that both are consistent against the alternative that only the IV set is. Our data set consists of 640 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the Mercato dei Titoli di Stato (MTS) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread and was obtained, together with the instrumental and exogenous variables, from Bloomberg.

Panel A: First-Stage Regression

Variable	MODEL1	MODEL2	MODEL3	MODEL 4	MODEL5	MODEL6	MODEL7
Intercept	0.000	0.000	0.001	0.000	0.001	0.001	0.000
ΔCDS_{t-1}	0.203 ***	0.206 ***	0.138 ***	0.209 ***	0.025	0.179 ***	0.033
ΔBA_{t-1}	-0.009	-0.01	-0.015	-0.012	-0.01	-0.009	-0.008
ΔBA_{t-2}	-0.004	-0.006	-0.011	-0.009	0.000	-0.007	0.002
ΔBA_{t-3}	0.002	0.000	-0.004	-0.003	0.001	0.000	0.003
$\Delta CCBSS_t$	0.156 ***	0.158 ***	0.211 ***	0.172 ***	0.055 **	0.129 ***	0.046 **
$\Delta USVIX_t$	0.055 **	0.058 **	0.16 ***	0.085 ***	0.046 **	0.002	0.000
$\Delta Yield_t^{DE}$	-0.996 ***	-0.636 ***	.	.	.	.	-0.448 ***
$\Delta Yield_t^{FI}$	0.482 ***	.	.	-0.653 ***	.	.	0.155
$\Delta Yield_{t-1}^{DE}$	.	.	-0.148 **	.	.	.	-0.065
ΔCDS_t^{ENEL}	.	.	.	.	0.563 ***	.	0.483 ***
ΔCDS_t^{ENI}	.	.	.	.	0.101 **	.	0.053
$\Delta CDS_t^{FINMECC}$	.	.	.	.	0.229 ***	.	0.214 ***
$\Delta Euro50_t$	.	.	.	.	.	-1.371 ***	-0.091
Adj R-Sq	0.400	0.392	0.236	0.342	0.592	0.387	0.634
F Test	54.016***	59.555***	29.09***	48.144***	103.557***	58.268***	85.694***
F Test IV	90.53***	169.19***	6.44**	108.23***	187.60***	162.32***	100.38***

Panel B: Second-Stage Regression

Variable	MODEL1	MODEL2	MODEL3	MODEL 4	MODEL5	MODEL6	MODEL7
Intercept	-0.007	-0.002	-0.005	-0.002	-0.003	-0.003	-0.003
ΔCDS_t	0.722*	0.629	3.723	0.436	0.719**	1.299***	0.748**
ΔCDS_{t-1}	0.759***	0.777***	0.178	0.814***	0.759***	1.647***	0.754***
ΔBA_{t-1}	-0.349***	-0.350***	-0.306***	-0.353***	-0.349***	-0.341***	-0.349***
ΔBA_{t-2}	-0.214***	-0.215***	-0.179***	-0.218***	-0.214***	-0.207***	-0.214***
ΔBA_{t-3}	-0.166***	-0.166***	-0.156***	-0.167***	-0.166***	-0.164***	-0.166***
$\Delta CCBSS_t$	0.390**	0.410**	-0.244	0.450***	0.391***	0.268	0.385***
$\Delta USVIX_t$	0.222*	0.237*	-0.258	0.268*	0.222*	0.130	0.218*
Hausmann-Wu	0.24	0.05	2.65	0.05	0.72	3.79*	1.23

[*] Significant at a 10% level. [**] Significant at a 5% level. [***] Significant at a 1% level.

Int.2. The MTS Datasets and Market Structure

The MTS Datasets

There are four types of database currently offered by MTS. At the highest level, "daily summaries" including aggregate price and volume information regarding the trading of European bonds are published. At the second level, the "trade-by-trade" data including all transactions, stamped at the millisecond level, are available. However, neither of the two aggregate databases has any information on the price quotations of the instruments at the dealer, or even the market-wide, level. The publicly available data set at the third level includes the three best bid and ask prices and the aggregate quantities offered at those levels. Prior studies, not using the data set at the third level, are unable to describe the market in its entirety, as the two dimensions indicating willingness to trade, quotes, and orders, for primary dealers and dealers respectively, were not available previously. Only *actual trading* events are observable in the second-level data set, and *trading intent* as a pre-trade measure cannot be measured. Thus, it is not possible to study liquidity provision, as measured by the dealers' willingness to trade, as evidenced by their bid and offer quotations, based on this data set. We use the third-level data set from July 2010 to June 2011.

In contrast, the data set we analyze between June 2011 and December 2012 is at the fourth level and is by far the most complete representation of the market available, and has been released only recently. It covers *all* trades, quotes, and orders that took place on the MTS market between June 1, 2011 and December 31, 2012. Every event is stamped at the millisecond level, and the order IDs permit us to link each order to the trade that was eventually consummated from it. Every quote, or "proposal", in this market can be followed in the database in terms of their "revisions" over time, thanks to a "single proposal" identifier. We take advantage of the higher detail available in this data set in Section Int.8 of the internet appendix, where we repeat our analysis using alternative liquidity measures.

Despite the difference in the details contained in the third- and fourth-level databases, calculating a market-wide bid-ask spread measure leads to very similar values, regardless of the data set that is used. We measure the bid-ask spread at a five-minute frequency for each bond, then average it throughout the day for each bond and then across bonds, to obtain a market-wide measure, separately, for the two databases. Figure Int.1 shows the bid-ask spread series calculated with the third-level (fourth-level) data set in red (blue), for the seven months of overlap of the two datasets. While the two series are almost always indistinguishable from each other (their correlation is 0.975), differences between them appear largely when the largest spikes are present in the time series. These spikes, however, were winsorized in our analysis, after taking first differences.

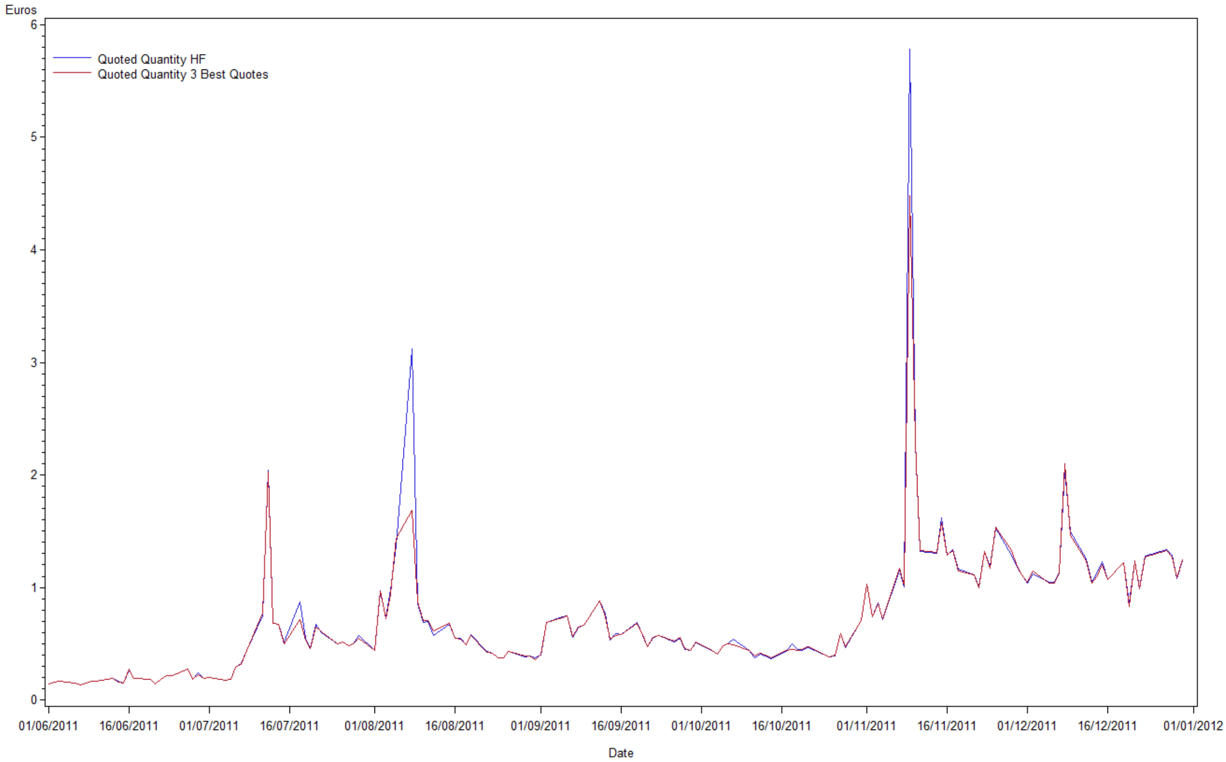


Figure Int.1: **Market-Wide Bid-Ask Spread from the High-Frequency and the Three-Best-Quotes Datasets.** This figure plots the evolution of the market-wide bid-ask spread obtained from two different datasets (the high-frequency and three-best-quotes datasets) for the overlapping period between June and December 2011. Our data set consists of seven months of trading in Italian sovereign bonds, from June 1, 2011 to December 31, 2011, and was obtained from the Mercato dei Titoli di Stato (MTS) Global Market bond trading system.

The MTS Market Structure

Market participants can decide whether they want to trade a sovereign bond on the European market or on that country's domestic market. While every Euro-zone bond is quoted on the domestic markets, only bonds that are issued for an amount higher than a certain threshold can be traded on the EuroMTS platform. Even though the two markets are not formally linked, most dealers participate in both venues. The previous literature (**??**) has shown that the two markets essentially constitute a single venue.[1] Thus, in our analysis, we consider trading in both markets. The liquidity measures used in this paper do not depend on where the order placement and trading activity take place.

There are two kinds of trader in the sovereign bond markets, primary dealers and other dealers. Primary dealers are authorized market-making members of the market. That is, they issue standing quotes, which can either be single-sided or double-sided, on the bonds they have been assigned. They indicate the quantity they are willing to trade and the non-negative fraction of that quantity they are willing to "show" to the market. Primary dealers can be on the passive side, when their proposals are "hit" or "lifted," and/or on the active side of the market, when they submit orders aimed at "hitting" or "lifting" another primary dealer's standing quote. Primary dealers have market-making obligations that, in spite of some relaxations that were made after 2007, still require each primary dealer not to diverge from the average quoted times and spreads calculated among all market makers. In this market, the event of crossed quotes is guaranteed not to occur, except by chance, since, when the opposite sides of two proposals cross, a trade takes place for the smaller of the two quoted quantities.[2] Other dealers with no market-making responsibilities can originate a trade only by "hitting" or "lifting" the primary dealers' standing quotes with market orders. However, it should be noted that primary dealers are also on the active side of 96% of the trades present in our database.

[1] By this we mean that a sell or buy order could "trade-through" a better price if the trader sent the order to the market with the worse of the bid or ask prices, respectively. However, MTS assures market participants that their trading platforms always show quotations from both the domestic and the European market, when available.

[2] While this is one way for the primary dealers to trade, it seldom happens. Hence, we do not include trades originating in this manner in our sample.

Int.3. Yield Spread - CDS Dynamics

In this section, we address the concern that between the CDS spread and the BTP yield spread with the German sovereign bond counterpart, two alternative measures of credit risk, there exists a lead-lag relation or, alternatively, that the credit risk discovery happens first in one of the markets and is then transmitted to the other. Figure Int.2 shows that the two measures are very highly correlated in the changes (75%), confirming that the two measures do indeed comove to a very high extent.

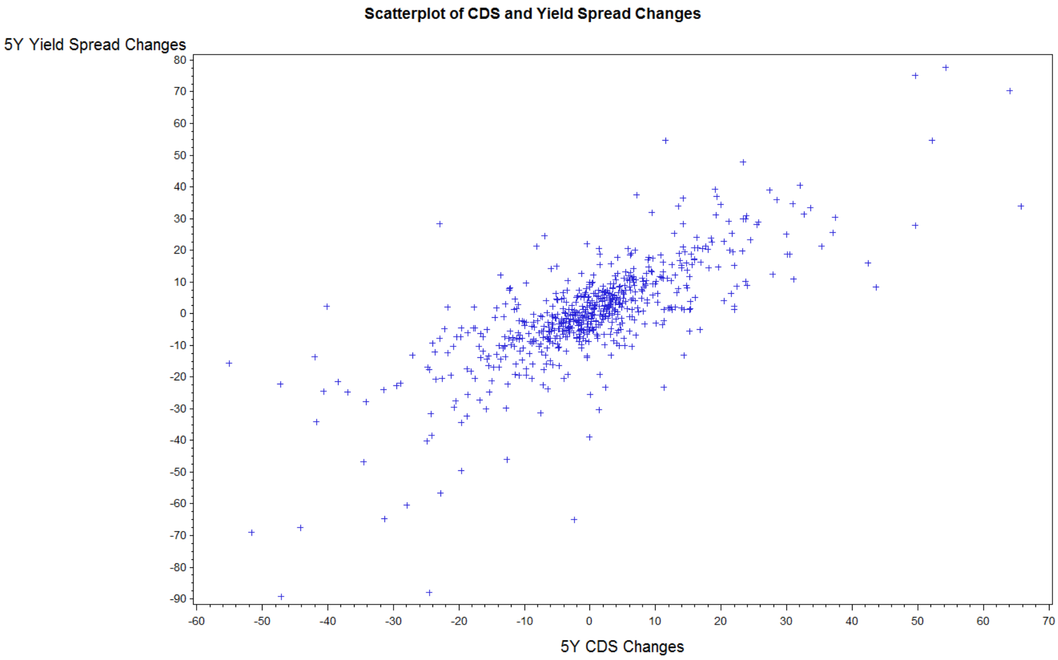


Figure Int.2: Each dot in this scatterplot represents a daily observation of the changes in the bond yield spread and the CDS spread, for an Italian underlying bond. The bond yield spread is calculated between the Italian and German bonds with five years to maturity. The CDS spread is the spread for a five-year US-denominated CDS contract. All data were obtained from Bloomberg and span our data sample of 641 trading days from July 1, 2010 to December 31, 2012.

To address the goal of determining the dynamics between the two measures, we perform a VARX(1,0) analysis of the measures ΔCDS_t, the change in the CDS spread, and ΔYS_t, the change in the yield spread to the German Bund, augmented with the exogenous variables $\Delta CCBSS_t$ and $\Delta USVIX_t$. Table Int.2 shows the results of the analysis: There exists no lead-lag relation between the CDS spread and the yield spread, as the Granger-causality panel shows. The correlation between the contemporaneous residuals, however, is very high (72%), suggesting that, if credit risk is indeed incorporated in one market first and then transmitted to the other, the credit risk transmission takes place within the same day. These results suggest that, when performing an analysis using daily data, the credit risk discovery dynamics should not be a concern, for example when determining the dynamics of credit risk and liquidity, as in the case of this study.

Table Int.2: **Results for the Granger-Causality Analysis of the Italian CDS Spread and Yield Spread.** This table presents the results for the regressions of the day-t changes in the *CDS Spread*, ΔCDS$_t$, and the Italian yield spread, ΔYS_t, on the lagged terms of both variables. The data have a daily frequency. The significance refers to heteroskedasticity-robust t-tests. Heteroskedasticity-robust F-test statistics and their significance are reported for the null hypothesis of each variable Granger-causing the other. We also report the contemporaneous correlation in the model residuals. Our data set consists of 640 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012. The CDS spread refers to a USD-denominated, five-year CDS spread and the yield spread refers to the spread between the five-year notch of the Italian term structure and its German counterpart. Both variables were obtained from Bloomberg.

Variable	ΔCDS_t	ΔYS_t
ΔCDS_{t-1}	0.085	0.001
ΔYS_{t-1}	0.087	0.081
ΔCCBSS$_t$	1.700***	1.414***
ΔUSVIX$_t$	1.714**	2.029**
Intercept	0.167	0.240
Granger-Causality Tests		
$YS \xrightarrow{GC} CDS$	1.69	.
$CDS \xrightarrow{GC} YS$	.	0.00
Residuals' Correlation		
ΔBA_t	1.000	0.715
ΔCDS_t	0.715	1.000

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Int.4. Price Volatility and CDS Liquidity

Price Volatility

A variable that we have not included in the analysis of Section 6 is the intraday price volatility of the bonds. Microstructure models (e.g., **?**, among others) suggest that an increase in price volatility should decrease the amount of liquidity offered to the market by market makers because of concerns about the risk of the inventory they carry. Moreover, the effect of heightened credit risk could affect liquidity only through price volatility, and not necessarily directly. For example, a worsened public finance situation could accentuate the uncertainty regarding the true value of the sovereign bond and the informativeness of its price, and hence affect its market liquidity. As a matter of fact, the price volatility, σ_t^2, (measured as the intraday variance of the five-minute mid-quote changes for each bond, averaged into a market-wide daily measure) and the *Bid-Ask Spread* are highly correlated in our sample, even in differences (59%).

We thus need to test the effect of a change in credit risk, *after* controlling for the effect of volatility on the liquidity measure. We therefore estimate a VAR, as in Equation (4), with the changes in the *CDS Spread*, *Bid-Ask Spread*, and bond price volatility, σ_t^2. The lag structure selected by the modified Akaike criterion is 6, due to the stickiness of the volatility measure. Table Int.3 reports the results for the Granger-causality test, while Figure Int.3 shows the IRFs for the VARX(6,0) system. The Granger-causality test shows that we cannot reject the hypotheses that any variable is Granger-causing the other two. However, Figure Int.3 shows that the bid-ask spread significantly leads the volatility of returns (and not the CDS spread), while a shock to volatility seems not to significantly affect the illiquidity measure, at least not in an economically significant fashion. It is clear from Panel (b) that the main driver of the illiquidity variable dynamics is the CDS spread, as we posited in the main body of the paper.

Finally, we repeat the threshold estimation from Equation (6), adding $\Delta\sigma^2$ as an explanatory variable. The test for the presence of the threshold is significant at the 1% level and confidence intervals around the threshold estimate can be seen in Figure Int.4. The estimates of Equation (6), with the addition of the bond market volatility, are shown in Table Int.4. The contemporaneous bond price volatility is indeed significant at the 1% level and it increases the R^2 by 20%. However, the estimates of the parameters related to the $CDS\ Spread$ dynamics are remarkably similar to those of Table 4 Panel B.

Table Int.3: **Results for Granger-Causality with Variance of Returns.** We regress changes in the liquidity measure, changes in credit risk, and changes in the volatility of the returns, on their own lags and the lags of the other two variables, and on contemporaneous changes in macro variables in a VARX(6,0) setting. Heteroskedasticity-robust F-test statistics and their significance are reported for the null hypothesis of no Granger-causality from one variable to the other two. Our data set consists of 640 days of trading in the sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the MTS (Mercato dei Titoli di Stato) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread. The CDS spread and the macro variables were obtained from Bloomberg.

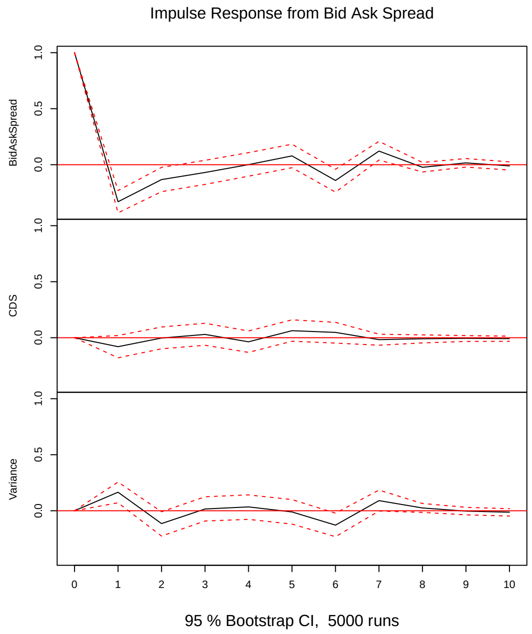
Granger-Causality Tests			
$BA \xrightarrow{GC} CDS + \sigma^2$	5.071***		
$CDS \xrightarrow{GC} BA + \sigma^2$	4.282***		
$\sigma^2 \xrightarrow{GC} CDS + BA$	3.483***		
Residuals' Correlation			
	ΔBA_t	ΔCDS_t	$\Delta\sigma^2_t$
ΔBA	1.000	0.113	0.631
ΔCDS	0.113	1.000	0.031
$\Delta\sigma^2$	0.631	0.031	1.000

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

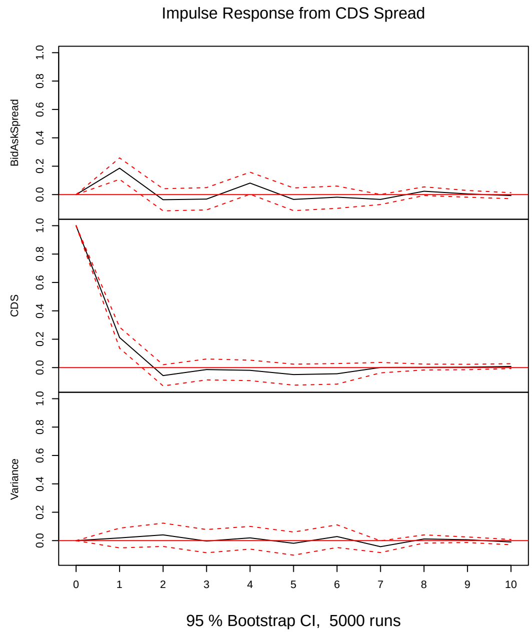
Table Int.4: **Results for the Regression of the Bid-Ask Spread on the CDS spread and Macro Variables and Bond Return Volatility.** This table presents the results for the regression of the change in the *Bid-Ask Spread* (the change in the quoted bid-ask spread) on day t, ΔBA_t, on its lagged terms, and on the change in the CDS spread on day t, ΔCDS_t, and its lagged terms, and the bond return volatility, using daily data. The statistical significance refers to heteroskedasticity-robust t-tests. The Test column reports the heteroskedasticity-robust test result for whether the two parameters above and below the threshold are equal and distributed as chi-square(1). Our data set consists of 640 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the Mercato dei Titoli di Stato (MTS) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread. The CDS spread and the macro variables were obtained from Bloomberg.

Variable	I[CDS≤500]	I[CDS>500]	Test
ΔCDS_t	0.420**	1.874***	8.44***
ΔCDS_{t-1}	0.840***	-0.738**	13.89***
ΔBA_{t-1}	-0.201***		
ΔBA_{t-2}	-0.116***		
ΔBA_{t-3}	-0.125***		
$\Delta CCBSS_t$	0.287**		
$\Delta USVIX_t$	0.105		
$\Delta\sigma^2_t$	0.092***		
Intercept	-0.001		
Adj R^2	0.449		
N	637		

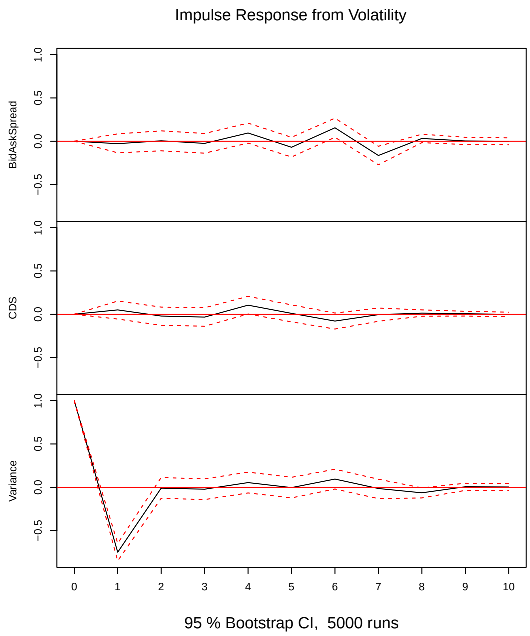
* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.



(a) Shock to the bond market liquidity



(b) Shock to the CDS spread



(c) Shock to the bond market volatility

Figure Int.3: **Impulse Response Functions for the VARX(6,0) System for Bid-Ask Spread, CDS Spread, and Volatility.** This graph shows the evolution of the impulse response functions to a shock in the bond market liquidity, as measured by the bid-ask spread, the CDS spread, and the bond market return volatility, in Panels (a), (b), and (c) respectively. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian sovereign bonds and quotes for the CDS spread, from July 1, 2010 to December 31, 2012.

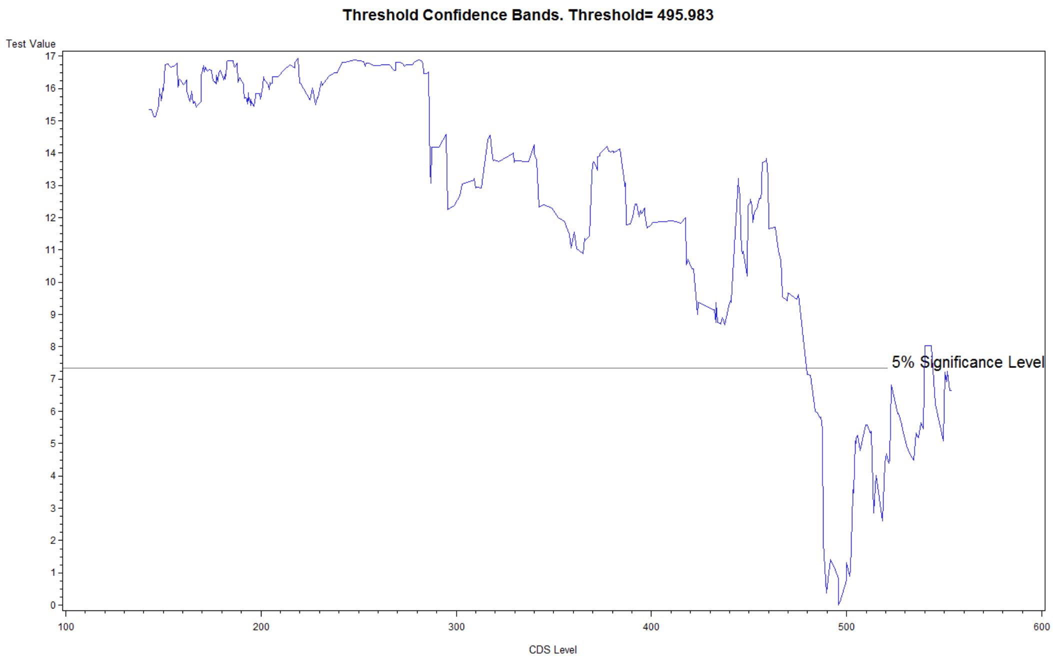


Figure Int.4: **Test to Determine Confidence Bands around the CDS Threshold with the Addition of Bond Return Volatility.** The test statistic described in Appendix B is plotted here for Equation (6), with the addition of bond return volatility. The test statistic is normalized at 0 at the threshold that minimizes the sum of squared residuals. The horizontal line at 7.35 marks the 5% confidence values for the threshold. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian sovereign bonds, from July 1, 2010 to December 31, 2012.

CDS Market Liquidity

Another variable that could affect the dynamics of the system we analyze is the market liquidity of the CDS contract itself: If the CDS spread is affected by the demand and supply of credit-event insurance, measured by its own bid-ask spread, and we do not include this liquidity variable in our system, we could be ignoring a significant determinant of the system's dynamics. We investigate this issue in detail. We replicate the analysis from Section 6.1 by adding a third endogenous variable, $\Delta CDS\,BA_t$, the change in the daily bid-ask spread for a CDS contract. We construct this measure by averaging bid-ask spread observations sampled at a five-minute frequency from high-frequency CDS quotes obtained from CMA. Figure Int.5 shows the time-series of CDS liquidity, Table Int.5 shows the Granger-causality results for the VARX(6,0), and Figure Int.6 shows the IRFs for the system (after standardizing the variables).

While the Granger-causality from the CDS spread to the other two variables is the most significant, the causation from the liquidity of the CDS market to the other two variables is also significant. However, the IRFs show that the prior finding that a change in the CDS spread significantly affects the bond market bid-ask spread is unchanged. A change in CDS liquidity has only a marginally statistically significant effect on the liquidity of the bond market seven days after the shock. The inclusion of the CDS spread in the VAR system does not, thus, affect our conclusion regarding the dynamic relation between credit risk and market liquidity.

On the other hand, Table Int.5 shows that the residual correlation is high between the liquidity of the bond and CDS markets, and one might be concerned that the CDS level was capturing the CDS liquidity, although the residual correlation of the latter two is low. In Table Int.6 we repeat the analysis of Table 4 Panel B, including the liquidity of the CDS market as one of the explanatory variables. Figure Int.7 reports the threshold confidence band. The threshold selected by the procedure is very close to that selected the first time we performed the analysis (496.55 vs. 488.04), although the confidence band around it is rather large. However, Table Int.6 shows that the parameters related to the $CDS\ Spread$ dynamics are remarkably similar to those of Table 4 Panel B. We thus conclude that, although the liquidity of the CDS market is significantly partially correlated with the liquidity of the bond market (as the literature on commonality in liquidity would suggest), the inclusion of the CDS liquidity does not invalidate the results in the main part of the study regarding the relation between credit risk and market liquidity.

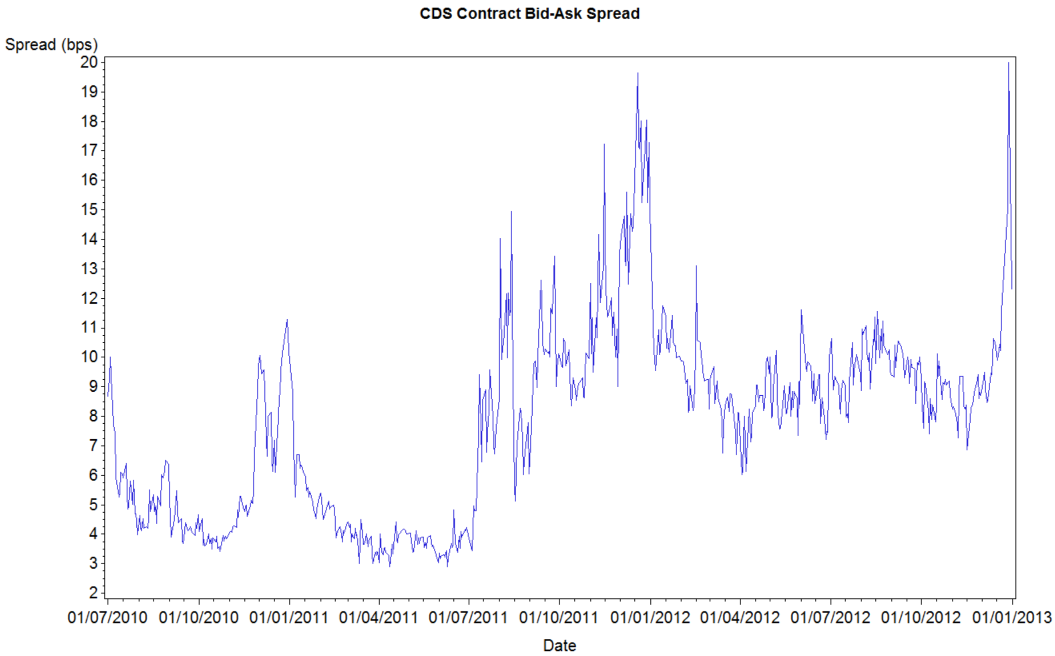
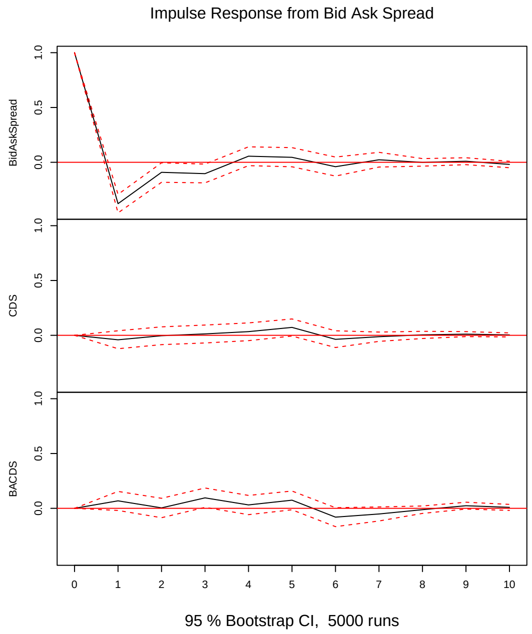


Figure Int.5: The daily average absolute bid-ask spread for the CDS contract was obtained from the CMA data, and spans our sample period of July 1, 2010 to December 31, 2012.

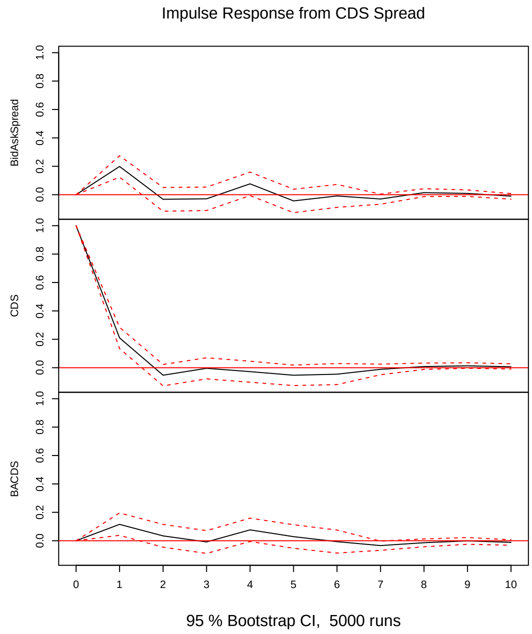
Table Int.5: **Results for the Granger-Causality Analysis of the Italian CDS Spread, Bond Liquidity, and CDS Liquidity.** This table presents the results for the regressions of the day-t changes in *CDS Spread* ΔCDS_t, the Italian bond market bid-ask spread ΔBA_t, and the Italian CDS bid-ask spread $\Delta BACDS_t$ on their lagged terms and the contemporaneous changes in CCBSS and USVIX. The data have a daily frequency. Heteroskedasticity-robust F-test statistics and their significance levels are reported for the null hypothesis of each variable Granger-causing the others. We also report the contemporaneous correlation in the model residuals. Our data set consists of 640 days of trading in Italian sovereign bonds, between July 1, 2010 and December 31, 2012. The CDS spread and bid-ask spread refer to a USD-denominated, five-year CDS spread. The CDS spread was obtained from Bloomberg, the CDS bid-ask spread from CMA, and the bond market bid-ask spread from MTS data.

Granger-Causality Tests			
$BA \xrightarrow{GC} CDS\&BACDS$	1.56*		
$CDS \xrightarrow{GC} BA\&BACDS$	2.51***		
$BACDS \xrightarrow{GC} BA\&BACDS$	2.43***		
Residuals' Correlation			
	ΔBA_t	ΔCDS_t	$\Delta BACDS_t$
ΔBA_t	1.000	0.119	0.312
ΔCDS_t	0.119	1.000	0.132
$\Delta BACDS_t$	0.312	0.132	1.000

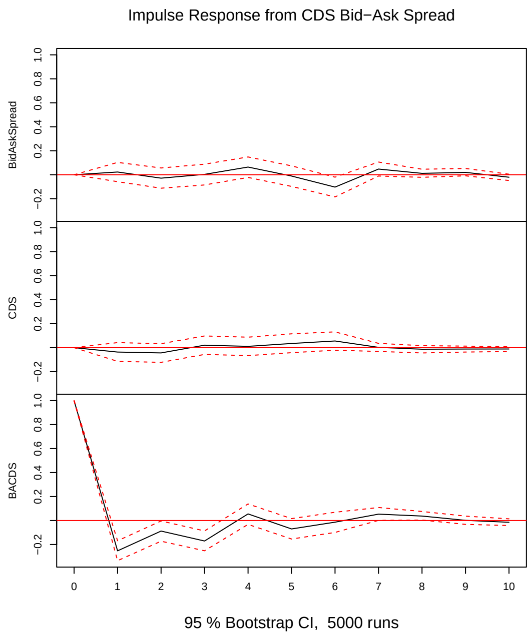
* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.



(a) Shock to the bond market liquidity



(b) Shock to the CDS spread



(c) Shock to the CDS market liquidity

Figure Int.6: **Impulse Response Functions for the VARX(6,0) System for the Bid-Ask Spread, CDS Spread, and CDS Liquidity.** This graph shows the evolution of the impulse response functions to a shock in the bond market liquidity, as measured by the bid-ask spread, the CDS spread, and the CDS bid-ask spread, in Panels (a), (b), and (c) respectively. Our data set consists of transactions, quotes, and orders for all 152 fixed-rate and floating Italian sovereign bonds and quotes for the CDS spread, from July 1, 2010 to December 31, 2012.

Table Int.6: **Results for the Regression of the Bid-Ask Spread on the CDS Spread, Macro Variables and CDS Liquidity.** This table presents the results for the regression of the change in the bid-ask spread (the change in the quoted bid-ask spread) on day t, ΔBA_t, on its lagged terms, and on the change in the CDS spread on day t, ΔCDS_t, and its lagged terms, using daily data for the bid-ask spread and the CDS spread. The statistical significance refers to heteroskedasticity-robust t-tests. The Test column reports the heteroskedasticity-robust test result for whether the two parameters above and below the threshold are equal and distributed as chi-square(1). Our data set consists of 624 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the Mercato dei Titoli di Stato (MTS) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread and the macro variables were obtained from Bloomberg.

Variable	I[CDS≤500]	I[CDS>500]	Test
ΔCDS_t	0.209	2.008***	7.84***
ΔCDS_{t-1}	0.884***	-0.588	8.40***
ΔBA_{t-1}	-0.338***		
ΔBA_{t-2}	-0.194***		
ΔBA_{t-3}	-0.176***		
$\Delta CCBSS_t$	0.329**		
$\Delta USVIX_t$	0.118		
$\Delta BACDS_t$	0.428***		
Intercept	-0.001		
Adj R^2	0.276		
N	624		

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

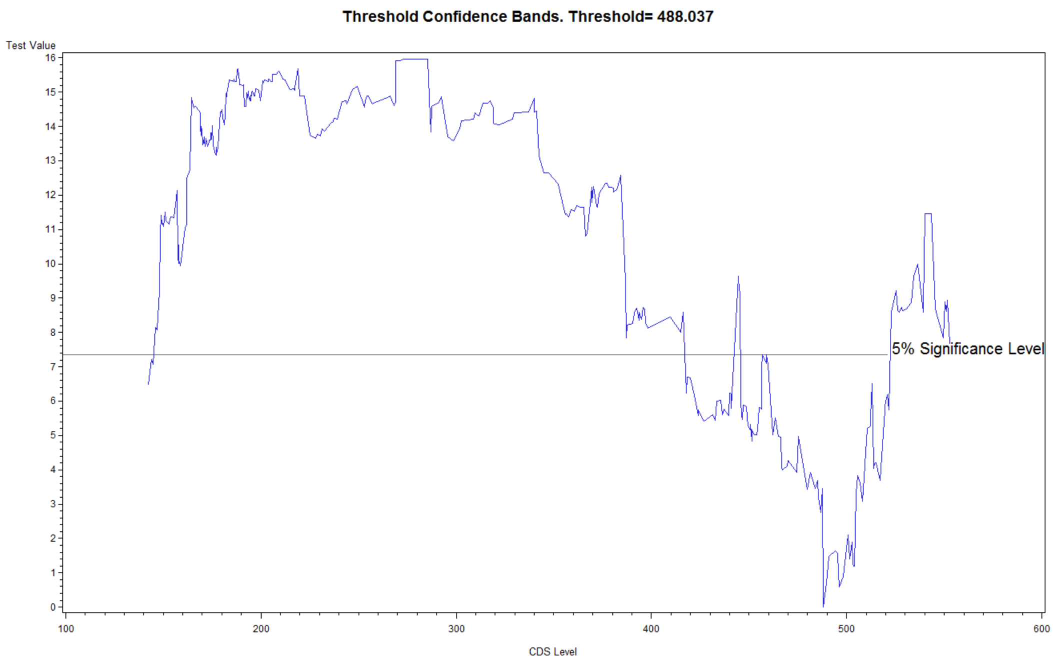


Figure Int.7: **Test to Determine Confidence Bands around the CDS Threshold with the Addition of CDS Liquidity.** The test statistic described in Appendix C is plotted here for Equation (6), with the addition of CDS liquidity. The test statistic is normalized at 0 at the threshold that minimizes the sum of squared residuals. The horizontal line at 7.35 marks the 5% confidence values for the threshold. Our data set consists of transactions, quotes, and orders for all 152 fixed-rate and floating Italian sovereign bonds, from June 1, 2011 to December 31, 2012.

Int.5. Higher Winsorization Level

In this section, we replicate Table 5, after winsorizing the data at the 5% level, rather than the 1% level, and report the estimates in Table Int.7. The parameters related to the CDS spread dynamics when the CDS spread level is above the threshold are smaller, which was expected since we winsorized observations belonging to that part of the sample. The main results, however, are qualitatively unchanged from the analysis in the main part of the paper.

Table Int.7: **Results for the Regression of the Bid-Ask Spread on the CDS Spread and Macro Variables after a 5% Winsorization.** This table presents the results for the regression of the change in the bid-ask spread (the change in the quoted bid-ask spread) on day t, ΔBA_t, on its lagged terms, and the change in the CDS spread on day t, ΔCDS_t, and its lagged terms, using daily data for the bid-ask spread and the CDS spread. The regressions are presented for Equations 6 and 5 in Panels A and B respectively. Parameters multiplying the identity operator $[CDS \leq (>)500]$ are reported under the $[CDS \leq (>)500]$ column. The statistical significance refers to heteroskedasticity-robust t-tests. The Test column reports the heteroskedasticity-robust test results for the two parameters above and below the threshold being equal and distributed as chi-square (1). Panel A (B) is based on the pre-(post-)structural-break sample. Our data set consists of 641 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the Mercato dei Titoli di Stato (MTS) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread and the macro variables were obtained from Bloomberg.

Variable	Panel A: 2011			Panel B: 2012
	I[CDS≤500]	I[CDS>500]	Test	
ΔCDS_t	0.478	2.867***	9.36***	0.161
ΔCDS_{t-1}	0.808***	-1.326**	9.66***	0.582**
ΔBA_{t-1}	-0.255***			-0.488***
ΔBA_{t-2}	-0.177***			-0.265***
ΔBA_{t-3}	-0.132**			-0.155***
$\Delta CCBSS_t$	0.355**			0.788***
$\Delta USVIX_t$	0.309*			-0.105
Intercept	0.003			-0.004
Adj R^2	0.233			0.237
N	377			260

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Int.6. Additional Results on Threshold Regressions

The Bootstrapped Test Distributions

In Section 6.2 and 7.1 we reported the test statistic and its significance for the test of the presence of the threshold in Equations 6 and 8. The distribution of the test, bootstrapped according to **?**, is reported in Figures Int.8, Int.9, and Int.10 for the thresholds shown in Figures 6, 9, and 12, respectively.

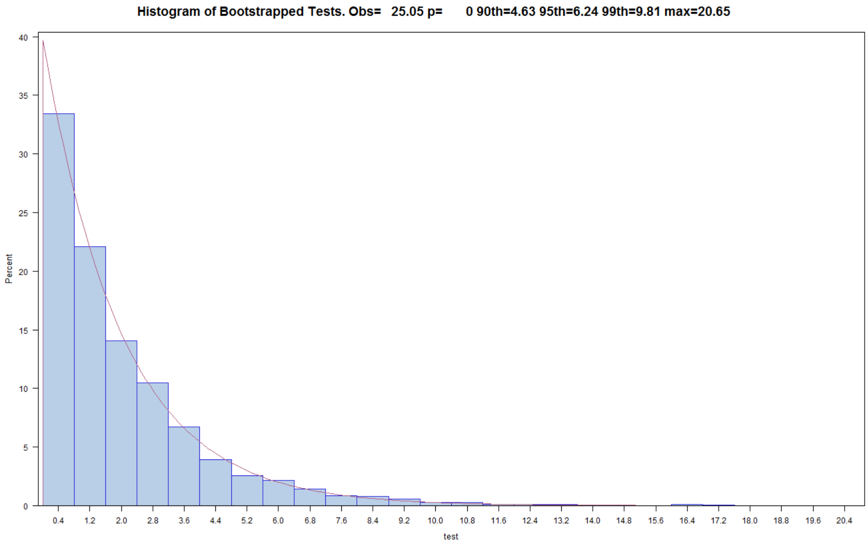
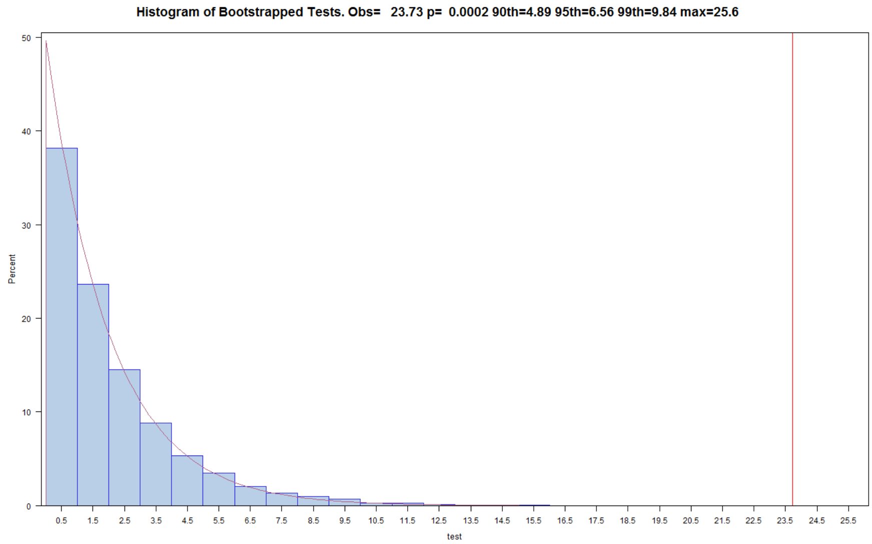
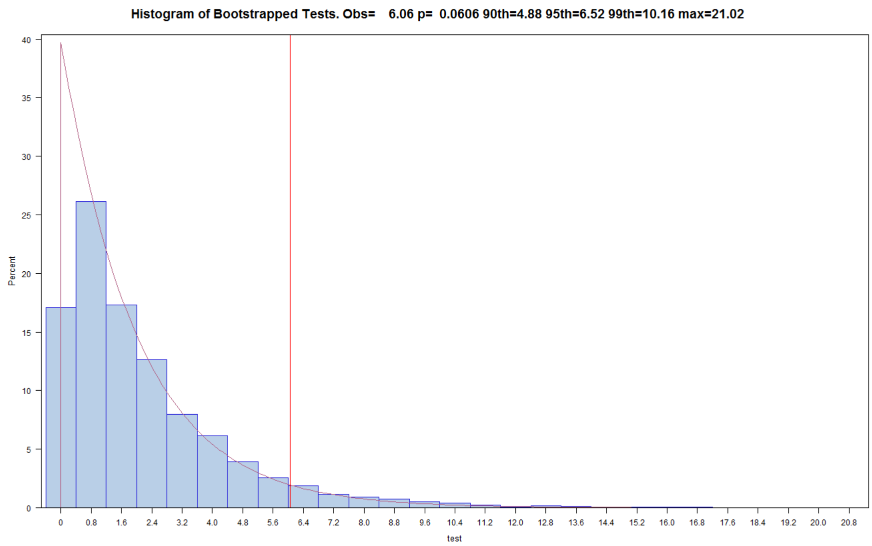


Figure Int.8: **Bootstrapped Distribution for the Test for Threshold Presence for Equation (6) and Observed Test Value** We bootstrapped the distribution of the test for the presence of a threshold and plot it here. The curve superimposed on the empirical distribution is a chi-square distribution with as many degrees of freedom as there are parameters that are allowed to change in the specification, for reference. The observed test statistic was 25.05. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian government bonds, from July 1, 2010 to December 31, 2012.



(a) Threshold Confidence Bands Determination: 2011 Sample



(b) Threshold Confidence Bands Determination: 2012 Sample

Figure Int.9: **Bootstrapped Distribution for the Test for Threshold Presence for Equation (6) and Observed Test Value for Two Subsamples** We bootstrapped the distribution of the test for the presence of a threshold separately for the subsamples before and after December 21, 2011, and plot those distributions in Panels (a) and (b), respectively. The vertical red line marks the observed test value (23.73 and 6.06, respectively), while the curve superimposed on the empirical distribution is a chi-square distribution with as many degrees of freedom as there are parameters that are allowed to change in the specification, for reference. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian government bonds, from July 1, 2010 to December 31, 2012.

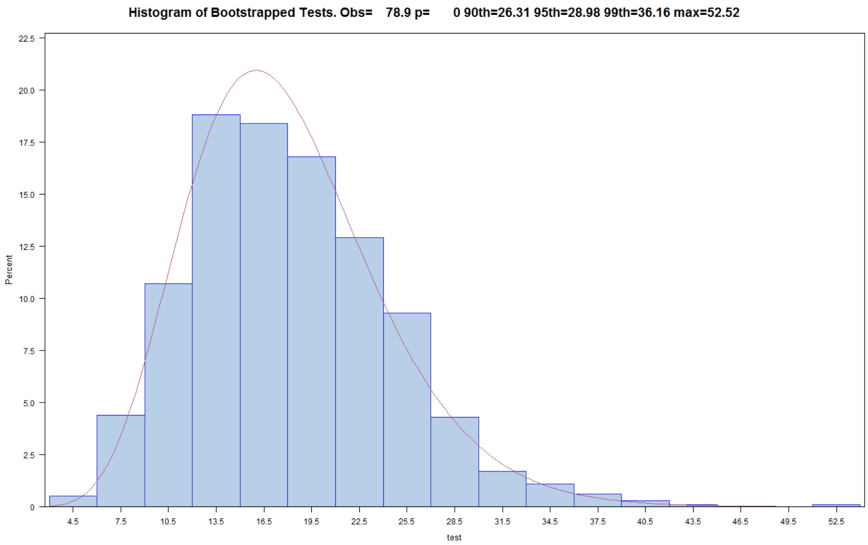


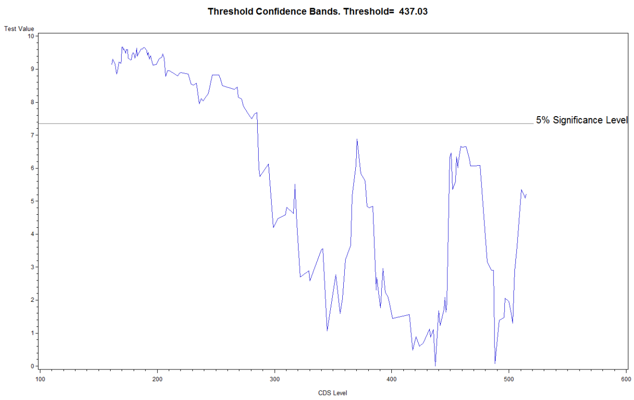
Figure Int.10: **Bootstrapped Distribution for the Test for Threshold Presence for Equation (8) and Observed Test Value** We bootstrapped the distribution of the test for the presence of a threshold and plot it here. The observed test statistic is 78.9. The curve superimposed on the empirical distribution is a chi-square distribution with as many degrees of freedom as there are parameters that are allowed to change in the specification, for reference. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian government bonds, from July 1, 2010 to December 31, 2012.

Maturity Bucket Specific Thresholds

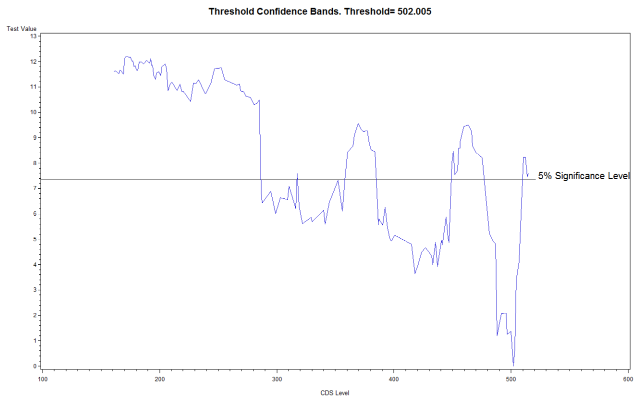
In Section 7.1, we estimated Equation (8) as a pooled OLS panel regression, and showed that the threshold result was robust to this alternative specification. Alternatively, to test the robustness of our results, we can estimate Equation (8) *separately* for each maturity bucket. We therefore estimate

$$\begin{aligned}\Delta BA_t = &\alpha_0 + \sum_{i=1}^{3} \alpha_i \Delta BA_{t-i} + I\left[CDS \leq \hat{\gamma}\right]\left(\sum_{j=0}^{1} \beta_j \Delta CDS_{t-j}\right) \\ &+ I\left[CDS > \hat{\gamma}\right]\left(\sum_{j=0}^{1} \tilde{\beta}_j \Delta CDS_{t-j}\right) + \beta_2 USVIX_t + \beta_3 CCBSS + \epsilon_t\end{aligned} \tag{1}$$

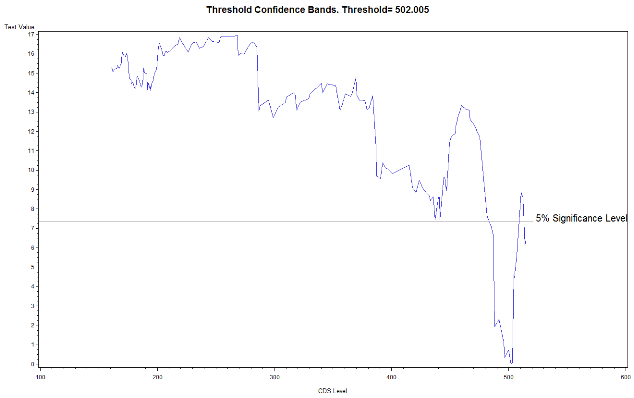
for each maturity group. The CDS spread level that is used as a discontinuity variable is the CDS spread for the five-year maturity, since this is the reference maturity and it is explicitly mentioned in the "Sovereign Risk Framework" (**?**). Figure Int.11 shows the threshold confidence band determination for each of the nine maturity buckets for which we can estimate Equation (1). For each group the threshold is found for a CDS spread of 497 or 502, with 500 always contained within the confidence bands, with the exception of the group with the shortest maturity. We interpret the finding that the relation between market liquidity and credit risk shows a structural break regardless of the maturity of the bonds, when the five-year CDS is 500 bp, as supporting and showing the robustness of the results contained in the main body of the paper.



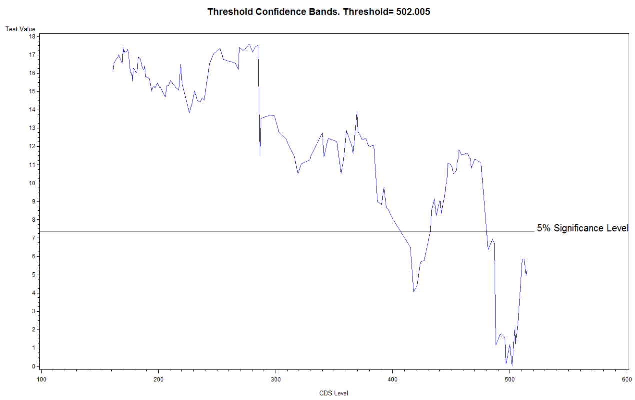
(a) Group 3: 3 to 9 months



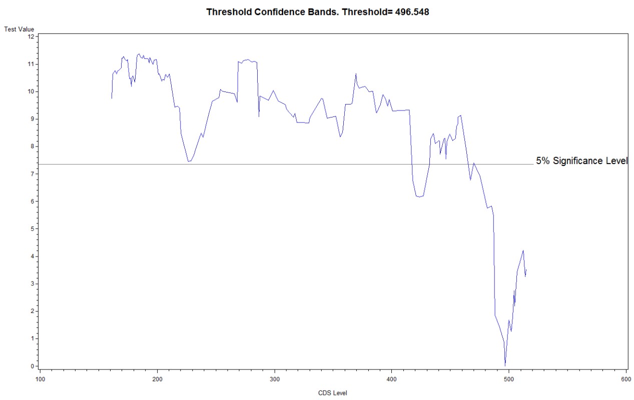
(b) Group 4: 0.75 to 1.25 years



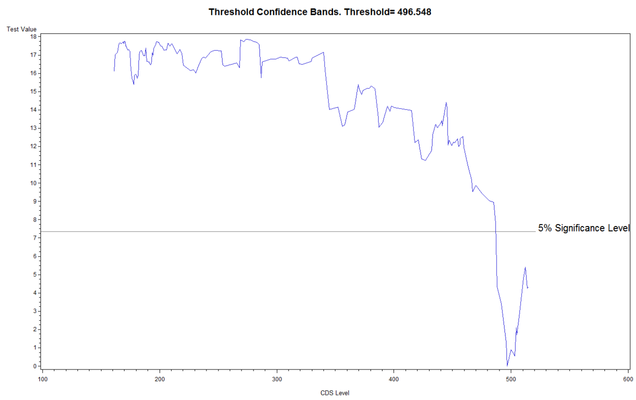
(c) Group 5: 1.25 to 2 years



(d) Group 6: 2 to 3.25 years

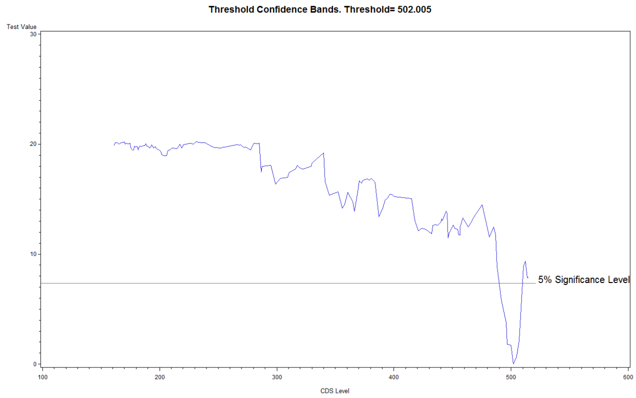


(e) Group 7: 3.25 to 4.75 years

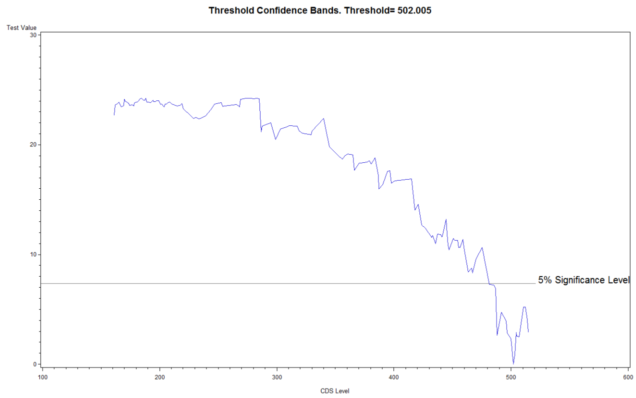


(f) Group 8: 4.75 to 7 years

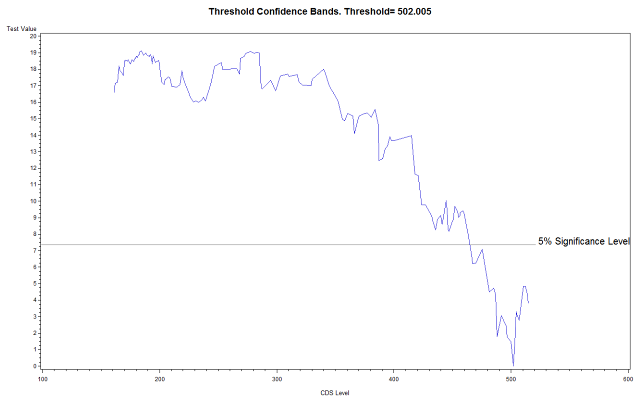
Figure Int.11: **Test to Determine Confidence Bands around the CDS Threshold for each Maturity Group.** The test statistic described in Appendix B is plotted here for Equation (1), estimated for each maturity group. The test statistic is normalized at 0 at the threshold that minimizes the sum of squared residuals. The horizontal line at 7.35 marks the 5% confidence values for the threshold. Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian sovereign bonds, divided into 11 maturity groups, from July 1, 2010 to December 31, 2012. [Continued]



(g) Group 9: 7 to 10 years



(h) Group 10: 10 t0 15 years



(i) Group 11: 15 to 30 years

Int.7. Granger-Causality Below and Above the CDS Threshold

We repeat the VAR analysis, while only using the dates when the CDS is below and above the threshold, separately, and report the results in Table Int.8, in Panels A and B, respectively. Regarding the lead-lag relation between CDS and market liquidity, even above 500 bp, the CDS spread leads the bid-ask spread. However, given that the contemporaneous correlation between the CDS spread and the bid-ask spread is very high, when the CDS spread is above 500 bp, and that both the CDS spread and the bid-ask spread are subject to mean reversion, excluding the contemporaneous changes in the VAR analysis induces a negative relation between the bid-ask spread and the CDS spread at lag 3. Nevertheless, the analysis including the contemporaneous CDS changes shows that there is indeed a positive relation between the CDS spread and the bid-ask spread, where the CDS spread is the driver, as confirmed by the instrumental variable analysis. Repeating the analysis for the subsample below 500 bp leads to results similar to those for the whole sample reported in Table 3.

Table Int.8: **Results for the Granger-Causality Analysis of the Italian CDS Spread and Bond Liquidity when below the Threshold.** This table presents the results for the regressions of the day-t changes in the CDS spread ΔCDS_t, and the Italian bond market bid-ask spread ΔBA_t, on the lagged terms of both variables. The data have a daily frequency. The significance refers to heteroskedasticity-robust t-tests. Heteroskedasticity-robust F-test statistics and their significance levels are reported for the null hypothesis of each variable Granger-causing the other. Our data set consists of 541 and 96 days of trading in Italian sovereign bonds, between July 1, 2010 and December 31, 2012, when the CDS level is below and above the threshold found in Section 6.2, in Panels A and B, respectively. The CDS spread refers to a USD-denominated, five-year CDS spread and was obtained from Bloomberg.

Panel A: $CDS < 500bp$		
Variable	ΔBA_t	ΔCDS_t
ΔCDS_{t-1}	1.035***	0.200***
ΔBA_{t-1}	-0.342***	-0.011
ΔCDS_{t-2}	0.032	-0.087*
ΔBA_{t-2}	-0.229***	-0.007
ΔCDS_{t-3}	0.262	0.047
ΔBA_{t-3}	-0.177***	-0.004
$\Delta Euribor - DeTBill_t$	0.007	0.034
$\Delta CCBSS_t$	0.533***	0.204***
$\Delta USVIX_t$	0.189	0.153***
Intercept	0.001	0.000
Granger-Causality Tests		
$CDS \xrightarrow{GC} BA$	7.263***	.
$BA \xrightarrow{GC} CDS$	.	0.377
Panel B: $CDS > 500bp$		
Variable	ΔBA_t	ΔCDS_t
ΔCDS_{t-1}	0.067	0.233***
ΔBA_{t-1}	-0.427***	-0.025
ΔCDS_{t-2}	-0.881	-0.106
ΔBA_{t-2}	-0.172	-0.020
ΔCDS_{t-3}	-1.196*	-0.198
ΔBA_{t-3}	-0.111	0.001
$\Delta EuriborDeTBill_t$	0.112	0.061
$\Delta CCBSS_t$	0.620	0.236***
$\Delta USVIX_t$	0.985***	0.163***
Intercept	0.013	0.006
Granger-Causality Tests		
$CDS \xrightarrow{GC} BA$	3.68**	.
$BA \xrightarrow{GC} CDS$	.	1.237

* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.

Int.8. Results for Other Liquidity Measures

In the main body of the paper we conducted the analyses focusing on a single measure for the (il)liquidity of the bond market, the *Bid-Ask Spread*, since it is both the most familiar and most indicative of market conditions. Nonetheless, in order to validate the results presented in the prior sections, we employ a cohort of other liquidity measures and show that they are all highly correlated with the *Bid-ask Spread*. Even so, we repeat most of the analysis from the earlier sections, using these measures. Due to data set limitations, however, we repeat the analysis with other liquidity measures only for the subsample covering 152 bonds and 406 trading days between June 2011 and December 2012, for which the tick-by-tick data are available.[3]

The proxies we use can be divided into two main categories: quote-based and trade-based measures. Quote-based measures include the total quoted quantity (*Quoted Quantity*), and the market depth measure, *Lambda*, while the *Effective Spread* constitutes our trade-based measure. The *Effective Spread* measures the actual spread experienced by traders, while *Quoted Quantity* measures the largest amount a trader could buy or sell at any point in time, if she were not concerned with execution costs. The depth measure *Lambda* attempts to combine the bid-ask spread and the quoted quantity by measuring by how much a trader would move the best bid (ask) if she were to trade €15 million of a given bond.[4] Mathematically, the *Lambda* on the ask side would be defined as $\lambda^a = E\left[(P_t^a - P_{t-1}^a)(Q_t)\,|Q_t = 15M\right] = E\left[\Delta P_t^a(Q_t)\,|Q_t = 15M\right]$, where P_t^a is the time t ask price following a buy trade of quantity $Q_t = 15M$, and λ^b would be defined similarly. In order to represent both sides of the market, we consider the mean, $\lambda = \frac{\lambda^a + \lambda^b}{2}$, in our empirical estimations, as a market depth measure. As for the trade-based measures, the effective bid-ask spread *Effective Spread* is calculated as $Q \cdot (AP - M) \cdot 2$, where $Q = 1$ if it is a buy order, $Q = -1$ if it is a sell order, AP is the face-value-weighted trade price, and M is the mid-quote in place at the time the order arrives.[5]

All quote-based measures are calculated at a five-minute frequency for each bond, and then averaged across bonds to calculate a daily market-wide measure.[6] The *Effective Spread* is calculated for our sample of the whole market, with volume-weighting of the trades of all bonds. Figure Int.11 shows the time-series evolution of the liquidity variables and Table Int.9 shows the correlations between them. The measures tend to comove and clearly follow the same evolution. The *Bid-Ask Spread* is the liquidity measure that most highly correlates with the others; all absolute correlations between it and the other variables exceed 59% (44%) in levels (differences),

[3]The differences between the two datasets we use are presented in Section Int.2 of this internet appendix.

[4]This amount was chosen since it is at the 90th percentile of the overall market in terms of trade size. As traders might split up large amounts over several subsequent trades, *Lambda* captures the price movement caused by a relatively large trade requiring immediacy. It is conceptually equivalent to the concept of market depth defined by **?**.

[5]We do not include two widely known trade-based liquidity metrics, the Amihud illiquidity measure and the Roll measure, in the list of alternative liquidity measures. The MTS market is characterized by high-frequency *quote updates*, but not high-frequency *transactions*. However, the MTS database provides detailed order book information, enabling us to compute a liquidity measure, the hypothetical market impact, for buy and sell orders separately (*Lambda*). Thus, due to the large number of quotes relative to trades, *Lambda* is a far better and more granular measure for this market than the Amihud measure. Additionally, market makers in the MTS market post firm quotes that are executable immediately, so that the difference between best ask and best bid (quoted bid-ask spread) indicates the market-making risk perceived by professional market makers at any point in time. Therefore, there is no need to rely on alternative estimations of the bid-ask spread, such as the Roll measure, since the actual measure is itself available.

[6]It is common in the sovereign bond literature to separate the bonds into on-the-run and off-the-run issues, or to only consider the former, reckoning that the former are more liquid and more sought after by investors. The Italian sovereign issuer, the *Tesoro*, often reissues existing bonds, thus enhancing their liquidity, and causing the on-the-run/off-the-run dichotomy to lose its relevance. In any event, we checked whether there were differences in the quoted or effective bid-ask spread for "new" issues compared to the prior issues and did not find any significant differences. For this reason, we average our liquidity measures across all bonds without sorting them by remaining maturity or age since issue.

with λ_t being the least correlated with it.

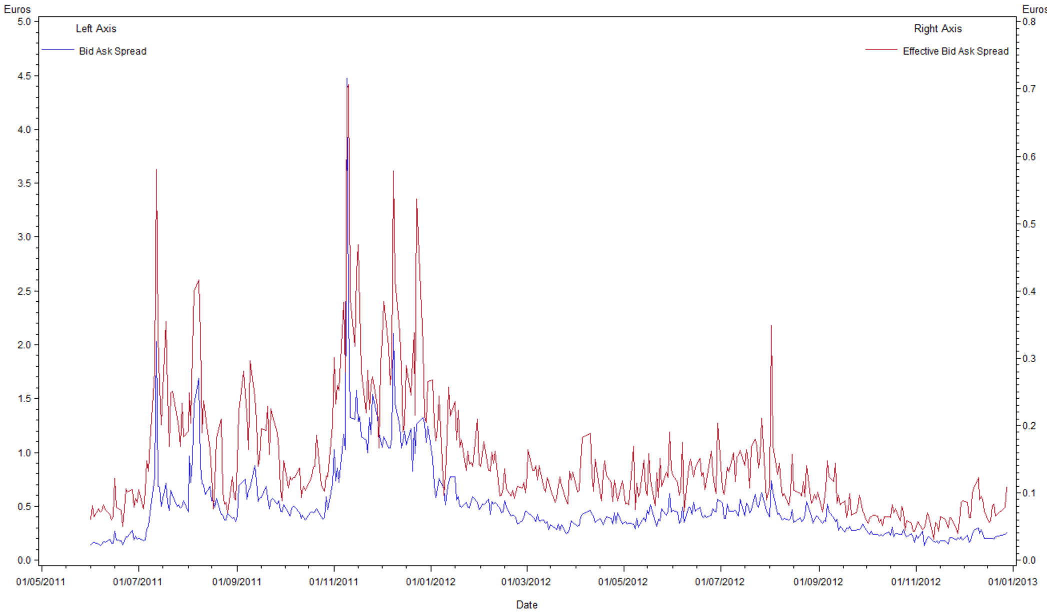
To check the robustness of the results in Section 6, we repeat the analysis in which we estimated Equation (5), the threshold test in Equation (6) for the sample up to December 21, 2011, and the structural break of Section 6.3, using the other liquidity variables described in this section, namely the *Quoted Quantity*, the *Effective Spread*, and *Lambda*. The number of lags for each variable and the *CDS Spread* are determined using the same methodology as for the *Bid-Ask Spread*. The results are reported in Table Int.10, while Figure Int.12 shows the plots of the identification of the threshold in the relation between changes in liquidity and changes in the Italian *CDS Spread* level for the 2011 subsample, and the structural break test, as performed in Section 6.3 for the *Bid-Ask Spread*.

Figure Int.12 shows that the structural break around the LTRO settlement (Panels e, f, and i) is also a feature of the *Quoted Quantity* and *Effective Spread*, as is the 500 bp threshold in the regression of the changes in the liquidity measure on its lags and the changes in the Italian *CDS spread* and its lag and the macro variables, for the 2011 subsample (Panels c, d, and h) for the *Quoted Quantity* and *Lambda*. A 10% change in the Italian *CDS Spread* is contemporaneously associated with a 14% decrease in *Quoted Quantity*, a 33% increase in the *Effective Spread*, and a 52% increase in *Lambda*, when the CDS spread for Italian bonds is above 500 bp, compared to a 7% decrease, a 10% increase, and a 28% increase when the Italian *CDS Spread* is below the same threshold. After the ECB intervention, a change in the Italian *CDS Spread* has no significant effect on any liquidity measure. The sensitivity of the *Effective Spread* is lower than that of the *Bid-Ask Spread* because of the endogeneity of the trading decision: traders will choose to trade when the *Bid-Ask Spread* is comparatively low, thus dampening the sensitivity of the *Effective Spread* to changes in market conditions. The dynamics of the relation between credit risk and liquidity are confirmed by the analysis of the alternative liquidity measures, so that the lagged change in credit risk is significant when the market is relatively quiet, while, in a stressed market, when the Italian *CDS Spread* is above 500 bp, the liquidity changes contemporaneously with the credit risk.

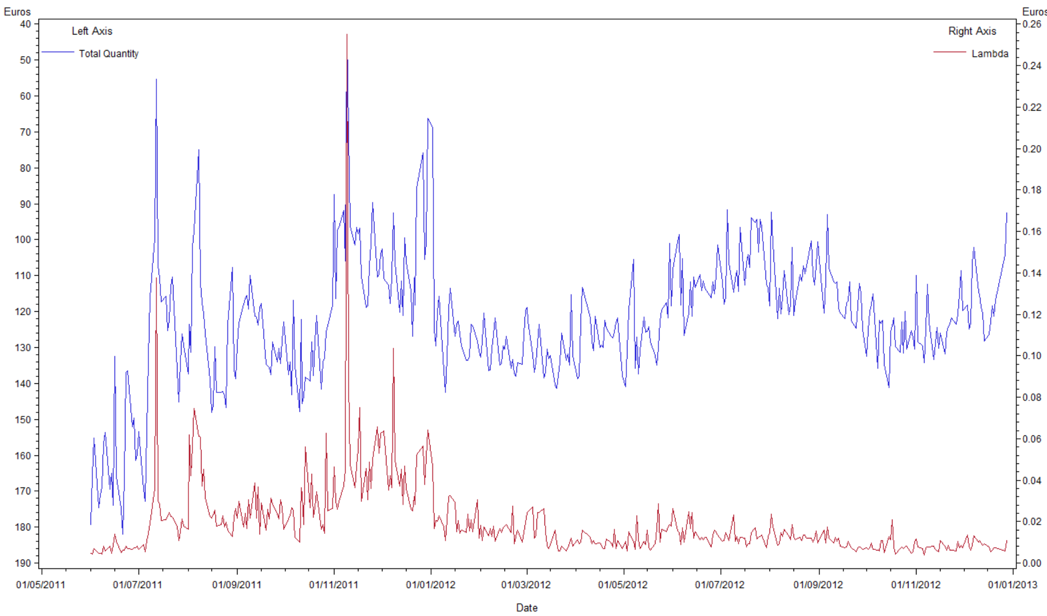
An alternative measure of liquidity used in the previous literature for markets with few quotes and trades is the volume traded on the market, or, alternatively, the number of daily transactions. Figure Int.13 shows the total number of *Trades* and the trading *Volume* (in billions of euros) exchanged on the MTS. It is evident that these two variables share a strong commonality in movement and a clear cyclical pattern. We reckon that the peaks coincide with auctions of new bonds, the reopening of previous issues, and the releases of relevant economic variables and events, over time. In contrast to the previous literature, we find a very low correlation between changes in *Trades* (*Volume*) and the *Bid-Ask Spread* of about -11% (-13%). Since the *Bid-Ask Spread* correlates highly with other market liquidity measures and not with the *Volume*, we conclude that *Trades* and the trading *Volume* in the Italian sovereign bond market are mostly driven by factors other than market liquidity and, therefore, act as a poor proxy for it.

Table Int.9: **Time-series Correlations of Trade- and Quote-based Liquidity Measures.** This table shows the time-series correlations between the bid-ask spread and the liquidity measures defined in Section Int.8 in levels (differences) above (below) the diagonal. The sample consists of the quotes and trades from 406 days in our sample. *Bid-Ask Spread* is the difference between the best bid and the best ask, *Effective Spread* is the effective bid-ask spread paid by the traders, *Quoted Quantity* is the face value quantity offered on average per bond on the bid and ask side in millions of euros, *Lambda* is a measure of depth. Our bond-based data, obtained from the Mercato dei Titoli di Stato (MTS), consist of transactions, quotes, and orders for all 152 fixed-rate and floating Italian sovereign bonds (Buoni Ordinari del Tesoro (BOT) or Treasury bills, Certificato del Tesoro Zero-coupon (CTZ) or zero-coupon bonds, Certificati di Credito del Tesoro (CCT) or floating notes, and Buoni del Tesoro Poliennali (BTP) or fixed-income Treasury bonds) from June 1, 2011 to December 31, 2012.

Differences\Levels	Bid-Ask Spread	Quoted Quantity	Lambda	Effective Spread
Bid-Ask Spread	1.000	-0.591	0.904	0.890
Quoted Quantity	-0.600	1.000	-0.496	-0.557
Lambda	0.437	-0.402	1.000	0.789
Effective Spread	0.512	-0.508	0.240	1.000



(a) Quoted and Effective Bid-Ask Spread



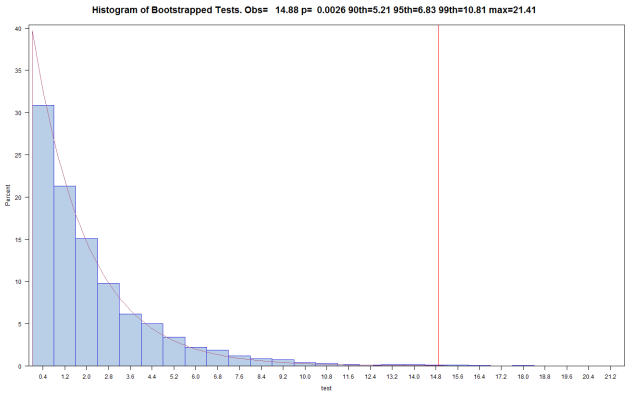
(b) Quoted Quantity and Lambda

Figure Int.11: **Time-Series of Liquidity Measures.** Panel (a) shows the time-series evolution of the *Quoted* (in blue) and *Effective* (in red) *Bid-Ask Spread*, while Panel (b) shows the depth measure *Lambda* (in red) and *Quoted Quantity* (in blue). Our liquidity measures are described in detail in Section Int.8. Our data set consists of transactions, quotes, and orders for all 152 fixed-rate and floating Italian sovereign bonds (Buoni Ordinari del Tesoro (BOT) or Treasury bills, Certificato del Tesoro Zero-coupon (CTZ) or zero-coupon bonds, Certificati di Credito del Tesoro (CCT) or floating notes, and Buoni del Tesoro Poliennali (BTP) or fixed-income Treasury bonds) from June 1, 2011 to December 31, 2012.

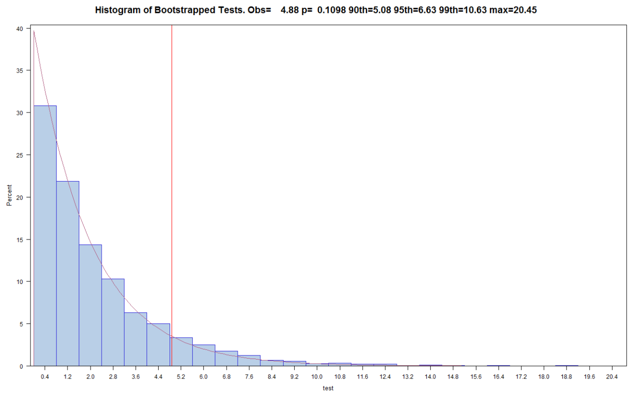
Table Int.10: **Other Liquidity Variables: Results for Subsamples Based on Time and CDS Level.** This table presents the results for the regression of the changes in several liquidity measures on their lagged terms, and the change in the CDS spread on day t, ΔCDS_t, and its lagged terms, and contemporaneous changes in macro variables, using daily data. Panel A(C) reports the regressions as specified in Equation (5) for the whole (post-structural-break) sample and Panel B reports the regressions as specified in Equation (6). The alternative liquidity measures employed here are *Quoted Quantity* ΔQQ_t, *Effective Spread* ΔES_t, and *Lambda* $\Delta\lambda_t$, described in Section Int.8. Parameters multiplying the identity operator $[CDS \leq (>)500]$ are reported under the $[CDS \leq (>)500]$ column. The statistical significance refers to heteroskedasticity-robust t-tests. The Test column reports the heteroskedasticity-robust test results for the two parameters above and below the threshold being equal and distributed as chi-square (1). The subsamples are based on our data set, which consists of 406 days of trading in Italian sovereign bonds, from July 1, 2010 to December 31, 2012, and was obtained from the MTS (Mercato dei Titoli di Stato) Global Market bond trading system. The CDS spread refers to a USD-denominated, five-year CDS spread and macro variables were obtained from Bloomberg.

Variable	Panel A	Panel B: 2011			Panel C: 2012
	All Sample	$I[CDS \leq \hat{\gamma}]$	$I[CDS > \hat{\gamma}]$	Test	
		Dependent Variable: Quoted Quantity, QQ_t			
ΔCDS_t	-0.077	0.245	-1.367***	9.06***	-0.203
ΔCDS_{t-1}	-0.265	-0.676**	0.709*	7.31***	-0.036
ΔQQ_{t-1}	-0.330***	-0.232*			-0.393***
ΔQQ_{t-2}	-0.309***	-0.125			-0.479***
ΔQQ_{t-3}	-0.201***	-0.131*			-0.289***
$\Delta CCBSS_t$	-0.098	0.002			-0.270*
$\Delta USVIX_t$	-0.280***	-0.438***			0.022
Intercept	-0.000	0.001			-0.004
Adj. R^2	0.191	0.279			0.255
		Dependent Variable: Effective Spread, ES_t			
ΔCDS_t	0.851**	0.679	3.291***	5.19**	0.649
ΔCDS_{t-1}	0.526	0.973*	0.528	0.13	-0.287
ΔES_{t-1}	-0.427***	-0.219***			-0.598***
ΔES_{t-2}	-0.320***	-0.217***			-0.458***
ΔES_{t-3}	-0.224***	-0.218***			-0.283***
$\Delta CCBSS_t$	0.393	-0.002			0.719
$\Delta USVIX_t$	0.383*	0.521**			0.142
Intercept	-0.002	0.001			-0.008
Adj. R^2	0.221	0.204			0.302
		Dependent Variable: Lambda, λ_t			
ΔCDS_t	0.120	-0.254	5.207***	8.58***	-0.352
ΔCDS_{t-1}	1.276**	2.781**	-0.871	6.42**	0.157
$\Delta\lambda_{t-1}$	-0.535***	-0.453***			-0.574***
$\Delta\lambda_{t-2}$	-0.285***	-0.125*			-0.357***
$\Delta\lambda_{t-3}$	-0.241***	-0.181**			-0.303***
$\Delta CCBSS_t$	0.673*	0.160			1.473**
$\Delta USVIX_t$	0.228	0.318			-0.303
Intercept	0.000	0.003			-0.003
Adj. R^2	0.257	0.307			0.272

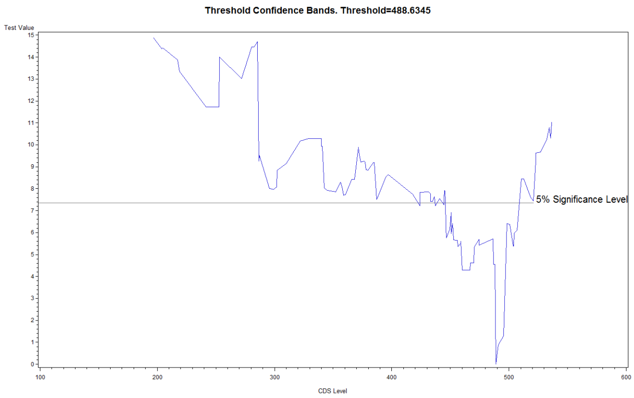
* Significant at a 10% level. ** Significant at a 5% level. *** Significant at a 1% level.



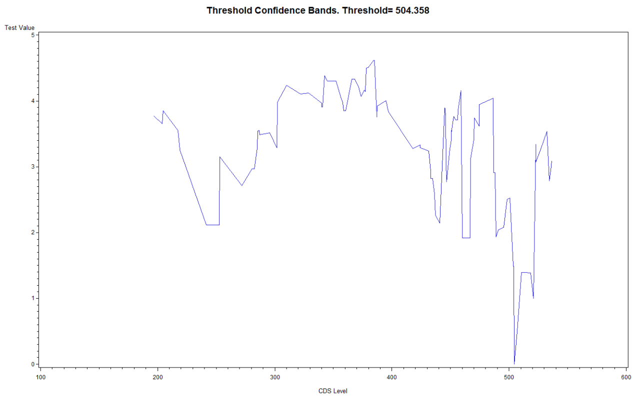
(a) Quoted Quantity: Threshold Presence Test



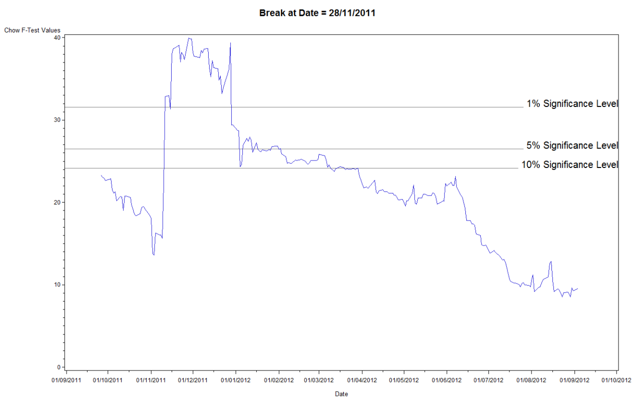
(b) Effective Spread: Threshold Presence Test



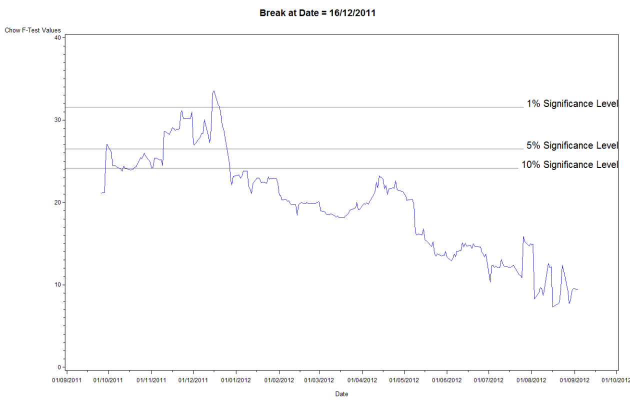
(c) Quoted Quantity: Threshold Confidence Bands Determination



(d) Effective Spread: Threshold Confidence Bands Determination

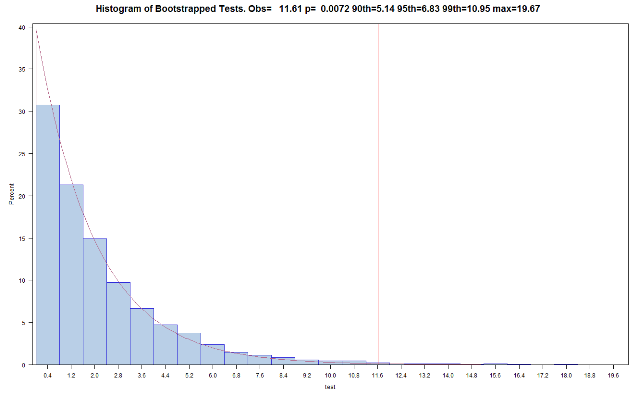


(e) Quoted Quantity: Structural Break

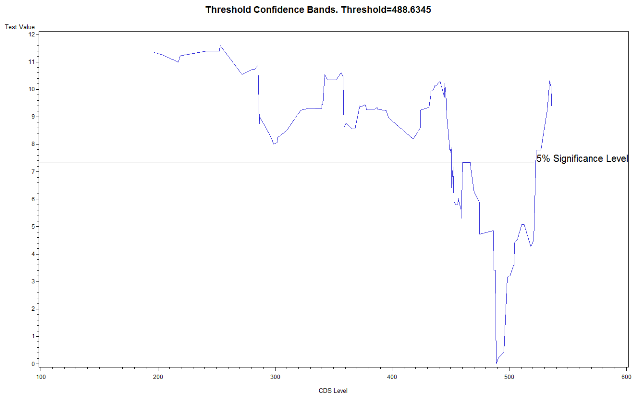


(f) Effective Spread: Structural Break

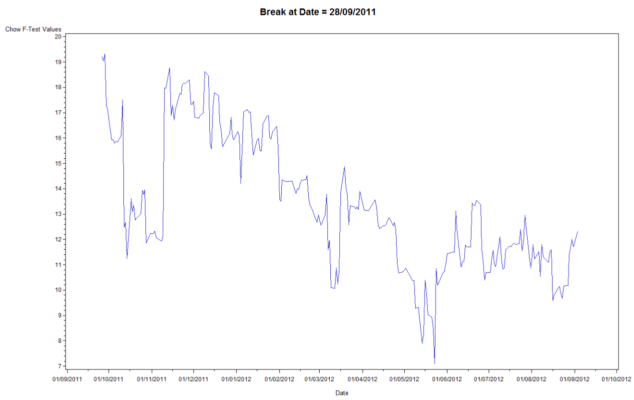
Figure Int.12: **Bootstrapped Threshold Significance Test Distribution and Confidence Bands Determination for the 2011 Subsample and Structural Break Test for Alternative Liquidity Measures.** We bootstrapped the distribution of the test for the presence of a threshold and plot it in Panels (a), (b), and (g) for the 2011 subsamples, for Equation (6) performed using *Quoted Quantity*, *Effective Spread*, and *Lambda*, respectively, instead of *Quoted Spread* as the liquidity measure. The vertical red lines mark the observed test values, while the curve superimposed on the empirical distribution is a chi-square distribution with as many degrees of freedom as there are parameters that are allowed to change in the specification, for reference. [Continued]



(g) Lambda: Threshold Presence Test



(h) Lambda: Threshold Confidence Bands Determination



(i) Lambda: Structural Break

Figure Int.12: **Bootstrapped Threshold Significance Test Distribution and Confidence Bands Determination for the 2011 Subsample and Structural Break Test for Alternative Liquidity Measures.** [Continued] The test statistic described in Appendix B is plotted here in Panels (c), (d), and (h) for the 2011 subsamples for Equation (6) performed using *Quoted Quantity*, *Effective Spread*, and *Lambda*, respectively, instead of *Bid-Ask Spread* as the liquidity measure. The test statistic is normalized at 0 at the threshold that minimizes the sum of squared residuals. The horizontal line at 7.35 marks the 5% confidence values for the threshold. Panels (e), (f), and (i) present the structural break for Equation (6) performed using *Quoted Quantity*, *Effective Spread*, and *Lambda*, respectively, instead of *Bid-Ask Spread* as the liquidity measure. The horizontal lines mark the 10%, 5%, and 1% significance levels for the largest of the Chow F-values.

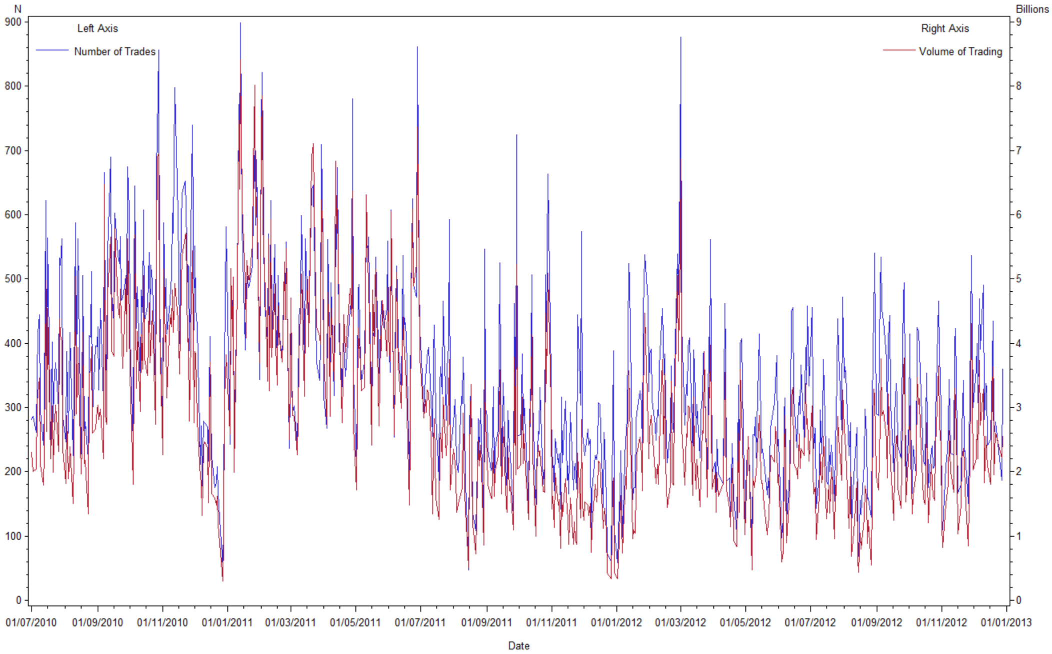


Figure Int.13: **Time-Series of Trades and Volume.** The time-series evolution of the overall market volume, right-hand axis (in red), in billions of euro, and the overall number of trades, left-hand axis (in blue). Our data set consists of transactions, quotes, and orders for all 189 fixed-rate and floating Italian sovereign bonds (Buoni Ordinari del Tesoro (BOT) or Treasury bills, Certificato del Tesoro Zero-coupon (CTZ) or zero-coupon bonds, Certificati di Credito del Tesoro (CCT) or floating notes, and Buoni del Tesoro Poliennali (BTP) or fixed-income Treasury bonds) from July 1, 2010 to December 31, 2012.

References