Systemic Risk in Clearing Houses:

Evidence from the European Repo Market

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July 12, 2014

Abstract

We examine whether the Centralized-Counterparty Clearinghouse (CCP) behind the General Collateral (GC) repos traded on two large repurchase agreement (repo) platforms potentially suffered from systemic risk during the European sovereign debt crisis in 2008-2011. We find that GC repo rates respond to movements in sovereign risk, in particular at the peak of the crisis in 2011 and in GIIPS countries. This is surprising given that our data are from the safest segment of the European repo market, in which the CCP assumes counterparty default risk. We document that in 2011 the repo market behaved as if the probability of CCP default (conditional on sovereign default) was very large, and did not react to increases in haircuts. The ECB's 36-month long-term refinancing operation of December 2011 alone was able to disconnect the CCP from the sovereign crisis. Overall, our evidence is consistent with CCPs providing some protection in periods of intermediate sovereign stress (2009-2010), but being ineffective at the peak of the sovereign crisis (2011). Our findings have important implications for the increasing role that CCPs, many of which are interconnected, are required to play under the European Market Infrastructure Reform (EMIR) and the Dodd-Frank Act in the USA.

JEL classifications: E58, E43, G01, G21

Keywords: repurchase agreement; sovereign debt crisis; LTRO; secured money market lending

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* All authors are from the Finance Department of HEC Paris. We acknowledge financial support from the Investissements d'Avenir Labex (ANR-11-IDEX-0003/Labex Ecodec/ANR-11-LABX-0047). We would like to thank Harry Huizinga, Stefan Nagel, as well as participants at the First HEC-Princeton Finance Conference and the third Bank of Canada / Banco de España workshop on international financial markets for their comments and suggestions. All remaining errors are our own.

1. Introduction

Central (Clearing) Counterparties (CCPs), also known as “clearing houses”, are a fundamental component of the post-trade infrastructure of modern financial markets. In normal times CCPs eliminate counterparty risk by inserting themselves between the buyer and the seller of an agreed-upon trade and by becoming the counterparty for either side. They do so in exchange of imposing a collateral-specific haircut, a contribution to their “default fund”, and concentration limits. Clearing houses permit anonymous trading in the market and increase efficiency of trading through multi-lateral settling among participating institutions. Moreover they allow mutualization of idiosyncratic risks through default fund coverage and reliance on the member institutions for an orderly wind-down of positions in case of a member failing (BIS-IOSC, 2012). As such CCPs can help increase financial stability.

However, limited historical evidence suggests that clearing houses may not always mitigate systemic risk (White, 2007).[2] In fact, in the wake of the recent financial crisis, regulators are concerned that CCPs are themselves becoming “too-big-to-fail” institutions that might require bailouts. This is because CCPs concentrate the clearing of trades among large dealers and mutualization may spread risks among members and markets (Coeuré, 29 March, 2014). This is all the more so as many markets are interconnected because they rely on the same clearing house company or because different CCPs are interconnected among themselves (e.g., BIS-OISCO, March 2004, p. 35).[3] Finally, their number (currently 17 in the EU) and size are likely to increase under the G20 initiated regulatory push to move the trading of standardized derivatives from Over The Counter (OTC) markets to electronic trading

[2] Recent clearing house failures were limited to futures exchanges (Parisian Caisse de Liquidation in 1974, Kuala Lumpur Commodities Clearing House in 1983, and Hong Kong Futures Exchange Clearing House in 1984). Recent near-failures of CCPs involve the Chicago Mercantile Exchange and Chicago Board of Options Exchange’s Option Clearing Corporation after the October 1987 crash (Kiff et al., 2010, p. 108-109).

[3] For example, LCH.Clearnet that is the clearinghouse company in the repo markets that we consider also provides clearing services in CDS, commodities, equities, government bonds, interest rate swaps, and foreign exchange, among others.

platforms backed-up by clearing houses.[4] In spite of the importance of CCPs, little is known empirically about how they are affected in times of a financial crisis. The goal of this paper is to contribute to this line of research by examining CCP-cleared European repurchase agreement (repo) transactions.

More specifically, we examine whether the CCP behind two of the three largest electronic platforms for the European repo market was subjected to systemic risk during the European sovereign debt crisis of 2008-2012. In this market, sovereign bonds are used as collateral to obtain interbank liquidity via repo transactions. This collateralized interbank lending market, which has become very large in recent years (with a daily volume of about €400bn in the Eurozone for instance according to the 2013's ECB money market survey), is crucial for the mutualization of liquidity shocks across banks. When sovereign crises arise, government bonds become worse collateral. This can affect the borrowing conditions on the repo market, which in turn may reduce interbank liquidity and weaken the banking system, as in Martin, Skeie and Von Thadden (2014).

To examine the impact of the European sovereign debt crisis on the European repo market through the build-up of stresses in a major CCP, we focus on a large segment of this market, i.e., one-day repos that use sovereign debt as the underlying General Collateral (GC), that are matched anonymously via an electronic trading platform, and that are settled on the same clearing house. Because they are CCP-cleared, these collateralized transactions should be immunized against risk fluctuations of the underlying assets – in our case, sovereign debts from different European countries. This is our null hypothesis, which we test for EZ countries that vary in the intensity of their sovereign crisis, and for different levels of sovereign stress. In a nutshell, our findings are consistent with the CCP-cleared repo market being immune

[4] Both European Market Infrastructure Reform (EMIR) that came into effect on August 16, 2012 and Title VII of the 2010 Dodd-Frank Act in the USA have specific provisions that require that the trading of standardized OTC derivatives be done through exchanges or clearing houses.

against sovereign stress when this stress is moderate. In times of extreme sovereign stress, however, repo market participants appear to factor-in the higher probability of CCP default conditional on sovereign default into their repo pricing. Remarkably, the significant increases in CCP-imposed collateral-specific haircuts have no impact on the repo market.

Our data come from two of the largest repo trading platforms (BrokerTec and MTS), which account for a daily volume of about €50bn. These data are particularly suitable for studying the interbank repo market. First, since the financial crisis CCP cleared transactions are becoming an increasing part of all repo transactions, to reach 70% of the total in 2012 (Figure 1). Second, because the underlying collateral can be one of the many country-specific treasury issues allowed in the underlying basket, GC repos are only motivated by cash lending and borrowing, not by securities lending.[5] Third, all participants in this market are investment and commercial banks. Fourth, the participants in the automated trading systems (ATS) that we consider remain anonymous. Finally, BrokerTec and MTS repo trading platforms rely on the same clearing house group: LCH.Clearnet. Overall, our data account for a large fraction of the European interbank repo market. Our €50bn daily volume needs to be compared with a total volume of European interbank repos of about €250bn, out of which approximately €120bn is CCP-cleared (Figure 2).[6]

[Insert Figures 1 and 2 here.]

We first provide a simple framework to outline the connection between repo rates and country CDS spreads, which we use to proxy for the intensity of sovereign stress. The framework highlights the key role of haircuts, counterparty default risk, and CCP default to explain the repo rate-to-CDS spread sensitivity. Consistent with such a framework, we find a

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[5] As opposed to "special" repos, whose motivation is the borrowing of a particular security, typically to manage dealer inventories or to obtain a short position.

[6] The interbank market is mostly constituted of secured (i.e. repo, bilateral or trilateral) transactions. By comparison, the average daily volume on the unsecured interbank market is €60bn (ECB Money Market Study, 2012).

strong positive relation between the CDS spreads of sovereign debt issued by European countries and the rates of repo transactions using the same sovereign debt as collateral. This relation is the strongest at the peak of the sovereign debt crisis in the Eurozone, in 2011, and is concentrated in the countries that were affected the most by the crisis, namely, GIIPS countries (Greece, Ireland, Italy, Portugal and Spain). The same relation does not exist for "safe haven" countries such as Germany, or in times of moderate sovereign stress, in 2009 and 2010. We find a similar negative connection, albeit weaker, between repo volume and CDS spreads.

Next, we ask why sovereign stress spread to the interbank repo market in spite of the protection offered by the CCP. We provide several pieces of evidence consistent with the view that market participants perceived this protection as effective in 2009 and 2010, but not at the peak of the sovereign crisis, in 2011. First, we find that in 2011, the haircut policy of the CCP was unable to stabilize the market. When the collateral becomes riskier, the CCP can raise the haircut to reduce the riskiness of the repo transaction (Jurek and Stafford, 2013). To evaluate the effectiveness of such policies, we run event studies around large changes in haircuts. We find that in 2011, haircut changes have no effect on the relation between sovereign CDS spreads and repo rates. Second, we try to disentangle the effects of counterparty default risk and perceived CCP-failure risk on the repo rate-to-CDS spread sensitivity. We estimate counterparty default risk by regressing bank CDS spreads on sovereign CDS spreads. We find that our estimated counterparty default risk is not high enough in 2011 to explain the repo-to-CDS spread sensitivity. This suggests that in 2011, which corresponds to the peak of the sovereign crisis in the Eurozone, investors behaved as if the CCP did not offer any protection against counterparty default. This is consistent with higher perceived risks concerning CCPs mentioned above.

Finally, we look at the effectiveness of monetary policy to restore normality on the repo market. We investigate the effects of the various interventions of the European Central Bank (ECB). We find that only the 36-month Long-Term Refinancing Operations (LTROs) of December 2011 was effective at disconnecting repo markets from sovereign risk.

Our paper contributes to several literatures. First, it is related to papers linking the structure of interbank markets to their resilience in crisis times. Gai, Haldane, and Kapadi (2011) provide an analysis of a banking network connected through unsecured interbank and secured repo markets, and show that a small shock to the restricted set of financial assets that serve as collateral can lead to a collapse of unsecured and secured interbank markets. Acemoglu, Ozdaglar, and Tahbaz-Salehi (2013) study the resilience of financial systems to counterparty risk. They show that dense banking networks are good at absorbing moderate shocks but are vulnerable to larger shocks. Our finding that the CCP structure was successful at insulating the repo market from the sovereign crisis in 2009-2010, when the crisis was moderate, but not in 2011, when it reached its peak, is consistent with this view. Menkveld (2014 a, b) analyzes the systemic nature of CCPs and discusses risk management techniques that could mitigate this risk. Our paper offers an analysis of a CCP-intermediated market that is very large and crucial for the funding of European banks, and that is subjected to significant stress on its collateral, namely, European sovereign bonds. In that sense, it also contributes to the literature on the sovereign-bank nexus (Acharya, Dreschler and Schnabl, 2014; Acharya and Steffen, 2013; Gennaioli, Marin and Rossi, 2013), and to the broader literature on interbank markets (Alfonso, Kovner, and Schoar, 2011 on the Fed funds market, or Bech, Klee, and Stebunovs, 2011 on the triparty repo market).

This paper also contributes to the literature on the repo market. Most recent academic studies have focused on the evolution of the US triparty repo market during the 2008-2009 crisis (Gorton and Metrick, 2010; Copeland, Martin and Walker, 2010; and Krishnamurty, Nagel, and Orlov, 2013). The European repo market is different, and interesting, in two dimensions. First, while the US market is dominated by triparty repo (settlement, but not counterparty risk, is managed by a bank), transactions conducted on electronic platforms and cleared via a CCP predominate in Europe (ECB, 2012). Second, the European repo market is central to the conduct of monetary policy, because it is an active interbank market where the ECB intervenes directly via its Main Refinancing Operations (MRO) and its Long Term Refinancing Operations (LTRO). Existing papers on the European repo market have focused on the microstructure of the ECB's main refinancing operations through repo auctions (e.g., Bindseil, Nyborg, and Strebulaev, 2009) and the tensions reflected therein occurring in 2008 after the Lehman collapse (Cassola, Hortaçsu, and Kastl, 2013). Dunne, Fleming and Zholos (2011 and 2013) use ICAP BrokerTec transactions (microstructure) data to examine the linkages between ECB monetary policy (through its repo auctions) and interbank repo lending, as reflected in the funding liquidity risk. Hördahl and King (2008) compare how the US, UK and European repo markets behaved during 2007-2008. The closest paper to ours is the one by Mancini, Ranaldo and Wrampelmeyer (2014), who primarily look at a different segment of the European market that relies on a different CCP (Clearstream), in which banks are also active. Their main finding, in apparent contrast to ours, suggests that the repo segment they focus on to be remarkably resilient during the crisis, both in terms of rate and volume. The reason is that their focus is on the GC Pooling (GCP) repo from Eurex, whose underlying basket includes a large list of high quality sovereigns (rated A3/A- or above). Lenders in a GCP repo transaction may receive any bond in this list in exchange of their cash, which explains the resilience of this segment during the crisis. Mancini, Ranaldo and Wrampelmeyer (2014) also examine all comprehensive (GC plus specials) value-weighted repo rate and total repo volume indexes for Germany, France and Italy from ICAP and MTS. They find that French and Italian repo markets were less resilient during the crisis, something which they believe is linked with the quality of the underlying collateral. We also find that for high quality sovereigns (non-GIIPS) the repo rates are insensitive to country CDS and that the sensitivity is only present for GIIPS GC repos. However, in contrast to Mancini, Ranaldo and Wrampelmeyer (2014), our focus is on (i) the perceived CCP default risk as reflected in the repo market, (ii) the potential role of CCP-imposed haircut increases, and (iii) the impact of ECB's unorthodox monetary policy intervention on the secured lending market.

In its analysis of the ECB's monetary intervention to stabilize the repo market, our paper also contributes to the literature on non-conventional monetary policy, which is still in its infancy. Krishnamurthy and Vissing-Jorgensen (2011) analyze the reaction of various asset prices to QE announcement by the Federal Reserve. Their conclusion is that QE can have a persistent effect on asset prices. Freixas, Martin and Skeie (2011) propose a model where central bank liquidity provision in times of crisis is necessary to induce optimal bank liquidity choices. Finally, Krishnamurthy, Nagel, and Vissing-Jorgensen (2013) find that ECB's bond purchases significantly reduced the default risk of Italian, Spanish, and Portuguese government debt. Our study is closer to their analysis, as our empirical results show how central bank can restore some normal conditions on a dislocated repo market. In contrast to, Krishnamurthy, Nagel, and Vissing-Jorgensen (2013), who find that 36-month LTROs had little effect, we find that 36-month LTROs were needed to remove stress from the repo market.

The paper proceeds as follows. Section 2 details our data sources and the variables used in our analysis. We present our results in Section 3. Section 4 discusses our findings and concludes.

2. Institutional background and data

2.1. Institutional background

The repo market has three different segments: OTC bilateral, tri-party repos, and CCP-cleared. On the OTC market, both parties bear the counterparty risk and set the haircuts. Tri-party repos are operations in which a private bank organizes the settlement of the operations, but does not bear the counterparty risk. CCP-cleared repos are transactions in which a clearinghouse bears the counterparty risk and therefore sets the haircut centrally. Among all of these transactions, some are intermediated via broker-dealers, and some are intermediated via anonymous electronic platforms. These platforms are typically - but not necessarily - connected to a clearinghouse, which arranges the settlement of the transaction, and bears the counterparty risk. Finally, repos are typically classified into "General Collateral" (GC) and "special". GC repos are loans whose collateral belongs to a certain predetermined list. GC repos are mostly motivated by the need to borrow cash. "Special" repos are loans against a specific collateral (e.g., "Italian fixed rate bond maturing in 2017"). These transactions are often motivated by the desire to sell short a specific security, in order to arbitrage the yield curve or manage an inventory.

Along these dimensions, the US and the European repo markets differ widely. As of May 2012, the US repo market is estimated to be $3.04 trillion (€2.35 trillion), of which 53% is triparty-, 32% bilateral-, and only 15% are GC-repos (Copeland, et al., 2012). The Eurozone repo market is estimated to be €5.6 trillion as of June 2012 (based on a survey of 62 large banks by ICMA), but it differs significantly in its composition: as of 2012, approximately 56% of the market consists of transactions conducted on electronic platforms offering clearing services via a CCP, 33% of bilateral (non-CCP) transactions, and only roughly 11% of triparty repos (according to a survey of 105 banks by the ECB, Euro Money

Market Study, 2012). Focusing on the European repo market allows us to explore the benefits of having a centrally cleared market in times of collateral (in this case, sovereign) stress. Another important difference between the European and the US markets is that banks are very active in repo markets in Europe, while the US repo market mostly serves to finance the shadow banking system (see Krishnamurthy, Nagel, and Orlov, 2013 for the US; and Mancini, Ranaldo and Wrampelmeyer, 2014 for Europe).

In this paper, we focus on GC, electronically matched, and CCP-cleared repos. This ensures that we really focus on an interbank market driven by funding needs. The CCP structure should in principle insulate this market from movements in collateral values and counterparty risk.

2.2. Data

2.2.1. Repo rate and trading volume data

Our data come from two large electronic platforms and cover the period from January 1st, 2008 to June 30, 2012. The bulk of our repo rate and volume data are from ICAP BrokerTec, a multi-lateral electronic repo (and government bond) trading platform. For Italian GC, we rely on data from MTS Repo, which is the main electronic repo platform for institutions of that country. LCH.Clearnet group provides clearing house services to ICAP BrokerTec and MTS Repo. For both platforms, we obtain, for all GC repo transactions broken down by country and maturity, daily repo rates and daily volumes.

In this study, we restrict ourselves to one-day GC repo transactions.[7] GC repos are motivated by the need of cash of the security lender. The security lender (typically, a bank looking for short-term funding) is allowed to provide any collateral in the GC list, which is

[7] There are no maintenance margins for 1-day repos, for which only the initial haircuts matter. Moreover, in one-day repos the uncertainty regarding default premium of the underlying sovereign bond is also reduced to a minimum (compared to, say, 1- or 3-month repos).

considered to be safe enough to warrant cash lending at the repo rate. On the contrary, "special repos", which specify exactly the security that serves as collateral, are typically transactions in which the cash lender wants to short a specific security (for speculation or inventory management). Hence, focusing on GC repo allows us to narrow the focus of our study on the interbank market. In terms of maturity, we restrict our analysis to one-day repo transactions, which represent about 97% of total volume in our data. These one-day transactions are denoted as "overnight", "tomorrow next" and "spot next" depending on the day of delivery. Our daily country-level repo rate ($REPO\_RATE_{c,t}$) is the volume-weighted average of these three rates. The GC volume ($REPO\_VOLUME_{c,t}$) is the daily sum of all one-day repo rates transactions on a given day for a given country. For some of our tests we use haircut data from LCH.Clearnet, which provides clearinghouse services to both ICAP BrokerTec and MTS.

[Insert Figures 3 and 4 here.]

Figure 3 presents the evolution of daily volumes (averaged by month) of repo transactions for two groups of countries: GIIPS countries (Greece, Italy, Ireland, Portugal and Spain), and non-GIIPS countries. The average daily volumes have the same order of magnitude, but the volume of GIIPS repos goes down from about €35bn in 2008-2009 to about €20bn in June 2012. Non-GIIPS repos are stable around €20bn. Figure 4 provides a more detailed breakdown by country. Note that each panel uses a different scale. Panel A reports trading volume for Italy, France and Germany. These three countries are over-represented, but our dataset has transactions with sovereign collateral from 11 different countries. Altogether, the three countries have trading volume of about €30bn per day. Panel B of Figure 4 reports numbers for Austria, Belgium, Spain, Finland and the Netherlands. In this second panel, trading volume is never zero, but it is of smaller scale (approximately €1bn per day, except for Belgium and the Netherlands, which have some €2bn of daily volume).

Panel C shows volume for the three countries that eventually went through a bailout program (Greece, Portugal and Ireland): Their private repo markets shut down entirely as soon as the banks from these countries obtained assistance. We exclude from the sample all observations corresponding to countries under bailout program (after April 2010 for Greece, November 2010 for Ireland and April 2011 for Portugal).

We do not have the universe of the European GC repo market. Next to MTS and BrokerTec, there are two other large trading platforms in Europe, which also offer CCP services: Eurex Repo in Germany and MEFF, which is focused on Spanish institutions (each of which has its own clearing house). Mancini, Ranaldo and Wrampelmeyer (2014) use data from Eurex Repo, and focus on a different type of collateral ("GC Pooling"). Trading volume in their data (about €50bn daily) is about the same size as ours (Figure 2). The crucial difference is that their GCP lumps together all sovereigns graded above A3/A-, while our GC repos are not pooled: Each country has a separate one. On our market, there are stronger linkages between government debt and the repo rate. On the GCP market, there is a risk (which apparently did not materialize during the period they study) that the market gets flooded with relatively low quality collateral in times of stress since lenders are not allowed to differentiate - or even observe - the collateral they receive.

2.2.2. Sovereign and bank risk data

We match our repo data with each country's daily credit default swap rates from Datastream database using the five-year senior CDS series ("sovereign CDS" in our tables). We also calculate counterparty risk for all banks in a given country using the simple average of (five-year) individual bank senior CDS rates to the extent they are available on Datastream. Our use of the country average CDS reflects both a data constraint and an institutional feature of the market. Our data are not on a trade-by-trade basis and therefore do not contain the identity of the two counterparties. But since trading on BrokerTec and MTS repo markets is anonymous, the informational advantage of traders compared to the econometrician is likely to be modest.

2.3. The unfolding of the Euro crisis in our data

This section provides a short description of the data and preliminary evidence that the repo market was connected with the developments of the European sovereign crisis.

[Insert Figure 5 here.]

We report in Figure 5 the repo rates of GIIPS and non-GIIPS transactions over the period that we study (2008-mid 2012). For comparison purpose, we also reproduce the ECB rate corridor (the deposit rate, which is the lower bound, and the lending facility rate, which is the upper bound). In normal times, the repo rate follows the main ECB policy rate, because the ECB's interventions (Main Refinancing Operations (MROs)) are auctions with partial allotment whose goal was to align the repo rate with the main policy rate (see Cassola, Hortaçsu, and Kastl, 2013, for a description). After October 2008, the ECB greatly expands the size of its interventions (auctions change from partial to full allotment), so that the repo rate converges quickly to the deposit rate (Mancini, Ranaldo, and Wrampelmeyer, 2014). In mid-2010, the Greek sovereign crisis becomes more acute, and all repo rates increase again, up to 50bp above the ECB deposit rate although the ECB does not scale down the size of its MROs. In the summer of 2011, the sovereign crisis spreads to Italy and Spain, and the repo market separates two groups of sovereigns. GIIPS repos remain 50bp higher than the deposit rate, while non-GIIPS repos fall. This situation lasts for about half a year, until the 36-month LTRO of December 2012 realigns the two rates with the lower bound of the corridor.[8] Over

[8] Until early 2008, the ECB regularly conducted 3-month LTROs. To improve banks' liquidity in the face of the worsening sovereign debt crisis, the ECB introduced 6-month LTROs in March 2008 and 12-month LTROs in July 2009. The December 2011 36-month LTRO differs from its predecessors by its size (€489bn as opposed to €25bn for 12-month LTROs of 2009) and maturity (36-months as opposed to 3- to 12-months previously). It should be noted that December 11, 2011 LTRO announcement also included information on the second 36-month LTRO of February 2012.

the entire period, the average repo rate is not stationary (the Dickey-Fuller test fails to reject the unit root hypothesis at 89%). In our empirical analysis, we deal with this issue by focusing on several subperiods (2008-Lehman, 2009-2010, 2011, 2012H1) during which the repo rate is stationary. During all of these subperiods except the first one, Dickey-Fuller statistics clearly reject the unit root hypothesis, and the time series show no statistically significant trend. In addition, in all of our specifications we use the difference between the repo rate and the ECB deposit rate (see below). This difference is theoretically motivated (see our next section), and is stationary both within each subperiod and over the entire period.

[Insert Figure 6 here.]

Figure 6 displays the evolution of average sovereign CDS spreads of GIIPS and non-GIIPS countries. In line with the evolution of the repo market, CDS spreads for the two groups of countries move very closely until the Greek crisis erupts in the beginning of 2010. The two groups start to drift apart but the difference remains moderate until the spring of 2011 (when Portugal officially requires assistance to fund its sovereign borrowing). Between mid-2011 and the end of 2011, GIIPS CDS spreads increase from 5 to 25%, while non-GIIPS CDS are flat. This sharp divergence accompanies our evidence from the repo market, in which we also observe a divergence between GIIPS and non-GIIPS countries over the same period.

[Insert Figure 7 here.]

Aggregate variables may, however, be misleading. In Figure 7, we report the correlation between the average repo rate and the average CDS spread. We take the difference between the repo rate and the ECB deposit rate to make the series stationary. We then compute the average sovereign CDS spread and the average adjusted repo rate, each day, across all 11 countries in our sample. We obtain a time series of 1,124 daily observations, which we plot in Figure 7. We find that the time-series relationship between repo rates and sovereign risk is actually negative and statistically significant (in particular in 2009 and 2011). Hence, aggregate repo rates do not seem to react to sovereign stress. If anything, they react negatively, i.e., repo borrowing becomes cheaper in times of stress. Such a finding is consistent with Mancini, Ranaldo, and Wrampelmeyer (2014), who find that overall the European repo market is unaffected by the sovereign crisis in the Eurozone. The goal of the present paper is to exploit the country-by-country variation to refine the test. As it turns out, we find a sharp contrast between the reactions of repo markets to the Eurozone sovereign crisis in GIIPS vs. non-GIIPS countries. Our conceptual framework suggests a channel that is consistent with these results: during periods of significant sovereign stress, the probability of CCP insolvency (conditional on counterparty and sovereign defaults) increases. This is a highly plausible scenario given that the CCP (LCH.Clearnet Ltd.) behind one of the platforms that we consider (BrokerTec) has a default fund of roughly €0.9bn and equity capital (book value) of only €0.013bn. In contrast the daily repo volume in the markets we consider was approximately €50bn, roughly 60% of which was with GIIPS sovereign debt, resulting in a cushion of 3% of daily volume.

[Insert Table 1 here.]

Table 1 reports summary statistics of the main variables used in subsequent tests and described above for the entire sample period (January 2008 to June 2012) and for the four subperiods we consider in the tests: “Normal times” (January 2008 to Lehman Brothers’ bankruptcy on September 15, 2008); “Sovereign stress times” (January 2009 to December 2010); “Sovereign crisis times” (January 2011 to the day before the 36-month LTRO on December 20, 2011); and “post-LTRO period” (January to June 2012).

3. Explaining repo rates: A conceptual framework

To analyze the pricing of repo loans, we start from a stylized risk-neutral no-arbitrage model. Assume that lenders arbitrage between overnight lending on the repo market at r^{REPO} and lending with no risk to the ECB at the deposit rate r^{ECB}. Repo lending of 1€ is collateralized with 1/(1-h) € of sovereign bonds, where h is the haircut. The sovereign bond defaults with probability π.

We make the simplifying assumption that, in the absence of sovereign default, the repo loan is essentially risk-free. This assumption can be justified as follows: When both the borrower and the CCP default, the repo lender obtains the bond.[9] In the absence of sovereign default, the lender is made whole as long as daily fluctuations of the bond price are below the haircut. We assume that the haircut policy is set conservatively enough. In case of sovereign default however, the loss given default is distributed between 0 and 1 according to a function of c.d.f. F(.). Conditional on sovereign default, the expected LGD is thus $\int_h^1 (x-h)dF(x) = G(h)$. G(.) is a decreasing function of h: Bigger haircuts allow to minimize the loss in case of default.

Denote p the probability, *conditional* on sovereign default, that the counterparty defaults. This probability p can be estimated for instance by regressing bank CDS spreads on sovereign CDS spreads as in Acharya, Dreschler and Schnabl (2014); we do this Table 7. Finally, we denote λ the probability that the CCP defaults, *conditional* on both counterparty

[9] During our period of study there were no clear Europe-wide standardized recovery or resolution procedures to follow if a European CCP's "waterfall" provisions do not suffice to absorb losses generated by a clearing house member institution that defaults. Waterfall provisions (e.g., ISDA, 2013; Elliott, 2013) are (in the order of loss absorption after the exhaustion of the previous provision): initial margins posted by the defaulting member (collateral in the form of cash or safe securities), CCP's default fund contribution by the defaulting member, an initial tranche of CCP's capital, CCP's default fund contributions by the other member institutions, additional CCP default fund contributions by non-defaulting member institutions (the so-called "rights of assessment" provision), a secondary (and final) tranche of CCP's capital, imposing haircuts on existing positions of non-defaulting members for orderly resolution.

and sovereign defaults. As in Krishnamurthy, Nagel, and Vissing-Jorgensen (2013) we rely on risk-neutral probabilities rather than the true physical probabilities of default.

Because lenders always have the choice to lend to ECB at the deposit rate, a no-arbitrage condition implies:

$$r^{ECB} = (1\text{-}p\lambda\pi)\ r^{REPO} - p\lambda\pi G(h) \qquad (1)$$

which, after straightforward manipulation and first order approximation, leads to:

$$r^{REPO} = r^{ECB} + (p\lambda G(h)/G(0)).(\pi G(0)) \qquad (2)$$

Equation (2) is a no-arbitrage condition that allows us to think about the pricing of repo lending. It states that the repo rate should be a function of the sovereign's probability of default π. The sovereign CDS spread measures $\pi G(0)$, the probability of default times the loss given default.

This simple framework allows us to interpret the results of our regressions. By regressing the repo rate on sovereign CDS spread, we obtain $p\lambda G(h)/G(0)$, which measures the conditional probabilities of default of the counterparty and the CCP, as well as the LGD given the haircut. This will be our main empirical strategy. Our null hypothesis is that repo rates should not depend on sovereign CDS spreads. This may happen because the CCP never defaults (i.e., λ is small), because counterparty default is unlikely (i.e., p is small), or because haircut policies are very conservative (i.e., h is large enough). In all three cases, the CCP-intermediated repo is a perfectly safe transaction, insulated from sovereign default. Besides clarifying the meaning of our null hypothesis, our framework allows us to tentatively quantify the conditional default probability of the CCP, λ, as we do in our penultimate section.

4. Main results

4.1. Sovereign default risk and repo rates

In the spirit of equation (2) we run the following regression, for country c, at date t:

$$\textit{Repo Rate}_{c,t} - r^{ECB}_{t} = \alpha_c + \delta_t + \delta_{c,m} + \beta.\textit{Sovereign CDS}_{c,t} + \varepsilon_{c,t} \qquad (3)$$

where the LHS variable is the spread between the repo rate on country c and the ECB deposit rate (which is our measure of the safe rate of return here). The coefficient of interest is β, the sensitivity of the repo rate to the sovereign CDS spread. According to the no-arbitrage equation (2), β contains the joint effect of (1) the CCP default conditional default probability, (2) the counterparty conditional default probability, and (3) the haircut policy. Our null hypothesis is that haircuts are conservative even in case of sovereign default, and/or that the CCP is resilient enough to ensure that $\beta=0$.

In our baseline specification, the regression also includes country fixed effects (α_c) and time fixed effects (δ_t) to account for movements in the common factors affecting the European repo market (as those explored in Mancini, Ranaldo and Wrampelmeyer, 2014). We cluster error terms $\varepsilon_{c,t}$ at the daily level, across countries. To make sure we are identifying β on higher frequency comovements of CDS and repo rates, we also report regressions with country-month fixed effects $\delta_{c,m}$. This allows us to force identification on daily variations within month. Finally, note that *Repo Rate*$_{c,t} - r^{ECB}_{t}$ is a stationary variable: The Dickey-Fuller statistic over the entire period is 4.768, which allows us to reject the unit root hypothesis at the 0.01%-level.

[Insert Table 2 here.]

The results appear in Panel A of Table 2. In the first column of Panel A, we consider the entire period (2008 to mid-2012). The link between sovereign CDS spreads over the entire time period and across countries is significantly positive: the coefficient estimate for *Sovereign CDS* is equal to 0.0604 and statistically significant at the 1%-level. Our null hypothesis, that in CCP-cleared transactions repo rates should be insensitive to sovereign risk, is rejected. The effect is economically sizable: a one-standard deviation increase in the sovereign CDS spread (96bp) leads to an average increase of 6 basis points in the repo rate (compared to a sample mean of 33bp and standard deviation of 40bp). Thus, repo markets were pricing in a non-negligible risk of default of the CCP.

We then look at changes in this implicit belief over the period. We split our sample period into the four sub-periods described in Section 2.3: "Normal times", "sovereign stress times", "sovereign crisis times", and "post-36-month-LTRO". In columns 2 to 5 of Panel A in Table 2, we run the same regression as in the first column separately for each of the sub-periods. In "normal times", i.e., before September 15, 2008 (in column 2), the coefficient estimate for *Sovereign CDS* is equal to –0.00613 and is statistically insignificant. In other words, during this first period, the repo market was not stressed. Markets did not expect any CCP or counterparty default.

When the crisis hits, however, the relation between GC-repos and sovereign CDS rates appears, and it becomes stronger, both economically and statistically, when the sovereign debt crisis worsens, in 2011. In "sovereign stress times", the coefficient estimate for *Sovereign CDS* (in column 3) is equal to 0.0140 and is statistically significant at the 1%-level: a one standard-deviation increase in the sovereign CDS rate leads to an average increase of about 1 basis point (=0.0140×76) in the GC-repo rate for all Eurozone countries considered together. The effect is statistically significant but modest economically. In column 4, however, during "sovereign crisis times" (during 2011), a one standard-deviation increase in the sovereign CDS spread has a much bigger impact. It leads to an average increase of about 21 basis points in the repo rate (=0.186×114).

The stress sharply decreases with the implementation of the 36-month LTRO of December 21, 2011. Post-LTRO, during the first six months of 2012, the coefficient estimate for *Sovereign CDS* goes back down to 0.0334 (still statistically significant at the 1% level), suggesting that following LTRO implementation, the stress that had built up in the repo market abated but did not disappear.

To make sure we identify coefficients on high frequency comovement between CDS spreads and repo rates, we replicate the above regressions including country-month fixed effects. This approach allows us to control for slower movements in country-specific risk factors.[10] We report the results in Table 2, Panel B.

In this very demanding specification, the link between GC-repo rates and CDS spreads becomes insignificant in all the columns, except in column 4, in which we examine the "sovereign crisis" period (2011). The coefficient estimate is reduced to 0.0765 but it is still statistically significant at the 5%-level: a one-standard deviation increase in the CDS spread leads to a 9-basis points increase on average for all one-day Eurozone GC-repo rates combined across countries. The coefficient is thus significant, but significantly weaker than in the baseline specification with only market-wide pricing factors. This relative weakness is consistent with the findings of Mancini, Ranaldo, and Wrampelmeyer (2014) who find little pricing of market stress on repo rates. However, as we see in the next section, this finding conceals a large amount of heterogeneity between GIIPS and non-GIIPS countries.

4.2. Counterparty risk and sovereign risk

In our framework, the coefficient β corresponds to $p\lambda G(h)/G(0)$, which represents the joint conditional default of the CCP and the counterparty, as well as the effect of the haircut. In this section, we investigate whether β is the same in GIIPS and non-GIIPS countries. A

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[10] An alternative way to control for such slow movements in country-specific factors is to include time trends in the regressions. Doing so yields the same results as including country-month fixed effects.

difference may arise because the haircut on GIIPS countries, whose bonds are riskier, may be too low (h varies across countries). An alternative interpretation is that p, the conditional counterparty default probability, is higher in GIIPS countries. In other words, even though the platforms we consider are anonymous, hence the counterparty is unknown, the market operators can still infer the nationality of the borrower from the collateral: For instance, a borrower bringing Spanish collateral is more likely to be Spanish, having ran out of higher quality collateral to lend. The platform used also helps to infer the counterparty's nationality: A borrower using MTS is likely to be an Italian bank for instance.

In Table 3, we test whether the sensitivity of repo rates to sovereign risk differs between GIIPS and non-GIIPS countries. We create an indicator variable named *GIIPS*, which is equal to one for countries in the GIIPS category, and zero otherwise. We then add to equation (3) an interaction term *GIIPS×Sovereign CDS*. The coefficient on this interaction term measures the extent to which repo rates are differentially sensitive to sovereign CDS spreads across the two groups of countries.

[Insert Table 3 here.]

We report regression results in Table 3. As before, Panel B includes country-month fixed effects, while panel A does not. Altogether, these results suggest that the positive sensitivity of repo rates to CDS spreads is mostly driven by GIIPS countries. In fact, looking across the two panels, for the entire 2008-2012 period (column 1), this relation is statistically significantly negative for non-GIIPS countries: the coefficient on *Sovereign CDS* (the non-interacted term) is -0.0202 (significant at 1%-level) in Panel A, and -0.0430 (significant at 5%-level) in the more demanding specification of Panel B. This is evidence of flight to quality. When non-GIIPS CDS spreads increase, this indicates general stress on EU sovereigns.[11] In which instance, the CDS spreads of GIIPS countries go up even more, which increases the relative attractiveness of safe haven sovereign debt as collateral. Consistently with this and as expected, the coefficient estimates for the interacted variables *GIIPS×Sovereign CDS* are positive and statistically significant at 1% in column 1 of both panels. When perceived sovereign risk measured by CDS spreads on sovereign debt increases, a divide appears across the repo markets of Eurozone countries: Repo investors escape the repo markets from GIIPS countries and fly to quality, i.e., to the repo markets of the safest countries of the Eurozone. The estimate of Panel B (0.0525) indicates that a 96bp increase in sovereign CDS spreads (a one-standard deviation increase) raises repo rates by some 5bp on average. But this relatively modest effect conceals the fact that the effect was concentrated during the sovereign crisis.

Consistent with our previous findings from Table 2, the relation between sovereign CDS spreads and repo rates becomes more pronounced at the peak of the crisis, as does the divergence between GIIPS and non-GIIPS countries. The coefficients on the two variables *Sovereign CDS* and *GIIPS×Sovereign CDS* are insignificant before November 2008 (column 2). They start diverging in 2009-2010 (column 3), even though they remain insignificant in our most demanding specification (Panel B). At the peak of the crisis (in 2011, column 4), the divergence becomes strongly significant in all specifications. Taking estimates from Panel B, in 2011, a one standard deviation increase in the sovereign CDS spread of GIIPS countries is associated with a 114x0.208=24bp increase in the GC-repo rates of these countries. Consistent with our previous findings, this relation between underlying sovereign-debt risk and short-term GC-repo rates decreases only after the introduction of the first 36-month

[11] This is apparent from Figure 6. Average CDS spreads of GIIPS and non-GIIPS countries comove strongly. Over the entire period that we study, the correlation between the two series is 0.76. In 2011, the peak of the sovereign crisis, it reaches 0.85.

LTRO in December 2012, when the coefficient estimate for the interacted term becomes negative but statistically insignificant (column 5).

4.3. Repo volume and sovereign risk

In this Section, we ask whether sovereign risk affects trading volume on the repo market. To do this, we run variants of equation (3), in which the dependent variable is the daily volume traded instead of the repo rate. We take the logarithm of 1+volume, and remove observations corresponding to missing repo rates. Our results are not sensitive to this convention, and carry through when we incorporate the missing rate observations and assign them a zero volume. Regression results are reported in Tables 4 and 5, which are are structured exactly like Tables 2 and 3 for the ease of reading.

[Insert Table 4 here.]

Table 4 shows that repo volume is, on average across countries, quite sensitive to local sovereign risk, but that this effect is identified on low frequency comovement. Panel A shows a strong negative relationship between CDS spreads and repo volume over the entire period (column 1), but also in 2009-2010, in 2011 and even in the first semester of 2012 (in columns 3, 4 and 5, respectively). In 2011, a one-standard deviation increase in CDS spreads (114bp) leads to a volume reduction of about 47% ($1-e^{-0.55\times 1.14}$). At the average volume level (€6.02bn), this corresponds to a drop of €2.5bn in daily trading volume. From Panel A the impact thus looks large.

This effect is however identified on low (monthly) frequency movements in country-level factors. Once we include country-month dummies, the average effect becomes statistically insignificant in all periods, including 2011 (Panel B). We notice, however, that the coefficient is not driven to zero, it only becomes more noisily estimated. It is thus impossible to reject the hypothesis that the effect uncovered at low frequencies also holds at the daily frequency. We also note that these results are opposite to what Mancini, Ranaldo, and Wrampelmeyer (2014) find on the GCP repo market. This is probably due to the higher resilience of the GCP market - though the reason behind this resilience remains somewhat of a mystery. GCP repo's larger collateral base is likely to generate more substitution towards relatively lower quality collateral when closing the transaction.

We then look at the differential impact of sovereign stress on repo volume between GIIPS and non-GIIPS countries. As we discussed above, the haircut policy of GIIPS debt, or the probability of default of counterparties using such debt as collateral might be different across the two categories of countries. To study this difference, we thus add to the regression an interaction term *GIIPS×Sovereign CDS*. The coefficient on this interaction term indicates the differential impact of sovereign stress on repo volume for GIIPS countries. We report the results in Table 5.

[Insert Table 5 here.]

We find that volume seems to be negatively affected by sovereign stress, but the coefficient is noisily estimated. In column 1 of Panel A, the simple specification with daily fixed effects delivers a strong positive coefficient on the interaction term, which is difficult to interpret. It is however mostly due to the presence of Spain in the sample, whose volume traded surges in the later part of 2011 (see Figure 4), precisely when the Spanish CDS spread is the highest. When we run the regression of column 1 excluding Spain, the coefficient on the interaction term becomes negative. To make sure we are identifying our coefficient on higher frequency movements, we then move to panel B, in which we include country-month fixed effects. In this second specification, the coefficient on the interaction term is equal to -0.631 and significant at the 5%-level. The effect is strongest during the 2009-2010 period and in

2011. In 2011, the effect is large: A one-standard deviation increase in CDS spreads leads to a 46% reduction in daily volume. This effect is large because daily volume fluctuates a lot.

5. The transmission channel between sovereign CDS spreads and repo rates

Our objective, in this section, is to understand the determinants of the transmission from sovereign stress to repo rates. If we take equation (2) literally, the sensitivity of repo rates to CDS spreads should be equal to $p\lambda G(h)/G(0)$. It means that sovereign stress transmits to repo rates more when (1) haircuts are set less conservatively, (2) the conditional counterparty failure increases or, (3) the conditional probability of CCP failure increases. In this section, we investigate the relative importance of these determinants both in the time series and between GIIPS and non-GIIPS countries.

5.1. Haircuts

We first investigate the effect of haircuts on repo rates. In our framework, the $G(h)/G(0)$ term implies that their sensitivity to sovereign stress should decrease when h goes up. To verify that this is the case, we use a difference-in-differences methodology. We focus on three instances in which haircuts were increased sharply, and ask whether the repo rate-to-CDS spread sensitivity was affected by changes in haircuts. In doing this exercise, we acknowledge that the haircut change is itself endogenous and most probably responds to evolutions in sovereign stress. To deal with this concern, we focus on relatively short periods around haircut changes, but we acknowledge this method is imperfect.

[Insert Figure 8 here.]

Haircut dynamics for France, Spain and Italy, available from the website of LCH.Clearnet (the clearing house for the transactions in our sample), are shown in Figure 8. These haircuts are averaged across maturity groups (below and above 7 years). We focus on three episodes in which haircuts are raised by LCH.Clearnet by more than 100bp. The first two haircut changes occurred in Spain (December 16, 2010 and September 21, 2011), the last one in Italy (November 10, 2011). For the two Spanish changes, we focus on a 3-month window around the haircut change, because the haircut follows a relatively neat "step function". The downside of these two "experiments" is that they correspond to relatively modest haircut rises (about 100bp). The Italian shock of 2011 is much more dramatic since the haircut goes up from approximately 6% to 10%. The problem with this change is that it only lasted a month, after which the haircut went back down to 7%. To deal with this shortcoming, we restrict ourselves to a 1-month window around November 10 for the Italian test.

[Insert Table 6 here.]

Results are reported in Table 6. For each shock, we run a variant of equation (3) in which we interact all terms with a *POST* dummy variable equal to one after the haircut change, and zero before. We report the results of these regressions in columns 1, 3 and 5. These regressions are similar to "simple diffs" in which we look at the change in repo rate-to-CDS spread sensitivity before and after the haircut change. In this case, the coefficient of interest is the interaction term *POST*×*Sovereign CDS*. We then extend the sample to all other countries and add to the specification the *HC Country* dummy variable, which is equal to one if the country experiences a haircut change (the "treatment" country), and zero otherwise. The coefficient of interest in these regressions is the triple interaction *POST*×*HC Country*×*Sovereign CDS*. We report the results of these regressions in columns 2, 4 and 6 of Table 6.

Overall, the results are consistent with haircuts being effective in "normal times", but not in the second half 2011, the peak of the sovereign crisis in Europe. For the two shocks occurring in 2011, the sensitivity increases strongly after the shock, which we interpret as evidence that the haircut increase was not large enough to prevent the repo market from reacting to sovereign stress. In the Italian case of November 10, 2011 (column 5), the repo rate-to-CDS spread sensitivity is zero the month before the haircut change, and increase to 0.359 after the change. This coefficient is significant at the 1% level and corresponds approximately to a 35bp increase in repo rates for a one-standard deviation increase in Italian CDS spreads. This finding carries out in the true diff-in-diff exercise of column 6. The Spanish case of September 21, 2011, is similar (columns 3 and 4). Results indicate, however, that the first Spanish haircut seems to have been more effective at reducing stress on the repo market. In column 2 (the difference-in-differences estimation), the excess sensitivity of Spanish repo rates to CDS spreads goes down from a statistically positive 0.195 before the haircut change to 0.195-0.231=-0.036 after the change, which is close to zero and statistically insignificant. In sum, haircut changes seem to have the power of calming market stress in "normal times", but not during the worst of the sovereign crisis.

5.2. Counterparty risk

When counterparty risk (p in our model) goes up, we expect the sensitivity of repo pricing to sovereign risk $p\lambda G(h)/G(0)$ to increase. This happens because, for a given default probability of the CCP, the lender has a higher chance of receiving the collateral. Thus, we check here that changes in p (the counterparty default probability conditional on sovereign default) explain changes in the sensitivity to sovereign stress. Also, in the cross-section, we ask whether differences in p may explain the difference in stress between GIIPS and non-GIIPS countries.

To measure p, we regress the average CDS spread of banks in a country on the sovereign CDS spread of the same country. This approach relies on several reasonable assumptions. First, we assume that borrowers on the repo market using, say, Italian collateral, correspond to the average Italian bank for which CDS quotes are available. Since the trading platform is anonymous, the econometrician is not too much at a disadvantage compared to market operators. One difference is that repo traders expect banks that are not Italian (but hold a lot of Italian bonds), or banks that have no CDS quote, to be other possible counterparties. They also know that cash-short banks are more likely to tap the repo market than cash-rich ones. To verify robustness, we have measured bank-level stress using the average CDS spread of banks, weighted by each bank's holdings of the sovereign of the country, which may include foreign banks, rather than the CDS spread of local banks. The results are similar.

Our measurement of p relies on the following equation:

$$P = p\pi + \rho(1-\pi) = (p-\rho)\pi + \rho \qquad (4)$$

where P is the unconditional probability that a bank defaults, π is the default probability of the sovereign bond, p is the probability of bank default conditional on sovereign default , and ρ is the probability of bank default conditional on sovereign non-default. Assuming that $(p-\rho)$ is stable over time, the regression coefficient of P (measured by the average bank's CDS spread) on π (measured by the sovereign CDS spread) is $(p-\rho)$.

[Insert Table 7 here.]

We run this regression, and report the results in Table 7. We use the following specification:

$$\Delta CDS_{c,t}^{banks} = \alpha_c + \delta_t + \beta.\Delta CDS_{c,t}^{sov} + \varepsilon_{ct} \qquad (5)$$

where Δ represents daily differences and the δ_t terms are day dummies. Error terms ε_{ct} are clustered at the day level. $CDS_{c,t}^{sov}$ is the spread of the 5-year CDS on sovereign debt. $CDS_{c,t}^{banks}$ is the average spread of CDSs of banks in country c. We use first difference in

CDS spreads (both for banks and sovereigns) because we cannot reject the possibility that these series have unit roots, even within the various subperiods that we analyze. First differentiation thus avoids that our estimates of β are polluted by common drifts. We check that first-differenced variables are indeed stationary.

Results from Panel A, which exploit all countries in our sample, are consistent with the idea that the conditional counterparty default probability p went up drastically between 2009 and 2011. Over the entire period, the coefficient is equal to 0.209 and is strongly significant statistically. During the pre-sovereign crisis period (from 2008 to September 2009), the coefficient is tiny and insignificant, but it goes up to 0.407 during the 2009-2010 period. Hence, during this period, market prices suggest that the default probability of local banks increases by 40 percentage points when their sovereign defaults. This evolution is similar to findings in Acharya, Dreschler and Schnabl (2014). The coefficient is then divided by two in 2011 but remains strongly significant (0.204). It then goes back to zero in the post-LTRO period. Overall, the 2009-2011 period, which corresponds to years during which sovereign stress has more impact on repo rates (see Table 2), is also the period during which the conditional counterparty default probability p is the highest, consistent with our model. There is, however, a timing gap that we discuss in Section 5.3 below.

Our analysis in Table 3 shows that the repo rate-to-CDS spread sensitivity was higher during the crisis in GIIPS countries than in non-GIIPS countries. Panels B and C of Table 7 suggest that this can be in part due to the difference in counterparty default probability. Over the entire period, the regression coefficient is 0.168 for GIIPS countries (significant at 1%), and 0.0435 for non-GIIPS countries (insignificant). Hence, a part of the bigger stress experienced by the GIIPS repo market can be attributed to increased counterparty risk, in a situation in which the default of the CCP was considered possible.

5.3. "Rational" CCP default pricing

When the sensitivity of repo rates to sovereign stress goes up, it may be because haircuts are less conservative, because counterparties are more likely to default, or because the CCP is expected to default. We have found in the two previous sections that changes in haircuts and counterparty risk are broadly consistent with differences across country groups, and over time, with the reaction of repo rates to sovereign risk. But an important gap remains: in 2009-2010, the repo rate-to-CDS spread sensitivity ($\lambda pG(h)/G(0)$) does not increase very much, while counterparty risk (p) seems to be going up sharply. In 2011, it is the opposite: the GIIPS repo market becomes very sensitive to counterparty risk ($\lambda pG(h)/G(0)$ goes up), while the conditional default of GIIPS banks seems to be smaller (p goes down).

One way to reconcile this finding with our framework is by assuming that λ, the CCP default probability, went up between the 2009-2010 and 2011. Notice that haircuts were very low throughout 2009-2010, and increased during 2011 (see Figure 8). Thus, both $G(h)/G(0)$ and p decreased during the period, so the only way to explain an increase in $\lambda pG(h)/G(0)$ is with an increase in λ. In other words, with safer counterparties and more conservative haircuts in 2011, the only factor that can explain the high repo rate-to-sovereign stress sensitivity in 2011 is a decrease in the perceived reliability of the CCP.

The model is very stylized and thus cannot be precisely calibrated, but it helps to discuss orders of magnitude. Doing so, we can see that markets in 2011 seemed to be expecting an extremely high probability of CCP default. Let us focus on GIIPS countries. Table 3, Panel B, shows that the repo sensitivity to sovereign risk went up from 0 to 0.208 between the 2009-2010 period and 2011. First, we need to calculate p, the conditional counterparty default probability. From equations (4) and (5), the β coefficient obtained by regressing bank CDS spreads on the CDS spreads of their sovereign is an estimate of (p-ρ). Going back to equation (4), we can back out p as:

$$p = (1-\pi_a)\beta + P_a \sim \beta \quad (6)$$

where π_a and P_a are the average sovereign default and counterparty default probabilities over the period, while β is the regression coefficient of equation (5). The implicit assumption in the above formula is that p does not vary at the frequency we are using to estimate equation (5). Given formula (6), and using numbers for the average GIIPS country, we obtain that p_{2011}= (1-0.0274)×0.0176+0.039=0.21 . Given the estimate of the repo-sovereign sensitivity in Table 3, Panel B, we obtain that $\lambda \approx 0.208 / (0.21 \times G(h) / G(0)) = G(0) / G(h) > 1$.

Hence, in 2011, repo markets behaved as if they expected that, conditional on sovereign and counterparty defaults, the default probability of the CCP was 1 (or at least extremely high). This very high expectation is to be compared to an implicit probability close to 0 in 2009-2011: The repo-sensitivity coefficient is 0 (from Table 3, Panel B), while p is non zero during this period (using formula (6) again, we can calibrate it to be 0.41).

Thus, the CCP seems to be offering protection in times of moderate stress (2009-2010), during which sovereign risk was not transmitted to the repo market, in spite of the fact that counterparty risk (p) was high. In times of heavy sovereign stress, however, the CCP was considered by markets as offering very little protection, if any. The back-of-the-envelope calibration of the model thus gives conclusions that are similar to the haircut analysis of Section 5.1.

5.4. The impact of non-conventional monetary policy

Next we study the responses of the ECB to the crisis and how they affected the link between sovereign distress and repo rates. To tackle the sovereign debt crisis and its impact on the financial sector, the ECB launched several one- and three-year Long-Term Refinancing Operations (LTROs), through which it offered very long-term repo to European banks. The ECB extended the maturity of its interventions on the repo market as the sovereign crisis deepened. In April 2008, the ECB moved the maturity from 3 to 6 months. In May 2009, it further raised the duration to 1 year. Finally, in December 2011, following the increased stress in financial markets, the ECB extended the maturity of the LTRO to three years and announced that another three-year LTRO would be conducted in February 2012. The goal of these LTROs was to disconnect the repo rates from sovereign stress. By agreeing to carry on its own balance sheet, for a long period of time, stressed sovereigns at a very low rate and with a generous haircut policy, the ECB wanted to outcompete money lenders such as the ones we model in Section 3.

To more precisely assess the effectiveness of LTROs in breaking the loop between the sovereign debt crisis and short-term financing of European banks, we run event studies around each of the last four LTROs. We focus on one-month periods before and after each operation. In Table 8, the dependent variable is the GC repo rate and the variable of interest is the interaction between the country's CDS spread (*Sovereign CDS*) and an indicator variable equal to one after the LTRO (*POST*).

[Insert Table 8 here.]

As expected given our previous results, the December 2011 three-year LTRO was the most effective at stabilizing the repo market. The coefficient estimate on *POST*×*Sovereign CDS* is only significant at the 5% level for the 2009 LTRO and at the 1% level for the December 2011 LTRO. But the December 2011 LTRO affected the relation between sovereign CDS spreads and repo rates more than the 2009 LTRO: the coefficient on the interaction term is -0.565 in column 3 (December 2011 LTRO) and -0.132 in column 1

(December 2009 LTRO). This variable is insignificant in column 2, in which we study the effect of the October 2011 LTRO. This might be because this LTRO was more limited in its maturity (one year vs. three years for the December 2011 LTRO) and in its scope. Panel B of Table 8, in which we separate GIIPS and non-GIIPS countries, shows that the December 2011 LTRO was effective in breaking the relation between CDS spreads of sovereign debt and repo rates where it was the strongest, i.e., in GIIPS countries.

4. Conclusion

We provide evidence that CCPs stabilize repo markets in times of moderate sovereign stress, but that only the central bank can restore stability on the repo market by breaking up the sovereign-to-repo market loop that appears in times of high sovereign stress. We start by documenting the sensitivity of repo market rates to sovereign default risk during the Eurozone crisis. This sensitivity is very high, even for CCP-cleared repos, in which lenders are in principle protected against counterparty risk. We propose a simple framework that allows us to decompose this sensitivity into (1) CCP default, (2) counterparty default, and (3) haircut policy effectiveness. In 2009-2010, the sensitivity is low, in spite of significant counterparty risk. One haircut increase experience seems to have been effective at reducing repo stress. Overall, markets behave as if the CCP was able to insulate the repo market from stress in 2009-2010. In 2011, however, attempts at raising haircuts prove ineffective. The repo-to-sovereign risk sensitivity increases strongly, despite the fact that counterparty default decreases somewhat. Our estimates are consistent with CCP conditional default probabilities close to one, i.e., with the idea that the CCP was powerless at restoring stability on the repo market. The December 2011 36-month LTRO implemented by the ECB was successful in breaking the sovereign-to-repo market loop. This is another piece of evidence that financial stability and monetary policy are linked.

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Figure 1: The Rise of CCP Repos

This figure presents the breakdown of the Eurozone repo market by type of repos from 2003 to 2013 in percentage of the total. Numbers are in percent of total repo volume. *Source: ECB Money Market Survey 2013.*

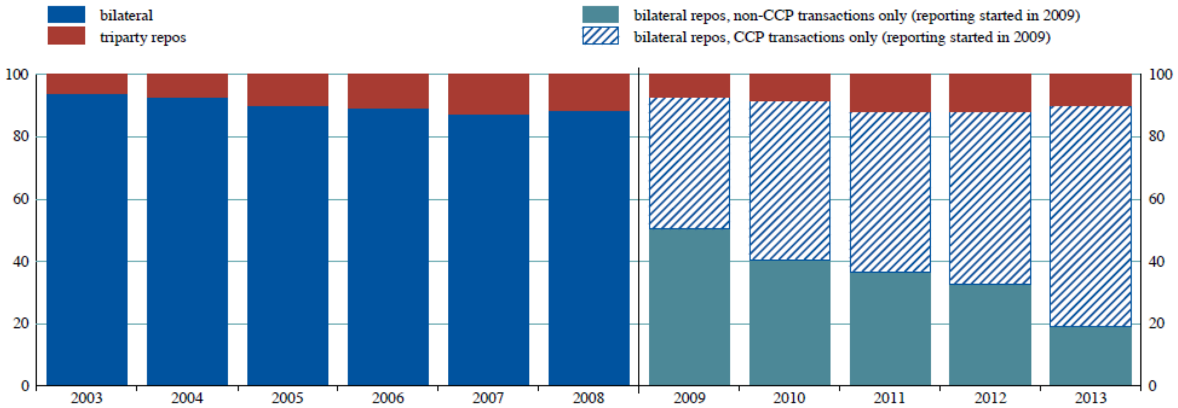


Figure 2: Average daily trading volume in the Eurozone interbank repo market

This figure presents the evolution of different segments of the Eurozone interbank repo market between 2008 and 2012. Interbank Secured, Interbank Secured Bilateral and Interbank Secured Bilateral CCP based, Eurex GC Pooling are from Mancini, Ranaldo and Wrampelmeyer (2014). MTS/ICAP GC is the sum of one day GC repo trades in our dataset. All numbers are in €bn of average daily volume. *Source: Mancini, Ranaldo and Wrampelmeyer (2014), ICAP/MTS*

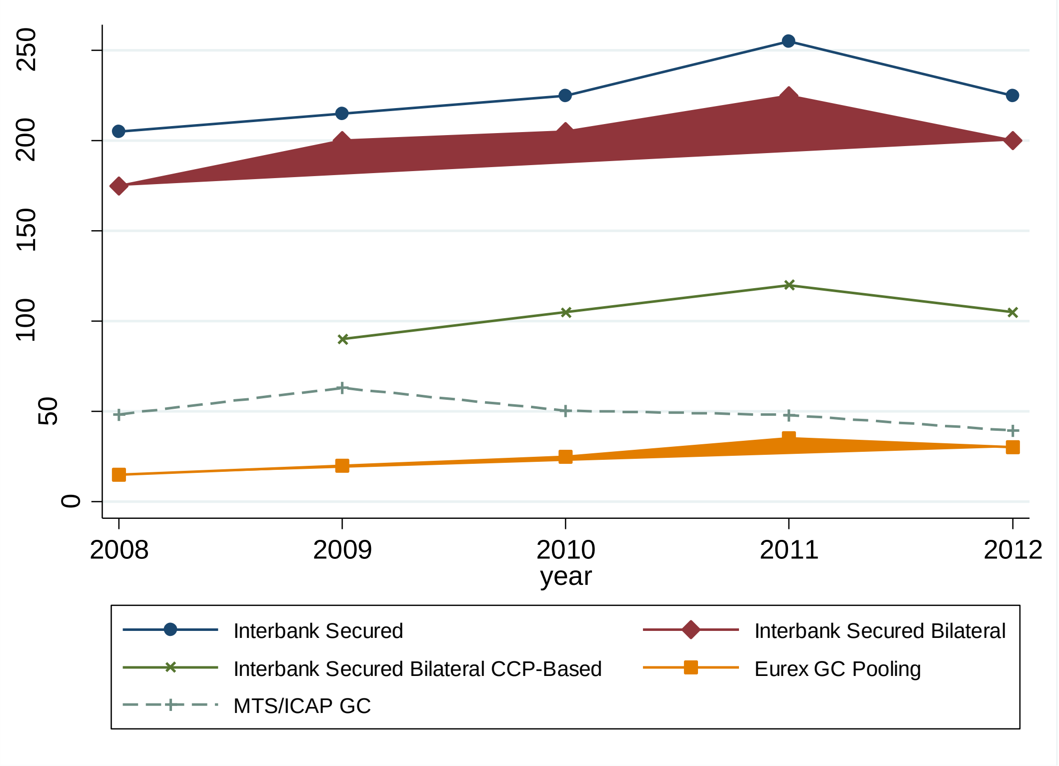


Figure 3: Evolution of the volume of repo transactions in the Eurozone, GIIPS vs Non GIIPS 2008-2012 S1

This figure presents the evolution of the average daily volume of General Collateral repo in the Eurozone over our sample period, between 2008 and June 2012, for GIIPS countries (Greece, Ireland, Italy, Portugal and Spain) and non-GIIPS countries. The scale of the y-axis is in €bn.

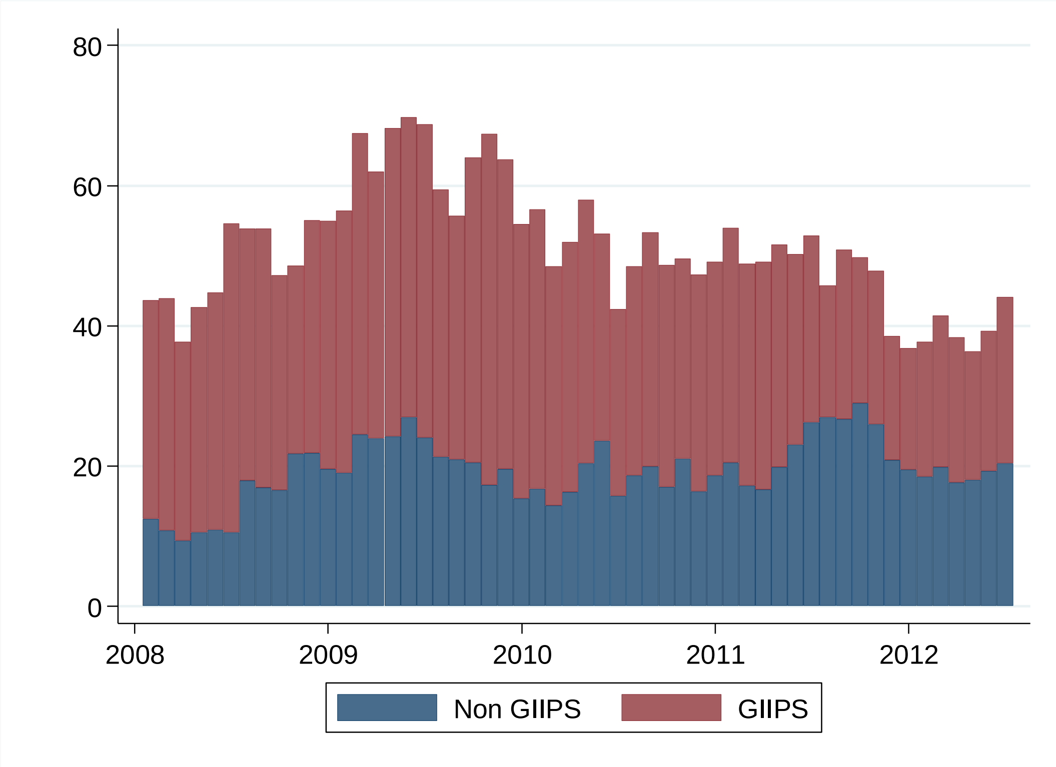
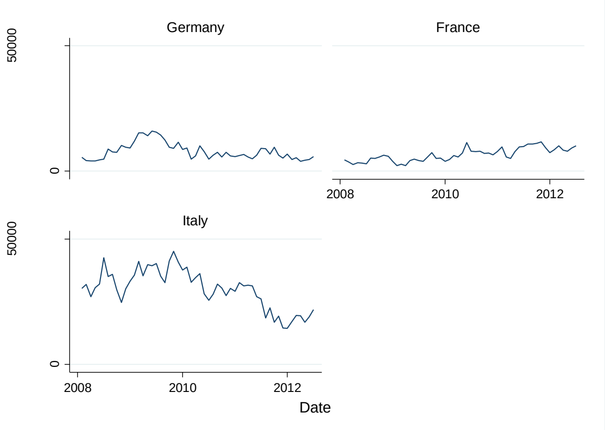


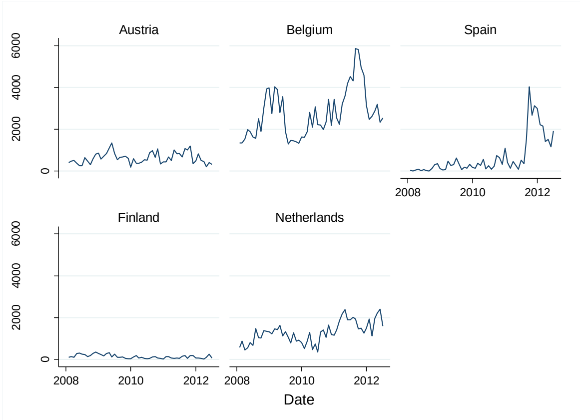
Figure 4: Evolution of the volume of repo transactions in the Eurozone, by country 2008-2012 S1

This figure presents the evolution of the average daily volume of General Collateral repo in the Eurozone over our sample period, between 2008 and June 2012, by country. All amounts are in €m, but each panel uses a different scale. Panel A is restricted to Germany, Italy and France. Panel B presents all other countries that did not seek foreign assistance through of a bailout program. Panel C is restricted to countries that entered assistance programs (Ireland, Portugal, Greece). The start dates of the programs are indicated by red vertical lines.

Panel A: Germany, France, Italy



Panel B: Austria, Belgium, Spain, Finland, the Netherlands



Panel C: Greece, Ireland, Portugal

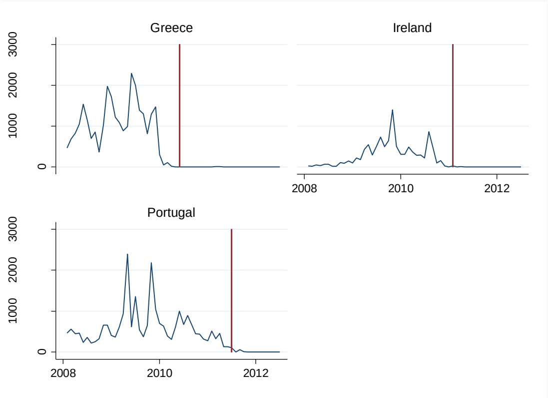


Figure 5: Interest Rates, 2008-2012 S1

This figure presents the evolution of the ECB marginal lending and deposit rates, as well as the average GC repo rate for GIIPS (Greece, Ireland, Italy, Portugal and Spain) and non-GIIPS Eurozone countries over the 2008-2012 S1 period. Numbers are in percent.

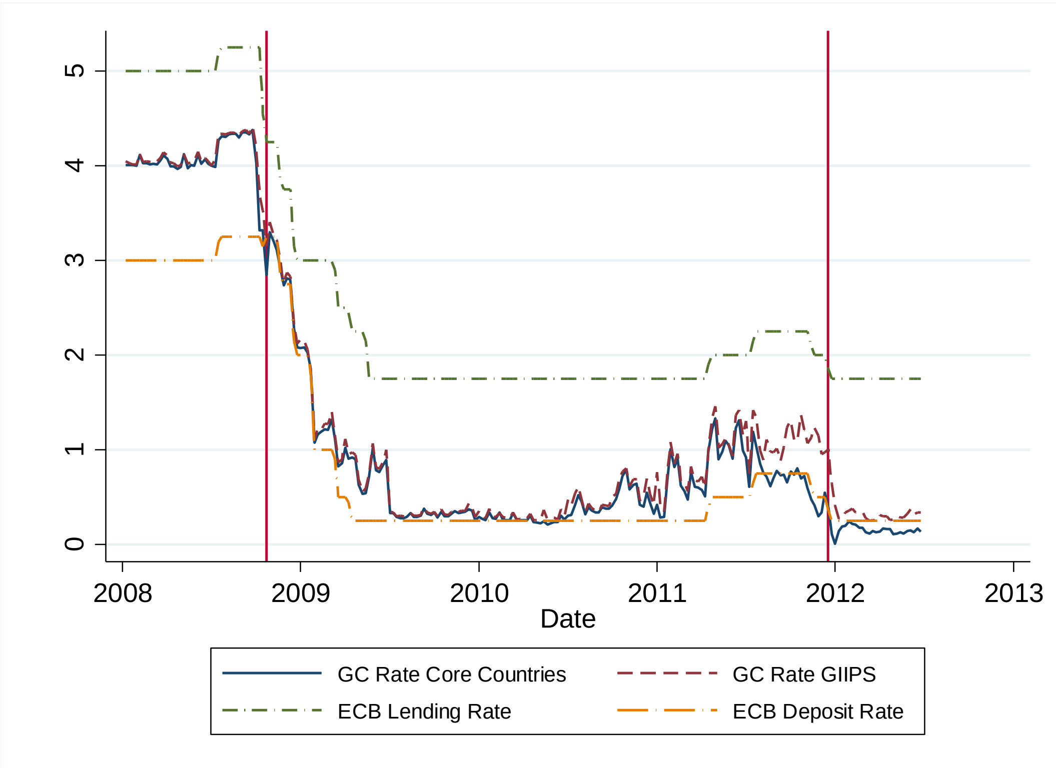


Figure 6: Sovereign CDS Spreads, 2008-2012 S1

This figure presents the evolution of the weekly average of Sovereign CDS spreads for GIIPS (Greece, Ireland, Italy, Portugal and Spain) and non-GIIPS Eurozone countries between 2008 and June 2012. CDS spreads are in percent.

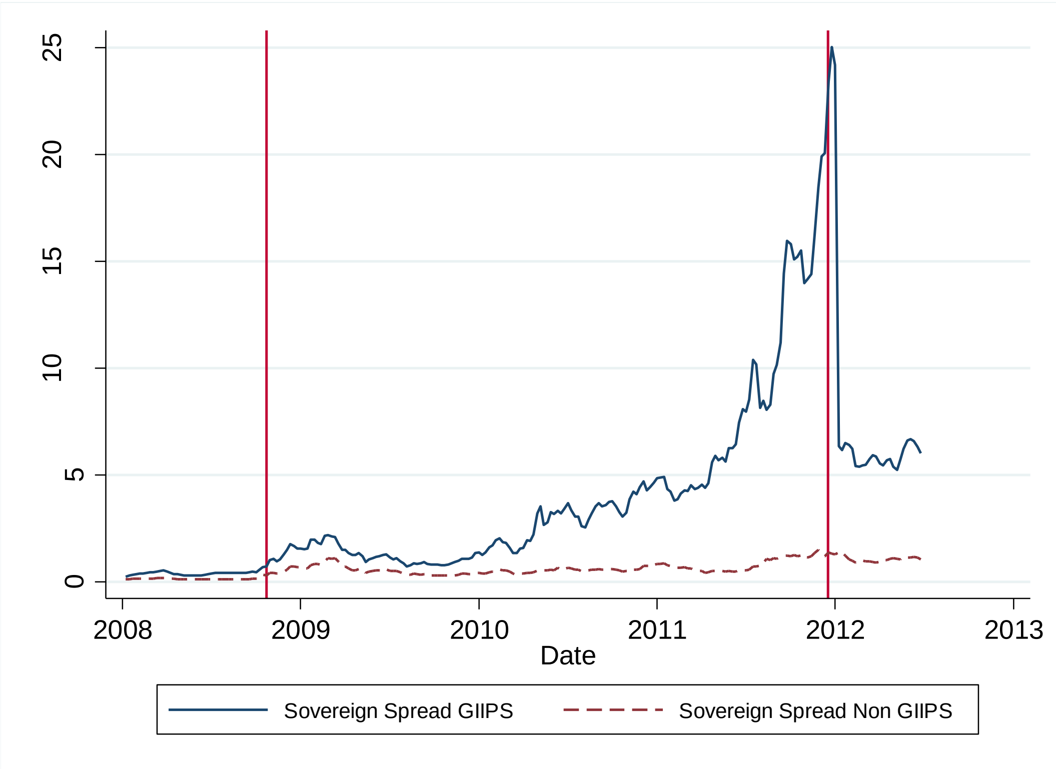


Figure 7: Relationship between the Average Repo Rate and Average Sovereign CDS spread

This figure presents a scatter plot of the relationship between the average daily repo rate and the average daily sovereign CDS spread, across the 11 repo markets in our data. Each dot correspond to one day. On the x-axis, we report the average sovereign CDS spread, across the 11 countries. On the y-axis, we report the average difference between the repo rate and the ECB deposit rate across the same 11 countries. Our data has 1,124 observations, corresponding to all days between Jan 1, 2008 and June 30, 2012. The regression coefficient is -0.06, and the heteroskedacity-adjusted t-statistic is -13.6.

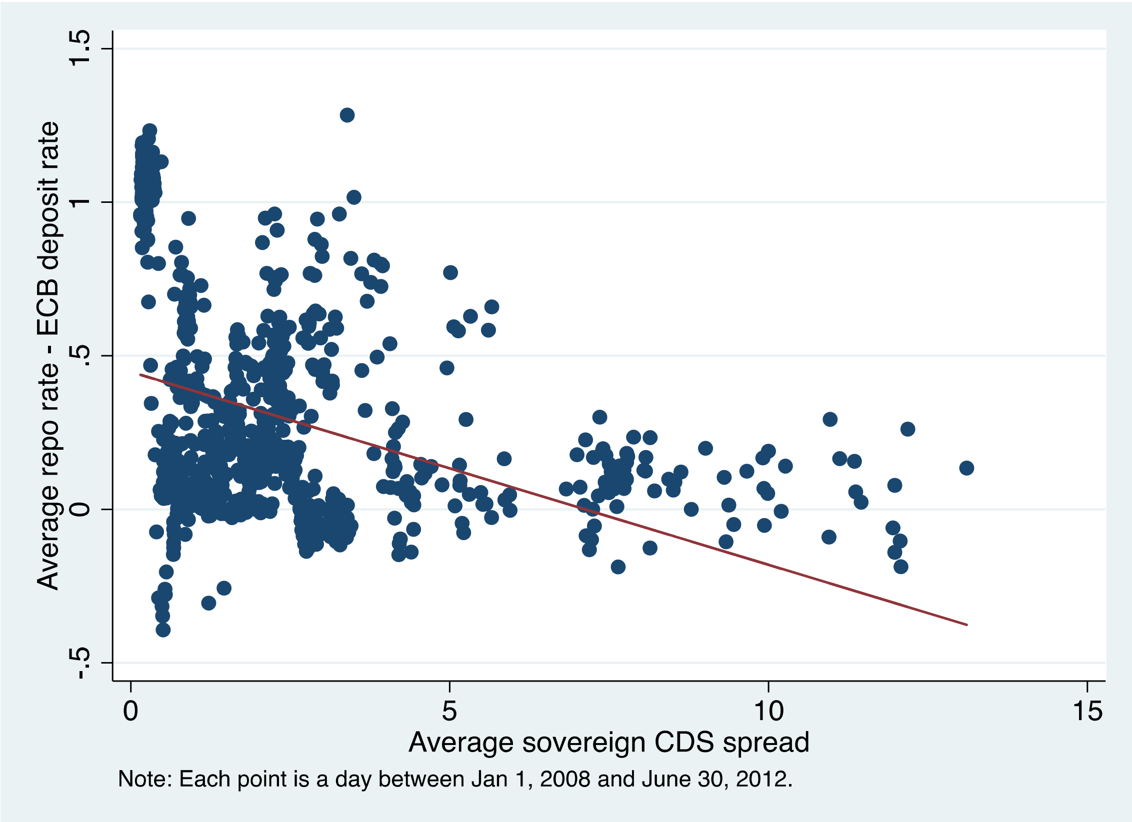


Figure 8: Evolution of haircuts

This figure presents the evolution of average haircuts applied to General Collateral repo transactions by ICAP BrokerTec in France, Italy and Spain between 2008 and June 2012. Haircuts are in percent.

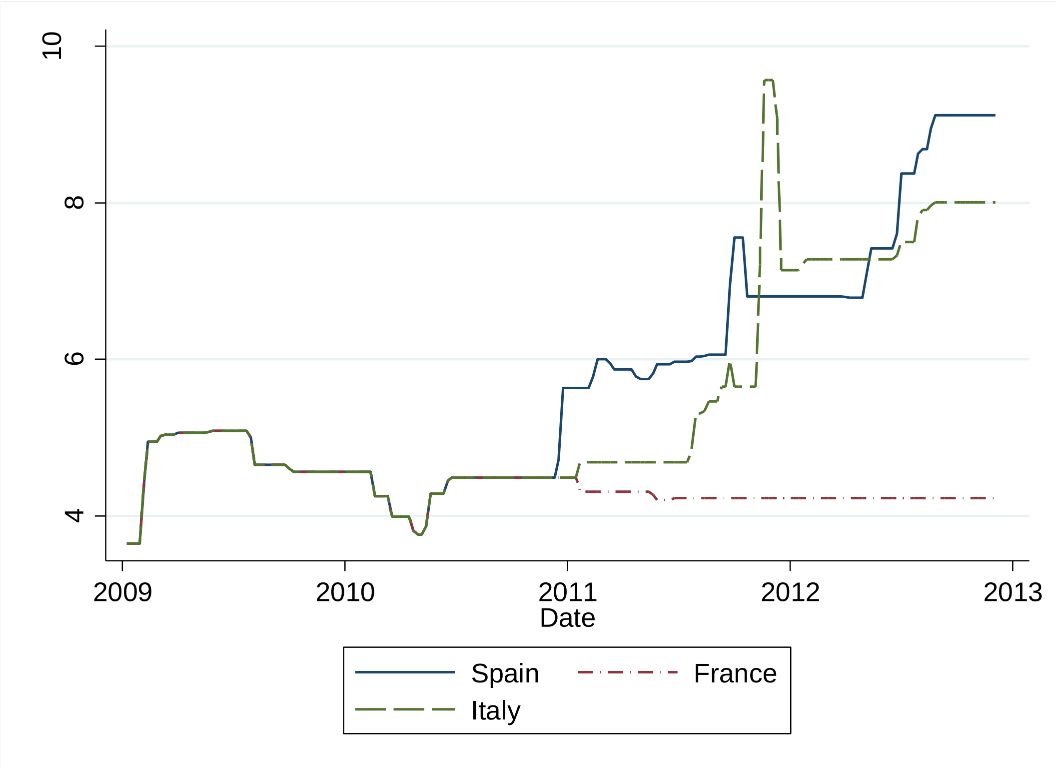


Table 1: Summary statistics

This table reports summary statistics over the entire sample period, and over each of the four subperiods we consider in subsequent tests. *Repo Rate-ECB Deposit Rate* is the country-level average daily general collateral (GC) repurchase agreement rate for one-day repo contracts minus the ECB deposit facility rate. *Daily Volume* is the country-level average daily trading volume of such repo contracts. *Sovereign CDS Spread* is the country-level average daily 5-year sovereign credit default swap rate. *Local Banks CDS Spread* is the country-level daily average 5-year CDS spreads of banks in the country. The sample is restricted to observations with non-missing *Repo Rate* data.

	Number of observations	Mean	Median	Std. Dev.	Min.	Max.
Jan. 2008 to June 2012						
Repo Rate-ECB Deposit Rate (Pct, Annualized)	8,866	0.33	0.15	0.40	-0.45	1.63
Daily Volume (Billions Euros)	8,866	6.02	1.75	9.98	0.03	61.77
Sovereign CDS Spread (Pct)	8,460	1.03	0.66	0.96	0.05	5.22
Local Banks CDS Spread (Pct)	7,709	1.99	1.54	1.29	0.35	9.24
Jan. 2008 to Lehman's bankruptcy						
Repo Rate-ECB Deposit Rate (Pct, Annualized)	1,498	1.05	1.05	0.06	0.71	1.46
Daily Volume (Billions Euros)	1,498	5.47	1.10	10.60	0.03	53.27
Sovereign CDS Spread (Pct)	1,169	0.22	0.18	0.15	0.05	0.64
Local Banks CDS Spread (Pct)	1,065	0.83	0.77	0.26	0.35	2.19
Jan. 2009 to Dec. 2010						
Repo Rate-ECB Deposit Rate (Pct, Annualized)	4,580	0.18	0.10	0.20	-0.45	1.63
Daily Volume (Billions Euros)	4,580	6.20	1.35	10.99	0.03	61.77
Sovereign CDS Spread (Pct)	4,503	0.96	0.67	0.76	0.17	4.81
Local Banks CDS Spread (Pct)	4,082	1.77	1.42	1.09	0.56	8.88
Jan. 2011 to Dec. 2011 LTRO						
Repo Rate-ECB Deposit Rate (Pct, Annualized)	1,909	0.30	0.30	0.32	-0.45	1.48
Daily Volume (Billions Euros)	1,909	6.30	3.15	8.16	0.03	47.21
Sovereign CDS Spread (Pct)	1,909	1.35	0.98	1.14	0.23	5.22
Local Banks CDS Spread (Pct)	1,738	2.64	2.27	1.41	1.09	9.24
Jan. 2012 to June 2012						
Repo Rate-ECB Deposit Rate (Pct, Annualized)	879	-0.05	-0.07	0.08	-0.21	0.22
Daily Volume (Billions Euros)	879	5.38	2.67	6.26	0.03	28.90
Sovereign CDS Spread (Pct)	879	1.75	1.21	1.20	0.28	4.73
Local Banks CDS Spread (Pct)	824	3.22	3.03	0.94	1.83	5.67

Table 2: GC-Repo Rates and Sovereign CDS Spreads

This table reports the estimates of fixed-effects panel regressions in which the dependent variable is the country-level average daily general collateral (GC) repurchase agreement rate minus the ECB deposit facility rate (*Repo Rate-ECB Deposit Rate)* and the explanatory variable is daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*). t-statistics are presented in parentheses. Standard errors are clustered at the daily level. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: Fixed-Effects Regressions

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(5) 2012 S1
Sovereign CDS	0.0604***	-0.00613	0.0140***	0.186***	0.0334***
	(14.37)	(-0.14)	(6.15)	(16.40)	(6.82)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country-month FE	No	No	No	No	No
Number of observations	9115	1169	4520	1892	879
R^2	0.962	0.816	0.939	0.922	0.934

Panel B: Fixed-Effects Regressions with Country-Month Effects

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(5) 2012 S1
Sovereign CDS	0.00933	-0.0576	-0.00441	0.0765**	0.0102
	(0.81)	(-0.61)	(-0.49)	(2.36)	(0.77)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No
Country-month FE	Yes	Yes	Yes	Yes	Yes
Number of observations	9115	1169	4520	1892	879
R^2	0.981	0.841	0.947	0.950	0.947

Table 3: GC-Repo Rates and Sovereign CDS Spreads – GIIPS vs. non-GIIPS

This table reports the estimates of fixed-effects panel regressions in which the dependent variable is the country-level average daily general collateral (GC) repurchase agreement rate minus the ECB deposit facility rate (*Repo Rate-ECB Deposit Rate).* The explanatory variables are daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*), and its interaction with an indicator variable that is equal to one for Greece, Ireland, Italy, Portugal and Spain, and zero otherwise (*GIIPS*). t-statistics are presented in parentheses. Standard errors are clustered at the daily level. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: Fixed-Effects Regressions

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(5) 2012 S1
Sovereign CDS	-0.0202***	-0.000445	-0.0180***	0.00503	0.0425***
	(-5.03)	(-0.00)	(-3.01)	(0.48)	(5.91)
GIIPS×Sovereign CDS	0.0754***	-0.00504	0.0321***	0.164***	-0.00943
	(13.39)	(-0.08)	(5.13)	(11.96)	(-1.09)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country-month FE	No	No	No	No	No
Number of observations	9115	1169	4520	1892	879
R^2	0.964	0.816	0.940	0.932	0.934

Panel B: Fixed-Effects Regressions with Country-Month Effects

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(5) 2011	(6) 2012 S1
Sovereign CDS	-0.0430**	0.0593	-0.00436	-0.107***	0.0200
	(-2.42)	(0.34)	(-0.16)	(-3.45)	(1.47)
GIIPS×Sovereign CDS	0.0525***	-0.111	-0.0000487	0.208***	-0.0105
	(2.58)	(-0.74)	(-0.00)	(5.01)	(-0.59)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No
Country-month FE	Yes	Yes	Yes	Yes	Yes
Number of observations	9115	1169	4520	1892	879
R^2	0.981	0.841	0.947	0.951	0.947

Table 4: GC-Repo Volume and Sovereign CDS Spreads

This table reports the estimates of fixed-effects panel regressions in which the dependent variable is the logarithm of the country-level daily general collateral (GC) repurchase agreement volume in €bn (*ln(Daily Volume+1))* and the explanatory variable is daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*). t-statistics are presented in parentheses. Standard errors are clustered at the daily level. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: Fixed-Effects Regressions

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(5) 2012 S1
Sovereign CDS	-0.328***	0.498	-0.891***	-0.554***	-0.351***
	(-7.14)	(0.31)	(-17.07)	(-6.78)	(-3.73)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country-month FE	No	No	No	No	No
Number of observations	10524	1405	5274	2102	960
R^2	0.646	0.803	0.673	0.708	0.792

Panel B: Fixed-Effects Regressions with Country-Month Effects

	(2) 2008-2012 S1	(3) 2008-Lehman	(4) 2009-2010	(5) 2011	(6) 2012 S1
Sovereign CDS	-0.154	5.853	-0.0565	-0.343	-0.515
	(-1.14)	(1.63)	(-0.35)	(-1.21)	(-1.47)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No
Country-month FE	Yes	Yes	Yes	Yes	Yes
Number of observations	10524	1405	5274	2102	960
R^2	0.785	0.829	0.758	0.817	0.829

Table 5: GC-Repo Volume and Sovereign CDS Spreads – GIIPS vs. non-GIIPS countries

This table reports the estimates of fixed-effects panel regressions in which the dependent variable is the logarithm of the country-level daily general collateral (GC) repurchase agreement volume in €bn (*ln(Daily Volume+1))*. The explanatory variables are daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*), and its interaction with an indicator variable that is equal to one for Greece, Ireland, Italy, Portugal and Spain, and zero otherwise (*GIIPS*). t-statistics are presented in parentheses. Standard errors are clustered at the daily level. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: Fixed-Effects Regressions

	(2) 2008-2012 S1	(3) 2008-Lehman	(4) 2009-2010	(5) 2011	(6) 2012 S1
Sovereign CDS	-0.735***	4.574	0.721***	-2.250***	0.223
	(-9.06)	(1.21)	(4.35)	(-10.90)	(0.84)
GIIPS×Sovereign CDS	0.386***	-3.631	-1.610***	1.595***	-0.596**
	(6.19)	(-1.25)	(-10.35)	(10.23)	(-2.34)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country-month FE	No	No	No	No	No
Number of observations	10524	1405	5274	2102	960
R^2	0.647	0.803	0.679	0.721	0.792

Panel B: Fixed-Effects Regressions with Country-Month Effects

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(5) 2011	(6) 2012 S1
Sovereign CDS	0.482	5.716	1.229**	0.395	-0.347
	(1.59)	(0.86)	(2.12)	(0.96)	(-0.69)
GIIPS×Sovereign CDS	-0.631**	0.129	-1.243**	-0.806**	-0.184
	(-2.20)	(0.03)	(-2.26)	(-1.98)	(-0.43)
Day FE	Yes	Yes	Yes	Yes	Yes
Country FE	No	No	No	No	No
Country-month FE	Yes	Yes	Yes	Yes	Yes
Number of observations	10524	1405	5274	2102	960
R^2	0.785	0.829	0.758	0.818	0.829

Table 6: The Impact of Haircuts on the Repo rate-to-CDS spread sensitivity

This table reports the estimates of OLS regressions explaining the daily general collateral (GC) repo rate minus the ECB deposit facility rate (*Repo Rate-ECB Deposit Rate)* around the changes of haircuts on Spanish repos of 16 December 2010, 21 September 2011 and on Italian repos of November 10 2011. The explanatory variables are daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*), an indicator variable equal to one after the haircut change (*POST*); an indicator variable equal to one for Spain or Italy (*HC COUNTRY*), and interactions between these variables. Columns 1 and 3 present the results for Spanish repo rates only in a 6-month window around the haircut change, respectively for the December 2010 and the September 2011 increases. Colum 5 presents the results for Italian repo rates only in a two-month window around the haircut change of November 2011. Columns 2 and 4 present the results for Spanish repo using a difference-in-differences estimation using repo rates from all Eurozone countries as the control group in a 6-month window around the two Spanish haircut changes. Column 6 presents the results for Italian repo using a difference-in-differences estimation using repo rates from all Eurozone countries as the control group in a two-month window around the November 2011 haircut change. In columns 1, 3 and 5, standard errors are corrected using the Newey-West procedure with a 5-day lag. In columns 2, 4 and 6, standard errors are clustered at the daily level. t-statistics are in parentheses. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

	Spain December 2010 HC Change		**Spain September 2011 HC Change**		**Italy November 2011 HC Change**	
	(1) Spain Only	(2) Spain and Others	(3) Spain Only	(4) Spain and Others	(5) Italy Only	(6) Italy and Others
Sovereign CDS	-0.0822	-0.278***	-0.305***	-0.249***	-0.0873	-0.106
	(-1.47)	(-5.78)	(-3.14)	(-6.43)	(-0.92)	(-1.46)
POST	0.587***	0.0894**	-1.258***	-0.320***	-1.313***	-0.0851*
	(2.83)	(2.18)	(-3.41)	(-8.51)	(-3.10)	(-1.82)
POST×Sovereign CDS	-0.210**	0.0206	0.446***	0.197***	0.359***	0.0545**
	(-2.38)	(1.66)	(3.72)	(9.88)	(3.40)	(2.57)
HC Country×Sovereign CDS		0.195***		-0.0569		0.0190
		(4.02)		(-0.72)		(0.18)
POST×HC Country		0.498**		-0.938***		-1.208**
		(2.45)		(-2.71)		(-2.35)
POST×HC Country×Sovereign CDS		-0.231**		0.249**		0.299**
		(-2.33)		(2.32)		(2.34)
Constant	0.524***	0.619***	1.251***	0.547***	0.814**	0.251**
	(4.19)	(10.96)	(4.32)	(6.93)	(2.23)	(2.15)
Country FE	No	Yes	No	Yes	No	Yes
Number of observations	88	1025	123	993	44	341
R^2		0.141		0.575		0.797

Table 7: Change in Local Banks' CDS spreads and change in Sovereign CDS spreads

This table reports OLS regressions of the change in local banks' CDS spreads on changes in the sovereign CDS spreads of their sovereign. *Change in Sovereign CDS* is the daily change of sovereign CDS. *Change in Local Banks CDS* is the daily change in the average CDS spread of local banks. t-statistics are presented in parentheses. GIIPS countries are Greece, Ireland, Italy, Portugal and Spain. Standard errors are robust to heteroscedasticity. T-statistics are in parentheses. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: All countries

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(6) 2012 S1
Change in Sovereign CDS	0.209***	0.0285	0.407***	0.204***	0.0415
	(5.39)	(0.19)	(7.40)	(3.35)	(0.95)
Day FE	Yes	Yes	Yes	Yes	Yes
Number of observations	9484	1106	4437	2232	1080
R^2	0.310	0.761	0.435	0.239	0.301

Panel B: GIIPS countries

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(6) 2012 S1
Change in Sovereign CDS	0.168***	0.234	0.396***	0.176**	0.0255
	(3.66)	(0.61)	(4.61)	(2.28)	(0.55)
Day FE	Yes	Yes	Yes	Yes	Yes
Number of observations	4269	487	2008	992	480
R^2	0.390	0.805	0.512	0.329	0.381

Panel C: Non-GIIPS countries

	(1) 2008-2012 S1	(2) 2008-Lehman	(3) 2009-2010	(4) 2011	(6) 2012 S1
Change in Sovereign CDS	0.0435	-1.122***	0.179**	-0.0171	0.0474
	(0.83)	(-3.49)	(2.38)	(-0.23)	(0.68)
Day FE	Yes	Yes	Yes	Yes	Yes
Number of observations	5215	619	2429	1240	600
R^2	0.592	0.829	0.599	0.591	0.733

Table 8: The impact of LTROs

This table reports the estimates of OLS regressions explaining the daily general collateral (GC) repo rate minus the ECB deposit facility rate (*Repo Rate-ECB Deposit Rate)* around the four Long-Term Refinancing Operations (LTROs) implemented by the ECB in December 2009, October 2011, December 2011 and March 2012. The estimation period is from one month before to one month after each LTRO. The explanatory variables are daily country-level 5-year sovereign credit default swap rate (*Sovereign CDS*); and interactions of this variable with an indicator variable that is equal to one for Greece, Ireland, Italy, Portugal and Spain, and zero otherwise (*GIIPS*), and with an indicator variable equal to one post-LTRO (*POST*). t-statistics are presented in parentheses. Standard errors are clustered at the daily level. *, **, and *** denote statistical significance at the 10%-, 5%-, and 1%-level, respectively.

Panel A: Event study around LTROs

	(1) 1Y LTRO DEC 2009	(2) 1Y LTRO OCT 2011	(3) 3Y LTRO DEC 2011	(4) 3Y LTRO FEB 2012
Sovereign CDS	0.0538	0.234***	0.245***	0.0600***
	(1.20)	(2.86)	(3.02)	(3.19)
POST×Sovereign CDS	-0.132**	0.104	-0.565***	-0.000886
	(-2.18)	(0.77)	(-4.11)	(-0.02)
Day FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
LTROS×Country FE	Yes	Yes	Yes	Yes
Number of observations	351	347	315	312
R^2	0.707	0.894	0.900	0.938

Panel B: Event study around LTROs – GIIPS vs. non-GIIPS

	(1) 1Y LTRO DEC 2009	(2) 1Y LTRO OCT 2011	(3) 3Y LTRO DEC 2011	(4) 3Y LTRO FEB 2012
Sovereign CDS	0.0873	-0.0765*	-0.130**	0.0216
	(0.13)	(-1.98)	(-2.17)	(0.99)
POST×Sovereign CDS	-0.106	0.162***	0.0524	-0.0625
	(-0.16)	(2.86)	(0.71)	(-1.30)
GIIPS× Sovereign CDS	-0.0336	0.408***	0.415***	0.0735*
	(-0.05)	(5.71)	(7.60)	(1.78)
POST×GIIPS× Sovereign CDS	-0.0254	-0.167	-0.743***	0.0481
	(-0.04)	(-1.32)	(-6.40)	(0.69)
Day FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
LTRO×Country FE	Yes	Yes	Yes	Yes
Number of observations	351	347	315	312
R^2	0.707	0.912	0.919	0.940