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Abstract

Since the burst of the sovereign debt crisis, investors perceive the concrete possibility of a breakup of the Eurozone. We exploit CDS quotes for contracts denominated in different currencies and with different default clauses to estimate the network of breakup and default risk spillovers in the Eurozone isolating the relevant factors with regularization techniques. Our main result is that redenomination shocks to France and Italy have economically large spillovers. However, while redenomination shocks to France increase the risk of a breakup of the Eurozone, redenomination shocks to Italy increase the risk of sovereign defaults, like sovereign debt restructurings.

Keywords: redenomination risk, CoVaR, elastic net, LASSO

JEL Classification: G1, C4, C5

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1 Introduction

At least since the burst of the sovereign debt crisis, investors and policy makers worry about the default of one, or more, members of the Eurozone. Fluctuations in sovereign default risks have large real effects because they are associated with fluctuations in borrowing costs, for both sovereigns and private investors, and affect the balance sheets of financial institutions that hold government bonds. In an outright sovereign default, a country stops servicing its debt. Throughout history, countries have alternatively printed money to service debt in a devalued currency. However, Eurozone members do not have access to this second option, unless they abandon the euro area and redenominate their debt in a new undervalued currency. In this scenario, the Eurozone would breakup, and the very existence of the euro would be jeopardized, with risks to all members.

Investors use credit default swaps (CDS) to buy protection against defaults. In this paper, we exploit sovereign CDS with different contractual definitions to estimate the risk-adjusted probabilities of outright default and redenomination by three members of the Eurozone: France, Germany, and Italy. Additionally, and for the same set of three countries, we exploit CDS in different currencies to estimate the expected depreciation of the euro conditional on a debt redenomination. We use high-frequency variations in these probabilities to estimate a network of breakup and default risk spillovers across all Eurozone countries. We start from a large network, and isolate the most relevant nodes using machine learning regularization techniques. Our main result is that redenomination shocks to France and Italy have economically large spillovers. However, while redenomination shocks to France increase the risk of a breakup of the Eurozone, i.e., the probability that also other sovereigns would redenominate their debt, redenomination shocks to Italy increase the risk of sovereign defaults, like sovereign debt restructurings.

Sovereign debt markets are central to the macroeconomy of a country. Not only do changes in the prices and liquidity of sovereign debt securities affect governments' cost of financing, but they can also impact the extension of credit by financial institutions. Because the Treaty on European Union makes no provision for exit, no one knows exactly what could happen if such event had to occur. A common view is that departure from the euro area would be associated with a significant rise in government spreads and debt-servicing costs (Eichengreen, 2010). But, most likely, the consequences will depend on which country decides to leave. If a country decides to leave the Eurozone, then debt redenomination is likely to be optimal. In fact, without a redenomination, the real value of debt would increase under the assumption that the new domestic currency depreciates against the euro. It is less controversial the view that exit by one member would raise doubts about the future of the monetary union and would likely precipitate a further shift out of euro-denominated assets. In addition, we should expect spillovers arising from the damage to the balance sheets of banks in other countries with investments in the one abandoning the euro[1].

A sovereign CDS is an insurance contract in which the reference entity is the sovereign government. A default is triggered when the sovereign is considered in default by major credit rating agencies. The CDS premium (or spread) is the periodic payment the protection buyer will have to make until maturity of the contract to the protection seller; in return, the seller agrees to pay a third party debt if this party is in default (Duffie, 1999, Pan and Singleton, 2008). Under the current CR14 clauses, investors are protected against the possibility that a member of the Eurozone decides to redenominate its public debt in a new currency. The International Swaps and Derivatives Association (ISDA) introduced the CR14 contracts in response to the increased perceived risk of redenomination after the Eurozone sovereign debt crisis. On the contrary, investors are not protected against this risk under contracts based on the previous CR clauses, in the case of France, Germany and Italy. This is because the CR clauses do not treat as a credit event a debt redenomination by G7 countries. Therefore, the difference between the premium of the CR14 and the CR contracts, for France, Germany, and Italy, captures the risk-adjusted expected losses conditional on a sovereign debt redenomination. Investors can also buy, for both the CR14 and CR contracts, CDS denominated in different currencies to hedge the risk of a depreciation of the euro conditional on a credit event, which would most likely

[1]For empirical work on the relationship between sovereign debt markets and the macroeconomy see, for example, Adelino, Cunha, and Ferreira (2017), Becker and Ivashina (2018), Acharya, Eisert, Eufinger, and Hirsch (2018); while Gennaioli, Martin, and Rossi (2014) provide an interesting theoretical framework. For a discussion on debt redenomination after a country exit from the Eurozone see, for example, Canofari, Marini, and Piersanti (2015), Pastor and Veronesi (2018), Kremens (2019), Balduzzi, Brancati, Brianti, and Schiantarelli (2019).

reduce the real payouts of any default insurance contracts. We use the difference between the premium of contracts denominated in U.S. dollar and euro to measure the risk-adjusted expected depreciation of the euro conditional on a credit event, like an outright default or a debt redenomination.

In order to estimate the network of breakup risk spillovers in the Eurozone, we start from the ΔCoVaR measure of systemic risk developed by Adrian and Brunnermeier (2016). Given two variables Y and X, ΔCoVaR is defined as the change in value at risk (VaR) of Y conditional on X being at its VaR relative to its median state. We critically extend this measure with respect to two dimensions. First, we estimate a multiple-regression version of ΔCoVaR, which we label ΔMCoVaR, to account for additional relevant variables, and their interactions with the X variable. For example, X could be a sovereign in a situation of distress because of the effect of a third, omitted, sovereign Z. Second, we deal with the curse of dimensionality using machine learning regularization techniques, and we combine the Least Absolute Shrinkage and Selection Operator (LASSO) and ridge methods and consider the elastic net (Zou and Hastie, 2005). The combination of a multiple-regression version of ΔCoVaR with the elastic net enables us to identify the systemic risk contributors out of a large sample of candidate factors. Our results show that redenomination shocks spillover to other Eurozone members, increasing the redenomination premium of other sovereigns. These effects are significant, economically important, and as large as 20 percent of the unconditional daily VaR. While redenomination shocks to France increase the risk of a breakup of the Eurozone, redenomination shocks to Italy increase the risk of sovereign defaults, like sovereign debt restructurings. Accounting simultaneously for redenomination shocks in many sovereigns is crucial in identifying the risk contributions of different countries and factors. For example, when we consider the effects of redenomination shocks to France, we find that they *directly* affect the risk of a debt redenomination by Germany and Italy. In addition, our model identifies second round, or *indirect*, effects of Italian redenomination shocks to the risk of a debt redenomination by Germany that increase investors' expectation of a euro depreciation.

To evaluate the robustness of our analysis, we perform a battery of robustness checks. First, we estimate the network of redenomination risk spillovers also using the standard ΔCoVaR

(Adrian and Brunnermeier, 2016). This univariate systemic risk measure confirms our results, but also finds additional significant contributing effects. However, these effects depend on an omitted variable problem. Once the potential simultaneous effect of all the factors is correctly estimated, the contribution of these factor is not significant. Second, we corroborate our results by estimating an alternative multiple-regression version of ΔCoVaR using the LASSO in place of the elastic net quantile regression. Because LASSO selects, by construction, a smaller number of significant factors, the estimated effects are stronger, but the selected significant coefficients are the same as those we find with the elastic net estimation. Third, we study the out of sample performance of our model, for both the elastic net and post-LASSO specifications, and show that the former makes less frequent mistakes. Finally, we show that our results are unchanged using CDS with different maturities.

This paper contributes to two strands of the literature. The first looks at default risk in the Eurozone and estimate the redenomination risk using CDS in different currencies (De Santis, 2018, Borri, 2019); market quotes from prediction markets (Klose and Weigert, 2014); and bonds under domestic and foreign jurisdiction (Bayer, Kim, and Kriwoluzky, 2018). The papers closest to ours are Cherubini (2019) and Kremens (2019), who also measure redenomination risk using CDS with different default clauses. With respect to this strand of the literature, we further isolate the currency premium component of redenomination risk; we focus on the entire term structure; and we study the spillover effect of default and breakup risks in the Eurozone. Second, this paper contributes to the literature on networks and vulnerability to tail-risk. In this paper, we estimate the vulnerability of Eurozone countries with the reduced-form risk-measure ΔCoVaR, or conditional value-at-risk, first proposed by Adrian and Brunnermeier (2016)[2]. CoVaR is a measure of risk conditional upon an adverse shock, where risk is the standard value at risk. While CoVaR is a univariate systemic risk-measure, the literature on networks has explored multi-variate, multi-quantile models (White, Kim, and Manganelli, 2015); and high-dimensional networks (Fan, Härdle, Wang, and Zhu, 2018, Hautsch, Schaumburg, and Schienle, 2014). This paper builds a bridge between these two methodologies for the estimation

[2]There exist several alternative measures of systemic risk and exposure to tail-risk. For example, Acharya, Engle, and Richardson (2012), Billio, Getmansky, Lo, and Pelizzon (2012), Brownlees and Engle (2017), Acharya, Pedersen, Philippon, and Richardson (2017).

of tail-risk exposure and proposes a multiple-regression version of CoVaR, based on quantile estimations with elastic net, that can accommodate high-dimensional environments, and has a more flexible penalty function than the ℓ_1-norm penalty characterizing the LASSO. Using a different framework, based on variance decomposition in VAR models, Gross and Siklos (2019) estimate spillover effects among a large set of financial institutions in the Eurozone using the elastic net. Xu, Li, Jiang, and He (2019) is the only other extension of CoVaR to multiple variables and is based on LASSO. With respect to this paper, we evaluate the post-LASSO procedure proposed by Belloni and Chernozhukov (2011) to address the risks of bias estimates and over-shrinking the retained variables (Fan and Li, 2001); and of selection of relevant regressors in case of cluster structure among highly correlated covariates (Zou and Hastie, 2005).

The rest of the paper is organized as follows: section 2 presents the data and describes our measure of redenomination risk and its decomposition; section 3 presents the MCoVaR model, and our estimates for the network of breakup and default risk spillovers; section 4 shows that our results are robust with respect to various controls and extend the analysis to the entire term structure; finally, section 5 presents our conclusions.

2 Redenomination Risk

This section presents the data and a decomposition of the redenomination premium in components related to pure redenomination risks and currency risks conditional on a credit event.

2.1 Data

We collect daily sovereign CDS data for a sample of countries in the Eurozone from Markit for the period 10/1/2014 to 7/1/2019. The countries in the sample are: Austria, Germany, France, Belgium, Spain, Finland, Ireland, Italy, Portugal, and Spain. We exclude Greece as its public debt is mostly held by official lenders in the period covered by our analysis. CDS are available in different currencies, in different tenors, and with different default clauses. Default clauses specify the events that constitute a “default” and trigger the CDS. We focus on CDS contracts denominated in euros and U.S. dollars, and based on the standard CR and CR14 default clauses, which treat the redenomination event in part differently. While in our baseline analysis we focus on CDS contracts with a horizon of 5 years, which are the most liquid, in the robustness analysis we also explore the entire term structure, from 6 to 180 months. Table 2 presents the summary statistics for the sample Eurozone sovereign CDS with default clauses CR14 (in Appendix A we present similar quantitatively results for contracts with default clauses CR). We first summarize the stylized facts for the CDS premia in levels (Panel A of the Table). First, the CDS premium for dollar contracts is on average higher and more volatile than for euro contracts. Intuitively, this evidence reflects investors' expectation of a euro depreciation conditional on a credit event in the Eurozone and the volatility of the spot exchange rate. Second, we observe that there exists a large heterogeneity in the CDS premia across countries. For example, while for Italy the mean euro CDS premium is approximately 125 basis points (bp), for Germany it is just 9 basis points. These differences reflect the large heterogeneity in sovereign default risks in the Eurozone. Third, CDS premia are volatile and, for countries with relatively high default risk, can reach very large values. For example, despite the fact that our sample starts after the sovereign debt crisis in the Eurozone, for Italy the maximum premium in euro is approximately 240bp, and the 95 percent value at risk is approximately equal to 200bp. We now summarize the main stylized facts for the changes in CDS premia (Panel B of the Table). First, daily changes in CDS premia are on average very close to zero for all countries, and an order of magnitude more volatile for Italy, Portugal, and Spain. Second, for all countries, daily changes in CDS premia have large values of kurtosis, indicating that extreme values are more likely than if their distribution was normal.

Appendix A presents additional details on CDS contracts and on the different default clauses, and stylized facts for CR contracts in dollars and euro (see Table A1); on the gross and net notional of sovereign CDS contracts (see Figure A1) and trade counts (see Table A2); on bid/ask spreads (see Table A3).

Table 1: Summary Statistics

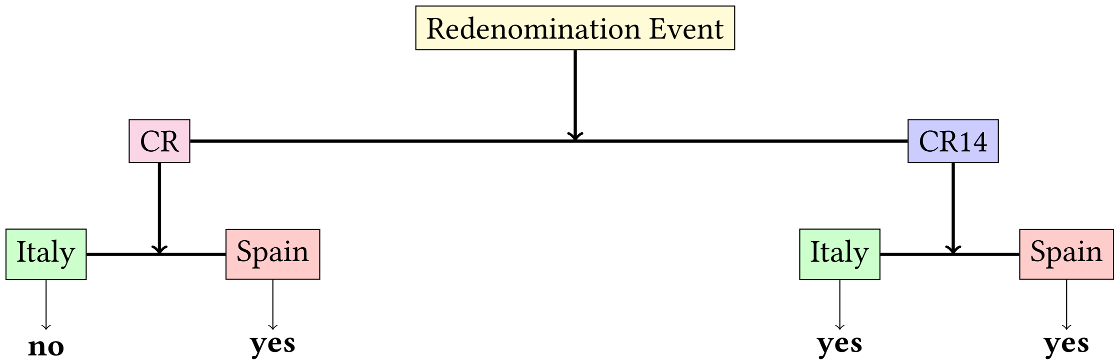
	Panel A: CR14 – levels (bp)									
	euro CDS premium					dollar CDS premium				
	μ	σ	min	max	VaR	μ	σ	min	max	VaR
Austria	15.194	5.489	5.513	27.310	22.698	21.495	6.750	11.565	37.949	30.455
Belgium	23.388	10.025	8.381	52.940	39.014	32.307	11.949	14.760	68.012	50.561
Finland	14.417	4.197	8.334	24.463	20.256	19.333	5.282	11.910	31.517	27.243
France	22.552	8.018	10.646	47.997	39.620	31.931	10.287	15.635	68.242	53.526
Germany	9.760	2.598	4.618	17.303	14.583	15.091	3.701	8.351	30.838	21.838
Ireland	36.498	12.766	15.206	80.938	56.018	45.725	14.175	20.305	91.698	68.269
Italy	125.099	36.551	61.398	238.905	199.728	151.859	45.835	85.354	286.095	246.256
Portugal	147.495	70.453	34.537	330.494	258.650	171.391	77.464	43.669	355.309	293.432
Spain	61.471	17.751	24.283	110.869	90.499	78.323	18.616	35.977	136.714	106.565
	Panel B: CR14 – first differences (bp)									
	Δ euro CDS premium					Δ dollar CDS premium				
	μ	σ	S	K	VaR	μ	σ	S	K	VaR
Austria	-0.013	0.594	1.436	59.334	0.599	-0.015	0.503	2.055	31.660	0.645
Belgium	-0.022	0.779	8.559	186.427	0.669	-0.024	0.896	6.747	135.916	0.907
Finland	-0.009	0.451	0.908	34.061	0.487	-0.014	0.654	1.587	32.493	0.797
France	-0.019	1.062	-2.094	73.119	1.115	-0.018	1.322	-2.502	91.761	1.317
Germany	-0.005	0.550	-0.499	36.304	0.567	-0.007	0.542	0.968	79.571	0.613
Ireland	-0.026	1.391	1.862	48.022	1.831	-0.030	1.289	4.601	86.628	1.646
Italy	0.018	5.916	3.999	82.054	7.548	0.032	5.944	5.366	104.027	7.089
Portugal	-0.118	5.677	1.270	13.072	8.314	-0.127	5.312	1.612	18.252	7.232
Spain	-0.034	2.806	1.739	21.209	3.930	-0.041	2.919	2.347	30.830	3.995

Notes: This table reports summary statistics for the sample Eurozone sovereign CDS contracts in euros and dollars, with default clause CR14 (in Appendix A we present the same descriptive statistics for contracts with default clause CR). Panel A refers to the CDS premia in levels and reports means (μ), standard deviations (σ), minimum values (min), maximum values (max), and value at risks with confidence 5% (VaR). Panel B refers to the CDS premia in first differences and reports means (μ), standard deviations (σ), skewness (S), kurtosis (K), and value at risks with confidence 95% (VaR). All CDS are with a horizon of 5 years. Data are daily from Markit for the period 10/1/2014 to 7/1/2019 and reported in basis points.

2.2 Decomposition of Redenomination Risk

For contracts based on ISDA 2003 default definitions (i.e., CR), redenomination does not trigger a credit event as long as it involves the currencies of the G7 countries and AAA-rated OECD economies. The current ISDA 2014 definitions (i.e., CR14) limit these currencies to the "lawful currencies of Canada, Japan, Switzerland, the United Kingdom, the U.S., and the euro and any successor currency to any of the aforementioned currencies (which in the case of the euro, shall mean the currency which succeeds to and replaces the euro in whole)" (ISDA, 2014). Therefore, under the current CR14 clause, investors are always protected against the possibility that a Eurozone country decides to redenominate its public debt in a new currency. On the contrary, investors are not protected against this risk under contracts based on the previous CR clause if the redenomination involves the currencies of France, Germany, and Italy, since they are G7 countries. For example, Figure 1 considers the effect of a debt redenomination in Italy and Spain for CR and CR14 sovereign CDS contracts. A debt redenomination in Italy or Spain triggers both the CR14 contracts, but only the CR contracts of Spain. This is because Italy is part of the G7, while Spain is not.

Figure 1: Redenomination and Default Clauses



Notes: This figure exemplifies the response of sovereign CDS contracts with different default clauses conditional on a redenomination event. We consider default clauses CR and CR14, and two countries: Italy, and Spain. Note that "yes" and "no" refer to whether the CDS is triggered, or not.

In this paper we exploit the differences in the default clauses for CR and CR14 contracts to construct a measure of redenomination risk. Specifically, denote with $CDS^{i,d,k}$ a credit default swap contract for country i = {France, Germany, Italy}, default clause $d = \{CR, CR14\}$, and denominated in currency $k = \{€, \$\}$ (i.e., either the euro or the U.S. dollar). We denote the redenomination premium in currency k with

$$RP_t^{i,k} = CDS_t^{i,CR14,k} - CDS_t^{i,CR,k} \tag{1}$$

Intuitively, (1) measures, possibly up to a liquidity premium, the premium that investors are willing to pay to buy an insurance against the risk of redenomination for Eurozone G7 countries. Therefore, we take (1) as measure of the risk-adjusted expected loss conditional on a redenomination event in sovereign i[3].

[3]Note that differences between CR and CR14 contracts also depend on the "Asset Package Delivery" (APD) clause introduced by the ISDA 2014 credit derivative definitions. However, the APD does not distinguish between G7 and non-G7 countries (see Appendix A and the discussion in Kremens (2019) for further details). Also, if investors expect an outright default following a debt redenomination, then CR and CR14 contracts should have

Suppose investors expect a depreciation of the euro conditional on a credit event in the Eurozone, like a sovereign default or the redenomination of public debt in a newly issued currency. Investors can hedge the currency risk conditional on a credit event with CDS contracts denominated in different currencies. For example, investors can hedge the currency risk with CDS contracts denominated in U.S. dollars. Specifically, denote with S_t the nominal dollar-euro exchange rate, in units of dollars per euro, at time t. A euro denominated CDS contract (long protection) has a premium of €$C_0^{€}$ fixed at time $t = 0$, and a notional of $\$1 = €(1/S_0)$, implying an annualized payment of €$C_0^{€}/S_0$. A dollar denominated CDS, given the same notional, has an annual payment of $\$C_0^{\$}$, which is equivalent to €$C_0^{\$}/S_t$ at the spot exchange rates on the settlement dates. Investors call quanto-CDS a credit default swap on European sovereigns usually denominated in U.S. dollars. Eurozone sovereign CDS in U.S. dollars have on average higher premia than those in euros because investors expect the currency of a country in default to depreciate substantially (Reinhart, 2002, Na, Schmitt-Grohé, Uribe, and Yue, 2018). The quanto-CDS *premium* (or simply *quanto*) is defined as non-standard currency CDS premium minus standard currency CDS premium. The standard currency is the U.S. dollar. Therefore, we denote the quanto for country i with

$$Q_t^{i,d} = CDS_t^{i,d,€} - CDS_t^{i,d,\$} \tag{2}$$

where $d = \{CR, CR14\}$ denotes the default clause of the contracts used to build the quanto. Note that the quanto premium gives exposure to currency depreciation conditional on default, possibly up to a liquidity premium, because the only uncertain cash flow is the euro value in the dollar contract. Specifically, by buying the euro-denominated protection and selling the dollar-denominated one, investors can construct a position that benefits if there is no euro depreciation conditional on default (Lando and Bang Nielsen, 2018, Augustin, Chernov, and Song, 2018, Kremens and Martin, 2019)[4].

the same premium. Therefore, (1) measures the risk-adjusted expected loss conditional on a redenomination event not followed by an outright default.

[4]Note that an obligation is deemed deliverable into the contract settlement regardless of its currency of denomination or that of the CDS contract. This means that one and the same bond could be delivered into the settlements of CDS contracts of different denominations. Chernov, Gorbenko, and Makarov (2013) explain how the payoffs of a CDS contract are determined when a credit event occurs.

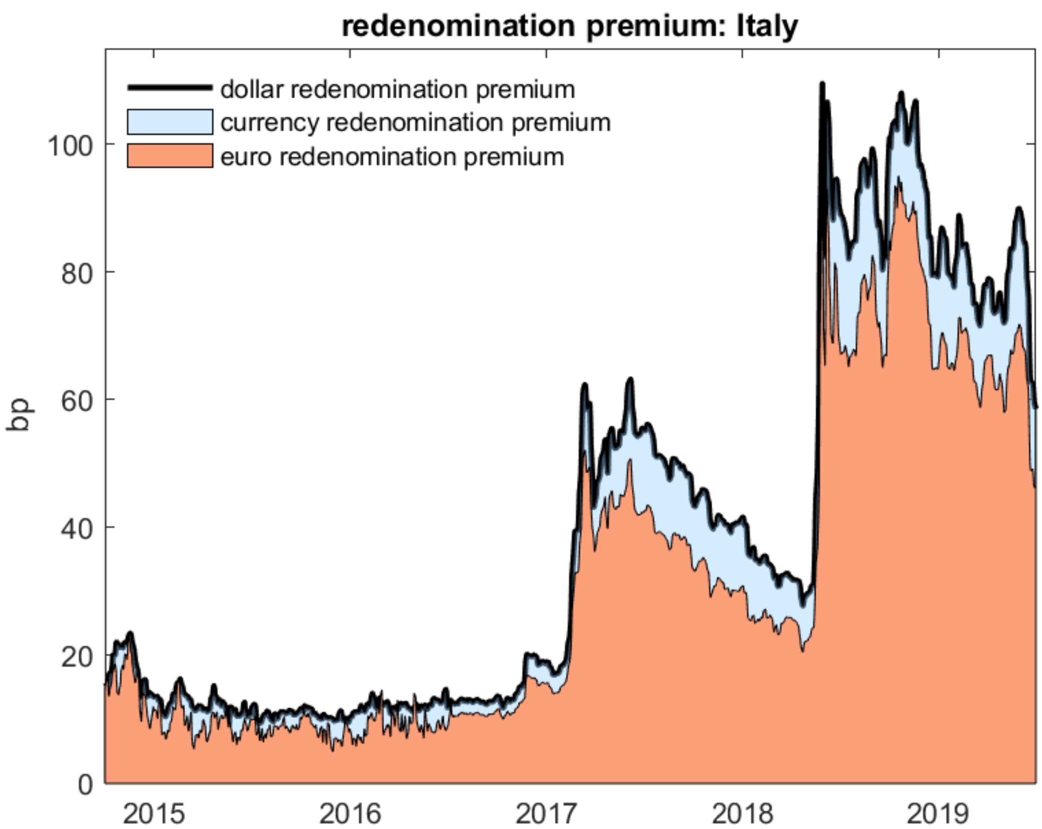
In what follows, we present a decomposition of the dollar redenomination premium in (1), for the G7 Eurozone sample countries, in components associated with the *direct*, euro, redenomination risk premium and the currency risk premium conditional on a redenomination event. Specifically, we decompose the dollar redenomination premium in

$$RP_t^{i,\$} = \underbrace{RP_t^{i,€}}_{\text{euro redenomination premium (ERP)}} + \underbrace{(Q_t^{i,CR} - Q_t^{i,CR14})}_{\text{currency redenomination premium (CRP)}} \quad (3)$$

where $i = \{\text{France, Germany, Italy}\}$. The two components in equation (3) have a clear interpretation. The first component represents the euro redenomination premium, or ERP. This is the premium investors must pay to receive a euro payoff in case of a redenomination of sovereign debt by country i. The second component represents the currency redenomination premium, or CRP. This is the additional premium investors must pay to receive a dollar payoff, rather than a euro payoff, in case of a redenomination of sovereign debt by country i. Note that the currency redenomination premium is equal to the difference between the quanto premium constructed using, respectively, the CDS with CR and CR14 default clauses. CRP measures the risk-adjusted euro expected depreciation conditional on the redenomination of sovereign i. As an illustrative example, Figure 2 plots for one country, Italy, the dollar redenomination premium (black solid line), along the two components identified in equation (3). First, the figure shows that the redenomination premium is always positive. Intuitively, CDS contracts with default clauses CR14 are more expensive, as they insure investors against the same risks covered by the CDS with default clauses CR, and additionally against the redenomination risk. Second, most of the dollar redenomination premium is explained by the risk-adjusted probability of redenomination, captured by the euro redenomination premium (orange shaded area). The currency redenomination premium accounts, on average, for only 20% of the total. However, the relative importance of the currency redenomination premium fluctuates over time and goes from approximately 3% of the total for the 5% quantile, to almost 40% at the 95% quantile. Third, the redenomination premium for Italy presents two large spikes, explained by two political shocks which increased the Italian redenomination risk. The first spike corresponds to the constitutional referendum that brought down the incumbent pro-

Europe government (i.e., 12/4/2016); and the second spike corresponds to the sworn into office of a new euro-skeptic government (i.e., 6/11/2018). In Figure A2 in Appendix A we present similar figures for France and Germany. While for Germany the dollar redenomination premium, and its two components, are always smaller than 5 bp, for France they increase over the sample and have a spike in April 2017 at the times of the French elections. As for Italy, also for France and Germany the currency redenomination premium accounts to less than 30% of the dollar redenomination premium.

Figure 2: Decomposition of the Redenomination Premium: Italy



Notes: This figure plots the redenomination premium for Italy based on CDS contracts with a horizon of 5 years (solid black line), along the two components from the decomposition in equation (3): the euro redenomination premium and the currency redenomination premium. All series are smoothed with a 5-day moving average and reported in basis points. Data are daily from Markit for the period 10/1/2014 to 7/1/2019.

Table 2 presents descriptive statistics for our measure of redenomination risk, i.e., the redenomination premium, along the two components identified in equation (3), for France, Germany and Italy. The top panel reports mean, standard deviation, minimum and maximum values, and 95 percent value at risk for the variables in levels; the bottom panel reports mean, standard deviation, skewness, kurtosis and 95 percent value at risk for the variables in first differences. We summarize the information provided by Table 2 as follows. First, the mean dollar redenomination premium is positive for all countries and can be as low as 1.99 bp for Germany and as high as 38.63 bp for Italy. Second, for France and Italy the volatility of the dollar redenomination premium is approximately equal to its mean, while for Germany it is equal only to half of the mean value. Third, for all countries, the dollar redenomination premium is mostly accounted for by the euro redenomination premium, i.e., our measure of risk-adjusted probability of a redenomination event. For example, in the case of Italy, the country with the highest mean dollar redenomination premium, the euro redenomination premium is equal to approximately 31 bp while the currency redenomination premium is only equal to 7 bp. Fourth, considering the variables in first differences, we note that the redenomination premium, and its two components, are positively skewed for Italy and negatively skewed for France. Fifth, for all countries, the redenomination premium, and its two components, have large kurtosis. Finally, for variables in first differences, we note that the unconditional value at risks have a magnitude of only a few basis points per day. For example, in the case of Italy, value at risk ranges from approximately 2.1 bp *per day* in the case of the dollar redenomination premium to 3.1 bp *per day* in the case of the currency redenomination premium.

Table 2: Summary Statistics Redenomination Premium

	Panel A: levels (bp)														
	dollar redenomination premium					currency redenomination premium					euro redenomination premium				
	μ	σ	min	max	VaR	μ	σ	min	max	VaR	μ	σ	min	max	VaR
France	6.601	5.698	-1.321	36.200	15.018	2.067	2.240	-5.728	10.460	6.383	4.558	3.815	-0.373	25.740	9.907
Germany	1.999	0.871	-0.812	4.637	3.133	0.299	1.137	-4.171	4.099	1.423	1.694	0.780	-0.931	4.961	2.917
Italy	38.633	30.353	6.148	121.343	96.279	7.387	5.567	-5.086	22.856	17.172	31.246	25.384	1.857	108.850	79.686
	Panel B: first differences (bp)														
	Δ dollar redenomination premium					Δ currency redenomination premium					Δ euro redenomination premium				
	μ	σ	S	K	VaR	μ	σ	S	K	VaR	μ	σ	S	K	VaR
France	0.009	0.861	-7.828	174.364	0.814	0.003	0.749	-0.581	24.386	1.153	0.005	0.818	-3.557	71.192	1.022
Germany	0.003	0.244	0.627	13.365	0.354	0.003	0.463	0.030	23.089	0.556	-0.000	0.416	0.398	23.218	0.474
Italy	0.015	2.328	8.988	210.905	2.162	-0.001	2.016	0.937	19.328	3.158	0.017	3.060	4.219	116.392	3.651

Notes: For France, Germany and Italy, this table reports summary statistics for the redenomination premium based on CDS contracts with a horizon of 5 years, and the two components from the decomposition in equation (3): the euro redenomination premium and the currencyre-denomination premium. Panel A refers to the variables in levels, and reports means (μ), standard deviations (σ), minimum values (min), maximum values (max), and value at risks with confidence 95% (VaR). Panel B refers to the variables in first differences, and reports means (μ), standard deviations (σ), skewness (S), kurtosis (K), and value at risks with confidence 5% (VaR). Data are daily from Markit for the period 10/1/2014 to 7/1/2019 and reported in basis points.

3 Model

In this section we describe the methodology we use to analyze the network of redenomination risk spillovers among Eurozone countries and the estimation results. Building on the ΔCoVaR measure of systemic risk, developed by Adrian and Brunnermeier (2016), we critically introduce a multiple-regression framework and consider machine learning regularization techniques to account for a high-dimensional set of candidate contributing factors. We denote our systemic risk measure multiple-regression CoVaR, or MCoVaR.

3.1 Conditional Value-at-Risk

Let Y and X be two real-valued random variables. We denote the realizations of Y and X at time t as y_t and x_t, respectively, for $t = 1, \cdots, T$, and focus on $Q_\theta(y_t|\mathbf{I}_{t-1}, x_t)$; that is, the θ-th quantile of y_t conditional on the information set available at $t-1$ as well as on x_t, for $\theta \in (0, 1)$. For the sake of simplicity, we set $Q_\theta(y_t|\mathbf{I}_{t-1}, x_{i,t}) \equiv Q_\theta(y_t)$. In our study, Y and X quantify the default risks of two different countries. As a result, $Q_\theta(y_t)$ represents a measure of tail risk (i.e., the value at risk, or VaR) when θ takes large values in the interval $(0, 1)$; that is, when focusing on the right tail of the conditional distribution of y_t. We aim at measuring the relationships between y_t and x_t in the occurrence of tail events and, for this purpose, set $\theta \in [0.95, 1)$.

We start off the measure of systemic risk introduced by Adrian and Brunnermeier (2016), which builds on the following (linear) conditional quantile model:

$$Q_\theta(y_t) = \delta_\theta + \lambda_\theta x_t + \boldsymbol{\gamma}_\theta \mathbf{M}'_{t-1}, \tag{4}$$

where $\mathbf{M}_{t-1}$ is a $1 \times K$ vector of control variables observed at time $t-1$.

We estimate the parameters in (4) using the quantile regression method introduced by Koenker and Bassett (1978) and denote the resulting coefficients as $\widehat{\delta}_\theta$, $\widehat{\lambda}_\theta$ and $\widehat{\boldsymbol{\gamma}}_\theta$. We then compute the CoVaR as:

$$CoVaR_{t,\theta,\tau}^{y_t|x_t=\widehat{q}_\tau(x_t)} = \widehat{\delta}_\theta + \widehat{\lambda}_\theta \widehat{q}_\tau(x_t) + \widehat{\boldsymbol{\gamma}}_\theta \mathbf{M}'_{t-1}, \tag{5}$$

where $\widehat{q}_\tau(x_t)$ is the τ-th sample quantile of x_t; we set $\tau \in [0.95, 1)$ such that $q_\tau(x_t)$ reflects the VaR of x_t at the level τ.[5]

In what follows, we save on notation and do not use t, θ and τ as subscripts or $y_t|x_t = \widehat{q}_\tau(x_t)$ as superscript when we refer to the CoVaR. We can also compute the CoVaR of y_t conditional on the normal (or median) state of x_t:

$$CoVaR_{t,\theta,1/2}^{y_t|x_t=\widehat{q}_{1/2}(x_t)} = \widehat{\delta}_\theta + \widehat{\lambda}_\theta \widehat{q}_{1/2}(x_t) + \widehat{\boldsymbol{\gamma}}_\theta \mathbf{M}'_{t-1}. \tag{6}$$

By subtracting (6) from (5), we obtain the ΔCoVaR, which takes the following form:

$$\Delta CoVaR_{\theta,\tau}^{Y|X} = \widehat{\lambda}_\theta \left[\widehat{q}_\tau(x_t) - \widehat{q}_{1/2}(x_t)\right]. \tag{7}$$

The ΔCoVaR quantifies the marginal impact of x_t on the VaR of y_t, i.e., when x_t moves from its median, or normal state, to its VaR, or distress state. As a result, the larger the ΔCoVaR is, the higher the vulnerability of country Y to shocks to country X. We estimate the quantiles of y_t and x_t at the same level; that is, we set $\theta = \tau$. Hence, we further simplify the notation by setting $\Delta CoVaR_{\theta,\tau}^{Y|X} = \Delta CoVaR_\theta^{Y|X}$.

3.2 Multiple-regression Conditional Value-at-Risk

The ΔCoVaR of Adrian and Brunnermeier (2016) quantifies the marginal contribution of a shock to the conditioning sovereign X to the VaR of Y, when x_t moves from its median to its own VaR. However, this method does not consider the potential effects of other sovereigns when estimating the relationships between x_t and y_t in their extreme quantiles. For instance, let us consider three different sovereigns and denote the changes in their CDS spreads, or redenomination premia, at time t as $x_{1,t}$, $x_{2,t}$ and $x_{3,t}$, respectively. We can evaluate the impact of both $x_{1,t}$ and $x_{2,t}$ on the VaR of $x_{3,t}$ by computing, respectively, $\Delta CoVaR_\theta^{X_3|X_1}$ and $\Delta CoVaR_\theta^{X_3|X_2}$.

[5] Note that we could also use $\widehat{Q}_\tau(x_t)$ in (5) in place of $\widehat{q}_\tau(x_t)$, where $\widehat{Q}_\tau(x_t)$ is dynamically estimated from the following quantile regression model: $Q_\tau(x_t) = \alpha_\tau + \boldsymbol{\beta}_\tau \mathbf{M}'_{t-1}$, for $t = 2, \ldots, T$.

The estimation of these ΔCoVaRs is based on the following models:

$$Q_\theta(x_{3,t}) = \delta_{1,\theta} + \lambda_{1,\theta} x_{1,t} + \boldsymbol{\gamma}_{1,\theta}\mathbf{M}'_{t-1}$$

$$Q_\theta(x_{3,t}) = \delta_{2,\theta} + \lambda_{2,\theta} x_{2,t} + \boldsymbol{\gamma}_{2,\theta}\mathbf{M}'_{t-1},$$

which are estimated separately, preventing us from capturing the interactions between $x_{1,t}$ and $x_{2,t}$ when measuring their impact on $Q_\theta(x_{3,t})$. We overcome this limitation by including all the N sovereigns in our study in a unique quantile regression model. For instance, when estimating the θ-th conditional quantile of the N-th sovereign, we define the following specification:

$$Q_\theta(x_{N,t}) = \delta_\theta + \boldsymbol{\lambda}_\theta \mathbf{x}'_{t,-N} + \boldsymbol{\phi}_\theta \mathbf{M}'_t + \boldsymbol{\gamma}_\theta \mathbf{M}'_{t-1}, \tag{8}$$

where $\mathbf{x}_{t,-N} = [x_{1,t}\ x_{2,t}\ \cdots\ x_{N-1,t}]$, $\boldsymbol{\phi}_\theta = [\phi_{1,\theta}\ \phi_{2,\theta}\ \cdots\ \phi_{N-1,\theta}]$, and $\boldsymbol{\lambda}_\theta = [\lambda_{1,\theta}\ \lambda_{2,\theta}\ \cdots\ \lambda_{N-1,\theta}]$. Note that, for additional flexibility, we introduce $\boldsymbol{\phi}_\theta$ which is a vector of coefficients for the controls at time t.

Our method should be flexible in dealing with large values of N. Nevertheless, the number of parameters to estimate in (8) increases with N and the resulting accumulation of estimation errors becomes a critical issue when the variables of interest are highly correlated. We do not know a priori which of the covariates in (8) are relevant to explain $Q_\theta(x_{N,t})$. A large number of regressors typically implies overfitting issues, whereas we run the risk of an omitted variable bias when using a restricted subset of covariates. We deal with the curse of dimensionality using regularization techniques. Specifically, we combine the Least Absolute Shrinkage and Selection Operator (LASSO) and ridge methods and consider the elastic net. Zou and Hastie (2005) compare the LASSO and the ridge regression, showing that neither technique consistently outperforms the other. This evidence has prompted them to develop a convex combination of the LASSO ($||\boldsymbol{\beta}_\theta||_1$) and the ridge ($||\boldsymbol{\beta}_\theta||_2^2$) penalty functions; that is, the elastic net. The elastic net provides a sparse model with a good prediction accuracy, inheriting the benefits of both the LASSO and the ridge regression. The elastic net quantile regression model builds on the minimization of the following loss function:

$$L(\delta_\theta, \boldsymbol{\beta}_\theta) = \frac{1}{T-1}\sum_{t=2}^{T} \rho_\theta \left(x_{N,t} - \delta_\theta - \boldsymbol{\beta}_\theta \mathbf{Z}'_t\right) + \nu \left[\alpha ||\boldsymbol{\beta}_\theta||_1 + \frac{1-\alpha}{2}||\boldsymbol{\beta}_\theta||_2^2\right], \quad (9)$$

where $\nu > 0$ and $0 \leq \alpha \leq 1$. The parameter ν regulates the magnitude of the penalization, whereas α determines the weights of the penalty functions $||\boldsymbol{\beta}_\theta||_1$ and $||\boldsymbol{\beta}_\theta||_2^2$ in (9). Therefore, when minimizing the loss function in (9), we need to compute the optimal value of α and ν. In contrast, the loss functions of the standard LASSO and ridge objectives depend only on ν. We jointly calculate the optimal values of α and ν by employing a 10-fold cross-validation, which is commonly used in applied machine learning, being flexible and easy to understand and implement, providing at the same time accurate results (Hastie, Tibshirani, and Friedman, 2009). The cross-validation method is flexible to be used for any penalized quantile regression model, regardless of the specification of the penalty function.

We efficiently minimize the function in (9) by implementing the Semi-Smooth Newton Coordinate Descent (SNCD) algorithm proposed by Yi and Huang (2017).[6] The standard errors of the coefficients resulting from (9) are computed using the nonparametric xy-pair method (Davino, Furno, and Vistocco, 2014). After estimating the parameters from (9), we compute the multiple-regression CoVaR (MCoVaR) of the N-th sovereign conditional on either the distress or the median state of the i-th sovereign (for $i = 1, \cdots, N-1$), respectively, as follows:

$$MCoVaR_{t,\theta,\tau}^{x_{N,t}|x_{i,t}=\widehat{q}_\tau(x_{i,t})} = \widehat{\delta}_\theta + \sum_{\substack{j=1 \\ j\neq i}}^{N-1} \widehat{\lambda}_{j,\theta} x_{j,t} + \widehat{\lambda}_{i,\theta}\widehat{q}_\tau(x_{i,t}) + \widehat{\boldsymbol{\phi}}_\theta \mathbf{M}'_t + \widehat{\boldsymbol{\gamma}}_\theta \mathbf{M}'_{t-1}, \quad (10)$$

$$MCoVaR_{t,\theta,1/2}^{x_{N,t}|x_{i,t}=\widehat{q}_{1/2}(x_{i,t})} = \widehat{\delta}_\theta + \sum_{\substack{j=1 \\ j\neq i}}^{N-1} \widehat{\lambda}_{j,\theta} x_{j,t} + \widehat{\lambda}_{i,\theta}\widehat{q}_{1/2}(x_{i,t}) + \widehat{\boldsymbol{\phi}}_\theta \mathbf{M}'_t + \widehat{\boldsymbol{\gamma}}_\theta \mathbf{M}'_{t-1}. \quad (11)$$

We then obtain the ΔMCoVaR by subtracting (11) from (10) :

$$\Delta MCoVaR_\theta^{X_N|X_i} = \widehat{\lambda}_{i,\theta}\left[\widehat{q}_\tau(x_{i,t}) - \widehat{q}_{1/2}(x_{i,t})\right]. \quad (12)$$

[6]We standardize the regressors before minimizing the loss in (9) such that they are expressed in the same scale.

We note that the quantities defined in (7) and (12) take the same form. Nevertheless, $\widehat{\lambda}_{i,\theta}$ in (12) is computed taking into account the relationships among all the sovereigns in our study and selecting only the ones which have a significant impact on the VaR of $x_{N,t}$. In contrast, the univariate-regression approach of Adrian and Brunnermeier (2016) always produces non-null ΔCoVaR values, even if a conditioning sovereign has a poor impact when compared to the other sovereigns.

3.3 Estimation Results

In this section we present the results of our estimation for two models. In the first model, the dependent variable is the dollar redenomination premium described in (3), i.e., the premium required to buy dollar insurance against the risk of a debt redenomination. In the second model, the dependent variable is the dollar CDS premium with CR14 clauses, i.e., the dollar premium required to buy insurance against the risks of an outright sovereign default or sovereign debt redenomination. In both models, the covariates are the euro redenomination premium (ERP) and currency redenomination premium (CRP) of France, Germany and Italy; and all variables are in first differences and constructed using contracts with a maturity of 5 years. In addition, all regressions also include a set of control and state variables, and a variable which captures liquidity shocks to the sovereign CDS market. Specifically, we include the time t and $t-1$ returns of the S&P Global Euro equity index; the IBOXX Euro corporate index; the VDAX volatility index; and the euro 1-month OIS index, which we obtain from Datastream. These variables capture time-variation in the redenomination and default premia not directly related to sovereign default shocks. We construct liquidity shocks starting from the principal components of the differences between CR14 and CR dollar contracts for Austria, Belgium, Spain, Finland, Ireland, Portugal, and Spain. In fact, for these countries we should expect no difference between CR14 and CR contracts, as they are both triggered by a redenomination event. However, in the data we observe small but significant and time-varying differences which we take as proxy for shocks to the liquidity of the sovereign CDS market[7].

[7] In all regressions we include the first two principal components of the differences between CR14 and CR dollar contracts for Austria, Belgium, Spain, Finland, Ireland, Portugal, and Spain, which account for more than 80 percent of the common variation. In the tables, we report only the coefficients corresponding to the first principal component, which we label "liquidity premium", as the coefficients corresponding to the second principal

We use the first model to study the network of breakup risks: i.e., the spillover of a redenomination shock in one Eurozone country on the redenomination risks of other Eurozone countries. We use the second model to study the network of default risks: i.e., the spillover of a redenomination shock in one Eurozone country on the default risks of other Eurozone countries. By decomposing the redenomination premium of the covariates in its ERP and CRP components, we are able to separately assess the effect of a *direct* redenomination shock and of an *indirect* currency redenomination shock. The former is proxied by the euro redenomination premium (ERP), and the latter by the currency redenomination premium (CRP). Note that, in the first model, we exclude form the covariates the ERP and CRP corresponding to the sovereign in the dependent variable.

Table 3 presents our main results. The top panel refers to the first model, and the bottom panel to the second model. Rows denote the response variable for each sovereign. Columns denote, for each sovereign, the covariates: the euro redenomination premium, the currency redenomination premium, and the liquidity premium. The table reports the estimates for the contribution of each covariate to the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the response variable, and we denote with stars the level of significance of the corresponding coefficients $\widehat{\lambda}_{i,\theta}$ in (12). For example, a value of 1% associated to the coefficient $\widehat{\lambda}_{i,\theta}$ (e.g., the ERP for France), indicates that the value at risk of the response variable (e.g., the response of the redenomination premium of Germany) increases by 1% when the variable i moves from its median state to the level θ%. In the empirical estimation we set $\theta = 0.95$%. Importantly, the coefficient of X is estimated simultaneously accounting for the effect of additional covariates (e.g., the ERP for Italy). We start by describing the estimation results for the first model, i.e., the response of the redenomination premium. First, we find that none of the covariates contributes significantly to the conditional value at risk of France. Therefore, large shocks to the redenomination risk in France depend mostly on domestic French factors. Second, shocks to France and Italy contribute significantly to the conditional value at risk of Germany. In fact, we find significant coefficients corresponding to the French ERP and Italian CRP. Both factors contributes approximately to 16 percent of the unconditional

component are never significant. Note that the first principal component is highly and positively correlated to the mean differences between the CR14 and CR dollar contracts for these sovereigns.

value at risk of Germany. Interestingly, these shocks propagate through different channels. While the contribution of France goes through a direct increase of its redenomination risk (i.e., ERP), the contribution of Italy goes through an increase in the expected depreciation of the euro conditional on a debt redenomination. Third, only redenomination shocks to France contribute significantly to the conditional value at risk of Italy. Specifically, similarly to the case of Germany, also in the case of Italy the contribution of France goes through a direct increase in its redenomination risk, and is approximately equal to 16% of the unconditional value at risk. In addition, also the liquidity factor contributes significantly to the conditional value at risk of the Italian redenomination premium. Our interpretation of these results is that redenomination shocks to France increase the breakup risk of the Eurozone, as they contribute significantly to the increase in the redenomination risks of both Germany and Italy. On the contrary, the contribution of the shocks to Italy are indirect: conditional on a breakup, a redenomination of the Italian sovereign debt is expected to lower the value of the euro, and thus increase the cost of insurance against a German redenominationexpressed in dollars. Note that the unconditional value at risk of the German redenomination premium is one order of magnitude smaller than for Italy. Therefore, although the contribution of French ERP shocks to Germany and Italy is similar as a fraction of the unconditional value at risk, the spillover to Italy is economically larger. We now consider the estimation results for the second model, i.e., the response of the default premium. In this case, we consider the effect also for the remaining sample countries, and not only France, Germany, and Italy. Not also that for these countries we cannot distinguish between the redenomination and the default premium, even though we expect the default premium component to be the largest. First, we find that all sample countries are exposed to redenomination shocks to Italy. While for Finland and Germany the contribution of Italian redenomination shocks goes through the CRP, for all the other countries it goes through a direct increase in the Italian redenomination premium. The magnitude of the effects can be as low as 7.87% in the case of Austria, and as large as 19.52% in the case of France. Interestingly, for Austria, Belgium, and France we find a significant contribution of both the currency and direct redenomination effect. Second, we find that shocks to France and Germany also have a significant contribution, but on a smaller number of countries. Specifically, while shocks to France contribute to the increase in the ΔMCoVaR of Germany and Italy through the direct redenomination effect, shocks to Germany contribute to the increase in the ΔMCoVaR of Belgium and Ireland through a currency depreciation effect. Finally, shocks to the liquidity factor contribute significantly to the increase in the default premium of France, Italy, Portugal and Spain. Our interpretation of these results is that, while shocks to the redenomination risk of France increase the risk of a breakup of the Eurozone, shocks to the redenomination risk of Italy increase the risk of default. For example, investors might expect that after a redenomination of the Italian sovereign debt, the Eurozone would survive, but many countries would seek a debt restructuring, which would trigger the CDS contracts, because they might be forced to bail-out the domestic financial sector.

In section 4 we compare our results for the ΔMCoVaR to those obtained using the original ΔCoVaR from Adrian and Brunnermeier (2016). In addition, we show that our results are robust to an alternative regularization method based on post-LASSO and on using CDS with different maturities. Finally, we consider the out of sample performance of the model both in the case of estimation with elastic net, and post-LASSO.

4 Robustness

In this section we present a number of extensions and robustness results. First, we compare our results to those we would obtain with the original ΔCoVaR from Adrian and Brunnermeier (2016). Second, we show that the baseline estimates obtained with the elastic net are robust with respect to an alternative regularization method using the post-LASSO penalty function. Second, we study the out of sample performance of our model, for both the elastic net and post-LASSO specifications, and show that the former makes less frequent mistakes. Finally, we show that our results are robust to using CDS with different maturities.

4.1 Univariate-ΔCoVaR

In this section we present estimation results using the original ΔCoVaR by Adrian and Brunnermeier (2016) for the two models. The first model considers the response of the redenomi-

Table 3: Estimation Results: ΔMCoVaR

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	0.000	0.000	0.000	3.173	7.529
GERMANY	-9.899	16.511***	--	--	15.164***	2.155	-0.774
ITALY	6.042	16.654***	0.907	3.674	--	--	30.489***

(b) MODEL 2: response of the default premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	9.990	4.609	8.087*	-4.345	9.465*	7.870***	7.455*
BELGIUM	7.681	0.000	10.490*	-7.035*	11.444*	15.527***	7.569
FINLAND	4.248	-2.056	0.790	-3.193	5.312*	-0.373	1.649
FRANCE	--	--	9.593*	-3.512	18.655***	19.520***	13.942**
GERMANY	1.198	7.910*	--	--	15.752**	5.857	7.813
IRELAND	0.000	4.365	10.000*	-2.610	6.763	12.850***	3.011
ITALY	3.391	5.565**	3.208	-1.856	--	--	11.817***
PORTUGAL	3.221	0.913	3.811	-3.333	3.630	10.827***	11.534***
SPAIN	4.617	0.739	4.404	-3.074	3.692	14.745***	9.198***

Notes: This table reports the estimates of the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the dependent variable, for equation (12) for two models using the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12). Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

nation premium of France, Germany, and Italy. The second model considers the response of the default premium in all sample Eurozone countries. In both cases, we consider the same covariates that we use in the baseline estimation with elastic net discussed in section 3.3. However, and differently from the ΔMCoVaR, in the estimation of the ΔCoVaR we estimate univariate regressions for each of the different covariates. We present our results in Table 4. We start by discussing the first model. First, we confirm the results that redenomination shocks to France contribute significantly to the increase in the redenomination risks of Germany and Italy. Specifically, the contribution of France goes through the ERP and is similar, but somewhat higher, than what we found using the ΔMCoVaR. Intuitively, while the ΔMCoVaR considers simultaneously the effects of all the covariates, the ΔCoVaR considers each of the covariates in isolation, and can end up attributing a larger weight to some covariates because of an omitted variable bias. For example, we observe that, when using the ΔCoVaR, and differently with respect to the results for the ΔMCoVaR, the Italian CRP's contribution to Germany redenomination premium is not significant, while the contribution of the French ERP is significant but larger in magnitude. Therefore, while also the univariate ΔCoVaR captures the significant French contribution to a Eurozone breakup, it misses instead the additional effect originating from the expected euro depreciation conditional on a debt redenomination by Italy. Note that, according to our results, the latter is more likely conditional on the French redenomination shock. Second, we confirm that France is insulated with respect to redenomination shocks in Germany and Italy; and that liquidity shocks are important contributors to the increase in the redenomination premium. We now discuss the results of the second model. Interestingly, while the ΔCoVaR confirms our result that redenomination shocks to Italy contribute to the default premium of all sample Eurozone countries, it also incorrectly predicts a significant (negative) contributions from German redenomination shocks because of the omission of relevant factors in the estimating regressions.

4.2 LASSO

In our baseline estimation we use the elastic net to address the risk of over-shrinking. In this section, we evaluate the robustness of our results with an alternative methodology, that is the

Table 4: Estimation Results: ΔCoVaR

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	9.165	-4.874	-12.167	11.798	18.434*
GERMANY	-19.386	20.387***	--	--	9.345	-1.565	-0.747
ITALY	-0.833	17.762***	-1.274	10.714	--	--	40.884***

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	21.220*	2.502	19.343**	-16.608**	5.622	7.005	18.469**
BELGIUM	18.183	-3.663	27.875***	-20.878**	8.931	15.811***	24.359*
FINLAND	9.645	-8.730	6.837	-11.590*	26.572**	-3.860	5.332
FRANCE	--	--	19.727**	-13.686**	8.292	25.390***	38.825***
GERMANY	2.588	17.012***	--	--	19.711	10.107	18.587**
IRELAND	-1.790	8.568	19.774**	-17.285**	0.960	15.979***	19.470
ITALY	21.726***	10.417**	12.363*	-8.640	--	--	24.999**
PORTUGAL	9.761	5.431	9.830	-7.056	-3.158	19.141***	35.950***
SPAIN	19.898***	-0.631	9.218	-7.909*	-1.547	16.896***	15.894*

Notes: This table reports the estimation coefficients for equation (7) (Adrian and Brunnermeier (2016)'sΔCoVaR) for two models, expressed as a fraction of the unconditional value at risk of the dependent variable. The ΔCoVaR measures the change in the value at risk of the response variable when the covariate moves from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t - 1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficient of the ΔCoVaR. Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

post-LASSO. Following Belloni and Chernozhukov (2011), who provide an extensive analysis of the properties of LASSO in a quantile regression framework, we estimate the parameters in (8) by minimizing the following loss function:

$$L(\delta_\theta, \boldsymbol{\beta}_\theta) = \frac{1}{T-1}\sum_{t=2}^{T} \rho_\theta \left(x_{N,t} - \delta_\theta - \boldsymbol{\beta}_\theta \mathbf{Z}_t'\right) + \nu \frac{\sqrt{\theta(1-\theta)}}{T-1} \sum_{j=1}^{N+K-1} \widehat{\sigma}_j |\beta_{j,\theta}|, \tag{13}$$

where $\mathbf{Z}_t = [\mathbf{x}_{t,-N}, \mathbf{M}_{t-1}]$ and $\boldsymbol{\beta}_\theta = [\boldsymbol{\lambda}_\theta, \boldsymbol{\gamma}_\theta]$; $\widehat{\sigma}_j$ is the sample standard deviation of the j-th variable in $\mathbf{Z}_t$ and $\beta_{j,\theta}$ is the j-th element in $\boldsymbol{\beta}_\theta$ (for $j = 1, \cdots, N+K-1$); $\rho_\theta(u) = u\left(\theta - \mathbb{I}_{\{u<0\}}\right)$ is the asymmetric loss function characterizing the quantile regression method introduced by Koenker and Bassett (1978), where $\mathbb{I}_{\{\cdot\}}$ is an indicator function which takes the value of one if the condition in $\{\cdot\}$ is true and the value of zero otherwise; $\nu > 0$ is a tuning parameter. The tuning parameter ν determines the intensity of the ℓ_1-norm penalty in (13): the greater ν is, the larger the number of coefficients in (13) which approach zero, resulting in a sparser solution. Therefore, only the intercept δ_θ would be different from zero for sufficiently large values of ν. Different methods have been proposed to select the optimal tuning parameter. Among them, we use the data-driven method proposed by Belloni and Chernozhukov (2011), which has optimal asymptotic properties. It requires to compute the following quantity:

$$\Lambda = (T-1) \max_{1\leq j\leq N+K-1} \left| \frac{1}{T-1} \sum_{t=2}^{T} \left[\frac{z_{j,t}\left(\theta - \mathbb{I}_{\{e_t \leq \theta\}}\right)}{\widehat{\sigma}_j \sqrt{\theta(1-\theta)}} \right] \right|, \tag{14}$$

where $z_{j,t}$ denotes the j-th variable in $\mathbf{Z}_t$, whereas $e_1, \cdots, e_T$ are i.i.d. uniform $(0,1)$ random variables.

We then estimate the empirical distribution function of Λ by running B iterations and compute the optimal value of ν as follows:

$$\nu^\star = c \cdot \Lambda(1-\beta|\mathbf{Z}_t), \tag{15}$$

where $\Lambda(1-\beta|\mathbf{Z}_t)$ is the $(1-\beta)$-th quantile of Λ conditional on $\mathbf{Z}_t$, whereas $c > 1$ is a scalar parameter.[8]

[8] Following Belloni and Chernozhukov (2011), we set $B = 100000$, $1-\beta = 0.9$ and $c = 2$ in our empirical analysis.

The LASSO is widely used in the statistical and econometric literature because it has important properties. Nevertheless, it also suffers from some limitations. For instance, it typically provides biased estimates, over-shrinking the retained variables (Fan and Li, 2001). Following Hautsch et al. (2014), we address these limitations using a post-LASSO procedure. Specifically, we first minimize the loss function in (13) and discard the j-th regressor in $\mathbf{Z}_t$ if its shrunken coefficient is, in absolute value, sufficiently close to zero; that is, if $\left|\widehat{\beta}_{j,\theta}\right| < \eta$, for $j = 1, \ldots, N+K-1$ (we set $\eta = 1e-12$ in the estimation). In contrast, we include the covariates which are LASSO-selected (i.e., the ones whose coefficients are, in absolute value, greater than or equal to η) in $\widetilde{\mathbf{Z}}_t$. In a second step, we then estimate the parameters of the LASSO-selected variables from the following standard quantile regression model (i.e., without imposing any penalty function):

$$L\left(\widetilde{\delta}_\theta, \widetilde{\boldsymbol{\beta}}_\theta\right) = \frac{1}{T-1} \sum_{t=2}^{T} \rho_\theta \left(x_{N,t} - \widetilde{\delta}_\theta - \widetilde{\boldsymbol{\beta}}_\theta \widetilde{\mathbf{Z}}_t'\right), \tag{16}$$

whereas the coefficients of the regressors which are not LASSO-selected are set equal to zero. We compute the standard errors of the coefficients resulting from (16) using a well-known bootstrapping procedure; that is, the xy-pair method, which provides accurate results without assuming any particular distribution of the error term (Davino et al., 2014).

Table 5 presents the results of the estimation of the spillover effects using post-LASSO for the models: the response of the redenomination premium and of the default premium. For both models, we find that the results with post-LASSO confirm the results we obtain with the elastic net. As expected, the magnitude of the effects estimated with post-LASSO is on average larger than with elastic net, as post-LASSO sets to zero some of the covariates. Therefore, this alternative regularization method confirms our conclusion that, while redenomination shocks to France increase the risk of a breakup of the Eurozone, redenomination shocks to Italy increase the risk of sovereign defaults.

4.3 Out-of-sample performance

We evaluate in this section the out-of-sample performance of our estimation methods, using a rolling window scheme which is suitable for time series analyses. In particular, we divide

Table 5: Estimation Results: ΔMCoVaR (post-LASSO)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	--	--	--	3.290	16.191*
GERMANY	--	18.891***	--	--	17.487*	--	--
ITALY	--	19.927***	--	--	--	--	33.518***

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	--	--	14.001*	--	--	2.966	17.898**
BELGIUM	--	--	32.718*	7.849	--	12.756*	4.766
FINLAND	--	--	--	--	--	--	--
FRANCE	--	--	14.494*	--	39.909***	35.671***	9.109
GERMANY	--	--	--	--	--	1.078	23.373**
IRELAND	--	--	19.291**	--	--	12.183**	--
ITALY	--	--	5.622	--	--	--	23.562***
PORTUGAL	--	--	7.294	--	--	11.433*	23.849**
SPAIN	--	--	--	--	--	19.489***	11.879*

Notes: This table reports the estimates of the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the dependent variable, for equation (12) for two models using the post-LASSO. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index; the IBOXX Euro corporate index; the VDAX volatility index; and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12). Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

our dataset into nested subsamples (that we use as training sets) having an increasing length, including iteratively additional information. As a result, we build estimation windows which are, from time to time, updated to capture the most recent dynamics of the market without losing the past history of the CDS movements. We then test the estimates obtained (ex-ante) from a given training set ending at time t on a validation set (including realizations observed ex-post) which spans the time interval $[t+1, t+w]$. Therefore, we assess the performance of our estimation methods from a forecasting perspective; that is, we derive estimates from data which do not go beyond the training set and evaluate their capability in anticipating events occurring in the immediate future.

First, we consider the first training set which covers the interval $[1, 100]$, from which we estimate the parameters of the following model using the elastic net penalty function described in section 3:[9]

$$Q_\theta(x_{j,t}) = \delta_{\theta,[1:100]} + \boldsymbol{\lambda}_{\theta,[1:100]}\mathbf{x}'_{t,-j} + \boldsymbol{\gamma}_{\theta,[1:100]}\mathbf{M}'_{t-1}. \tag{17}$$

Second, we consider the realizations of the first validation set (i.e., the data belonging to the interval $[101, (101+w-1)]$) and, keeping the coefficients $\widehat{\delta}_{\theta,[1:100]}$, $\widehat{\boldsymbol{\lambda}}_{\theta,[1:100]}$ and $\widehat{\boldsymbol{\gamma}}_{\theta,[1:100]}$ derived from (17), we obtain the following quantiles:

$$\widehat{Q}_\theta(x_{j,t}) = \widehat{\delta}_{\theta,[1:100]} + \widehat{\boldsymbol{\lambda}}_{\theta,[1:100]}\mathbf{x}'_{t,-j} + \widehat{\boldsymbol{\gamma}}_{\theta,[1:100]}\mathbf{M}'_{t-1}.$$

Third, we then compute the out-of-sample *hit* values (or violations) defined as follows:

$$h_{j,t} = \begin{cases} 1 & \text{if } x_{j,t} > \widehat{Q}_\theta(x_{j,t}) \\ 0 & \text{otherwise} \end{cases}, \tag{18}$$

for $t = 101, \cdots, (101+w-1)$ and $j = 1, \cdots, N$.

We repeat the procedure described above for the subsequent training and validation sets. The successive training sets are obtained by adding, from time to time, w observations to the previous estimation window. For instance, the second training set covers the interval $[1, (101+w-1)]$, whereas the third one is defined on $[1, (101+2w-1)]$. The increasing size of

[9]We include $[1:100]$ in the subscript of the parameters in (17) to highlight the fact that they are derived from the data observed in the interval $[1, \ldots, 100]$.

the resulting subsamples makes the analysis robust with respect to the length of the estimation window. In contrast, the validation sets, the number of which is equal to W, have a constant length (w), covering, respectively, the time intervals $[101, (101+w-1)]$, $[(101+w), (101+2w-1)]$, $[(101+2w), (101+3w-1)], \ldots$ For each of the W validation sets, we compute the violations using the estimates derived from the corresponding training sets. We then build an $N \times (w \cdot W)$ matrix $\mathbf{H}$ which includes the overall violations:

$$\mathbf{H} = \begin{bmatrix} h_{1,101} & h_{1,102} & \cdots & h_{1,100+w\cdot W} \\ h_{2,101} & h_{2,102} & \cdots & h_{2,100+w\cdot W} \\ \vdots & \vdots & \ddots & \vdots \\ h_{N,101} & h_{N,102} & \cdots & h_{N,100+w\cdot W} \end{bmatrix}. \tag{19}$$

We set $w = 20$ in our empirical analysis and, given the data availability, obtain $W = 55$ validation sets. We implement these procedures for both the elastic net and the post-LASSO estimation methods. In doing so, we can check whether and to what extent the out-of-sample performance of a penalized quantile regression model changes according to the specification of the penalty function. We compare the elastic net and the post-LASSO focusing on both the bias and the variance of the out-of-sample outcome, taking into account the target quantile level $\theta = 0.95$; that is, we should expect, on average, a proportion of violations which approaches $1 - \theta = 0.05$. For this purpose, we compute both the mean and the standard deviation of the violations for each row of $\mathbf{H}$ defined in (19) (i.e., for each sovereign as response variable).

We implement this exercise for our two models. The first model has the change in the dollar redenomination premium of country j as response variable. In contrast, the second model has the change in the dollar CDS spread of country j as response variable, for $j = 1, \cdots, N$. We report the results derived from these two models in Table 6 and Table 7 and summarize them as follows.

The violations produced by the elastic net exhibit a lower variance in ten out of twelve cases. In contrast, the estimates derived from the post-LASSO are more volatile, resulting in a greater uncertainty and larger confidence intervals. From a financial risk-management viewpoint, the elastic net offers more conservative estimates than the post-LASSO, as the former generates, on average, lower values of violations in all but one case. Moreover, the percentage of violations is greater than the threshold of $\theta = 0.05$ only in two cases when using the elastic net. In contrast, the post-LASSO exceeds the threshold of $\theta = 0.05$ in six cases, touching sometimes relevant values; see, for instance, the results for Germany and Italy in Table Table 7. Therefore, the elastic net is more appealing for both financial regulators and risk managers to mitigate or prevent ex-ante the effects of tail events.

Table 6: Out-of-sample statistics, response of the redenomination premium

	Elastic Net		post-LASSO	
	MEAN	ST. DEV.	MEAN	ST. DEV.
FRANCE	1.983	7.115	2.975	6.978
GERMANY	3.802	5.955	3.802	6.204
ITALY	5.620	10.804	6.777	11.181

Notes: The table reports the mean (%) and the standard deviation (%) of the proportions of out-of-sample violations computed over $W = 55$ validation sets, using the change in the dollar redenomination premium of each country in the first column as response variable. We use both the elastic net (left panel) and the post-LASSO (right panel) methods to obtain the estimates in the corresponding training sets. Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

Table 7: Out-of-sample statistics, response of the CDS premium

	Elastic Net		post-LASSO	
	MEAN	ST. DEV.	MEAN	ST. DEV.
AUSTRIA	2.479	4.755	3.802	5.955
BELGIUM	2.479	5.631	3.967	6.914
FINLAND	4.959	7.753	6.446	9.161
FRANCE	3.802	8.654	4.628	8.145
GERMANY	5.124	7.340	7.603	8.309
IRELAND	3.802	7.325	4.628	8.145
ITALY	4.959	8.319	8.264	9.095
PORTUGAL	2.479	6.621	5.950	9.086
SPAIN	1.983	4.505	5.289	6.898

Notes: The table reports the mean (%) and the standard deviation (%) of the proportions out-of-sample violations computed over $W = 55$ validation sets, using the change in the dollar default risk premium of each country in the first column as response variable. We use both the elastic net (left panel) and the post-LASSO (right panel) methods to obtain the estimates in the corresponding training sets. Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

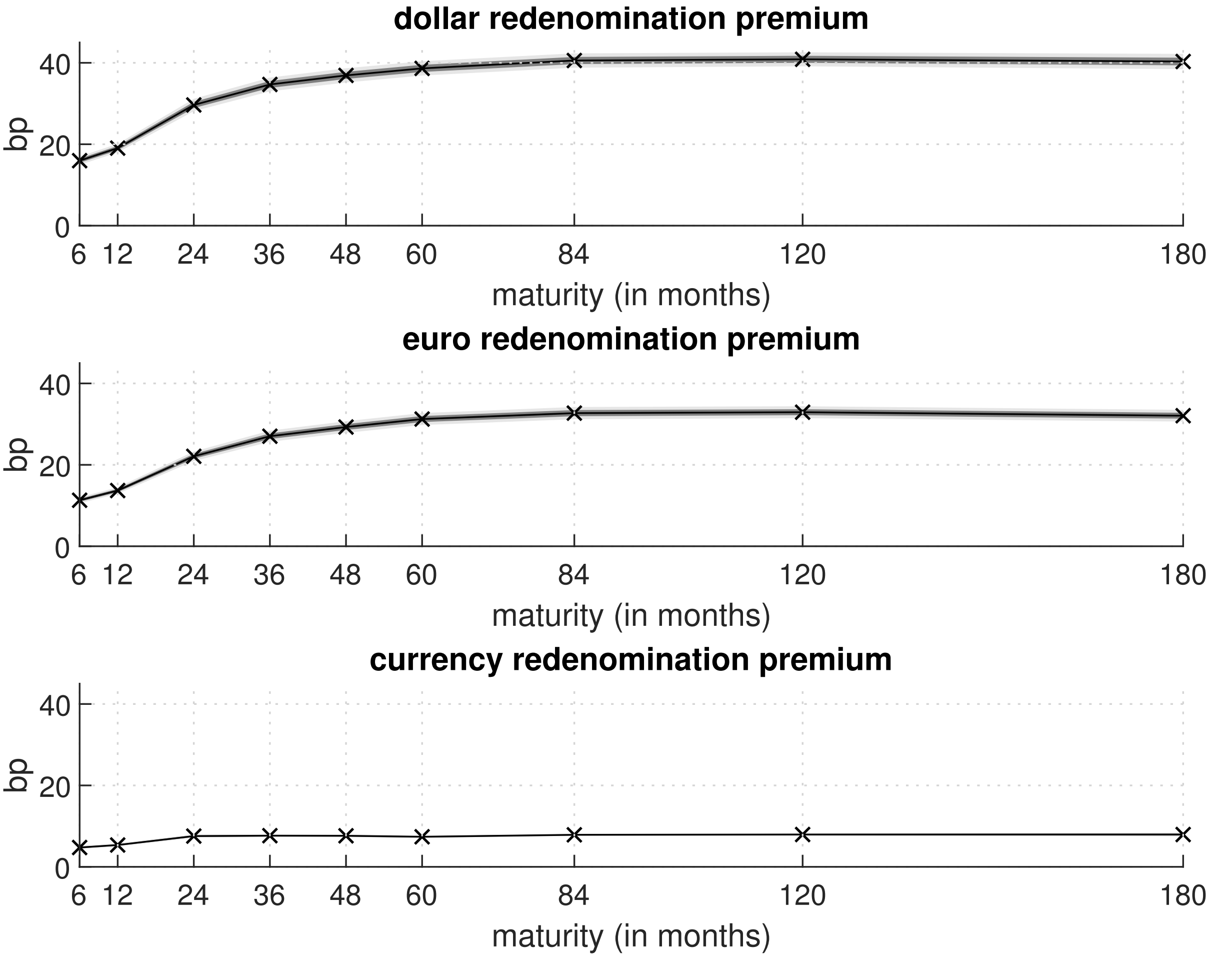
4.4 Different Maturities

In this section we explore the robustness of our results with respect to using CDS with different maturities. We start with a description of the stylized facts regarding the entire term structure of the redenomination premium, and its decomposition, using CDS contracts for maturities that go from 6 to 180 months. As an example, Figure 3 plots the evolution of the dollar redenomination premium (top panel); the euro redenomination premium (middle panel); and the currency redenomination premium (bottom panel), for Italy. The figures for France and Germany are qualitatively similar. First, we find that the dollar and euro redenomination premia increase with maturity up to 120 months, and then are approximately flat. Second, we find that also the currency redenomination premium increases with maturity up to 120 months, and then declines. We then estimate the ΔMCoVaR with elastic net using CDS with different maturities and find that our baseline results are robust to this extension. While in the appendix we report the detailed results for all countries and maturities, Figure 4 summarizes the estimation of the contributions to the Italian ΔMCoVaR for both models. In the figure we consider maturities of 3 years (squares), 4 years (circles), 5 years (triangle) and 7 years (diamonds), and use a solid color to denotes estimates significant at the 5% level. The top panel refers to the first model, i.e., the effect on the redenomination premium; the bottom panel refers to the second model, i.e., the effect on the default premium. In both cases, we find that the results presented in section 3.3 are confirmed. For both models, we find a positive contribution of the French ERP and the liquidity premium at all maturities. In addition, and for the first model, we also find a significant contribution of the French CRP at the 4 year maturity; and, for the second model, we find a significant contribution of the French and German CRP at the 3-year maturity.

5 Conclusions

Since the burst of the sovereign debt crisis, investors perceive the concrete possibility of a breakup of the Eurozone. We exploit CDS quotes for contracts denominated in different currencies and with different default clauses to estimate the network of breakup and default risk spillovers in the Eurozone isolating the relevant factors with regularization techniques.

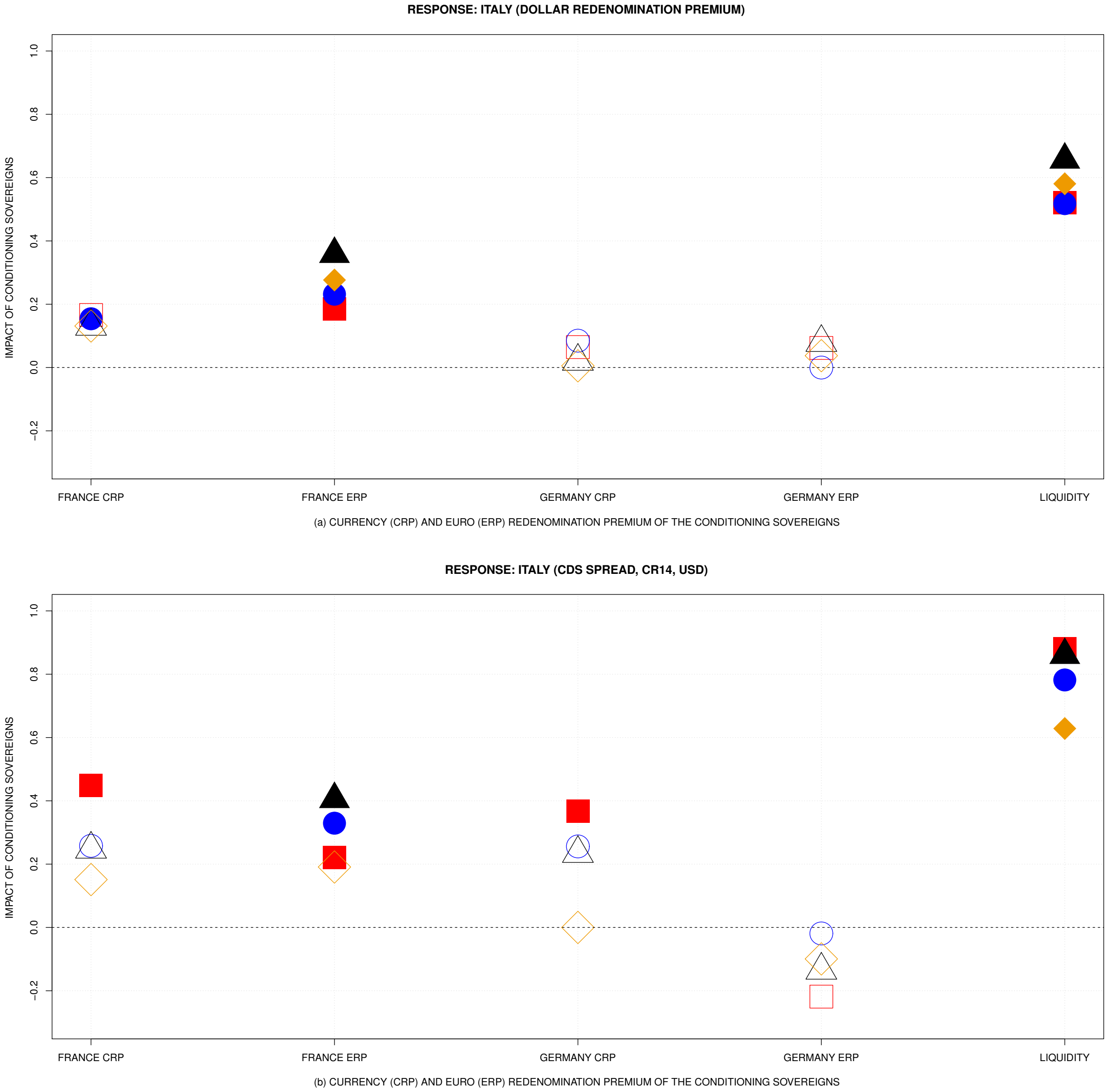
Figure 3: Term Structure of the Redenomination Premium: Median Country



Notes: This figure plots the term structure of the redenomination premium for Italy along the two components from the decomposition in (3): the euro redenomination premium and the dollar redenomination premium. The dark shaded area corresponds to one-standard-error bands around the point estimates; the light grey shaded area corresponds to 95% confidence intervals. Data are from Markit for the period 10/1/2014 to 7/1/2019 and are reported in basis points.

Our main result is that redenomination shocks to France and Italy have economically large spillovers. However, while redenomination shocks to France increase the risk of a breakup of the Eurozone, while redenomination shocks to Italy increase the risk of sovereign defaults, like sovereign debt restructurings. Our network model builds on the ΔCoVaR measures of systemic risk (Adrian and Brunnermeier, 2016), but critically considers the simultaneous effect of different conditional factors and incorporates machine learning regularization methods to deal with the large number of nodes. This model can be immediately be adapted to estimate spillover effects or exposure to systemic risks in different markets.

Figure 4: ΔMCoVaR at Different Maturities (Italy)



Notes: This figure plots the estimates of of the ΔMCoVaR for equation (12) for two models: model 1 (response of dollar redenomination premium, top panel); and model 2 (response of default premium, bottom panel) for Italy for maturities of 3 years (squares), 4 years (circles), 5 years (triangle) and 7 years (diamonds). We use the same covariates presented in the baseline analysis of section 3.3. The estimates are obtained using the model specification with the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. We denote with solid colored symbols the estimates that are significant at the 10 percent level. Data are daily from Markit for the period 10/1/2014 to 7/1/2019.

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Appendix (not for pubblication)

This appendix contains additional material relative to Bonaccolto, Giovanni, Nicola Borri, and Andrea Consiglio. "Breakup and Default Risks in the Eurozone." (2019).

A Data

In this section we provide additional details on the data used in the paper.

A.I Additional Summary Statistics

In the paper we present and discuss descriptive statistics relative to CR14 sovereign CDS contracts. Table A1 presents the same descriptive statistics relative to CR CDS contracts, denominated in euro and dollars. Panel A refers to CDS levels, and panel B to the first differences. We note that the main stylized facts relative to CR sovereign CDS contracts are the same as those discussed in the main text and relative to CR14 CDS contracts.

Table A1: Summary Statistics (CR Contracts)

	Panel A: CR − levels (bp)									
	euro CDS premium					dollar CDS premium				
	μ	σ	min	max	VaR	μ	σ	min	max	VaR
Austria	12.874	5.338	5.080	24.641	20.146	19.077	7.341	8.617	36.366	28.801
Belgium	21.178	10.718	7.684	51.016	38.855	27.753	12.773	11.383	63.482	47.652
Finland	13.056	4.145	6.838	22.850	19.050	17.849	5.874	9.308	29.794	25.994
France	18.006	7.755	7.234	42.513	32.659	25.314	10.198	10.822	53.586	43.581
Germany	8.054	2.521	3.892	16.235	12.589	13.092	4.031	6.203	27.570	19.723
Ireland	31.714	13.413	10.097	73.448	51.916	39.405	15.638	13.867	86.573	63.748
Italy	93.854	21.849	41.287	147.471	128.199	113.226	25.112	58.001	177.497	156.697
Portugal	129.554	70.344	26.856	315.019	240.132	148.953	77.815	30.706	333.771	273.772
Spain	50.891	21.122	15.143	103.564	82.140	63.472	22.016	25.216	124.374	95.232
	Panel B: CR − first differences (bp)									
	Δ euro CDS premium					Δ dollar CDS premium				
	μ	σ	S	K	VaR	μ	σ	S	K	VaR
Austria	-0.013	0.495	0.869	59.334	0.672	-0.020	0.576	3.416	31.660	0.721
Belgium	-0.023	0.747	5.120	186.427	0.821	-0.027	0.795	7.864	135.916	0.829
Finland	-0.012	0.460	0.677	34.061	0.617	-0.014	0.418	1.347	32.493	0.553
France	-0.020	0.795	2.269	73.119	0.986	-0.026	0.900	4.652	91.761	0.993
Germany	-0.009	0.531	-0.363	36.304	0.624	-0.010	0.481	0.660	79.571	0.511
Ireland	-0.024	1.121	2.860	48.022	1.412	-0.030	1.173	5.402	86.628	1.353
Italy	0.001	3.872	1.996	82.054	5.216	0.017	4.258	2.763	104.027	5.951
Portugal	-0.090	5.212	1.515	13.072	7.457	-0.115	5.087	1.959	18.252	6.781
Spain	-0.033	2.516	1.410	21.209	3.598	-0.039	2.878	1.917	30.830	4.240

Notes: This table reports summary statistics for the sample Eurozone sovereign CDS contracts in euros and dollars, with default clause CR. Panel A refers to the CDS premia in levels and reports means (μ), standard deviations (σ), minimum values (min), maximum values (max), and value at risks with confidence 5% (VaR). Panel B refers to the CDS premia in first differences and reports means (μ), standard deviations (σ), skewness (S), kurtosis (K), and value at risks with confidence 5% (VaR). All CDS are with a horizon of 5 years. Data are daily from Markit for the period 10/1/2014 to 7/1/2019 and reported in basis points.

A.II Credit Event Definitions: 2003 vs. 2014

The International Swaps and Derivatives Association (ISDA) sets the rules governing the CDS market. ISDA periodically updates the standardized definitions. Kremens (2019) provides a detailed descriptions of these definitions and evolution. The most recent update was implemented in September 2014. One of the new term, with respect to the earlier definitions released in 2003, refers to the set of events that constitute a restructuring, defined in Section 4.7 of the ISDA definitions. Under the 2003 definitions, a sovereign could redenominate an obligation in a number of "permitted currencies" without triggering a default. These permitted currencies are the legal tender of any G7 country, or the legal tender of any country which is a member of the OECD and has a local currency long-term debt rating of AAA or higher. Since France, Germany, and Italy are part of the G7 countries, under these rules these governments could issue a new currency and redenominate existing debt in this new currency without triggering CDS contracts. For example, the Italian government could issue a new "lira" and redenominate its sovereign debt in this new, likely undervalued, currency. In response to the Eurozone sovereign crisis, and the growing concerns about a possible redenomination of the Italian government debt, ISDA amended Section 4.7 in the new 2014 definition. In the new and current version, the only permitted currencies are "the lawful currency of Canada, Japan, Switzerland, the United Kingdom, the U.S., and the euro and any successor currency to any of the aforementioned currencies (which in the case of the euro, shall mean the currency which succeeds to and replaces the euro in whole)". Therefore, under the 2014 definitions (CR14), a redenomination into a new French, German, or Italian currency triggers sovereign CDS contracts. This is not the case for CDS contracts under the 2003 definitions (CR).

A.III Asset Package Delivery

Differences between CR and CR14 sovereign CDS contracts also depend on the "Asset Package Delivery" (APD) clause introduced by the ISDA 2014 credit derivative definitions. However, for APD there is no distinction between G7 and non-G7 countries. Specifically, APD allows market participants to deliver assets resulting from the corresponding deliverable obligations that have been converted in connection with a restructuring event. These assets are also used to determine the final price in an auction (i.e., the recovery value). In instances where bonds are fully expropriated and no assets are delivered in exchange, the value of the asset package will be deemed to be zero (see Kremens (2019) for further details).

A.IV Liquidity

It is common view that sovereign CDS contracts are largely more liquid than the underlying sovereign bonds. In order to discuss some liquidity facts relative to the Eurozone sovereign CDS market, in this section we present two sets of data. First, Table A2 and Figure A1 present information on the CDS notional and number of trade counts using data from swapsinfo[10]. We note that Italy, Germany, and France are the countries with the largest net CDS notional. For example, at the end of 2018 the net notional for the Italian sovereign CDS was approximately equal to 12 billions of euro (and, correspondingly, 300 billions of euro of gross notional). For all three countries we observe a decline in the net notional levels since 2012. Also in terms of average trade counts, sovereign CDS of these three countries are the most liquid instruments. For example, in the case of Italy, this number is equal to 10,874 trades per day. Austria is the

[10]We are grateful to Lukas Kremens for sharing this data.

country in our sample with the smallest average number of daily trades, equal to 2,069. We note that these figures are very large compared to the daily number of transactions in the sovereign bond market. Finally, Table A3 reports information on bid/ask spreads. We obtained bid/ask spreads from Bloomberg, while CDS quotes are from Markit. The minimum average bid/ask spread is for Germany, and is equal to 3 bp, and the largest is for Portugal, and is approximately equal to 20 bp. We note that bid/ask spreads do not increase substantially in bad times. For example, in the case of Italy, the average bid/ask spread is approximately 7 bp and the 95% quantile is approximately 10 bp. Assuming normality, with 95% confidence, the bid/ask spreads for Italy are in the 3-11 bp range.

Table A2: CDS Notional

	gross notional (bn)			net notional (bn)			trade counts		
	mean	max	min	mean	max	min	mean	max	min
Austria	45.77	64.49	19.46	4.30	8.60	1.65	2069	2898	912
Belgium	46.97	71.12	24.63	4.10	7.50	2.73	2459	3793	1021
Spain	144.02	223.94	62.57	10.30	19.04	3.70	6401	10668	2531
France	116.53	185.90	53.78	13.11	25.68	6.73	5259	7860	2059
Germany	102.93	164.19	42.54	13.07	22.39	5.53	3302	6176	1230
Italy	342.03	446.32	221.21	19.71	29.46	12.97	10874	15528	5831
Netherlands	24.65	37.52	11.56	2.62	4.28	1.55	1313	2059	589

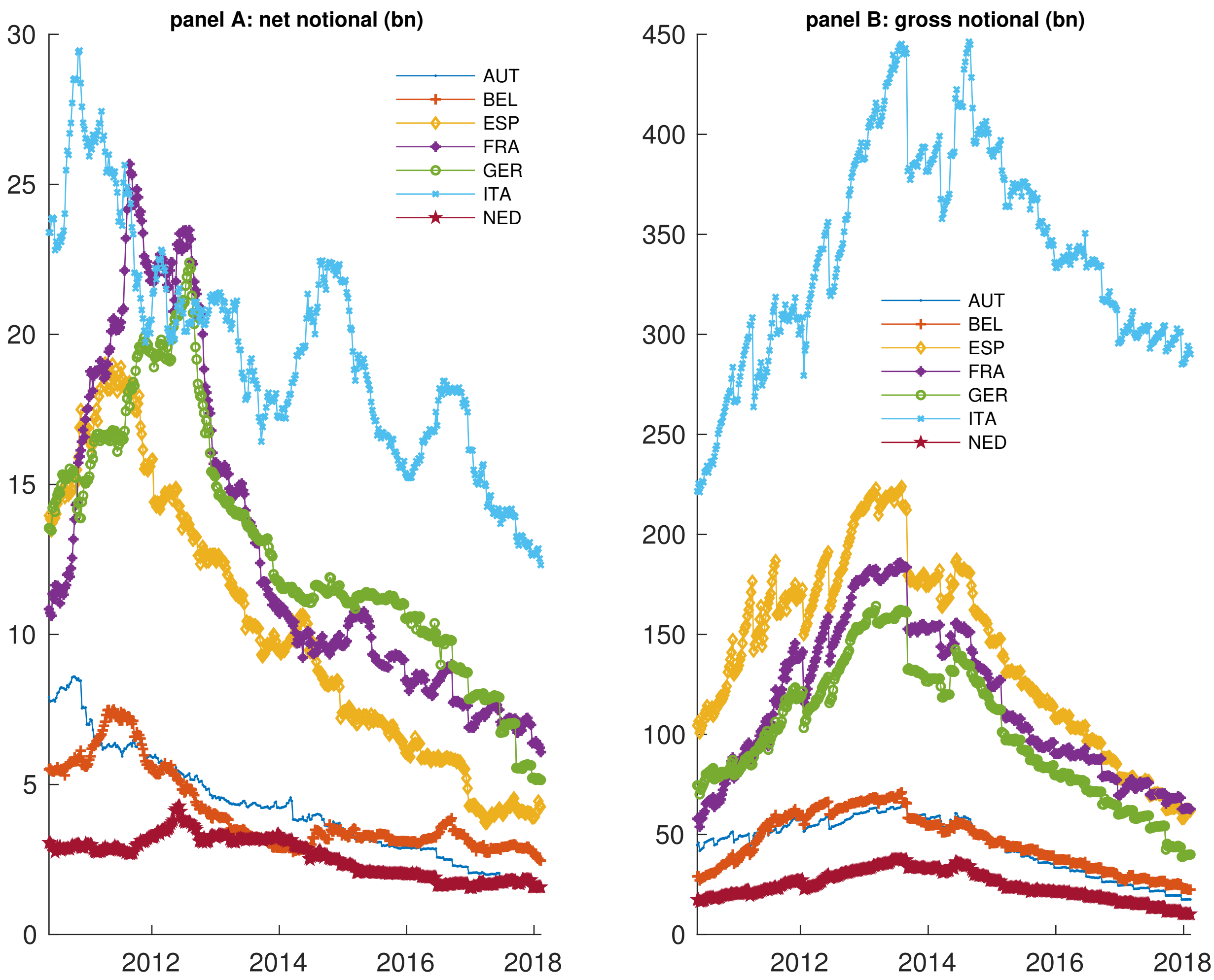
Notes: This table reports descriptive statistics for the sovereign CDS notionals and trade counts for some of the countries in our sample. Data are from swapsinfo for the period 5/2010 to 2/2018 at the weekly frequency. CDS notionals are in billions of euro. Trade counts are weekly.

Table A3: Bid/Ask

	μ	σ	min	max	$median$	VaR
Belgium	5.973	0.224	4.000	6.000	6.000	6.000
Finland	4.000	0.000	4.000	4.000	4.000	4.000
France	4.985	0.255	2.000	6.000	5.000	5.000
Germany	3.010	0.100	3.000	4.000	3.000	3.000
Ireland	6.978	0.243	4.000	7.000	7.000	7.000
Italy	7.126	2.029	1.473	12.412	7.359	9.943
Portugal	19.896	0.978	10.000	20.000	20.000	20.000
Spain	6.984	0.177	5.000	7.000	7.000	7.000

Notes: Data are daily from Bloomberg for CR14 contracts denominated in U.S. dollars and maturity 5Y for the period 10/1/2014 to 7/1/2019 and reported in basis points. Bid/ask spread is defined as the difference between ask and bid premia.

Figure A1: CDS Notional



Notes: This figure plots the evolution of net (panel A) and gross (panel B) of sovereign CDS notionals for some of the countries in our sample. Data are from swapsinfo for the period 5/2010 to 2/2018 at the weekly frequency. CDS notionals are in billions of euro.

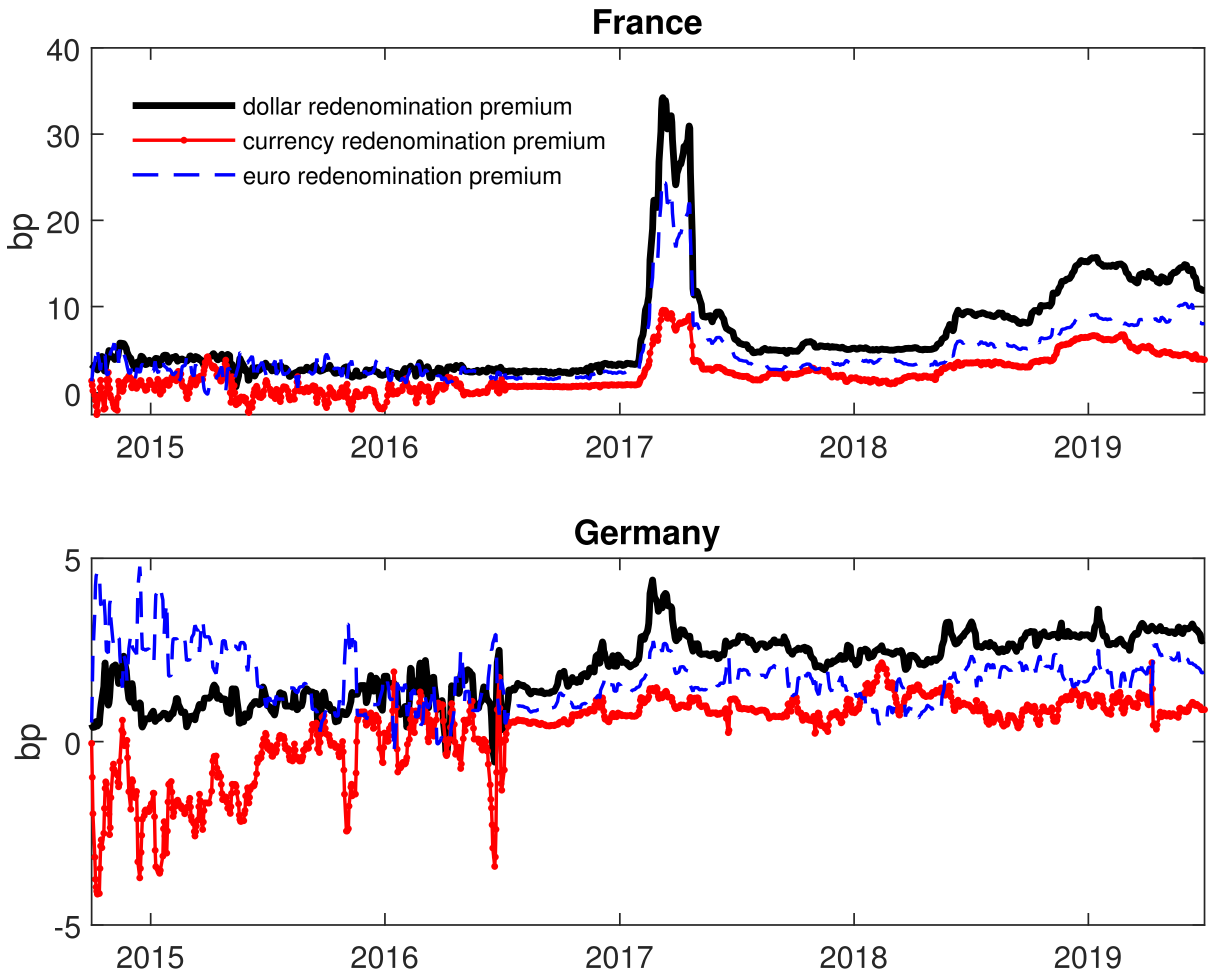
A.V Redenomination Premia

Figure A2 plots the evolution of the dollar redenomination premium, and its two components: the euro redenomination premium and the currency redenomination premium, for France (top panel) and Germany (bottom panel). While for Germany the dollar redenomination premium, and its two components, are always smaller than 5 bp, for France they increase over the sample and have a spike on April 2017 at the times of the French elections. As for Italy, also for France and Germany the currency redenomination premium accounts to less than 30% of the dollar redenomination premium.

A.VI Sovereign CDS and Bond Yields

In this paper we focus on the spillover of redenomination shocks on the redenomination and default premium of Eurozone countries. Fluctuations in sovereign risks are associated to fluctuations in macroeconomic activity, for example because they are associated to fluctuations in governments' borrowing costs. Using data since June 2018, Gros (2018) estimates that 50% of

Figure A2: Redenomination Premium (France and Germany)



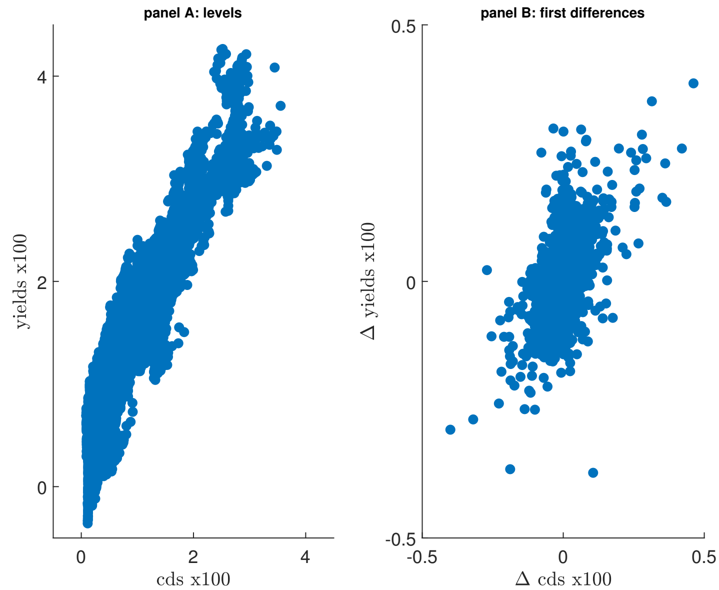
Notes: This figure plots the redenomination premium for France (top panel) and Germany (bottom panel), along the two components from the decomposition in (3): the euro redenomination premium and the currency redenomination premium. All series are constructed with CDS contracts with a maturity of 5 years; smoothed with a 5-day moving average; and are reported in basis points. Note that the top and bottom plots have different ranges for the y-axis. Data are daily from Markit for the period 10/1/2014 to 7/1/2019.

the increase in the spread of Italian sovereign bonds is due to redenomination risk. Figure A3 is a scatter plot of cds premia and sovereign yields for all the sample Eurozone countries. In the left panel, we consider these variables in levels; in the right panel in first differences. The figure shows a clear positive relationship between sovereign risk, measured by the sovereign CDS, and sovereign bond yields. Figure A4 presents a similar scatter plot for redenomination premia and sovereign bond yields, considering France, Germany, and Italy. In this case, the relationship is weaker. In section B.III of this appendix we also directly report the estimation of the ΔMCoVaR for a model in which the dependent variables are the sovereign bond yields.

B Estimation Results

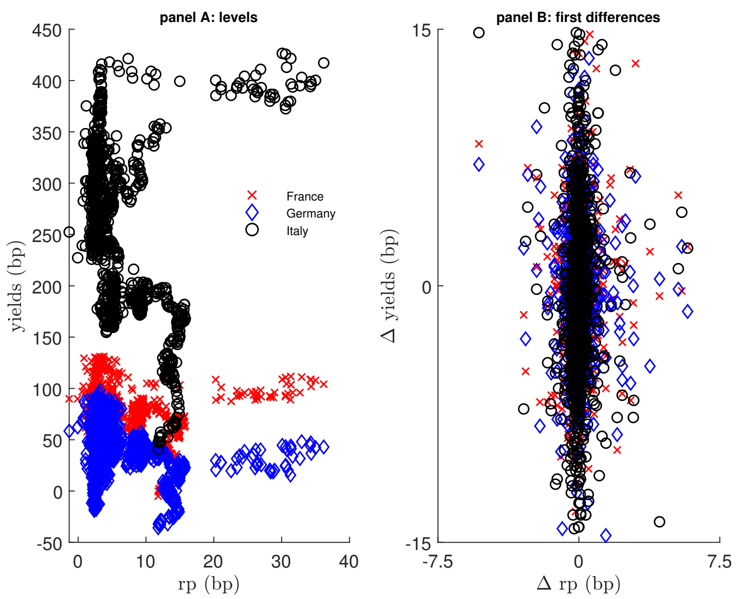
This section presents additional estimation results.

Figure A3: Sovereign CDS and Bond Yields



Notes: This figure is a scatter plot of sovereign bond yields against sovereign CDS premia. In the left panel, we consider these variables in levels; in the right panel in first differences. Data are for the Eurozone sample countries for the period 10/1/2014 to 7/1/2019 at daily frequencies. CDS data are from Markit. Sovereign bond yields are from Datastream for benchmark 10-year government bonds.

Figure A4: Redenomination Premia and Bond Yields



Notes: This figure is a scatter plot of sovereign bond yields against redenomination premia. In the left panel, we consider these variables in levels; in the right panel in first differences. In both cases we report values in basis points (bp). Data are for France (red crosses), Germany (blue diamonds), and Italy (black circles) for the period 10/1/2014 to 7/1/2019 at daily frequencies. CDS data are from Markit. Redenomination premia are built using the differences between CR14 and CR sovereign CDS in dollars. Sovereign bond yields are from Datastream for benchmark 10-year government bonds.

B.I ΔMCoVaR Coefficients

In this section, we report the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12) from the estimation of the ΔMCoVaR with both elastic net and post-LASSO for the baseline maturity of 5 years.

Table A4: Estimation Coefficients (Elastic Net, Maturity 5Y)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	0.000	0.000	0.000	0.007	0.024
	--	--	(2.524)	(0.899)	(0.259)	(0.566)	(1.542)
GERMANY	-0.030	0.057***	--	--	0.017***	0.002	-0.001
	(2.006)	(1.484)	--	--	(0.620)	(0.385)	(0.733)
ITALY	0.113	0.349***	0.035	0.168	--	--	0.261***
	(10.368)	(9.373)	(9.285)	(16.519)	--	--	(8.942)

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	0.057	0.029	0.095*	-0.060	0.019*	0.014***	0.019*
	(3.493)	(2.319)	(5.315)	(5.215)	(1.115)	(0.534)	(1.036)
BELGIUM	0.060	0.000	0.169*	-0.134*	0.032*	0.039***	0.027
	(6.140)	(3.456)	(10.252)	(8.099)	(1.777)	(1.067)	(2.312)
FINLAND	0.029	-0.016	0.011	-0.054	0.013*	-0.001	0.005
	(1.989)	(1.290)	(4.258)	(4.284)	(0.701)	(0.260)	(0.692)
FRANCE	--	--	0.237*	-0.103	0.080***	0.075***	0.076**
	--	--	(14.034)	(9.969)	(2.185)	(1.278)	(2.963)
GERMANY	0.006	0.047*	--	--	0.030**	0.010	0.019
	(2.777)	(2.628)	--	--	(1.400)	(0.639)	(1.260)
IRELAND	0.000	0.069	0.291*	-0.090	0.034	0.058***	0.019
	(6.011)	(6.078)	(17.644)	(14.701)	(2.952)	(1.560)	(3.341)
ITALY	0.214	0.395**	0.420	-0.288	--	--	0.342***
	(17.457)	(16.448)	(34.702)	(32.255)	--	--	(12.226)
PORTUGAL	0.199	0.063	0.487	-0.504	0.081	0.214***	0.325***
	(18.862)	(9.649)	(39.605)	(37.908)	(5.953)	(7.111)	(10.744)
SPAIN	0.158	0.028	0.313	-0.259	0.046	0.162***	0.144***
	(11.646)	(6.740)	(21.333)	(17.497)	(3.845)	(2.711)	(5.353)

Notes: This table reports the estimates of the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12) of the ΔMCoVaR for two models using the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. In parenthesis we report standard errors. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

B.II Additional Maturities

In this section we report the results of the estimation of the ΔMCoVaR for maturities 3, 4 and 7 years using the elastic net. We find that our baseline results are robust to using CDS with different maturities.

B.III Effect on Sovereign Bond Yields

In this section we present estimation results of the ΔMCoVaR in a model where the dependent variables are sovereign bond yields. We obtain sovereign bond yields from Datastream for the benchmark 10 year government bonds. The covariates are the same of our baseline model. In this case, we find that the spillovers of redenomination shocks are more limited. Specifically, we find that only redenomination shocks to Italy spillover to other Eurozone countries. Portugal and Spain are affected directly by the Italian ERP, and France by the Italian ERP. Finally, we find that shocks to the liquidity of the sovereign CDS markets are associated to an increase in the Italian sovereign bond yields.

Table A5: Estimation Coefficients (post-LASSO, Maturity 5Y)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	--	--	--	0.007	0.052*
	--	--	--	--	--	(2.125)	(3.011)
GERMANY	--	0.065***	--	--	0.019*	--	--
	--	(2.297)	--	--	(1.129)	--	--
ITALY	--	0.418***	--	--	--	--	0.287***
	--	(9.481)	--	--	--	--	(9.043)

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	--	--	0.164*	--	--	0.005	0.046**
	--	--	(9.856)	--	--	(1.349)	(2.176)
BELGIUM	--	--	0.528*	0.150	--	0.032*	0.017
	--	--	(28.002)	(24.580)	--	(1.683)	(4.696)
FINLAND	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
FRANCE	--	--	0.358*	--	0.172***	0.136***	0.050
	--	--	(19.140)	--	(4.204)	(3.397)	(5.807)
GERMANY	--	--	--	--	--	0.002	0.056**
	--	--	--	--	--	(1.146)	(2.389)
IRELAND	--	--	0.562**	--	--	0.055**	--
	--	--	(24.222)	--	--	(2.663)	--
ITALY	--	--	0.737	--	--	--	0.682***
	--	--	(91.862)	--	--	--	(23.168)
PORTUGAL	--	--	0.932	--	--	0.226*	0.673**
	--	--	(110.509)	--	--	(12.064)	(27.703)
SPAIN	--	--	--	--	--	0.215***	0.186*
	--	--	--	--	--	(6.423)	(9.883)

Notes: This table reports the estimates of the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12) of the ΔMCoVaR for two models using the post-LASSO. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \dots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. In parenthesis we report standard errors. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

Table A6: Estimation Results (Elastic Net, Maturity 3Y)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	0.000	0.000	0.000	0.000	0.000
GERMANY	-7.099	5.642	--	--	14.340*	0.000	12.522
ITALY	7.296	8.129*	2.840	2.724	--	--	22.912**

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	6.435	0.000	14.610***	-3.304	1.356	5.122*	0.000
BELGIUM	9.426	3.530	4.890	-22.798***	10.407	4.407	3.287
FINLAND	18.246***	-6.506**	0.000	-0.602	11.237**	-0.626	12.680**
FRANCE	--	--	7.134*	-4.734	8.989**	9.268***	3.845
GERMANY	6.585	9.388*	--	--	3.111	2.213	14.191*
IRELAND	0.323	0.983	8.438*	-2.941	2.089	5.757**	0.000
ITALY	6.166***	3.042*	5.049**	-2.998	--	--	12.080***
PORTUGAL	3.103	0.000	4.630*	-4.385*	1.728	9.512***	16.355***
SPAIN	4.067	1.389	5.639*	-2.638	0.000	10.649***	8.030**

Notes: This table reports the estimates of the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the dependent variable, for equation (12) for two models using the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12). Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

Table A7: Estimation Results (Elastic Net, Maturity 4Y)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	-0.246	0.604	0.379	0.763*	1.354*
GERMANY	-3.290	5.058**	--	--	3.904	0.667	0.850
ITALY	7.115*	10.698**	3.919	0.000	--	--	23.918***

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	17.721***	5.705	13.648	-1.312	7.769	10.304*	-2.093
BELGIUM	5.937	4.355	7.210	-16.959***	7.113	7.238***	10.473
FINLAND	7.968**	-6.263**	-2.279	-2.275	8.128**	0.000	2.671
FRANCE	--	--	8.615	-1.153	11.992***	11.569***	5.740
GERMANY	2.890	8.990*	--	--	12.706*	9.076**	5.331
IRELAND	0.908	0.000	6.171	-0.625	3.965	5.049**	0.581
ITALY	3.537	4.518**	3.512	-0.260	--	--	10.727***
PORTUGAL	2.680	0.000	3.895	-2.527	2.736	9.734***	14.088***
SPAIN	1.725	2.951	5.052	-2.182	0.000	8.668***	5.653

Notes: This table reports the estimates of the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the dependent variable, for equation (12) for two models using the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12). Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

Table A8: Estimation Results (Elastic Net, Maturity 7Y)

(a) MODEL 1: response of the redenomination premium

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
FRANCE	--	--	0.000	0.000	0.000	5.123*	3.525
GERMANY	-3.710	6.605***	--	--	1.040	0.220	1.204
ITALY	5.313	11.192**	0.222	1.517	--	--	23.498**

(b) MODEL 2: response of the CDS spread

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	3.536	4.059	0.000	-0.848	0.000	6.108***	6.207*
BELGIUM	3.501	0.000	1.980	-3.821**	2.502	5.387*	3.458
FINLAND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FRANCE	--	--	5.788	-1.567	13.912***	19.369***	16.632**
GERMANY	0.000	1.842	--	--	0.580	4.576**	2.421
IRELAND	0.000	0.000	1.158	-0.776	0.680	10.806***	0.000
ITALY	2.057	2.597	0.000	-1.351	--	--	8.548*
PORTUGAL	1.110	0.258	1.800	-3.612	3.598	10.354***	11.814***
SPAIN	1.460	-0.537	1.665	-2.994	4.712	14.948***	9.618**

Notes: This table reports the estimates of the ΔMCoVaR, expressed as a fraction of the unconditional value at risk of the dependent variable, for equation (12) for two models using the elastic net. The ΔMCoVaR measures the change in the value at risk of the response variable when the covariates move from their median to the 95% quantile. In the first model, the dependent variable is the change in the dollar redenomination premium of country i; in the second model, the dependent variable is the change in the dollar CDS CR14 premium of country i. The independent variables are the redenomination premia (ERP) and currency redenomination premia (CRP) of the remaining countries $j = 1, \ldots, J$ and $j \neq i$. We always include the $t-1$ returns of the S&P Global Euro equity index, the IBOXX Euro corporate index, the VDAX volatility index, and the euro 1-month OIS index as set of state variables. Three stars denote significance at the 1% confidence level; two stars denote significance at the 5% confidence level; one star denotes significance at the 10% confidence level. Statistical significance refer to the coefficients $\widehat{\lambda}_{i,\theta}$ from equation (12). Data are daily from Markit and Datastream for the period 10/1/2014 to 7/1/2019.

Table A9: Effect on Sovereign Bond Yields

	FRANCE		GERMANY		ITALY		LIQUIDITY
	CRP	ERP	CRP	ERP	CRP	ERP	
AUSTRIA	-0.312	0.000	-0.568	0.000	0.063	-0.473	0.000
BELGIUM	-0.013	0.000	-2.148	1.015	0.707	0.000	0.413
FINLAND	-0.871	0.000	-0.406	0.000	0.000	-0.012	0.000
FRANCE	--	--	-0.378	0.000	2.893*	-0.563	0.537
GERMANY	-2.243	0.000	--	--	0.000	-0.507	0.000
IRELAND	0.000	-0.286	0.000	-0.311	-0.304	0.000	0.000
ITALY	0.954	0.000	0.945	-0.789	--	--	7.026**
PORTUGAL	3.322	-1.328	2.586	-3.241	-0.483	3.240**	0.000
SPAIN	0.210	0.000	1.651	-0.773	0.000	3.773**	2.416

Notes: The dependent variable are sovereign bond yields for the benchmark 10-year maturity. The model is estimated by elastic net. Marginal effect is reported as a percentage of the unconditional value at risk of sovereign bond yields. Liquidity is proxied by the first two principal components of the spread difference between CDS with contracts CR14 and CR for non-G7 Eurozone countries. Regressions always include a set of control (time t) and state (time $t-1$) variables. Standard errors are computed using the nonparametric xy-pair method (Davino et al., 2014). Data are daily for period 10/1/2014 to 7/1/2019 from Markit and Datastream.