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Guarantee requirements by European central counterparties and international volatility spillovers

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ABSTRACT

This analysis addressed the potential systemic effects of guarantee requirements by central counterparties. Using data from the Spanish BME and German Eurex central clearing counterparties and controlling for tail risk and monetary and real activity variables, we found a significant, positive, and robust relationship between the guarantees required and the spillover or total connectedness effects among nine financial assets in the Spanish, United States, and German capital markets. Bad economic times also had a significant incremental effect on the relationship between guarantees and connectedness. These findings are robust across central clearing corporations and futures contracts in the IBEX 35, DAX 30, and EURO STOXX 50. In addition, an event study indicated that global spillover effects tend to increase before central counterparty institutions raise their guarantees. The implication of the findings is that European clearing institutions react to rather than cause bad economic times.

1. Introduction

This study examines the systemic implications of the practices of central clearing counterparties (CCPs) in the derivative segment of the market, stemming from potential volatility spillover effects to other asset classes and markets. Specifically, we focus on the impacts that increased guarantee requirements from CCPs during volatile markets and bad economic times have on systemic risk. In other words, we are concerned with the possibility that an event at the CCP level could trigger severe instability in large international markets around the world.

It is well-founded that the activities of CCPs tend to reduce counterparty credit risk, especially in the derivative segment of the market. However, the literature has considered a given asset class or market segment in isolation. As Pirrong (2013) and Kubitza et al. (2019) pointed out, when taking a more global perspective, netting and collateralization may also have redistributive risk effects because of the interconnection between the different assets and institutions of the financial system. Consequently, rising margins could destabilize markets, especially during bad economic times. In their pioneer study, Brunnermeier and Pedersen (2009) argued that fragility in liquidity is in part because of increased margins, which may lead to undesirable illiquidity–volatility spirals. The implications of the practices of CCPs when systemic risk is explicitly introduced remain unclear.

Therefore, our key concern is to understand CCP risk management activities, given the existence of potential effects on systemic risk. How can we relate the required time-varying guarantee requirements with potential distortions in the stability of financial

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markets precisely due to practices of CCPs? Given the relevance of adverse shocks associated with the illiquidity-volatility spirals, a reasonable way of analyzing systemic financial instability is to study volatility spillovers, not only across international markets but also across alternative assets, which could potentially be caused by CCPs requiring additional guarantees during those stressed times. The main contribution of our research is to formally analyze the relationship between connectedness of asset classes traded in several international markets, in the sense of adverse volatility spillover shocks, and the changes announced by CCPs regarding guarantee requirements in their derivative segment. In other words, are these practices causing adverse volatility shocks that are transmitted from one asset class to the others within an international context? Although our resulting statistical evidence signals potentially significant volatility transmission, the important issue is how to distinguish between correlation and causality. Our second contribution is to use an event study framework to provide clarifying evidence on the usual tension between causality and correlation regarding the effects of required guarantees.

Although previous literature is certainly scarce, there are two papers on the potential systemic effects of CCP management practices, relatively close to the present research. First, Boissel et al. (2017) focused on CCPs that cleared the repo market during the Eurozone sovereign debt crisis. Specifically, they showed that during this bad economic period, the repo rates effectively responded to time-varying sovereign risk, suggesting that CCPs suffer significant stress. Interestingly, the repo rates behaved as if the conditional probability of a CCP default was indeed large. Second, Abruzzo and Park (2016) analyzed the determinants of margin changes on a set of futures margins from the Chicago Mercantile Group (CME Group). They found that volatility spikes and competition with the International Exchange (to attract more trading volume) are the two key determinants of margins. More precisely, they indicated that the CME Group quickly raises margins when volatility increases, but it does not rapidly lower margins when volatility declines. This finding supports our concern regarding procyclicality, as the behavior of the CME Group suggests that procyclicality is particularly worrisome during recessions.

Our study is more directly focused on the systemic effects of guarantees required and margining. In this regard, we employed the example of two European CCPs as a concrete illustration of these potentially problematic effects. To the best of our knowledge, this is the first available evidence on the specific relationship between margining practices from CCPs and connectedness among stocks, volatilities, and Treasury bonds across several international markets. Specifically, we employ data from the Spanish BME and German Eurex CCPs to analyze the international volatility spillover effects across risk-neutral volatilities, stock market returns, and government bond returns from the Spanish, German, and United States (U.S.) capital markets from January 2007 to April 2018.[1]

Overall, our analysis is carried out in two stages. In the first step, we determine whether the increased guarantee requirements and margining from two European CCPs during volatile markets and bad economic times are significantly correlated with higher connectedness among the alternative asset classes in the three aforementioned international markets.[2] In this case, volatility spillover (connectedness) effects are obtained using the methodological econometric framework of Diebold and Yilmaz (2014), which is well-suited for analyzing financial system interconnectedness. Our empirical results indicate that the total volatility spillover connections in the risk-neutral volatilities, market returns, and Treasury bond returns of Spain, the U.S., and Germany significantly increase when there is an increase in the margin requirements by the Spanish BME or German Eurex CCPs. More importantly, even after controlling for tail risk and monetary and real activity measures, during bad economic times, there are higher correlations between the margin requirements and spillover connections among the financial assets in our global sample, regardless of the specific recession data. This robust evidence on the positive relationship between margining and connectedness may signal reasonable concerns regarding the effects of the management decisions made by European CCPs on systemic risk.[3] However, as these results do not imply causality effects, it is necessary to distinguish whether the increase in spillover effects is because of the margining activities by the CCPs during volatile and illiquid times or if it is simply a reaction to the increase in connectedness, a plausible characteristic of bad economic times.

In the second step, and to clarify these tensions between correlation and causality, we conduct an event-time analysis around the increases in the guarantees required by the CCPs and the corresponding connectedness behavior. The idea is to determine whether CCPs exacerbate bad economic times or simply react to them. Hence, we isolate the specific effect of the margin increase to conclude that they tend to react to bad economic times rather than being the origin or cause of the illiquidity–volatility spirals.

The remainder of this study is as follows. Section 2 briefly discusses the institutional framework and situates this research within the current debate on the advantages and potential conflicts associated with CCPs. Section 3 includes the data, while Section 4 presents the empirical results on connectedness and directional spillovers. Section 5 discusses the relationship between connectedness, margining, and recessions for the Spanish BME and German Eurex CCPs, while Section 6 extends the previous analysis by conducting an event study on the reaction of connectedness to increases in guarantee requirements. Finally, Section 7 presents the conclusion. As for the Appendix, it describes the statistical estimation procedures employed in this study, especially the connectedness or volatility

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[1] An important requirement for this research is enabling a series over a relatively long sample period. To the best of our knowledge, this is the first available empirical evidence that uses such detailed data on the guarantee requirements of European CCPs. Moreover, we willfully choose two CCPs representing two philosophical differences between the founding countries of the Eurozone. We therefore introduce potentially conflicting interest in the prudential practices of CCPs.

[2] Note that, when necessary, CCPs change the level of the guarantees required in euros. In this regard, the margin call level is 80% of the guarantees. Thus, we can indistinctly speak about guarantees and margining.

[3] Of course, regulation forces CCPs to maintain the so-called default funds, which cover all of the asset classes cleared by them. In each case, the default fund is calibrated to cover the losses from a simultaneous default of the CCPs' two largest clearing members. CCPs work with a confidence level of 99.9%.

spillover effects and the event study.

2. The institutional framework and basic lines of research on central clearing counterparties

In the aftermath of the Great Recession (December 2007 to June 2009), regulators around the world agreed that central clearing through well-functioning CCPs, especially in the derivative segment of the market, can reduce systemic risk and prevent credit defaults from disseminating across the world's financial system. As relevant examples, the Dodd–Frank Wall Street Reform and Consumer Protection Act of 2010 (known as the Dodd–Frank Act) and the European Market Infrastructure Regulation of 2012 of the European Securities and Markets Authority introduced compulsory central clearing of standardized over-the-counter derivatives through CCPs. In this regard, after two institutions agree on a financial contract, a CCP places itself between them and becomes a buyer to the seller, and vice versa. More formally, the key benefit of CCPs is that they mutualize the idiosyncratic component of counterpart credit risk through two main instruments. First, they allow participant institutions with offsetting positions to net their exposures. This is called "netting," and its purpose is to reduce risk exposures in the financial system. Second, they require appropriate collateral when standing between buyers and sellers to avoid future counterparty defaults and potential propagation through the financial system.[4]

Although these ideas appear intuitive and helpful, the Squam Lake Report (2010) pointed out that "to ensure that clearinghouses reduce rather than magnify systemic risk, they should be required to have strong operational controls, appropriate collateral requirements, and sufficient capital". Indeed, the literature has extensively analyzed the appropriateness of regulating CCPs. Specifically, there are three basic lines of research: 1) a discussion of the illiquidity effects from margining, based on time-changing volatility; 2) the optimal design of CCPs and the associated incentives for generating demand of central clearing, with a related discussion on the optimal number of clearing houses; and 3) the effects of netting and collateralization on systemic risk.

As for the first line of research, Brunnermeier and Pedersen (2009) showed that margins can ultimately increase illiquidity when volatility is time-varying. Additionally, if a liquidity shock increases volatility returns, then it may raise a clearing house's future volatility expectations and lead to increased margins. This may also force traders to delever their positions in bad economic times, further generating a drop in funding liquidity. In this context, it is crucial for CCPs to distinguish between fundamental and simple liquidity shocks before changing margin requirements, precisely to avoid destabilizing margin management practices.[5]

Regarding the optimal design of CCPs, Duffie and Zhu (2011), Duffie et al. (2015), and Duffie (2015) argued that fragmentation of clearing houses across multiple competing institutions may reduce the advantages from net offsetting exposures, thus increasing counterparty risk. Similarly, Benos et al. (2019) found that fragmenting clearing across multiple CCPs can be costly because global traders cannot net their positions across CCPs. However, it is also true that excessive concentration may enhance systemic risk because of moral hazard and the "too-big-to-fail" risk. Related to the design issue is the need to understand the determinants of the demand for central clearing. Bellia et al. (2017) used confidential European trade repository data on sovereign credit derivatives swap (SCDS) transactions to show that among all of the transactions reported in 2016 regarding Italian, German, and French SCDSs, clearing members cleared approximately 53 % of their transactions. Yet, their reasons differed. Specifically, counterparty risk was the main reason among the Italian SCDSs, while margin costs was the key variable for the German and French SCDSs. This finding suggests that clearing decisions are related to portfolio holdings and full exposure to the CCPs rather than individual contracts.[6]

As for the third line of research, Pirrong (2013) argued that netting and collateralization can reduce counterparty credit risk if derivatives were individually reviewed. However, netting may have redistributive risk effects on other assets and institutions in the financial system, which from an overall perspective, may increase or reduce systemic risk. Similarly, increasing margining and collaterals may stabilize the system by reducing leverage and credit risk. However, this may have undesired interconnectedness effects, as the default funds of CCPs depend on systemic financial institutions that are more exposed and more likely to be negatively affected during bad economic times. In fact, it is well-known that margins tend to be higher in volatile markets and for assets that are more illiquid, as they are more difficult to hedge and usually take more time to liquidate. These mechanisms make sense because they not only diminish CCP risk but also the risk of their members. As mentioned earlier, this argument only holds if the derivatives are individually viewed. As with netting, when taking a more global view, margining and collateralization may have redistributive implications, which may not imply a reduction of systemic risk.[7] Importantly, financial institutions that are members of CCPs are connected through not only derivatives but also through other contracts and assets. For example, Huang et al. (2021) showed that during stressed markets, CCPs are exposed to elevated crowding of clearing members in the tails, which may become problematic if this is a

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[4] See Menkveld and Vuillemey (2021) for a review paper about the effects of CCPs on the functioning of financial markets, the design and associated resilience of CCPs, and the key regulatory issues. The review focuses on the economic rationales of central clearing. See also Vuillemey (2020), who analyzed CCPs as a contracting innovation to show that they generally solve the problem of missing markets, reduce adverse selection, and facilitate the entry of new traders.

[5] Biais et al. (2016) showed that if the seller's moral hazard is reasonably low, then the margins may benefit risk-sharing rather than being destabilizing for the financial system. They also argued that contrary to Brunnermeier and Pedersen (2009), their model endogenized the margins, taking as given the asset values in the margin account of the seller. Hence, in their model, the insurance role provided by CCPs is the key characteristic for explaining why central clearing can improve the allocations within financial systems. Additionally, Acharya and Bisin (2014) provided a positive argument in favor of central clearing, based on the improvement of information disclosure.

[6] Using the example of the failure of a derivative CCP in Paris in 1974, Bignon and Vuillemey (2020) argued that the recognition of agency problems should be part of the optimal design for the recovery and resolution rules of CCPs.

[7] Kubitza et al. (2019) showed that higher systemic risk leads to an increase in counterparty risk exposures, with multilateral netting related to bilateral netting. They also argued that this is especially true during extremely bad economic times.

consequence of speculation. In two related papers, Menkveld (2017) proposed a new measure of exposure, based on tail risk and especially designed to capture crowded positions, while López et al. (2017) proposed the CoMargin methodology to estimate collateral requirements in CCPs. Their approach focused on the tail risk of clearing members and its interdependence with other participants. As pointed out in the introduction, our research rests on the concerns associated with the latter argument, namely, the potential systemic effects of the risk management practices followed by CCPs.

3. Data

As for the data, we used two major datasets. First, with respect to guarantees, we had daily data on the guarantee level (in euros per position) required by BME Clearing on the futures contracts in the IBEX 35 index and the daily guarantee level (in euros per position) required by Eurex Clearing on the futures contracts in the DAX 30 and EURO STOXX 50. These futures contracts account for a large part of the total trading volume managed in each of the CCPs. For example, in 2018, the futures contracts in the IBEX 35 index represented approximately 40 % of the total open interest of the derivatives segment for BME Clearing, with this segment being the largest of the five in which it clears trades. On average, between 2015 and 2018, the financial derivative segment represented 47.8 % of the total guarantees deposited by traders in BME Clearing, ranging from 44.8 % in 2015 to 49.2 % in 2018.[8] In the case of Eurex Clearing, the trading volume of futures contracts in the DAX 30 and EURO STOXX 50 (negotiated through Eurex) was 83.5 % of the total trading volume in the Amsterdam (AEX), France (CAC), Madrid (IBEX), Milan (MIB), and Zurich (SMI) exchanges.[9]

Panel A of Fig. 1 presents the guarantee required (in euros per position) and the guarantee level per unit of futures in the IBEX 35 index. Specifically, the margin call level is 80 % of the guarantee level throughout the sample period. This figure also shows the recession bar charts for the Spanish economy. As expected, the guarantee in euros, the guarantee level required per unit of the index, and the corresponding margin call are relatively high during bad economic times. They steadily increased after the summer of 2007, reaching a historical maximum value of 1450 € between, October 20, 2008, and February 25, 2009.

Panel B of Fig. 1 shows the requirements for the futures in the EURO STOXX 50. As expected, the guarantees required, and margins increased significantly during the Eurozone recessions. This is consistent with the Spanish evidence shown in Panel A. Moreover, in April 2011, Eurex Clearing changed its risk management policy regarding the guarantees required on futures contracts in both the DAX 30 and EURO STOXX 50. These guarantees then changed on a daily basis. Although the precise risk management practice has not been made public, it seems that Eurex Clearing establishes minimum guarantee intervals for periods of relatively low volatility, as a function of stock index levels. Hence, during these periods, the guarantee per unit of futures remains relatively stable, as shown in Panel B. Only during periods in which there is an increase in volatility is the required guarantee no longer flat.

The second dataset contains daily data for the major asset classes in the three capital markets (i.e., Spain, the U.S., and Germany) from January 2007 to April 2018. Specifically, we used the data regarding the risk-neutral one-month volatilities in the Spanish, U.S., and German markets denoted as VIBEX, VIX, and VDAX, respectively. The risk-neutral volatilities not only reflect a forward-looking measure or the expectation of volatility over the options expiration period but also are associated with the expected fears in the market. Moreover, we had the daily market returns from the IBEX 35, S&P500, and DAX 30 indices as well as the 10-year government bond returns of Spain, the U.S., and Germany. Note that in addition to considering the CCP data of Spain and Germany, we also included the data of the U.S. because of its significant influence on international markets.

4. Analysis of connectedness

The stylized facts of international financial returns and the coordinated expected risk premia across asset classes during the Great Recession have motivated an increasing interest in the formal analysis of connectedness in the sense of volatility spillover effects. This section presents our empirical evidence related to total and directional connectedness among the nine analyzed assets. By connectedness we mean measures of how much future unexpected variation in one financial asset is explained by current shocks to other assets. For this purpose, we employed the methodological econometric framework of Diebold and Yilmaz (2014, 2015, 2016), which is especially convenient in our context since it is based in the decomposition of the variance of the forecast error under a vector autoregression (VAR) framework. This decomposition is a nice characteristic of the methodology because it allows inferring the forecast error variance of each variable into parts attributable to all other variable shocks in the system. It allows obtaining connectedness measures that capture not only the dynamic interactions between the variables along time, but also the directional connectedness from one to the others. The directional connectedness from one variable X_i to another variable X_j in the VAR system is the fraction of the H-step-ahead generalized error variances in forecasting X_j that are due to shocks in X_i.[10] Note that we wanted to

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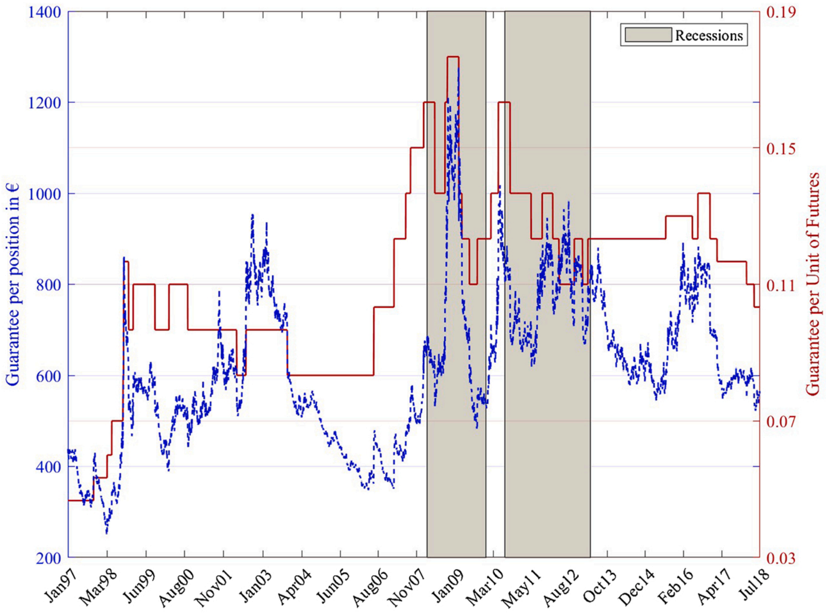
[8] BME Clearing is one of several CCPs authorized by ESMA, in accordance with EMIR. Like other CCPs, BME Clearing performs interposition functions, including registration, central counterparty, and clearing and settlement services. It also clears trades on five groups of financial assets: equity, fixed-income, financial derivatives, energy, and interest rate derivative segments. See https://www.bolsasymercados.es for a detailed description of the Spanish Stock Exchange and BME Clearing.

[9] Eurex is the largest European options and futures market. It is a pan-European derivative exchange initially operated by Deutsche Börse and the SIX Swiss Exchange. Since 2012, it has been solely owned by Deutsche Börse. Eurex offers trading in European-based derivatives, with all transactions cleared through Eurex Clearing. This group comprises four companies in the derivatives business: Eurex Exchange, European Energy Exchange, Eurex Clearing, and Eurex Repo. See https://www.eurex.com for a detailed description of the Eurex group.

[10] Appendix A contains a brief but formal discussion of the statistical procedure employed in our analysis.

Panel A: Futures Contracts in the IBEX 35 from January 10, 1997, to July 2, 2018



Panel B: Futures Contracts in the EURO STOXX 50 from January 2, 2003, to March 14, 2019

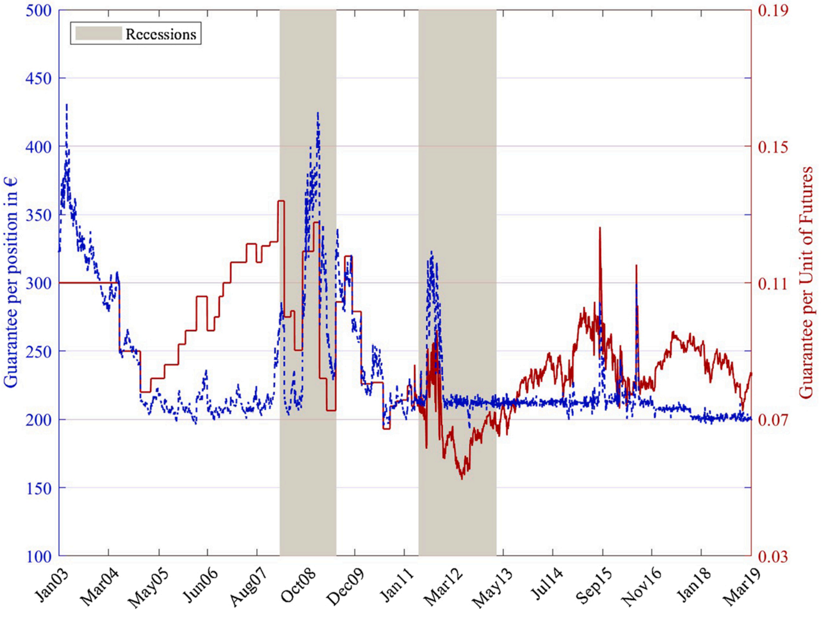


Fig. 1. The Guarantee Requirements per Unit of the Futures Contracts in the European Stock Market Indices.
The left axis of these figures shows the guarantee level in euros per position required by BME Clearing on the futures contracts in the IBEX 35 and by the Eurex CCP on the futures contracts in the EURO STOXX 50. On the right axis, we display the percentage that represents the guarantee level per unit of futures contracts in the IBEX 35 and EURO STOXX 50. The gray bars represent the recession dates of the Spanish and Eurozone economies, respectively.

understand the potential volatility spillover effects and not simply the correlations among assets and markets. This explains why this methodology is particularly appropriate for our purpose.

Table 1
Average of Connectedness Dynamics of the Spanish, U.S., and German Assets from January 3, 2007, to April 26, 2018.

	VIBEX	IBEX 35	SP BOND	VIX	S&P500	U.S. BOND	VDAX	DAX 30	GE BOND	FROM OTHERS
VIBEX	25.66	8.29	2.96	19.01	7.50	4.74	20.25	7.67	3.90	74.34
IBEX 35	3.14	32.64	6.16	3.83	13.95	7.33	3.73	21.58	7.64	67.36
SP BOND	2.26	9.15	48.45	2.76	5.83	8.67	2.38	7.34	13.16	51.55
VIX	15.65	6.22	2.96	28.26	14.10	5.01	16.74	7.57	3.51	71.74
SP&500	2.16	14.09	4.59	9.22	35.41	9.13	2.98	16.02	6.39	64.59
US BOND	1.89	8.38	6.86	3.30	10.50	39.65	2.25	8.69	18.46	60.35
VDAX	19.56	6.80	2.95	20.36	8.11	4.82	24.23	9.56	3.60	75.77
DAX 30	2.73	21.09	4.68	4.41	15.82	7.55	5.08	31.66	6.98	68.34
GE BOND	1.95	9.01	10.37	2.45	7.40	18.74	2.08	8.56	39.43	60.57
TO OTHERS	49.34	83.05	41.54	65.34	83.23	65.99	55.49	87.00	63.64	
FROM OTHERS	74.34	67.36	51.55	71.74	64.59	60.35	75.77	68.34	60.57	
NET	-25.00	15.70	-10.02	-6.41	18.64	5.64	-20.28	18.66	3.07	66.07

This table shows the average of estimated connectedness dynamics computed daily with 120-day rolling window for the period between January 3, 2007, to April 26, 2018. The numbers are the average percentages of connectedness among the risk-neutral volatilities, stock market returns, and government bond returns for the Spanish, U.S., and German markets. They also represent the average variance of the forecast error of each asset into parts attributable to system shocks. Entry [*i* (row), *j* (column)], for example, the VIBEX, IBEX 35 entry, represents the average directional connectedness from *j* to *i*, which means that, on average, shocks to the IBEX 35 are responsible for 8.28 % of the 12-day-ahead variance of the forecast error in the VIBEX. The "FROM OTHERS" column is the row sum (excluding the diagonal entries) that gives the average total directional connectedness from all other series to asset *i*. The "TO OTHERS" row is the column sum (excluding the diagonal entries) that gives the average total directional connectedness from series *j* to the others. NET is the difference between the TO and FROM rows that gives the average net total directional connectedness from asset *j* to the others. The bottom-right entry is the average total connectedness (the average from connectedness or, equivalently, the average to connectedness) among all the assets in the sample. The VIBEX, VIX, and VDAX are the risk-neutral volatilities of the Spanish, U.S., and German equity markets, respectively. The IBEX 35, S&P500, and DAX 30 are the stock market indices of Spain, the U.S., and Germany, respectively. The SP BOND, US BOND, and GE BOND are the 10-year government bonds of Spain, the U.S., and Germany, respectively.

We estimate dynamic connectedness measures using a 120-day rolling overlapped sample windows.[11] This analysis is crucial for understanding how the spillover effects among the nine assets in this research behave throughout the economic cycle, and how the dynamic spillovers react to a given exogenous shock. In Table 1 we show the average percentages of the alternative measures of the daily connectedness dynamics. We choose a forecasting horizon (*H*) of 12 days following the recommendation of Diebold and Yilmaz (2014, 2015, 2016). They point out that, although intuitively, there are more chances for connectedness to appear as *H* lengthens, the conditioning information also becomes progressively less valuable in the variance decompositions of the conditional forecast error.[12] Looking at the "FROM OTHERS" column, the VIBEX, the VDAX and to a slightly lesser extent the VIX, are the assets receiving more volatility from the other series, and the three risk-neutral volatilities are mainly responsible for the variance of the forecast error among them. Conversely, government bond returns are the assets that receive less volatility from the other variables in the system. This is particularly true for the Spanish government bond returns.

Similarly, the "TO OTHERS" row shows that the three stock market returns are the variables sending more volatility to all the other assets. Interestingly, the DAX 30 has a greater effect on the IBEX 35 than the S&P500. Moreover, the Spanish bond returns send less volatility to others, signaling their limited influence on the U.S. and German capital markets. Indeed, the Spanish bond returns have a large idiosyncratic volatility connection, as observed from the diagonal entry (i.e., 48.5 % of their volatility is because of shocks in the Spanish bonds themselves). It only has a certain connection with the German bond, while the U.S. and German bonds send volatility to one another.

The last row of Table 1 presents the average net total directional connectedness dynamics from each asset to all the others. In this regard, the stock market returns of the three countries are the assets that send volatility to the rest, while the Spanish government bond

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[11] We check the robustness of our empirical results employing also a 66-day rolling window estimation. Given the similarities between the results, we discuss the findings for the 120-day rolling window case.

[12] As expected, given the different robustness tests provided by Diebold and Yilmaz (2014, 2015, 2016), our results are very stable for horizons between 8 and 16 days, so that volatility connectedness are practicable indistinguishable.

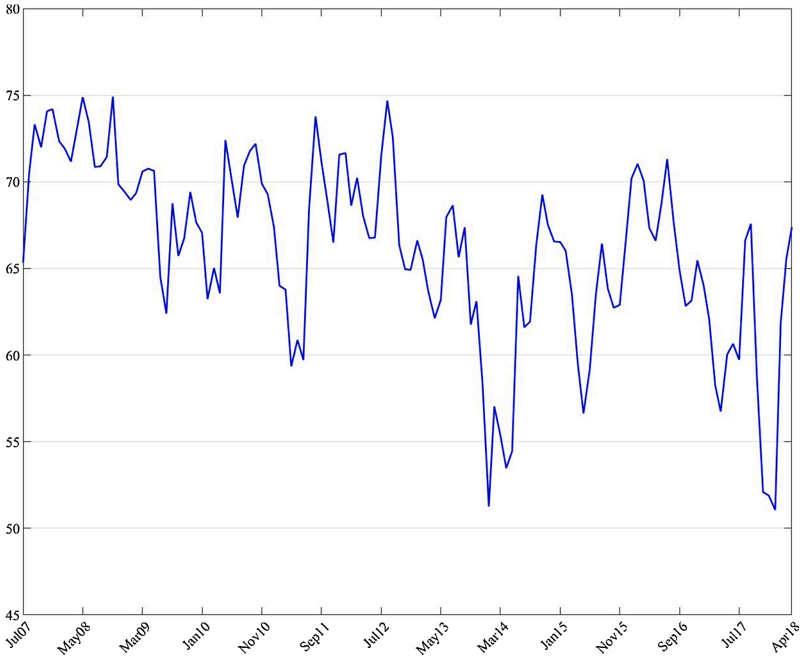
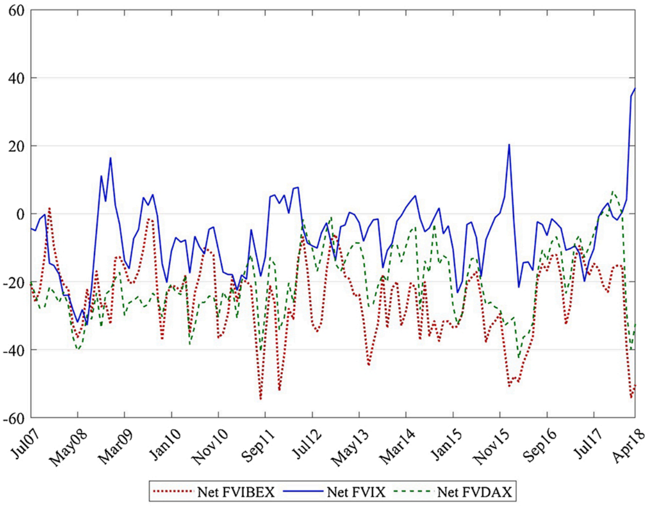


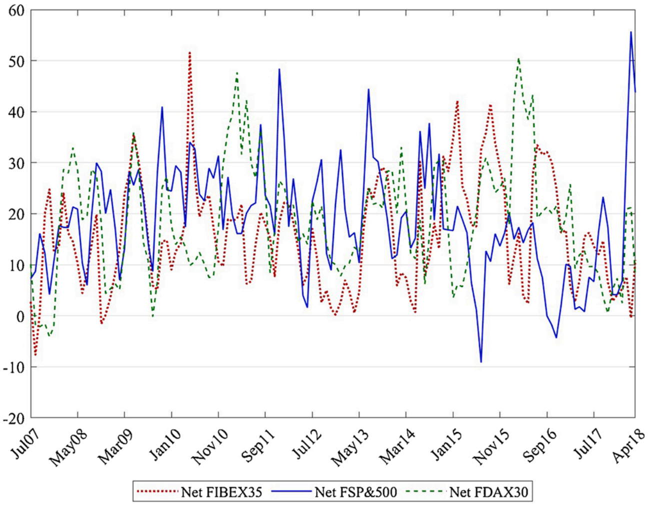
Fig. 2. The total monthly connectedness dynamics between the Spanish, U.S., and German Risk-Neutral Volatilities, Stock Market Returns, and Treasury bond returns from July 2007 to April 2018.

This figure displays the total monthly connectedness dynamics, calculated as the average daily percentages of the total spillover effects within each month in the sample. The daily spillovers are estimated over a 120-day rolling-sample window during the sample period for a 12-day-ahead forecast error variance. Total volatility connectedness is estimated using the risk-neutral volatilities, stock market indices, and the 10-year government bonds of Spain, the U.S., and Germany.

Panel A: Monthly Net Directional Connectedness Dynamics from Risk-Neutral Volatilities to the System



Panel B: Monthly Net Directional Connectedness Dynamics from Stock Market Returns to the System



Panel C: Monthly Net Directional Connectedness Dynamics from the 10-year Treasury Bond Returns to the System

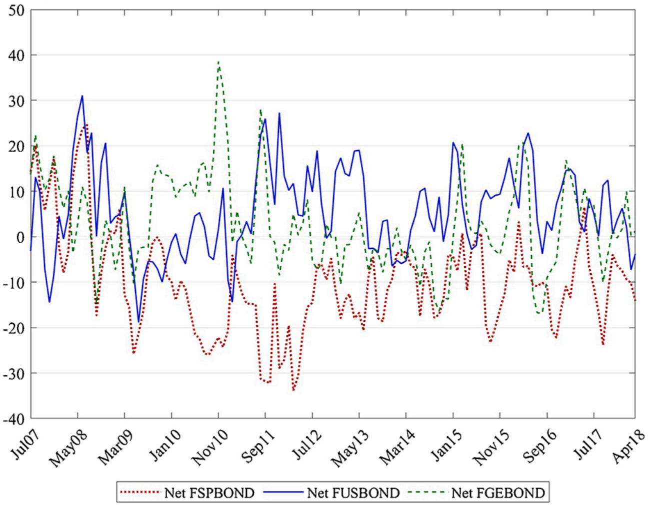


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Fig. 3. Monthly Net Directional Connectedness Dynamics from Risk-Neutral Volatilities, Stock Market Returns, and Government Bond Returns to the System formed by the Spanish, U.S., and German Capital Markets: July 2007-April 2018.
This figure displays the monthly net connectedness dynamics from the VIBEX, the VIX, and the VDAX (Panel A.), from the IBEX35, SP500, and DAX30 (Panel B,), and from the SPBOND, USBOND, and GEBOND (Panel C.) to the system formed by the Spanish, U.S., and German capital markets. It is calculated as the average daily percentages of net spillovers effects within each month in the sample. The daily spillovers are estimated over 200-day rolling-sample window during the sample period for a 12-day ahead forecast error variance. SPBOND, USBOND and GEBOND are 10-year Government bond returns of the Spanish, U.S. and German economies, respectively.

returns and the Spanish and German risk-neutral volatilities are the net receivers of volatility from the others. Finally, the bottom-right entry, which is equal to 66 %, presents the average total connectedness dynamics among all the assets in the system.[13]

Although the previous averages values gives an overall picture of connectedness dynamics among asset classes and markets, from the point of view of our research, it is especially important to look at the time evolution of connectedness. Fig. 2 shows that the monthly total connectedness dynamics changes significantly over the sample period. In this case, the monthly connectedness is calculated as the average daily percentage within each month. As expected, the behavior of total connectedness reflects higher spillovers during financial and economic stress. For instance, the maximum total connectedness was 74.9 % in October 2008 but in August 2012 (a critical period for the stability of the Eurozone), such connectedness was also relatively high at 74.7 %. This suggests that the system tends to be more connected during bad economic times. Subsequently, the minimum value of 51.1 % occurred in January 2018, while the average connectedness dynamics was 66.1 %, with a standard deviation of 5.3 % calculated at a monthly frequency.

Panel A of Fig. 3 shows the connectedness dynamics from each of the risk-neutral volatilities to the system. For most of the sample period, the VIBEX and the VDAX are net receivers of volatility from other assets. On the other hand, the VIX becomes a net sender of volatility to other assets from October 2008 to January 2009, October 2011 to April 2012, November 2015 to January 2016, and September 2017 to April 2018. However, it is also true that the VIX becomes a net receiver of volatility in other time-periods, and especially between November 2007 to August 2008. The behavior of the three stock market indices shows a completely different behavior compared to the risk-neutral volatilities. The time-varying net connectedness of the three indices to the system is shown in Panel B of Fig. 3. During basically all months over the sample period, they are net senders of volatility. The notable exception is the S&P500 index, which became a net receiver of volatility during July 2015, and just before the Presidential elections from September to November of 2016. Finally, the behavior of Government bond returns presents a more asymmetric behavior across the three countries compared to the stock market returns. The Spanish Treasury bond tends to be a net dynamically receiver of volatility. This is illustrated in Panel C of Fig. 3 where the Spanish bond net spillovers remain negative during most of the sample period. The U.S. and German bonds tend to present dynamically positive net spillovers. The most remarkable behavior shown in Panel C of Fig. 3 corresponds to the German bond becoming an extreme net sender of volatility to other assets from October to December of 2010. This is explained by the notable deal between the French and German prime ministers who, on October 18, 2010, met in Deauville (France) to sign an agreement in which Germany abandoned its requirement for strong and ex ante control over national budgets and deficits.

5. The relationship between connectedness and margining practices: the potential systemic effects during bad economic times

As illustrated in Fig. 1, the procyclical (relative to volatility) nature of the prudential practices of CCPs around the world, with respect to guarantee requirements and margins, raises a concern regarding the potential effects of these practices on systemic risk from contagion among assets and institutions. Note that when recognizing this source of spillover, the procyclicality of margining is certainly difficult to avoid. It is precisely because of this drawback that generating formal evidence on the relationship between margining and connectedness is important for better understanding global financial stability. Additionally, note that spillovers per se may not be problematic. What is problematic are the illiquidity–volatility spirals described by Brunnermeier and Pedersen (2009). In fact, using data from our sample period, we ran an ordinary least squares (OLS) regression of the log of total connectedness on the conditional correlation between the VIX and the market-wide illiquidity metric proposed by Abdi and Ranaldo (2017).[14] The estimated slope of this regression was equal to 0.150, with an Heteroskedasticity-Autocorrelation-Consistent (HAC)-based *t*-statistic of 4.19 and an R^2-squared value of 23 %. Thus, it is important to point out that the illiquidity–volatility spiral seems to be present in our sample period. This is how the following results should be interpreted and how we should understand the potential systemic effects.

We first start by analyzing the relationship between connectedness and margining practices. In this case, we performed the

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[13] Additionally, we estimated the unconditional full sample connectedness across all nine assets as well as among the three assets for each of the capital markets, in isolation from the other two markets. Using the nine assets the total connectedness is equal to 58.2%, somewhat lower than the average of 66% obtained for the dynamic analysis. Using the three assets of each market, the relatively low values of the total system connectedness (approximately 18%, 26%, and 30% for the Spanish, German, and U.S., respectively), along with the higher ones observed in Table 1 suggest that these capital markets (especially Spain) are strongly influenced by the behaviors of the other two markets.

[14] We employed an effective spread estimator closely inspired by the measure of Abdi and Ranaldo (2017), which calculated the daily close, high, and low prices of stocks traded in the NYSE, AMEX, and NASDAQ. The estimated illiquidity across stocks and days within each month were also aggregated to obtain the monthly market-wide illiquidity proxy. Abdi and Ranaldo (2017) also showed that their metric outperforms other available low-frequency estimators. The market-wide illiquidity proxy used in this study has been estimated by Abad et al. (2021). We thank them for allowing us to use their data.

Table 2
The Relationship Between Total Connectedness with Guarantee Requirements and the Recession Dates from June 27, 2007, to April 26, 2018.

PANEL A: CONNECTEDNESS AND MARGINING			
	BME–IBEX 35	Eurex–DAX 30	Eurex–EURO STOXX 50
INTERCEPT	4.044	4.057	4.055
	(145.5)	(153.2)	(161.9)
MARGINING	1.474	1.621	1.619
	(5.87)	(5.52)	(5.87)
ADJ R^2	0.079	0.059	0.066
PANEL B: MARGINING AND RECESSIONS			
PANEL B.1: BME–IBEX 35	RECESSION: SPAIN	RECESSION: THE U.S. and THE EUROZONE	RECESSION: SPAIN, THE U.S., and THE EUROZONE
INTERCEPT	0.092	0.092	0.092
	(78.75)	(88.59)	(76.65)
RECESSIONS	0.013	0.017	0.011
	(5.59)	(6.44)	(4.90)
ADJ R^2	0.121	0.183	0.092
PANEL B.2: Eurex–DAX 30	RECESSION: GERMANY	RECESSION: THE U.S. and THE EUROZONE	RECESSION: GERMANY, THE U.S., and THE EUROZONE
INTERCEPT	0.078	0.077	0.077
	(116.3)	(118.7)	(114.7)
RECESSIONS	0.007	0.009	0.007
	(3.51)	(4.35)	(3.91)
ADJ R^2	0.067	0.105	0.075
PANEL B.3: Eurex–EURO STOXX 50	RECESSION: THE EUROZONE	RECESSION: THE U.S. and THE EUROZONE	RECESSION: GERMANY, THE U.S., and THE EUROZONE
INTERCEPT	0.078	0.078	0.076
	(110.5)	(109.2)	(185.5)
RECESSIONS	0.012	0.012	0.011
	(4.50)	(4.52)	(5.99)
ADJ R^2	0.123	0.123	0.131
PANEL C: CONNECTEDNESS, MARGINING, AND RECESSIONS			
PANEL C.1: BME–IBEX 35	RECESSION: SPAIN	RECESSION: THE U.S. and THE EUROZONE	RECESSION: SPAIN, THE U.S., and THE EUROZONE
INTERCEPT	4.087	4.115	4.093
	(145.5)	(135.0)	(146.5)
MARGINING	0.833	0.549	0.712
	(2.96)	(1.85)	(2.49)
MARGINING× RECESSION	0.423	0.589	0.534
	(4.43)	(6.09)	(5.48)
ADJ R^2	0.121	0.149	0.148
PANEL C.2: Eurex–DAX 30	RECESSION: THE EUROZONE	RECESSION: THE U.S. and THE EUROZONE	RECESSION: GERMANY, THE U.S., and THE EUROZONE
INTERCEPT	4.103	4.143	4.113
	(139.4)	(156.7)	(142.0)
MARGINING	0.867	0.278	0.681
	(2.40)	(0.86)	(1.91)
MARGINING× RECESSION	0.540	0.866	0.629
	(4.05)	(8.31)	(4.80)
ADJ R^2	0.090	0.152	0.108
PANEL C.3: Eurex–EURO STOXX 50	RECESSION: THE EUROZONE	RECESSION: THE U.S. and THE EUROZONE	RECESSION: GERMANY, THE U.S., and THE EUROZONE
INTERCEPT	4.123	4.132	4.110
	(165.6)	(164.5)	(136.8)
MARGINING	0.563	0.413	0.689
	(1.88)	(1.35)	(1.73)
MARGINING× RECESSION	0.683	0.785	0.499
	(6.35)	(7.62)	(3.39)
ADJ R^2	0.101	0.154	0.103

This table shows the relationship between the total connectedness among the risk-neutral volatilities, stock market returns, and government bond returns for the U.S., German, and Spanish markets and the guarantees required by the Spanish BME CCP on the futures contracts in the IBEX 35 and the guarantees required by the German Eurex CCP on the futures contracts in the DAX 30 and EURO STOXX 50. We also analyzed the effects of the recession dates by considering three alternative dates for each margining data case. For the futures contracts in the IBEX 35, we used the recession dates of Spain, the combined recession dates of the U.S. and the Eurozone, and the total combined recession dates of Spain, the U.S., and the Eurozone. For the futures contracts in the DAX 30, we used the recession dates of Germany, the combined recession dates of the U.S. and the Eurozone and the total combined recession dates of Germany, Spain, the U.S., and the Eurozone. For the futures contracts of the EURO STOXX 50, we used the recession dates of the Eurozone, the combined recession dates of the U.S. and the Eurozone, and the total combined recession dates of Germany, Spain, the U.S., and the Eurozone. Panel A presents the results of the following OLS regression with daily data: $LnC_t = \beta_0 + \beta_1 Mg_t + \varepsilon_t$, where LnC_t is the log of total connectedness for all assets and countries, and Mg_t is the guarantee per unit of each of the futures contracts on any given day t. Panel B shows the results of the following OLS regression of margins on a recession dummy variable, denoted as REC_t, which takes the value 1 when there is a recession date or equals 0 otherwise: $Mg_t = \beta_0 + \beta_1 REC_t + \varepsilon_t$. Panel C presents the results of the following OLS regression that includes an interaction term between margining and recessions: $LnC_t = \beta_0 + \beta_1 Mg_t + \beta_2 Mg_t \times REC_t + \varepsilon_t$. HAC standard errors were used in all three panels. The number of lags used in the HAC standard errors is given by the expression $0.75T^{1/3}$, where T is total number of observations.

following OLS regression with HAC standard errors and daily data:

$$LnC_t = \beta_0 + \beta_1 Mg_t + \varepsilon_t, \tag{1}$$

where LnC_t is the log of total connectedness dynamics among the nine assets in the three capital markets, and Mg_t is the guarantee requirement per unit of the futures contracts in the IBEX 35, DAX 30, or EURO STOXX 50 on any given day t. The results, presented in Panel A of Table 2, show a positive and strong significance relation between connectedness and margining.

Panel B of Table 2 reports the results from the OLS regression of margining on recession dates:

$$Mg_t = \beta_0 + \beta_1 REC_t + \varepsilon_t, \tag{2}$$

where REC_t takes the value 1 when day t belongs to a month in which there is an official recession or equals 0 otherwise. We considered three alternative sets of recession dates based on the margining data.[15] Note that there were notable differences between the various economies in terms of recession dates.[16] The results show that in all three margining cases, there was a strong, positive, and significant relationship between margining and recessions, implying that margining tends to be significantly higher during recession periods. The values of the R-squared statistics also provide relevant information. For example, margining in the IBEX 35 not only increases during bad economic times in the Spanish economy but also when there is a global crisis, as shown by the high R-squared of 18.3 % when employing the combined recession dates of the U.S. and Eurozone. Similarly, when we look at margining for the DAX 30, the U.S. recessions seem to be relatively important with respect to other bad economic times, as shown by the high R-squared value in Panel B.

Panel C of Table 2 incorporates the interaction effects between recessions and the margining data employed in the previous regression. Hence, we ran the following regression with daily data to capture the incremental effects of the relationship between connectedness and margining during recessions:

$$LnC_t = \beta_0 + \beta_1 Mg_t + \beta_2 Mg_t \times REC_t + \varepsilon_t, \tag{3}$$

where, as earlier, REC_t takes the value 1 when day t belongs to a month in which there is recession or equals 0 otherwise. Outside of recessions, the positive relationship between total connectedness and margining is not always statistically different from zero but depends on the recession and market employed. However, it becomes unambiguously positive and highly significant during recessions, independent of the margining dataset used in the analysis. Furthermore, the use of the combined international recession dates is accompanied by higher R-squared values. For example, in the Spanish case, margining and recession dates explain approximately 15 % of the variability of total connectedness when we include the recession dates of the U.S. and Eurozone. The results using the Eurex data also suggest the importance of global effects from bad economic times. Specifically, using the DAX 30 data, the highest R-squared value is equal to 15.2 %, and it occurs when we include both the U.S. and Eurozone recessions. In the same line, using the EURO STOXX 50 data, the U.S. recessions appear relevant even when we consider the Eurozone in our analysis. Overall, these results indicate a negative signal for the potential effects of procyclical margining on systemic risk.

Table 3 presents the results regarding the economic drivers of total connectedness dynamics for the Spanish, German, and Eurozone cases. We now add economic and monetary controls to the previous relationship between total connectedness and margining, including the SKEW index. This reflects the tail risk that the market assigns to a large drop in prices, industrial production growth, and changes in the one-month Treasury bills. In the case of the EURO STOXX 50, industrial production growth and changes in short-term Treasury bills are the weighted average of production growth and Treasury bills for Germany, France, Spain, and the United Kingdom (U.K.), in which the weights are the yearly percentages of the gross domestic product (GDP) of each country over the total GDP of the four countries. Moreover, we controlled for the Economic Policy Uncertainty Index proposed by Baker et al. (2016) for Spain, Germany, and Europe, respectively. The inclusion of uncertainty is reasonable, given that Bekaert et al. (2013) showed that risk-neutral

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[15] These dates were obtained from the webpage of the Spanish Economic Association at www.asesec.org/CFCweb/en/; from the NBER Business Cycle Dating Committee at https://www.nber.org/cycles/recessions/html/; and from Euro Area Business Cycle Dating Committee at https://cepr.org/content/euro-area-business-cycle-committee/, respectively.

[16] The U.S. economy did not experience a recession during the Eurozone sovereign debt crisis, and the Spanish economy was not in recession from December 2007 to March 2008. However, in contrast to the U.S. and Eurozone, the Spanish economy was in recession from October 2010 to August 2011 and from April 2013 to June 2013.

Table 3

The Economic Drivers of Total Connectedness Based on Monthly Data from July 2007 to April 2018.

PANEL A: SPAIN

LN TOTAL CONNECTEDNESS	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
INTERCEPT	4.042	4.088	3.877	3.924	3.945	3.981	3.952
	(62.74)	(65.41)	(50.32)	(52.44)	(38.62)	(37.34)	(38.94)
MARGINING	1.492	0.815	1.445	0.796	0.830	0.647	0.734
	(2.62)	(1.35)	(2.61)	(1.33)	(1.16)	(0.82)	(1.02)
MARGINING× RECESSION	-	0.434	-	0.417	0.403	0.507	0.478
		(2.26)		(2.39)	(2.29)	(2.89)	(2.68)
LN SKEW INDEX	-	-	0.106	0.104	0.104	0.096	0.098
			(3.30)	(3.15)	(3.13)	(3.06)	(3.15)
IPI GROWTH	-	-	-	-	−0.053	−0.094	−0.035
					(−0.15)	(−0.26)	(−0.10)
CHANGE T. BILL	-	-	-	-	−1.106	−0.398	−1.049
					(−0.71)	(−0.24)	(−0.68)
LN UNCERTAINTY	-	-	-	-	−0.005	−0.006	−0.003
					(−0.21)	(−0.23)	(−0.13)
Adj R^2	0.089	0.138	0.195	0.240	0.225	0.239	0.245

PANEL B: GERMANY

LN TOTAL CONNECTEDNESS	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
INTERCEPT	4.044	4.090	3.954	3.999	4.068	4.006	3.952
	(73.45)	(66.43)	(60.86)	(54.12)	(25.82)	(35.67)	(30.99)
MARGINING	1.782	1.029	1.061	0.208	0.331	0.213	0.348
	(3.10)	(1.42)	(1.77)	(0.27)	(0.47)	(0.32)	(0.47)
MARGINING× RECESSION	-	0.514	-	0.555	0.614	0.913	0.626
		(1.96)		(2.22)	(2.44)	(4.87)	(2.50)
LN SKEW INDEX	-	-	0.093	0.098	0.094	0.091	0.090
			(2.81)	(2.83)	(2.67)	(2.78)	(2.66)
IPI GROWTH	-	-	-	-	0.485	0.569	0.518
					(1.69)	(2.03)	(1.84)
CHANGE T. BILL	-	-	-	-	−1.068	−1.580	−0.116
					(−0.22)	(−0.33)	(−0.02)
LN UNCERTAINTY	-	-	-	-	−0.015	0.006	0.009
					(−0.60)	(0.34)	(0.50)
Adj R^2	0.056	0.098	0.123	0.175	0.168	0.246	0.177

PANEL C: THE EUROZONE

LN TOTAL CONNECTEDNESS	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
INTERCEPT	4.044	4.115	3.961	4.029	4.011	4.005	3.962
	(79.36)	(84.90)	(63.29)	(66.40)	(34.50)	(34.42)	(36.52)
MARGINING	1.748	0.658	1.114	−0.116	−0.018	−0.094	−0.833
	(3.30)	(1.19)	(1.97)	(−0.18)	(−0.03)	(−0.15)	(−1.07)
MARGINING× RECESSION	-	0.672	-	0.721	0.785	0.850	0.842
		(3.38)		(3.85)	(3.82)	(4.32)	(3.29)
LN SKEW INDEX	-	-	0.085	0.093	0.093	0.089	0.093
			(2.54)	(2.51)	(2.51)	(2.63)	(2.66)
IPI GROWTH	-	-	-	-	1.405	1.269	0.852
					(2.10)	(1.95)	(1.21)
CHANGE T. BILL	-	-	-	-	−2.826	−2.102	−3.749
					(−0.57)	(−0.42)	(−1.27)
LN UNCERTAINTY	-	-	-	-	0.001	0.005	0.022
					(0.07)	(0.272)	(1.31)
Adj R^2	0.081	0.154	0.134	0.219	0.218	0.241	0.238

Panel A contains the empirical results for Spain, Panel B contains those for Germany, and Panel C contains those for the Eurozone. This table presents the results of the following OLS regression with HAC standard errors and monthly data: $LnC_t = \beta_0 + \beta_1 Mg_t + \beta_2 Mg_t \times REC_t + \beta_3 LnSkew_t + \beta_4 \Delta IPI_t + \beta_5 \Delta Tbill_t + \beta_6 LnUnc_t + \varepsilon_t$, where LnC_t is the log of the total connectedness dynamics among the risk-neutral volatilities, stock market returns, and government bond returns for the U.S., German, and Spanish markets, measured as the monthly average of daily connectedness within a given month; Mg_t is the guarantee per unit of the futures contracts in the IBEX 35 (Panel A), DAX 30 (Panel B), and EURO STOXX 50 (Panel C) on any given month t, measured as the monthly average of daily guarantees within a given month (required by the Spanish BME or German Eurex CCPs); REC_t, which takes the value 1 when there is a recession date or equals 0 otherwise; and $LnSkew_t$ is the log of the SKEW index during month t, again estimated as the average of the daily SKEW index within the corresponding month. The other control variables, ΔIPI_t,ΔTbill_t, and $LnUnc_t$ are the Spanish, German, and Eurozone changes in industrial production and one-month Treasury bills, and the log of the Economic Policy Uncertainty Index, respectively. In Panels A and B, we employed industrial production growth, Treasury bill, and the Economic Policy Uncertainty Index for Spain and Germany, respectively. In Panel C, industrial production growth and Treasury bill changes are the weighted average of industrial production growth and the short-term rates for Germany, France, Spain, and the U.K., where the weights are the percentages of the GDP of each country during each year on the total GDP of the four countries. Models 1 through 5 employ the official recession dates of the Spanish (Panel A), German (Panel B), and Eurozone (Panel C) economies. Models 6 and 7 employ for the Spanish BME CCP (Panel A) the combined recession dates of the U.S. and the Eurozone and the combined recession dates of Spain, the U.S., and the Eurozone, respectively. For the German Eurex CCP, Panels B and C employ the combined recession dates of the U.S. and Eurozone and the combined recession dates of Germany, the U.S., and the Eurozone, respectively.

volatilities can be decomposed into two components reflecting risk aversion and uncertainty. Consequently, the use of such volatilities requires controlling for a proxy of uncertainty.

Therefore, we ran the following OLS regression and monthly data:[17]

$$LnC_t = \beta_0 + \beta_1 Mg_t + \beta_2 Mg_t \times REC_t + \beta_3 LnSkew_t + \beta_4 \Delta IPI_t + \beta_5 \Delta Tbill_t + \beta_6 LnUnc_t + \varepsilon_t \tag{4}$$

where LnC_t is the total connectedness dynamics, measured as the monthly average of the daily connectedness within a given month, and $LnSkew_t$ is the log of the SKEW index during month t, again estimated as the average of the daily SKEW index within the corresponding month. The other control variables, ΔIPI_t,ΔTbill, and $LnUnc_t$ are changes in industrial production, one-month Treasury bills, and the log of the Economic Policy Uncertainty Index, respectively.

Overall, the results for all three economic areas are similar, thus confirming the robust and positive relationship between total connectedness and margining during recessions, even after controlling for all the previous variables. This finding is also robust across alternative regression specifications. Furthermore, the total spillover effects tend to be positively related to tail risk and, in the cases of the DAX 30 and EURO STOXX 50 futures contracts, there seems to be a positive (although weak) relationship between connectedness and industrial production growth. In fact, margining, the interaction between margining and recessions, and tail risk explain between 18 % and 24 % of the variability of total connectedness among the nine assets of the Spanish, U.S., and German capital markets.

6. An event study on the relationship between margining practices and connectedness dynamics

Our previous evidence raises the two competing questions of this research: Do margining activities by CCPs increase the spillover effects across international markets during volatile and illiquid economic times? Conversely, do connectedness and margining react to bad economic times characterized by highly volatile and illiquid markets? Under the second scenario, margining practices are simply a reaction to bad economic times, although the additional collateral requirements could also exacerbate the illiquidity–volatility spirals and the corresponding spillover effects. However, under this scenario, even after accepting that amplifying effects would certainly be possible, the prudential practices of CCPs would not be the initial cause for increased systemic risk. Thus, we argue that this research may provide new economic insights that may help design future regulatory actions.

Next, we provide additional evidence that helps discriminate between the previous two alternatives. Specifically, we performed an event study on the time periods in which CCPs increase their collateral requirements. In this case, any moment of time in which we observed an increase in the guarantee was classified as an event date. Then, we analyzed the behavior of the overall connectedness in a pre-specified window around the event time.

Given the practices of CCPs, it is important to clarify our understanding of an event and the corresponding number of events. For the Spanish case, an event occurred every time there was an increase in the guarantee per position in euros. Over the sample period, i.e., from January 3, 2007, to April 26, 2018, there were 13 events. For the German case, up to April 27, 2011, there were 15 events in this sub-period. However, from April 28, 2011, onward, an event occurred when the guarantee was greater than the mean plus three times its standard deviation. In this case, the mean was estimated using 120 days. This procedure generated 32 events in this second sub-period, totaling 47 events for Germany. It is important to note that we selected three (rather than two) standard deviations over the mean to maintain a similar proportion of events over the number of days in both sub-periods. Using the same procedure, we had 14 and 36 events in both sub-periods, respectively, for a total of 50 events in the case of the EURO STOXX 50.

The next stage involved first calculating the abnormal connectedness for a day τ in event time. This is defined as the difference between the total connectedness and its conditional mean, estimated with either 120 or 245 days before the event window. Then, we determine the cumulative average abnormal connectedness (*AAC*) over the event window.[18]

We also present the empirical results separately for the Spanish, German, and EURO STOXX 50 cases. Table 4 shows the *AAC*, given by expression (B.4) in Appendix B for all three markets and the conditional mean estimated with either 120 or 245 days. The results are similar to the number of days employed to estimate the conditional mean. For the Spanish market, the highest *AAC* is obtained at day +1. In fact, it is the only market in which we observe a high and positive jump in the *AAC* between days 0 and +1. For the German and EURO STOXX 50 markets, the highest *AAC* occurs the day before the event date. Meanwhile, higher increases in the *AACs* are observed before the event time during days −3 to −1 and on day −1 for the German and EURO STOXX 50 markets, respectively. In all three cases, the *AACs* are positive five days before the event date. This evidence suggests that abnormal connectedness starts to increase

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[17] The monthly frequency of these regressions is because of the availability of industrial production and the economic policy uncertainty data.

[18] The statistical design of this event study follows Campbell et al. (1997), who used stock returns and the market model to define abnormal returns. For details on the methodology, see Appendix B at the end of this paper.

Table 4

The Average Abnormal Connectedness (AAC) Around the Increases of Guarantee Requirements from June 26, 2007, to April 26, 2018.

	SPAIN		GERMANY		EURO STOXX 50	
Event Date	AAC Mean over 120 days	AAC Mean over 245 days	AAC Mean over 120 days	AAC Mean over 245 days	AAC Mean over 120 days	AAC Mean over 245 days
−5	0.016	0.012	0.017	0.023	0.035	0.040
−4	0.018	0.013	0.014	0.021	0.035	0.040
−3	0.014	0.009	0.016	0.023	0.035	0.040
−2	0.015	0.010	0.019	0.025	0.033	0.038
−1	0.012	0.007	0.020	0.027	0.035	0.040
0	0.014	0.009	0.016	0.022	0.031	0.036
+1	0.024	0.019	0.015	0.021	0.030	0.035
+2	0.021	0.016	0.012	0.018	0.028	0.033
+3	0.005	0.000	0.019	0.025	0.027	0.032
+4	0.016	0.011	0.013	0.019	0.023	0.028
+5	0.016	0.011	0.010	0.017	0.020	0.025
+6	0.012	0.007	0.013	0.019	0.020	0.025
+7	0.000	−0.005	0.008	0.014	0.013	0.018

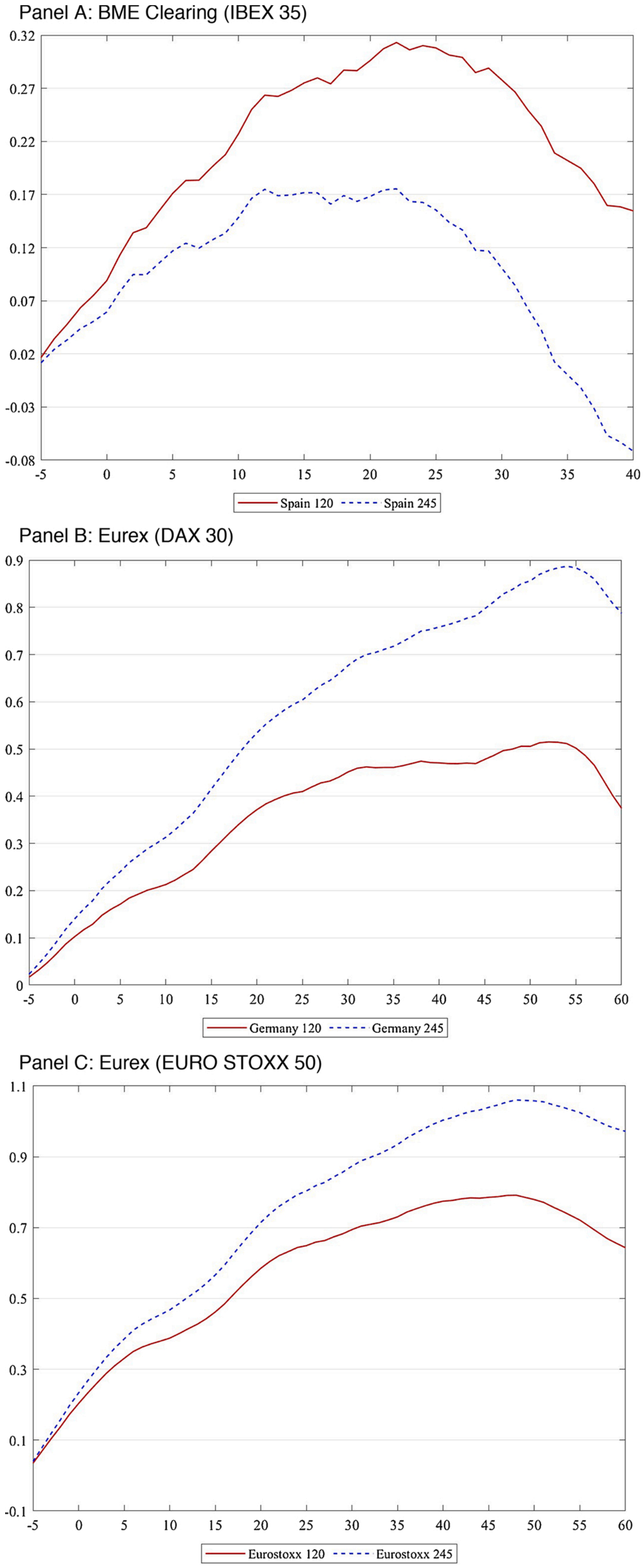
This table shows the average abnormal total connectedness among the risk-neutral volatilities, stock market returns, and government bond returns for the Spanish, U.S., and German markets around the event date, which is defined as any moment of time in which there is an increase in the guarantee requirements of CCPs. We define abnormal connectedness for a day τ in event time as the difference between the total connectedness and its conditional mean, estimated with either 120 or 245 days before the event window. The guarantee requirements are for the futures contracts in the IBEX 35, DAX 30, and EURO STOXX 50, as established by the Spanish BME and German Eurex CCPs.

Table 5

The Cumulative Average Abnormal Connectedness ($\overline{CAC}$) Around the Increases of Guarantee Requirements from June 26, 2007, to April 26, 2018.

	SPAIN		GERMANY		EURO STOXX 50	
Event Window	$\overline{CAC}$ Mean over 120 days	$\overline{CAC}$ Mean over 245 days	$\overline{CAC}$ Mean over 120 days	$\overline{CAC}$ Mean over 245 days	$\overline{CAC}$ Mean over 120 days	$\overline{CAC}$ Mean over 245 days
[−5, −4]	0.034	0.024	0.031	0.044	0.069	0.079
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, −3]	0.048	0.033	0.047	0.066	0.104	0.119
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, −2]	0.063	0.044	0.066	0.091	0.137	0.157
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, −1]	0.075	0.051	0.086	0.118	0.172	0.197
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, 0]	0.089	0.059	0.102	0.140	0.203	0.233
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +1]	0.113	0.079	0.117	0.161	0.233	0.268
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +2]	0.134	0.095	0.129	0.179	0.261	0.300
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +3]	0.139	0.094	0.148	0.204	0.287	0.332
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +4]	0.155	0.106	0.161	0.223	0.311	0.360
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +5]	0.171	0.117	0.171	0.240	0.331	0.385
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +6]	0.183	0.124	0.184	0.259	0.350	0.410
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
[−5, +7]	0.183	0.120	0.193	0.274	0.363	0.428
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

This table shows the cumulative average abnormal total connectedness among the risk-neutral volatilities, stock market returns, and government bond returns for the Spanish, U.S., and German markets over the event window, which is set up around an event date and defined as any moment of time in which there is an increase in the guarantee requirements of CCPs. We define abnormal connectedness for a day τ in event time as the difference between the total connectedness and its conditional mean, estimated with either 120 or 245 days before the event window. In the parentheses, we report the *p*-value associated with the test statistics, given by expression (B.9) in Appendix B. The guarantee requirements are for the futures contracts in the IBEX 35, DAX 30, and EURO STOXX 50, as established by the Spanish BME and German Eurex CCPs.



(caption on next page)

Fig. 4. The Long Cumulative Average Abnormal Connectedness ($\overline{CAC}$) Relative to the Mean Calculated from 120 and 245 Days Before the Event Window.
This figure shows the cumulative average abnormal total connectedness over a long pre-specified window (i.e., from −5 to +60 days around the event date), which is defined as any moment of time where there is an increase in the guarantee requirements of BME Clearing (Panel A) and Eurex (Panels B and C) associated with the futures contracts in the IBEX 35, DAX 30, and EURO STOXX 50, respectively. We define abnormal connectedness for a day τ in event time as the difference between the total connectedness and its conditional mean, estimated with either 120 or 245 days before the event window.

before the requirement of additional guarantees by the CCPs.

In Table 5, we show the cumulative *AAC* during the event window, given by Eq. (B.6) in Appendix B. We report the results for both estimation periods of the conditional mean for 120 and 245 days. In all the cases, the $\overline{CACs}$ continue to grow throughout the event window, that is, from day −5 to day +7. Moreover, all the $\overline{CACs}$ are statistically different from 0. Thus, the conclusion is clear and very robust across the Spanish BME and German Eurex CCPs.

Furthermore, total connectedness starts to increase before the rise in the guarantees required by the CCPs. In all three markets, the $\overline{CACs}$ increase significantly during the event window, that is, from day −5 to day 0 (the event day). Hence, it seems that margining practices are simply a reaction to bad economic times. Meanwhile, total connectedness increases because of the progressive deterioration of the economic conditions rather than causing such conditions.[19] However, it is also true that the increasing behavior of the $\overline{CACs}$ after the event date suggests that CCP management practices may exacerbate the spillover effects. To investigate this possibility, we estimated the abnormal market portfolio returns in the three stock indices after the event date. The results show that abnormal market returns decrease after the event date. This additional evidence suggests that the increasing $\overline{CACs}$ are associated with poor economic conditions following event dates rather than related to institutional practices.

Finally, Fig. 4 presents the cumulative AAC for a long event window, which confirms that total connectedness starts to decrease several days after the event date. In this regard, the Spanish case shows an early decline relative to the German and EURO STOXX 50 markets.

7. Conclusion

A key recommendation of the Squam Lake Report (2010) is that regulators should consider the implications and incentives stemming from regulations not only for individual institutions but also for the global financial system. This basic idea also applies directly to the management practices of CCPs. In this regard, financial firms are not only connected through derivatives but through all financial contracts. From the perspective of systemic risk, it is unclear a priori what effects emerge from the redistributive credit risk raised from the multilateral netting and collateral requirements. The procyclicality (relative to volatility) of margining with undesirable consequences for funding liquidity, especially during bad economic times and highly volatile markets also deserves an empirical analysis regarding the implications of the spillover effects among asset classes and markets.

Overall, this study provides robust evidence on the positive relationship between margining and volatility spillover effects among risk-neutral volatilities, stock market returns, and government bond returns across three capital markets. Using data from the Spanish BME and German Eurex CCPs, we show that increased margining tends to be significantly accompanied by higher connectedness among all nine assets. Although CCPs operate default funds and have large capital buffers, the significant positive relations may have consequences on their members if the spillover effects are serious. Such positive relations between spillovers and guarantee requirements reported in this research are also significantly amplified during bad economic times or times of higher volatility and lower funding liquidity. This seems to be the case even after controlling for tail risk and monetary and real activity measures in the Spanish and Eurozone economies. This finding is independent of the specific recession data in our analysis, including the recession dates from the U.S. economy.

Our evidence could signal potentially relevant systemic risk, especially because there is a high probability that CCPs around the world (and not only the European CCPs) make decisions associated with higher margins during similar periods. Conversely, our evidence is limited in time and data, and more importantly, the reported empirical evidence reflects the usual tension between the correlation and causality effects of the practices of CCPs on the business cycle. Thus, to provide further economic insights, we performed an event study around the days in which CCPs increase their guarantee requirements. We report robust results showing that CCPs tend to react to bad economic times rather than being the origin or the cause of the illiquidity–volatility spirals. Furthermore, average abnormal total connectedness starts to significantly increase before CCPs raise their guarantee requirements.

Finally, our results deserve further research by using a more comprehensive intraday database. The relationship between intraday margin calls for major players and connectedness dynamics could lead to important policy implications. Future research should also clarify the appropriateness of counter-cyclical regulations with specific buffers, as opposed to procyclical ones.

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[19] It is important to note that when defining the event date, with reductions in the required guarantees by the CCPs, the cumulative AAC continuously decreases during the event window. This additional evidence supports the idea that CCPs react to rather than cause either good or bad economic conditions.

Data availability

Data will be made available on request.

The data that has been used is confidential.

Author statement

Ana González-Urteaga: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – Original Draft, Writing – Review & Editing, Funding acquisition.

Gonzalo Rubio: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – Original Draft, Writing – Review & Editing, Funding acquisition.

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Appendix A. Estimation of Connectedness

We consider a covariance stationary N-variable VAR(P)

$$X_t = \sum_{p=1}^{P} \phi_p X_{t-p} + \varepsilon_t, \tag{A.1}$$

where $\varepsilon_t \sim (0, \Sigma)$ is a vector of independently and identically distributed disturbances, and X_t denotes an N-dimensional vector of economic variables. To estimate the specific variance decomposition, we rewrite the VAR(P) model as a moving average representation $X_t = \sum_{\tau=0}^{\infty} A_\tau \varepsilon_{t-\tau}$, where the $N \times N$ coefficient matrices are estimated by $A_\tau = \phi_1 A_{\tau-1} + \phi_2 A_{\tau-2} + \ldots + \phi_p A_{\tau-P}$, with A_0 being the identity matrix and $A_{\tau-p} = 0$ for any $p > \tau$.

These moving average coefficients allow for the variance decomposition to parse the H-step-forecast error variances of each variable into proportions associated with system shocks. The variance proportions defined as the fraction of the H-step-ahead generalized variance of the forecast error of variable X_i that is due to shocks to another variable X_j are given by

$$\widetilde{C}^{G}_{j\to i}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} \left(e'_i A_h e_j\right)^2}{\sum_{h=0}^{H-1} \left(e'_i A_h \Sigma A'_h e_i\right)^2}, \tag{A.2}$$

where σ_{jj} is the standard deviation of the error term for the jth equation, i.e., the squared root of the diagonal elements of the variance–covariance matrix Σ, and e_i is the vector with 1 as the ith element or 0 otherwise.

This generalized variance decomposition eliminates the dependence of the connectedness effects on the ordering of the variables (Koop et al., 1996; Pesaran and Shin, 1998). Conversely, this procedure account for correlated shocks assuming normality. Thus, in the case of risk-neutral volatilities, approximate normality is obtained by taking the natural logarithm of volatilities. Nevertheless, as the shocks to each variable are not orthogonalized, the row sum of the variance decomposition is not equal to 1. Consequently, each entry of the variance decomposition matrix is normalized by the row sum as

$$C^{G}_{j\to i}(H) = \frac{\widetilde{C}^{G}_{j\to i}(H)}{\sum_{j=1}^{N} \widetilde{C}^{G}_{j\to i}(H)} \times 100. \tag{A.3}$$

Hence, the reported results are in percentage terms and note that, by construction $\sum_{j=1}^{N} C^{G}_{j\to i}(H) = 100$ and $\sum_{i,j=1}^{N} C^{G}_{j\to i}(H) = N \times 100$. The measure $C^{G}_{j\to i}(H)$ represents the pairwise directional connectedness from X_j to X_i at a forecasting horizon H. It also represents the percentage of the variation in variable X_i which is because of shocks in X_j. It takes high values when the intensity of the directional connectedness or spillover from X_j to X_i is high. When there is no directional connectedness from one series to the other, the indicator equals 0.

By partially aggregating, we estimated the total directional connectedness with the two versions “FROM” and “TO”

$$C^{G}_{\bullet\to i}(H)=\frac{\sum^{N}_{\substack{j=1\\ i\neq j}} C^{G}_{j\to i}(H)}{\sum^{N}_{j,i=1} C^{G}_{j\to i}(H)}\times 100=\frac{\sum^{N}_{\substack{j=1\\ i\neq j}} C^{G}_{j\to i}(H)}{N}\times 100$$

$$C^{G}_{i\to\bullet}(H)=\frac{\sum^{N}_{\substack{j=1\\ i\neq j}} C^{G}_{i\to j}(H)}{\sum^{N}_{j,i=1} C^{G}_{i\to j}(H)}\times 100=\frac{\sum^{N}_{\substack{j=1\\ i\neq j}} C^{G}_{i\to j}(H)}{N}\times 100. \tag{A.4}$$

The net total directional connectedness is obtained by taking the difference between the two measures. It indicates the difference between the spillover effects transmitted by X_i to all other portfolios and those received by X_i from all other variables. If the connectedness transmitted from X_i is higher (lower) than the connectedness received by X_i, the net total directional will be positive (negative).

Finally, we obtained a measure of the total system connectedness, given by the ratio of the sum of the off-diagonal elements of the variance decomposition matrix to the sum of all of its elements:

$$C^{G}(H)=\frac{\sum^{N}_{\substack{i,j=1\\ i\neq j}} C^{G}_{j\to i}(H)}{\sum^{N}_{j,i=1} C^{G}_{j\to i}(H)}=\frac{\sum^{N}_{\substack{i,j=1\\ i\neq j}} C^{G}_{j\to i}(H)}{N}. \tag{A.5}$$

Appendix B. The Event Study Methodology

We defined $\tau=0$ as the event date, $\tau=t_1+1$ to $\tau=t_2$ as the event window, and $\tau=t_0+1$ to $\tau=t_1$ as the estimation window. We also defined the abnormal connectedness for a day τ in event time as

$$AC_\tau=\ln C_\tau-\overline{\ln C_{t_{0+1},t_1}}, \tag{B.1}$$

where $\ln C_\tau$ is the log of the total connectedness among the three assets and three capital markets discussed in Section 5, and $\overline{\ln C_{t_{0+1},t_1}}$ is the conditional mean of the total connectedness over the estimation window. Next, we defined $\widehat{AC^v}$ as the L-dimensional vector of abnormal connectedness from the event window t_1+1 to t_2. Under the null hypothesis that the given event has no impact on connectedness and assuming the normality of the abnormal connectedness, we have

$$\widehat{AC^v}\sim N(0,V), \tag{B.2}$$

where V is the diagonal variance matrix of abnormal connectedness given by

$$V=E\left[\widehat{AC^v}\,\widehat{AC^v}'\,|\ln C^v\right], \tag{B.3}$$

and $\ln C^v$ is the time-dimensional vector of total connectedness over the estimation window.

For a sample of n events, we defined AAC^v as the sample average of the n abnormal connectedness vector as

$$AAC^v=\frac{1}{n}\sum_{e=1}^{n}\widehat{AC^v_e} \tag{B.4}$$

$$Var[AAC^v]=\frac{1}{n^2}\sum_{e=1}^{n}V_e. \tag{B.5}$$

We now denote $\overline{CAC}(\tau_1,\tau_2)$ as the cumulative average abnormal connectedness from τ_1 to τ_2,where $t_1<\tau_1\leq\tau_2\leq t_2$, and let λ be a L-dimensional vector with ones for τ_1 to τ_2 or zeros otherwise. Then

$$\overline{CAC}(\tau_1,\tau_2)=\frac{1}{n}\sum_{e=1}^{n}\lambda\cdot AAC^v \tag{B.6}$$

$$Var\left[\overline{CAC}(\tau_1,\tau_2)\right]=\widehat{\overline{\sigma}}^2(\tau_1,\tau_2)=\lambda' Var[AAC^v]\lambda. \tag{B.7}$$

Therefore, it follows from (11) that under the null hypothesis

$$\overline{CAC}(\tau_1,\tau_2)\sim N\left(0,\overline{\sigma}^2(\tau_1,\tau_2)\right). \tag{B.8}$$

Moreover, inferences are drawn from the following statistics:

$$J = \frac{\overline{CAC}(\tau_1, \tau_2)}{[\widehat{\overline{\sigma}}^2(\tau_1, \tau_2)]^{1/2}} \overset{a}{\sim} N(0, 1). \tag{B.9}$$

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