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SYSTEMIC RISK: MEASURES AND DETERMINANTS

María Rodríguez-Moreno

Fundación UCEIF

CANTABRIA CAMPUS INTERNACIONAL
Banca, Finanzas y Actividad Empresarial

Editorial Universidad Cantabria

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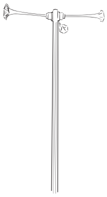

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A mi marido Sergio,
a mis padres Jesús y Mª del Carmen,
y a mi hermana Carmen.
Gracias por vuestro apoyo incondicional.

FUNDACIÓN DE LA UNIVERSIDAD DE CANTABRIA PARA EL ESTUDIO Y LA INVESTIGACIÓN DEL SECTOR FINANCIERO (UCEIF)

La Fundación de la Universidad de Cantabria para el Estudio y la Investigación del Sector Financiero (UCEIF), promovida por la UC y el Banco Santander, nació en el año 2006 con el fin de convertirse en un referente nacional e internacional en la generación y transmisión del conocimiento, la formación de alto nivel y la I+D en el sector financiero. Actualmente viene desarrollando proyectos de gran envergadura, organizando su actividad en dos ámbitos de actuación: banca y finanzas, por un lado, y actividad empresarial, con especial atención al emprendimiento y a las PYMES, por otro. Ambas se articulan por medio de los dos centros creados en el seno de la Fundación UCEIF y gestionados por ella, en 2012: el Santander Financial Institute (SANFI) y el Centro Internacional Santander Emprendimiento (CISE).

La misión del Santander Financial Institute (SANFI) es la generación, difusión y transferencia del conocimiento sobre el sector financiero, para lo que cual identifica, desarrolla, apoya y promociona el talento y la innovación que ostente un liderazgo sostenible y responsable socialmente, con el propósito de contribuir al bienestar, desarrollo y progreso social como centro líder por su excelencia e impacto social.

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- Atracción de Talento, con diferentes acciones para el desarrollo de líneas de investigación estratégicas dedicadas al estudio de los "Mercados Globales", al desarrollo e innovación de "Procesos Bancarios", al conocimiento de la "Historia Bancaria y Financiera" y al desarrollo del "Financial Supercomputing".

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- Premios a Tesis Doctorales, con el fin de promover y reconocer la generación del conocimiento a través de actuaciones en el ámbito del doctorado que desarrollen, impulsen el estudio y la investigación en el Sector Financiero.

- Y por último, la línea editorial, en la que se enmarcan estos Cuadernos de Investigación, con el objetivo de poner a disposición de la sociedad en general, y de la comunidad académica y profesional en particular, el conocimiento generado en torno al

Sector Financiero fruto de todas las acciones desarrolladas en el ámbito de la Fundación, y especialmente los resultados de las Becas, Ayudas y Premios a Tesis Doctorales.

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- Global Entrepreneurship Monitor (GEM) España, siendo el representante institucional del país a nivel mundial en este programa de investigación, difusión y compromiso con el Emprendimiento, los emprendedores y la creación de empresas, de alcance mundial.

- “YUZZ Jóvenes con Ideas”, concurso de talento tecnológico para jóvenes de 18 a 30 años que se desarrolla, con una periodicidad anual y ámbito nacional.

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Las actividades desarrolladas por la Fundación UCEIF, se enmarcan dentro del Área de Banca, Finanzas y Actividad Empresarial del proyecto Campus de Excelencia Cantabria Campus Internacional, donde periódicamente se organizan diversos cursos y encuentros con la UIMP y la UC, así como los "Encuentros de Economistas Especialistas en Iberoamérica" convocados por la SEGIB anualmente.

Finalmente destacar su participación como patrono en la creación, en alianza con las Universidades de Murcia, Politécnica de Cartagena y Cantabria, de la Fundación para el Análisis Estratégico y Desarrollo de la Pyme, en cuyo seno se crea la Red Internacional de Investigadores en Pymes. Fruto de esta actuación se elaboran diversos Informes sobre la Pyme en Iberoamérica, tanto a nivel de la región en su conjunto como en los distintos países.

FRANCISCO JAVIER MARTÍNEZ GARCÍA
Director de la Fundación UCEIF

ÍNDICE

ABSTRACT

In this Thesis, I study the measurement and the determinants of systemic risk, paying special attention to the role of the Credit Default Swaps (CDSs) either as financial instruments containing valuable information about the soundness of the reference institutions or as a market whose distress contributes to potential systemic shocks on the economy. The measurement of systemic risk is addressed from two perspectives, aggregate and individual contribution to systemic risk where the former refers to the level of systemic risk in the overall economy and the last to the individual contribution of each financial institution to the overall systemic risk. The analysis of the determinants of the individual contribution of financial institutions to systemic risk focuses on the effect of their portfolio holdings of derivatives. Finally, I study the liquidity commonalities and their determinants in the corporate CDS worldwide markets. The main participants in these markets are systemically important financial institutions (SIFIs) and so, abrupt changes in the market liquidity could cause systemic shocks on the overall economy and as a consequence, adverse effects on the global stability. Next, I summarize the main findings of the three chapters of this Thesis.

In Chapter 1 I adopt an aggregate perspective to estimate and compare two groups (macro and micro) of high-frequency market-based systemic risk measures using European and US interbank rates, stock prices and credit derivatives data from 2004 to 2009. Measures belonging to the macro group gauge the overall tension in the financial sector and micro group measures rely on individual institution information to extract joint distress. I rank the measures using three criteria: i) Granger causality tests, ii) Gonzalo and Granger metric, and iii) correlation with an index of systemic events and policy actions. I find that the best systemic measure in the macro group is the first principal component of a portfolio of CDS spreads whereas the best measure in the micro group is the multivariate densities computed from CDS spreads. These results suggest that simple measures based on CDSs outperform measures based on interbank rates or stock market prices.

Chapter 2 relies on the banks individual contribution to systemic risk. In this chapter I estimate and compare five measures of such contributions to systemic risk and find that a new measure proposed in this chapter, Net Shapley Value, outperforms the others using a sample of 91 U.S. bank holding companies from 2002 to 2011. The Net Shapley Value of institution j is defined as the weighted average of the marginal contribution to the subsystem's risk across all possible subsystems containing institution j in which the portfolio can be split, apart from the subsystem composed of the institution j in isolation. Using this measure, I study the impact of the banks' portfolio holdings of financial derivatives on the banks' individual contribution to systemic risk over and above the effect of variables related to size, interconnectedness, substitutability, and other balance sheet information. I find that the banks' holdings of foreign exchange and credit derivatives increase the banks contributions to systemic risk whereas holdings of interest rate derivatives decrease it. Nevertheless, the proportion of non-performing loans over total loans and the leverage ratio have much stronger impact on systemic risk than derivatives holdings. I also find that before the subprime crisis credit derivatives contributed to decrease systemic risk whereas during the crisis holdings of derivatives led to increase it. So, credit derivatives seemed to change their role from shock absorbers to shock issuers. This effect is not observed in the other types of derivatives.

Finally, in Chapter 3 I focus on the liquidity commonalities in the corporate CDS market and their determinants. The analysis of liquidity commonalities in this market is motivated by the fact that the CDS market contains valuable information to construct systemic risk measures, as shown in Chapter 1, and also because the banks' holdings of these derivatives have been found to be significant determinants of systemic risk, as documented in Chapter 2. In addition, the main participants in the CDS market are systemically important financial institutions (SIFIs). For these reasons, a high level of liquidity commonalities would imply that abrupt changes in the liquidity of the CDS market could cause systemic shocks on the overall economy and, in a context of an illiquid CDS market firms could not be able to timely manage their credit exposures. This study presents robust evidence suggesting the existence of significant liquidity commonalities. Using daily data for 438 firms from 25 countries that comprises the period 2005-2012, I find that these commonalities vary over time, being stronger in periods in which the global, counterparty, and funding liquidity risks increase. However, commonalities do not depend on firm's characteristics. The level of the liquidity commonalities differs across economic areas being on average stronger in the European Monetary Union. The effect of market liquidity is stronger than the effect of industry specific liquidity in most industries excluding the banking sector. Additionally, I document the existence of asymmetries in commonalities around financial distress episodes such that the effect of market liquidity is stronger when the CDS market price increases.

1. SYSTEMIC RISK MEASURES: THE SIMPLER THE BETTER?[1]

This chapter provides a general overview of what systemic risk is and the adequacy of the available tools to measure its intensity. Systemic risk appears when generalized malfunctioning in the financial system threatens economic growth and welfare. The causes of malfunctions can be related to multiple mechanisms such as macro imbalances (e.g., excessive credit expansion in the private or public sector), correlated exposures (e.g., herding behavior), contagions, asset bubbles, negative externalities (e.g., banks too big to fall) or information disruptions (e.g., freezes in the interbank market). Given this lengthy but incomplete list of possible mechanisms influencing systemic risk, it seems safe to posit that more than one risk measure is needed to capture its complex nature, in particular, that policymakers charged with the responsibility of ensuring financial stability should rely on a wide array of measures.

The measurement of systemic risk can be addressed from two alternative perspectives, at aggregate level and individual contribution level. The former perspective focuses on the intensity of systemic risk in a certain economy (i.e., specific country or economic area) or a portfolio of financial institutions that appropriately represents to a certain economy. On the contrary, the individual contribution perspective focuses on the contribution of each financial institution to the overall systemic risk. In this chapter I take the former perspective while in Chapter 2 I address the measurement of the individual contribution of systemic risk to the financial institutions.

In addition, the measurement of the aggregate systemic risk has been addressed from a wide variety of perspectives (see surveys by De Bandt and Hartmann (2000), Acharya, Pedersen, Philippon and Richardson (2011) and International Monetary Fund (2011)). Essentially, two types of indicators are suggested: first, slow moving low-frequency

1. This chapter is a preliminary and summarized version of the paper Rodriguez-Moreno and Peña (2013).

indicators based on balance sheet aggregates or macroeconomic data and second, high-frequency indicators based on market prices and rates. However, little is known of the relative quality of the different measures.

In this chapter I analyze the quality of the different aggregate systemic risk measures, focusing on high-frequency, market-based indicators (daily prices and rates)[2]. The aim is to estimate a set of systemic risk indicators in two economic areas (the Western Europe and the U.S.) from 2004 to 2009 and compare them in order to shed some light on the adequacy of the existing methods to determine the intensity of the systemic risk. For comparability reasons, measures under study are classified in two groups: macro and micro. The macro group gauges the overall tension in the financial sector and the micro group relies on individual institution information to extract joint distribution distress at portfolio level. This information would help regulatory institutions to design a *toolkit* to prevent systemic risk episodes in which the micro group of measures can be used as an early warning indicator that will alert the regulator that an individual (systemically important) bank is in trouble. The macro group of measures will deliver the same message when a group of them are in dire straits.

This chapter is divided into 4 sections. Section 1.1 and 1.2 present the systemic risk measures and the criteria of comparison, respectively. Section 1.3 shows the empirical results and Section 1.4 concludes.

1.1. Systemic risk indicators

Group of macro indicators

LIBOR spreads (LS): This group of measures involves the use of the LIBOR as the reference interest rate relative to either the Overnight Interest Swap (OIS) or Treasury bills (TBILL), usually known as LIBOR spreads.

2. The low-frequency measures focus on the evolution of macroeconomic (overall market) or balance sheet indicators (individual institution) in order to detect the buildup of possible imbalances or tensions in the economy and in the financial sector. These measures provide a global perspective but, by their very nature, the low-frequency indicators cannot inform policymakers of imminent financial distress. All those indicators are beyond the scope of this chapter.

LIBOR spreads measure the distress in the interbank market basically due to liquidity or default risk. In addition, during turmoil periods, the LIBOR-TBILL spread also reflects willingness of investors to lend against Treasury bills (the best form of collateral), measuring the "flight to quality" effect. The disruption of the interbank market hampers financial sector activity, decreasing the flow of credit and thus, hindering economic performance.

Principal component analysis (PCA) of portfolios of CDS spreads: Credit Default Swaps (CDS) are credit derivatives that provide insurance against the risk of default of a certain company ("name"), and hence, their spreads measure the risk tackled by bondholders of the reference entity. This measure consists of performing a Principal Component Analysis (PCA) on a pool of bank's CDS to extract the common default probability across the most important financial institution.

Systemic factor extracted from the CDS indexes and their tranches: CDS indexes are credit derivatives that provide insurance against the risk of default on a pool of highly liquid companies and CDS index tranches are synthetic collateralized debt obligations (CDOs) based on a CDS index, where each tranche references a different segment of the loss distribution of the underlying CDS index. Bhansali, Gingrich, and Longstaff (2008) propose to extract the idiosyncratic, sectorwide and economy-wide or systemic risks from the US and European CDS indexes and their tranches by means of a linearized three-jump model. This systemic risk measure assesses the risk of a massive economy wide default scenarios embedded in the traded indexes and tranches prices.

Group of micro indicators

Systemic risk index (SI): In the spirit of Merton's (1973) structural model, Lehar (2005) proposes a set of systemic risk measures based on the probability of default of a certain proportion of banks in a given financial system: Systemic Risk Index based on the expected Value of bank's asset portfolio (SIV) and Systemic Risk Index based on the expected Number of defaulted banks (SIN). The probability of default is linked to the relationship between the expected banks' asset value and their liabilities. Every measure is estimated using five different triggers for a systemic event (i.e., 5, 10 and 15, 25 and 50% of portfolio's default).

Multivariate densities (MD): Segoviano and Goodhart (2009) propose a set of banking stability measures based on the distress dependence of financial institutions extracted from the bank's CDS. The authors propose two measures for common distress in the banking system: the Joint Probability of Distress (JPoD) that measure the probability of all banks in the portfolio becoming distressed and the Banking Stability Index (BSI) that shows the expected number of banks to become distressed, conditioned on the fact that at least one bank has become distressed. The estimation of the common distress becomes harder as we increase the number of banks under analysis. In order to overcome this problem, we analyze this measure using "reduced portfolios" according to three criteria: (a) level of CDS spread; (b) level of liabilities; (c) level of the liabilities over market value ratio.

Aggregate of individual co-risk (CR): Adrian and Brunnermeier (2008) propose a set of measures of the individual contribution of financial institutions to the overall systemic risk based on traditional risk management tools like Value-at-Risk (*VaR*) and Expected Shortfall (*ES*). The authors measure the individual contribution to systemic risk as the difference between the distress level of a portfolio of financial institutions conditioned on institution *i* being in distress and the unconditioned distress level. Distress levels are measured using the *VaR* and *ES* concepts and give two measures: $\Delta CoVaR_i$ and $\Delta CoES_i$. In order to get a systemic risk measure at aggregate level we add up the individual contributions to systemic risk under the hypothesis that the sum of the individual contribution provides insight about the aggregate systemic risk.

Table 1.1 summarizes the all estimated systemic risk measures, their corresponding categories and main characteristics in terms of basic information, objective and relation with systemic risk.

Table I.1 Description of the systemic risk measures

This table summarizes the main characteristics of the systemic risk measures in terms of: (i) theoretical approach; (ii) author; (iii) group (macro/micro) (iv) category; (v) data requirements; (vi) objective of the measure; and (vii) relationship with systemic risk.

Measure	Author[a]	Group	Category	Data requirements	Objective	Relationship with systemic risk[b]
LIBOR spread (LS)		Macro	• LIBOR-OIS • LIBOR-TBILL	Short-term LIBOR, swap rates and Treasury yields	To measure the distress in the interbank market. • LIBOR-OIS: Liquidity and default risk • LIBOR-TBILL: Liquidity, default risk and flight to quality effect	The higher the liquidity and default risk, the higher is the systemic risk. Flight to quality effect also increases as systemic risk increases.
Principal component analysis (PCA)		Macro	First principal component (FPC)	Credit default swap (CDS) spreads of the portfolio European and US banks	To measure the common factor that drives the CDS spreads (spreads are considered as indicators of the default probability)	The higher the common factor that explain the default probability, the higher the systemic risk
CDS indexes and tranches (CDS)	Bhansali, Gingrich and Longstaff (2008)	Macro	They propose to measure of systemic risk from indexes of CDSs	CDS index and tranches of the CDX and iTraxx Europe. These indexes are composed by the most liquid firms but not all firms are financials.	To assess the risk of a massive economy wide default scenarios embedded in index tranche prices	The higher the risk of a massive economy wide default, the higher the systemic risk
Systemic risk index based on structural credit risk model (SI)	Lehar (2005)	Micro	• SIV: Measure based on the value of expected default institutions • SIN: Measure based on the number of expected default institutions	• Market capitalization of individual banks • Balance sheet information • Correlation among bank returns	To measure the default probability of certain proportion of the total system	The higher the probability of a joint default, the higher the systemic risk

Measure	Author[a]	Group	Category	Data requirements	Objective	Relationship with systemic risk[b]
Multivariate Densities (M D)	Segoviano and Goodhart (2009)	Micro	• JPoD: Joint probability of default • BSI: Banking stability index	• CDSs of selected banks • Banking systems portfolio multivariate density (BSM D): distress interdependence structure	To measure the common distress in the banking system. • JPoD: Measures the probability of all the banks in the portfolio becoming distress • BSI: Reflects the expected number of banks becoming distressed given that at least one is in distress	• The higher the JPoD, the higher the systemic risk • The higher the BSI, the higher the probability of contagion and hence, the higher the systemic risk
Aggregate co-risk (CR)	Adrian and Brunnermeier (2008)	Micro	• AΔCoVaR: Sum delta co-value-atrisk • AΔCoES: Sum delta co-expected shortfall	• Equity prices and returns of considered banks • Market information such as: VIX/VDAX, 3M Libor-OIS, change in TBill 3M, 10Y-3M TBill, Banking Index and accounting information	• ΔCoVaRi measures how the systems VaR change when bank i is in distress (spillover of institution i to the system) • AΔCoVaR measures the aggregate spillover effect • The same concept applies to AΔCoES	• The higher the AΔCoVaR, the higher the contagion of distress and the higher the systemic risk • The higher the AΔCoES, the higher the contagion of distress and hence, the higher the systemic risk

[a] We do not report the field “author” when it is a widely employed measure.

[b] We use the definition of systemic risk jointly provided by the FSB, IMF and BIS (2009).

Our analysis of systemic risk is focused on two portfolios which contain the largest banks in Western Europe (including non-Eurozone) and United States (US)[3]. The main data inputs are single-name CDS spreads, liabilities and equity prices. The CDS spreads and equity prices are reported on a daily basis (end of day) while the liabilities are reported on annual terms. These variables are obtained either from Reuters or DataStream depending on the data availability in both data sources. Additionally, other aggregate market variables are required, for instance, the 3-month and 10-year LIBOR, swap rates and Treasury yields. We employ interest rates from the two economic areas: US and the Eurozone[4], [5]. These variables are obtained from Reuters. Moreover, CDS index spreads are also employed: the US CDS index investment grade spreads (CDX IG 5y) and the European (iTraxx Europe 5y) as well as their tranches. Index spreads and their tranches come from Markit.

Figure 1.1 depicts of the estimated measures. In spite of being expressed in different units, we observe a common pattern in most of the measures. From the beginning of the sample period until the summer 2007 all variables remains completely flat. Since the subprime crisis started in August 2007, two phases can be distinguished. The first phase spans from August 2007 to August 2008. During this period we observe a steady but moderate increase in the systemic risk. The second phase of the crisis starts with a remarkable jump after the Lehman Brothers bankruptcy (September 2008). Then, the systemic risk measures skyrocket reaching the maximum in March 2009. After that episode, all measures followed a downward trend, ending the sample period at pre-crisis levels. This behavior may be related to the announcement of generalized bail-out plans and the very lax stance of the monetary policy.

3. The Western European portfolio is composed of Barclays Bank, BBVA, BNP Paribas, Commerzbank, Credit Agricole, Credit Suisse , Danske Bank, Deutsche Bank, Dexia, HSBC Bank, ING Bank, Intesa Sanpaolo, KBC, Lloyds TSB , Nordea Bank, RBS, Santander, Societe Generale, UBS and Unicredito. The US portfolio is composed of Bank of America Corp, Capital One FC, Citigroup, Comerica, Harris Corp, JPMorgan Chase & Co, Keycorp, Morgan Stanley, PNC , State Street Corp, Suntrust, US BC and Wells Fargo & Co.

4. Reuters uses French government bonds as the benchmark for the Eurozone up to 05/08/2010. After that date, German government bonds are the benchmark.

5. Our Western European portfolio is composed of Eurozone and non-Eurozone banks (i.e., Denmark, Sweden, Switzerland and the UK). Regarding the second group, we also analysed the UK's LIBOR spreads because of the global importance of that financial system. However, analysis of UK spreads does not add additional information to Eurozone spreads.

Figure 1.1 Systemic risk measures

This figure depicts the estimation of the systemic risk measures presented in Table 1.1. Panel A and C report the macro group of indicators for the European and the US portfolios, respectively. Panel B and D report the micro group of indicators for the European and the US portfolios, respectively.

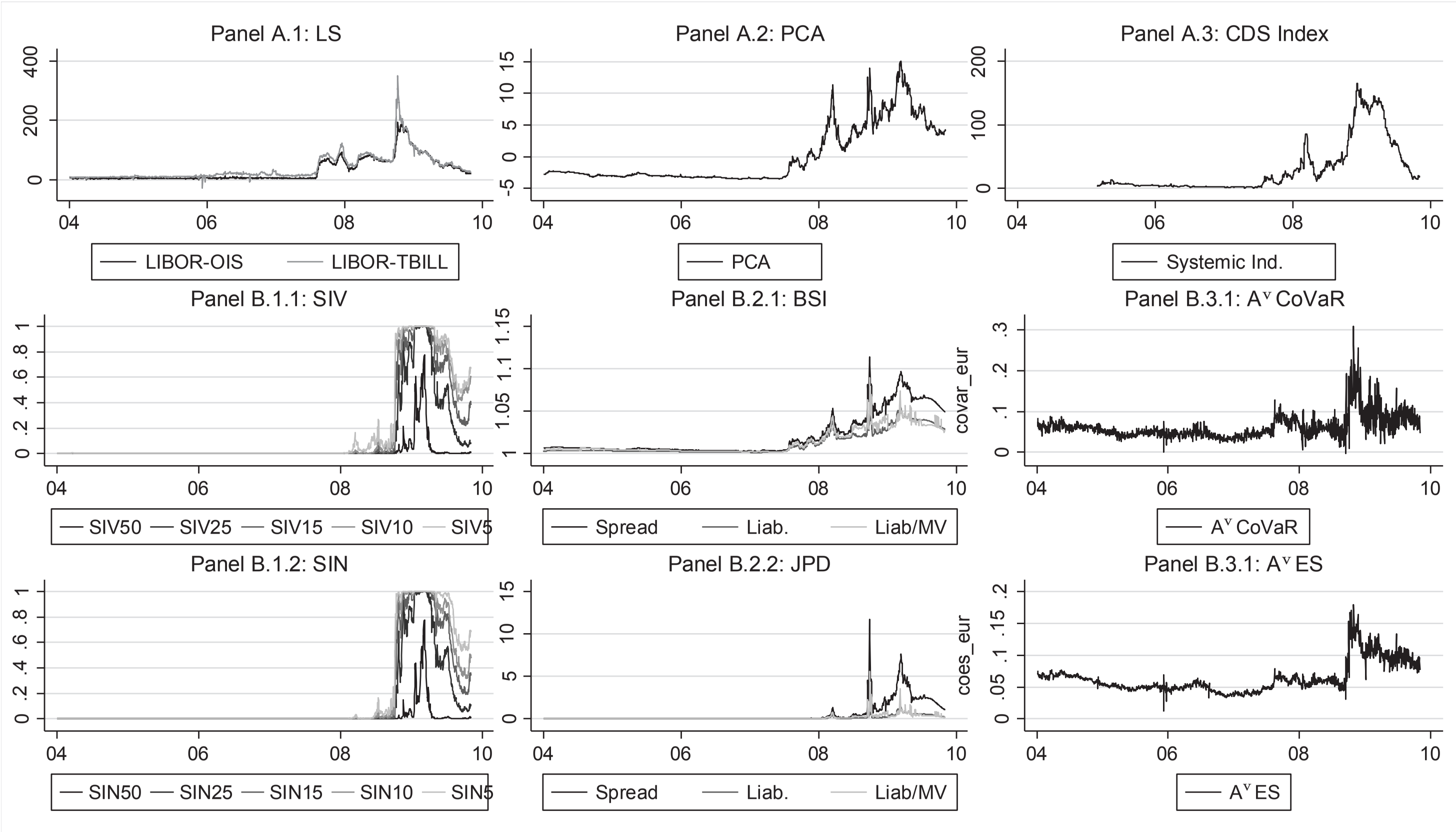
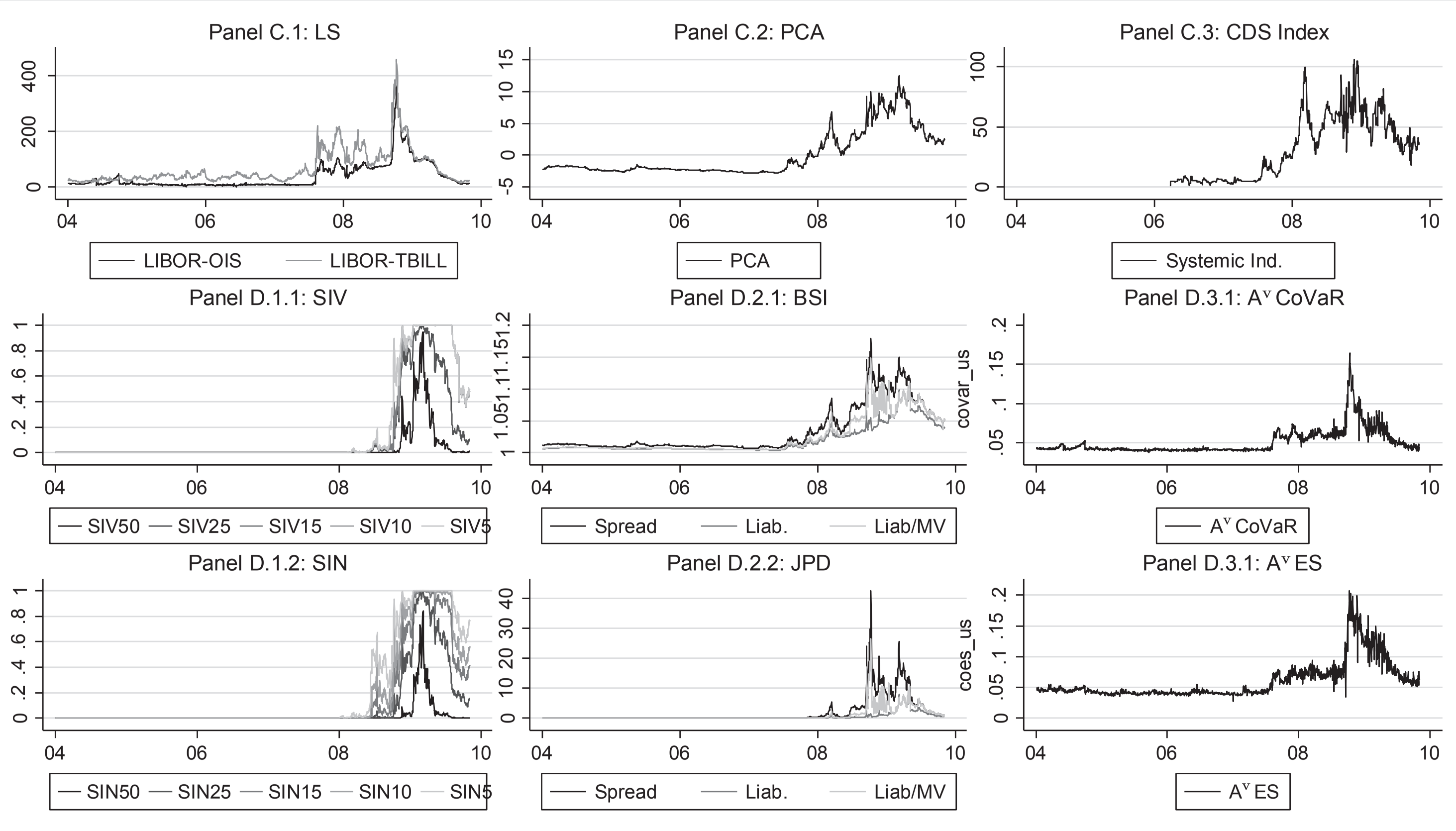


Figure 1.1 Con't Systemic risk measures



1.2. Criteria of comparison

Next, I compare the estimated measures as follows. First, given that most of the estimated measures provide more than one category (see Table 1.1); I select the best performing category within each measure using their correlation with an index of systemic events and policy actions constructed from the Federal Reserve Bank of St. Louis' crisis timeline as the basic criterion[6],[7],[8]. This criterion enables us to keep those categories that better fit with the actual development of systemic risk. I then compare the best performing categories within each group (macro and micro) using two additional criteria: i) Granger causality tests, and ii) Gonzalo and Granger (GG) metric. The first criterion gives information about whether measure X is a leading indicator of measure Y. The second criterion relates to each measure with a common component, which may be interpreted as the underlying systemic risk trend in the economy. The intuition is that if measure X contributes to this common component to a greater extent than measure Y, then X is preferable. The performance of each measure is judged by their scores on each of the three criteria. For instance, to rank the measures according to the Granger causality test I give a score of +1 to measure X if X Granger-causes measure Y and I give a score of –1 to X if X is caused in the Granger sense by Y. By doing this, the best measure gets the highest positive score and the worst measure the highest negative score. I apply the same procedure to the correlation index and the GG metric. Finally, I add the scores provided by the three criteria for each measure.

1.3. Empirical results

Table 1.2 reports the results of the comparison across different category of measures. According to these results, the best high-frequency, market-based systemic risk measure in the macro group, in both U.S. and in Europe portfolios, is simply the first principal component of a portfolio which contains the CDS of the main banks (PCA). On the contrary, the

6. Timeline crisis can be accessed via http://timeline.stlouisfed.org/.
7. To implement this criterion we carry out a multinomial regression where the dependent variable is the influential event variable (i.e., a categorical variable that takes value 1 whenever there is an event; –1 whenever there is a political action; 0 otherwise) and the explanatory variable is the systemic risk measure. The correlation is determined by the McFadden R-squared of the regression.
8. For instance, the LS measure contains two categories, LIBOR-OIS and LIBOR-TBILL. The former has the highest correlation with the index and therefore it is the one I use for the subsequent analysis.

worst measure is the one based on the LIBOR-OIS spread. The best measure in the micro group in both economic areas is the multivariate densities (MDs), that is again based essentially on bank's CDS, while the worst is the aggregate of co-risk (CR) measures. According to these results, I document that simple measures based on credit derivatives (CDSs) seem to perform better than measures based on interbank rates or stock market prices. Therefore the high-frequency credit derivatives market-based measures are the best indicators in our sample to warn that a systemic event or crisis is close at hand. This result holds both in the case of measures in the macro group as well as those measures in the micro group. It certainly seems that signals of impending financial distress that come from the CDS market are clearer and louder than the ones coming from other markets.

Table 1.2 Horse race

This table reports the ranking scores for the European and US banks using the three criteria: (i) Granger causality test; (ii) Gonzalo and Granger metric; (iii) McFadden R-squared. I also report the final score, which is the sum of the scores across classifications. Panel A and B refer to the European and the US portfolio, respectively.

Panel A: European portfolio				
Criteria	Granger causality test	GG Metric	McFadden R-squared	Final Score
Panel A1: Macro				
PCA	2	0	2	4
CDS	-1	0	0	-1
LS	-1	0	-2	-3
Panel A2: Micro				
MD	0	2	2	4
SI	0	0	0	0
CR	0	-2	-2	-4
Panel B: US portfolio				
Criteria	Granger causality test	GG Metric	McFadden R-squared	Final Score
Panel B.1: Macro				
PCA	1	1	2	4
CDS	0	-2	0	-2
LS	-1	1	-2	-2
Panel B.2: Micro				
MD	0	2	2	4
SI	1	0	-2	-1
CR	-1	-2	0	-3

1.4. Conclusion

In this chapter, I estimate and compare a set of high-frequency market-based systemic risk measures which are classified in two groups: macro and micro. Measures in the first group give information on how much systemic risk there is as a whole in the system and measures in the second group rely on individual institution information to gauge joint distress at portfolio level. The empirical application uses data on European and US financial markets and largest banks in the period from 2004 to 2009.

Our overall results suggest that the measures based on CDSs outperform measures based on the stock market and on the interbank market. Some of the economic reasons behind these results follow; most banks have several traded claims (stocks, bonds, CDS) that contain information on the individual and joint probability of default and therefore on systemic risk. Equity prices do not provide direct information on these probabilities and therefore one specific model (structural or otherwise) must be employed to compute the implied default probabilities. Although there are some encouraging results in this line as documented in Forte and Peña (2009) and in Liao, Chen and Lu (2009), much more work is needed before this approach can be relied upon by policymakers. Both CDSs and bond prices could be a more promising alternative because their spreads and yields, respectively, give a direct measure of these default probabilities. However corporate bonds suffer from lack of standardization which provokes illiquidity and market segmentation. In fact the prominent role of CDS may be due to their standardized nature, their higher liquidity and the professionalized market in which they are traded. The CDS market is almost entirely institutional with hardly any retail presence. Furthermore, the empirical evidence suggests that the CDS market leads the credit rating agencies (Hull, Predescu and White, 2004) and the bond market (Blanco, Brennan, and Marsh, 2005). Also, Berndt and Obreja (2010) identify a common factor that explains around 50% of the variation in corporate CDS returns and show that this component is closely related to the super-senior tranche of the iTraxx Europe index, referred to the economic catastrophe risk indicator. The previous discussion helps to understand why measures based on CDSs work better in providing information on systemic risk which is a manifestation of extreme joint default risk in the financial sector.

A related question is how these measures can aid policymakers. The measures in this paper can be used as a tool to prevent systemic crisis. The micro group of measures can be used as an element of an early warning system that will alert the regulator that an individual (systemically important) bank is in trouble. The macro group of measures will deliver the same message when a group of them are in dire straits. The regulator can then step in before the impairment spreads to other banks and to the real economy. The specific mechanism can take different forms, for instance setting critical thresholds for the measures. When a given measure rises above that critical value, the regulator should carry out an assessment of the situation. If the market signals are indeed accurate and a systemic event comes into view, some form of intervention can ensue such as forcing the bank (if the signal comes from individual-institution based measures) or a group of banks (if the signal is from the aggregate indicator of the banking sector) to issue equity until the risk indicator moves back below the threshold. If the risk indicator does not fall below that threshold within a predetermined period of time, the regulator would intervene. Therefore, using historical figures as reference in combination with other similar information from other indicators (low-frequency measures), the policymaker can devise a set of warning flags triggering increasingly stronger regulatory and supervisory actions. Our suggestions are in agreement with the market-based corrective actions proposed by Bond, Goldstein and Prescott (2010) and by Hart and Zingales (2011).

A word of caution is in order. The success of the market-based corrective actions relies on the market's ability to collect relevant information quickly, and to make it known widely. Prices in the CDS market may sometimes give wrong signals (i.e. provide inaccurate prices) because some irrational exuberance or panic. Therefore the efficiency, transparency and quality of the CDS market become issues of paramount importance. By the same token it is crucial to guarantee that the CDSs are properly collateralized and transparently traded on an organized exchange. This guarantees that counterparty risk is largely eliminated, and the positions of the various parties are known. The current regulatory initiatives on this respect towards moving CDS trading to organized exchanges, which require better collateralization to protect the exchange's members, will certainly help to improve CDS prices' reliability.

2. DERIVATIVES HOLDINGS AND SYSTEMIC RISK IN THE U.S. BANKING SECTOR[9]

Since the beginning of the financial and economic crisis, the concern about systemic risk has increased, becoming a priority for regulatory authorities. These authorities realized that systemic risk is not a transitory problem and consequently, new institutional arrangements have been approved to address this challenging issue. The Financial Stability Oversight Council (FSOC) in the US and the European Systemic Risk Board (ESRB) in the EU have been set to identify systemic risk, prevent regulatory loopholes, and make recommendations together with existing regulatory authorities. The concerns about systemic risk have also extended to securities markets regulators. Thus, the International Organization of Securities Commissions' (IOSCO) has also established a Standing Committee on Risk and Research to coordinate members' monitoring of potential systemic risks within securities markets.

In Chapter 2, I study systemic risk measures that provide a measurement of the individual contribution of each financial institution to the overall systemic risk and theirs determinants, paying special attention to the role of derivatives holding in the banks' balance sheet. In the current set up, this information could help to the banking regulatory institutions not only to improve currently available systemic risk measures and warning flags but also to develop a taxation system on the basis of the externalities generated by a banks' impact on systemic risk. Additionally, it could help securities market regulators in understanding the contribution of traded financial instruments, for instance financial derivatives, to systemic risk in order to consider new regulatory initiatives. Finally, investors should be concerned with the extent to which derivatives holdings affect the systemic impact of a given bank in order to assess the appropriate reward required to bear this kind of risk. Stulz (2010) pointed out the lack of rigorous empirical studies on the social

9. This chapter is a preliminary and summarized version of the paper Mayordomo, Rodriguez-Moreno and Peña (2014).

benefits and costs of derivatives and in particular their role in the financial crisis 2007-09.

The spectacular growth in banks' balance sheet over recent decades reflected increasing claims within the financial system rather than with non-financial agents. One key driver of this explosive intra-system activity came from the growth in derivatives markets and consequently in the growth of derivatives holdings in the banks' balance-sheets. A proportion of this growth may have been motivated by their use for hedging and trading purposes. Both activities are regarded as potentially useful and profitable by banks. However, it is well known that financial decisions that are rational at individual level can have negative consequences at system level. Is this also the case with respect to the banks' holdings of financial derivatives? The, admittedly very scarce, literature on this subject suggests that this might be the case[10]. However, to the best of my knowledge, no evidence is available on the direct impact of derivatives holdings on the banks' individual contributions to systemic risk. Ours is a first attempt to fill this gap.

So, this chapter aims to improve our understanding of these social costs and benefits examining whether the use of financial derivatives was a relevant factor in the destabilization of the banking system during the recent financial crisis. For this aim I combine two analyses; I first measure the banks' individual contributions to systemic risk and then, I estimate the effects of their holdings of financial derivatives on the banks' contributions to systemic risk.

This chapter is divided into 3 sections. Section 2.1 presents the systemic risk measures and the comparison among them. Section 2.2 shows the analysis of the determinants. Section 2.3 concludes.

10. Nijskens and Wagner (2011) report that the first use of credit derivatives is associated with an increase in bank's risk. In the same vein, Calmès and Théoret (2010) find that off-balance-sheet activities reduce banks' mean returns, simultaneously increasing the volatility.

2.1. Comparison among the systemic risk indicators

Individual contribution to systemic risk

Chapter 1 provides an overview of what systemic risk is and focuses on the intensity of this risk in a certain economy or portfolio of financial institutions. On the contrary, this chapter focuses those measures that determine the contribution of individual financial institutions to the overall systemic risk.

Co-risk: Adrian and Brunnermeier (2011) propose a set of measures of the individual contribution of financial institutions to the overall systemic risk based on traditional risk management tools like Value-at-Risk (*VaR*) and Expected Shortfall (*ES*). The authors measure the individual contribution to systemic risk as the difference between the distress level of a portfolio of financial institutions conditioned on institution *i* being in distress and on its median state. Distress levels are measured using the *VaR* and *ES* concepts and give two measures: ΔCoVaR and ΔCoES.

Asymmetric ΔCoVaR: López, Moreno, Rubia and Valderama (2011) present a variation of the standard ΔCoVaR specification that allows for asymmetries in the impact of positive and negative returns on the performance of the systemic risk.

Gross Shapley Value (GSV): Tarashev, Borio, and Tsatsaronis (2010) propose to combine the Shapley Value (Shapley, 1953) solution concept in game theory and standard risk management tools to measure systemic risk[11]. Thus, they measure the individual contribution to systemic risk as the average contributions to systemic risk of bank *i* in all possible portfolios in which the whole financial system can be divided. The contribution to systemic risk is defined as the difference between the *VaR* of every possible portfolio of institutions and the *VaR* of that portfolio after the exclusion of bank *i*.

Net Shapley Value (GSV): Mayordomo, Rodríguez-Moreno and Peña (2014) propose an alternative measure to the GSV called NPV in which

11. The Shapley Value attributes to individual players the average of their incremental contributions to the worth of all possible groups of other players.

we get rid of the idiosyncratic component present in the former measure by subtracting from the GSV the VaR of the bank i[12].

I carry out the estimation of these measures on a set of US bank holding companies whose total assets are above $5billion in either the first quarter of 2006 or the first quarter of 2009. Thus, I focus on relatively big banks in either the pre-crisis or the ongoing crisis period. Additional filters are banks for which we have information on their stock prices, banks that held at least one type of derivatives analyzed in this paper, and, we exclude banks that defaulted or were acquired before 2007[13]. The final sample consists of quarterly information for 91 bank holding companies from March 2002 to June 2011[14].

The Bank Holding Company Data (BHCD) from the Federal Reserve Bank of Chicago is our primary database. Additional information (VIX, 3-monthTbill rate, 3-month repo rate, 10-year Treasury rate, BAA-rate bond, and MSCI index returns) is collected from DataStream and the Federal Reserve Bank of New York.

Table 2.1 Descriptive Statistics of Bank Holding Companies

This table reports the name of the 91 banks which form the sample and related information about their size (average market value in millions of U.S. dollars).

id Bank Holding	Market Value	id Bank Holding	Market Value
1 Alabama National Bancorp	1,063	47 M&T Bank	9,396
2 Amcore Financial	467	48 Marshall & Ilsley	6,824
3 Associated Banc-Corporation	2,939	49 MB Financial	804
4 Bancorpsouth	1,636	50 Mellon Financial	16,300
5 Bank of America	140,000	51 Metlife	31,400
6 Bank of Hawaii	2,201	52 National Penn Bancshares	758
7 Bank of New York Co	27,000	53 NBT Bancorp	661
8 Bank of New York Mellon	38,100	54 New York Community Bancorp	4,612
9 BB&T	18,200	55 Newalliance Bancshares	1,492

12. This chapter is an abbreviated version of the Mayordomo, Rodríguez-Moreno and Peña (2014).
13. I deal with bank mergers as in Hirtle (2008) who adjusts for the impact of significant mergers by treating the post-merger bank as a different entity from the pre-merger bank. This is the case of the case of the Bank of New York Company and Mellon Financial Corp.
14. The BHCD provides information about 7.800 banks holdings that were alive before 2002.

id Bank Holding	Market Value	id Bank Holding	Market Value
10 Bok Financial	2,589	56 Northern Trust	12,300
11 Boston Private Financial	569	57 Old National Bancorp	1,318
12 Capital One Financial	16,900	58 Pacific Capital Bancorp	941
13 Cathay General Bancorp	1,095	59 Park National	1,230
14 Central Pacific Financial	510	60 PNC Financial Services	19,600
15 Charles Schwab	21,500	61 Privatebancorp	588
16 Chittenden Corp	1,119	62 Provident Bankshares	644
17 Citigroup	188,000	63 Regions Financial New	9,923
18 Citizens Republic Bancorp	970	64 Sky Financial Group	2,583
19 City National	2,681	65 South Financial Group	1,012
20 Colonial Bancgroup	1,758	66 State Street	19,000
21 Comerica	7,893	67 Sterling Bancshares	621
22 Commerce Bancshares	2,989	68 Sterling Financial	572
23 Community Bank System	571	69 Suntrust Banks	18,700
24 Cullen Frost Bankers	2,537	70 Susquehanna Bancshares	1,004
25 CVB Financial	878	71 SVB Financial Group	1,503
26 East West Bancorp	1,418	72 Synovus Financial	6,150
27 FNB	978	73 TCF Financial	2,986
28 Fifth Third Bancorp	21,300	74 Texas Capital Bancshares	547
29 First Citizens Bancorporation	411	75 Trustmark	1,488
30 First Commonwealth Financial	761	76 United States Bancorp	46,700
31 First Horizon National	3,939	77 Ucbh Holdings	921
32 First Midwest Bancorp	1,280	78 UMB Financial	1,310
33 First National of Nebraska	1,222	79 Umpqua Holdings	817
34 Firstmerit	1,935	80 United Bankshares	1,219
35 Fulton Financial	2,066	81 United Community Banks	721
36 Glacier Bancorp	765	82 Valley National Bancorp	2,390
37 Greater Bay Bancorp	1,315	83 Wachovia Corp	48,200
38 Hancock Holding	1,040	84 Webster Financial	1,762
39 Harleysville National Corp	450	85 Wells Fargo and Company	104,000
40 Huntington Bancshares	4,518	86 Wesbanco	530
41 Iberiabank	583	87 Western Alliance Bancorp	580
42 International Bancshares	1,405	88 Whitney Holding Corp	1,411
43 Investors Bancorp	1,480	89 Wilmington Trust	1,924
44 Investors Financial Services	3,005	90 Wintrust Financial	776
45 JP Morgan Chase and Co	117,000	91 Zions Bancorporation	5,051
46 Keycorp	10,200		

Table 2.1 contains the 91 banks and information about their size (market capitalization in millions of dollars). In terms of size we observe a huge variance across banks under the analysis being by far Bank of America, Citigroup and JP Morgan the largest banks in the sample.

Criteria of Comparison

As in Chapter 1 I use two criteria to rank the five measures: (a) the correlation with an index of systemic events and policy actions, and (b) the Granger causality test. The first criterion compares the correlation of each measure with the main systemic events and policy actions and the second criterion points out the measures acting as leading indicators of systemic risk. Both criteria focus on different aspects of systemic risk and complement to each other to provide a robust diagnostic of the most reliable individual contribution to systemic risk measures[15].

In the first criterion I employ the McFadden R-squared to rank the alternative measures. For each bank i in the sample I run a multinomial regression in which the dependent variable is the IEV and the explanatory variable is the systemic risk measure j for bank i (where $j = 1, \ldots, 5$ and $i = 1, \ldots, 91$) and then estimate the McFadden R-squared. The comparison of the different pairs of systemic risk measures, referred to the same bank, is done by assigning a score of +1 to the measure with the highest R-squared and −1 to the one with the lowest. Finally, I add up the scores obtained for each measure across the 91 banks[16]. By doing this, I avoid penalizing those measures that provide leading information and penalizing those events or political actions which have been discounted by the market before the event.

The second criterion is based on the Granger causality test (Granger, 1969). To rank the measures I give a score of +1 to a given measure X if X Granger causes another measure Y at 5% confidence level and −1 if X is caused in the Granger sense by Y. As a consequence, the best measure gets the

15. In Chapter 2 we use an additional criterion based on the Gonzalo and Granger's (1995) methodology. To carry out this analysis, the pairs of systemic risk measures have to be cointegrated. However, this requirement is not satisfied in several of the pairs of measures and so, we do not consider it.
16. This ranking procedure is related to the well-known Condorcet voting method. However to avoid some of the problems of the Condorcet approach we also allow for negative as well as positive scores.

highest positive score and the worst measure the highest negative score. Next, we add up the scores obtained by each measure across the 91 banks.

Finally I add up the obtained scores to select the measure. Table 2.2 contains the scores. Comparing the five measures, we observe that under both criteria, the NSV outperform the other systemic risk measures. Therefore, for the baseline analysis we use the NSV as the proxy for the bank contribution to systemic risk.

Table 2.2 Ranking of Systemic Risk Measures

This table reports the ranking of five systemic risk measures: Net Shapley value (NSV), Gross Shapley Value (GSV), Co-risk measures (ΔCoVaR and ΔCoES), and asymmetric ΔCoVaR. The ranking is based on the average McFadden R-squared and Granger causality test. The comparison of different pairs of systemic risk measures, referred to the same bank, based on the McFadden R-squared criterion is done by assigning a score of +1 to the measure with the highest R-squared and −1 to the lowest. The comparison based on the Granger causality test is done by applying the test to pairs of systemic risk measures, referred to the same bank, and giving a score of +1 to measure X if X Granger causes another measure Y at 5% confidence level and −1 if X is caused in the Granger sense by Y. Finally we add up the scores obtained by each measure across the 91 banks to obtain the one with highest score.

	Net Shapley Value	Gross Shapley Value	Delta co-value-at-risk	Delta co-expected-shortfall	Asymmetric Delta co-value-at-risk
McFadden R-squared	266	84	-44	-280	-26
Granger causality test	13	10	-20	-1	-2
Total	279	94	-64	-281	-28

2.2. Determinants of the individual contribution to systemic risk

Research questions

Next, using the NSV as the dependent variable, I examine six issues: (1) is there a relationship between the banks' holdings of financial derivatives and their contributions to systemic risk?; (2) is this relationship uniform across derivatives classes?; (3) are there other balance sheet asset items which are significant contributors to systemic risk beside financial derivatives?; (4) is the impact on systemic risk the same irrespective of whether the derivative is held for trading or for other purposes?; (5) in the case of credit derivatives, is their impact dependent on whether the bank is net protection seller or net protection buyer?; (6) is the relationship between derivatives holdings and systemic risk sensitive to the emergence of the subprime crisis?.

To address these research questions I implement a panel regression analysis in which the individual bank *i*'s contribution to systemic risk in quarter *t* is regressed on the following variables (all in quarter *t-1*): bank's holdings of derivatives, proxies for the standard drivers of systemic risk (size, interconnectedness, and substitutability)[17], other balance sheet information and the aggregate level of systemic risk[18]. This information is either directly collected or estimated from the BHCD.

Evolution of the bank derivatives holdings

I consider five types of derivatives: credit, interest rate, foreign exchange, equity, and commodity. The holdings of derivatives are measured in terms of the fair value that is defined as "the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants in the asset's or liability's principal (or most advantageous) market at the measurement date".

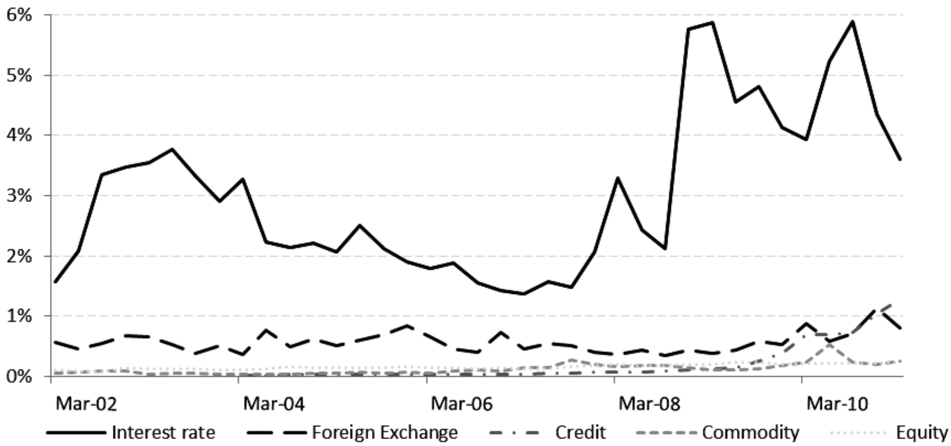
Figure 2.1 depicts the average fair values of the banks holdings of the five types of derivatives under analysis over total assets. Interest rate derivatives represent the most widely used derivative during the whole sample period. Between 2003 and September 2007 they performed a downward trend that finished with the eruption of the subprime crisis in summer 2007. At the time of the Lehman Brothers collapse, the weight of interest rate derivatives more than doubled moving from 2% to 6% in one quarter. Since then, the holdings of interest rate derivatives have remained high and evolved within the 4-6% interval. Between 2002 and the Lehman Brothers episode, foreign exchange derivatives were the second most used derivatives and remained below 1% during almost the entire sample period. Credit derivatives

17. See BIS (2011).
18. The aggregate systemic risk is obtained as the sum of the individual contribution levels to systemic risk of the U.S. commercial banks, dealer-broker and insurance companies.

performed a remarkable increase after summer 2007 and reached their maximum level in March 2009. In that period credit derivatives became the second most frequently used derivatives. Equity and commodity derivatives have lower weight in the sample. Equity derivatives did not experience large variations while commodity derivatives increased after the Bearn Stearns collapse probably coinciding with the increase in the commodity prices.

Figure 2.1 Banks' holdings of derivatives relative to total assets

This figure depicts the average ratio across banks of the fair value of derivatives holdings relative to total assets. The figure includes the following types of derivatives: interest rate, foreign exchange, credit, equity and commodity. The ratio is reported in percentages.



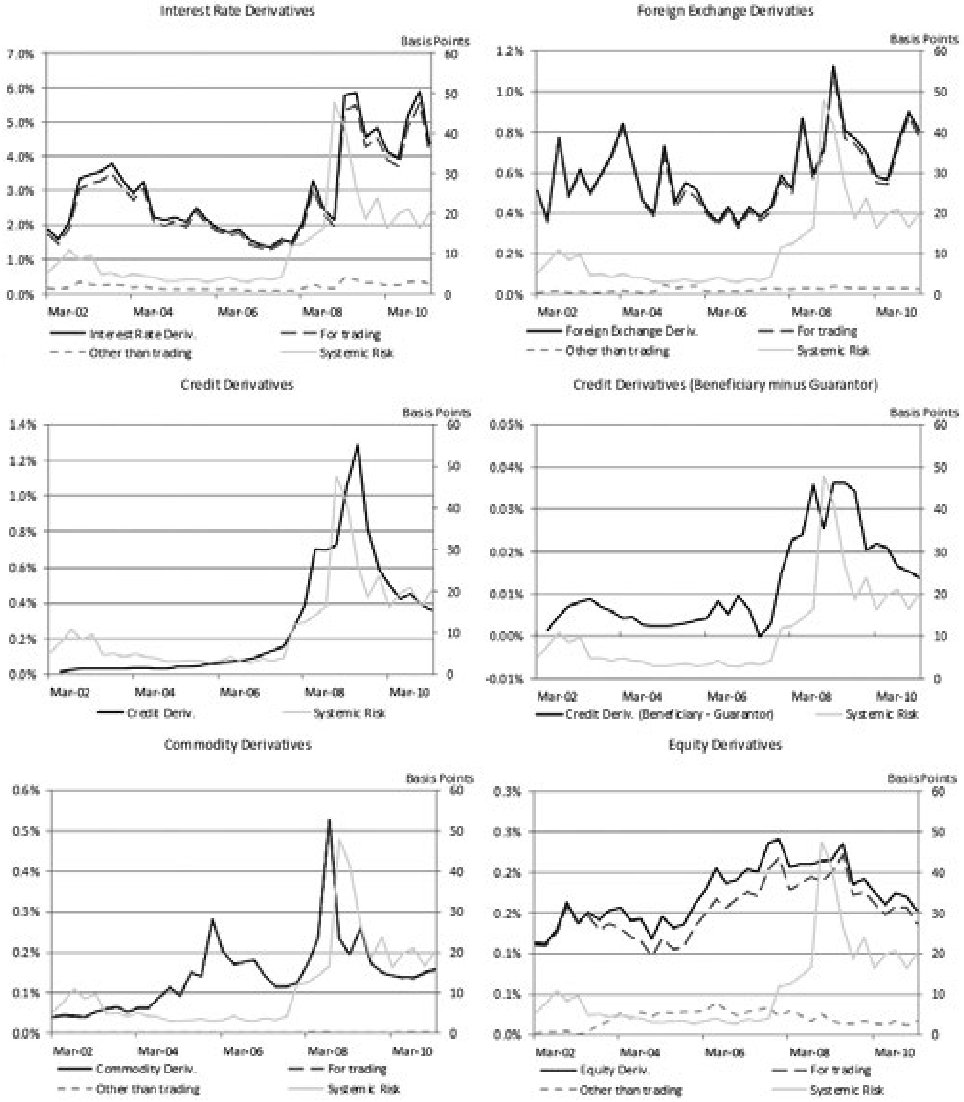
In addition, for the interest rate, foreign exchange, equity, and commodity derivatives we distinguish the effect of the holdings of derivatives held for trading from the ones held for purposes other than trading. Contracts held for trading purposes include those used in dealing and other trading activities accounted for at fair value with gains and losses recognized in earnings. Derivative instruments used to hedge trading activities are also reported in this category. For the credit derivatives we distinguish the effects of the holdings of derivatives in which the bank is the guarantor (protection seller) or the beneficiary (protection buyer).

Figure 2.2 depicts the banks' average contribution to systemic risk jointly with the average fair value of derivatives ratio held across banks for trading and for other purposes than trading relative to total assets lagged one period. For the credit derivatives we distinguish the effects of the holdings of derivatives in which the bank is the guarantor (protection seller) or the beneficiary (protection buyer).

There is a common upward trend in the evolution of all derivatives holdings after the burst of the financial crisis. The extensive use of derivatives for trading purposes could be due to banks moving towards innovative fee-producing activities as pointed out by Allen and Santomero (2001). These trading activities have generated substantial revenues for large banks as can be observed in the OCC's Quarterly Reports on Bank Trading and Derivatives Activities but they have also led to large losses. Nevertheless, the relation with the average contribution to systemic risk seems to vary across types of derivatives. In interest rate and commodity derivatives panels, we observe that one quarter before the date corresponding to the most pronounced increase in systemic risk, holdings held for trading depict a downward trend, equity holdings for trading purposes remained stable during this systemic episode. On the other hand, there exist a strong and positive relation between systemic risk and the positions in both credit and foreign exchange derivatives lagged one quarter. In addition beneficiary positions of credit derivatives are, on average, larger that the guarantor positions which implies that net guarantors are other non-bank financial institutions (insurance companies, hedge funds).

Figure 2.2 Systemic risk measure and banks' holdings of derivatives held for trading and for purposes other than trading relative to total assets

This figure depicts the average ratio across banks of the fair value of derivatives held for trading and for purposes other than trading relative to total assets (in percentages) in addition to the banks' average contribution to systemic risk (in basis points). The systemic risk measure is the average Net Shapley value across the 91 bank holdings (right axis). The figure includes the following types of derivatives (by order of appearance): interest rate, foreign exchange, credit, equity and commodity. In the case of credit derivatives, we report the average holdings relative to total assets and the average difference between the fair value of credit derivatives in which the banks act as beneficiary (buy protection) and those in which they act as guarantor (sell protection). The series corresponding to the average bank holdings of derivatives are lagged one period (*t-1*) and the systemic risk measure is depicted at period *t* such as they appear in the paper regressions.



Determinants of the individual contribution to systemic risk

Table 2.3 addresses the first three research questions of this chapter. Column 1 reports the estimated coefficients of the panel regression analysis and their standard errors. In addition columns (2) and (3) report information about the magnitude of this impact. Column (2) reports the average impact on the individual contribution to systemic risk of a one standard deviation change in the independent variable while columns (3) measures the economic impact and is calculated as the average impact on the individual contribution to systemic risk of a one standard deviation change in the independent variable over the average individual contribution to systemic risk.

Table 2.3 Baseline Regression

This table reports the results of the baseline unbalanced panel regressions. The dependent variable is the individual contribution to systemic risk measured as the Net Shapley Value which is measured in basis points. Our database is formed of 91 banks and spans from 1Q2002 to 2Q2011. We estimate the coefficients by means of a Prais-Winsten robust to heteroskedasticity, contemporaneous correlation across panels. Column 1 reports the results where bank holdings of derivatives are measured by means of the total fair value (sum of positive and negatives). Column 2 reports the standardized coefficient (i.e., the regression coefficient as in column 1 times standard deviation of the corresponding explanatory variable). Column 3 contains the standardized coefficient (as in column 2) over the mean of the dependent variable (in percentage) for the variables which are different from zero at 1 or 5% significance levels. The symbol *** (**) denotes the significance level at 1% (5%). The results correspond to the estimated coefficient and the robust standard errors.

	(1)	(2)	(3)
	Coefficient [SE]	Standardized coefficient	Economic Impact (%)
Log market value$_{t-1}$	-4,16 [2,51]	-1,627	
Log of squared market value$_{t-1}$	0,09 [0,08]	1,006	
Commercial paper$_{t-1}$ /TA	30,62 [31,56]	0,051	
Loan to banks$_{t-1}$ /TA	19,71 [44,78]	0,032	
Total loans$_{t-1}$ /TA	9,67*** [2,84]	0,416	3,755
Non-interest to interest income$_{t-1}$	0,79 [0,83]	0,099	
Correlation with S&P500$_{t-1}$	2,36 [2,89]	0,349	
Net balance to bank$_{t-1}$ /TA	477,97*** [95,60]	0,200	1,803
Net balance to non-bank$_{t-1}$ /TA	-23,38 [17,40]	-0,098	
Leverage$_{t-1}$	0,15*** [0,04]	1,161	10,486
Maturity mismatch$_{t-1}$	0,21 [2,62]	0,007	
Total deposits$_{t-1}$ /TA	-18,16*** [3,47]	-0,719	-6,493

	(1)	(2)	(3)
	Coefficient [SE]	Standardized coefficient	Economic Impact (%)
Non-performing loans$_{t-1}$ /Total loans	136,40*** [44,56]	1,955	17,655
Aggregate systemic risk measue$_{t-1}$	67,13*** [16,82]	7,147	64,550
Aggregate systemic risk measue$_{t-2}$	-27,54 [16,51]	-2,932	
Credit derivatives$_{t-1}$ /TA	34,33*** [8,22]	0,110	0,989
Interest rate derivatives$_{t-1}$ /TA	-11,51*** [2,78]	-0,168	-1,517
Foreign exchange derivatives$_{t-1}$ /TA	93,58*** [24,68]	0,225	2,036
Equity derivatives$_{t-1}$ /TA	-39,55 [43,21]	-0,028	-0,256
Commodity derivatives$_{t-1}$ /TA	-26,29** [12,36]	-0,031	-0,276
Constant	46,06** [19,82]		

Time Effects	Yes
Number of Observations	2947
Number of Groups	91
Min. Observations per Group	13
Avg. Observations per Group	33,2
Max. Observations per Group	36
R-squared	0,4904

There is a significant relation between the credit, interest rate, foreign exchange and commodity derivatives holdings of bank *i* in quarter *t* and the contribution to systemic risk of bank *i* in period *t+1*. Equity derivatives holdings do not affect systemic risk. Therefore, these results document that there is that derivatives holdings act as leading indicators of systemic risk contributions. Nevertheless, the effect is not uniform across derivatives. Concretely, banks' holdings of credit and foreign exchange derivatives have an increasing effect on systemic risk whereas holdings of interest rate and commodity derivatives have a decreasing effect. In addition, foreign exchange derivatives have the highest economic impact among derivatives on systemic risk.

This relationship between the derivatives holdings and systemic risk goes in line with some stylized facts previously documented in the literature. For example, Carter and Sinkey (1998) and Downing (2012) documents that banks use interest-rate derivatives to hedge interest rate risk. Kiff, Elliot, Kazarian, Scarlata, and Spackman (2009) state that a large portion of CDS buyers do not hold the underlying bond but are either speculating on the default of the underlying reference or protecting other interests, what could reinforce the systemic effect of those holdings. Regarding the foreign exchange derivatives, some authors such as Duffie and Zhu (2011) alert to some negative systemic implications of the clearing process of these derivatives in just one clearing house.

Regarding the effect of the size, substitutability, interconnectedness and balance-sheet related variables, we find that increases in the following variables increase systemic risk contributions: total loans, net balance to banks belonging to the same banking group, leverage ratio and the proportion of non-performing loans over total loans. On the other hand, increases in total deposits decreases systemic risk. The effect of the size related variables is not significant given that size is our primary criterion for sample selection. The variables with the highest economic impact on systemic risk are the proportion of non-performing loans to total loans and the leverage ratio. For instance, one standard deviation increase in the proportion of non-performing loans to total loans in quarter *t*, increases the bank's contribution to systemic risk in quarter *t+1* to 17% above its average level.

Summing up, although the two variables with the highest economic impact on the bank's contribution to systemic risk are the non-performing loans relative to total loans and the leverage variables; the bank's holdings of financial derivatives also have significant effects but of a much lower magnitude. These results do not imply that the use of derivatives by banks is inconsequential as far as systemic risk is concerned. They do imply that their impact, albeit statistically significant, plays a second fiddle in comparison with traditional variables such as leverage or the proportion of non-performing loans over total loans. Furthermore, the use of derivatives could indirectly affect the systemic contribution of banks given that derivatives require limited up-front payments and enable banks to take more leveraged positions. Additionally, the use of derivatives could lead to diminished monitoring of loans when the banks are considered to have used the right hedging strategies.

Next, I address research questions four and five in Table 2.4 by splitting derivatives holdings according to their purpose. Column (1) reports the estimated coefficient of the panel regression and the standard deviations. Column (2) reports the economic impact of those variables.

Derivatives held for purposes other than trading do not significantly contribute to systemic risk. However, foreign exchange and interest rate derivatives for trading purposes and to lesser extent equity derivatives affect systemic risk. Finally, we observe that as banks act as a net beneficiary when participating in the credit derivatives markets, its contribution to systemic risk increases.

Table 2.4 Analysis of the held position

This table reports the results of a variation in the baseline unbalanced panel regressions in which we focus on the held position on derivatives. For credit derivatives we study the difference between fair value of holdings in which the bank is the beneficiary and the holdings in which the bank is the guarantor. For interest rate, foreign exchange, equity and commodity derivatives we distinguish holdings used for trading and for purposes other than trading using two different variables. The dependent variable is the individual contribution to systemic risk measured as the Net Shapley Value which is measured in basis points. Our database is formed of 91 banks and spans from 1Q2002 to 2Q2011. We estimate the coefficients by means of a Prais-Winsten robust to heteroskedasticity, contemporaneous correlation across panels. Column 1 reports the coefficients relative to holdings of derivatives. Column 2 reports the economic impact in percentage. It is assessed as the standardized coefficient over the mean of the dependent variable and is reported for the variables which are different from zero at 1 or 5% significance levels. The symbol *** (**) denotes that the variable is significant at 1% (5%). The results correspond to the estimated coefficient and the robust standard errors.

	(1)	(2)
	Coefficient [SE]	Economic Impact (%)
Beneficiary minus Guarantor$_{t-1}$ / TA	932,01*** [357,42]	1,242
Interest rate derivatives held for purposes other than trading$_{t-1}$ /TA	224,71 [117,51]	
Interest rate derivatives held for trading$_{t-1}$ /TA	-8,44*** [2,79]	-1,021
Foreign exchange derivatives held for purposes other than trading$_{t-1}$ /TA	60,3 [242,19]	
Foreign exchange derivatives held for trading$_{t-1}$ /TA	102,63*** [26,09]	2,098
Equity derivatives held for purposes other than trading$_{t-1}$ /TA	105,07 [62,01]	
Equity derivatives held for trading$_{t-1}$ /TA	-145,03** [58,43]	-0,737
Commodity derivatives held for purposes other than trading$_{t-1}$ /TA	-2498,5 [2,927]	
Commodity derivatives held for trading$_{t-1}$ /TA	-18,65 [12,74]	
Constant	57,15*** [19,22]	
Control variables	Yes	
Time Effects	Yes	

These findings are also supported by previous literature on that topic. Fan, Mamun, and Tannous (2009) suggest that the reduction in risk gained from using foreign exchange derivatives for hedging purposes is offset by the increase in trading activities. Banks could use this type of derivatives to hedge foreign exchange risk and be engaged in trading activities which would expose them to additional risk at the same time. Hirtle (1997) shows that the increase in the use of interest rate derivatives by U.S. bank holdings, which served as derivatives dealers, correspond to a greater interest rate risk exposure during the period 1991-1994. This result could be reflecting that derivatives enhance interest rate risk exposure for bank holding companies. Results of the credit default swaps are supported by the fact that a buyer of a CDS contract assumes counterparty risk since the protection seller could default, so the concern of heightened counterparty risk around the Lehman Brothers collapse could explain this effect. Moreover, as pointed out by Giglio (2011), the buyer of protection could suffer even larger loses if the default of the reference entity triggers the default of the counterparty (double default), given that the buyer would have a large amount owed by the bankrupt counterparty.

Finally I address the last research question by means of Table 2.5. In contracts to Table 2.3, the novelty here is that I split the fair value of the holdings of every derivative in two variables: the first variable represents the holdings of derivatives multiplied by a dummy variable which is equal to one before the first quarter of 2007 (no crisis dummy) while the second variable is obtained by multiplying the holdings of derivatives and a dummy variable which equals one after the first quarter of 2007 (crisis dummy). We observe a negative effect of the credit derivatives holdings on systemic risk before the subprime crisis but a positive and significant effect during the crisis which evidences a change of role of the credit derivatives. Credit derivatives behaved as shock absorbers before the subprime crisis but as credit issuers during the crisis. This change of role is not observed in other derivatives.

Table 2.5 Sensitivity to the subprime crisis

This table reports the results of a variation in the baseline unbalanced panel regressions in which I distinguish the role before and during the crisis of every derivative in a separate way. The dependent variable is the individual contribution to systemic risk measured as the Net Shapley Value which is measured in basis points. The database is formed of 91 banks and spans from 1Q2002 to 2Q2011. I estimate the coefficients by means of a Prais-Winsten robust to heteroskedasticity, contemporaneous correlation across panels. I split the holdings of derivatives in two variables: the first variable represents the holdings of derivatives up to the first quarter of 2007 and the second variable represents the holdings of credit derivatives after the first quarter of 2007. I consider the total fair value of credit (column 1), interest rate (column 2), foreign exchange (column 3), equity (column 4) and commodity (column 5) derivatives. The results presented correspond to the estimated coefficient relative to holdings of derivatives. The symbol *** (**) denotes the significance level at 1% (5%).

	(1)		(2)		(3)		(4)		(5)	
	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact
Credit derivatives t-1 /TA * no crisis dummy	-115,82									
Credit derivatives $_{t-1}$ /TA * crisis dummy	24,16**	0,74								
Credit derivatives $_{t-1}$ /TA			42,13**	1,22	1,13	0,03	23,12		31,56***	0,91
Interest rate derivatives $_{t-1}$ /TA * no crisis dummy			-10,69***	-1,30						
Interest rate derivatives $_{t-1}$ /TA * crisis dummy			-12,78***	-2,32						
Interest rate derivatives $_{t-1}$ /TA	-10,65***	-1,40			-8,67***	-1,14	-10,67***	-1,41	-11,37***	-1,50
Foreign exchange derivatives $_{t-1}$ /TA * no crisis dummy					57,71					
Foreign exchange derivatives $_{t-1}$ /TA * crisis dummy					123,03***	4,03				

	(1)		(2)		(3)		(4)		(5)	
	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact	Coefficient	Economic Impact
Foreign exchange derivatives $_{t-1}$ /TA	94,58***	2,07	91,75***	2,01			94,73***	2,08	93,69***	2,05
Equity derivatives $_{t-1}$ /TA * no crisis dummy							-65,31			
Equity derivatives $_{t-1}$ /TA * crisis dummy							-6,75			
Equity derivatives $_{t-1}$ /TA	-11,59		-45,79		-18,63				-39,84	
Commodity derivatives $_{t-1}$ /TA * no crisis dummy									-37,54**	-0,28
Commodity derivatives $_{t-1}$ /TA * crisis dummy									-13,48	
Commodity derivatives $_{t-1}$ /TA	-22,72		-26,71**	-0,28	-24,98**	-0,26	-26,17**	-0,28		
Constant	46,72**		46,79**		45,46**		44,75**		46,41**	
Control variables	Yes		Yes		Yes		Yes		Yes	
Time Effects	Yes		Yes		Yes		Yes		Yes	
Number of Observations	2947		2947		2947		2947		2947	
Number of Groups	91		91		91		91		91	
R-squared	0,4908		0,4905		0,4922		0,4906		0,4905	

2.3. Conclusion

The recent financial crisis has exposed the dangers lurking in oversized banking sector balance sheets. One major concern for regulators has been the astonishing growth in derivatives markets and consequently in the swelling of derivatives holdings in banks' balance-sheets. The aim of this paper is to address the extent to which this situation has increased systemic risk.

First, I propose an alternative measure of the individual contribution to systemic risk that is based on the Gross Shapley Vale and that we call Net Shapley Value. This measure allows me to get rid of the idiosyncratic component present in the last measure. Then, I compare alternative systemic risk measures and find that the Net Shapley Value outperforms the others. Using the Net Shapley Value as our proxy for systemic risk I find strong evidence of derivative holdings acting as leading indicators of banks' systemic risk contributions. However, the sign of the impact vary types of derivatives. In addition, the derivatives impact on systemic risk is only found when the derivative is held for trading. Furthermore, I find that before the subprime crisis credit derivatives decreased systemic risk whereas after the crisis increased it. But foreign exchange, interest rate, equity and commodity derivatives influence systemic risk in the same way in both time periods.

Surprisingly, the data suggest that if a bank is net protection buyer its credit derivatives holdings increase its individual contribution to systemic risk. This fact casts doubt on the real role of these controversial instruments with respect to banks' contributions to systemic risk. The concern about heightened counterparty risk around the Lehman Brothers collapse could explain this effect.

Finally, other balance sheet variables are also leading indicators of systemic risk contributions. In addition, variables as leverage and non-performing loans have the stronger economic impact.

These results provide some implications for regulators and bankers alike. The move toward increasing derivatives holdings might be endogenous to the banking industry, in the sense that it was first originated by banks themselves. In the last years banks shifted their activities from the traditional lending activities toward, a priori, more profitable ones, like trading derivatives. But the reasons for doing that are related to low profitability of traditional activities. Based on the endogeneity of this move toward activities that increased profitability at the price of higher exposure to market risks, this paper suggest that some of these activities, in particular trading in interest rate derivatives had actually reduced the contribution of individual banks to systemic risk. On the other hand, trading in foreign exchange and credit derivatives (during the crisis) had increased their contributions to systemic risk. So the claims that all derivatives have pernicious effects on the overall financial system are not borne out by the data. Therefore, the process of re-regulation that is under way in many countries should be carefully designed to avoid hindering activities that are actually diminishing systemic risk. Financial stability is a public good that can inform corporate investment and financing decisions and thus any new regulatory initiative should be very carefully designed to give the different instruments within an asset class, in this case, derivatives, the appropriate regulatory oversight.

3. LIQUIDITY COMMONALITIES IN THE CORPORATE CDS MARKET AROUND THE 2007-2012 FINANCIAL CRISIS[19]

In Chapter 3 I study the liquidity commonalities in the corporative Credit Default Swap market around the 2007-2012 financial crisis. According to the main conclusions in Chapters 1 and 2, Credit Default Swaps are key instruments in understanding systemic risk either at aggregate or individual contribution levels. Additionally, during the 2007-2012 financial crisis, we have witnessed severe episodes of liquidity shortage in many markets being this shortage especially noticeable in the CDS market because of the uncertainty about the net amount, the structure, and the counterparty risk of such exposures. As a consequence, many firms have had difficulties to timely manage their credit risk exposures. This situation posed important challenges at the individual level but also from a global stability perspective. These facts point out the importance of considering the extent to which the shortage of liquidity has spread over the different contracts traded in the CDS market, and the factors that affect such scarcity.

This Chapter focuses on factors that may affect this shortage in market liquidity, and specifically the extent to which liquidity commonalities in the CDS market are of material importance in this regard. Liquidity commonalities can be defined as the co-movement of individual liquidity measures with market –and industry– wide liquidity. The objective of this Chapter is to provide new evidence on the co-movement in liquidity for the CDS market, which was firstly documented by Pu (2009), from a threefold perspective: firstly, the analysis of the time-varying behavior of the commonalities putting special emphasis on the financial crisis events; secondly, the use of different economic areas and industries for the analysis of such commonalities; and, thirdly the analysis of the factors influencing this co-movement at both aggregate and firm levels.

19. This chapter is a preliminary and summarized version of the paper Mayordomo, Rodriguez-Moreno and Peña (2014).

The typology of the participants in the CDS market, the high degree of concentration, and the role of credit derivatives during the financial crisis affecting both the financial sector and real economy make the analysis of the existence and the behavior of liquidity commonalities in the CDS market a topic of special relevance for regulators, risk managers, and investors. The fact that the main participants in the CDS market are systemically important financial institutions (SIFIs) facilitates that any shock affecting credit derivatives could revert directly on these institutions and could have implications in terms of financial stability. It is worth mentioning that the liquidity risk derived from the typology of the banks participating in the CDS market could be exacerbated by the high degree of concentration of the market activity in the hands of a few SIFIs acting as market participants. This high degree of market concentration may have implications in terms of the impact of large shocks on market liquidity. In fact, Mayordomo and Peña (2014) show that liquidity commonalities have significant effects on the pricing of the CDS of European non-financial firms and on the co-movements among CDS prices during the recent financial crisis.

The analysis of the determinants of the commonalities in liquidity is also certainly a timely topic because, as remarked by Dewatripont, Rochet, and Tirole (2010), developing a better understanding of what drives illiquidity at the individual and aggregate levels should stand high on the agenda of economists and policy makers alike.

This chapter is divided into 3 sections. Section 3.1 presents the estimation of the liquidity commonalities and Section 3.2 shows the analysis of their determinants. Section 3.3 concludes.

3.1. Liquidity commonalities: measures and estimation

Liquidity measure

The baseline liquidity measure employed in this chapter is the relative quoted spread (RQS). For a given firm j at time t it is defined as:

$$RQS_{j,t} = \frac{Ask_{j,t} - Bid_{j,t}}{\frac{(Ask_{j,t} + Bid_{j,t})}{2}} \quad (3.1)$$

This measure has been widely employed in the previous literature and avoids any bias in the results due to the dependence on the level of the CDS premium or the degree of risk as could be the case when one uses the bid-ask CDS spread in absolute terms.

Estimation methodology and results

Several methodologies have been used to study the existence of liquidity commonalities[20]. A detailed comparison of the different estimators can be found in Anderson, Binner, Björn and Nilsson (2010). These authors distinguish two classes of methodologies for the estimation of systematic liquidity: (i) weighted average estimators based on concurrent liquidity shocks, and (ii) principal component estimators based on both concurrent and past liquidity shocks. Their results show that the two types of estimators are largely equivalent because the simpler estimators give, in most cases, similar results to the complex estimators under different evaluation criteria and liquidity measures.

Baseline analysis

Following Chordia, Roll, and Subrahmanyam (2000), I use cross-sectional equally weighted averages to construct the market liquidity measure employed for the estimation of liquidity commonalities. The estimation of the liquidity commonality is carried out through the following "market model" time series regression that is estimated by means of Ordinary Least Squares (OLS):

20. There is a wide array of variables to measure liquidity but one of the most common liquidity measures employed in the fixed-income and the CDS literature is the bid-ask spread. In fact, Fleming (2003) finds that the bid-ask spread is the best measure of liquidity in the bond market. For this reason, the primary liquidity measure employed in our baseline analysis focuses on the bid-ask spread.

$$DL_{j,t} = \alpha_j + \beta_{1j}\, DL_{M,j,t-1} + \beta_{2j} DL_{M,j,t} + \beta_{3j}\, DL_{M,j,t+1} + \beta_{4j} DS_{M,j,t-1} + \beta_{5j} DS_{M,j,t} + \beta_{6j} DS_{M,j,t+1} + \beta_{7j} DS^2_{j,t} + \varepsilon_{t,j} \quad for\ j = 1, \ldots ,438 \tag{3.2}$$

where $DL_{j,t}$ represents the daily percentage changes of the relative quoted spread for firm j $RQS_{j,t}$). $DL_{M,j,t}$ and $DS_{M,j,t}$ are the percentage changes of the contemporaneous market liquidity and market CDS premium, respectively, and are obtained as an equally weighted average of the individual percentage changes in the liquidity measure ($DL_{j,t}$) and in the CDS prices ($DS_{j,t}$) of all the firms with the exception of firm j[21]. I include one lag and one lead of the market liquidity percentage changes and the market CDS premium percentage changes to capture any lagged spurious dependence induced by an association between returns and spread measures. Finally, ($DS^2_{j,t}$) denotes the square of the CDS premium return for firm j and it is employed to proxy for single-firm volatility[22]. The use of percentage changes rather than levels is due to two reasons: (i) our interest lies in testing whether liquidity co-moves and (ii) liquidity levels are more likely to follow non-stationary processes.

Liquidity commonalities can be defined as the co-movement of individual liquidity measures with market liquidity. Hence, they are measured as the sum of the betas for the lagged, contemporaneous and lead market liquidity.

I estimate the baseline liquidity commonalities (Equation (3.2)) at two levels. On the one hand, I estimate the annual coefficients using daily information for every calendar year. On the other hand, I estimate the daily coefficients using 1-year rolling windows such that I obtain a daily measure of commonalities on the basis of the one year ago observations.

21. The exclusion of one CDS avoids constraints on the average coefficients. If one uses all the CDS to compute the equally weighted average, the cross-sectional mean of the coefficients is constrained to exactly a unit. The potential effects of cross-sectional dependence on the estimated coefficients due to the use of each individual liquidity measure as a component of the explanatory variables for all the other regressions are investigated in the robustness test section.

22. The average correlation between the square of the CDS premium return and the percentage changes of the relative quoted spread is 0.03 what confirms that the volatility measure is not related to liquidity.

Table 3.1 reports the results for the estimation of Equation (3.2). In the interest of brevity I report the "sum" and "median", which refer to the cross-sectional average and median of the sum of the contemporaneous, lead, and lag betas, respectively. The coefficients are estimated year by year from 2005 to 2011.

On the basis of the sum of the three coefficients we find a positive and significant effect of the CDS market liquidity on the individual liquidity measures over the eight years of the sample. The median follows the same trend but the estimated levels are lower. The explanatory power as measured by the R-squared is not very high, ranging from 4% in 2005 to 9% in 2010, but it is in line with other papers using the same methodology, such as Chordia, Roll, and Subrahmanyam (2000) analysis of the stock market commonalities. This fact suggests that there are additional explanatory variables that this methodology is not identifying.

An interesting result is the observed trend in the liquidity commonalities, which seems to evolve over time according to the economic conditions. It suggests that liquidity commonalities could be state-dependent as it is documented in Figure 3.1, which contains the cross-sectional median of the sum of the contemporaneous, lead and lag daily coefficients using 1-year rolling windows. Note that in the subsequent analysis we use the median to avoid any potential extreme betas, although the correlation between the median and average betas obtained in the baseline analysis is equal to 0.95.

Figure 3.1 shows the median of the sum of liquidity commonalities from 2006 to 2012. We observe that the lowest levels of liquidity commonalities occur during year 2006, which is a tranquil period. During the whole year 2007 there is a monotonic increasing trend. The high liquidity commonalities reached by the end of 2007 persist until summer 2009 when there is a decrease that persists until the end of the year. The levels of commonalities remain relatively constant until March 2010. From this date commonalities exhibit a remarkable increase that reaches its maximum value around May 2010, coinciding with the Greek rescue, and remains high until March 2011 when there is a significant drop. A new increase is observed by June-July 2011 coinciding with the European Council of 21st July in which there was a failure to arrive at a clearly articulated and adequately funded agreement to guarantee the viability of Greece's public finances. Liquidity commonalities remain around this level until the end of the sample. Summing up, these results suggest the existence of co-movements between the single-name CDS liquidity and the market-wide liquidity.

Table 3.1 Baseline regression

This table reports the effect of market liquidity on firm-specific liquidity. This table summarizes the cross-sectional averages of the slopes of the contemporaneous, lagged, and leading market liquidity measures that are estimated by Ordinary Least Squares (OLS). "Sum" refers to the cross-sectional average of the sum of the contemporaneous, lead, and lag betas. We report the t-statistic for "Sum". "Median" refers to the cross-sectional median of the sum of the contemporaneous, lead, and lag betas.

	2005	2006	2007	2008	2009	2010	2011
Sum	0,52	0,63	0,97	0,88	0,73	0,89	0,86
t-statistic	8,29	10,15	24,09	28,16	13,06	24,50	23,74
Median	0,46	0,56	0,89	0,86	0,62	0,87	0,78
Mean R-squared	0,04	0,04	0,05	0,08	0,06	0,09	0,08

Figure 3.1 Daily liquidity commonalities

This figure reports the daily effect of market liquidity on firm-specific liquidity using 1-year rolling windows (i.e., cross-sectional median of the sum of the contemporaneous, lead and lag market liquidity effects). It contains the baseline methodology in which market liquidity and returns are obtained using equally weighted averages. Vertical lines refer to the Lehman Brothers (September 15th, 2008) collapse and Greek's bailout requests (April 23rd, 2010).

Additional analyses

Literature on the liquidity commonalities in the CDS market is scarce and focuses on the co-movement between individual liquidity measures and the market liquidity. In order to contribute to the understanding of the CDS market in general, and the flow of the liquidity in particular, we conduct additional analysis to capture the specificities of this market.

I first take advantage of the available dataset which consist of daily 5-year CDS information for 438 listed firms from 25 countries and span from 1 January 2005 to 31 March 2012[23]. I group those firms into 5 economic areas (US (236 firms), the European Monetary Union (108 firms), the UK (41 firms), Japan (15 firms), and others (28 firms)) and estimate the market liquidity at economic area. By doing that we study whether the liquidity commonalities in the CDS market are a global or a regional phenomenon. Figure 3.2 reports the cross-sectional median of the aggregate liquidity commonalities for each economic area. Liquidity commonalities are still present when the analysis is carried out at economic area level but the degree of co-movement varies across economic areas.

I next study whether the intensity of the liquidity commonalities varies depending on the performance of the CDS market (i.e., market CDS returns have a positive or negative sign). For such aim, we use two interaction variables obtained as the product of the percentage changes in market liquidity and two different dummy variables: (i) a dummy that takes value one when the market CDS premium is going up at a given date; and (ii) a dummy that takes value one when the market CDS premium is going down. I use the same methodology as in Equation (3.2) but excluding the lagged and lead values of the changes in market liquidity.

23. The sample does not include sovereign or unlisted reference entities. The use of the 5-year maturity CDS contracts is due to the higher liquidity in these contracts. The reference entities belong to the following countries (the number of firms in each country in brackets): the United States (236), the United Kingdom (41), France (35), Germany (24), Japan (15), Canada (11), Italy (9), the Netherlands (9), Switzerland (7), Australia (6), Finland (6), Spain (6), Sweden (6), Hong Kong (5), South Korea (4), Belgium (3), Malaysia (3), Portugal (3), Ireland (2), Singapore (2), Austria (1), Denmark (1), Greece (1), New Zealand (1), and Norway (1).

Figure 3.2 Daily liquidity commonalities by economic area

This table reports the daily effect of market liquidity on firm-specific liquidity using 1-year rolling windows (i.e., cross-sectional median of the sum of the contemporaneous, lead and lag market liquidity effects) being the market liquidity defined by economic area. Panel A depicts the cross-sectional median for all sample firms and Panel B to F depicts the cross-sectional median for firms belonging to the corresponding economic areas (United States, the European Monetary Union, the United Kingdom, Japan, and Others, respectively). Vertical lines refer to the Lehman Brothers (September 15th, 2008) collapse and Greek's bailout requests (April 23rd, 2010).

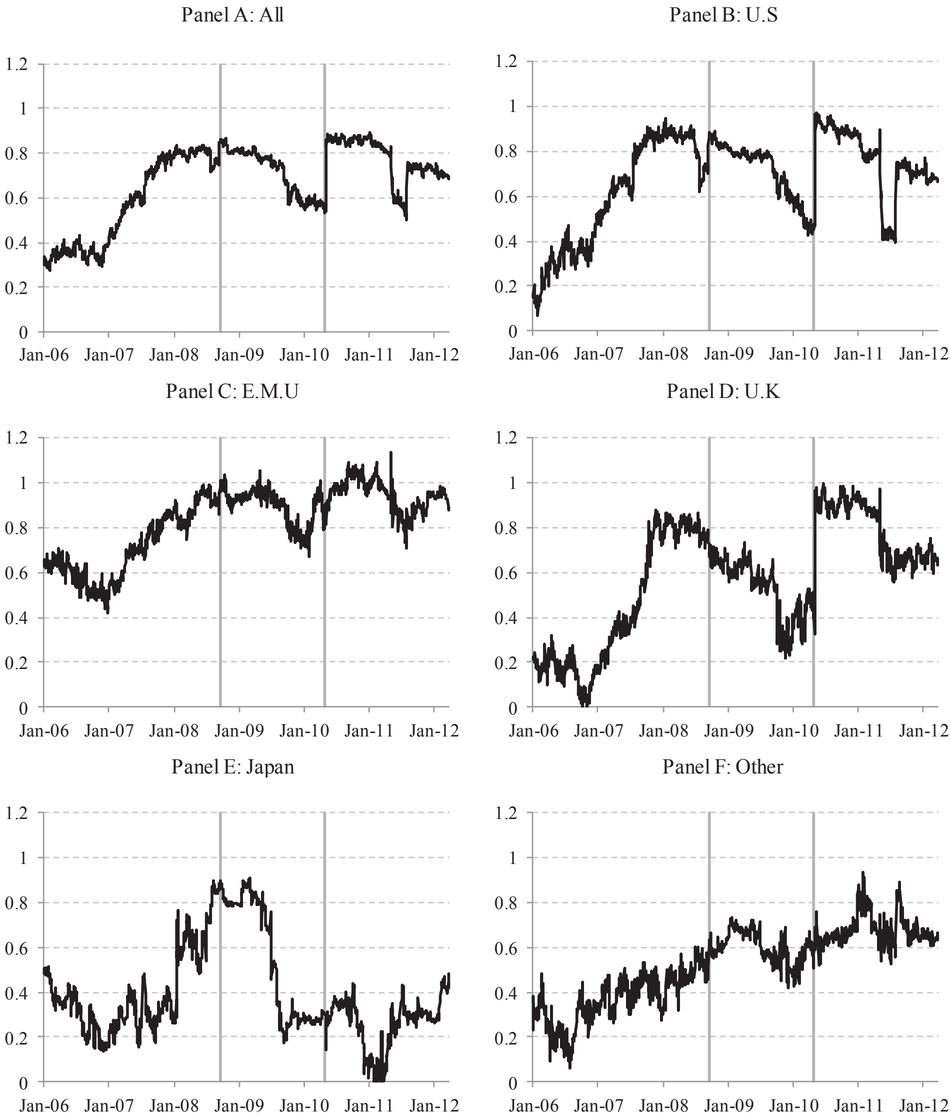
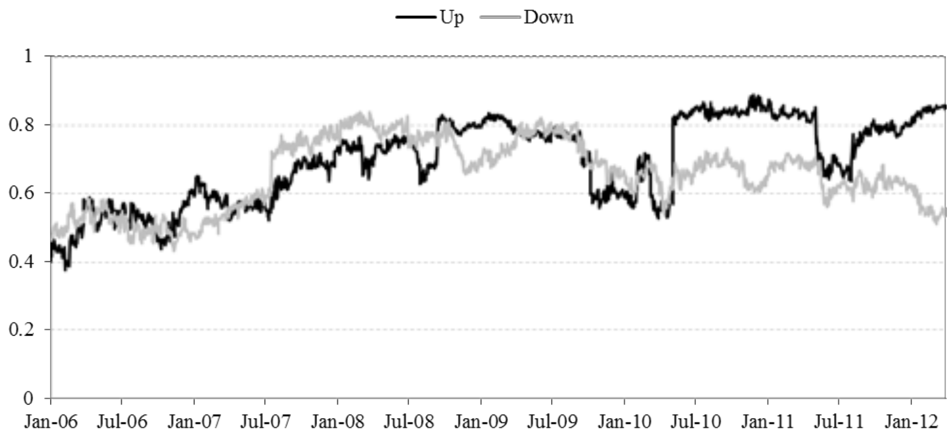


Figure 3.3 shows the result of the analysis. We observe that liquidity commonalities are larger when the market CDS premium increases around highly disrupted events (e.g., Lehman Brothers collapse or Greek bailout). These results suggest the existence of asymmetries in commonalities around financial distress episodes such that the effect of market liquidity is stronger when the CDS market price increases, meaning that commonalities based on the information for these dates could be more informative around specific risky events[24].

In addition I study whether the degree of co-movement of the individual liquidity is stronger at market than at industry level or vice versa. To do that I include in Equation (3.2) the lagged, contemporaneous, and leading percentage change in the industry liquidity, obtained using only the firms that belong to the same industry that firm *j*. We consider 28 out of 41 industries distinguished by the Industry Classification Benchmark (ICB), which is available from Datastream.

Figure 3.3 Analysis of asymmetries

This table reports the daily effect of market liquidity on firm-specific liquidity using 1-year rolling windows (i.e., cross-sectional median of the contemporaneous market liquidity effect) in which we split up the contemporaneous effect into two depending on whether the market CDS returns have a positive or negative sign. We use the baseline specification and interact the market liquidity measure with a dummy for positive changes in the CDS market returns and on the other hand with a dummy for negative changes in the CDS market returns. We also exclude the lagged and lead values of the changes in market liquidity.



24. I check the correlations between the variable for the market returns and the two market liquidity measures that represent both types of asymmetries and find that they are 0.40 and –0.45 for the up and down market returns references, respectively. Thus, there are not problems of collinearity derived from the joint use of market returns and the asymmetric liquidity measure.

Table 3.2 reports the annual results referring to the liquidity commonalities to be compared with those obtained in Table 3.1. Attending to the sum of the lagged, current, and leading coefficients, the industry commonality remains almost constant from 2005 to 2007 and increases in 2008 to remain almost invariable up to 2011. However, we find a significant increase in the market commonality from 2005 to 2007 and a decrease in 2008 and 2009 that are consistent with those obtained in Table 3.1. We obtain a new increase in the effect of market liquidity commonalities in 2010 followed by a decrease in 2011.

Table 3.2: Market and industry liquidity commonalities

This table reports the effect of market and industry liquidity on firm-specific liquidity. This table summarizes the cross-sectional averages of the slopes of the contemporaneous, lagged, and leading market and industry liquidity measures. The slopes are estimated by Ordinary Least Squares (OLS). "Sum" refers to the cross-sectional average of the sum of the contemporaneous, lead, and lag betas. We report the t-statistic for "Sum". "Median" refers to the cross-sectional median of the sum of the contemporaneous, lead, and lag betas.

	2005		2006		2007		2008		2009		2010		2011	
Sum	0,35	0,20	0,46	0,21	0,75	0,23	0,57	0,32	0,46	0,29	0,57	0,32	0,47	0,38
t-statistic	5,39	7,30	7,47	7,48	16,69	9,32	16,40	12,55	7,94	10,88	9,84	5,42	11,41	9,85
Median	0,31	0,12	0,36	0,16	0,65	0,17	0,53	0,29	0,41	0,22	0,64	0,21	0,49	0,34
Mean R-squared	0,07		0,07		0,08		0,11		0,09		0,12		0,11	

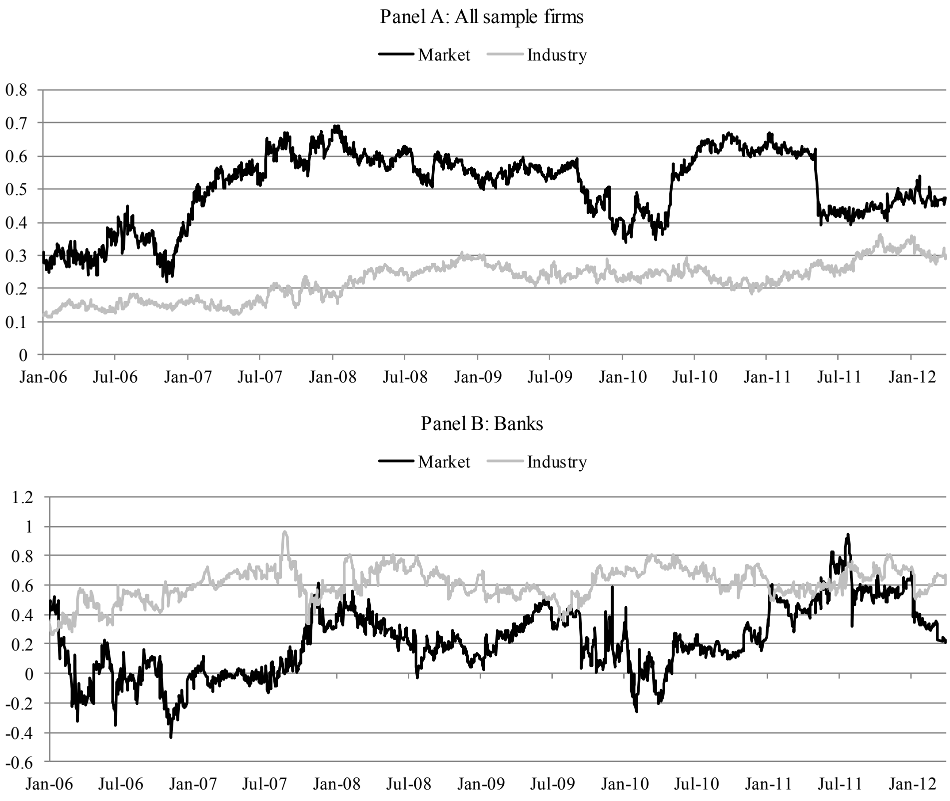
We also test whether this pattern is common for all industries by stratifying the results at industry level and find that the banking industry is the only sector in which industry liquidity is significantly stronger than market liquidity for all the considered years. This finding could be explained by a strong effect of potential determinants of liquidity commonalities (such as global, liquidity or counterparty risks) that are specific of this sector. In fact, the main players in the CDS market are banks[25]. Figure 3.4 reports this effect over time. It contains the cross-sectional median of the sum of the contemporaneous, lead and lag daily coefficients of market and industry liquidity measures using 1-year rolling windows for all firms and for the banking and real estate sectors. In line with the previous finding we observe that market liquidity commonalities are stronger than the industry commonalities but

25. Results are not reported for brevity but are available upon request.

the spread narrows from 2011 on. As obtained in the annual analysis, industry commonalities in the banking sector are stronger than market commonalities for the whole sample with the exception of some weeks around summer 2011.

Figure 3.4 Market vs. industry daily liquidity commonalities

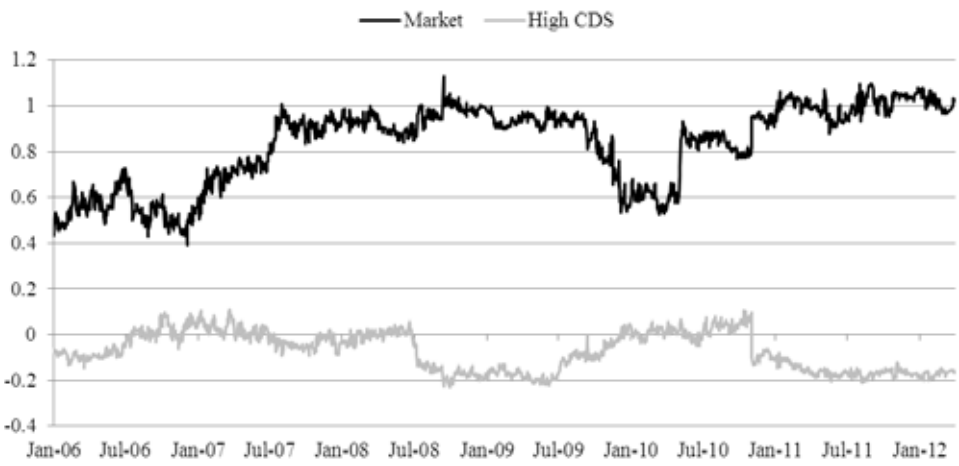
This figure depicts the daily effect of market and industry liquidity on firm-specific liquidity using 1-year rolling windows (i.e., cross-sectional median of the sum of the contemporaneous, lead and lag liquidity effects) where industry liquidity measure is constructed as an equally weighted average of the relative bid-ask spreads for firms belonging to the same industry. Panel A and B report the cross-sectional median of all sample firms and banks, respectively.



Finally I test whether those firms with the highest credit risk could be the ones causing some commonality effects. For such aim, I include in Equation (3.2) the contemporaneous, leading and lagged percentage changes of the high credit risk firms' liquidity measure that is constructed using only those firms that belong to the top quartile according to their level of CDS prices. Figure 3.5 reports the results of this analysis. It contains the median of the cross-sectional average of the sum of the contemporaneous, lead and lag daily coefficients of market and high CDS liquidity measures, using 1-year rolling windows. The results suggest that liquidity commonalities are not driven by the liquidity of the reference entities with the highest CDS prices because it is close to zero during the whole sample.

Figure 3.5 Market vs. high CDS daily liquidity commonalities

This figure depicts the daily effect of market and high CDS liquidity on firm-specific liquidity using 1-year rolling windows (i.e., cross-sectional median of the sum of the contemporaneous, lead and lag liquidity effects) where high CDS liquidity measure is constructed as the equally weighted average of the relative bid-ask spreads of firms belonging to the top quartile according to their level of CDS prices.



3.2. Determinants of the liquidity commonalities

After checking the existence of liquidity commonalities in the CDS market, I proceed with the analysis of their determinants using two different perspectives: aggregate and firm level.

Determinants of liquidity commonalities at aggregate level

To conduct this analysis I first estimate the individual monthly liquidity commonalities using daily information for every calendar month where the market model is a variation of Equation (3.2) in which we do not include the leads and lags of any variable. Next I construct the monthly aggregate beta as the median of the firm's betas referring to the contemporaneous market liquidity. Finally, I conduct the following analysis:

$$Median(\beta_1)_m = \eta_0 + \eta_1 \; Risk\ Factor_m + \varepsilon_m \tag{3.3}$$

in which we regress the aggregate betas for every month *m* on the monthly averages of three risk factors: global risk (proxied by VIX), global liquidity/ funding costs (proxied as the difference between the 90-day U.S. AA-rated commercial paper interest rates for the financial companies and the 90-day U.S. T-bill), and counterparty risk in the CDS market (proxied by means of the first principal component obtained from the CDS premium of the main banks acting as dealers in the market). The monthly averages of the global and counterparty risks are integrated of order one while the global funding costs and the betas series do not exhibit a unit root. Thus, we use the first difference of the global and counterparty risk proxies as the explanatory variables.

Panel A of Table 3.3 reports the results. The first three columns include the effects of the three potential determinants of the liquidity commonalities individually. We observe that the liquidity commonalities' betas are well explained by the economy-wide variables. The first column confirms that the global risk has a positive and significant effect on the estimated betas. This variable has a powerful explanatory power as the R-squared of 25% suggests. One possible explanation is that the CDS market participants are strongly and homogenously affected by the shocks to the global economy, given the high degree of concentration of the market participants in this market. This result could also reflect the higher sensitivity of the CDS market to the global market factors. This result is in line with the findings of Kempf and Mayston (2008), among others, for the stock market in the sense that they find that commonality is much stronger in falling markets than in rising markets.

I next test how counterparty risk affects the degree of co-movement. The increase in counterparty risk could make it more difficult to find a counterparty to sell/buy protection, which lowers liquidity. The results of the second column show that as counterparty risk increases, liquidity commonalities also increase. The explanatory power of this variable is lower than the one of global risk but it is not negligible (16%).

Another potential global effect to consider as a determinant of liquidity commonalities is the role of capital constraints. The effect of such constraints on stock market liquidity commonality is documented by Comerton-Forde, Hendershott, Jones, Moulton, and Seasholes (2010) and Brunnermeier and Pedersen (2009). We consider the capital constraints as a dimension of liquidity related to the overall funding constraints which should affect the investments in CDS. We find a positive and significant effect of the funding costs variable defined in levels. This variable has explanatory power (0.13) but lower than the ones for the two previous factors. The previous empirical evidence implies that as the funding cost increases, and as a consequence the liquidity risk also increases, so do the liquidity commonalities.

In the fourth column we use the three variables at the same time as explanatory variables and find similar results in terms of the degree of significance and the R-squared increases to 0.32. The results are also robust to other specifications[26].

26. Similar results are obtained when we use another global risk proxy as the VDAX index. We also repeat the analysis using the mean betas instead of the median and we find that the economic variables have positive and significant signs, although the estimated R-squared are lower. We repeated the regression using quarterly instead of monthly betas and obtained similar results.

Table 3.3 Determinants of liquidity commonalities

This table reports the analysis of the determinants of liquidity commonalities at aggregate and firm levels. Panel A reports the effect of aggregate factors where we regress monthly aggregate betas on the monthly average of global, counterparty and funding cost risk, separately (columns I to III) and jointly (column IV), using OLS robust heteroskedasticy. Panel B reports the effect of individual factors where we run cross-sectional regressions by OLS for every date (1625) in the sample and calculate the average coefficient which is reported in the first column. The standard errors reported in brackets are the corrected for autocorrelation using the Newey-West methodology. These errors are obtained after regressing with Newey-West standard errors adjustment the loadings on each factor, which are shown in the first column, on a constant. The second column shows the change in the dependent variable after a change in the explanatory variable of one standard deviation (SD). The SD is obtained as the mean SD of the variable across all the firms. The third column is the ratio between the effect on the dependent variable of a change one SD in each regressor and the average beta across all the firms and over the whole sample. *** (** and *) indicates that the estimated coefficient is significant at a level of 1% (5% and 10%, respectively).

Panel A: Determinants of liquidity commonalities at aggregate level

	I	II	III	IV
ΔGlobal Risk	0,020*** (0,00)			0,013*** (0,00)
ΔCounterparty Risk		0,091*** (0,03)		0,048** (0,02)
Global Funding Costs			0,155*** (0,06)	0,092** (0,04)
Constant	0,369*** (0,02)	0,361*** (0,02)	0,306*** (0,03)	0,326*** (0,02)
Number of Observations	84	84	85	84
F(1,82)	26,59	11,18	7,9	20,8
Prob > F	0,00	0,00	0,01	0,00
R-Squared	0,25	0,16	0,13	0,32

Panel B: Determinants of liquidity commonalities at individual level

	Coefficient	1 SD change	1 SD change relative to
Size	-0,005 (0,00)	-0,002	-0,002
Leverage	0,035 (0,05)	0,001	0,002
CDS premium	0,000 (0,00)	0,009	0,011
Volatility stock price	3,523 (5,85)	0,012	0,014
3-month interbank rate	0,049*** (0,01)	0,093	0,115
Volatility stock index	32,939*** (5,38)	0,248	0,304
Constant	0,323*** (0,06)		
Average R-squared	0,03		

Determinants of liquidity commonalities at firm level

The analysis of the determinants of the market liquidity on individual liquidity is carried out on the basis of the daily liquidity commonalities estimated in Equation (3.2) using 1-year rolling windows. Concretely, we use the sum of the betas for the lagged, contemporaneous and lead market liquidity measures as the dependent variable. As the liquidity commonalities are based on overlapping information, we run a Fama-MacBeth cross-sectional regression for every day in the sample to avoid time series dependencies and to exploit the cross-sectional dimension. The standard errors are corrected for autocorrelation using the Newey-West methodology[27].

$$Sum\ Betas_{i,t} = \delta_0 + \delta_1 Firm\ Info_{i,t} + \delta_2 Country\ Info_{i,t} + \varepsilon_i \quad where\ \ t = 1, \dots, 1625 \tag{3.4}$$

Among the determinants of the co-variation between the CDS and market illiquidity measures we use firm and country specific variables. Among the former variables, we use proxies for the firm size, leverage, level of credit risk, and firm shares' squared returns (volatility). Among the variables referred to the country of origin of the firm, we use proxies for the volatility of the stock indexes and 3-month interbank interest rate.

Panel B of Table 3.3 reports the result of this analysis. According to them, firm specific characteristics such as size (log of market capitalization), leverage (ratio of total debt to total assets), level of credit risk (CDS premium) and volatility in the stock prices (squared of the stock returns) do not significantly affect to the individual liquidity commonalities. On the contrary, I document a strongly significant effect of the global risk variables. Additionally, the constant term is also positive and highly significant suggesting that other global risk variables lead to a larger exposition of CDS single-names liquidity to market liquidity.

27. The number of lags employed in the Newey-West regressions must grow with the sample size to ensure consistency when the moment conditions are dependent. We use a lag length determined by the widely employed method of the number of observations raised to the power of 1/3 that is equal to 12 lags.

Liquidity commonalities as indicators of global risk

Finally I check whether the cross-sectional median of the individual liquidity commonalities provides additional informational with respect to the aggregate risk measures around the two most relevant periods of financial distress (Lehman and Greek events) by means of a Granger causality test. This test enables us to examine whether past information of liquidity commonalities helps to explain the current behaviour of the risk measures and vice versa. The results of Section 3.1 suggest that the asymmetric commonalities referred to the increases of CDS market prices perform particularly well around stress periods. Using an interval of three months before and after the previous events, I first run a Granger causality test between the baseline and the asymmetric commonalities and find that asymmetric commonalities Granger-cause the other measure around the two events[28]. Next, using this asymmetric commonalities measure, I perform the same analysis with respect to the global, counterparty, and funding liquidity risks and find that commonalities Granger-cause the three risk measures around the Lehman Brothers' collapse but only the funding liquidity risk around the Greek's bailout requests. This result reinforces the role played by the CDS around the Lehman's collapse as shock issuers (see Chapter 2) and suggests a lower effect of this market around the Greek episode.

3.3. Conclusion

Corporate CDS individual liquidity measures co-move with the aggregate liquidity in the corporate CDS market. I present extensive empirical evidence based on data for the period 2005-2012 in support of this claim. The liquidity commonalities are still present when we analyze the co-movement of firms located in the same economic area, but the degree of commonality differs across them being the EMU the region with the average stronger commonalities during the whole sample period. Regarding the effect of market and industry commonalities, the effect of the market is usually stronger than the one of the industry in most industries but there are some exceptions as the banking industry. The liquidity commonalities are time-varying and increase in times of

28. Results are robust to longer intervals.

financial distress characterized by high counterparty, global, and funding liquidity risks. Nevertheless, the co-movement of the firm's liquidity with the market liquidity does not depend on firm's characteristics such as size, leverage, credit risk, or equity volatility but on global risk factors as the aforementioned. In this line, I find that the Lehman Brothers collapse and the Greek's bailout requests trigger a significantly increase in commonalities. In fact, the results suggest the existence of asymmetries in commonalities around these episodes of financial distress such that the effect of market liquidity is stronger when the CDS market price increases. Finally, I find that liquidity commonalities provide informational efficiencies relative to the three previous aggregate risks around periods of financial distress originated or amplified by the CDS market such as Lehman Brothers collapse.

Some implications for traders, investors, and regulators follow. First, these results are consistent with inventory risk being the main source of the commonalities in liquidity. Second, the CDS market has a high probability of suffering sudden changes in aggregate liquidity. Third, and given that the degree of commonality differs across economic areas, the expected returns on CDSs of otherwise similar companies located in different countries might differ. Given that the expected returns before costs are related to trading costs; the higher the trading costs, the higher the expected returns. The more sensitive an asset is to the liquidity commonality component, the greater its expected return must be. Finally, regulators should consider whether the standardization of the CDS contracts and the implementation of a Central Counterparty Clearing House would alleviate the CDS market's relative propensity for abrupt changes in liquidity.

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This book studies the measurement and the determinants of systemic risk, paying special attention to the role of the Credit Default Swaps (CDSs) either as financial instruments containing valuable information about the soundness of the reference institutions or as a market whose distress contributes to potential systemic shocks on the economy. The measurement of systemic risk is addressed from two perspectives, aggregate and individual contribution to systemic risk where the former refers to the level of systemic risk in the overall economy and the latter to the individual contribution of each financial institution to the overall systemic risk. The analysis of the determinants of the individual contribution of financial institutions to systemic risk focuses on the effect of their portfolio holdings of derivatives. Finally, this thesis studies the liquidity commonalities and their determinants in the corporate CDS worldwide markets. The main participants in these markets are systemically important financial institutions (SIFIs) and so abrupt changes in the market liquidity could cause systemic shocks on the overall economy and, as a consequence, could have adverse effects on global stability.

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