Journal of Banking & Finance 45 (2014) 84–104

Contents lists available at ScienceDirect

Journal of Banking & Finance

journal homepage: www.elsevier.com/locate/jbf

Derivatives holdings and systemic risk in the U.S. banking sector

Sergio Mayordomo [a,1], Maria Rodriguez-Moreno [a,*], Juan Ignacio Peña [b]

[a] University of Navarra, School of Economics and Business Administration, Edificio Amigos, Campus Universitario, 31009 Pamplona, Spain
[b] Universidad Carlos III de Madrid, Department of Business Administration, C/Madrid, 126, 28903 Getafe, Madrid, Spain

ARTICLE INFO

Article history:
Received 7 June 2013
Accepted 23 March 2014
Available online 18 April 2014

JEL classification:
C32
G01
G21

Keywords:
Systemic risk
Derivatives
Shapley value

ABSTRACT

This paper studies 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. Using a sample of 95 U.S. bank holding companies from 2002 to 2011, we compare five measures of the banks' contribution to systemic risk and find that the new measure proposed in this study, Net Shapley Value, outperforms the others. Using this measure we find that banks' aggregate holdings of five classes of derivatives do not exhibit a significant effect on the bank's contribution to systemic risk. On the contrary, the banks' holdings of certain specific types of derivatives such as 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. Therefore, the derivatives' impact plays a second fiddle in comparison with traditional banking activities related to the former two items.

1. Introduction

Since the beginning of the current financial and economic crisis, the concern about systemic risk has increased, becoming a priority for regulatory authorities. The International Monetary Fund, Bank of International Settlements and Financial Stability Board define systemic risk as the "risk of disruption to financial services that (i) is caused by an impairment of all or parts of the financial system and (ii) has the potential to have serious negative consequences for the real economy". Regulatory 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 U.S. and the European Systemic Risk Board (ESRB) in the E.U. 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 this setting it is crucial for the banking regulatory institutions to be able to analyze and understand the determinants of a banks' contribution to systemic risk. This information would help them 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, securities market regulators are interested 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 benefits and costs of derivatives and in particular their role in the financial crisis 2007–2009. This paper 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.

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 purposes justified by

* Corresponding author. Fax: +34 948 425626.
E-mail addresses: smayordomo@unav.es (S. Mayordomo), mrodriguezm@unav.es (M. Rodriguez-Moreno), ypenya@eco.uc3m.es (J.I. Peña).
[1] Fax: +34 948 425626.

http://dx.doi.org/10.1016/j.jbankfin.2014.03.037
0378-4266/

theory supporting the rationality of hedging decisions at individual bank level (e.g., Koppenhaver, 1985). This stance also finds support in empirical evidence suggesting the advantages of different hedging strategies for financial firms, again at individual level, see among others Jaffe (2003). However, another substantial proportion of this growth is due to proprietary trading activities by banks. Both activities, hedging and trading, 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, Calmès and Théoret (2010) find that off-balance sheet activities reduce banks' mean returns, simultaneously increasing the volatility of their operating revenue and therefore increasing banks' systemic risk. Nijskens and Wagner (2011) report that the first use of credit derivatives is associated with an increase in a bank's risk, largely due to an increase in banks' correlations and therefore in their systemic risk. However, as far as we know, 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. For such aim, we combine two analyses; we first measure the banks' individual contributions to systemic risk and then, we estimate the effects of their holdings of financial derivatives on the banks' contributions to systemic risk.

To assess the banks' contributions to systemic risk we use the following five measures: ΔCoVaR, ΔCoES, Asymmetric ΔCoVaR, Gross Shapley Value (GSV) and Net Shapley Value (NSV). The ΔCoVaR is the difference between the Value at Risk (VaR) of the banking system conditional on bank *i* being in distress minus the VaR of the banking system conditional on bank *i* being in its median state. The ΔCoES applies the same idea but using the Expected Shortfall instead of the VaR (see Adrian and Brunnermeier, 2011). The Asymmetric ΔCoVaR represents a variation of the standard ΔCoVaR specification that allows for asymmetries in this specification (see Lopez et al., 2011). The GSV measures the average contribution to systemic risk of bank *i* in all possible groups in which the whole financial system can be divided (see Tarashev et al., 2010). Finally we propose an alternative measure to the GSV called NSV in which we get rid of the idiosyncratic component present in the former measure by subtracting from the GSV the VaR of the bank *i*.

We estimate these five measures for a subset of the 95 biggest U.S. bank holding companies for the period that spans from 2002 to 2011. We then compute the correlation of the systemic risk measures with an index of systemic events and run a Granger causality test between pairs of measures; and find that the NSV presents the closest association with the index and Granger causes more frequently the other measures. Then, using this measure of systemic risk as the dependent variable, we analyze the effect 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.

The main results of the paper can be summarized as follows. We find a significant relationship between the fair values of certain derivatives holdings of given bank in a given quarter and the bank's contribution to systemic risk one quarter later. Nevertheless, this relationship is not uniform across derivatives classes. Banks' holdings of credit and foreign exchange derivatives have an increasing effect on systemic risk whereas holdings of interest rate derivatives have a decreasing effect. Therefore, some types of derivatives holdings act as leading indicators of systemic risk contributions. However, the banks' aggregate holdings of the five classes of derivatives employed in our study do not exhibit a significant effect on the bank's contribution to systemic risk.

Given that the baseline model directly relates the banks' derivatives activity to their individual contribution to systemic risk, the results may potentially suffer for endogeneity problems in the sense that banks with certain specific characteristics self-select them into derivatives participation. To address this concern we provide three pieces of evidence that enable us to confirm that our findings come indeed from a causal relation between banks' derivatives holdings and their contribution to systemic risk.

Besides derivatives there are other balance sheet items that are significant contributors to systemic risk. Thus, increases in the following variables (measured as ratios over total assets) led to increases in systemic risk contributions: total loans, net balance to banks belonging to the same banking group, leverage ratio, and the proportion of non-performing loans (measured in this case, relative to total loans). On the other hand, increases in total deposits decrease systemic risk. The variables with the highest economic impact on systemic risk are the proportion of non-performing loans to total loans and the leverage ratio. In fact, their economic impact is much higher than the one corresponding to derivatives holdings. Therefore, the derivatives' impact plays a second fiddle in comparison with traditional banking activities related to the former two items.

The rest of the paper is organized as follows. Section 2 describes the methodology. In Section 3 we describe the data. Section 4 reports the reliability of the different systemic risk measures to define the most convenient for the later analysis. Section 5 reports the main empirical findings referred to the effect of banks' holdings of derivatives and other banks' characteristics on systemic risk. In Section 6 we address the endogeneity problem. In Section 7 we present some robustness tests, and we conclude in Section 8.

2. Methodology

2.1. Systemic risk: Measures and comparison

We consider the following five measures of the individual contribution of banks to systemic risk: (i) ΔCoVaR, (ii) ΔCoES, (iii) Asymmetric ΔCoVaR, (iv) Gross Shapley Value (GSV) and (v) Net Shapley Value (NSV). The details of the characteristics and the estimation of the systemic risk measures can be found in Appendix B.[2]

As in Rodriguez-Moreno and Peña (2013) we 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.[3]

In the first criterion we use an influential event variable (IEV), which is a categorical variable that captures the main events observed and policy actions taken during the financial crisis based

[2] Acharya et al. (2011a,b) propose an alternative measure of the individual contribution to systemic risk called realized SES that measures the propensity of bank *i* to be undercapitalized when the whole system is undercapitalized. We exclude this measure from the discussion in the main text because, by construction, it is quarterly estimated and we cannot carry out the comparison with the considered five measures. Nevertheless, we estimate this measure, conduct the baseline regression to analyze the determinants of banks contributions to systemic risk and find that the results are fully in agreement with the main findings of this paper.

[3] In Rodriguez-Moreno and Peña (2013) the authors 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.