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A vine-copula conditional value-at-risk approach to systemic sovereign debt risk for the financial sector

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ABSTRACT

We investigated systemic sovereign debt distress affecting European financial systems and the systemic risk implications for its European partners of a potential Greek debt default before and after the onset of the financial and debt crises, using the conditional value-at-risk (CoVaR) measure, characterized and computed using copulas and vine copulas. Before the debt crisis, sovereign debt was found to imply positive systemic risk for domestic financial systems across Europe. However, with the onset of the Greek crisis, the systemic impact of sovereign debt increased for countries like Greece, Italy and Portugal, while remaining stable or reduced for other countries. Regarding the systemic impact of sovereign Greek debt distress, our evidence indicates that negative impacts were limited to a small set of countries, notably Belgium, Italy, the Netherlands and Portugal.

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1. Introduction

How would a sovereign default impact on a country's financial system? Does sovereign default in one country impact on the financial systems of other countries? In view of the recent global financial and European debt crises, the answers to such questions have acquired great importance for investors, regulators and researchers.

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We measured the systemic effect of domestic sovereign debt distress on domestic financial systems in European countries in the aftermath of recent financial and debt crises. We also measured the systemic effect of potential Greek debt distress on the financial systems of other European countries for the same period. Recent research (e.g., Reinhart & Rogoff, 2009a) has shown that systemic risk in financial markets increases considerably in times of crisis and has adverse effects that extend to the real economy. The links between financial crises and sovereign debt distress have been specifically documented by Reinhart and Rogoff (2009b, 2010) in relation to sovereign distress spreading to financial systems when banks hold substantial government debt in their portfolios (as happened in Italy, Portugal and, to a lesser extent, Spain).[1] Furthermore, sovereign debt portfolios of banks in European countries have been demonstrated to show a growing 'home bias', thereby increasing domestic sovereign holdings with sovereign solvency risk (Battistini, Pagano, & Simonelli, 2014), while reinforcing the 'diabolic loop' between sovereign distress and bank solvency (Brunnermeier et al., 2011). Therefore, accurately quantifying how a possible sovereign default in the eurozone could impair the performance of a financial system has practical interest for both investors and regulators.

Over the last few years, researchers have developed numerous systemic risk measures to account for the impact of failure of a financial institution on an entire financial system and vice versa. To capture possible risk spillovers between markets, Adrian and Brunnermeier (2011) proposed using conditional value-at-risk (CoVaR), a measure that provides information on the value-at-risk (VaR) of a market conditional on the fact that another market is in financial distress. This measure was later generalized by Girardi and Ergün (2013) by considering the VaR of a market conditional on the fact that another market's returns take values less than or equal to its VaR. Other authors have proposed alternative risk measures based on marginal expected shortfall (Acharya, Pedersen, Philippon, & Richardson, 2010), extreme value theory (De Jonghe, 2010; Zhou, 2010), principal component analysis (Billio, Getmansky, Lo, & Pelizzon, 2012; Kritzman, Li, Page, & Rigobon, 2011), default probabilities (Gray & Jobst, 2010; Huang, Zhou, & Zhu, 2009; Huang, Zhou, & Zhu, 2012; Jin & Nadal De Simone, 2014; Lehar, 2005; Segoviano & Goodhart, 2009), distance to default (Saldías, 2013) and network analysis (see, e.g., Allen, Babus, & Carletti, 2010; Halaj & Kok Sorensen, 2013; Tarashev, Borio, & Tsatsaronis, 2010).[2]

We chose CoVaR—because VaR is arguably the risk measure most widely used by investors, financial institutions and regulators—and characterized CoVaR systemic risk in terms of copulas (Mainik & Schaanning, 2012). Firstly, to account for the effects of domestic sovereign debt risk on the domestic financial system, we employed bivariate copulas so that CoVaR could be obtained in a two-step procedure. Thus, for the confidence level for CoVaR and the cumulative probability for VaR for the domestic sovereign debt market, we could compute CoVaR cumulative probability from a copula function. We then inverted the marginal distribution function for this cumulative probability in order to obtain CoVaR. Secondly, to account for the systemic impact of a potential Greek sovereign debt default on the financial system of other European countries, taking into account the link between domestic financial and sovereign debt markets we extended the copula CoVaR representation to a multivariate setting by considering the vine-copula approach, which allows systemic risk to be assessed using a hierarchical dependence construction given by a set of bivariate copulas. In this way, we could take into account dependence between the Greek sovereign market and the sovereign and financial systems of other countries; hence, the impact of sovereign default—in the domestic or Greek or both markets—on the financial system could be obtained in a three-step procedure: (1) for the given cumulative VaR probability and for the CoVaR confidence level, we computed the cumulative probability for VaR referring to the domestic sovereign debt market from a copula function; (2) using this information we computed the cumulative CoVaR probability from a copula function; and finally, (3) to obtain CoVaR we inverted the marginal distribution function for this cumulative probability.

We measured the impact of sovereign debt default on the financial systems for both eurozone core countries (Austria, Belgium, Finland, France, Germany and the Netherlands) and eurozone peripheral countries (Italy, Greece, Portugal and Spain) for the period 2000–2012. Our results point to substantial

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[1] Other channels of transmission of sovereign risk to financial institutions such as collateral, rating or guarantee channels were also identified by BIS (2011).

[2] Bisias et al. (2012) offer a comprehensive review on systemic risk measurement.

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