Assessing Systemic Risk and its Determinants for Advanced and Major Emerging Economies: the Case of ΔCoVaR

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Abstract. The paper examines conditional risk relationships among sovereign CDS prices and stock market indices for 11 economies with particular relevance for international portfolio investment holdings (Canada, China, Brazil, France, Germany, Italy, Japan, Russia, Spain, the USA, and the UK). The analysis is based on delta conditional value at risk (ΔCoVaR). The UK, France, and Italy significantly contribute to the overall systemic risk in both markets. The USA, the UK, and Russia appear to be important contributors to it in the stock market. In the meantime, the advanced economies exhibit much higher resilience to the systemic risk propagation in comparison with China, Brazil and Russia. Gross government debt to GDP, state fragility index, EU membership and world gross GDP share of a country in distress are key determinants of ΔCoVaRs for the sovereign CDS prices. Stock market total value traded to GDP and world gross GDP share of a country in distress drive ΔCoVaRs in the stock market. In both cases geographic distance tends to deter systemic risk propagation. Inflation, trade and financial openness as well as common language and time zone differences are less important predictors of bilateral ΔCoVaR exposures.

Keywords: CDS, CoVaR, ΔCoVaR, financial depth, gravity equation, quantile regression, spillover, systemic risk

JEL codes: F37, G15, G23.

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1. Introduction

In the aftermath of the 2007–2008 global financial crisis increasing importance has been attached to systemic risk assessment. Since then over 30 baseline systemic risk measures and their modifications have been proposed (Bisias et al. 2012, Blancher et al. 2013). One of the most widespread indicators among them is conditional value at risk (CoVaR) introduced by Adrian and Brunnermeier (2011)[2].

They define CoVaR as the value at risk of a financial institution (or a financial system) conditional on institutions being under stress. It appears to be a flexible measure as it can be applied to gauge contributions to the systemic risk by individual financial institutions, markets or by countries. Among most recent contributions in the first vein, Lee et al. (2012) and Borri et al. (2014) use CoVaR to analyze systemic risk of the banking sector in Korea and Italy respectively while Castro and Ferrari (2014) adopt this measure to identify systemically important banks in the EU. López-Espinosa et al. (2012a, b) investigate the determinants of systemic risk in a large sample of international banks. Bernal et al. (2014) compare relative contribution of three segments of the financial sector (banking, insurance and other financial institutions) to the systemic risk in the USA and the Eurozone. Drakos and Kouretas (2015) conduct a similar analysis, focusing on foreign financial corporations' contribution to domestic systemic risk in the USA and the UK. On country level, Wing Fong and Wong (2012) use CoVaR to examine conditional risk relationships in the sovereign CDS market. Yang et al. (2014) employ CoVaR to quantify interest rate risk of EU countries conditional on the interest rate movements in the USA. Suh (2014) proposes a new contagion measure based on CoVaR and concludes that its magnitude is large even for stable economies in the Eurozone. Reboredo and Ugolini (2014) construct CoVAR measures based on copulas to estimate systemic risk in the European sovereign debt market.

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[2] It is hard to assert that the systemic risk measures are spotlessly accurate. There is evidence that CoVaR as well as MES (marginal expected shortfall) and SRISK proposed by Acharya et al. (2010) and Brownlees and Engle (2015) are sometimes outperformed by the metrics directly related to firms' balance sheets, e.g. Benoit et al. (2013), Benoit (2014), and Idier et al. (2014). Nonetheless, CoVaR appears to be ahead of other indicators, judging by the number of citations in Google Scholar (1040 citations for Adrian and Brunnermeier (2011) paper vs. 800 for Acharya et al. (2010) and 343 for Brownlees and Engle (2015) as of early May 2015).

In this paper ΔCoVaR, an indicator based on the conventional CoVaR, is used to examine conditional risk relationships among the economies which are the most important international portfolio investors or recipients based on the annual Coordinated Portfolio Investment Survey (CPIS) data for 2009–2012 issued by the IMF. The sample also comprises 3 major emerging economies – China, Brazil and Russia. Overall, the list includes 11 economies (Brazil, Canada, China, France, Germany, Italy, Japan, Spain, Russia, the UK and the USA). As the CPIS provides information on aggregate investment into two broad classes of assets – debt and equity securities, the conditional risk relationships among the countries are proxied by the bilateral ΔCoVaR values derived from sovereign CDS prices and stock market indices. These values refer to the time span between January 2010 and February 2014. In addition to the estimation of the bilateral ΔCoVaR exposures, the determinants underlying the magnitude of the relationships are examined.

The following notable results are obtained. The UK, France and Italy are significant contributors to the overall systemic risk in both dimensions. As for the CDS prices, the main contributors are also Germany, Russia and China. The USA, the UK and Russia exhibit the highest average ΔCoVaRs in the stock market. The advanced economies, especially the USA, Japan, Germany and the UK, are more resilient to the adverse external spillovers. Conversely, the emerging economies, in particular Russia, are the most vulnerable to the overall systemic risk. This tail risk dependence is especially pronounced in the stock market. On bilateral level, the highest ΔCoVaR values are observed for the emerging markets and for most distressed EU economies in this sample – Spain and Italy. However, unlike Italy, the contribution of Spain to the systemic risk is muted. Gross government debt to GDP, state fragility index, EU membership and world gross GDP share of a country in distress are key determinants of ΔCoVaRs for the sovereign CDS prices. Stock market total value traded to GDP and world gross GDP share of a country in distress drive ΔCoVaRs in the stock market. In both cases geographic distance tends to deter systemic risk propagation. Inflation, trade and financial openness as well as common language and time zone differences are less important predictors of cross-country ΔCoVaR exposures.

The paper proceeds as follows. Section 2 presents the methodology and data. Section 3 discusses the baseline results of ΔCoVaR estimation, Section 4 investigates ΔCoVaR determinants. Section 5 checks the robustness of the findings reported in Sections 3 and 4. Section 6 concludes.

2. Methodology and Data

2.1 CoVaR and Δ CoVaR estimation

2.1.1 Model specification

The starting point of CoVaR estimation is computing VaR for the variables in question. VaR_q^j is defined as the maximum change in a variable associated with country *j* at a confidence level $(1-q)$. In the model, a country that faces a dramatic change in the variable, e.g. an increase in the CDS price or, conversely, a fall of a stock market index at the 99th percentile, is said to be in distress. Formally, it can be expressed as

$$\Pr(\Delta S^j \leq VaR_q^j) = q \qquad (1)$$

where ΔS^j is the change of the variable of country *j* and q denotes the probability of observing such a dramatic change.

$CoVaR_q^{i|j}$ denotes the VaR of country i conditional on country *j* when the latter has reached its level of VaR_q^j at an extreme quantile q. Therefore, equation (1) can be transformed as follows

$$\Pr(\Delta S^i \leq CoVaR_q^{i|j} | \Delta S^j = VaR_q^j) = q \quad (2).$$

Quantile regressions which link the variables of country i with those of country *j* are used to estimate the conditional risk[3]. The specification is represented as

[3] This is the baseline approach to CoVaR estimation as proposed by Adrian and Brunnermeier (2011). However, they also recognize that CoVaR exposures can be obtained from GARCH models, which, however, involves more intermediate computations, e.g. Girardi and Elgün (2013). The advantages of using quantile regressions lie in their relative simplicity and robustness in assessing relations between the variables at extremely high (low) percentiles rather than means. Besides, they are not demanding with respect to the distributional properties of data. The quantile regressions are not reported here but their outputs are available upon request.

$$\Delta S^{i} = \alpha_q^{i|j} + \beta_q^{i|j} \Delta S^{j} + \sum_{k=1}^{K} \gamma_{k,q}^{i|j} R_k + \varepsilon_k^{i|j} \quad (3)$$

where R_k corresponds to the state variable, or common risk factor k, and ε is the residual. At q quantile, the constant term $\alpha_q^{i|j}$ conveys the information specific to country i and $\beta_q^{i|j}$ shows how dependent the risk of country i on the risk of country j. After estimating the coefficients of the quantile regressions (αs, βs and γs), one can obtain $CoVaR_q^{i|\Delta S^j}$ by replacing ΔS^j from equation 3 with the corresponding VaR:

$$CoVaR_q^{i|\Delta S^j = VaR_q^j} = \alpha_q^{i|j} + \beta_q^{i|j} VaR_q^j + \sum_{k=1}^{K} \gamma_{k,q}^{i|j} R_k \quad (4).$$

To assess the marginal contribution of country j risk to country i, $\Delta CoVaR_q^{i|j}$ is specified as

$$\Delta CoVaR_q^{i|j} = CoVaR_q^{i|\Delta S^j = VaR_q^j} - CoVaR_q^{i|\Delta S^j = VaR_{0.5}^j} \quad (5)$$

and should be interpreted as the difference between the CoVaR of a country i conditional on the extreme risk associated with country j and the CoVaR of a country i conditional on the “normal”, median state of country j. By definition, the higher $\Delta CoVaR_q^{i|j}$, the more pronounced the spillover effect from country j to country i is[4].

2.1.2 Data for CoVaR and ΔCoVaR estimation

The initial variables for ΔCoVaR estimation are daily and weekly changes in 5-year sovereign CDS prices and stock market indices of 11 major economies (Brazil, Canada, China, France, Germany, Italy, Japan, Spain, Russia, the UK and the USA)[5]. The advanced economies in this sample belonged to top-10

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[4] As for sovereign CDS prices, the indicator is positive unless there is a statistically significant negative correlation between the CDS series of country i and j at high quantiles. Conversely, when stock market prices are considered, $\Delta CoVaR_q^{i|j}$ value should be negative by definition. In this case, its absolute value is referred to for the general rule to hold.

[5] All the data are retrieved from Bloomberg. 5-year sovereign CDS contracts tend to be more liquid compared to the contracts with other (e.g. 3- or 10-year) durations. The following stock market indices are used: BOVESPA (Brazil), S&P/TSX (Canada), SSE Composite (China), CAC 40 (France), DAX (Germany), FTSE MIB (Italy), Nikkei 225 (Japan), IBEX 35 (Spain), MICEX (Russia), FTSE (the UK), Dow Jones Industrial (the USA). ΔCoVaR exposures are estimated on weekly data to check the robustness of the baseline (daily) results.

international portfolio investors/recipients according to the annual IMF releases of Coordinated Portfolio Investment Survey (CPIS) data for 2009–2012. The significance of China, Brazil and Russia in international financial markets has substantially increased in recent years (Armijo et al. 2014, Huotari and Hanemann 2014). Armijo and Katada (2015) also assert that the emerging economies have excelled in promoting their financial interests globally. They define this course as "financial statecraft". Inevitably, these developments have enhanced the emerging markets' impact on the global systemic risk. The coverage of their portfolio investment flows in the CPIS, however, is far from being complete and in the case of China can even be characterized as perfunctory. As a result, they were not listed among top-10 economies by portfolio asset holdings or volume of liabilities. Notwithstanding this fact, it seems legitimate to consider their role in the conditional risk relationships along with the eight advanced economies from the CPIS top-10 list[6].

The VIX index, the TED spread and the change in the slope of the yield curve are used as state variables in equations (3) and (4). The values of the state variables coincide with the date when VaR_q^j is observed. The VIX gauges implied volatility of the US stock market but has been recognized as an appropriate measure of global risk aversion that has a significant impact on different financial markets, including that of the sovereign CDS (Longstaff et al. 2011). The TED spread is the difference between the three-month LIBOR and the three-month T-bill interest rate. It captures perceived credit risk in international interbank lending. The slope of the yield curve is measured as the yield spread between the ten-year Treasury rate and the three-month T-bill interest rate. It characterizes the term structure of interest rates which is important for the valuation of the US fixed-income instruments but also has implications for the global economy as it has proved to be a leading indicator of the US GDP growth.

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[6] The Netherlands, Luxemburg and the Cayman Islands which were also listed among top-10 international portfolio investors/recipients in 2009–2012 are not considered due to their offshore status which makes net contribution to the global systemic risk hardly discernible. India as a major emerging market is not considered for data availability reasons as it has not issued international bonds denominated in foreign currencies and, hence, there are no sovereign CDS contracts for India. The CDS contracts for the State Bank of India which is the biggest state-owned financial institution are not an adequate proxy for the sovereign credit risk as their pricing may be heavily influenced by bank-specific issues, e.g. temporary liquidity shortages.

These state variables cover different markets and usually lead their national or regional equivalents (e.g. the VSTOXX indices which measure implied volatility for Europe), exhibiting high positive correlations with them. Taking this into account, the selection of state variables is confined to the three common risk factors to avoid overfitting the data and multicollinearity.

2.2 Determinants of ΔCoVaRs

2.2.1 Model specification

In their seminal paper, Adrian and Brunnermeier (2011) regress ΔCoVaRs of the US financial companies on their institutional characteristics such as size, leverage and maturity mismatch. After estimating bilateral ΔCoVaRs in the sovereign CDS and stock markets, a similar approach is pursued in this paper[7]. The goal of the exercise is to identify relevant predictors of systemic risk among macroeconomic fundamentals, macro-financial and institutional variables. Uncovering the predictors that determine the systemic risk magnitude is important from the regulatory perspective. It can be even more beneficial if the predictors lead ΔCoVaRs in the sovereign CDS and stock markets.

Against this backdrop, an assumption is made that the ΔCoVaRs for the observation period are largely dependent on how well the countries fared during the Great Recession period, i.e. in 2007–2009. This appears natural as the 2007–2009 financial crisis entailed serious public debt problems in the subsequent years. Three categories of potential predictors are considered: 1) financial depth ratios; 2) macroeconomic indicators; 3) institutional variables. These variables refer to the country in distress and the one being influenced. Therefore, the econometric model involves panel data estimation where the predictors referring to the 2007–2009 period are matched with the ΔCoVaR for January 2010–February 2014. The estimation method is panel least squares. The specification is as follows:

$$\Delta CoVaR_q^{i|j} = \lambda_i + \eta_t + X'_{it}\theta + X'_{jt}\omega + Y'_t\rho + \varepsilon_{it} \quad (6)$$

[7] Only statistically significant ΔCoVaRs will be regressed on country specific predictors.

where X'_{it} and X'_{jt} stand for the vectors of potential predictors that include the same indicators for country i and j, Y'_t is a vector of controls common for countries i and j, λ_i, η_t are country and period fixed effects. The specific variables that enter the panel regression are discussed below.

2.2.2 Potential predictors of ΔCoVaRs

Apparently, the magnitude of bilateral ΔCoVaRs can be related to the volume of bilateral cross-border debt and equity holdings. However, given the incomplete statistical coverage of the holdings in the CPIS, this empirical strategy is not feasible.

The economic variables that drive the bilateral portfolio investment flows can be considered as a viable alternative. The theoretical framework of such analysis is often gravity-type models which account for bilateral differences in macroeconomic and other potentially relevant variables as regressors. They also put a special emphasis on the transaction costs that may seriously distort international portfolio flows. The costs are proxied via geographic and language proximity measures.

This approach builds on the gravity models of international trade, and since the seminal papers by Martin and Rey (2004) and Portes and Rey (2005) has become ubiquitous in international finance. Most recent contributions include Okawa and Van Wincoop (2012) who provide a rigorous theoretical rationale for such models in finance, Chitu et al. (2014) who investigate the determinants of the US bilateral bond holdings. In the same vein, Balli et al. (2013) examine cross-border equity and bond flows among 33 high-income countries on sectoral level and De Moor and Vanpee (2013) find particular relevance of financial development and corporate governance indicators for bond and equity flows. There are also papers seeking to explore the variation in bilateral portfolio holdings which do not explicitly employ the gravity model but use a gravity-like specification and/or typical gravity regressors, e.g. Galstyan and Lane (2013).

In line with this strand of literature, typical gravity regressors are used to specify the equation (6), namely, geographic distance (*Distance*) and common language dummy (*Language*) sourced from the *GeoDist* database (Mayer and Zignago 2011) and the variable accounting for time zone differences (*TZD*) between countries i and j based on http://www.timeanddate.com data. The common language dummy is equal to 1 if two countries share the same language and 0 otherwise. The three variables obviously have common values for the two countries and belong in the vector of controls in equation (6). Geographic distance and time zone differences reduce bilateral asset holdings while a common language is likely to promote them. The inference finds an extensive theoretical and empirical support (Coeurdacier and Rey 2013). Therefore, one can expect the first two factors to be negatively correlated with ΔCoVaR. As for the common language, intuitively, the effect should be opposite. Yet, it is also possible to assume that a common language is a manifestation of cultural homogeneity that reduces information asymmetries, thereby facilitating coordination in financial risk monitoring and regulation. Besides, countries sharing the same language with many others have better opportunities for portfolio diversification. For them foreign bias in the sense of overweighing investments abroad may prevail over home bias. As a result, the effect of a common language on ΔCoVaR is less straightforward.

The X'_{it} and X'_{jt} vectors include financial depth ratios, macroeconomic and institutional variables. The financial depth ratios are the indicators characterizing the sustainability of public finances in 2007–2009 to explain ΔCoVaRs based on the sovereign CDS. Namely, this category comprises 1) general gross government debt relative to GDP; 2) general government overall balance to GDP; 3) total value of outstanding international debt issues to GDP which is also split into public and private issues. The higher these measures are in the country in distress and the one being influenced, the bigger the bilateral ΔCoVaRs should be.

The selection of indicators is motivated by the recent studies of sovereign CDS and bond spreads in advanced and emerging economies which emphasize the role of "fiscal space" indicators, e.g. Hilscher and Nosbusch (2010), Dieckman and Plank (2012), Aizenman et al. (2013a), Aizenman et al. (2013b), De Grauwe and Ji (2013) and Dell'Erba et al. (2013). Stock market capitalization to GDP and stock market total value traded to GDP are used as financial depth ratios in the panel regressions for ΔCoVaRs based on the stock market indices. Similarly, one can expect these variables to be positively correlated with the systemic risk. The financial depth data are retrieved from the IMF Fiscal Monitor and the World Bank Global Financial Development Database.

GDP growth rates, a country's share in gross world GDP, trade to GDP (a sum of exports and imports), net barter terms of trade and inflation rate measured as CPI are on the list of macroeconomic variables which come from the World Development Indicators database. GDP growth rates and net barter terms of trade are expected to have an inverse link with ΔCoVaR whereas a country's share in gross world GDP, trade to GDP[8] and inflation should intuitively exhibit positive correlations.

The financial openness index (Chinn and Ito 2008), state fragility index and EU membership dummy constitute the category of institutional variables. All the indicators are expected to increase systemic risk. The financial openness index quantifies how tightly capital account is regulated. It ranges from –1.86 ("least financially open") to 2.44 ("most financially open"). The state fragility index, a composite measure elaborated by the Fund for Peace (http://global.fundforpeace.org/), increases with the deterioration of institutions along 12 criteria ranging from the quality of public services to the factionalization of elites and external intervention. A higher degree of integration embedded in the EU membership dummy may have an adverse impact on financial stability, which can only be offset by a proper design of financial regulation and monitoring (Fecht et al. 2012, Ahrend and Goujard 2014). The EU membership dummy is equal to 1 if a country is a member state and 0 otherwise.

The macroeconomic and institutional variables are equally used in the panel regressions based on the sovereign CDS prices and stock market indices.

3 Results of ΔCoVaR estimation

3.1 ΔCoVaRs based on the sovereign CDS prices

Below the results of ΔCoVaR estimation on the daily and weekly sovereign CDS prices are presented (tables 1, 2).

Table 1

[8] A higher level of trade openness may exacerbate systemic risk due to the balance of payment identities. A country deeply involved in trade should also experience significant capital flows.

ΔCoVaR for changes in sovereign CDS spreads (in basis points), daily, 01.01.2010–28.02.2014.

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		0.09	-0.42	-0.55	-1.09	-0.36	-0.27	0.08	0.08	-0.96	0.38	-0.30
		(0.58)	(0.43)	(0.57)	(0.63)	(0.71)	(0.50)	(0.75)	(0.72)	(0.57)	(0.54)	(0.60)
CHINA	-3.14		**7.12**	**6.12**	**6.90**	**6.96**	**5.25**	**8.36**	**5.50**	**5.78**	**7.08**	**5.59**
	(2.47)		**(1.81)**	**(1.31)**	**(1.25)**	**(1.06)**	**(1.36)**	**(0.77)**	**(1.23)**	**(1.24)**	**(1.85)**	**(1.44)**
BRAZIL	1.76	**6.93**		**4.20**	**3.26**	**3.67**	**5.05**	**6.85**	**2.29**	3.66	**3.79**	**4.15**
	(2.13)	**(1.12)**		**(1.02)**	**(1.52)**	**(1.46)**	**(1.33)**	**(1.03)**	**(0.89)**	(1.99)	**(1.19)**	**(1.37)**
FRANCE	1.41	**4.45**	2.81		**5.96**	**4.54**	**5.19**	**3.71**	**4.63**	**4.92**	2.72	**4.03**
	(2.52)	**(1.51)**	(1.99)		**(1.00)**	**(1.90)**	**(1.81)**	**(1.88)**	**(1.48)**	**(1.43)**	(2.04)	**(1.76)**
GERMANY	-4.82	**4.23**	2.69	**6.15**		**3.88**	1.96	**5.11**	**4.41**	**5.28**	4.69	3.36
	(2.92)	**(1.90)**	(1.72)	**(1.42)**		**(1.47)**	(1.99)	**(1.94)**	**(1.99)**	**(1.02)**	(3.27)	(1.96)
ITALY	**-6.57**	**6.99**	**5.64**	**7.19**	**6.50**		**4.29**	**7.71**	**8.93**	**7.04**	**6.24**	**5.40**
	(2.76)	**(1.75)**	**(2.43)**	**(1.20)**	**(0.94)**		**(1.84)**	**(1.72)**	**(0.77)**	**(1.31)**	**(1.29)**	**(1.60)**
JAPAN	0.66	0.87	0.79	0.84	0.63	0.15		0.31	0.16	0.31	1.24	0.59
	(3.28)	(1.40)	(1.36)	(1.73)	(1.71)	(2.44)		(1.69)	(2.21)	(2.04)	(1.23)	(1.91)
RUSSIA	-0.57	**7.39**	**6.28**	**6.16**	**4.83**	**8.20**	**6.60**		**3.76**	**5.03**	**5.65**	**5.33**
	(3.22)	**(0.91)**	**(1.59)**	**(1.67)**	**(1.67)**	**(1.94)**	**(1.42)**		**(1.89)**	**(2.02)**	**(1.73)**	**(1.81)**
SPAIN	-4.39	**4.99**	**5.81**	**7.27**	**5.89**	**12.16**	2.64	**7.54**		**7.07**	1.77	**5.08**
	(3.39)	**(1.46)**	**(1.51)**	**(2.05)**	**(1.40)**	**(1.21)**	(2.14)	**(2.00)**		**(1.80)**	(2.75)	**(1.97)**
UK	-2.73	-0.38	2.39	1.01	**2.98**	**5.68**	1.46	**3.15**	**4.56**		**3.28**	2.14
	(2.74)	(1.28)	(1.71)	(1.41)	**(1.04)**	**(1.17)**	(1.46)	**(1.40)**	**(1.09)**		**(1.47)**	(1.48)
USA	-3.79	4.43	**3.75**	4.54	-0.09	-0.98	-2.28	**2.92**	-1.41	1.07		0.82
	(3.33)	(2.25)	**(1.48)**	(2.63)	(2.91)	(1.81)	(1.81)	**(0.45)**	(1.43)	(2.93)		(2.10)
Column Average	-2.21	**4.00**	**3.69**	**4.29**	**3.58**	**4.39**	2.99	**4.57**	**3.29**	**3.92**	**3.68**	
	(2.88)	**(1.42)**	**(1.62)**	**(1.51)**	**(1.41)**	**(1.52)**	(1.57)	**(1.36)**	**(1.37)**	**(1.63)**	**(1.74)**	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 99th percentile conditional upon the VaR of the countries listed in the first row at the 99th percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Table 2

ΔCoVaR for changes in sovereign CDS spreads (in basis points), weekly, 01.01.2010–28.02.2014.

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		0.67	-1.48	3.08	-0.72	1.45	1.77	2.40	1.29	1.07	**4.72**	1.42
		(2.70)	(2.92)	(1.25)	(1.60)	(0.86)	(1.08)	(2.89)	(0.81)	(2.25)	**(2.32)**	(1.87)
CHINA	-7.44		**22.60**	**15.75**	**9.92**	0.22	**18.23**	**21.82**	0.11	**10.07**	**18.78**	**11.01**
	(5.57)		**(7.62)**	**(6.54)**	**(4.37)**	(7.28)	**(3.55)**	**(3.52)**	(5.79)	**(5.12)**	**(2.38)**	**(5.18)**
BRAZIL	**-14.30**	**16.55**		**10.48**	**11.01**	-5.30	**16.89**	**19.25**	-2.41	**8.97**	**21.46**	8.26
	(6.07)	**(3.15)**		**(3.77)**	**(3.07)**	(7.77)	**(5.45)**	**(4.06)**	(5.68)	**(3.69)**	**(4.77)**	(4.75)
FRANCE	7.51	**21.00**	**15.11**		**17.12**	**12.67**	4.13	**17.69**	**8.31**	**14.93**	11.87	**13.03**
	(5.75)	**(9.28)**	**(7.62)**		**(3.90)**	**(2.64)**	(4.47)	**(8.93)**	**(1.46)**	**(6.41)**	(7.69)	**(5.82)**
GERMANY	-2.39	3.55	11.79	**17.62**		3.38	3.41	19.61	2.01	2.64	-4.28	5.74
	(3.98)	(4.87)	(6.32)	**(1.76)**		(4.36)	(3.06)	(10.01)	(3.72)	(4.56)	(6.34)	(4.90)
ITALY	2.38	**20.26**	4.30	**11.09**	5.77		11.63	13.69	**20.72**	6.90	8.61	10.53
	(8.49)	**(7.68)**	(10.48)	**(5.57)**	(5.68)		(8.39)	(12.27)	**(3.53)**	(5.55)	(5.88)	(7.35)
JAPAN	**-18.80**	**21.02**	-11.81	**-11.55**	**-12.18**	-0.03		9.61	-9.12	-9.92	-4.22	-4.70
	(6.73)	**(7.26)**	(10.21)	**(4.72)**	**(4.75)**	(8.65)		(9.72)	(5.68)	(5.23)	(12.07)	(7.50)
RUSSIA	-11.56	**24.09**	**22.81**	**15.72**	**10.05**	4.18	**16.75**		-11.64	**8.85**	**24.35**	10.36
	(7.58)	**(6.47)**	**(5.16)**	**(5.36)**	**(5.05)**	(8.61)	**(5.73)**		(8.00)	**(4.26)**	**(7.18)**	(6.34)
SPAIN	4.88	**18.47**	15.53	**8.62**	6.82	**22.30**	-2.28	**13.58**		8.82	7.72	10.45
	(4.55)	**(8.69)**	(9.67)	**(3.99)**	(4.94)	**(3.26)**	(5.73)	**(6.51)**		(6.41)	(6.02)	(5.98)
UK	-3.98	**10.87**	5.66	5.92	**12.12**	-0.70	4.78	**14.57**	-0.80		4.06	5.25
	(4.85)	**(3.12)**	(4.20)	(4.81)	**(2.22)**	(4.55)	(3.30)	**(5.23)**	(3.88)		(4.82)	(4.10)
USA	15.42	**40.30**	8.61	**11.09**	7.36	10.40	**29.57**	**41.39**	6.23	-3.16		**16.72**
	(9.54)	**(12.91)**	(8.44)	**(3.86)**	(5.66)	(6.02)	**(9.72)**	**(8.68)**	(4.79)	(5.80)		**(7.54)**
Column Average	-2.83	**17.68**	9.31	**8.78**	6.73	4.86	**10.49**	**17.36**	1.47	4.92	9.31	
	(6.31)	**(6.61)**	(7.26)	**(4.16)**	(4.12)	(5.40)	**(5.05)**	**(7.18)**	(4.33)	(4.93)	(5.95)	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 99th percentile conditional upon the VaR of the countries listed in the first row at the 99th percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Consequently, if this country is in a financial distress, its impact on international financial markets is likely to be stronger.

Column averages in the tables report each country's marginal contribution to the overall systemic risk whereas row averages assess the country's vulnerability to this risk. On daily data, Russia, Italy, France and China are the major contributors to the overall systemic risk. Judging by the row averages, China, Italy, Russia, Spain and Brazil suffer mostly from the system being in distress. The contributions to the systemic risk made by the UK and Germany appear to be relatively modest compared with the above mentioned countries. Their dependence on other countries' stress is limited as well, pointing to their higher level of resilience among the EU economies. The USA and Japan have a minor impact on the overall systemic risk and are not strongly affected by it. Arguably, one of the most unexpected results of this study is the humble contribution to the systemic risk made by Spain. With the exception of this result, the findings have much in common with Wing Fong and Wong (2012) who provide a similar ranking of the most resilient economies in the sovereign CDS market for the period between 14 December 2007 and 30 September 2011. On bilateral level, sizeable conditional risk relationships are observed for the distressed EU countries (e.g. between Spain and Italy) and between the emerging markets (Russia and China).

Using weekly data, the number of statistically significant ΔCoVaRs falls, reflecting the fact that lower frequency data provides less information for the correct measurement of the tail risk at an extreme quantile. The presence of many estimates negative in sign (e.g. in case of Japan) is for the same reason. These problems are reported by Wing Fong and Wong (2012) when they conduct robustness checks for the baseline daily estimations and, hence, are not specific to this study. However, even in light of these estimation shortcomings, some of the previous findings appear robust. For example, the list of major contributors to the overall systemic risk again includes Russia, France and China. Similar to the daily estimations, high ΔCoVaR values pertain to the conditional risk relationships between Spain and Italy and are found for Russia, China and Brazil.

3.2 ΔCoVaRs based on the stock market indices

The results of ΔCoVaR estimation based on the stock market indices are presented in Tables 3 and 4.

Table 3

ΔCoVaR for changes in stock market indices, daily, 01.01.2010–28.02.2014.

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		**0.58**	**0.91**	**0.92**	**1.02**	**0.70**	**0.49**	**0.80**	0.44	0.18	**1.14**	**0.72**
		(0.26)	**(0.19)**	**(0.22)**	**(0.29)**	**(0.35)**	**(0.19)**	**(0.37)**	(0.30)	(0.19)	**(0.41)**	**(0.28)**
CHINA	1.21		**1.54**	0.67	1.43	**1.47**	**2.71**	**1.60**	**1.09**	-1.16	1.79	1.23
	(0.87)		**(0.70)**	(0.73)	(0.73)	**(0.68)**	**(0.46)**	**(0.58)**	**(0.52)**	(0.66)	(1.08)	(0.70)
BRAZIL	**1.26**	**0.78**		0.66	**1.10**	**1.04**	0.24	**0.82**	**0.85**	0.15	**2.84**	**0.97**
	(0.46)	**(0.29)**		(0.43)	**(0.39)**	**(0.39)**	(0.55)	**(0.34)**	**(0.40)**	(0.42)	**(0.41)**	**(0.41)**
FRANCE	**1.83**	**1.63**	**1.33**		**3.38**	**3.06**	**1.17**	**1.92**	**2.77**	**-0.77**	**1.83**	**1.82**
	(0.59)	**(0.55)**	**(0.59)**		**(0.28)**	**(0.57)**	**(0.40)**	**(0.54)**	**(0.67)**	**(0.30)**	**(0.78)**	**(0.53)**
GERMANY	**2.09**	**1.52**	**1.43**	**3.27**		**2.32**	0.75	**2.41**	**2.10**	-0.41	**3.03**	**1.85**
	(0.62)	**(0.54)**	**(0.52)**	**(0.59)**		**(0.49)**	(0.55)	**(0.40)**	**(0.44)**	(0.39)	**(0.70)**	**(0.52)**
ITALY	**1.88**	**1.51**	**1.81**	**3.14**	**3.93**		**1.59**	**2.64**	**3.95**	-0.63	**2.33**	**2.21**
	(0.66)	**(0.60)**	**(0.57)**	**(1.06)**	**(0.46)**		**(0.48)**	**(0.67)**	**(0.46)**	(0.44)	**(0.91)**	**(0.63)**
JAPAN	1.22	**2.12**	-0.45	1.36	**2.00**	1.59		**2.97**	1.73	0.60	1.51	1.47
	(0.65)	**(0.42)**	(1.09)	(0.85)	**(0.58)**	(0.89)		**(0.60)**	(0.91)	(0.58)	(1.16)	(0.77)
RUSSIA	**2.36**	**3.22**	**2.63**	**3.25**	**3.18**	2.01	**2.24**		0.87	-0.62	**4.75**	**2.52**
	(1.00)	**(0.76)**	**(1.08)**	**(0.49)**	**(0.60)**	(1.17)	**(0.62)**		(1.19)	(0.78)	**(1.41)**	**(0.91)**
SPAIN	**1.29**	**1.56**	**1.68**	**3.16**	**3.88**	**3.46**	**1.54**	**1.77**		0.11	**3.32**	**2.18**
	(0.49)	**(0.55)**	**(0.40)**	**(1.29)**	**(0.42)**	**(0.47)**	**(0.61)**	**(0.68)**		(0.56)	**(0.64)**	**(0.61)**
UK	0.99	0.05	0.67	0.26	0.61	0.34	0.22	0.84	0.03		1.13	0.51
	(0.64)	(0.43)	(0.47)	(0.59)	(0.49)	(0.61)	(0.45)	(0.65)	(0.47)		(0.61)	(0.54)
USA	**0.80**	0.21	**0.89**	0.74	**1.22**	**1.16**	0.27	0.40	**0.77**	0.14		**0.66**
	(0.31)	(0.25)	**(0.21)**	(0.42)	**(0.18)**	**(0.21)**	(0.38)	(0.36)	**(0.22)**	(0.30)		**(0.28)**
Column Average	**1.49**	**1.32**	**1.24**	**1.74**	**2.18**	**1.71**	**1.12**	**1.62**	**1.46**	0.24	**2.37**	
	(0.63)	**(0.46)**	**(0.58)**	**(0.67)**	**(0.44)**	**(0.58)**	**(0.47)**	**(0.52)**	**(0.56)**	(0.46)	**(0.81)**	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 1st percentile conditional upon the VaR of the countries listed in the first row at the 1st percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Table 4

ΔCoVaR for changes in stock market indices, weekly, 01.01.2010–28.02.2014.

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		**1.27**	**3.69**	**2.08**	**2.01**	1.58	**3.04**	**2.88**	**1.67**	**3.89**	2.52	**2.46**
		(0.51)	**(0.93)**	**(0.91)**	**(0.96)**	(0.94)	**(1.14)**	**(0.76)**	**(0.68)**	**(0.95)**	(1.40)	**(0.92)**
CHINA	**4.52**		**3.84**	3.32	2.88	2.44	**2.80**	**4.22**	2.23	**5.22**	3.51	**3.50**
	(1.48)		**(1.36)**	(2.02)	(1.77)	(1.59)	**(1.10)**	**(1.13)**	(1.28)	**(1.46)**	(1.97)	**(1.52)**
BRAZIL	**4.25**	1.62		2.94	2.96	**3.52**	0.15	**3.23**	1.96	2.85	4.89	2.84
	(1.57)	(0.83)		(2.38)	(2.01)	**(1.36)**	(1.16)	**(1.48)**	(1.55)	(2.94)	(3.36)	(1.86)
FRANCE	0.70	1.00	1.45		**5.35**	**4.38**	1.35	**3.87**	**3.99**	**6.42**	**8.88**	**3.74**
	(1.09)	(0.93)	(2.21)		**(1.42)**	**(0.44)**	(0.96)	**(0.81)**	**(0.56)**	**(1.02)**	**(2.43)**	**(1.19)**
GERMANY	1.12	**4.67**	0.55	**9.60**		**5.08**	**4.08**	**4.14**	**4.69**	**5.27**	**8.62**	**4.78**
	(1.95)	**(1.44)**	(2.52)	**(1.73)**		**(1.48)**	**(0.98)**	**(1.38)**	**(1.48)**	**(1.50)**	**(2.26)**	**(1.67)**
ITALY	2.37	-0.31	**4.78**	**7.23**	**6.02**		0.46	**5.11**	**4.70**	**9.06**	4.41	**4.38**
	(1.76)	(1.65)	**(2.12)**	**(0.98)**	**(1.35)**		(1.56)	**(1.34)**	**(1.90)**	**(1.82)**	(3.19)	**(1.77)**
JAPAN	-4.50	-2.26	-6.84	**12.87**	**13.69**	3.61		-2.09	0.78	**7.91**	**15.94**	3.91
	(4.42)	(1.87)	(4.14)	**(4.62)**	**(4.02)**	(3.01)		(3.56)	(2.27)	**(3.21)**	**(6.04)**	(3.72)
RUSSIA	2.25	**5.44**	3.39	**5.45**	**7.39**	**4.82**	**2.66**		**7.44**	**12.58**	**11.07**	**6.25**
	(3.48)	**(2.70)**	(3.80)	**(2.71)**	**(2.49)**	**(1.91)**	**(0.88)**		**(2.59)**	**(4.95)**	**(4.35)**	**(2.99)**
SPAIN	1.48	-0.08	2.75	4.81	**3.29**	**8.31**	0.83	2.75		2.43	2.95	2.95
	(1.30)	(1.04)	(2.74)	(2.70)	**(1.22)**	**(1.12)**	(1.16)	(1.79)		(2.84)	(2.25)	(1.82)
UK	**3.01**	**1.75**	**4.72**	**4.62**	**3.80**	**2.95**	**2.08**	**3.33**	**3.06**		**4.64**	**3.40**
	(0.83)	**(0.54)**	**(1.43)**	**(0.80)**	**(0.76)**	**(0.46)**	**(0.89)**	**(0.94)**	**(0.69)**		**(1.53)**	**(0.89)**
USA	**3.13**	**1.80**	1.28	**2.84**	**2.27**	**2.13**	**2.54**	**3.32**	**2.28**	**3.05**		**2.46**
	(0.89)	**(0.64)**	(1.46)	**(0.70)**	**(0.50)**	**(0.46)**	**(0.83)**	**(1.09)**	**(0.57)**	**(0.43)**		**(0.76)**
Column Average	1.38	1.49	0.62	**5.58**	**4.96**	**3.88**	1.97	**3.08**	**3.28**	**5.87**	**6.74**	
	(1.88)	(1.21)	(2.27)	**(1.96)**	**(1.65)**	**(1.27)**	(1.07)	**(1.43)**	**(1.36)**	**(2.11)**	**(2.88)**	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 1st percentile conditional upon the VaR of the countries listed in the first row at the 1st percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

On daily data, the USA, Germany, France and Italy appear to be the major contributors to the overall systemic risk. In the meantime, the USA, Germany and

France are not strongly affected if the system is in distress while Russia, Italy and Spain are particularly prone to adverse external spillovers. Similar to the ΔCoVaRs in the sovereign CDS market, strong conditional risk relationships are found for the most susceptible EU countries, e.g. Germany and Italy or Spain, and between these distressed economies. It is also noteworthy that among the emerging economies Russia experiences the most pronounced influence from the advanced economies, with the USA impact on this country being the strongest for the entire set of bilateral ΔCoVaRs. In contrast to the conditional risk relationships based on the CDS prices, the tail risk dependence among Russia, China and Brazil based on the stock market indices is moderate.

The number of robust ΔCoVaRs estimated on weekly data also shrinks but not so dramatically as in the case of the weekly sovereign CDS prices. In general, the number of significant ΔCoVaRs based on the stock indices is higher. A plausible explanation is that stock market indices are easily tradable and liquid instruments while sovereign CDS contracts are over-the-counter (OTC) derivatives which are incomparably less liquid. It makes information transmission and arguably price discovery in the stock markets more rapid.

The list of the major contributors to the overall systemic risk measured on weekly stock market data is made up of the advanced economies – the USA, the UK, Germany and France. Except for Germany, they appear to be insulated relatively well from the system being in distress. Russia exhibits the least resilience to the spillovers, this time followed by Germany and Italy. No evidence of extremely high tail dependences between the EU economies is found. The conclusion is essentially the same for the emerging economies.

4 Determinants of ΔCoVaRs

The results of the panel estimation seeking to identify most important predictors of ΔCoVaRs are presented below (Table 5 and 6). These are reduced-form equations selected on the basis of Schwartz Bayesian Information Criteria (SBIC). The equations include only statistically significant regressors from the baseline equation 6.

Table 5

Determinants of ΔCoVaRs for changes in sovereign CDS spreads.

	Daily	Weekly
Gross government debt to GDP$_J$	0.05***	0.09***
	(0.01)	(0.01)
International private debt issues to GDP$_J$	0.05***	
	(0.01)	
World GDP share$_J$	0.18***	0.53***
	(0.03)	(0.08)
EU dummy	3.72***	16.89***
	(0.48)	(1.66)
Inflation$_j$	0.16***	
	(0.05)	
State fragility index$_J$	0.18***	0.52***
	(0.02)	(0.03)
Language		-8.72***
		(1.75)
Distance		-0.0004***
		(0.0001)
Financial openness$_J$		0.99***
		(0.28)
Constant term	-11.62***	-21.20***
	(2.03)	(2.28)
Cross-section and period fixed effects	*Yes*	*Yes*
Redundant cross-section and period fixed effects test F-statistic (p-value)	5.59 (0.00)	20.15(0.00)
No. of obs	189	144
Adj. R^2	0.57	0.90
SBIC	4.62	6.45

Notes: standard errors in parenthesis; *, **, *** – significance at 10, 5 and 1% respectively; j stands for the countries in distress.

Table 6

Determinants of ΔCoVaRs for changes in stock market indices.

	Daily	Weekly
Stock market total value traded to GDP$_J$	0.001**	0.005*
	(0.0005)	(0.003)
World GDP share$_J$		0.14***
		(0.03)
EU dummy		0.95**
		(0.43)
TZD	-0.06***	
	(0.02)	
Financial openness$_J$	0.09**	1.24**
	(0.04)	(0.57)
State fragility index$_J$		0.07*
		(0.04)
State fragility index$_I$	0.11**	
	(0.04)	
Inflation$_I$	0.12***	
	(0.04)	
Constant term	-3.61*	-2.04
	(2.05)	(2.85)
Cross-section and period fixed effects	*Yes*	*Yes*
Redundant cross-section and period fixed effects test F-statistic (p-value)	5.22(0.00)	10.92(0.00)
No. of obs	213	207
Adj. R^2	0.59	0.74
SBIC	2.88	4.63

Notes: standard errors in parenthesis; *, **, *** – significance at 10, 5 and 1% respectively, j stands for the countries in distress and i denotes the countries being influenced.

The F–test for redundant cross-section and period fixed effects strongly rejects the null of redundancy across all the 4 models. This test conducted for cross-section and period fixed effects separately corroborates the result. Hence, the specification used to estimate the panel regressions is valid.

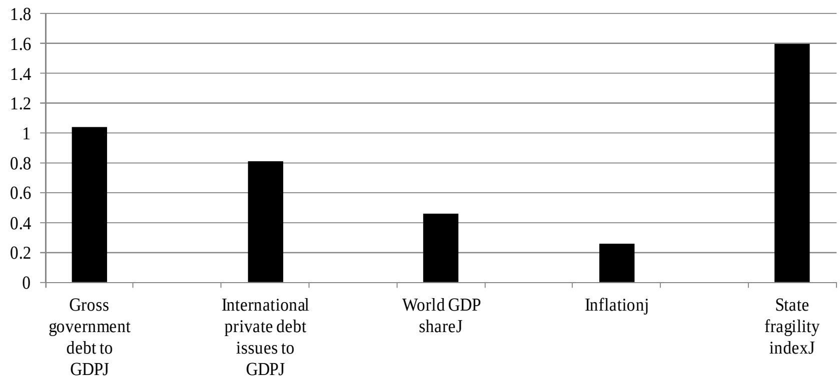
The tables 5 and 6 indicate that the financial depth ratios observed in distressed countries in 2007–2009 have significant explanatory power for bilateral ΔCoVaRs based on the sovereign CDS prices and stock market indices. As for the CDS prices, gross government debt to GDP appears to be the most important ratio characterizing fiscal space. Interestingly, the share of international private debt issues to GDP in distressed economies also drives the systemic risk for the countries under influence. This indicator can be positively related to ΔCoVaRs due to the "credit risk transfer" effect (Acharya et al. 2011, Ejsing and Lemke 2011, Alter and Schuler 2012). The economies undergoing the 2007–2009 crisis had to bail out private institutions, which amounted additional pressure on their fiscal positions and eventually aggravated the public indebtedness problem in January 2010 – February 2014. For ΔCoVaRs based on stock market indices, stock market total value traded to GDP outperforms the conventional stock market capitalization to GDP ratio as a ΔCoVaR predictor. Arguably, the former is a more informative variable as it indicates if the market capitalization is really matched by trading volumes.

The world gross GDP share of a country in distress proves to be a highly relevant predictor of systemic risk. It is consistent with the essence of ΔCoVaR as a measure of financial distress exogenously imposed on a country i by another country j . Naturally, the strength of this impact is dependent on the size of the country exerting the influence. For the same reason the minor role of the variables associated with countries under influence should not spark concerns. The positive correlation between the world gross GDP share and systemic risk legitimizes the ordinary means of ΔCoVaRs in Tables 1–4 rather than column and row averages weighted by countries' world gross GDP shares, as Wing Fong and Wong (2012) do. The use of weighted averages would create an upward bias for the countries' marginal contributions to the overall systemic risk, stemming from a kind of "double accounting". Besides the world gross GDP share, only inflation appears to be a significant determinant of systemic risk among macroeconomic indicators.

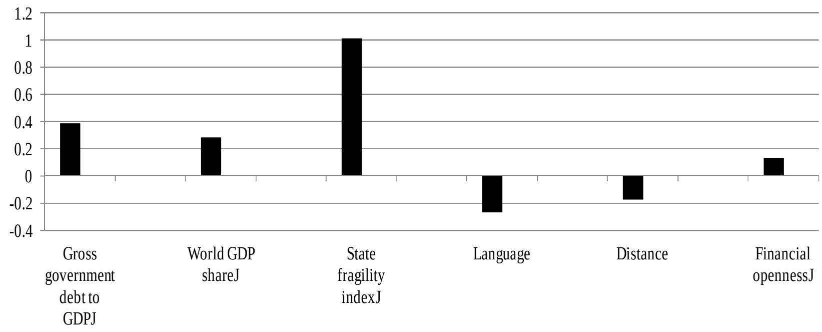
The institutional variables demonstrate high relevance for ΔCoVaRs. Their impact is in line with a priori expectations. Higher values of the financial openness and state fragility indices in 2007–2009 prompt the build-up of systemic risk in 2010 – February 2014. EU membership also increases ΔCoVaR values.

As for gravity-type regressors, their significance is far from being universal. Distance and common language dummy help explain ΔCoVaRs for weekly changes in the sovereign CDS prices while time zone differences is a significant predictor of ΔCoVaRs for daily changes in the stock market indices. Distance and time zone differences are negatively correlated with systemic risk. Common language also diminishes ΔCoVaRs, which is a controversial finding. Arguably, it is due to reduced information asymmetries and/or foreign bias presence, as conjectured in Section 2.2.2.

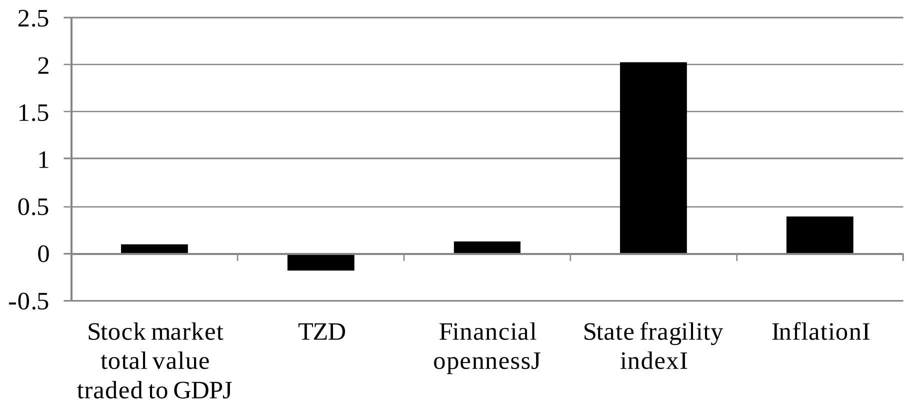
Panel least squares as an estimation method allows to compute how a one standard deviation (s.d.) change in the significant predictors (except dummies) affects the dependent variable. The response of ΔCoVaR is measured in the number of its own s.d. Figure 1 (a, b, c, d) displays the results for all the 4 specifications.



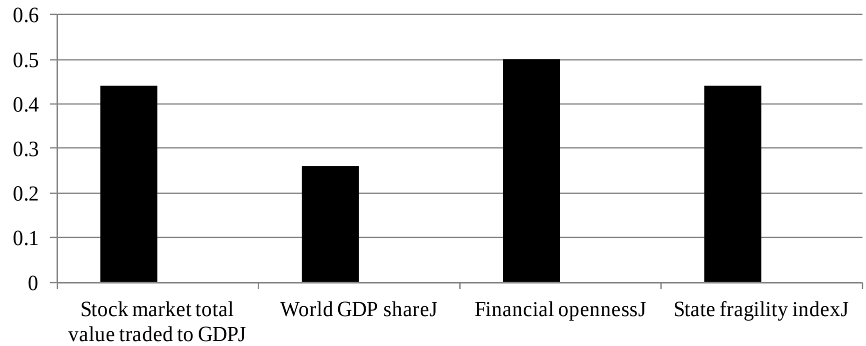
a)



b)



c)



d)

Figure 1. ΔCoVaR response to 1 s.d. change in predictors, in s.d., for daily sovereign CDS prices (a), weekly sovereign CDS prices (b), daily stock market indices (c), daily stock market indices (d).

The analysis emphasizes the state fragility index and financial depth ratios as the predictors that have the biggest impact on ΔCoVaR. It is noteworthy that in 3 of the 4 regressions the state fragility index induces more than a one s.d. change in ΔCoVaR. The economic significance of macroeconomic variables is less pronounced whereas the role of gravity-type regressors (distance, common language and time zone differences) is minor. It sends a signal to policymakers that institutional development is crucial not only to promote economic growth but also to curb systemic risk and adverse financial spillovers. Given the composition of the sample under analysis, the inference appears to be relevant for advanced economies as well.

The findings are consistent with the research by López-Espinosa et al. (2014) and Weiβ et al. (2014). López-Espinosa et al. (2014) stress that poor fundamentals (higher interest rates and public debt, looser monetary policy etc.) exacerbate systemic risk. Weiβ et al. (2014) argue that institutional issues, e.g. regulatory regimes in the banking sector, can outperform macroeconomic and sector-specific indicators (such as bank size, capital, leverage etc.) as determinants of systemic risk.

5 Robustness checks

It appears important to figure out if the findings reported above are robust. In this regard two issues need to be taken into account. First, the magnitude of bilateral ΔCoVaR exposures may be underestimated as the baseline approach does not account for a possible asymmetric reaction of the country i to negative and positive shocks from the country j . In case of the stock market indices, negative daily and weekly changes (a negative shock) may have a much stronger impact than positive ones. Similarly, positive daily and weekly changes in CDS prices (a negative shock) may also produce an asymmetric effect compared to daily and weekly decreases. López-Espinosa et al. (2012a, b) propose a simple, yet meaningful extension to the baseline approach to CoVaR estimation to account for the possible asymmetries:

$$\Delta S^{i} = \alpha_q^{i|j} + \beta_q^{i|j^+} \Delta S^{j} I_{(\Delta S^{j} > 0)} + \beta_q^{i|j^-} \Delta S^{j} I_{(\Delta S^{j} \leq 0)} + \sum_{k=1}^{K} \gamma_{k,q}^{i|j} R_k + \varepsilon_k^{i|j} \quad (7)$$

where $I_{(.)}$ is a dummy taking a value equal to one if the condition in the subscript is true and zero otherwise. The coefficients $\beta_q^{i|j^+}$ and $\beta_q^{i|j^-}$, if significant, reflect the asymmetric impact of positive and negative shocks. Then, like in the baseline estimations, ΔS^{j} values are replaced with VaRs. ΔCoVaR is computed as follows:

$$\Delta CoVaR_q^{i|j} = \beta_q^{i|j^+} \left[CoVaR_q^{i|\Delta S^{j^+} = VaR_q^{j^+}} - CoVaR_q^{i|\Delta S^{j^+} = VaR_{0.5}^{j^+}} \right] + \beta_q^{i|j^-} \left[CoVaR_q^{i|\Delta S^{j^-} = VaR_q^{j^-}} - CoVaR_q^{i|\Delta S^{j^-} = VaR_{0.5}^{j^-}} \right] \quad (8)$$

Second, as ΔCoVaR is based on high-frequency data, time zone differences may affect the bilateral exposures through the asynchronous trading effect. There are lags and leads for some countries' stock market indices and CDS prices in the sample. For example, if we consider the Chinese and American indices, the closing value of the Chinese one is already known when the US market opens. Therefore, the Chinese market incorporates news from the US market not on the same calendar day but with one day lag. The same logic applies to the relation between some stock market indices (and CDS prices) and the common risk factors linked with the US financial markets[9]. Accounting for the asynchronous trading effect is crucial for accurate causal inferences on high frequency financial data (e.g. Baumöhl and Vẏrost 2010) but may also be relevant for non causal systemic risk measurement as Engle et al. (2014) show.

Bilateral ΔCoVaR exposures based on daily data are re-estimated to account for both possible asymmetries and asynchronous trading. For weekly data only asymmetric effects are allowed for in this robustness check. After obtaining the bilateral exposures panel regressions are run again. The results are in Appendices A and B respectively.

The findings discussed in Sections 3 and 4 generally withstand the robustness check. As for CDS spreads, the emerging markets (in particular, Russia) keep on contributing most to the overall systemic risk. In the meantime, they experience most sizeable negative shocks. Among advanced economies the significance of Germany as a systemic risk contributor has grown substantially. However, France, Italy, the UK, and Japan are still important. With respect to stock market indices, Russia and the UK increase their roles as systemic risk contributors. In both cases, the ordering of countries by the magnitude of an external shock has changed less than the respective list by a contribution to the overall systemic risk though the absolute values of the exposures tend to increase. The robustness check on weekly data results in the orderings of countries close to the baseline estimations. It may signify that the asymmetric effects produced by negative shocks are not so powerful compared to the asynchronous trading effect. However, more detailed analysis of their relative power is left for future research.

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[9] EU countries, Russia, China, and Japan incorporate information with one day lag not only from the US market but also from Canada and Brazil. Baumöhl and Vẏrost (2010) also suggest that Japanese and Chinese markets should lag one calendar day behind EU counterparts to convey information flows correctly.

Financial depth ratios (gross government debt relative to GDP and stock market value traded to GDP) remain significant systemic risk determinants. The same applies to the world GDP share of a country in distress and EU membership dummy. The quality of institutions embedded in state fragility index retains high relevance in the case of CDS spreads but turns insignificant for stock market indices. The importance of inflation and financial openness diminish while geographic distance as a buffer to systemic risk propagation becomes more significant in comparison with other gravity-type regressors (common language dummy and time zone differences).

6 Conclusions

The paper empirically assesses conditional risk relationships among sovereign CDS prices and stock market indices of eight advanced economies and three major emerging markets. The relationships are measured by means of bilateral ΔCoVaR, a popular systemic risk indicator, for the period between 1 January 2010 and 28 February 2014.

The analysis reveals that the UK, France and Italy are significant contributors to the overall systemic risk in both dimensions. As for the CDS prices, the main contributors are also Germany, Russia and China. The USA, the UK and Russia exhibit the highest average ΔCoVaRs in the stock market. If resilience to the systemic risk is considered, advanced economies, especially the USA, Japan, Germany and the UK, appear to be better insulated.

By contrast, the emerging economies, in particular Russia, are weakly cushioned from adverse external spillovers. This tail risk dependence is especially pronounced in the stock market. On bilateral level, the highest ΔCoVaR values are found for the emerging markets and for most distressed EU economies in this sample: Spain and Italy. However, unlike Italy, the contribution of Spain to the systemic risk is muted.

Gross government debt to GDP, state fragility index, EU membership and world gross GDP share of a country in distress are key determinants of ΔCoVaRs for the sovereign CDS prices. Stock market total value traded to GDP and world gross GDP share of a country in distress drive ΔCoVaRs in the stock market. The state fragility and financial openness indices have the biggest impact on bilateral

ΔCoVaR exposures in the baseline estimations. However, after the robustness check they retain significance only for CDS spreads. The importance of inflation also shrinks. On the contrary, geographic distance becomes more significant as a result of the robustness check. It acts as a buffer for systemic risk propagation in CDS and stock markets. Its significance outperforms that of competing gravity-type regressors (common language dummy and time zone differences). All in all, there is no sharp difference between the baseline estimation and the robustness check.

The findings provide an unambiguous guideline for policymakers who should be keen to avoid excessive financial depth ratios and persistently improve the quality of institutions. The research also highlights the need to study further the significance of the asynchronous trading effect for systemic risk measurement.

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Appendix A

Table A1

ΔCoVaR for changes in sovereign CDS spreads (in basis points), daily, 01.01.2010–28.02.2014 (with asymmetric responses and asynchronous trading effect).

	Conditional upon the VAR of the following country											
	CANADA	CHINA	BRAZIL	FRANCE	GERMANY	ITALY	JAPAN	RUSSIA	SPAIN	UK	USA	Row Average
CANADA		1.48	1.11	-0.55	-1.09	-0.08	-0.28	1.93	**1.54**	-0.96	1.56	0.47
		(1.88)	(0.76)	(0.57)	(0.63)	(1.31)	(0.42)	(1.05)	**(0.75)**	(0.57)	(1.43)	(0.94)
CHINA	**16.42**		**3.36**	-1.01	5.55	2.06	**15.55**	**11.25**	4.50	**3.93**	6.66	**6.83**
	(6.56)		**(1.10)**	(2.11)	(3.21)	(4.17)	**(2.66)**	**(2.55)**	(5.54)	**(1.98)**	(4.79)	**(3.47)**
BRAZIL	**5.09**	**11.80**		**4.65**	**14.24**	**3.67**	**12.43**	**10.37**	**2.29**	**3.66**	**7.81**	**7.60**
	(2.28)	**(2.89)**		**(2.67)**	**(4.22)**	**(1.46)**	**(2.78)**	**(1.74)**	**(0.89)**	**(0.80)**	**(3.30)**	**(2.30)**
FRANCE	-0.94	**4.21**	**2.28**		**9.46**	**8.30**	**5.41**	**8.34**	**11.08**	**10.09**	-2.11	**5.61**
	(3.35)	**(1.53)**	**(0.88)**		**(3.17)**	**(1.57)**	**(0.94)**	**(3.97)**	**(1.76)**	**(2.34)**	(1.29)	**(2.08)**
GERMANY	**5.60**	**5.54**	1.95	**8.51**		**7.59**	**4.65**	**16.57**	**4.54**	**10.10**	-0.04	**6.50**
	(2.29)	**(1.37)**	(1.84)	**(0.61)**		**(0.81)**	**(1.25)**	**(4.92)**	**(1.84)**	**(1.54)**	(6.94)	**(2.34)**
ITALY	5.70	**7.22**	0.14	**14.29**	**20.59**		**5.31**	**18.29**	**17.08**	**18.40**	-3.14	**10.39**
	(5.14)	**(2.78)**	(1.01)	**(6.77)**	**(7.90)**		**(1.26)**	**(4.44)**	**(4.73)**	**(5.06)**	(1.23)	**(4.03)**
JAPAN	-3.41	**5.75**	**3.14**	2.12	2.00	**2.81**		9.13	**3.23**	**2.56**	1.86	2.92
	(2.05)	**(1.87)**	**(1.13)**	(2.22)	(1.31)	**(1.40)**		(4.78)	**(1.62)**	**(0.99)**	(3.05)	(2.04)
RUSSIA	7.72	**10.20**	9.86	**14.38**	**16.76**	**7.76**	**14.14**		**4.59**	**17.78**	**12.99**	**11.62**
	(7.18)	**(1.67)**	(5.29)	**(5.01)**	**(1.74)**	**(1.17)**	**(2.76)**		**(0.90)**	**(2.27)**	**(3.46)**	**(3.15)**
SPAIN	-1.37	**8.17**	-0.10	**12.34**	**26.39**	**18.00**	3.36	**14.95**		**18.49**	0.96	**10.12**
	(3.72)	**(3.25)**	(1.01)	**(2.98)**	**(11.29)**	**(0.89)**	(2.29)	**(1.94)**		**(5.25)**	(1.81)	**(3.44)**
UK	-1.13	0.01	1.00	**3.92**	**5.07**	**8.11**	**4.40**	**4.77**	**8.64**		0.23	**3.50**
	(2.06)	(0.50)	(0.66)	**(0.78)**	**(0.89)**	**(0.90)**	**(0.81)**	**(0.99)**	**(2.41)**		(0.97)	**(1.10)**
USA	3.58	**4.41**	**3.75**	**4.55**	7.63	-0.97	-2.28	**2.92**	**-1.38**	**13.04**		3.52
	(3.90)	**(1.57)**	**(1.48)**	**(1.58)**	(6.11)	(0.53)	(1.74)	**(0.45)**	**(0.60)**	**(4.51)**		(2.25)
Column Average	3.73	**5.73**	2.65	**6.32**	**9.71**	**4.90**	**5.73**	**9.02**	**4.50**	**8.70**	2.68	
	(3.85)	**(1.74)**	(1.52)	**(2.53)**	**(3.73)**	**(1.26)**	**(1.60)**	**(2.29)**	**(1.93)**	**(2.30)**	(2.83)	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 99^{th} percentile conditional upon the VaR of the countries listed in the first row at the 99^{th} percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Table A2

ΔCoVaR for changes in sovereign CDS spreads (in basis points), weekly, 01.01.2010–28.02.2014 (with asymmetric responses).

	Conditional upon the VAR of the following country											
	CANADA	CHINA	BRAZIL	FRANCE	GERMANY	ITALY	JAPAN	RUSSIA	SPAIN	UK	USA	Row Average
CANADA		-2.76	-1.48	-0.81	-1.83	1.45	-2.14	2.40	1.29	**-5.82**	1.23	-0.85
		(3.40)	(2.92)	(2.22)	(2.78)	(0.86)	(3.51)	(2.89)	(0.81)	**(1.72)**	(4.29)	(2.54)
CHINA	7.61		**29.07**	**34.04**	**14.02**	-5.14	**28.27**	**29.95**	8.63	**10.07**	**23.82**	18.03
	(8.21)		**(13.19)**	**(12.40)**	**(5.30)**	(11.43)	**(9.16)**	**(9.75)**	(13.65)	**(5.12)**	**(6.10)**	(9.43)
BRAZIL	7.56	**16.55**		**23.37**	**16.00**	-13.81	**29.27**	**19.25**	11.47	**23.42**	**23.24**	**15.63**
	(7.65)	**(3.15)**		**(8.10)**	**(6.21)**	(13.31)	**(8.04)**	**(4.06)**	(10.73)	**(7.54)**	**(7.18)**	**(7.60)**
FRANCE	11.05	-8.50	**15.11**		**17.12**	**12.67**	4.13	**17.69**	**22.53**	-1.09	-4.52	8.62
	(8.63)	(8.39)	**(7.62)**		**(3.90)**	**(2.64)**	(4.47)	**(8.93)**	**(5.54)**	(7.79)	(6.57)	(6.45)
GERMANY	-6.07	-3.77	11.79	**23.67**		3.38	3.41	19.61	3.42	8.93	-4.11	6.03
	(3.81)	(6.29)	(6.32)	**(5.48)**		(4.36)	(3.06)	(10.01)	(5.46)	(6.39)	(6.07)	(5.72)
ITALY	7.48	**20.26**	4.30	**27.01**	15.09		11.63	13.69	**31.34**	**23.75**	8.61	16.32
	(12.31)	**(7.68)**	(10.48)	**(10.01)**	(7.74)		(8.39)	(12.27)	**(5.64)**	**(8.23)**	(5.88)	(8.86)
JAPAN	-3.97	**92.54**	-11.81	-4.91	-7.74	4.60		9.61	-2.68	9.45	-16.31	6.88
	(9.31)	**(27.22)**	(10.21)	(8.06)	(9.37)	(12.01)		(9.72)	(11.15)	(10.01)	(12.72)	(11.98)
RUSSIA	2.94	**25.79**	**22.81**	**32.25**	22.37	4.18	**29.55**		-1.47	30.85	**36.17**	**20.54**
	(5.13)	**(6.51)**	**(5.16)**	**(15.64)**	(12.01)	(8.61)	**(11.16)**		(5.40)	(16.23)	**(15.43)**	**(10.13)**
SPAIN	8.93	**18.47**	**32.05**	**25.18**	15.79	**26.14**	-2.28	**13.58**		-8.76	14.41	14.35
	(7.76)	**(8.69)**	**(15.41)**	**(8.44)**	(12.32)	**(7.41)**	(5.73)	**(6.51)**		(10.62)	(9.73)	(9.26)
UK	-5.63	**10.87**	5.66	-5.84	**11.64**	11.39	4.78	3.33	1.57		4.06	4.18
	(5.43)	**(3.12)**	(4.20)	(9.27)	**(3.21)**	(7.27)	(3.30)	(8.43)	(5.77)		(4.82)	(5.48)
USA	17.26	46.23	8.61	26.19	**51.75**	37.63	**29.57**	**61.92**	**26.09**	-3.16		**30.21**
	(14.54)	(28.75)	(8.44)	(14.50)	**(18.72)**	(16.64)	**(9.72)**	**(21.98)**	**(9.18)**	(5.80)		**(14.83)**
Column Average	4.72	**21.57**	11.61	18.02	15.42	8.25	**13.62**	**19.10**	10.22	8.76	8.66	
	(8.28)	**(10.32)**	(8.40)	(9.41)	(8.16)	(8.45)	**(6.65)**	**(9.45)**	(7.33)	(7.95)	(7.88)	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 99^{th} percentile conditional upon the VaR of the countries listed in the first row at the 99^{th} percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Table A3

ΔCoVaR for changes in stock market indices, daily, 01.01.2010–28.02.2014 (with asymmetric responses and asynchronous trading effect).

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		**0.58**	**1.39**	**0.95**	**1.48**	**1.34**	**0.49**	**1.69**	**0.90**	**1.08**	**1.82**	**1.17**
		(0.15)	**(0.39)**	**(0.47)**	**(0.37)**	**(0.55)**	**(0.19)**	**(0.73)**	**(0.31)**	**(0.20)**	**(0.51)**	**(0.39)**
CHINA	**3.58**		2.61	**1.64**	**3.23**	**2.31**	**5.52**	2.50	3.15	**2.25**	**5.12**	**3.19**
	(1.04)		(1.80)	**(0.18)**	**(0.87)**	**(0.76)**	**(1.41)**	(1.74)	(2.69)	**(0.68)**	**(2.51)**	**(1.37)**
BRAZIL	**1.29**	**0.78**		**2.09**	**1.71**	**1.54**	0.77	**0.82**	**1.48**	**0.99**	**3.33**	**1.48**
	(0.28)	**(0.21)**		**(0.78)**	**(0.29)**	**(0.52)**	(1.04)	**(0.16)**	**(0.67)**	**(0.19)**	**(0.48)**	**(0.46)**
FRANCE	**2.88**	**2.66**	2.93		**4.40**	**5.03**	**3.77**	**4.15**	**6.64**	**4.80**	**2.40**	**3.97**
	(0.87)	**(0.51)**	(2.44)		**(0.54)**	**(0.75)**	**(0.36)**	**(1.06)**	**(1.62)**	**(0.78)**	**(0.81)**	**(0.97)**
GERMANY	**3.90**	**2.05**	**2.16**	**4.27**		**3.41**	**4.01**	**4.45**	5.47	**3.96**	**2.53**	**3.62**
	(1.03)	**(0.46)**	**(0.99)**	**(0.51)**		**(0.24)**	**(1.28)**	**(0.87)**	(3.51)	**(0.58)**	**(0.79)**	**(1.03)**
ITALY	**1.00**	0.32	0.45	**4.76**	**3.29**		**1.10**	**4.15**	**4.60**	**4.63**	1.25	**2.56**
	(0.37)	(0.44)	(0.49)	**(2.35)**	**(0.41)**		**(0.37)**	**(1.91)**	**(0.91)**	**(0.67)**	(0.72)	**(0.86)**
JAPAN	0.06	**3.04**	0.65	**1.38**	**2.48**	1.95		**5.05**	**-0.56**	**3.23**	3.92	2.12
	(0.78)	**(0.93)**	(2.01)	**(0.23)**	**(0.48)**	(1.91)		**(1.50)**	**(0.15)**	**(1.50)**	(2.14)	(1.16)
RUSSIA	2.75	**3.24**	2.94	**3.80**	**3.43**	**4.77**	**2.29**		**3.86**	**2.92**	**2.82**	**3.28**
	(1.66)	**(1.14)**	(2.28)	**(0.47)**	**(0.35)**	**(0.80)**	**(0.24)**		**(1.21)**	**(0.56)**	**(0.50)**	**(0.92)**
SPAIN	0.76	**1.78**	0.07	**6.38**	**6.07**	**4.54**	**0.97**	7.88		**4.84**	0.98	**3.43**
	(0.71)	**(0.46)**	(0.81)	**(0.74)**	**(0.73)**	**(0.38)**	**(0.36)**	(4.18)		**(1.36)**	(0.64)	**(1.04)**
UK	**2.32**	**1.14**	**0.99**	**2.66**	**2.89**	**3.40**	**1.39**	**4.25**	**2.99**		**3.60**	**2.56**
	(0.80)	**(0.17)**	**(0.42)**	**(0.12)**	**(0.28)**	**(0.33)**	**(0.43)**	**(0.82)**	**(0.30)**		**(0.84)**	**(0.45)**
USA	**1.56**	**0.64**	**1.11**	**1.49**	**1.58**	**1.69**	**0.75**	**1.91**	**1.39**	**2.00**		**1.41**
	(0.65)	**(0.26)**	**(0.20)**	**(0.16)**	**(0.24)**	**(0.28)**	**(0.35)**	**(0.29)**	**(0.11)**	**(0.31)**		**(0.29)**
Column Average	**2.01**	**1.62**	1.53	**2.94**	**3.06**	**3.00**	**2.11**	**3.68**	**2.99**	**3.07**	**2.78**	
	(0.82)	**(0.47)**	(1.18)	**(0.60)**	**(0.46)**	**(0.65)**	**(0.60)**	**(1.33)**	**(1.15)**	**(0.68)**	**(0.99)**	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 1^{st} percentile conditional upon the VaR of the countries listed in the first row at the 1^{st} percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Table A4

ΔCoVaR for changes in stock market indices, weekly, 01.01.2010–28.02.2014 (with asymmetric responses).

	Conditional upon the VAR of the following country											
	CANADA	**CHINA**	**BRAZIL**	**FRANCE**	**GERMANY**	**ITALY**	**JAPAN**	**RUSSIA**	**SPAIN**	**UK**	**USA**	**Row Average**
CANADA		**1.27**	**4.74**	**2.87**	**3.02**	**3.86**	2.69	3.33	**1.67**	**3.89**	2.97	**3.03**
		(0.51)	**(1.18)**	**(1.13)**	**(1.54)**	**(1.32)**	(1.92)	(1.80)	**(0.68)**	**(0.95)**	(2.35)	**(1.34)**
CHINA	3.74		**5.17**	5.13	**8.84**	2.44	**2.80**	**4.22**	2.23	**5.22**	3.51	**4.33**
	(2.02)		**(2.62)**	(2.84)	**(3.07)**	(1.59)	**(1.10)**	**(1.13)**	(1.28)	**(1.46)**	(1.97)	**(1.91)**
BRAZIL	2.06	1.62		**13.12**	2.96	**8.21**	1.18	4.62	6.57	**9.56**	7.10	5.70
	(4.00)	(0.83)		**(4.87)**	(2.01)	**(3.18)**	(2.16)	(2.47)	(4.68)	**(4.00)**	(4.85)	(3.30)
FRANCE	1.25	1.00	1.45		**5.35**	**4.76**	**3.56**	**3.87**	**5.26**	**5.95**	**8.88**	**4.13**
	(1.84)	(0.93)	(2.21)		**(1.42)**	**(0.98)**	**(1.74)**	**(0.81)**	**(1.17)**	**(1.20)**	**(2.43)**	**(1.47)**
GERMANY	4.67	**9.14**	0.55	**10.21**		**8.48**	**5.53**	**4.14**	**7.46**	**10.23**	**19.71**	**8.01**
	(2.64)	**(3.26)**	(2.52)	**(2.00)**		**(1.44)**	**(2.21)**	**(1.38)**	**(2.60)**	**(2.34)**	**(6.70)**	**(2.71)**
ITALY	2.37	-0.31	**4.78**	**7.23**	**6.02**		5.28	**5.11**	**6.14**	**8.50**	4.41	**4.95**
	(1.76)	(1.65)	**(2.12)**	**(0.98)**	**(1.35)**		(2.77)	**(1.34)**	**(1.20)**	**(1.86)**	(3.19)	**(1.82)**
JAPAN	-4.50	3.24	-6.04	**21.90**	**14.64**	**20.61**		-2.98	-4.73	**33.14**	**41.13**	11.64
	(4.42)	(8.54)	(6.34)	**(8.50)**	**(5.31)**	**(8.58)**		(5.69)	(6.50)	**(13.04)**	**(17.23)**	(8.41)
RUSSIA	1.48	**5.44**	3.39	**5.45**	**7.39**	**9.61**	**2.66**		**7.44**	**15.84**	**11.07**	**6.98**
	(4.48)	**(2.70)**	(3.80)	**(2.71)**	**(2.49)**	**(3.29)**	**(0.88)**		**(2.59)**	**(4.73)**	**(4.35)**	**(3.20)**
SPAIN	1.48	-0.08	-5.03	4.81	**3.29**	**8.31**	0.83	-1.66		0.83	2.72	1.55
	(1.30)	(1.04)	(3.84)	(2.70)	**(1.22)**	**(1.12)**	(1.16)	(1.99)		(3.02)	(2.31)	(1.97)
UK	**4.49**	**3.17**	**10.16**	**4.82**	**7.37**	**3.50**	**6.93**	**6.69**	**3.91**		**4.75**	**5.58**
	(0.91)	**(1.59)**	**(3.38)**	**(0.96)**	**(1.05)**	**(0.72)**	**(1.76)**	**(1.17)**	**(0.93)**		**(1.83)**	**(1.43)**
USA	**5.02**	**6.16**	**7.50**	**3.33**	**3.19**	**2.21**	**4.04**	**5.69**	**2.28**	**3.05**		**4.25**
	(1.00)	**(2.11)**	**(2.37)**	**(0.88)**	**(0.58)**	**(0.89)**	**(1.39)**	**(1.37)**	**(0.57)**	**(0.43)**		**(1.16)**
Column Average	2.21	3.06	2.67	**7.89**	**6.21**	**7.20**	**3.55**	**3.30**	**3.82**	**9.62**	**10.63**	
	(2.44)	(2.32)	(3.04)	**(2.76)**	**(2.00)**	**(2.31)**	**(1.71)**	**(1.91)**	**(2.22)**	**(3.30)**	**(4.72)**	

Notes: each cell contains ΔCoVaR of the corresponding country listed under the first column at the 1^{st} percentile conditional upon the VaR of the countries listed in the first row at the 1^{st} percentile. The standard error is obtained by the standard bootstrap method and reported in parenthesis. ΔCoVaRs in bold are significant at the 5% level.

Appendix B

Table B1

Determinants of ΔCoVaRs for changes in sovereign CDS spreads.

	Daily	Weekly
Gross government debt to GDP$_J$	0.03**	0.07***
	(0.01)	(0.02)
Trade openness$_J$	0.09***	
	(0.03)	
World GDP share$_J$	0.21*	
	(0.11)	
EU dummy	2.94***	
	(1.08)	
State fragility index$_J$	0.07***	0.50**
	(0.03)	(0.19)
Language		-6.25**
		(3.00)
Distance	-0.0002**	-0.0005**
	(0.0001)	(0.0002)
Financial openness$_J$		7.45***
		(2.68)
Constant term	-2.20	-10.14
	(3.65)	(14.52)
Cross-section and period fixed effects	*Yes*	*Yes*
Redundant cross-section and period fixed effects test F-statistic (p-value)	5.24 (0.00)	16.95(0.00)
No. of obs	210	123
Adj. R^2	0.56	0.81
SBIC	6.41	7.59

Notes: standard errors in parenthesis; *, **, *** – significance at 10, 5 and 1% respectively; j stands for the countries in distress.

Table B2

Determinants of ΔCoVaRs for changes in stock market indices.

	Daily	Weekly
Stock market total value traded to GDP$_J$	0.002*	0.01***
	(0.001)	(0.003)
World GDP share$_J$	0.06***	0.16***
	(0.02)	(0.03)
EU dummy	0.79***	
	(0.24)	
Distance	-0.0002***	
	(0.0000)	
Inflation$_J$	0.06***	
	(0.02)	
Constant term	3.43***	4.75***
	(0.25)	(0.42)
Cross-section and period fixed effects	*Yes*	*Yes*
Redundant cross-section and period fixed effects test F-statistic (p-value)	7.46(0.00)	16.26(0.00)
No. of obs	273	210
Adj. R^2	0.73	0.78
SBIC	3.14	5.94

Notes: standard errors in parenthesis; *, **, *** – significance at 10, 5 and 1% respectively; j stands for the countries in distress.