UNIVERSITY OF CAMBRIDGE
Judge Business School

Centre for
Risk Studies

University of Essex

Network Analysis of Systemic Risk, Core Global Banking System and of Eurozone Crisis: Early Warning Signals

Mateusz Gątkowski

In collaboration with:

Sheri Markose, Simone Giansante, Mehmet Goktan

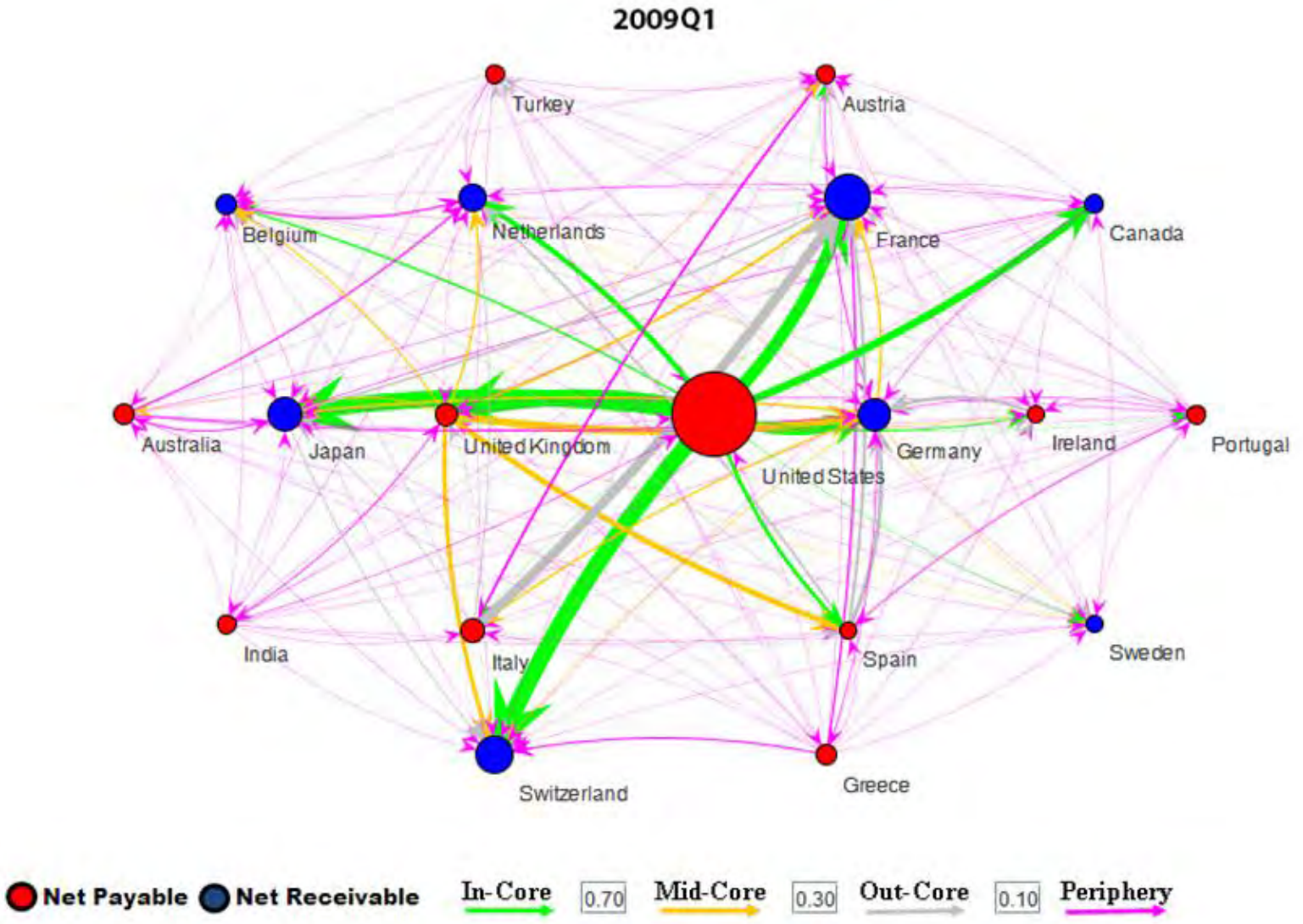
9 September 2015

Financial Risk & Network Theory, Cambridge

Agenda

- Part I: Motivation
- Part II: The Core Global Banking System Network
- Part III: The Systemic Risk Index (Markose et al. 2012)

Core Global Banking System Network



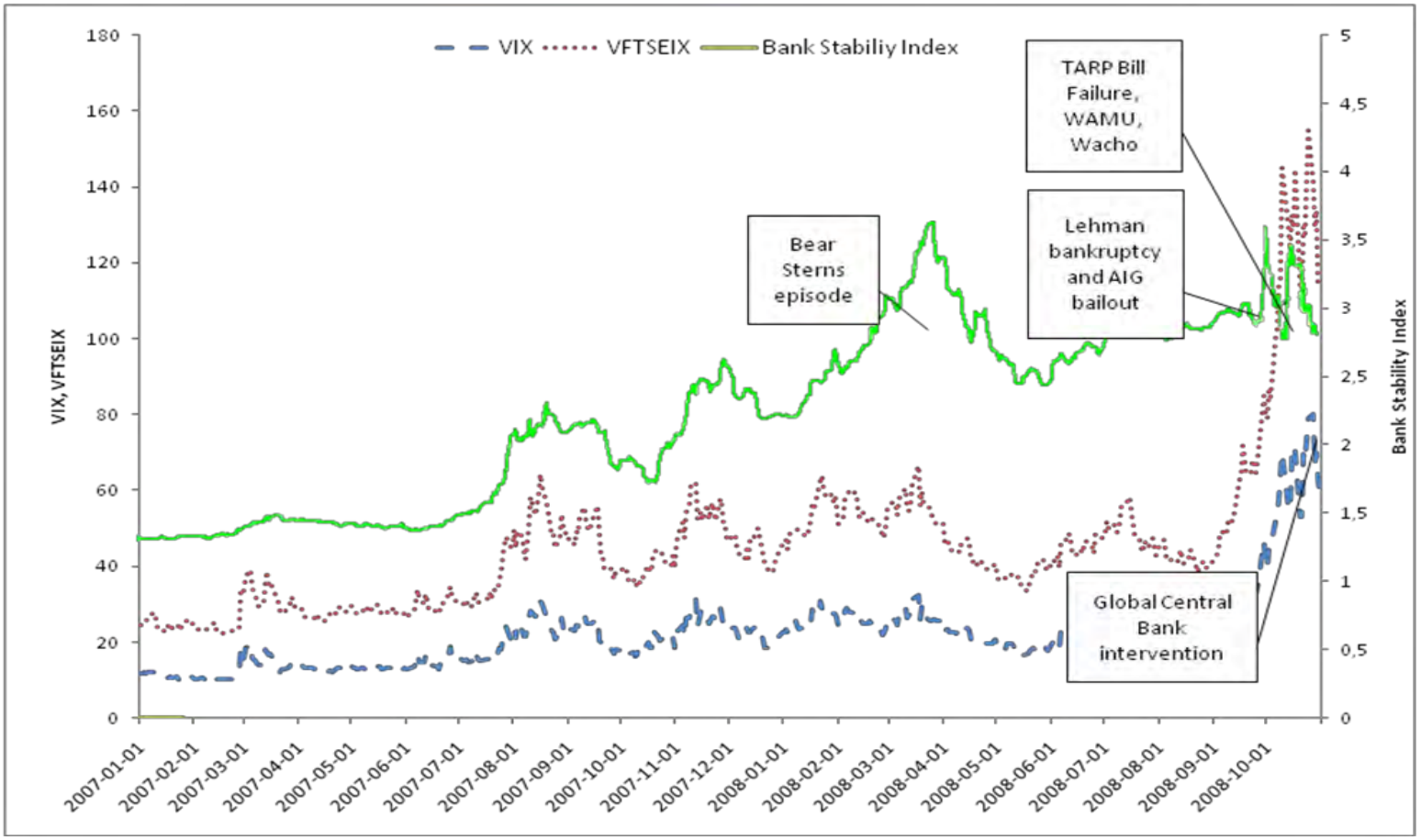
Systemic Risk Index for the Core Global Banking System Network (2005-2014)

- CGBSN: Australia, Austria, Belgium, Canada, France, Germany, Greece, India, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Motivaton

- The need for early warning signals for a build up of the systemic risk (Early Warning Excercise by IMF and FSB)
- Coincidence of market-price based systemic risk indices with the crisis (Arsov et al. (2013) – IMF Working Paper)
- Topology matters to the contagion – the empirical structure of the financial markets has to be well understood (Markose et al. (2010))

Banking Stability Index (Segoviano, Goodhart 2009) vs VIX and V-FTSE Indexes

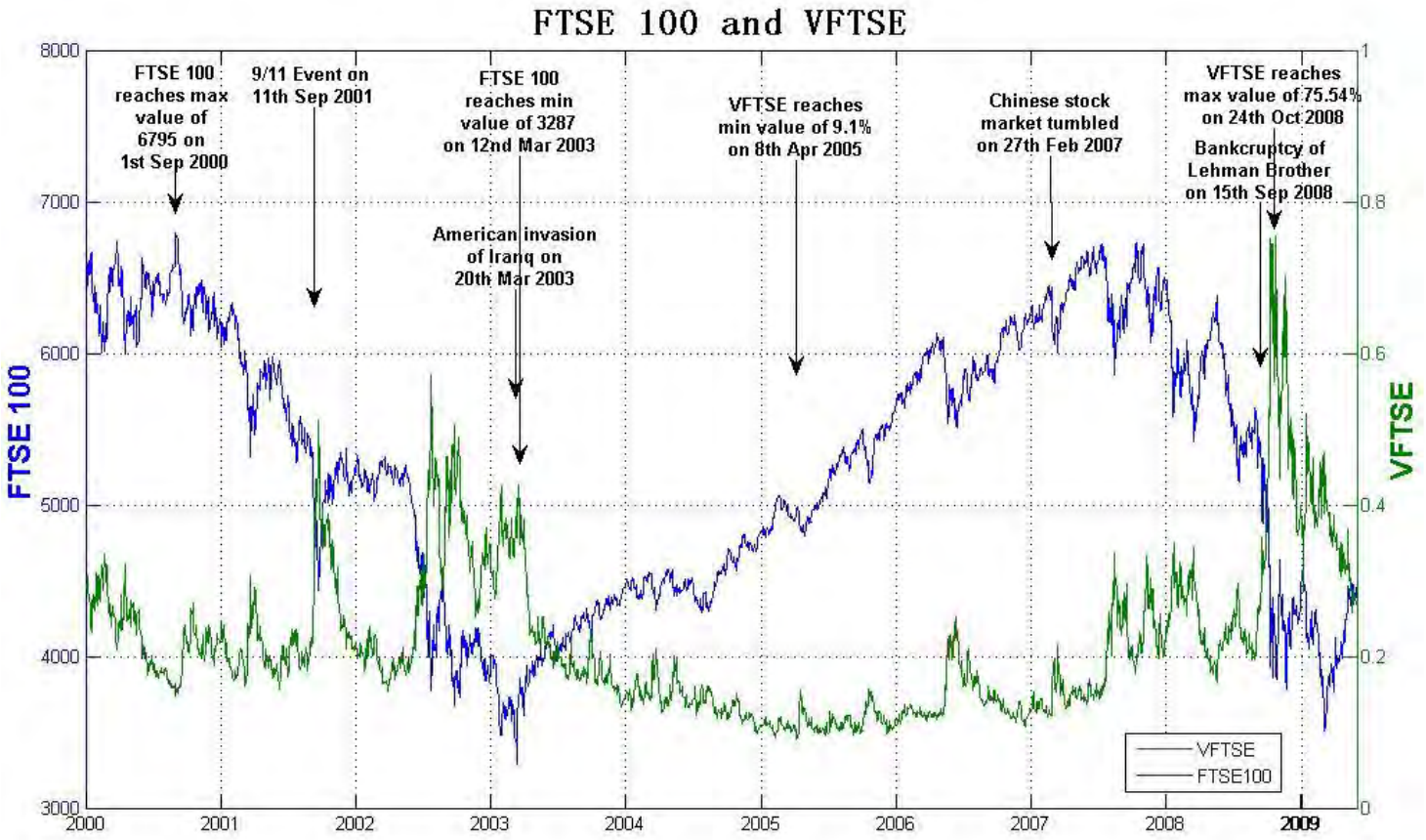


- Sadly market data based indices spike contemporaneously with crisis devoid of requisite info for Early Warning System

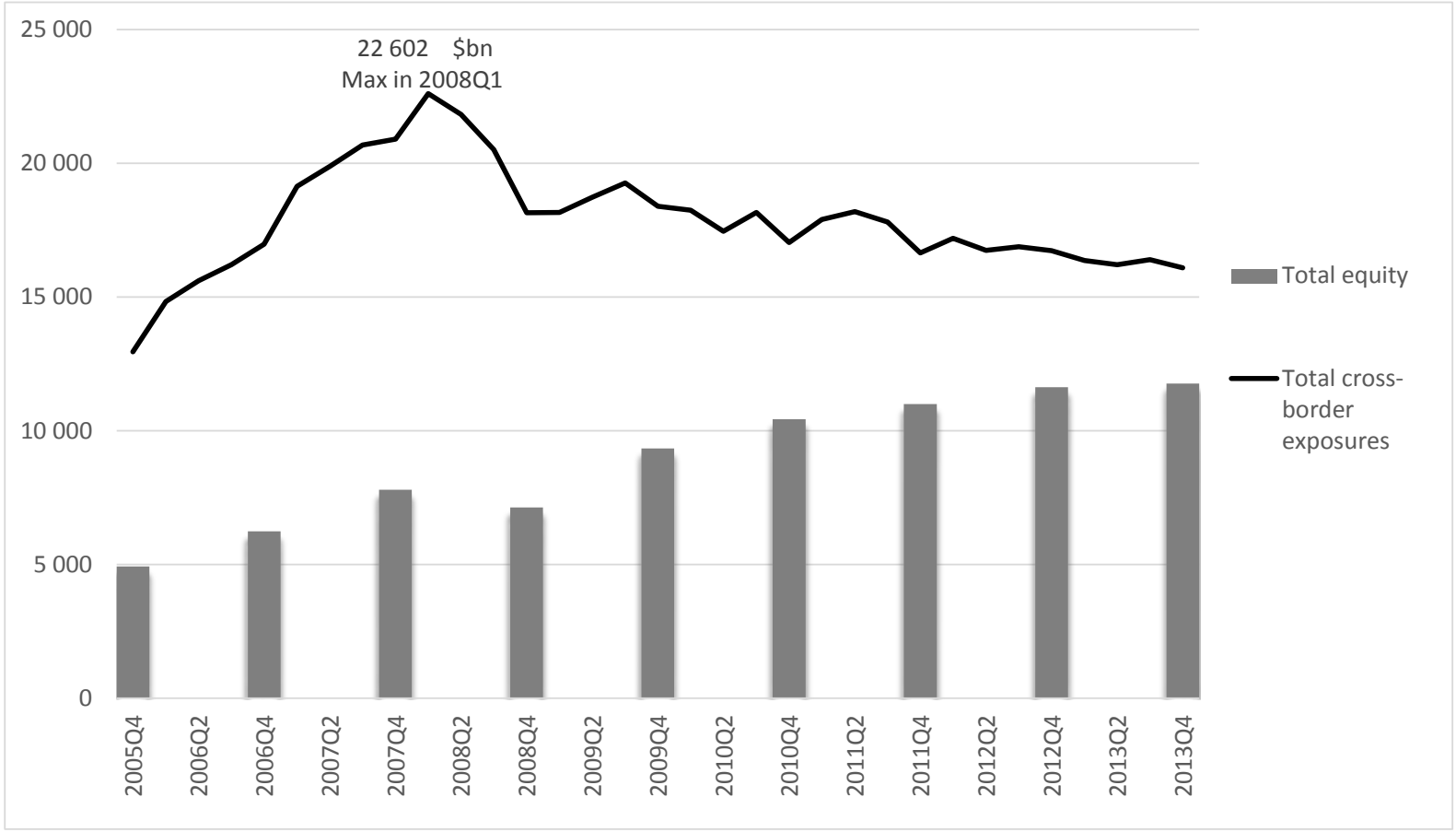
Market price based systemic risk measures lack early warning capabilities

- Major drawback of market price based systemic risk measures: they suffer from paradox of volatility (Borio and Drehman, 2009) or paradox of financial stability issues first addressed by Hyman Minsky (1982).
- As credit growth boosts asset prices, CDS spreads and VIX indices which are inversely related to asset prices are at their lowest precisely before the crash when asset prices peak → see procyclicality of leverage Adrian and Shin (2010, 2011).
- Market based statistical proxies for systemic risk are at best contemporaneous with the crisis in markets, at worst they spike after crisis. Arsov et al. (2013) – IMF WP/13/115 now call market based systemic risk indices Coincident and Near Coincident Systemic Risk Measures: conceded absence of early warning capabilities.

Paradox of Volatility (Borio and Drehman (2009); Minsky (1982)) Volatility low during boom and at local minimum before market tanks: hence misled regulators "great moderation"



Data: BIS and Bankscope

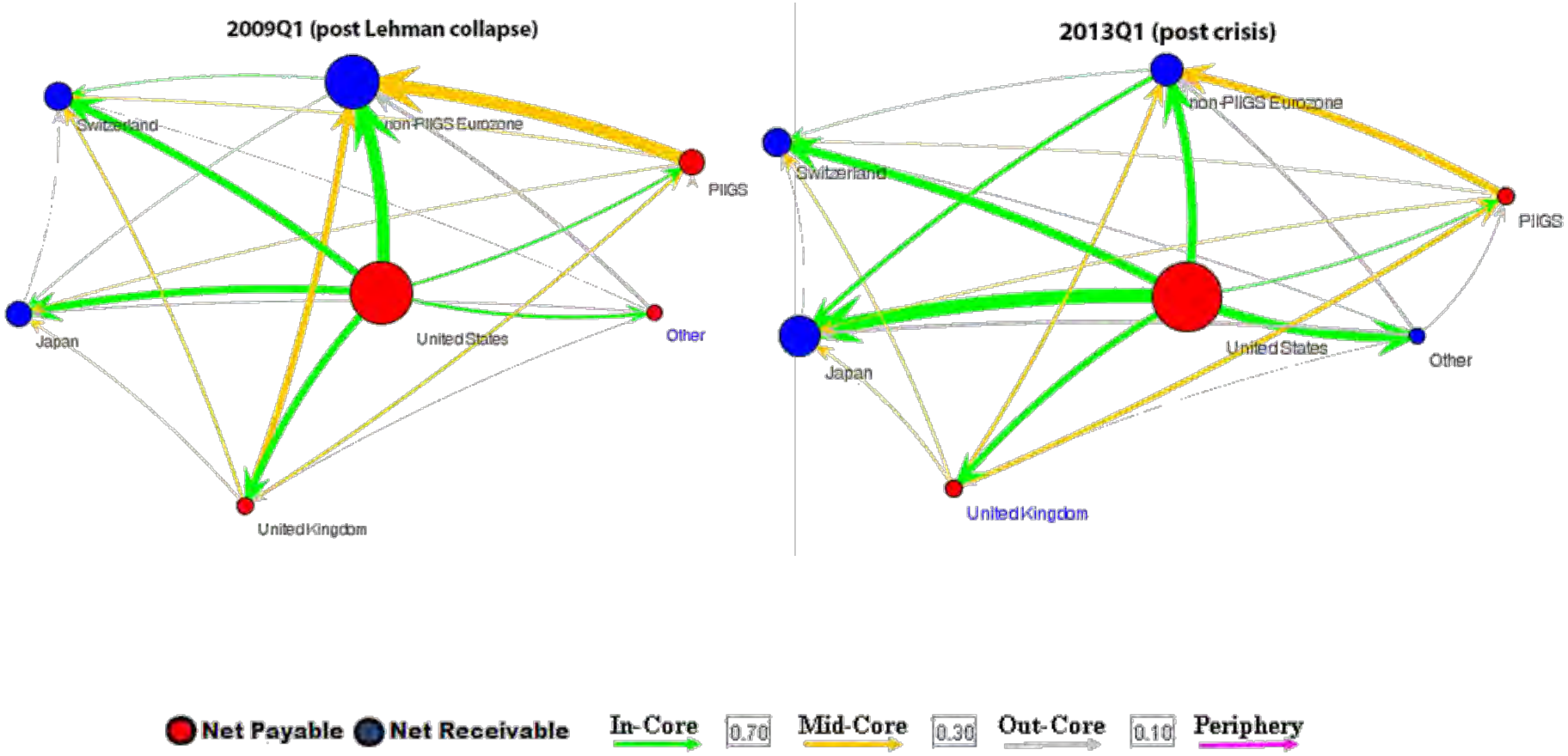


Data quality

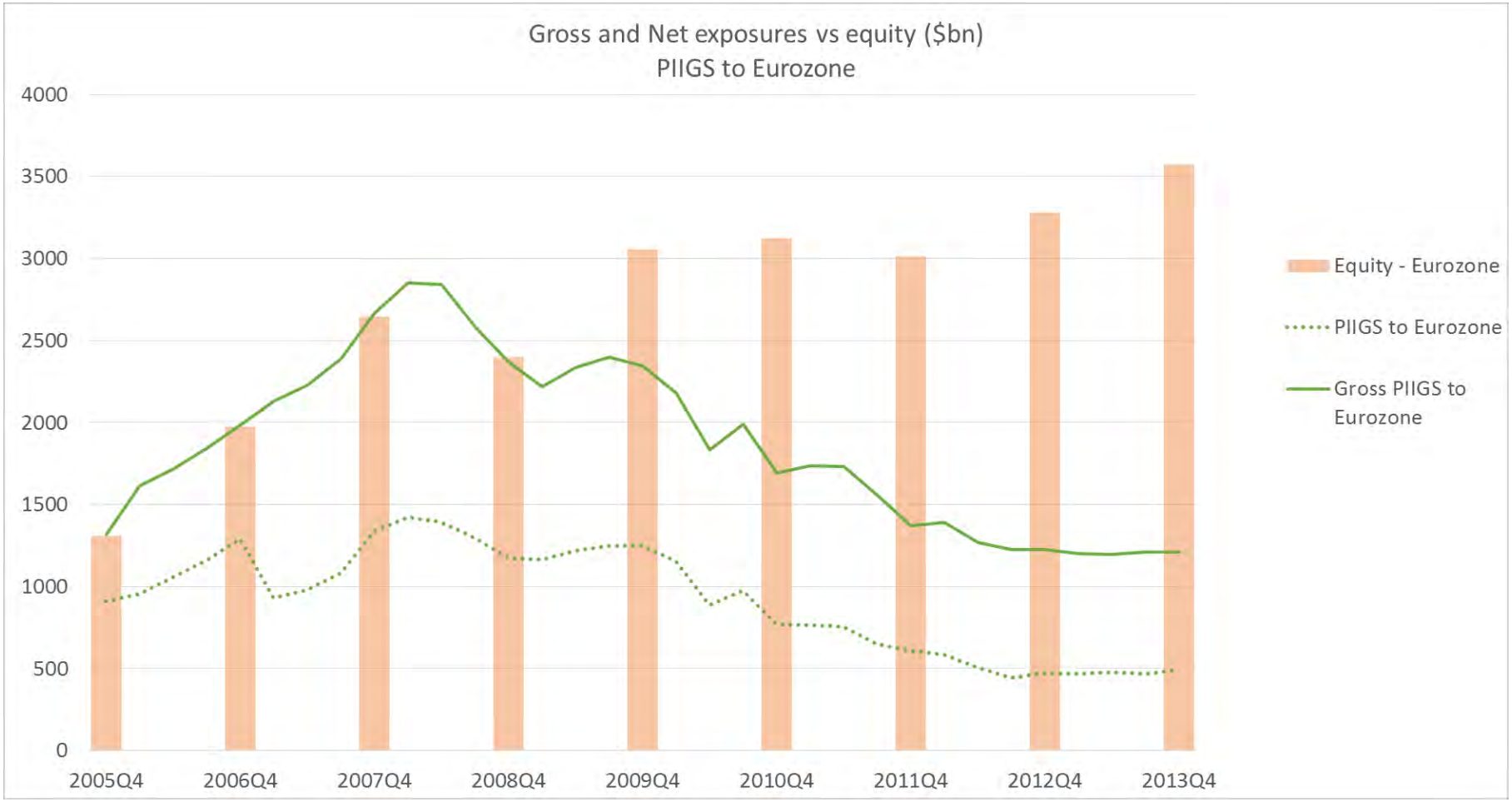
Country	*Number of banks*
Australia	53
Austria	267
Belgium	74
Canada	92
France	382
Germany	1803
Greece	15
India	102
Ireland	34
Italy	608
Japan	663
Netherlands	78
Portugal	34
Spain	159
Sweden	101
Switzerland	403
Turkey	106
Great Britain	467
United States	986
Eurozone	3454
Total	**6427**

Country	*Share of the assets of reporting banks*								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
Australia	29%	96%	97%	97%	97%	~100%	~100%	~100%	~100%
Austria	86%	96%	98%	98%	99%	99%	100%	100%	93%
Belgium	95%	95%	95%	96%	99%	~100%	100%	99%	96%
Canada	7%	8%	8%	8%	9%	96%	99%	100%	98%
France	80%	84%	85%	98%	98%	99%	99%	100%	99%
Germany	36%	63%	78%	79%	98%	~100%	100%	~100%	88%
Greece	99%	100%	100%	100%	100%	100%	100%	100%	~100%
India	85%	90%	94%	96%	96%	~100%	~100%	99%	98%
Ireland	90%	93%	94%	94%	94%	95%	100%	100%	94%
Italy	76%	88%	90%	98%	97%	98%	100%	~100%	99%
Japan	68%	71%	89%	91%	98%	99%	100%	99%	98%
Netherlands	76%	76%	78%	79%	98%	~100%	~100%	99%	~100%
Portugal	90%	94%	94%	93%	95%	95%	100%	~100%	~100%
Spain	66%	67%	68%	76%	77%	93%	96%	97%	98%
Sweden	87%	96%	97%	97%	97%	99%	~100%	100%	~100%
Switzerland	89%	88%	89%	90%	93%	96%	97%	100%	96%
Turkey	47%	71%	84%	96%	96%	96%	98%	100%	89%
Great Britain	90%	95%	95%	96%	98%	99%	~100%	~100%	98%
United States	92%	92%	93%	92%	96%	97%	99%	97%	96%
Total	**75%**	**81%**	**87%**	**89%**	**94%**	**98%**	**99%**	**99%**	**96%**

Changes in CGBS network
the exposure of non-PIIGS Eurozone to PIIGS fell



Cross border exposures were far too excessive relative to capital (Eurozone vs PIIGS)



Operationalizing Systemic Risk Index metrics
What do we want from them?

- Capacity of SR metrics to **provide early warning** of potential system failure and the capacity to signal sudden shift in systemic importance of Fis.

- **Systemic importance depends on other SI nodes (Higher round effects)**: In an important observation first made by Gauthier et al (2010), SRIs in relation to macro-prudential capital (and liquidity buffers) should be modelled in a fixed point framework.

- **Analytical ex ante SRI metrics** and ex post simulation based capital losses (no assumption of exogenous shocks).

Solvency Contagion and Stability of Matrix Θ' : Netted impact of i on j relative to j's capital

$$\Theta = \begin{bmatrix} 0 & \frac{(x_{12}-x_{21})^+}{C_{20}} & \cdots & \frac{(x_{1j}-x_{j1})^+}{C_{j0}} & \cdots & \frac{(x_{1N}-x_{N1})^+}{C_{N0}} \\ \frac{(x_{21}-x_{12})^+}{C_{10}} & 0 & \cdots & \frac{(x_{2j}-x_{j2})^+}{C_{j0}} & \cdots & \frac{(x_{2N}-x_{N2})^+}{C_{N0}} \\ \vdots & \vdots & 0 & \cdots & \cdots & \cdots \\ \frac{(x_{i1}-x_{1i})^+}{C_{10}} & \vdots & \cdots & 0 & \cdots & \frac{(x_{iN}-x_{Ni})^+}{C_{N0}} \\ \vdots & \vdots & \cdots & \cdots & 0 & \cdots \\ \frac{(x_{N1}-x_{1N})^+}{C_{10}} & \frac{(x_{N2}-x_{2N})^+}{C_{20}} & \cdots & \frac{(x_{Nj}-x_{jN})^+}{C_{j0}} & \cdots & 0 \end{bmatrix}$$

where $(x_{ij}-x_{ji})^+$ is the net exposure of banking system *j* to country *i*, and $c_{j0} > 0$ is an initial capital of banking system *j*

From Epidemiology, inspired by Robert May's work:

Failure of *i* at q+1 determined by the criteria that losses exceed a predetermined buffer ratio (ρ) of Tier 1 capital

„Economists should hang out more with biologists"
Mark Flood, Financial Risk & Network Theory

$$u_{iq+1} = (1 - \rho)\, u_{iq} + \sum_j \frac{(x_{ji} - x_{ij})^+}{C_{i0}}\, u_{jq}^1$$

(i) First term is i's own survival probability given by the remaining capital C_{iq} at q relative to initial capital C_{i0}, ρ is common cure rate and (1 - ρ) is rate of not surviving in the worst case scenario.

(ii) The sum of 'infection rates'= sum of net liabilities of its *j* failed counterparties relative to its own capital is given by the term $\sum_j \frac{(x_{ji} - x_{ij})^+}{C_{i0}}$

Stability of the dynamical network system : Eigen Pair (λ_{max}, v)

In matrix algebra dynamics of bank failures:

$$\mathbf{U}_{t+1} = [\Theta' + (1- \rho)\mathrm{I}]\, \mathbf{U}_t = \mathbf{Q}\, \mathbf{U}_t$$

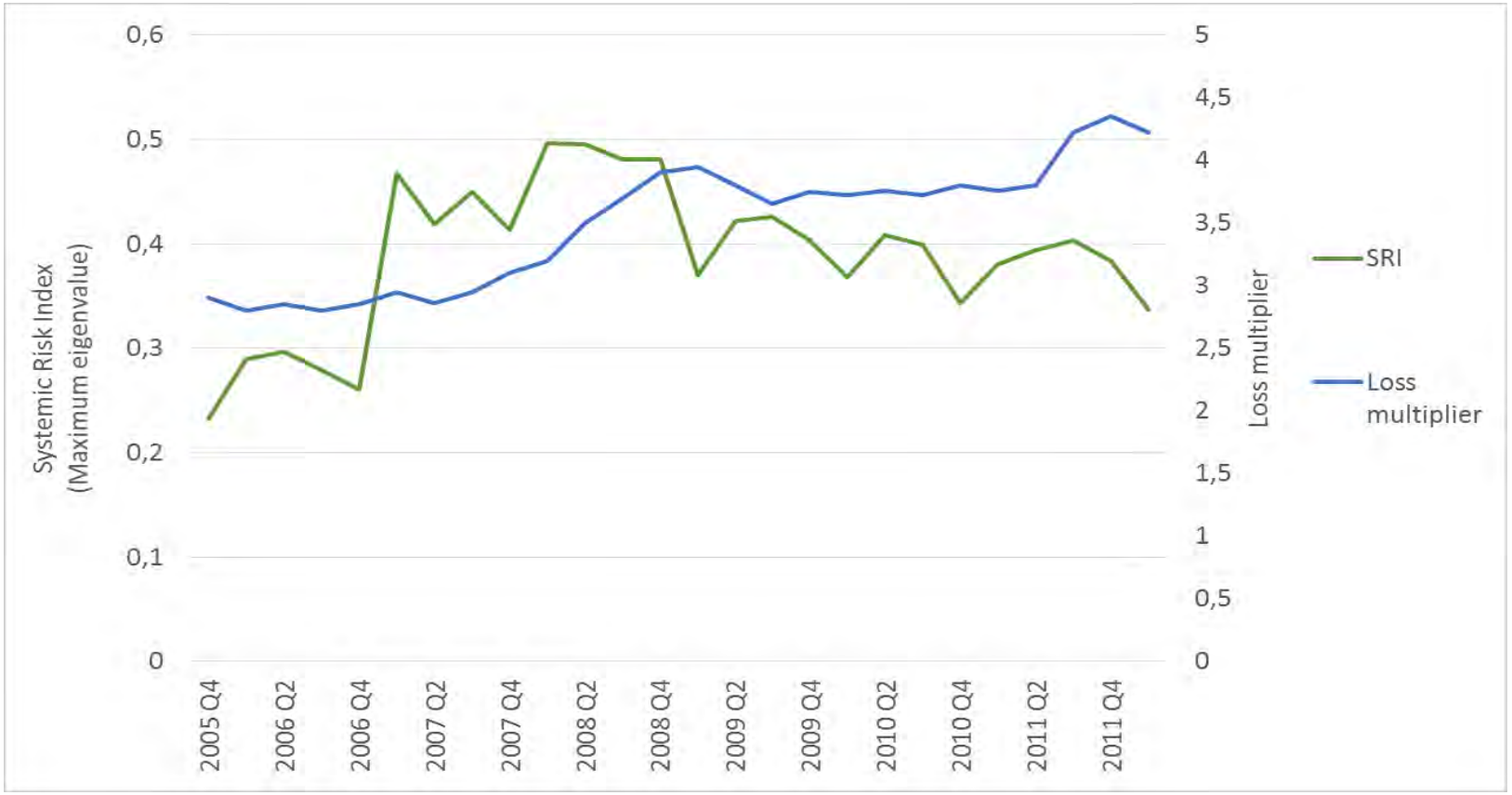
The system stability will be evaluated on the basis of the power iteration of the matrix

- After q iterations $\boldsymbol{U}_q = \boldsymbol{Q}^q \boldsymbol{U}_0$

Stability Condition $\lambda_{max}(\Theta') < \rho$

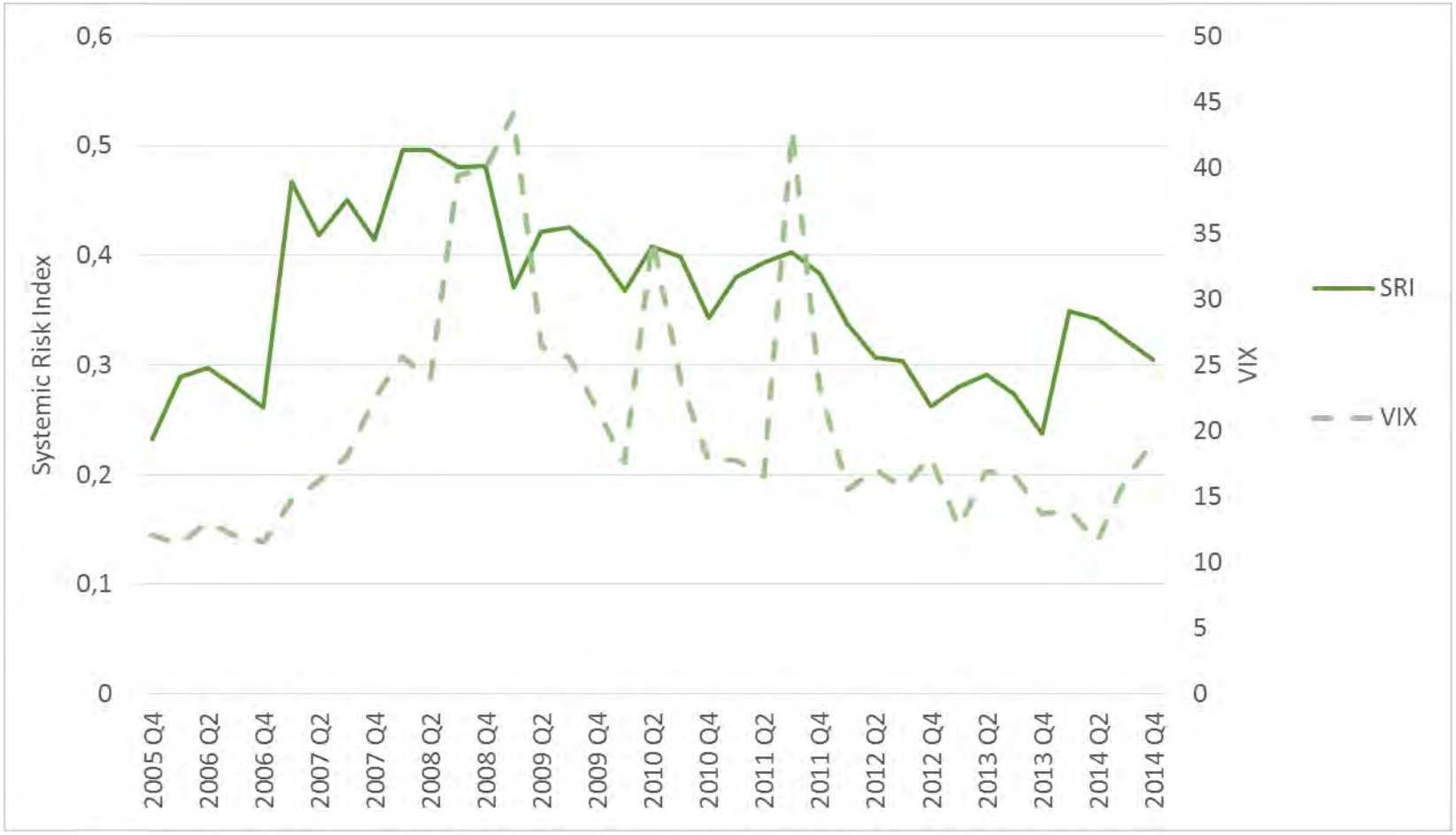
I is identity matrix and ρ is the is the solvency threshold in terms of Tier 1 capital, λ_{max} is maximum eigenvalue of Θ'

Maximum Eigenvalue SRI vs Loss multiplier (Castren and Rancan (2014)) for BIS Global Flows 2005Q4-2012Q1



- Loss multiplier peaks well after crisis has started and assets of FIs has been substantially depleted. Max Eigenvalue of matrix of exposures relative to equity capital of exposed national banking systems captures growing instability

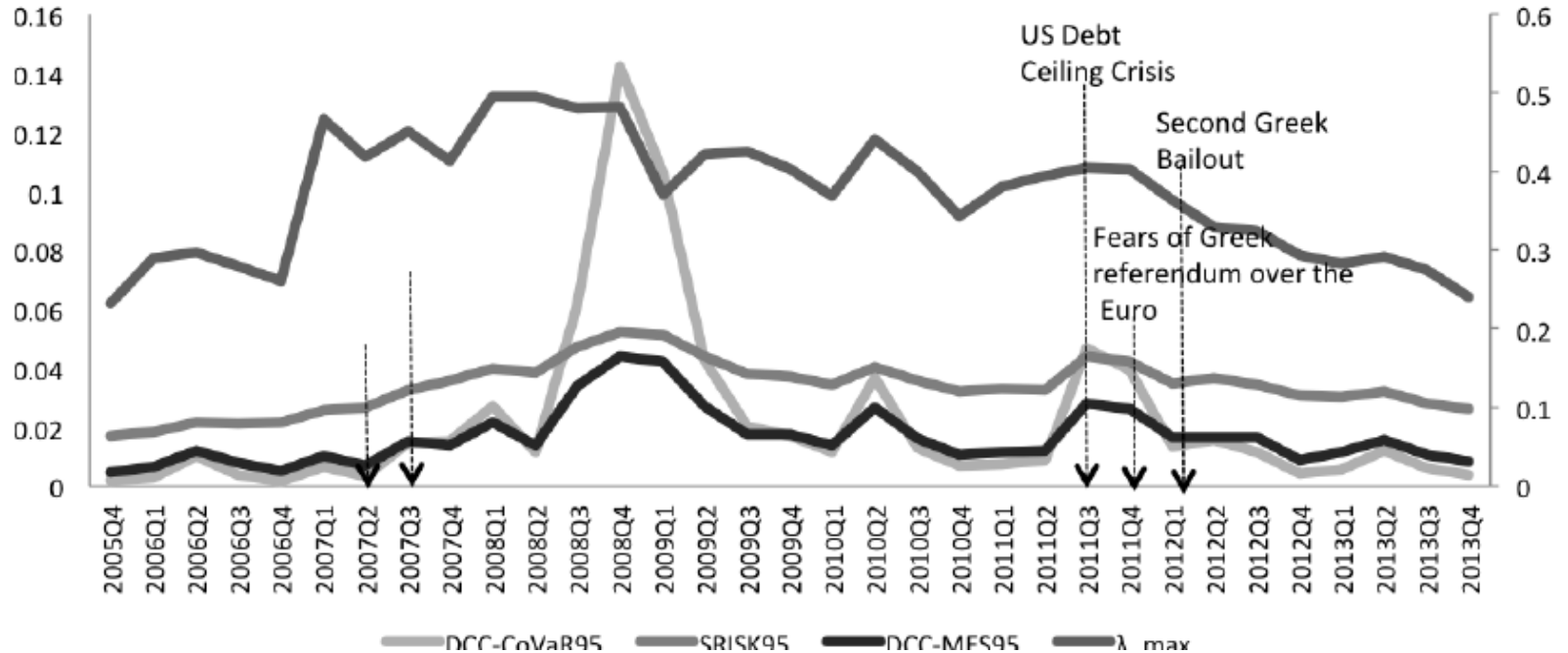
Maximum Eigenvalue SRI vs VIX 2005Q4-2014Q4



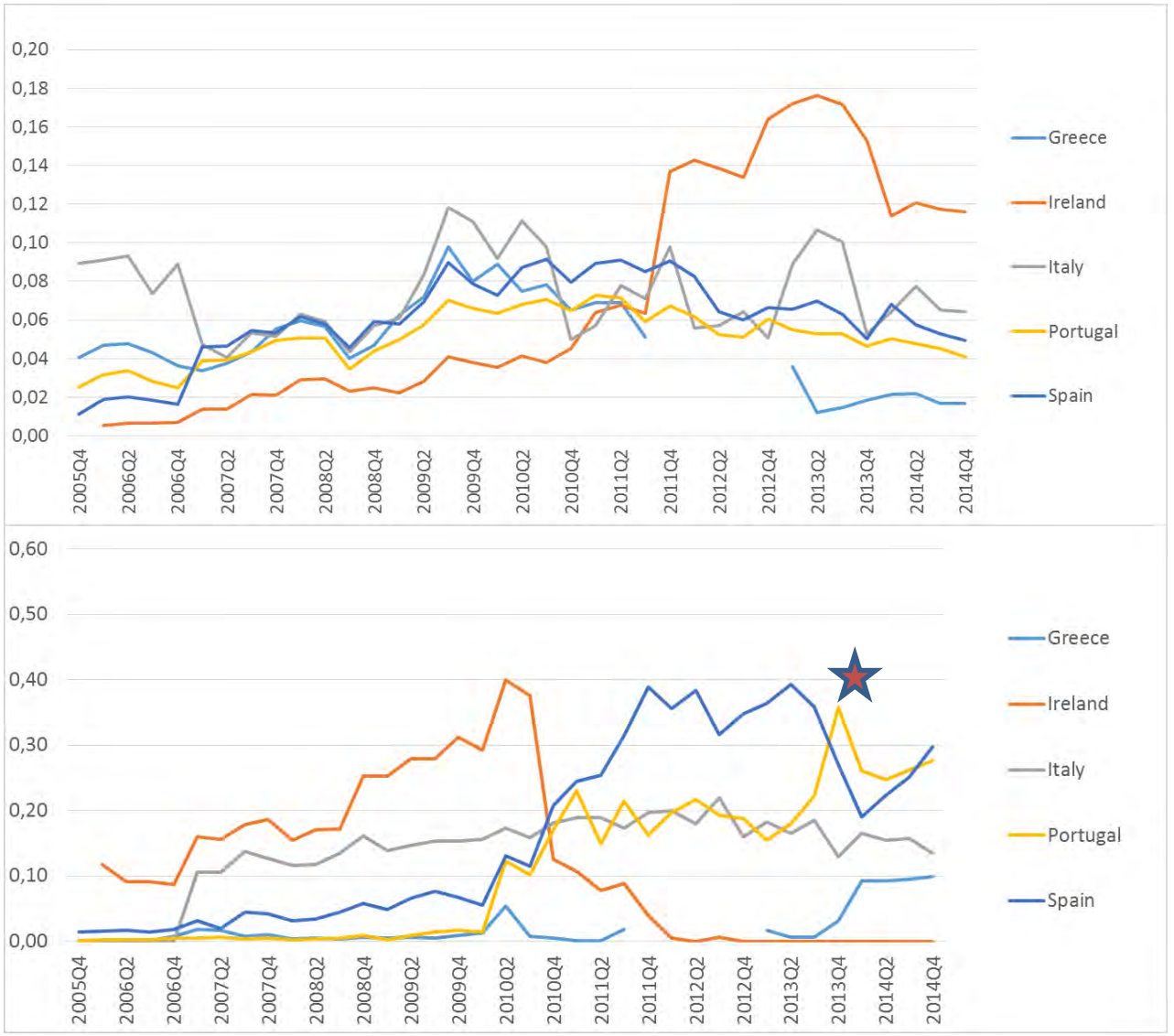
- The volatility increases DURING the crisis…
- Note: 2014 results for SRI are preliminary

Max Eigenvalue (RHS Axis) of Core Global Banking Network; Statistic SRIs based on MSCI Financial Country 19 Indexes with MSCI World (22 countries) Financial Index to Proxy Market Returns

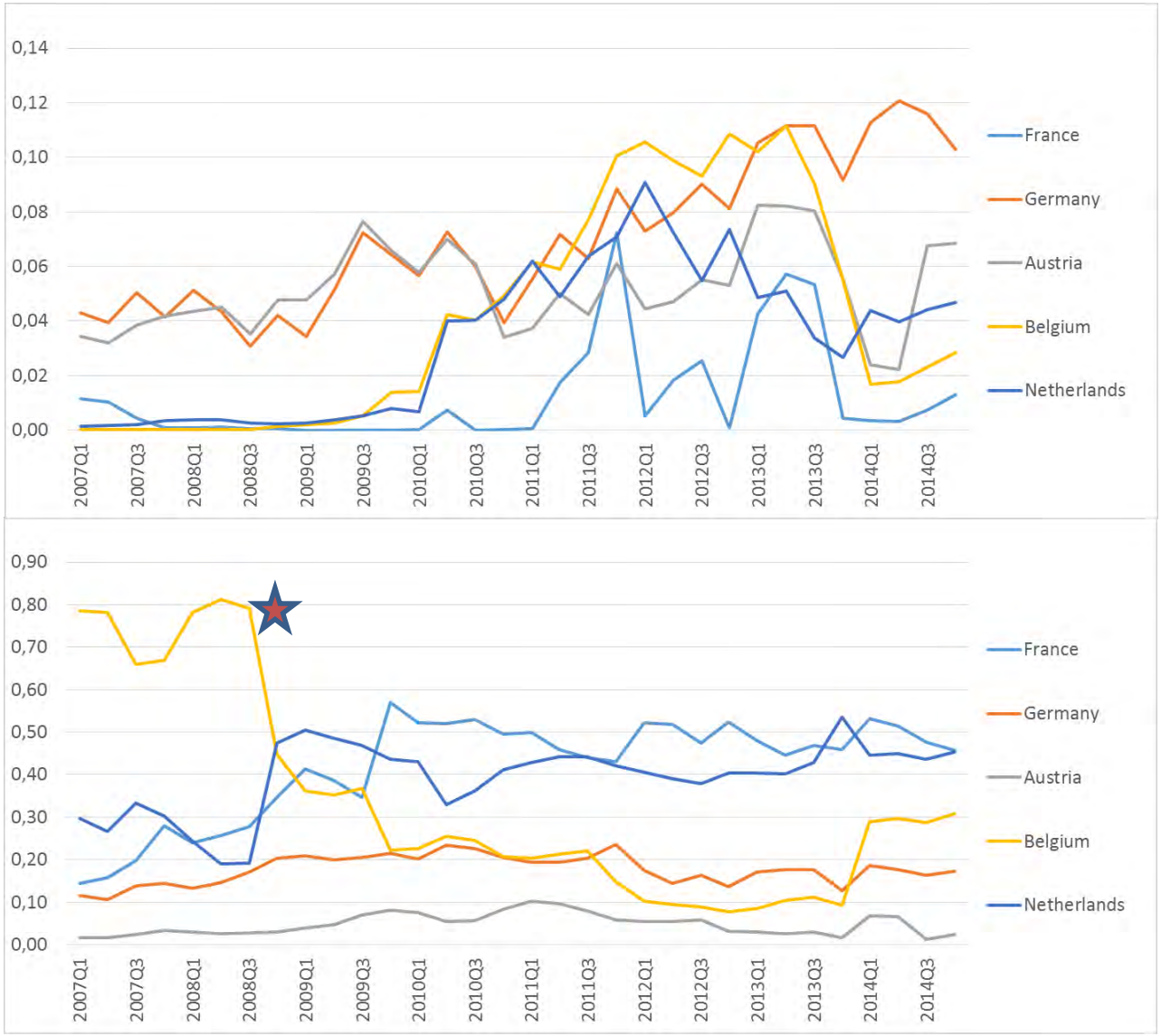
Maximum Eigenvalue (λ_{max}) of the CGBSN vs. DCC-ΔCoVaR, DCC-MES and SRISK during the period (2005Q4-2013Q4).



Top Panel Gives Systemic Importance of PIIGS; Bottom Panel Shows Vulnerability of National Banking Systems Note Portugal Taking Top Place in 2013



Top Panel Gives Systemic Importance; Bottom Panel Shows Vulnerability of National Banking Systems
Note Belgium Vulnerability in 2008



Thank you for your attention

Mateusz Gątkowski
mgatko@essex.ac.uk

References

- Adrian, T., and Shin, H. S., (2010). Liquidity and Leverage. *Journal of Financial Intermediation,* 19 (3): 418–37.
- Adrian, T., and Shin, H. S., (2011). Financial Intermediary Balance Sheet Management. *Annual Reviews in Financial Economics*
- Arsov, I., Canetti, E., Kodres. E, and S. Mitra, (2013), "Near-Coincident" Indicators of Systemic Stress, *IMF Working Paper* WP/13/115
- Borio, C , and Drehmann, M., (2009). Towards an Operational Framework for Financial Stability: 'Fuzzy' Measurement and its Consequences. in *Banco Central de Chile (ed), Financial Stability, Monetary Policy and Central Banking*, also available as *BIS Working Paper No 284*.
- Castrén, O., & Rancan, M. (2014). Macro-Networks: An Application to Euro Area Financial Accounts. *Journal of Banking and Finance,* Elsevier, vol. 46, pages 43-58
- Gauthier, C., Lehar, A., & Souissi, M. (2010*).* Macroprudential regulation and systemic capital requirements. *Bank of Canada Working Paper*
- Kalbaska, A., Gątkowski, M., Eurozone sovereign contagion: Evidence from the CDS market (2005-2010). *Journal of Economic Behavior & Organization*, 83(3), 657-673
- Markose, S. M. (2012). Systemic Risk from Global Financial Derivatives: A Network Analysis of Contagion and Its Mitigation with Super-Spreader Tax. *IMF Working Paper*. No.12/282.
- Markose, S. M. (2013). Systemic Risk Analytics : A Data Driven Multi-Agent Financial Network (MAFN) Approach. *Journal of Banking and Regulation*, 1–29.
- Markose, S., Etrovic, A., N., Gątkowski, M. (2015). Early Warning and Systemic Risk in Global Banking: Financial Network and Market Price-based Methods. *Preprint submitted to Elsevier*
- Markose, S., Gątkowski, M. , Giansante, S., Goktan M. (2015). Network Analysis of Systemic Risk, Core Global Banking System and of Eurozone Crisis: Early Warning Signals. *In preparation*
- Markose, S., Giansante, S., & Shaghaghi, A. R. (2012). “Too interconnected to fail” financial network of US CDS market: Topological fragility and systemic risk. *Journal of Economic Behavior & Organization*, *83*(3), 627–646. doi:10.1016/j.jebo.2012.05.016.

References

- Markose, S., Giansante, S., Gątkowski, M., Shaghaghi, A. R. (2010). Too interconnected to fail: financial contagion and systemic risk in network model of CDS and other credit enhancement obligations of US banks. *University of Essex, Department of Economics, Discussion Paper Series*, 683, February
- May, R. M. (1972). Will a Large Complex system be Stable? *Nature, 238 (5364)*, 413–414.
- May, R. M. (1974). *Stability and Complexity in Model Ecosystems*, Princeton University Press.
- Minoiu, C. and Reyes, J. A. (2013) A network analysis of global banking: 1978-2009. *Journal of Financial Stability*, 9(2), pp.168–184
- Minsky, H., (1982). The Financial-Instability hypothesis: Capitalist processes and the behavior of the economy. in Kindleberger and Laffargue, editors, *Financial Crises*.
- Minsky, H., (1986). *Stabilizing an Unstable Economy*. Yale University Press.
- Segoviano, M. and Goodhart, C., (2009). Banking Stability Measures. *IMF Working Paper*, No.09/14.
- Von Peter, G., (2007). International banking centres: a network perspective. *BIS Quarterly Review,* December.