Measuring Systemic Risk and Assessing Systemic Importance in Global and Regional Financial Markets Using the Expected Systemic Shortfall (ESS) Indicator

Lahmann / Kaserer (2011)

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1. Introduction

- The financial crisis exposed the relevance of ***systemic risk*** (definition: likelihood of the occurence of a *systemic event* in the financial sector with destabilizing effects on the financial system and the real economy)
- ***Systemically important financial institutions (SIFIs)*** is a related concept (definition: failure of a SIFI represents a *systemic event*)
- Common ***definition or measurement approaches*** for systemic risk and systemic importance are ***not yet available***
- We propose the ***Expected Systemic Shortfall (ESS) indicator*** which employs a credit portfolio simulation based on capital market data
- ESS-indicator represents the ***product of the probability of a systemic default event (PSD)*** and ***the expected tail loss (ETL)***
- The ESS-Methodology is applied to a ***global bank sample*** as well as to ***four regional sub-samples***
- We obtain the ***evolution of the aggregate systemic risk*** as well as an ***assessment of systemic importance*** on the global and regional levels

2. Related Literature

- Several measurement approaches have been proposed recently (e. g. Lehar (2005), Adrian/Brunnermeier (2008), Huang et. al. (2009), Kim/Giesecke (2010))
- Measurement approaches can be classified with respect to the data employed: financial statement data, mutual bank exposure data, capital market data
- Capital market data has certain advantages vis-à-vis other data (e. g. forward-looking, commonly available)
- Most approaches so far ***focus either on systemic risk or systemic importance***

➡ We propose a framework for measurement of ***both aspects*** based on standard measures from financial institution risk management

- Hitherto empirical implementations ***consider one regional financial market***

➡ We apply the ESS methodology both to a ***global sample*** as well as to ***four regional sub-samples***

Main contributions of this paper are the new methodology for measuring systemic risk *and* assessing systemic importance as well as the comprehensive empirical implementation

3. The ESS-Methodology (I/II)

Input parameters

Computed for each day during the sample period[1]

- Create hypothetical credit portfolio comprising the sample banks' liabilities[2]
- Estimate asset return correl. from market equity returns (Hull/White (2004))
- Risk-neutral PDs are estimated from CDS spreads (Tarashev/Zhu (2008b))

Credit portfolio simulation

Performed for each day during the sample period for *K* simulation iterations

- Conduct credit portfolio simulation assuming single risk factor model with standard normal distribution (default threshold results as $\Phi^{-1}\left(PD_{i,T}\right)$)
- Draw standard normally distributed samples with estimated correlation matrix and evaluate if default occured (draw sample LGD when default occured)
- Compute ***Probability of Systemic Default* (*PSD*)**, i. e. probability that total portfolio loss exceeds ***Systemic Loss Threshold* (*SLT***, given percentage of total sample bank liabilities – we assume 10%[3])
- Compute ***Expected Tail Loss* (*ETL*)** as the expected value of the total portfolio loss given the portfolio loss exceeds *SLT*, i. e. $ETL_t = E\left(L_t \mid L_t > SLT_t\right)$

Notes: 1. Linear gradient between available liability dates is assumed to obtain daily liabilities, 2. Use of credit portfolio model with input parameters estimated from capital market data is inspired by Huang et. al. (2009), 3. Results are also robust for other values.

3. The ESS-Methodology (II/II)

Absolute and relative ESS-indicator

- The ***absolute*** ESS-indicator is obtained as the product of the *PSD* and the *ETL*, i. e.

$$ESS_t = \Pr(L_t > SLT_t) \cdot E\left(L_t | L_t > SLT_t\right) = PSD_t \cdot ETL_t$$

- The ***relative*** ESS-indicator denotes the absolute ESS-indicator divided by the total sample bank liabilities on a given day

Relative contibution of individual institutions

- The ESS-indicator is an ***aggregate measure*** of systemic risk
- ***Relative contribution*** of individual banks to the aggregate systemic risk is also highly relevant, not least from a regulatory point of view
- ***Relative systemic loss (ESS) contribution*** is computed as a bank‘s percentage share of the portfolio loss when portfolio loss exceeds the systemic loss threshold, i. e.

$$c_{i,t} = \sum_{k=1}^{K} \frac{l_{i,t,k}}{L_{t,k}} \quad when \; L_{t,k} > SLT_t$$

4. Data

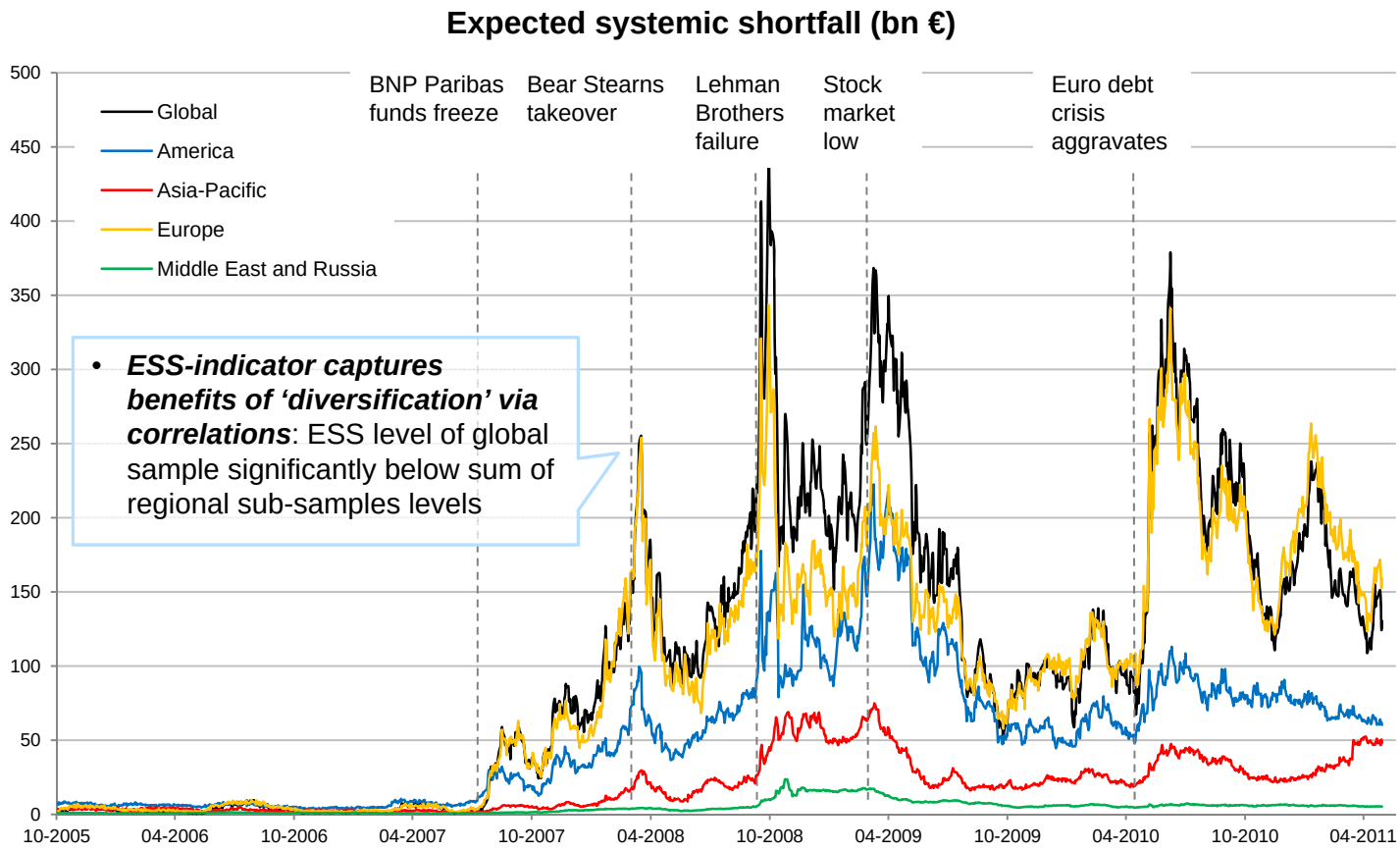
Sample composition

- All banks which meet the ***data availability criteria*** are included in the sample
  - Publicly available equity prices and liability data
  - At least 500 daily CDS spread observations since October 1, 2005
- ***Sample period*** comprises time period between October 1, 2005 and April 30, 2011
- ***Global sample*** comprises 83 banks from 28 countries,
- ***Four regional sub-samples***: American (12 US banks), Asia-Pacific (24 banks), Europe (38 banks), Middle East & Russia (9 banks)

Data sources

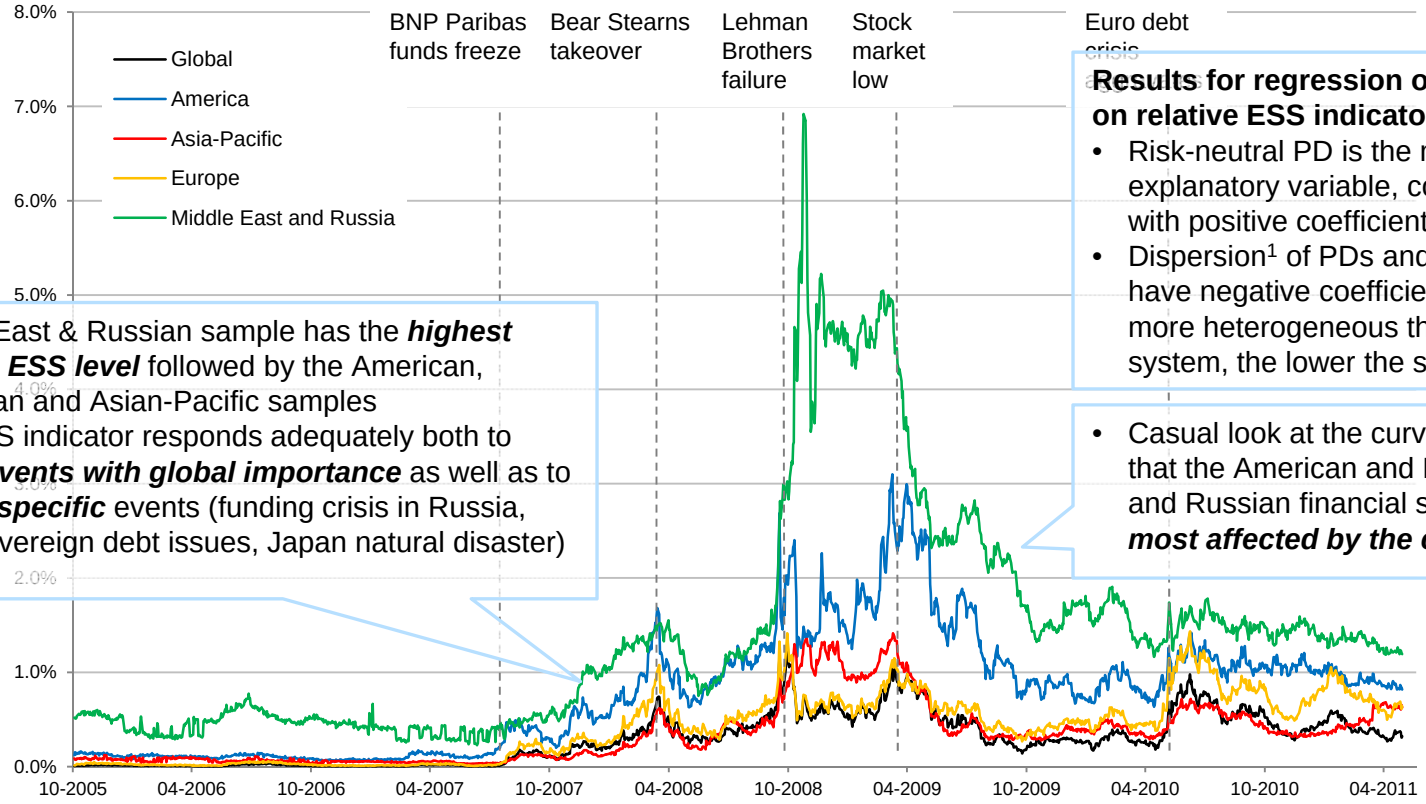
- CDS are obtained from CMA Market Data and Thomoson Reuters
- Equity quotes and other market data from Datastream
- Bank liabilities from Datastream and Worldscope

5. Empirical results - the *absolute* ESS-indicator



5. Empirical results - the *relative* ESS-indicator

Expected systemic shortfall relative to total liabilities



- Middle East & Russian sample has the ***highest relative ESS level*** followed by the American, European and Asian-Pacific samples
- The ESS indicator responds adequately both to ***crisis events with global importance*** as well as to ***region-specific*** events (funding crisis in Russia, Euro sovereign debt issues, Japan natural disaster)

Results for regression of input factors on relative ESS indicator

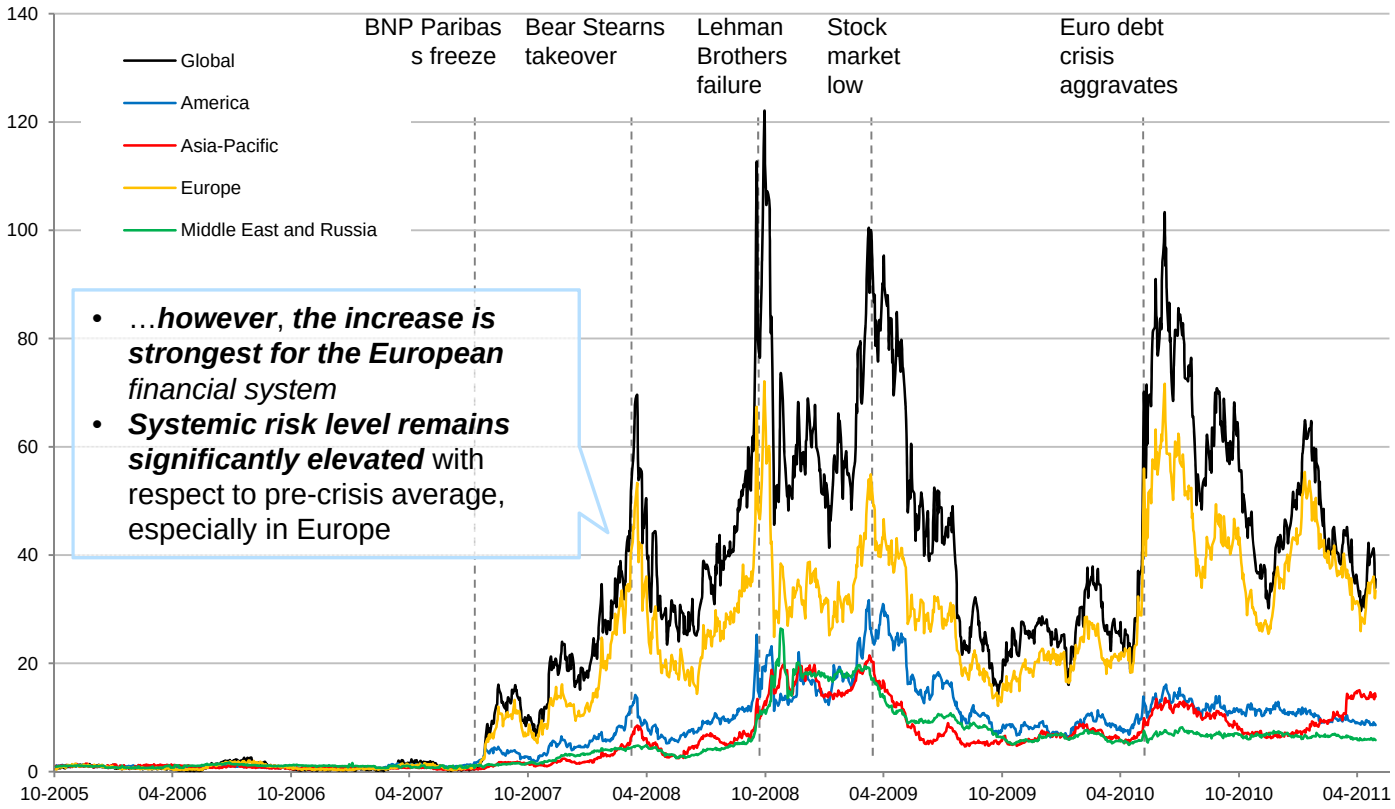
- Risk-neutral PD is the most important explanatory variable, correlations also with positive coefficient
- Dispersion[1] of PDs and correlations have negative coefficients, i. e. the more heterogeneous the financial system, the lower the systemic risk

- Casual look at the curves may suggest that the American and Middle Eastern and Russian financial systems are ***most affected by the crisis***…

Notes: 1. We define dispersion as the standard deviation of the respective variable at a particular point in time.

5. Empirical results - *relative change* of ESS-indicator

Relative change of absolute ESS indicator with respect to initial average



- …***however***, ***the increase is strongest for the European*** *financial system*
- ***Systemic risk level remains significantly elevated*** with respect to pre-crisis average, especially in Europe

5. Empirical results – relative ESS *contribution*

- The ***relative ESS contribution*** of individual banks is ***time-variant*** whereas the ***ranking is relatively constant*** over time
- The bank‘s ***size*** (in terms of total liabilities) is the ***main determinant*** for its relative ESS contribution followed by the bank‘s default probability
- The ***increase of the relative ESS contribution*** in the last 15 months of the sample period is strongest for banks in euro zone countries with sovereign debt issues
- ***Exemplary results*** **for American sub-sample[1]:**

			Relative systemic loss contribution				
No.	Bank name	Country	*Period 1*	*Period 2*	*Period 3*	*Period 4*	*Average*
1	American Express	US	0.8%	1.0%	1.0%	0.5%	0.8%
2	Bank of America	US	17.0%	15.0%	20.7%	27.7%	19.9%
3	Bank of New York Mellon	US	0.5%	1.2%	1.6%	1.4%	1.2%
4	Capital One Financial	US	0.6%	1.4%	1.2%	1.0%	1.0%
5	Citigroup	US	21.3%	25.9%	27.5%	23.1%	24.5%
6	Goldman Sachs	US	9.8%	12.1%	8.3%	5.9%	9.1%
7	JPMorgan Chase & Co.	US	23.0%	15.9%	14.1%	15.1%	17.1%
8	MetLife	US	2.9%	3.4%	5.7%	5.2%	4.3%
9	Morgan Stanley	US	18.5%	17.0%	7.6%	7.3%	12.7%
10	PNC Financial Services	US	0.6%	1.2%	2.0%	1.7%	1.4%
11	US Bancorp	US	1.6%	1.9%	2.3%	2.3%	2.0%
12	Wells Fargo	US	3.3%	3.9%	8.2%	8.8%	6.0%

Notes: 1. Period 1 ranges from October 1st, 2005 to February 28th, 2007, Period 2 ranges from March 1st, 2007 to July 31st, 2008, Period 3 ranges from August 1st, 2008 to December 31st, 2009, Period 4 ranges from January 1st, 2010 to April 30th, 2011.

6. Policy implications

- ***Macroprudential reguluation*** key component in new Basel III regulatory architecture
- ***Special regulatory treatment*** (e. g. bail-in debt, capital sur-charges) ***for systemically important financial institutions*** (SIFIs) envisioned in Basel III
- However, ***approach*** for assessment of systemic importance is ***not yet defined***
- Current ***proposals focus on bank size*** to measure systemic importance
- Based on our empirical findings we suggest the ***use of the relative ESS contribution*** in order to assess systemic importance
- This ***measure incorporates*** a bank‘s ***size*** and also its ***interconnectedness*** and ***overall risk profile*** are reflected as the ESS method is based on capital market data
- Implementation could take place in a ***binary fashion*** by declaring banks systemically important whose relative ESS contribution exceeds a certain threshold (e. g. by setting the ESS contribution threshold at 1% (3%), 23 (12) banks are *globally* syst. import.)
- Alternatively, the ESS contribution could be translated into **a *discrete or continuous measure*** of systemic importance to facilitate differentiation of degrees of systemic importance (e. g. additional measures for banks whose ESS contribution exceeds 3%)

7. Conclusion

- We propose the Expected Systemic Shortfall (ESS) indicator as a measure of systemic risk in the financial system
- The ESS-indicator is the product of the probability of a systemic default event and the expected loss in case this event occurs
- We provide a methodology to determine the relative contribution of individual banks to the aggregate ESS-indicator
- We apply the ESS methodology to a global sample and four regional sub-samples of banks and find that the ESS-indicator responds well to the relevant crisis events
- The ESS-indicator remains at an elevated level at the end of the sample period, particularly for the European sample (likely due to the European sovereign debt issues)
- The relative ESS contribution of individual banking groups is mainly driven by their size, providing a tentative confirmation of the common ‚too big to fail‘ statement
- We contribute to the ongoing discourse concerning the regulation of systemically important financial institutions by suggesting the use of the bank-specific relative contributions to the ESS-indicator as a measure for a bank’s systemic importance
- By applying a relative ESS contribution threshold of 1% to the results for the global sample we find that there are 23 globally systemically important banks

8. Further research questions (work in progress)

1. Inter-regional systemic risk contagion

- Does the systemic risk in one region impact the systemic risk in other regions?
- Specific topics (examples):
  - It is commonly assumed that the financial crisis has spread from the US financial system to other financial systems. Is this perception supported by the data[1]?
  - Does the sustained systemic risk increase in the European financial system impact other financial systems?

2. Systemic risk vs. non-bank Corporate sector credit and equity contagion

- Does systemic risk impact non-bank corporate sector CDS and equity (as suggested by the definition of systemic risk)?
- Are there differences regarding the impact of systemic risk on the non-bank corporate sector between regions and industries?

3. Sovereign risk and systemic risk interdependencies

- Does intra-region sovereign risk impact systemic risk (or maybe even vice versa: e.g. due to the impact of financial stability measures on state deficits)?
- Are there inter-regional spill-over effects from sovereign risk to systemic risk?

To be analyzed for all topics: Has the crisis changed the direction or magnitude of the above systemic risk causality relations?

Link to paper on SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1906682

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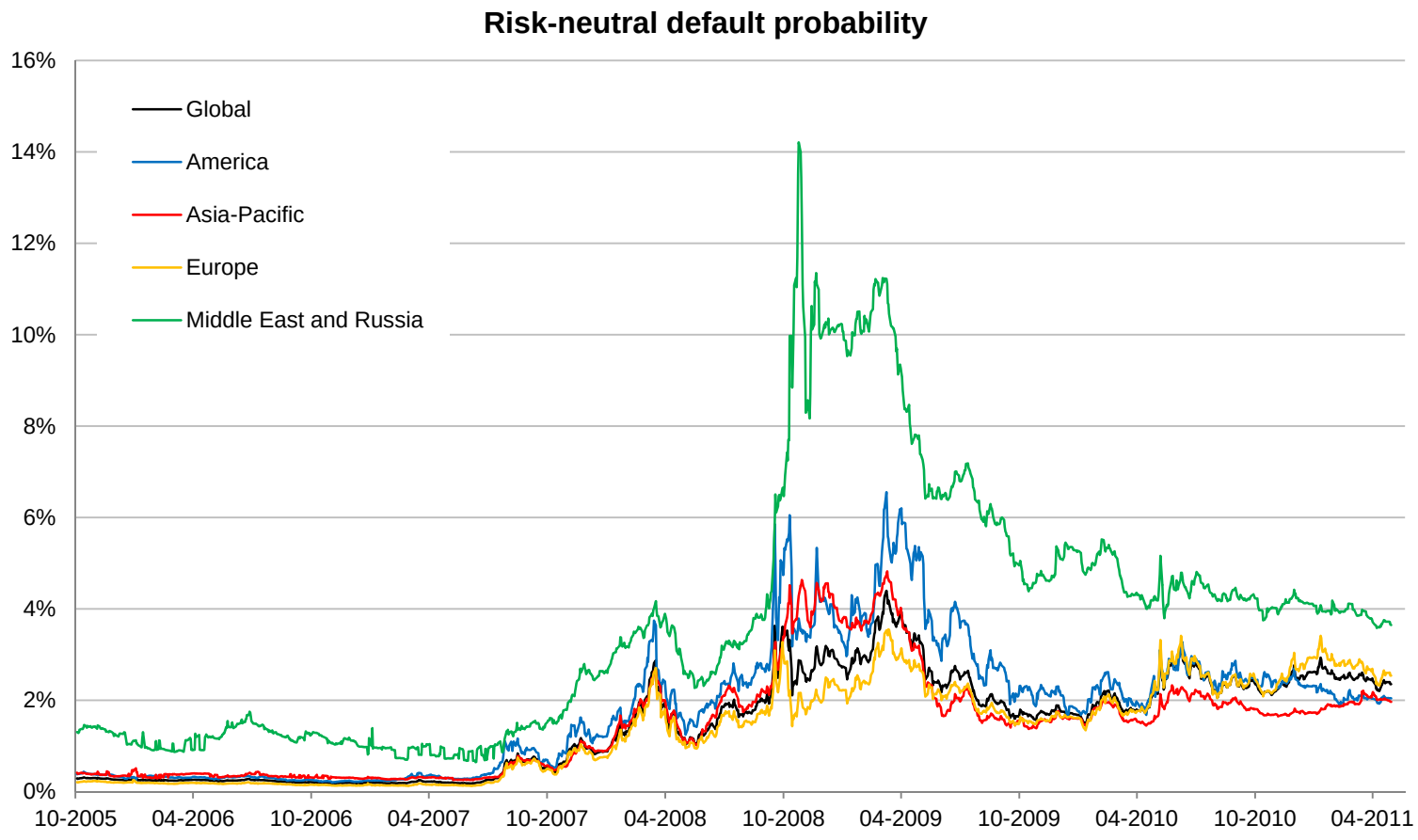
4. Data: Risk-neutral default probabilities



Notes: The panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities).

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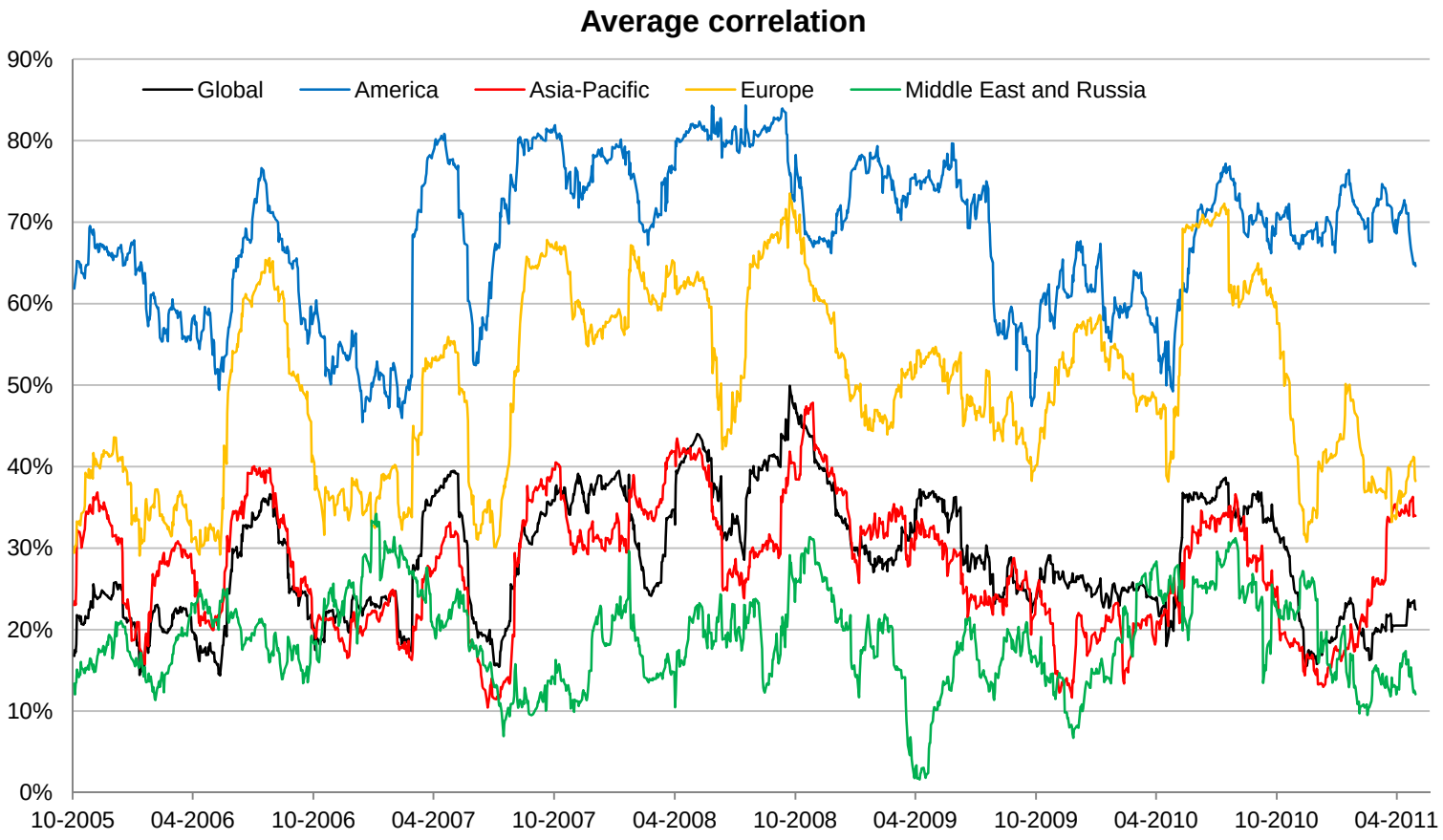
4. Data: Average correlation



Notes: The panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities).

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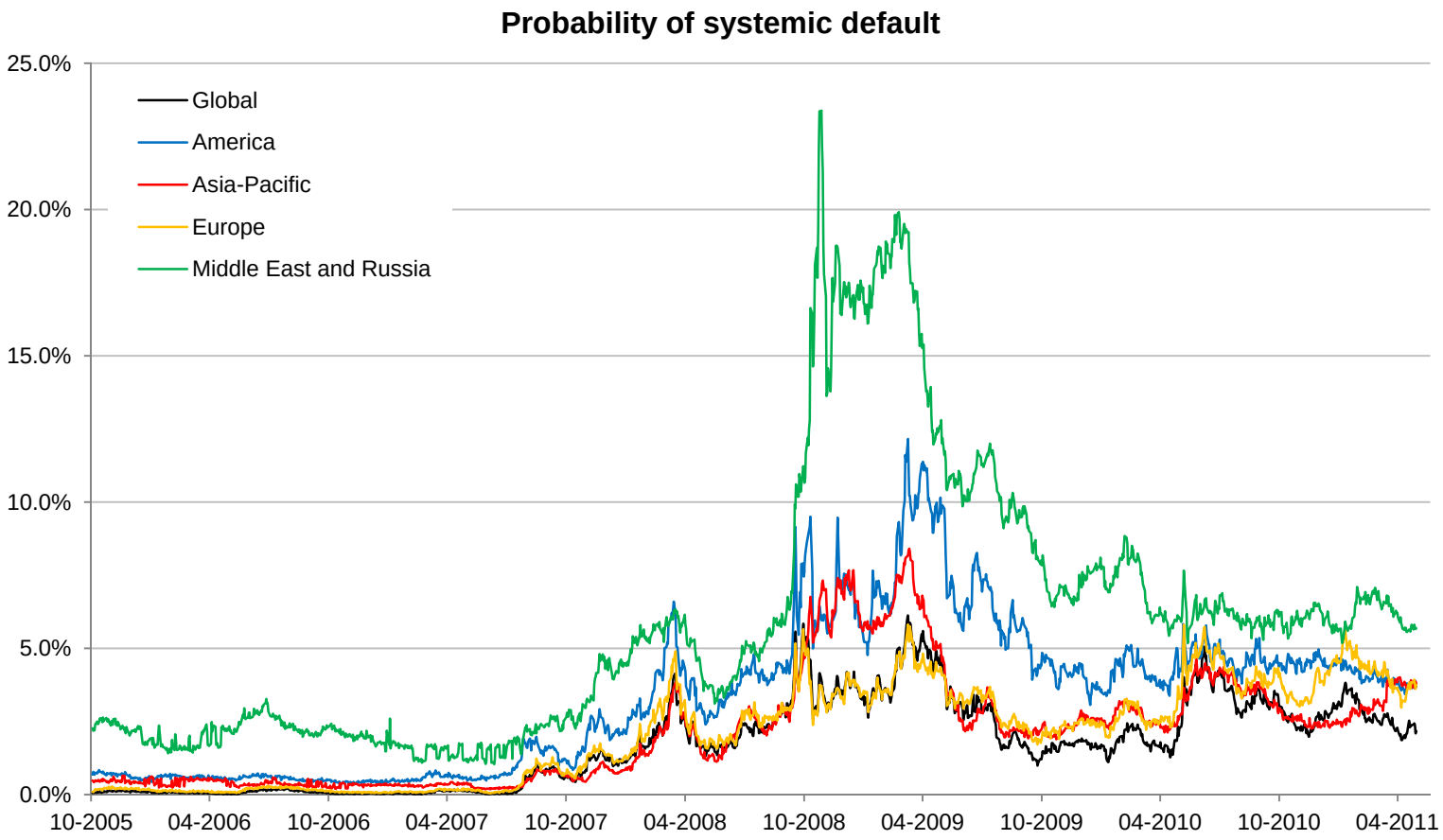
5. Empirical results: Probability of systemic default



Notes: The panel shows the probability of systemic default (PSD) in the respective samples over time. The PSD is one factor of the ESS indicator.

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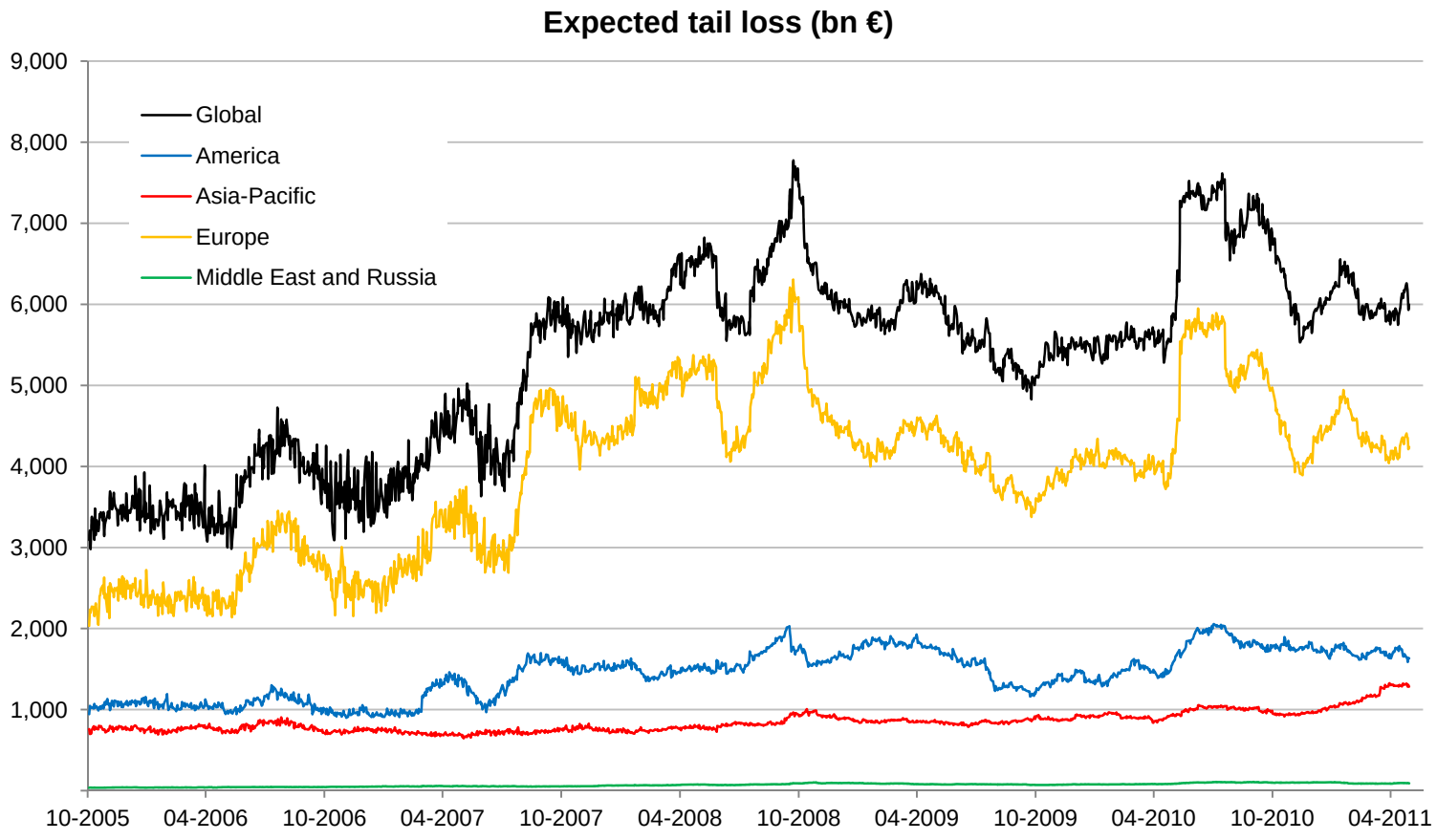
5. Empirical results: Expected tail loss



Notes: The panel shows the expected tail loss (ETL) in the respective samples over time. The ETL is one factor of the ESS indicator.