# MEASURING SYSTEMIC RISK AND ASSESSING SYSTEMIC IMPORTANCE IN GLOBAL AND REGIONAL FINANCIAL MARKETS USING THE ESS-INDICATOR

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**Abstract**

In this paper we propose a measure of systemic risk in the financial sector, the Expected Systemic Shortfall (ESS) indicator. The ESS-indicator is the product of the probability of a systemic default event and the expected tail loss in case this systemic event occurs. We compute the ESS-indicator using a credit portfolio simulation whose input parameters we estimate from market CDS spreads and equity return correlations. Also, a methodology for computing the relative systemic risk contributions of individual banks using the ESS-indicator is provided.

We apply the ESS methodology to a global sample of 83 international bank holding companies as well as to four regional bank sub-samples. Our empirical results show that the ESS-indicator responds adequately to both the financial crisis events with global importance and to the specific events in the regional sub-samples. The ESS-indicator reaches its peak in September 2008 and remains at an elevated level at the end of the sample period for all samples and particularly for the European sub-sample.

The relative systemic risk contribution of individual banking groups is mainly driven by their size, corroborating 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 relative systemic risk contributions to the ESS-indicator as a measure for a bank's systemic importance. By applying a systemic risk contribution threshold of one percent, our empirical results show that there are 23 globally systemically important banks.

**Keywords:** Systemic risk, global financial sector, systemically important financial institutions (SIFIs), expected systemic shortfall (ESS) indicator, too big to fail, financial crisis, European sovereign debt (Euro) crisis

**JEL classification:** G17, G20, G21, G28

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# 1 INTRODUCTION

In the ongoing overhaul of global banking regulation by the Basel Committee on Banking Supervision in the framework of 'Basel III', an approach for the identification and regulation of *systemically important financial institutions (SIFIs)* in the global financial system is yet pending. The regulation of SIFIs is a relevant aspect because these institutions may benefit from implicit government bailout guarantees as their failure would cause a *systemic event* with disruptions not only to financial markets but also to the economy at large. *Systemic risk* in the financial sector is an associated concept whose relevance has been exposed during the financial crisis and denotes the likelihood of the occurrence of a systemic event. One guiding principle in the elaboration of the new banking regulatory architecture is, therefore, the concept of macroprudential regulation which complements the microprudential or institution-level regulation by a system-wide dimension with the objective of mitigating systemic risk and ensuring efficient incentives for SIFIs.

While systemic risk and systemic importance are omnipresent notions in the current discourse on banking regulation, there is so far no agreement on the concepts for their measurement. Approaches for the measurement of *aggregate* systemic risk in the financial sector have been suggested by Lehar (2005) and Huang/Zhou/Zhu (2009). Huang/Zhou/Zhu (2010a) and IMF (2009) suggest methodologies to determine also the systemic importance of *individual* institutions.

In this paper we propose the 'expected systemic shortfall' (ESS) indicator which facilitates both the measurement of systemic risk in the aggregate financial sector *and* can be used to determine a bank's relative systemic risk contribution as a measure of its systemic importance. The ESS indicator is computed using a credit portfolio simulation model whose input parameters are estimated from market CDS spreads and equity return correlations. The indicator represents the product of the probability of a systemic default event and the expected loss when this systemic event occurs.

In related research work, Huang/Zhou/Zhu (2010a) and Huang/Zhou/Zhu (2010b) analyze systemic risk and systemic importance for the Asian-Pacific and US financial systems, respectively. However, a truly *global* analysis of systemic financial sector risk *and* systemic importance of banks is not available as of yet. Moreover, there is also no published research providing a comparison of the financial crisis impact on different regions using a standardized approach. In this paper we fill these gaps by applying our ESS methodology to a *global sample* of 83 banking groups as well as to *four regional sub-samples* comprising America, Asia-Pacific, Europe as well as Middle East and Russia in the period between October 2005 and April 2011. To the best of our knowledge, this is the most comprehensive analysis of systemic financial sector risk conducted so far.

We find that the ESS indicator of all samples reacts adequately to the financial crisis events with global importance and that the results for the regional sub-samples also capture appropriately the specific regional financial market events. The aggregate ESS indicator is mainly determined by average default probabilities whereas the relative systemic risk contributions by individual banks are primarily driven by the bank's size, corroborating the common 'too big to fail' statement. Moreover, the ranking of the relative systemic risk contributions by the sample banks is relatively stable over time.

The remainder of this paper is organized as follows. In Chapter 2 we review the literature on systemic risk measurement. We derive the ESS-indicator and the computation of the relevant input parameters in Chapter 3. The data used in the empirical analysis is outlined in Chapter 4 and the empirical results are elaborated in Chapter 5. We outline the regulatory policy implications in Chapter 6 and conclude in Chapter 7.

## 2 LITERATURE REVIEW

Approaches for the measurement of systemic risk and the assessment of systemic importance in the financial sector have been developed even before the financial crisis. The importance of this subject has grown significantly due to the recent financial crisis which is reflected in the sustained growth of literature on this topic. The approaches for the measurement of systemic risk can be classified with respect to the underlying data used: financial statement-based measures, exposure-based network models and measures based on capital market data.

The first type of approaches for the measurement of systemic risk uses financial statement data such as the share of non-performing loans, profitability, liquidity and capital adequacy measures. The disadvantages of this approach are that financial statement data are available only with a relatively low frequency, are published only with a substantial delay and information in financial statements is backward-looking despite IFRS accounting.[1] Drehmann/Tarashev (2011) find that while market data and model based approaches are usually favorable, 'simple indicators' based on financial statement and regulatory data (such as bank size, interbank borrowing and lending) can offer a handy approximation in the assessment of systemic importance.

Network models usually rely on mutual bank exposure data and model the direct connections among the banks to simulate the effects of a systemic event on the banks within the network. IMF (2009) and Espinosa-Vega/Sole (2010) apply a network model using the mutual bank exposures and the bank equity to model the effects of an initial default of one of the network banks on the other banks in the system. The systemic importance of a bank is derived based on the cumulated capital impairments which its initial default causes in the system.[2] Pokutta/Schmaltz/Stiller (2011) develop a similar network model that also facilitates the derivation of optimal bail-out strategies. As network models are usually based on confidential exposure data, their application is reserved for regulatory authorities and will – for the time being – be limited to the application within a country due to confidentiality restrictions. Besides, the required data are available only with a relatively low frequency.[3]

Systemic risk measurement approaches based on capital market-data have three key advantages vis-à-vis measures based on balance sheet and exposure data: they can be updated

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[1] See Huang/Zhou/Zhu (2009), p. 2036-2037.

[2] An extension of the model considers the effects of lost funding sources and consequent fire sales.

[3] E. g. the large exposure reporting in the European Union is carried out on a quarterly basis.

more frequently (usually daily), are forward-looking by nature and can be implemented by all interested parties. These approaches are described in the following.

Lehar (2005) computes the probability of default of several financial institutions as a measure for aggregate systemic risk based on the asset return correlations which are estimated using the Merton (1974) credit risk model. Chan-Lau/Gravelle (2005) and Avesani/Pascual/Li (2006) consider the banks in the sphere of competence of a regulator as portfolio and compute the probability of default of *n* portfolio banks (*n*th-to-default probability) as measure of systemic risk in the portfolio. Billio et al. (2010) analyze the correlations and dependencies prevailing in equity returns of different financial institutions in order to derive the systemic risk caused by these institutions. Kim/Giesecke (2010) use Moody's US default data together with capital market parameters[4] to derive an aggregate systemic risk measure and its term structure.

While the above market data based approaches can be used to measure *aggregate* financial sector risk, they are not appropriate to assess systemic importance. To this end, Acharya et al. (2010) measure systemic risk using the "systemic expected shortfall" (SES) measure which they define as the probability of an individual bank being undercapitalized when the whole system is undercapitalized. Adrian/Brunnermeier (2008) examine the systemic importance of banks based on equity data using the "Conditional Value at Risk" (CoVaR) metric which measures the value at risk of the whole financial system when one of the financial institutions experiences a distress situation. CoVaR can be used to assess the systemic importance of individual banks whereas it *cannot* be aggregated to measure aggregate systemic risk.

Huang/Zhou/Zhu (2009) employ a credit portfolio risk model using equity return correlations and CDS spreads to compute a risk-neutral measure of *aggregate* systemic risk, the distress insurance premium (DIP) for the US financial system. This measure represents the hypothetical insurance premium against the losses of a certain share of the total banking sector liabilities. Huang/Zhou/Zhu (2010a) extend the DIP approach by a methodology to determine the marginal DIP contribution of individual institutions which facilitates the assessment of systemic importance and apply it to the Asian-Pacific banking system. Huang/Zhou/Zhu (2010b) employ the same approach in analyzing the US financial sector.

The use of a credit portfolio simulation approach based on capital market data to derive the aggregate expected systemic shortfall (ESS) indicator in this paper was inspired by

[4] Inlcuding S&P 500, TED spread, the US yield curve.

Huang/Zhou/Zhu (2009). There are, however, three important differences between the two approaches. Firstly, we define the systemic default event as a portfolio loss of the sample bank liabilities which exceeds a percentage of the total liabilities of the *sample banks* whereas Huang/Zhou/Zhu (2009) define the loss threshold relative to the *total banking sector* liabilities. This difference makes our approach also appropriate for banking systems in which a major portion of the banks is not exchange-listed. Secondly, we derive the ESS-indicator in a transparent manner using standard measures from financial institutions risk management which facilitates the application of our indicator by other parties. Thirdly, the relative systemic risk contributions in our ESS methodology are also computed in a transparent fashion as byproduct of our credit portfolio simulation as opposed to using an additional importance sampling procedure as in Huang/Zhou/Zhu (2010a) and Huang/Zhou/Zhu (2010b) which facilitates the use of our methodology as an intuitive measure of a bank's systemic importance.

Apart from the methodological enhancements in systemic risk measurement, this paper also contributes on the empirical side as it is the first truly global analysis of systemic financial sector risk which also accounts for regional differences by separately analyzing four regional sub-samples. Previous work in this area has so far focused only on individual regions or countries. Due to the global perspective in the present paper we also to contribute to the ongoing discourse on the identification and regulation of systemically important financial institutions as our results can be used to identify those banks which are systemically important on a global scale.

# 3 THE ESS METHODOLOGY

In this chapter we describe the methodology of the ESS-indicator. In deriving our indicator we follow the approach by Huang/Zhou/Zhu (2009) and construct a hypothetical credit portfolio comprising the total liabilities of the banks in the sample and estimate the two key determinants for the credit portfolio risk, the asset return correlations and the default probabilities from capital market data. Based on these inputs we use an asset value model of portfolio credit risk in a Monte Carlo simulation to model the portfolio losses over time. The resulting loss distribution is used to derive the ESS-indicator as an aggregate measure of systemic risk. We also provide a methodology to determine the relative ESS contributions of individual institutions.

## 3.1 Estimating asset return correlations from equity returns

In order to model the default correlations of assets in a credit portfolio there are two predominant procedures. The first uses historical default data and is described in Jarrow (2001), Das et al. (2007) and Duffie et al. (2009), amongst others. While being theoretically appropriate, this procedure may result in severe estimation errors in practice as defaults are rare events, especially for high-rated obligors, such as major banking groups.[5]

The second approach uses credit or equity market data to estimate the default correlations indirectly by interpreting equity as a call option and debt as a put option on the underlying firm's assets as described in Merton (1974). The correlations of the market equity returns (or CDS spreads) of the firms under research are thus used as proxy for the asset return correlations. Tarashev/Zhu (2008b) obtain the asset return correlation by means of CDS spreads, Moody's Global Correlation model estimates the underlying asset value from equity market data and balance sheet parameters before calculating the asset return correlations, Hull/White (2004) suggest to use equity return correlations as proxy for asset return correlations for practical implementations.

In this paper we use the second approach and follow the suggestion by Hull/White (2004) to estimate the asset return correlations from the equity return correlations. Correlations derived from equity returns benefit from the high liquidity of exchange-traded equity shares which – under ideal market conditions – ensures that changes in the firm's default risk or overall

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[5] See Huang/Zhou/Zhu (2009), p. 2038.

market conditions are incorporated instantaneously in the firm's equity market price. The rationale for employing equity return correlations as proxy for the asset return correlations results from the fact that under constant firm leverage the asset and equity return correlations are equal.[6]

As the assumption of constant leverage is more likely to hold in the short-run, we estimate the correlations based on the equity returns from the past 50 trading days whereby we construct the symmetrical matrix of the pairwise equity return correlations of the banks under research for each day during the observation period. This correlation estimation methodology ensures that only the equity returns from a defined period of time are included in the correlation estimation so that the constant-leverage assumption at least approximately tends to hold.[7]

## 3.2 Calculating risk-neutral probabilities from CDS spreads

We estimate the other relevant determinant of portfolio credit risk, the probability of default (PD), from single-name credit default swap (CDS) spreads. A CDS is a contract which provides insurance against the default of a reference entity in exchange for a continuous payment of the CDS spread on the underlying notional value. The CDS market has grown substantially particularly since the turn of the millennium and CDS spreads are considered to be better measures of credit risk than bond spreads (see e.g. Longstaff/Mithal/Neis (2005) and Forte/Pena (2009)) or loan spreads (see e.g. Norden/Wagner (2008)).

Under the standard assumption that the present value of the indemnification payments in case of default (numerator of the subsequent equation) equals the present value of the CDS insurance payments (the denominator), the market CDS spread $s_{i,t}$ of bank $i$ can be written as

$$s_{i,t} = \frac{LGD_{i,t} \cdot \int_t^{t+T} e^{-r_\tau \tau} q_{i,\tau} d\tau}{\int_t^{t+T} e^{-r_\tau \tau} \left(1 - \int_0^\tau q_{i,u} du\right) d\tau} \tag{1}$$

where $LGD_{i,t}$ is the expected loss given default used in the pricing of the CDS, $r$ is the risk-free rate of return, $q_{i,\tau}$ denotes the annualized risk-neutral default intensity and $1-\int_0^\tau q_{i,u} du$ denotes the risk-neutral probability of survival of bank $i$ over the following $\tau$ years. By

[6] The derivation for this rationale is provided in Appendix 1.

[7] Huang/Zhou/Zhu (2009) use high-frequency equity return data to estimate correlation *forecasts* over periods of up to three months. High-frequency equity return data was not available for the present analysis.

assuming that the recovery rates are uncorrelated with the default rates and that both the risk-free and the default intensity term structures are flat, Duffie (1999) and Tarashev/Zhu (2008b) obtain the risk-neutral default probabilities $PD_{i,t}$ as

$$PD_{i,t} = \frac{a_t \cdot s_{i,t}}{a_t \cdot LGD_{i,t} + b_t \cdot s_{i,t}} \tag{2}$$

where $a_t \equiv \int_t^{t+T} e^{-r\tau} d\tau$ and $b_t \equiv \int_t^{t+T} \tau e^{-r\tau} d\tau$.[8] A flat default intensity term structure is also assumed in the subsequent analysis which is not necessarily given at any time in reality but has become standard practice among practitioners and researchers.[9]

It is important to take account of the fact that the resulting default probability is a *risk-neutral* measure. This means that it contains not only the *physical* default probability but also premium components such as the credit default risk premium and the liquidity risk premium. As the ESS indicator is computed using these risk-neutral PDs, the indicator also contains a combination of these components and is, consequently, also a risk-neutral measure. As there is no persuasive quantitative approach to decompose the individual components embodied in the risk-neutral PDs, one needs to rely on the commonly accepted observation that the increases in CDS spreads during the financial crisis can be attributed mainly to increases in the default and liquidity risk premium components. This observation is supported by the only slight increase of actual default rates during the financial crisis which suggests that the increase of CDS spreads in this time period resulted mainly from increased risk aversion and uncertainty with respect to the adequate height of default and liquidity risk premiums.[10] We further analyze the risk premium determinants of the ESS-indicator in section 5.2.

Another feature of the resulting default probability is that it is – similarly as the above equity return correlations –a market-based *forward-looking* measure in the sense that it contains an average of the default probability during the life of the CDS. In that respect it stands in clear contrast to backward-looking measures based e. g. on financial statement data, which only state what *has* occurred in the past as opposed to what *will* occur in the future.

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[8] See Tarashev/Zhu (2008b), pp. 6-7 and Huang/Zhou/Zhu (2010b), pp. 5-6.

[9] By comparing one and five year CDS spreads Huang/Zhou/Zhu (2009)come to the conclusion that there is no empirical evidence against this assumption.

[10] See Huang/Zhou/Zhu (2009), p. 2038.

## 3.3 Constructing the systemic risk indicator

The estimated equity return correlations and risk-neutral default probabilities are used as inputs for the Monte Carlo simulation using the single-risk-factor portfolio credit risk methodology of Gibson (2004) and Tarashev/Zhu (2008a), which we apply to the hypothetical credit portfolio comprising the total liabilities of the sample banks to obtain our expected systemic shortfall indicator. The methodology is elaborated in the following.

We assume that the asset values of the sample banks are characterized by the Vasicek (1987) single-risk-factor model, which postulates that a firm defaults when its assets fall below a certain threshold and that the asset values are determined by a single common risk factor:

$$V_{i,T} = \rho_i M_T + \sqrt{1-\rho_i^2} \cdot Z_{i,T} \tag{3}$$

where $V_{i,T}$ denotes the asset value of bank $i$ at time $T$, $M_T$ is the common risk factor and $\rho_i$ represents bank $i$'s exposure to the common factor. $Z_{i,T}$ denotes the idiosyncratic factor of bank $i$. The correlation between banks $i$ and $j$ is consequently given by $\rho_i \rho_j$.[11] In order to facilitate the model's implementation, we follow standard practice and assume that the common risk factor follows a *standard normal distribution* so that the default threshold of bank $i$ contingent on the realization of the common factor $M_T$ can be shown to equal $\Phi^{-1}\left(PD_{i,T}\right)$ where $\Phi^{-1}$ denotes the quantile of the standard normal distribution.[12]

In order to implement the Monte Carlo simulation for the $N$ banks in the sample we first estimate the symmetrical $N \times N$ correlation matrix $P_t$ and compute the $1 \times N$ vector of the 1-year risk-neutral default probabilities $PD_t$ for every day $t$ in the sample period. We then draw a $1 \times N$ vector $Y_t$ of standard-normally distributed variables whose correlation matrix is $P_t$. This procedure is repeated for $K$ simulation iterations, resulting in a $K \times N$ matrix of correlated normally distributed sample values for each day in the sample period.

A default for bank $i$ at the end of the one-year period under consideration occurs when the sampled value is below the default threshold, i. e. $Y_{i,t} < \Phi^{-1}\left(PD_{i,t}\right)$. When default occurs for bank $i$, we sample a LGD from a symmetrical triangular distribution with a mean of 0.55 in

[11] See Vasicek (1987), pp. 1-2.

[12] See Tarashev/Zhu (2008a), pp. 135-137.

the range [0.1, 1] which is a widely-used distribution assumption for LGDs.[13] Multiplying this sample LGD with the total liabilities of bank $i$ outstanding on day $t$ results in the corresponding loss $l_{i,k,t}$ of bank $i$. Summing over the losses of all $N$ banks in a particular simulation iteration $k$, we obtain the total portfolio loss $L_{k,t}$ which we use to construct the portfolio loss distribution $\Lambda_t$ for each observation day $t$.

We define the 'systemic loss threshold' (SLT) as a share of the total liabilities of the sample banks. When the total portfolio loss $L_{k,t}$ exceeds the $SLT_t$ we assume the occurrence of the systemic default event. We interpret this event as a situation in which the stability of the financial system is severely endangered due to the default of a substantial share of the bank liabilities in the system. In our analysis we assume the relative systemic loss threshold as 10 percent, i. e. $SLT^{rel} = 10\%$.[14] We define the 'probability of systemic default' (PSD) as the probability of the occurrence of the systemic default event, i. e. $\Pr\left(L_t > SLT_t\right)$, which we obtain from the portfolio loss distribution $\Lambda_t$ for each day $t$ in the sample period.

From the portfolio loss distribution $\Lambda_t$ we further derive the expected tail loss (ETL), which we define as the expected value of the total portfolio loss given that the portfolio loss exceeds the systemic loss threshold, i. e. $ETL_t = E\left(L_t | L_t > SLT_t\right)$. This definition is consistent with the common definition of expected shortfall in the financial risk management literature.

We obtain our expected systemic shortfall indicator by multiplying the probability of systemic default by the expected tail loss:

$$ESS_t = \Pr(L_t > SLT_t) \cdot E\left(L_t | L_t > SLT_t\right) = PSD_t \cdot ETL_t \tag{4}$$

The interpretation of the ESS-indicator is straightforward: it represents the product of the probability of a severe default event in the financial system multiplied by the expected value of the losses in case this default event materializes. It is also possible to evaluate the PSD and ETL individually in order to understand the drivers of the overall ESS measure. Furthermore

[13] See Tarashev/Zhu (2008a), pp. 145-146. In a robustness check exercise we use a Beta distribution for the LGD as suggested by Loeffler/Posch (2010).

[14] We also used 5% and 15% as relative systemic loss thresholds and find that the ESS over time shows the same trajectory as for 10% albeit – of course – on a different level. The definition of the relative SLT depends on the specific application.

we also compute the *relative* expected systemic shortfall indicator by dividing $ESS_t$ by the total liabilities of the sample banks outstanding at time $t$.

The ESS-indicator is an *aggregate* measure of systemic risk in the financial system accounting for *all* sample banks. However, it is also important to understand the relative contribution of *individual* banks to the aggregate systemic risk as macroprudential measures need to be introduced at the level of the individual institution. To this end we compute the relative systemic loss contribution[15] $c_{i,t}$ of bank $i$ when the total portfolio loss $L_{t,k}$ exceeds the systemic loss threshold in a simulation iteration. Summing over all $K$ iterations yields the contribution of each bank to the systemic risk indicator on sample day $t$

$$c_{i,t} = \sum_{k=1}^{K} \frac{l_{i,t,k}}{L_{t,k}} \; when \; L_{t,k} > SLT_t \tag{5}$$

Calculating this measure over the whole sample period results in the systemic risk contribution $c_i$ of bank $i$ which can be evaluated either by considering individual banks or groups of banks (e. g. all banks from a specific country).

### 3.4 Comparison with other indicators of systemic risk

While the usage of a credit portfolio approach and the estimation of its input parameters from capital market data to measure systemic risk was inspired by Huang/Zhou/Zhu (2009), there are a few, but important differences to the distress insurance premium (DIP) indicator developed in their paper. Huang/Zhou/Zhu (2009) assume the systemic loss threshold (SLT) as a percentage of the total liabilities of the *banking system*. While this may be adequate for the US banking system, where most relevant banks are exchange-listed (and consequently the sample banks' liability portfolio covers a larger share of the total banking system liabilities), it would be inappropriate for countries where a significant number of banks are not listed as is the case in many European countries.[16] Therefore, we define the SLT as a share of total liabilities of the *sample banks* in our analysis.

The DIP-indicator measures the cost of insurance against distress losses in excess of the SLT. While the computation methodology is not stated expressly by the authors, we conjecture that

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[15] In the subsequent elaboration we will refer to the (relative) systemic loss contribution also as (relative) systemic risk contribution and (relative) ESS contribution.

[16] The importance of state banks ("Landesbanken") in Germany but also the savings banks in several European countries supports this statement.

the DIP-indicator is computed by discounting the expected portfolio loss in excess of the SLT. As we derive our ESS-indicator using standard measures from financial institution risk management, it may have certain advantages in terms of transparency and usability vis-à-vis the DIP-indicator. Besides, Huang/Zhou/Zhu (2009) consider a three-month time horizon while we compute the portfolio loss at the end of a one-year time period. The relative contributions to the ESS measure are computed in a transparent fashion as byproduct of our credit portfolio simulation as opposed to an auxiliary importance sampling procedure in Huang/Zhou/Zhu (2010a) which facilitates the application of our methodology to measure the systemic importance of individual institutions.

Moreover, we compute the ESS measure for *each day* during the observation period which ensures that the indicator can respond immediately to financial market events. By contrast, Huang/Zhou/Zhu (2009), Huang/Zhou/Zhu (2010a), Huang/Zhou/Zhu (2010b) compute the DIP measure only on a *weekly* basis which leads to some delay in the indicator's response to financial market events. However, this is no drawback of the DIP per se but rather a disadvantage of the chosen implementation.

An important similarity is that both the DIP and the ESS-indicator are *risk-neutral* measures as they are derived from risk-neutral default probabilities obtained from market CDS spreads. This is also a distinguishing feature with respect to other measures of systemic risk described in the following. Besides, both the DIP and the ESS-indicator are coherent risk measures according to the definition by Artzner et al. (1999).

The systemic expected shortfall (SES) of Acharya et al. (2010) considers the probability of an individual bank to be undercapitalized when the system as a whole is undercapitalized. The marginal expected shortfall of individual banks is obtained by computing the expected loss of individual banks when the whole system is in distress. The SES-indicator is derived using equity market data, whereas the most important input for the ESS-indicator are CDS spreads which by construction are better predictors of credit risk.[17] The SES measure is also a coherent risk measure but differs from the ESS-indicator in that it defines the distress case as percentile of the portfolio loss distribution, whereas we define it as percentage of the sample banks' total liabilities.

The Adrian/Brunnermeier (2008) CoVaR measure computes the value at risk of the financial system conditional on one bank being in distress. Our ESS measure takes the opposite

[17] See Longstaff/Mithal/Neis (2005), pp. 2216-2217.

approach by considering the contribution of an individual bank when the system as a whole is in distress. CoVaR can be used to determine the systemic importance of individual institutions, whereas it cannot be aggregated to measure the level of aggregate systemic financial sector risk. The CoVaR measure suffers from the general shortcomings of VaR-based measures as it is not a coherent measure of risk.

# 4 DATA

The methodology described in the previous chapter can in principle be applied to any portfolio of companies with publicly traded equity and CDS. As the focus of this paper is the analysis of systemic risk in the global financial system and regional sub-systems, we select bank holding companies according to the following data availability criteria: (I) at least 500 daily CDS spread observations are available since October 1st, 2005, (II) publicly available equity prices, (III) publicly available liability data. By applying these data availability criteria we obtain a global sample of 83 banks from 28 countries covering the following four regional sub-samples: America (12 banks), Asia-Pacific (24 banks), Europe (38 banks), Middle East and Russia[18] (9 banks). The sample period ranges from October 1st, 2005 until April 30th, 2011.

We compute equity returns from equity market prices provided by Thomson Datastream in order to estimate the equity return correlations. CDS spreads are obtained from CMA Market Data and Thomson Reuters using the mid-spread of the 5-year senior unsecured CDS spread to compute the corresponding risk-neutral default probabilities. As the LGDs used by market participants for pricing the CDS are not available in these databases we assume a LGD of 55% to compute the risk-neutral default probabilities. Total liabilities of the sample bank holding companies are obtained from the Thomson Worldscope database. A linear gradient is assumed between available liability dates to obtain the amount of total liabilities per day during the observation period.

We conduct the analysis both for the global sample, i. e. for all 83 banks, as well as for the four regional sub-samples individually which is also reflected in the subsequent elaboration: we first describe the data for the global sample and then proceed with the individual sub-samples before conducting a comparative analysis between the individual samples. The elaboration is structured in a way that the reader can also focus on specific samples only without loss of continuity.

## 4.1 Global financial system

The lower panel of Table 1 shows the 28 countries of the banks in the global sample as well as the total liabilities of the sample banks per country and their average (liability-weighted)

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[18] We summarize these two regions as one 'region' as neither of them could be unambiguously allocated to any of the other regions and because they are individually too small in terms of available sample data.

CDS spreads. The total liabilities of the banks covered in the analysis amount to 35.8 trillion EUR with an average of 1.3 trillion EUR per country. The countries with the highest total bank liabilities are France, Germany, Switzerland, the United Kingdom and the United States. During the four sub-periods of the sample period – 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 – the average liability-weighted CDS spread of all banks increases from 13 basis points to 139 basis points. In Period 4 the countries with the highest average bank CDS spreads are Greece, Ireland, Kazakhstan and Portugal whereas Denmark, Malaysia, Singapore and Sweden have the lowest bank CDS spreads. The ranking of the countries with respect to their banks' CDS spreads changes over time and the changes from Period 3 to Period 4 reflect particularly the impact of the Euro zone sovereign debt crisis (e. g. the Greek banks' average CDS spread increases more than ten-fold from 72 to 778 basis points).

Table 2 shows the same parameters as Table 1 on a bank level. The total liabilities per bank average 431 billion EUR. The largest banking groups in terms of total liabilities are Barclay's, BNP Paribas, Deutsche Bank and Royal Bank of Scotland. In Period 4 Greece's Alpha Bank and EFG Eurobank, Ireland's Allied Irish Banks and Kazakhstan's Kazkommertsbank have the highest CDS spreads whereas the three Singaporean banks and Sweden's Svenska Handelsbanken have the lowest CDS spreads. The ranking of the banks according to their CDS spreads is time-variant with the biggest changes occurring from Period 3 to Period 4.

Table 3 shows the sample banks' equity return correlations[19] as well as their end-2008 shareholder's equity on a country-level. The total equity of the sample banks adds up to 1.5 trillion EUR with a country average of 54 billion EUR. The countries with the highest average correlation of their sample banks' equity returns are France, Germany, Italy and Switzerland. On a bank level, Barclay's, BNP Paribas, Crédit Agricole and Societé Generale have the highest correlation as shown in Table 4. The evolution of the equity return correlation of the global sample is shown in the lower panel of Figure 1. It averages 24 percent in the period before August 2007. In August 2007 the correlation increases significantly to an average value of 37 percent in the period until November 2008. In addition to the elevated level of the average correlation, the standard deviation of the correlation also increases considerably.

[19] Computed as the mean of the daily pairwise stock return correlations between the respective bank and all other banks.

From December 2008 until April 2010 the average equity return correlation decreases to an average of 28 percent before rising to an average of 33 percent in May 2010. From June 2010 until the end of the observation period average correlations decrease to 26 percent, slightly above the pre-crisis average.

The upper panel of Figure 1 shows the liability-weighted average risk-neutral default probabilities of the banking groups in the global sample during the observation period. Before July 2007 the average risk-neutral default PDs are below 0.5 percent. Following the freezing of three investment funds by BNP Paribas in August 2007 the default probabilities are elevated before reaching a local maximum of 2.9 percent after the takeover of Bear Stearns by JP Morgan in March 2008. In the aftermath of the collapse of Lehman Brothers in September 2008, average risk-neutral PDs reach a second peak at 3.6 percent on September 29th, 2008. Following the financial stability measures in Europe and the United States taken in early October 2008, the default probabilities decline to a lower level before reaching an observation-period maximum of 4.4 percent on March 09th, 2009. After the G20 Summit in London in April 2009, the risk-neutral default probabilities fall again below two percent on average. At the time of the aggravation of the Euro sovereign debt crisis in May 2010 the average PDs increase again sharply and remain at two percent until the end of the observation period which is significantly above pre-crisis levels.

## 4.2 American financial system

The American sub-sample is represented by 12 banks from the United States as no other bank from the American continent met the described data availability criteria. The total liabilities of the American banks amount to 6.9 trillion EUR with an average of 577 billion EUR as shown in Table 1. Table 2 shows that the largest US sample banks in terms of total liabilities are Bank of America, Citigroup and JP Morgan. The average CDS spreads of the American sample increased from 16 basis points in Period 1 to 214 basis points in Period 3 and decreased to 134 basis points in Period 4. The US banks with the highest CDS spreads in Period 4 are MetLife, Morgan Stanley and Citigroup whereas American Express, JP Morgan and Wells Fargo have the lowest CDS spreads.

Table 5 shows the equity as of end-2008 and the average correlations of the American sample banks. In total, the US sample banks have a combined equity of 465 billion EUR with a mean of 39 billion EUR. In Period 4 Bank of America, JP Morgan and Wells Fargo are the banks with the highest correlation. The lower panel of Figure 2 shows the average equity return correlation of the American sub-sample during the observation horizon. From October 2005 until July 2007 the average correlation is 62 percent. During the financial crisis period between August 2007 and July 2009 equity return correlations in the US sub-sample hike to an average of 76 percent and return to a lower level of 59 percent from August 2009 until April 2010. Thereafter, average correlations increase by ten percentage points and maintain this level until the end of the observation period.

The upper panel of Figure 2 shows the liability-weighted average risk-neutral default probabilities of the US sample banks during the observation period. In the period between October 2005 and July 2007 the average risk-neutral default PDs are below 0.5 percent. The default probabilities are significantly elevated as of August 2007 and reach a local maximum of 3.7 percent in March 2008. In the aftermath of the collapse of Lehman Brothers in September 2008, the mean PD of the US sample banks reaches two local maxima on September, 17$^{th}$ 2008 (5.9 percent) and on October, 10$^{th}$, 2008 (6.0 percent). At a level of 6.6 percent the US banks reach their observation-period maximum on March 09$^{th}$, 2009. Thereafter, the average PD decreases to a value of 2 percent in end-April 2010. Afterwards it begins to rise again and reaches a local maximum on June 10$^{th}$, 2010 at 3.3 percent. Until the end of the observation period, the default probability averages 2.3 percent which is the quintuplicate of the pre-crisis average. In addition to the elevated *level* of the PDs during the financial crisis period, the dispersion[20] of the PDs is higher during this period.

## 4.3 Asian-Pacific financial system

The total liabilities of the Asian-Pacific banks amount to 5.2 trillion EUR with an average of 218 billion EUR per bank as shown in Table 1. The Australian, Chinese and Japanese banks have the highest total liabilities in this sub-sample. The average CDS spreads of the banks in the Asian-Pacific sample increase from 19 basis points in Period 1 to 169 basis points in Period 3 before decreasing to 108 basis points in Period 4. In Period 4 the countries with the highest average CDS spreads are China, India and Kazakhstan. The ranking of the countries with respect to their average CDS spreads is rather stable over time. Table 2 shows that Bank of China, Mizuho Financial Group and Sumitomo Mitsui Bank have the highest total liabilities in this sample. The Asian-Pacific banks with the highest CDS spreads in Period 4

[20] We measure dispersion as the standard deviation of all observations at a particular point in time.

are India's ICICI Bank as well as Kazakhstan's Halyk Bank and Kazkommertsbank whereas the three Singaporean sample banks have the lowest CDS spreads.

Table 6 shows the end-2008 equity and the average correlations of the Asian-Pacific sub-sample on a country and bank level. Together the Asian-Pacific banks have a combined equity of 264 billion EUR with a mean of 11 billion EUR. In Period 4 the countries with the highest average correlation are Australia, Korea and Singapore. On a bank-level Australia's Commonwealth Bank, Macquarie Bank and National Australia Bank and Korea's Kookmin Bank have the highest average correlation. The equity return correlation of the Asian-Pacific sub-sample banks during the sample period are shown in the lower panel of Figure 3. The average correlation is 26 percent in the period between October 2005 and June 2007. During the crisis period between July 2007 and July 2009 equity return correlations increase to an average of 33 percent. From August 2009 until the end of the observation period, the average correlations decrease to 24 percent which is even below the pre-crisis average.

The average risk-neutral default probabilities of the banks from the Asia-Pacific region during the observation period are shown in the upper panel of Figure 3. Before August 2007 the risk-neutral PDs average 0.3 percent. The default probabilities are elevated as of August 2007 and reach a local maximum of 2.7 percent in March 2008. Until mid-September 2008 average PDs amount to 1.8 percent and reach a local maximum of 4.7 percent on October 29th, 2008. The observation period maximum of 4.8 percent is reached on March 10th, 2009 and until the end of the observation period the risk-neutral PDs average 1.9 percent.

## 4.4 European financial system

The total liabilities of the banks in European sub-sample amount to 23.3 trillion EUR with an average of 613 billion EUR per country as shown in Table 1.[21] The largest European countries in terms of total liabilities of their sample banks are France, Germany and the United Kingdom. The average liability-weighted CDS spreads of all sample banks increase markedly from 10 basis points in Period 1 to 145 basis points in Period 4. The countries with the highest average bank CDS spreads in Period 4 are Greece, Ireland and Portugal. These countries also show the strongest increase in their bank CDS spreads from Period 3 to Period 4 reflecting the impact of the Euro zone sovereign debt crisis (e. g. Greece' average bank CDS spreads

[21] The majority of the banks from the European Union were also covered in the stress test conducted by the Committee of European Banking Supervisors published in July 2010 which applied stress scenarios to the positions of individual institutions.

increase from 72 to 778 basis points). The largest banking groups in the European sample in terms of total liabilities are Barclay's, BNP Paribas, Deutsche Bank and Royal Bank of Scotland as shown in Table 2. The banks with the highest CDS spreads in Period 4 are Greece's Alpha Bank and EFG Eurobank, Ireland's Allied Irish Banks and Portugal's Banco Commercial and Espirito Santo.

Table 7 shows the end-2008 total equity of the European sample banks and their average correlations during the four sample periods on a country level. The European sample banks have a combined equity of 744 billion EUR with an average of 53 billion EUR per country. The sample countries with the highest average equity return correlations in Period 4 are France, Italy and Spain. Table 8 shows that the equity per bank averages 20 billion EUR and that the banks with the highest average correlations in Period 4 are France's BNP Paribas and Societé Generale as well as Spain's Grupo Santander. The progress of the equity return correlation of the European sample banks is shown in the lower panel of Figure 4. It averages 41 percent in the period before August 2007. In August 2007 the correlation increases significantly to a mean value of 61 percent in the period until November 2008. In addition to the elevated level of the average correlation, the standard deviation of the correlation also increases considerably to 15 percent from 12 percent in the period before August 2007.[22] From December 2008 until April 2010 the average equity return correlation decreases to 49 percent before rising again to a higher level as the Euro sovereign debt crisis materializes in May 2010. From October 2010 until the end of the observation period the average correlations decrease again to an average value of the pre-crisis period.

The upper panel of Figure 4 shows the liability-weighted average risk-neutral default probabilities of the sample banking groups during the observation period. Before July 2007 the average risk-neutral default PDs are low at below 0.5 percent. After the freezing of three investment funds by BNP Paribas in August 2007 the default probabilities are elevated before reaching a local maximum of 2.7 percent after the takeover of Bear Stearns by JP Morgan in March 2008. Subsequent to the collapse of Lehman Brothers in September 2008, average risk-neutral PDs reach a second peak at 3.3 percent on 29 September 2008. Afterwards, the default probabilities decline to a lower level before reaching an observation-period maximum of 3.6 percent on March 12th, 2009. From April 2009 to April 2010 the average PDs average out 1.9 percent. Due to the aggravation of the Euro sovereign debt crisis in May 2010 the

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[22] This conclusion is drawn by considering the underlying data of Figure 4.

average PDs increase again sharply with an average of 2.6 percent until the end of the observation period.

### 4.5 Middle Eastern and Russian financial system

The Middle Eastern and Russian sub-sample consists of nine banks, six from the Middle Eastern region and three banks from Russia as shown in Table 2.[23] We summarize these two regions in our analysis as neither of them could be unambiguously allocated to any of the other regions and because they are individually too small in terms of available sample data. The total liabilities of the Middle Eastern and Russian banks amount to 354 billion EUR with an average of 39 billion EUR per bank (Table 1). Russia's WTB and Sberbank and the UAE's[24] Abu Dhabi Commercial bank are the largest banks in terms of total liabilities in this sub-sample.

The average CDS spreads in the Middle Eastern and Russian sub-sample increase from 69 basis points in Period 1 to 526 basis points in Period 3 but decrease again to an average of 279 basis points in Period 4. The banks with the highest CDS spreads in Period 4 are Russia's Bank of Moscow as well as UAE's Dubai Islamic Bank and Mashreqbank.

Table 9 shows the end-2008 equity and the average correlations of the banks in the sub-sample. The total equity in this sample amounts to 40.6 billion EUR and averages 4.5 billion EUR per bank. The banks with the highest correlation in the last period are Bank of Moscow, Commercial Bank of Qatar and National Bank of Abu Dhabi. The lower panel of Figure 5 shows the average equity return correlation of the Middle Eastern and Russian sub-sample during the observation period. The average correlation is 21 percent in the period between October 2005 and June 2007. During the crisis period between July 2007 and July 2009 equity return correlations decrease to an average of 17 percent. From August 2009 until the end of the observation period, the average correlations increase slightly to 19 percent which is still below the pre-crisis average.

The average risk-neutral default probabilities of the banks from the Middle East and Russia sub-sample during the observation period are shown in the upper panel of Figure 5. Before July 2007 the risk-neutral PDs average 1.1 percent. Between July 2007 and August 2008 the default probabilities rise to an average of 2.6 percent and reach an observation-period

[23] Due to the small sample size a *country level* analysis is not conducted for this sub-sample.

[24] UAE = United Arab Emirates.

maximum of 14.2 percent on October 24th, 2008. After this extreme hike, the risk-neutral PDs remain elevated until April 2009 (10 percent on average) and then return to lower levels until the end of the observation horizon (5 percent on average).

## 4.6 Comparative analysis of sample financial systems

Following the above description of the global sample and the four regional sub-samples we conduct a comparative analysis of the liability size, default probabilities and average correlations between the samples in this section.

From Table 1 it can be gathered that from the 37.8 trillion EUR total liabilities of the global sample, Europe is the largest sub-sample with a total of 23.3 trillion EUR (65 percent of total) followed by the American sample with total liabilities of 6.9 trillion EUR (19 percent). The Asian-Pacific sub-sample ranks third with 5.2 trillion EUR (15 percent) and the Middle Eastern and Russian sample is the smallest sub-sample with 354 billion EUR (1 percent). Due to these significant size differences across the sub-samples we will focus the comparison of the ESS results among the samples on the relative values and relative changes over time.

The upper panel of Figure 6 shows the average risk-neutral default probabilities of the global sample and the four sub-samples. The Middle Eastern and Russian sub-sample has the highest average default-probability of all samples over time (3.7 percent), followed by the American (1.8 percent), the global and Asian-Pacific samples (both 1.5 percent) and the European (1.4 percent) sub-samples. It is interesting to note that all samples except for the Middle Eastern and Russian sub-sample reach their observation period maximum in March 2009 after the stock-market low and not – as one may have expected – following the Lehman bankruptcy and the subsequent events in September and October 2008. It can further be observed that the default-probability (and respectively the CDS spreads) of the American sample banks show the highest volatility between September 2008 and September 2009. The default probabilities of the European and Asian-Pacific sub-samples move closely together from October 2005 until September 2008. The default probabilities of the banks from the Asian-Pacific region react more strongly and are more elevated than the PDs of the European banks between October 2008 and June 2009. From July 2009 until April 2010 the Asian-Pacific and European default probabilities move again together and the American banks' average default probability is slightly higher. As the Euro sovereign debt crisis aggravates in May 2010, the European banks' default probabilities upswing strongly and also the PDs from the other sub-samples increase slightly. The PD increase of the non-European sub-samples can probably be explained by the market uncertainty with respect to the global effects of the Euro sovereign debt crisis and the extent of exposure of banks around the globe to debt issued by financially frail Euro zone countries. The Euro zone sovereign debt crisis also has another notable impact: the European sub-sample is the only sample whose average default probabilities increase in Period 4, i. e. from August 2008 until December 2009, with respect to the average value in Period 3 (January 2010 to April 2011).[25]

The lower panel of Figure 6 shows the average correlations of the global sample and the four sub-samples. At an average level of 68 percent, the banks from the American sample have the highest average correlation of all sub-samples during the observation period. This is no surprise, however, because the American sample is the most homogeneous sub-sample as it is composed of major US banks exclusively. The average correlation of the American banks is always above that of the European banks except for the time between May 11th, 2010 and June 18th, 2010 where the co-movement of European banks' equity prices was particularly strong due to the market dislocations caused by the Euro zone sovereign debt crisis.

European banks' average correlations are at an average level of 50 percent the second highest of all sub-samples and are above the average correlations of the Asian-Pacific banks (28 percent) which applies also on a daily level except for six outlier days in March 2011. As the European sub-sample comprises mainly banks from an integrated economic and currency area (however with varying differences between the member countries), the ordering of its average correlations below the homogeneous American sub-sample and above the heterogeneous Asia-Pacific sub-sample appears adequate. The Middle East and Russia sample has the lowest average correlation among the sub-samples (19 percent) which is amongst others due to the fact that the sample banks are heterogeneous and stem from different emerging markets with rather specific characteristics.

There is a strong co-movement in the correlations of the American, Asian-Pacific and European sub-samples whereas the European and (particularly) Asian-Pacific sub-samples' correlations respond with more delay to the financial crisis events than the American correlations. The correlations of these three sub-samples increase even jointly in May 2010 in response to the European sovereign debt problems whereas the increase of the European sample's correlations are strongest. However, from June 2010 until the end of the observation

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[25] This is more obvious when the respective CDS spreads tables are compared.

period the co-movement relationship breaks down and correlations appear to be determined mainly by region-specific factors.

The global sample comprising all 83 banks from the four sub-samples has an average correlation of 29 percent during the observation period. As the average correlations are computed from the average of the correlations of one bank with all other banks and bearing in mind the number and heterogeneity of the banks and countries covered in the global sample it is obvious that high average correlations are rare events. In fact, the global sample's average correlation reaches a value of 50 percent only once in the observation period on September 22nd, 2008. The average correlation of the global sample has a strong co-movement with the American, Asian-Pacific and European sub-samples, particularly in the time period before June 2010.

# 5 EMPIRICAL RESULTS

The ESS methodology elaborated in Chapter 3 is applied separately to the global sample and the four sub-samples to obtain the expected systemic shortfall indicator which is then analyzed with respect to its input variable determinants (section 5.1).[26] As the ESS indicator is a risk-neutral measure, we further analyze its risk premium determinants in section 5.2. The relative systemic risk contributions of individual countries and banks are elaborated in section 5.3. In each section of this chapter we describe the global sample as well as the four sub-samples and conduct a comparative analysis at the end of each section. As in the previous chapter, the elaboration is structured such that the reader can also focus on specific samples without loss of continuity.

## 5.1 Expected systemic shortfall indicator

In this section we describe the results from applying the ESS methodology as well as the input factor determinants of the ESS measures for each sample before comparing the individual sample results. As outlined in section 3.3 the absolute ESS-indicator represents the probability of the portfolio losses exceeding the systemic loss threshold multiplied by the expected tail loss in case this systemic default event occurs. The relative ESS-indicator denotes the ratio of the absolute ESS-indicator to the total liabilities outstanding. In order to determine the end of the *international* financial crisis effects by means of the ESS indicator for each sample we define the end of the financial crisis period as the time period when the relative ESS indicator is below a third of its crisis peak for three consecutive months.[27]

We find that the ESS results for all samples reflect the events of the financial crisis with ‘global importance’ whereas the results for each sub-sample also reflect the region-specific events. Our regression analysis shows that the risk-neutral default probability is the single input factor with the highest explanatory power for the ESS-indicator for all samples.

### 5.1.1 Global financial system

The evolution of the ESS-indicator of the global sample over time is shown in Figure 7. Before the first indication of the sub-prime and financial crisis became evident in July 2007 the ESS-indicator was at a very low level, i. e. below 10 billion EUR (0.1 percent of total

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[26] The robustness of the results is confirmed by repeating the simulation using the Beta distribution suggested by Loeffler/Posch (2010) for the LGD instead of the triangular distribution.

[27] Consequently, we define the end rather as a period than as a point in time.

liabilities).[28] The indicator increased sharply to 59 billion EUR (0.2 percent) after the freezing of the BNP Paribas funds on August 16th, 2007. Thereafter the indicator rose steadily until it reached a first local maximum of 255 billion EUR (0.7 percent) on March 17th, 2008 following the arranged takeover of Bear Stearns by JP Morgan. Reflecting the crisis response of central banks and governments around the globe, the indicator decreased again to a local minimum of 86 billion EUR (0.3 percent) on May 2nd, 2008 when the central banks of the European Union, Switzerland and the United States jointly announced an expansion of liquidity-enhancing measures.[29]

On September 17th, 2008 – two days after the collapse of Lehman Brothers – the ESS indicator jumps to a level of 413 billion EUR (1.1 percent). The sample period maximum is reached on September 29th, 2008 at a level of 446 billion EUR (1.2 percent) which reflects the market uncertainty and dislocation after the Lehman default. In the fourth quarter 2008 frail financial institutions around the globe were supported or rescued by unprecedented government measures: amongst others the US government introduced the troubled asset relief program (TARP), France approved a 360 billion EUR rescue package, the German government rescued Hypo Real Estate and Her Majesty's Treasury forced capital injections into major UK banking groups. As a result of these measures the ESS-indicator decreased to 223 billion EUR (0.6 percent) on average until February 2009.

The systemic risk in the global sample reaches another local maximum of 368 billion EUR (1.0 percent) on March 9th, 2009, three days after global stock markets hit their crisis lows. In the subsequent 12 months after the G20 summit in London on April 2nd, 2009 the indicator decreased to an average value of 128 billion EUR (0.4 percent) which is only slightly above the average during the 12 months before the Lehman default.

With the exacerbation of the Euro zone and particularly Greece sovereign debt crisis in May 2010, the absolute ESS-indicator of the global financial system reached its second highest value in the observation period on June 8th, 2010 at 379 billion EUR (1.0 percent). Following the EU government interventions, the global ESS-indicator returned to an average level of 234 billion EUR (0.6 percent) in the third quarter 2010. In the fourth quarter 2010 the ESS measure decreased further to 110 billion EUR (0.3 percent) on November 15th, 2010 before

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[28] Relative ESS values are shown in brackets in the subsequent text.

[29] See US Federal Reserve (2008).

rising again sharply to 238 billion EUR (0.6 percent) in response to market uncertainty regarding the solvency of additional Euro member states (Ireland, Portugal, Spain).

By applying our definition for the end of the financial crisis, we come to the conclusion that the financial crisis effects in the global financial system abated in the fourth quarter 2009. However, at the end of the observation period, the global systemic risk remains significantly elevated (relative ESS of 0.4 percent compared to 0.01 percent at the beginning of the sample period) which implies a high degree of remaining market uncertainty regarding the prospects of financial institutions around the world in the face of an impending sovereign default in the Euro zone and an overarching re-assessment with respect to the risk associated with financial institutions debt amongst others.

The development of the factors constituting the ESS-indicator, the probability of systemic default (PSD) and the expected tail loss (ETL), of the global sample during the observation period are shown in Figure 8. The PSD reaches its peaks at the same points in time as the ESS-indicator whereas the ranking of the peaks differs slightly. The PSD increases from 0.1 percent at the beginning of the period to 6.1 percent in March 2009. At the end of the sample period, the PSD of the global sample amounts to *23 times* its initial average value.

The ETL denotes the expected loss in case the systemic default event occurs and, consequently, is an absolute measure. At the beginning of the sample period the ETL amounts to 3.4 trillion EUR and increases to 7.8 trillion EUR on September 22nd, 2008. From April 2009 to April 2010 the ETL averages 5.5 trillion EUR and increases markedly again in July 2010 to an average of 7.6 trillion EUR. The evolution of the ETL shows that the expected loss in case of a systemic default event increased significantly during the financial crisis and Euro zone's sovereign default crisis. At the end of the observation period it has about *twice* its initial value.

As a further step, we conduct regression analysis to identify the input factor determinants of the relative ESS indicator as shown in Table 10. Not surprisingly, the average risk neutral default probability is the most relevant single variable explaining 89 percent of the total variation of the indicator. Average correlation alone does not explain sufficiently the variation in the ESS-indicator ($R^2$ of 0.23) However, when added as explanatory variable to the risk-neutral default probability, the correlation improves the explanatory power of the regression equation whereas the PD remains the dominant explanatory variable: a PD increase by one percentage point raises the relative ESS-indicator by 21 basis points, whereas the same increase in average correlations only leads to a two basis points increase. The dispersion in risk-neutral default probabilities has a negative coefficient which means that a larger heterogeneity in the default probabilities of the sample banks leads ceteris paribus to a lower level of systemic risk. The regressions show that the default probabilities (or CDS spreads) could be used as a ‘quick’ approximation of the aggregate systemic risk measure.

### 5.1.2 American financial system

Figure 9 shows the evolution of the ESS measure for the American sub-sample. The absolute ESS indicator has an average value of 6 billion EUR (0.1 percent relative ESS) until June 2007. From July 2007 it rises steadily until it reaches a local maximum of 32 billion EUR (0.5 percent) on August 16th, 2007 after the subprime-related freezing of BNP Paribas funds. From this local peak the ESS indicator rises continuously with minor interruptions until it reaches another local maximum of 100 billion EUR (1.7 percent) on March 14th, 2008 amid market rumors about the financial difficulties of major US investment banks and just before the arranged takeover of Bear Stearns by JP Morgan. From April through June 2008 the ESS-indicator decreases to an average of 49 billion EUR (0.3 percent) with a local minimum of 37 billion EUR (0.6 percent) on May 2nd, 2008 as the Federal Reserve and other central banks announced the expansion of their measures directed at enhancing market liquidity for certain asset types.[27]

Despite the coordinated actions by central banks and governments around the world, the ESS indicator for the American sub-sample increases steadily until it culminates on September 17th, 2008 at a level of 178 billion EUR (2.7 percent) two days after the collapse of Lehman Brothers and amid news about a potential bankruptcy of American International Group (AIG).[30] After a slight decrease, the indicator peaks again on October 10th, 2008 at a level of 163 billion EUR (2.4 percent) and on November 21st, 2008 at 155 billion EUR (2.3 percent) reflecting the market uncertainty and an increased risk aversion with respect to exposures to financial institutions. In the aftermath of these peaks, the ESS indicator remains elevated and reaches its observation period maximum of 222 billion EUR (3.1 percent) on March 9th, 2009 just after the Dow Jones Industrial Average and the S&P 500 reach their crisis lows.

After another peak on March 31st, 2009 and the financial stability measures decided on the G20 summit in London on April 2nd, 2009, the ESS indicator in the American sub-sample decreases to an average of 82 billion EUR (1.2 percent) in the period until April 2010 with the

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[30] The AIG default was averted on the same evening by a liquidity facility from the Federal Reserve Bank of New York as the US government became AIG’s largest shareholder.

lowest post-crisis ESS value reached at 48 billion EUR (0.6 percent) on April 14th, 2010. The increase of the ESS indicator in May 2010 and the local maximum of 113 billion EUR (1.4 percent) reached on June 10th, 2010 are most likely to be explained by the Euro zone sovereign debt problems, especially the market uncertainty with respect to the exposure of US banks to debt originating from Euro zone crisis countries and their banks.[31]

According to our definition of the end of the financial crisis period, the curve of the ESS indicator permits the conclusion that the financial crisis effects in the American sub-sample subsided in the last quarter 2009. However, the elevated level of the ESS indicator at the end of the observation period (relative ESS of 0.8 percent vs. 0.1 percent at the beginning) points to a persisting increased level of systemic risk, a reassessment with respect to the risk posed by debt issued by banks and potentially also an uncertainty regarding effects of the European sovereign debt crisis on US banks.

The development of the factors constituting the ESS-indicator, the probability of systemic default (PSD) and the expected tail loss (ETL), in the American financial system during the observation period are shown in Figure 10. The PSD reaches its peaks at the same points in time as the ESS-indicator whereas the ranking of the peaks differs slightly, especially in September 2008: while the ESS indicator reaches its highest value in September 2008 on the 29th the PSD observed after the Lehman default on September 17th, 2008 is higher than the PSD on September 29th, 2008. The PSD at the beginning of the period averages 0.6 percent which compares to an observation period maximum of 12 percent on March 9th, 2009. The PSD at the end of the sample period amounts to the *sixfold* of its initial value.

The ETL denotes the expected loss in case the systemic default event occurs and, therefore, is an absolute measure. Until February 2007 the ETL of the American sub-sample averages around one trillion EUR. Interestingly, the ETL increases already during March 2007 and reaches a value of 1.5 trillion EUR on April 11th, 2007 at a time where the PSD is only slightly elevated. At a level of 2.1 trillion EUR, the ETL reaches its maximum on July 2nd, 2010. At the end of the sample period, the ETL is about 60 percent higher than at the beginning.

In order to identify the input factor determinants of the relative ESS indicator we conduct regression analysis as shown in Table 10. The average risk-neutral default probability is the

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[31] The impact of the ensuing US dollar appreciation versus the Euro on the US economy may also have played a role. At 1.22 USD/EUR the Dollar reached a four year high vs. the Euro on June 13th, 2010.

most relevant single variable explaining 99 percent of the total variation of the indicator for the American sub-sample. Average correlation alone does not explain sufficiently the variation in the ESS-indicator ($R^2$ of 0.17) and only has a negligible positive coefficient when included in the regression equation with the PD. The dispersion in risk-neutral default probabilities has a negative coefficient which means that a larger heterogeneity in the default probabilities of the sample banks leads ceteris paribus to a lower level of systemic risk. The regression results show that the default probabilities (or CDS spreads) could be used as a first order approximation of the systemic risk measure.

### 5.1.3 Asian-Pacific financial system

The development of the ESS indicator in the Asian sub-sample over time is shown in Figure 11. The ESS measure averages 2.8 billion EUR (0.1 percent of total liabilities) until June 2007. In July 2007 the indicator starts to rise which culminates in a peak of 6.1 billion EUR (0.2 percent) on August 21st, 2007 after BNP Paribas announces the closing of three funds due to subprime-related problems. In the time after this peak the ESS indicator rises steadily with few interruptions and reaches a local maximum of 29.7 billion EUR (0.6 percent) on March 18th, 2008 after the government-mediated acquisition of Bear Stearns by JP Morgan. In the aftermath of the Bear Stearns takeover the indicator first declined and then increased as of July 2008 in spite of the international financial market support measures.

After the Lehman Brothers bankruptcy and government support measures for the banks in the Asia-Pacific region[32] the ESS indicator has multiple peaks in October 2008 at levels of around 65 billion EUR (1.3 percent), culminating at a level of 69 billion EUR (1.4 percent) on October 29th, 2008. Until the end of the year 2008, the trajectory of the ESS indicator is highly erratic and reaches also elevated levels of around 67 billion EUR (1.3 percent). The elevated ESS levels in the fourth quarter 2008 reflect the global market uncertainty and risk aversion in the aftermath of the Lehman Brothers default but also the specific events in the Asia-Pacific region as major banks in the region announced large layoffs and regional economies slid into recession. The observation period maximum of the ESS indicator in the Asia-Pacific sample is observed on March 10th, 2009 at a level of 75 billion EUR (1.5 percent) briefly after the Hang Seng as well as other Asian and global stock markets hit their financial crisis lows.

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[32] E. g. China cut its interest rate on September 15th, 2008 for the first time since 2002 and other APAC countries also provided liquidity support to their banks.

Following the announcement of comprehensive measures to stabilize the global financial system during the G20 summit on April 2nd, 2009 the ESS indicator in the Asia-Pacific sample decreases to an average value of 24 billion EUR (0.4 percent) until early May 2010. On June 9th, 2010 the ESS indicator increases strongly to a value of 47 billion EUR (0.7 percent) which is presumably in response to the European sovereign debt crisis and the market uncertainty regarding the exposure of Asian-Pacific banks to affected Euro zone countries and their banks. After returning again to 22 billion EUR (0.3 percent) in November 2010, the indicator increases again whereas it is unclear if this increase is also due to the European debt crisis events. The devastation and market uncertainty caused by the earthquake and tsunami hitting Japan on March 11th, 2011 is reflected in the ESS indicator as of March 15th, 2011 when the indicator increased substantially by 23 percent to 46 billion EUR (1 percent) and climbed even further as the disaster of Japan's Fukushima nuclear plant evolved and the severe impact of the natural and nuclear disaster on Japan's economy became palpable.[33]

By interpreting the curve of the relative ESS indicator using our definition of the financial crisis end we conclude that the financial crisis effects in the Asian-Pacific sub-sample subsided in the last quarter 2009. The elevated level of the ESS measure at the end of the observation period (relative ESS of 0.7 percent vs. 0.1 percent at the beginning) points to a persisting increased level of systemic risk in the Asian-Pacific financial sector which is among other things explained by the imponderables resulting from the impact of the natural and nuclear disaster on Japan's economy and financial system.

The gradient of the probability of systemic default (PSD) and the expected tail loss (ETL) in the Asian-Pacific financial system during the observation period are shown in Figure 12. The PSD reaches its peaks at the same points in time as the ESS-indicator whereas the ranking of the peaks differs slightly, especially in October 2008 and April 2011. The PSD increases from an initial value of 0.4 percent to an observation period maximum of 8.4 percent on March 11th, 2009. The PSD at the end of the sample period equals more than *seven times* of its initial value.

The ETL represents the expected loss in case the systemic default event occurs and is hence an absolute measure. The ETL first increases after the Lehman Brothers default in September

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[33] As Japan is the largest country in the Asian-Pacific sub-sample in terms of total liabilities, changes of its banks' CDS spreads and equity return correlations have a significant impact on the whole sub-sample.

2008 from 800 billion EUR to 1 trillion EUR. Afterwards, the ETL decreases slightly and remains relatively constant before increasing further in the fourth quarter 2010. It hikes to its sample period maximum above 1.2 trillion EUR in March 2011 after Japan's tsunami. At the end of the sample period, the ETL is about 60 percent higher than at the beginning.

We conduct regression analysis to identify the input factor determinants of the relative ESS indicator as shown in Table 10. The average risk-neutral default probability is the most important single variable explaining 97 percent of the total variation of the indicator for the American sub-sample. Average correlation alone does not explain sufficiently the variation in the ESS-indicator ($R^2$ of 0.12). When correlation is included in the regression equation together with the PD, it has only a negligible positive coefficient. The dispersion in risk-neutral default probabilities has a negative coefficient which means that a larger heterogeneity in the default probabilities of the sample banks leads – other things being equal – to a reduced level of systemic risk. According to the regression results, the default probabilities (or CDS spreads) could be used as a first order approximation of the systemic risk measure.

#### 5.1.4 European financial system

The evolution of the ESS-indicator of the European sub-sample over time is shown in Figure 13. Before the first indication of the sub-prime and financial crisis became evident the ESS-indicator was at a very low level, i. e. below 10 billion EUR and 0.1 percent of total liabilities.[34] The indicator increased sharply to 57 billion EUR (0.3 percent) after the freezing of the BNP Paribas funds on August 16th, 2007. Thereafter the indicator rose steadily until it reached first a local maximum of 254 billion EUR (1.1 percent) on March 17th, 2008 following the arranged takeover of Bear Stearns by JP Morgan. Reflecting the crisis response of central banks and governments around the globe, the indicator decreased again to about 120 billion EUR (0.5 percent) in mid-July 2008.

Two weeks after the collapse of Lehman Brothers the indicator hikes to an observation period maximum of 343 billion EUR (1.4 percent) on September 29th, 2008. This sharp increase reflects the market anxiety and uncertainty after the Lehman Brothers collapse, which led globally to increased risk aversion especially with respect to debt issued by financial institutions. In the fourth quarter 2008 frail financial institutions in Europe were supported or rescued by unprecedented government measures: amongst others France approved a 360

[34] Relative ESS values are shown in brackets in the subsequent text.

billion EUR rescue package, the German government rescued Hypo Real Estate and Her Majesty's Treasury forced capital injections into major UK banking groups. As a result of these measures the ESS-indicator decreased to 150 billion EUR (0.6 percent) on average until February 2009. It reached another local maximum of 261 billion EUR (1.2 percent) on March 12th, 2009, one week after the Eurostoxx 50 and other global stock markets hit rock bottom. In the subsequent 13 months after the G20 summit in London on April 2nd, 2009 the ESS indicator in the European sample decreased to an average value of before the Lehman Brothers default.

The curve of the relative ESS indicator shows that according to our definition the effects of the *international* financial crisis in the European financial system subsided in the fourth quarter 2009. However, with the exacerbation of the Euro zone sovereign debt crisis in general and the support measures for Greece in particular the European financial system experienced its *specific* financial crisis: the absolute ESS-indicator reached its second highest value in the observation period on June 8th, 2010 at 341 billion EUR and the relative ESS measure even marginally exceeded the value reached on September 29th, 2008 (1.43 vs. 1.41 percent). After markets were reassured by Euro zone government measures to stabilize frail member countries by means of the provisional European Financial Stabilization Mechanism (EFSM), the ESS-indicator returned to an average level of 200 billion EUR (0.8 percent) in the third quarter 2010. In the fourth quarter 2010 the ESS measure decreased further to 121 billion EUR (0.5 percent) on November 15th, 2010 before rising again sharply to 264 billion EUR (1.1 percent) in response to market uncertainty regarding the solvency of additional Euro member states (Ireland, Portugal, Spain) and the sufficiency of the provisional EFSM to stabilize one or more financially tattered Euro zone countries and their financial institutions.

As Euro zone governments prepared the implementation of a permanent EFSM which was agreed upon by the Euro zone finance ministers on March 21st, 2011, the ESS measure declined again while remaining at a substantially elevated level towards the end of the observation period (relative ESS indicator of 0.6 percent versus 0.03 percent at the beginning) which most likely embodies the sustained market uncertainty with respect to the stability of the Euro currency and the solvency of certain Euro zone countries.

The development of the factors constituting the ESS-indicator, the probability of systemic default (PSD) and the expected tail loss (ETL), during the observation period are shown in Figure 14. The PSD reaches its peaks at the same points in time as the ESS-indicator whereas the ranking of the peaks differs slightly. While the absolute ESS measure reaches its maximum in September 2008, the PSD in June 2010 is slightly higher than the PSD values observed in September 2008 and March 2009. Initially, the average PSD equals 0.2 percent and it reaches its observation period maximum at a level of 5.8 percent on May 7th, 2010. At the end of the observation period the PSD amounts to the *twentyfold* of its initial value.

The ETL denotes the expected loss in case the systemic default event occurs and, therefore, is an absolute measure. Until July 2007 the ETL averages below 3 trillion EUR and increases to a peak of 6.3 trillion EUR on September 26th, 2008. At the end of the observation period the ETL is 80 percent higher than initially. The evolution of the ETL shows that the expected loss in case of a systemic default event increased significantly during the financial crisis period *and* the Euro zone's sovereign default crisis and that it remains at an elevated level at the end of the observation period.

As a further step, we would like to identify the input factor determinants of the relative ESS indicator. To this end we conduct regression analysis whose results are presented in Table 10. As expected, the average risk neutral default probability is the most relevant single variable explaining 92 percent of the total variation of the indicator. Average correlation alone does not explain sufficiently the variation in the ESS-indicator ($R^2$ of 0.29). When added as explanatory variable to the risk-neutral default probability, the correlation improves the explanatory power of the regression equation whereas the PD remains the dominant explanatory variable: a PD increase by one percentage point raises the relative ESS-indicator by 32 basis points, whereas the same increase in average correlations only leads to a one basis point increase. The coefficient of the dispersion in risk-neutral default probabilities is slightly negative which means that a larger heterogeneity in the default probabilities of the sample banks leads ceteris paribus to a lower level of systemic risk. The regressions show that the default probabilities (or CDS spreads) could be used as a first order approximation of the systemic risk measure.

### 5.1.5 Middle Eastern and Russian financial system

Figure 15 shows the evolution of the ESS measure for the Middle Eastern and Russian sub-sample. From October 2005 until October 2007, the indicator averages below 1 billion EUR (0.5 percent of total liabilities). The indicator begins to rise in November 2007 and reaches a local maximum of 4.4 billion EUR (1.6 percent) on March 31st, 2008 – first two weeks after the arranged takeover of Bear Stearns by JP Morgan. In the period until June 2008 the ESS indicator decreases again along with the calming of the global market sentiment at the time.

Thereafter, the indicator rises continuously and jumps to 9 billion EUR (2.6 percent) after the Lehman Brothers default on September 17th, 2008 before reaching an observation period maximum of 23.7 billion EUR (6.9 percent) on October 24th, 2008. The gradient of the ESS indicator and the high average level of 15 billion EUR (4 percent) from September 2008 to March 2009 reflect both the global financial crisis events and – even more so – the specific events in Russia (the largest country in this this sub-sample): Trading on Russian exchanges was suspended repeatedly in September and October 2008 due to extraordinary declines of the main Russian stock indices, the Russian government saw itself forced to provide several emergency liquidity facilities to Russian banks; on October 23rd, 2008 Standard & Poor's (S&P) changed its rating outlook for Russia's sovereign rating from stable to negative (amid worries that the support measures for the banking sector could overburden the financial capacity of the Russian government) and on December 8th, 2008 S&P downgraded Russia's currency rating.[35]

The ESS indicator has a local maximum on March 9th, 2009 at 17 billion EUR (4.9 percent) after global stock markets reached their financial crisis lows. Following the announcement of comprehensive financial stability measures at the G20 summit on April 2nd, 2009 the ESS indicator decreases to an average value of 8 billion EUR (2.4 percent) until early September 2009 and reaches a local minimum of 4.5 billion EUR (1.3 percent) on October 16th, 2009. At the end of November 2009, the indicator rises again as a result of the debt problems of the Emirate Dubai which also increases the risk premiums for debt of entities from other Middle Eastern countries. Following a decline until April 2010, the ESS indicator rises again (likely in May 2010 in response to the Euro zone sovereign debt crisis) and remains heightened (5 billion EUR, 1.2 percent) at the end of the observation period.

By applying our definition of the crisis end to the relative ESS curve of the Middle Eastern and Russian sub-sample we conclude that the financial crisis effects in this sub-sample abated in the fourth quarter 2009. The elevated level of the ESS measure at the end of the observation period (relative ESS of 1.2 percent vs. 0.5 percent at the beginning) points to a slightly increased level of systemic risk in the Middle Eastern and Russian financial sector.

The gradient of the probability of systemic default (PSD) and the expected tail loss (ETL) in the Middle Eastern and Russian financial system during the observation period are shown in Figure 16 Probability of systemic default and expected tail loss (Middle East and Russia). The

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[35] See Fidrmuc/Suess (2009) for a detailed elaboration of the financial crisis impacts on Russia.

PSD reaches its peaks at the same points in time as the ESS-indicator and also the rankings of the peak heights are largely consistent. At the beginning of the sample period the PSD amounts to 2.3 percent and increases tenfold to a dramatic 23 percent at the peak of the crisis in October 2008. The PSD at the end of the sample period equals about three times its initial value. The ETL represents the expected loss in case the systemic default event occurs and is hence an absolute measure. The ETL increases from its initial value of 40 billion EUR with minor interruptions until it reaches a peak of 102 billion EUR in October 2010. At the end of the sample period, the ETL is about twice as high as at the beginning.

We conduct regression analysis to identify the input factor determinants of the relative ESS indicator in the Middle Eastern and Russian sub-sample as shown in Table 10. The average risk-neutral default probability is the most important single variable explaining 97 percent of the total variation of the relative ESS indicator. Average correlation alone does not explain sufficiently the variation in the ESS-indicator. When correlation is included in the regression equation together with the PD, it slightly increases the explanatory power of the regression equation and the correlation has a marginally positive coefficient. The dispersion in risk-neutral default probabilities has a coefficient of -0.2 which means that a larger heterogeneity in the default probabilities of the sample banks leads ceteris paribus to a reduced level of systemic risk. According to the regression results, the default probabilities (or CDS spreads) could be used as a first order approximation of the systemic risk measure.

#### 5.1.6 Comparative analysis

In the following we conduct the comparative analysis between the above ESS results for the individual samples.

*Level and evolution of the ESS indicator*

Figure 17 shows the development of the absolute and relative ESS indicator for all samples over time. The ranking of the *average* absolute ESS-indicator reflects as expected the ranking of the total liabilities of the respective samples. What is more remarkable is that the level of the absolute ESS indicator of the European sub-sample *for certain time periods* is equal to or slightly greater than the absolute ESS indicator of the global sample (e. g. March till July 2008 and November 2010 till March 2011). This can be explained by the different levels of correlations and risk-neutral default probabilities as shown in Figure 6: During the whole sample period, the average correlations of the European sub-sample are significantly higher than the correlations of the global sample (50 vs. 29 percent) which also leads to a higher correlation of the samples drawn in the ESS simulation and consequently to more correlated outcomes (particularly in times of elevated default probabilities). This effect is even increased when the average risk-neutral PDs of the European sub-sample are higher than the average PDs of the global sample which is the case for the last nine months of the observation period. This impact of the correlations shows that the ESS methodology adequately captures the 'benefits of diversification' resulting from a more heterogeneous 'sample bank portfolio' and that a more heterogeneous financial system is favorable versus a more homogeneous financial system with respect to the resulting level of systemic risk.

In order to ensure comparability, we use the results of the relative ESS indicator to describe the differences in the evolution of the systemic risk level in the samples over time. The Middle East & Russia sample has the highest *average* relative ESS level (1.4 percent), followed by the American sample (0.8 percent), the European sample (0.4 percent), the Asian-Pacific sample (0.35 percent) and the global sample (0.3 percent). This ranking applies also to the relative ESS levels of the samples at the end of the observation period. As a closer examination of the default probabilities shows, however, this ranking can only be partially explained on grounds of the default probabilities: While the Middle Eastern and Russian as well as the American sub-samples have the highest average default probabilities, the default probability of the European sample is lower than the PDs of the global and Asia-Pacific sample which again reflects the impact of correlations in the derivation of the ESS indicator.

The evolution of the relative ESS for the Middle East and Russia sample appears somewhat decoupled from the other samples until March 2008 and as of September 2008 the gradient of the curve shows the Russia-specific effects of the financial crisis on the systemic risk in this sample. A closer look at the data underlying Figure 17 shows that the global financial crisis effects are first observed in the American sample which corroborates the common observation that the global financial crisis spread out from the US financial system. The relative ESS of the Asia-Pacific sample runs largely in sync with the European and global samples apart from a few outliers which are observed mainly in the fourth quarter 2008.

While a casual look at Figure 17 may suggest that the Middle Eastern and Russian as well as the American financial samples were most affected by the financial crisis, Figure 19 (which shows the relative change of the ESS indicator with respect to its initial three months average for all samples) contradicts this conclusion. It shows that - relative to the sample period average - the European and global financial systems were affected most by the financial crisis: at the peak of the crisis the relative ESS indicator of the global (European) sample equals 85 times (46 times) its initial value which compares to a multiple of 24 for the American, 17 for the Asian-Pacific and only 13 for the Middle East and Russia sub-sample (the averages of the relative change over time have the same ranking). The 'repricing of systemic financial sector risk' was particularly strong for the global sample because the ESS indicator for this sample was particularly low at the beginning of the sample (among other things due to very low correlations) so that the relative impact of the subsequent financial crisis (on correlations and PDs) was all the more pronounced.

We observe that the financial crisis effects subside in *each* sample in the fourth quarter 2009 according to our definition of the crisis end in terms of the relative ESS measure. It is noteworthy that the relative ESS at the end of the observation period has returned to lower (albeit not pre-crisis levels) only for the American, Asian-Pacific and Middle Eastern and Russian samples (2-8 times initial average) whereas it is still strongly elevated for the European sub-sample and the global sample (about twentyfold of initial average).[36] The strong relative increase and the sustained elevated level of systemic risk in the European and global financial system may suggest that the systemic risk in these financial systems was particularly 'underpriced' before the financial crisis. This conclusion is not meant to overshadow the fact that the systemic risk present in the Middle East and Russian as well as the American financial systems (measured in terms of the relative ESS indicator) is still the *most elevated* of all samples at the end of the observation period.

*Level and evolution of the probability of systemic default and the expected tail loss*

Figure 18 shows the evolution of the components of the ESS indicator, the probability of systemic default (PSD) and the expected tail loss (ETL) for all samples over time. The ranking of the PSD values (average and end of period) of the samples is consistent with the ranking of the relative ESS indicator, i. e. the PSD of the Middle Eastern and Russian and the American samples are highest (average value of 5.9 vs. 3.4 percent), followed by the European (2.1 percent), Asia-Pacific (2.2 percent) and global sample (1.7 percent). The upper panel of Figure 20 shows that the relative change of the PSD is the main driver of the high relative change of the ESS indicator over time. At the end of the sample period, the PSDs of the European and the global samples amount to the *twentyfold* of their initial value whereas the relative increases of the other samples are below the factor *eight*.

[36] The elevated level in the global sample is of course driven by the increased level in the European sample.

The development of the ETL is shown for all samples in the lower panel of Figure 18. As the absolute values are strongly determined by the sample's total liabilities it is more insightful to consider the relative changes of the ETL in the lower panel of Figure 20. At a multiple of 2.3 with respect to its initial average value, the Middle East and Russian sub-sample shows the highest increase at the end of the sample period whereas the expected tail losses of the other samples are about 1.5 to 1.7 times of their initial average value. This sustained elevated level of the ETL shows that the expected loss in case of a systemic default event increased significantly during the sample period. In conjunction with the elevated level of the PSD, the ETL also explains the persistent increased level of the ESS indicator.

*Input factor determinants*

A comparison of the regression results in Table 10 shows that the average risk-neutral default probability is the single variable with the highest 'positive' impact on the relative ESS indicator for all samples, i. e. the higher the average PD, the higher the systemic risk measure. Another feature of all sample regressions is that the dispersion in default probabilities has a significant negative sign which means that the higher the heterogeneity of the sample banks with respect to their risk-neutral PDs (or their CDS spreads), the lower is the relative ESS indicator. Average correlation alone does not have sufficient explanatory power for the relative ESS indicator whereas when it is included in the regression equation together with other variables it has a significant positive coefficient (albeit only marginal) which suggests that a higher correlation leads ceteris paribus to a higher level of systemic risk.

## 5.2 Risk premium determinants of the ESS-indicator

The default probabilities computed from CDS spreads are *risk-neutral*, i. e. they contain not only the expectation about the *actual* probability of default but also risk premium components such as the default risk premium and the liquidity risk premium. Since the ESS-indicator is computed using these risk-neutral default probabilities, it is by construction also a risk-neutral measure of systemic financial sector risk. Therefore, it is worthwhile to further analyze the individual risk premium determinants of the ESS-indicator.

As the default risk premiums on credit markets are not directly observable, adequate proxy measures need to be employed in this analysis. We use Moody's seasoned Baa-Aaa bond index spread and the TED spread as proxies for the credit default risk premium. Moody's Baa-Aaa bond spread is the difference between the average yields of Moody's seasoned Baa and Aaa corporate bond indices. The TED spread is the difference between the 3-month LIBOR rate and the yield of a 3-month US Treasury Bill. While both spreads are a market-based measure of the risk premiums for differences in credit quality, Moody's Baa-Aaa bond spread measures the differences in high and lower quality corporate bond ratings[37], whereas the TED spread measures the differences in credit quality between major financial institutions and the – by assumption – riskless US Treasury Bills.[38] In the following we refer, therefore, to the Baa-Aaa spread also as 'corporate default risk premium' and to the TED spread also as 'bank default risk premium'.[39]

In order to proxy the liquidity risk premium component we use the term spread which we define as the difference between the market yields of the 10-year and the 3-month US Treasury Bills. The term spread provides a market assessment for the compensation, which market participants require for holding a long-maturity versus a short-maturity asset with the same underlying characteristics. For the expected *actual* default rates, Moody's Expected Default Frequencies (EDF) or physical default probabilities from company ratings would be adequate proxy measures. However, as these measures are proprietary products which were unavailable for the present research, a measure for the expected actual default rates cannot be included in the following analysis.

We perform regression analysis separately for each sample using the relative ESS-indicator as dependent variable and the Baa-Aaa spread, the TED spread and the term spread both individually and together as independent variables (Table 11). In order to further analyze the time-varying impact of the three spreads on the ESS indicator we insert the actual values of the spreads into the estimated regression equation comprising all variables and obtain a specific area diagram for each sample (Figure 21).

In the following sections we elaborate the analysis results for each sample separately and conduct a comparative analysis among all sample-specific results in the last section.

### 5.2.1 Global financial system

The regression results for the global sample in Table 11 show that the corporate default risk premium has a significant positive coefficient of 27 basis points and it explains 46 percent of

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[37]See Chen/Collin-Dufresne/Goldstein (2009), p. 3367-3368.

[38]The TED spread is also used as a measure for the availability of bank wholesale funding.

[39] These notions are somewhat stereotypical as e. g. the Baa-Aaa spread also includes debt issues by financial institutions.

the variation in the relative ESS indicator. By contrast, the bank default risk premium alone does not have sufficient explanatory power ($R^2$=0.19) whereas its coefficient is also positive. The liquidity risk premium is the risk premium component with the highest explanatory power of the spreads in the regression analysis and shows as expected a positive coefficient. By including all risk premium components in the regression equation, the explanatory power is significantly increased (adjusted $R^2$ of 0.72) and the corporate default risk and the liquidity risk premiums turn out to be the risk premium components with the highest impact on the relative ESS indicator (coefficient of 0.16 and 0.10, respectively) whereas the bank default risk premium also has a significant positive coefficient of two basis points.

The global sample chart of Figure 21 shows the time-varying impact of the risk premium determinants on the relative ESS indicator for the global sample. Until July 2007 the Baa-Aaa spread is the component with the highest impact on the relative ESS measure and the other spreads are of minor importance. From August 2007 until April 2009, the impact of the other risk premium components increases whereas the corporate default risk premium remains the variable with the strongest influence. Interestingly, the bank default risk component has a significant impact on the relative ESS indicator only during the ‘core’ financial crisis period, i. e. from August 2007 until April 2009. From May 2009 until the end of the observation period, the liquidity risk premium has the dominant impact on the relative ESS indicator whereas the importance of the corporate default risk premium decreases to its pre-crisis level. The time-varying impact of the corporate default and liquidity risk premium components shows a relative increase of the liquidity risk aversion and a relative decrease in the default risk aversion among market participants during the financial crisis which persists at the end of the observation period.

### 5.2.2 American financial system

The risk premium determinants regression results for the American sample are shown in Table 11. The corporate default risk premium alone has the highest coefficient (0.76) and the highest explanatory power ($R^2$=0.62) of all *individual* risk premium components. The liquidity risk premium has the second highest coefficient (0.32) and explanatory power ($R^2$=0.65) of the single variables whereas the bank default risk premium alone has no sufficient explanatory power ($R^2$=0.18) although its coefficient is still significantly positive. Regression 4 shows the results obtained by including all risk premium components in the regression equation: The corporate default risk and the liquidity risk premium influence the relative ESS indicator most strongly (coefficient of 0.54 and 0.22, respectively) whereas the bank default risk premium coefficient is only marginally positive (0.02).

The area diagram for the American sample in Figure 21 shows that in the period until August 2007, the impact of the bank default risk and liquidity risk premium is negligible while the corporate default risk premium exerts the strongest influence on the systemic risk measure. The impact of the liquidity risk premium increases as of October 2007 and exceeds even the impact of the corporate default risk premium at the end of the sample period. The impact of the bank default risk premium is only discernible in the time period between August 2007 and March 2009. The increase of the liquidity risk premium’s impact relative to the corporate default risk premium’s impact during the financial crisis (which is sustained at the end of the observation period) reflects a change in risk aversion by market participants during the financial crisis.

### 5.2.3 Asian-Pacific financial system

The regression results for the Asian-Pacific sample in Table 11 show that the corporate default risk premium has a significant positive coefficient of 0.41 and it explains alone 71 percent of the variation in the relative ESS indicator. By contrast, the bank default risk premium alone does not have sufficient explanatory power ($R^2$=0.17) whereas its coefficient is also significantly positive (0.09). The liquidity risk premium alone has a coefficient of 0.15 and explains 45 percent of the variation of the relative ESS indicator. By including all risk premium components in the regression equation, the explanatory power is significantly increased (adjusted $R^2$ of 0.84) and the corporate default risk and the liquidity risk premiums are the only risk premium components which impact the relative ESS indicator (coefficient of 0.33 and 0.09, respectively) while the coefficient of the bank default risk premium is not significantly different from zero.

The Asian-Pacific sample chart of Figure 21 shows the time-varying impact of the risk premium determinants on the relative ESS indicator. Until July 2007 the Baa-Aaa spread is the component with the highest impact on the relative ESS measure and additionally only the liquidity risk premium has some impact. From August 2007 until April 2009, the impact of the liquidity risk premium component increases whereas the corporate default risk premium remains the variable with the strongest influence. Interestingly, the bank default risk premium has a significant impact on the relative ESS indicator only during the ‘core’ financial crisis period, i. e. from August 2007 until April 2009. From May 2009 until the end of the observation period, the impact of the liquidity risk premium increases while the corporate default risk premium decreases so that both premium components have roughly the same impact at the end of the observation period. The bank default risk premium has no discernible impact in the Asian-Pacific sample. The time-varying impact of the corporate default and liquidity risk premium components shows a relative increase of the market's liquidity risk aversion and a decrease in the default risk aversion between the beginning and the end of the financial crisis which persists at the end of the observation period.

### 5.2.4 European financial system

The risk premium determinants regression results for the European sample are shown in Table 11. In the single-variable regressions, the liquidity risk premium has the highest explanatory power ($R^2$=0.55) and a regression coefficient of 0.19. The corporate default risk premium has the highest coefficient (0.26) and an explanatory power of 26 percent whereas the bank default risk premium alone has no sufficient explanatory power ($R^2$=0.11) while its coefficient is positive (0.08). Regression 4 shows the results from including all risk premium components in the regression equation: The liquidity risk premium and the corporate default risk premium influence the relative ESS indicator most strongly (coefficient of 0.16 and 0.09, respectively) whereas the bank default risk premium coefficient is only slightly positive (0.02).

The area diagram for the European sample in Figure 21 shows the time-varying impact of the risk premium components during the observation period: While the corporate default risk premium has the largest average impact on the relative ESS indicator until July 2007, the impact of the liquidity risk premium increased considerably since August 2007 and exceeds the impact of the default risk components as of April 2008. Notably, the bank default risk premium is only significant in the during the 'core' financial period between August 2007 and May 2009. The increase of the liquidity risk premium's impact with respect to the corporate default risk premium's effect during the financial crisis reflects a change in risk aversion by market participants during the financial crisis.

### 5.2.5 Middle Eastern and Russian financial system

The regression results for the Middle East and Russia sub-sample in Table 11 show that the corporate default risk premium has a strongly positive coefficient of 1.67 and it explains alone 83 percent of the variation in the relative ESS indicator. By contrast, the bank default risk premium alone does not have sufficient explanatory power ($R^2$=0.15) whereas its coefficient is also significantly positive. The liquidity risk premium alone has a coefficient of 0.50 and explains 37 percent of the variation in the relative ESS indicator. By including all risk premium components in the regression equation, the explanatory power is significantly increased (adjusted $R^2$ of 0.90) and the corporate default risk and the liquidity risk premiums turn out to be the only risk premium components which positively impact the relative ESS indicator (coefficient of 1.49 and 0.24, respectively). The bank default risk premium's coefficient is marginally negative (-0.04).

The Middle East and Russia sample chart of Figure 21 shows the time-varying impact of the risk premium determinants on the relative ESS indicator for this sub-sample. Until August 2007 only the corporate default risk premium significantly impacts the relative ESS indicator. From September 2007 until the end of the observation period the impact of the liquidity risk premium increases. The area diagram shows that the bank default risk premium has no discernible impact on the ESS indicator. While the corporate default risk premium still has the largest impact during the last months of the sample period, it can be noted that the liquidity risk premium increased substantially over time. This time-varying impact of the risk premium components shows a relative increase of the liquidity risk aversion and a relative decrease of the default risk aversion among market participants during the observation period.

#### 5.2.6 Comparative analysis

In the following we compare the risk premium analysis results of the individual samples. Due to the different levels of the relative ESS indicator across the samples we will focus the comparison on the *ranking* of the respective risk premium proxy coefficients and the comparison of the risk premium impact over time as shown in Figure 21.[40]

The corporate default risk premium is the risk premium component which has the highest explanatory power for the relative ESS measure and the largest average regression coefficient across all samples except for the European relative ESS indicator which is best explained by the liquidity risk premium. The liquidity risk premium ranks second in terms of explanatory power and average regression coefficient. By contrast, the regression results for the bank default risk premium show that this variable alone has no sufficient explanatory power for the relative ESS measure and in combination with the other risk premium components, the resulting coefficients are only marginally positive (if at all).

[40] By contrast, a comparison of the level values of the coefficients will not be conducted due to the significant differences between the samples' coefficients.

The area diagrams in Figure 21 emphasize the dominant impact of the corporate default risk premium over time for all samples with the exception of the European sample for which the liquidity risk premium is more dominant. A pattern which is observable in all charts is the increased importance and level of the liquidity risk premium since the beginning of the financial crisis and the relative decrease of the corporate default risk from the peak of the financial crisis until the end of the observation period. This observation is tantamount to an increase of the liquidity risk aversion and a decrease of the credit risk aversion among market participants. While further research is required to explain this effect in more detail, this development may be due to two common observations from the financial crisis: firstly, during the financial crisis market participants were most concerned with credit defaults which in fact did not occur as strongly as suggested by the increase in CDS spreads;[41] secondly, the financial crisis exposed the importance of asset liquidity in a drastic fashion as markets for certain assets dried up in a matter of days which has increased the demand for liquid assets and is reflected in the sustained elevated level of the liquidity risk premium.[42]

## 5.3 Relative contribution to the ESS-indicator

While the expected systemic shortfall indicator measures the *aggregate* systemic risk prevailing in the respective financial system, the understanding of the relative contributions of countries and individual institutions to this aggregate financial sector risk is also highly relevant not least from a regulatory point of view. As described in section 3.3 we compute the contribution of individual banking groups to the ESS-indicator by determining the share of the total portfolio loss by individual banking groups when the portfolio loss exceeds the systemic loss threshold. By aggregating the bank-specific systemic loss contributions on a country level we obtain the measure for a country’s systemic risk contribution over time. In order to understand the drivers for the relative systemic risk contribution by banks we conduct regression analysis using bank-specific parameters (e. g. risk-neutral default probability, correlation, liability weight and interaction terms) as explanatory variables.

In the following sections we describe the results for each sample individually and conduct a comparative analysis in the last section.

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[41] See Huang/Zhou/Zhu (2010a), pp. 18-19.

[42] See Taylor (2009), p. 18; Moessner/Allen (2011), pp. 2-3.

### 5.3.1 Global financial system

Table 12 shows the relative systemic loss contributions on a country level for the global sample. The results show that the systemic risk contributions are time-variant whereas the ranking is relatively stable over time. The countries with the highest average systemic loss contributions during the observation period are France, the United States and the United Kingdom (in ascending order of the systemic loss share). In Period 4 France even has a higher systemic loss contribution than the United States. By considering Table 1 and Table 3 it becomes evident that these results are consistent with the CDS spreads, correlations and liabilities of these countries: while the US banks have the highest total liabilities and their average CDS spreads are slightly above those of their UK counterparts, their average equity return correlations are significantly lower than the correlations of the British and French banks. At a relative systemic loss contribution of below 0.3 percent, Kazakhstan, Malaysia, Singapore, Bahrain, Qatar and the UAE the systemic loss share of these countries is in fact negligible.

A few notable observations can be made by considering the changes in the systemic loss contributions between Period 3 (‘core financial crisis period’) and Period 4 (‘post financial crisis period’). Among the countries with total liabilities above two trillion EUR, Germany, Switzerland and the US have reduced their systemic loss contributions whereas France and the UK increased theirs. The countries whose systemic loss contribution increased by at least 40 percent from Period 3 to Period 4 are China, Greece, Portugal and Spain. While in China’s case this is due to an increase of total liabilities and correlations, the increase for the European countries can be explained by the severe increase in CDS spreads due to the Euro sovereign debt crisis (e. g. the share of Greece increased fivefold). The fact that the systemic risk contribution of Ireland has not increased from Period 3 to Period 4 despite the increase of its CDS spreads be explained by a decrease in Ireland’s total liabilities and its correlations. Korea, Malaysia and Singapore are the countries which decreased their systemic risk contributions most from Period 3 to Period 4 (relative decrease by 60-65 percent).

The relative systemic loss contributions for the individual banks in the global sample are shown in Table 13. The above general conclusions for the country level also apply on the bank level. The banks with the highest relative systemic risk contribution in Period 4 are Barclay’s, Deutsche Bank, Royal Bank of Scotland, Lloyds Banking Group and BNP Paribas. It should be noted that the strong increase in the systemic risk contribution of Bank of America in Period 3 is due to its takeover of Merrill Lynch and the increase in the systemic risk share of Lloyds Banking Group in Period 4 is due to its acquisition of HBOS. The actuality that no US banks are among the top five can be explained on grounds of the relatively low correlations of the US banks vis-à-vis their European counterparts.

The banks with the strongest increase in the systemic loss contributions from Period 3 to Period 4 are the banks from Euro zone countries with sovereign debt issues. All banking groups with total liabilities exceeding one trillion EUR have decreased their relative contribution from Period 3 to Period 4 with the notable exceptions of BNP Paribas, Crédit Agricole and Societé Generale. By defining systemic loss contribution thresholds of one/three/five percent one can conclude that 23/12/6 banking groups in the global sample exceed this threshold in Period 4.[43]

Table 21 shows the regression results for the determinants of the relative systemic risk contribution in the global sample. The liability weight turns out to be the single variable with the highest impact on a bank's systemic risk contribution. In regressions 2, 3 and 4 the estimated coefficient for the liability weight is even above one, which means that a one percentage-point increase of a bank's liability weight leads to a disproportionate increase in its relative contribution to the systemic risk. This finding corroborates the common concern that a bank's size is the main driver for the risk it poses to the financial system ('too big too fail'). Regression 4 exposes that correlations also have a 'positive' impact on banks' systemic risk contribution. Regression 1 shows that the bank-specific risk-neutral default probability alone has no sufficient explanatory power for the relative systemic risk contributions. Regressions 5 and 6 expose, however, that the interaction between liability weight and risk-neutral PD has a significant positive coefficient as does the interaction between the average correlation and the liability weight.[44]

### 5.3.2 American financial system

Table 14 shows the relative systemic loss contributions for the bank holding companies in the American sub-sample. The results show that the systemic risk contributions vary over time whereas the ranking is largely constant. The banks with the highest ESS contribution in Period 4 *and* during the whole sample period are JP Morgan, Bank of America and Citigroup (in ascending order of their systemic loss share). It should be noted that the strong increase in

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[43] This result will be revisited in the next chapter concerning the policy implications of the empirical results.

[44] The conclusions from Regression 6 need to be interpreted with some caution, however, as the variance inflation factors indicate the presence of multicollinearity.

the systemic risk contribution of Bank of America in Period 3 is due to its acquisition of Merrill Lynch. The banks which increased their systemic loss share most from Period 3 to Period 4 are Bank of America, JP Morgan and Wells Fargo (multiple of 1.1–1.3) whereas American Express, Goldman Sachs and PNC Financial Services significantly decreased their systemic risk contribution (factor of 0.6–0.8). By defining systemic loss contribution thresholds of five (ten) percent we conclude that three (seven) banking groups in the American sample exceed this threshold in Period 4.

Table 22 shows the regression results for the determinants of the relative systemic risk contribution in the American sample. The liability weight is the single variable with the highest impact on a bank's systemic risk contribution. The estimated coefficient for the liability weight is even above one in regressions 2 to 6, which means that a one percentage-point increase of a bank's liability weight causes a disproportionate increase in its relative contribution to systemic risk. This conclusion confirms common opinion that a bank's size strongly determines the risk it poses to the financial system. Regression 6 exposes that correlations also have a 'positive' impact on banks' systemic risk contribution whilst the negative coefficient for the correlation in Regression 4 is likely caused by an omitted variable bias. The bank-specific risk-neutral default probability alone has no sufficient explanatory power for the relative systemic risk contributions which is shown by Regression 1. However, Regressions 5 and 6 expose that the interaction between liability weight and risk-neutral PD has a significant positive coefficient.

### 5.3.3 Asian-Pacific financial system

Table 15 shows the relative systemic loss contributions on a *country* level for the Asian-Pacific sample. The results show that the systemic risk contributions are time-variant whereas the ranking is relatively constant over time. The countries with the highest average systemic loss contributions during the observation period are China, Australia and Japan (in ascending order of the systemic risk contribution). In Period 4 China ranks even ahead of Australia which is due to a strong relative increase of its total liabilities in this period. The countries with the lowest systemic risk contribution are Kazakhstan, Malaysia and Hong Kong.

Interestingly, China and Australia are also the countries which increased their systemic risk contribution most from Period 3 to Period 4 which is driven by the growth of the total bank liabilities of these two countries (multiple of 1.4 and 1.3, respectively). By contrast, the relative systemic loss contribution of Hong Kong, Korea and Singapore halved from Period 3 to Period 4. Overall, these changes increased the combined systemic loss contribution share of Australia, China and Japan from 80 percent in Period 3 to 90 percent in Period 4.

The relative systemic loss contributions for the *banks* in the Asian-Pacific sample are shown in Table 16. In Period 4 the banks with the highest systemic risk contribution are the Commonwealth Bank, Westpac Banking Corp, Sumitomo Mitsui Banking, Bank of China and Mizuho Financial Group. ANZ Banking Group, Westpac Banking Corp and Bank of China increased their systemic loss contribution most from Period 3 to Period 4 (multiple of 1.4-1.5) whereas India's ICICI Bank, Halyk Bank of Kazakhstan and Korea's Shinhan Group decreased their systemic risk contribution most (relative decrease of 60 percent). By defining systemic loss contribution thresholds of five (ten) percent the results show that six (three) banking groups in the Asian-Pacific sub-sample exceed this threshold in Period 4.

Table 23 shows the regression results for the determinants of the relative systemic risk contribution in the Asian-Pacific sample. The liability weight turns out to be the single variable with the highest impact on a bank's systemic risk contribution. In all regressions where the liability weight is included, its estimated coefficient is even above one, which means that an increase of a bank's liability weight leads to a disproportionate increase in its systemic risk contribution. This finding confirms the common proposition that a bank's size is the main driver for the risk it poses to the financial system. Regression 1 shows that the bank-specific risk-neutral default probability alone has no sufficient explanatory power for the relative systemic risk contributions whereas in conjunction with the liability weight and the average correlation it has a significant positive coefficient as does the average correlation. The coefficients of the interaction terms in Regressions 5 and 6 need to be interpreted with some caution as the variance inflation factors indicate the presence of multicollinearity.

### 5.3.4 European financial system

The relative systemic loss contributions by *country* for the European sub-sample are shown in Table 17. The systemic risk contributions vary over time, the ranking is rather constant. Switzerland, Germany, France and the UK are the countries with the highest average systemic loss contribution during the observation period (in ascending order of systemic risk contribution). However, in Period 4 Germany, Spain, France and the UK have the highest systemic risk contributions with a combined total of 74 percent. The Netherlands, Denmark and Greece have the lowest systemic loss contribution.

The countries which increased their relative systemic loss share most from Period 3 to Period 4 are Spain, Portugal and Greece due to their sovereign debt issues (multiplier of 1.4-3.5). One may wonder why Ireland's share even decreased slightly in Period 4 despite the increase of its average CDS spreads: this can be explained by the reduction of its total liabilities[45] and the decrease in Ireland's correlations which is likely due to the fact that the Irish government acquired major stakes in its banks during the financial crisis which 'decoupled' the Irish banks' stock prices somewhat from equity prices of other European banks. Denmark, Sweden and Switzerland are the countries which decreased their systemic risk contributions most strongly in Period 4.

Table 18 shows the systemic contributions of the *banks* in the European sample. Crédit Agricole, Royal Bank of Scotland, BNP Paribas and Lloyds Banking Group are the banks with the highest systemic risk contributions in Period 4. From Period 3 to Period 4 the banks which increased their systemic risk contributions most are the Greek and Portuguese banks. The strong systemic risk contribution increase of Lloyds Banking Group in Period 4 is due to its takeover of HBOS. The banks which decreased their systemic risk contributions most from Period 3 to Period 4 are Germany's IKB, Denmark's Danske Bank and Switzerland's UBS. By applying systemic loss contribution thresholds of one (five) percent the results show that 18 (9) banking groups in the European sub-sample exceed this threshold in Period 4.

The regression results for the determinants of the relative systemic risk contribution in the European sample are shown in Table 24. The liability weight is the single variable with the highest impact on a bank's systemic risk contribution. In Regression 3 and 4 the estimated coefficient for the liability weight is even above one, which means that an increase of a bank's liability weight leads to a disproportionate increase in its systemic risk contribution. This finding confirms the common claim that a bank's size is the main driver for the risk it poses to the financial system. Regression 1 shows that the bank-specific risk-neutral default probability alone has no sufficient explanatory power for the relative systemic risk contributions whereas in conjunction with the liability weight and the average correlation it has a significant positive coefficient as does the correlation. The interaction terms of default

[45] The reduction in total liabilities is also caused by a de-leveraging of the Irish sample banks.

probability, correlation and liability weight also have as expected significant positive coefficients in Regression 5 and 6.[46]

### 5.3.5 Middle Eastern and Russian financial system

Table 19 shows the relative systemic loss contributions by country for the Middle East and Russia sub-sample. The systemic risk contributions are time-variant whereas the ranking is relatively stable over time. Russia and the United Arab Emirates are the countries with the highest systemic risk contribution (combined share of 98 percent), Bahrain and Qatar only have minor systemic risk shares. The Middle Eastern countries have the strongest increase in systemic risk contribution from Period 3 to Period 4 (relative increase from 14 to 28 percent) while the share of Russia slightly decrease in this time which can partly be explained by the sustained high CDS levels of the UAE banks since Dubai's sovereign debt problems in the fourth quarter of 2009.

The systemic risk contributions of the individual banks in the Middle East and Russia sample are shown Table 20. Bank of Moscow, WTB and Sberbank have the highest systemic loss contribution in Period 4 whereas the Commercial Bank of Qatar, Arab Banking Corp and Mashreqbank contribute least to the systemic risk in this sub-sample. The largest increase in the systemic risk contributions from Period 3 to 4 are observed for Arab Banking Corp, Abu Dhabi Commercial Bank and Mashreqbank (multiplier of 1.3-1.6) whereas WTB, Bank of Moscow and Dubai Islamic bank reduce their systemic loss contribution in the last period (relative decrease of 1-20 percent).

Table 25 shows the regression results for the determinants of the relative systemic risk contribution in the Middle East and Russia sample. The liability weight turns out to be the single variable with the highest impact on a bank's systemic risk contribution. In all regressions where the liability weight is included, its estimated coefficient is even above one, which means that an increase of a bank's liability weight leads to a disproportionate increase in its systemic risk contribution. This finding confirms the claim that the size of a bank determines its riskiness for the aggregate financial system.

Regression 1 shows that the bank-specific risk-neutral default probability alone has no sufficient explanatory power for the relative systemic risk contributions whereas in conjunction with the liability weight and the average correlation it has a significant positive

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[46] The conclusions from Regression 6 need to be interpreted with some caution, however, as the variance inflation factors indicate the presence of multicollinearity.

coefficient as does the average correlation. The coefficients of the interaction terms in Regressions 5 and 6 are to be interpreted with some caution as the variance inflation factors indicate the presence of multicollinearity.

#### 5.3.6 Comparative analysis

Across all samples we can observe that the banks with the highest (smallest) relative systemic loss contribution are also the largest (smallest) in their sample in terms of total liabilities. Furthermore, at a similar level of relative liability share, the banks with the higher CDS spreads contribute more to the systemic risk. The strongest increase in systemic risk contribution from Period 3 to Period 4 is observed for the banks affected by 'special circumstances' such as the Euro zone sovereign debt crisis which strongly increased the risk contribution of Greece, Portugal and Spain and Dubai's sovereign debt problems which substantially increase the systemic risk contributions of the UAE (amongst other reasons).

The above observations are confirmed by comparing the regression analysis results concerning the determinants of the relative systemic risk contributions in Table 21 to Table 25 we find that the risk-neutral default probability alone has no sufficient explanatory power whereas together with the liability weight and the average correlation it has as expected a positive coefficient. The liability weight has the strongest impact on the relative ESS contribution with an average coefficient of even above one. This finding confirms the common concern that the higher a bank's size, the greater is the risk it poses to the financial system ('too big too fail'). A higher average equity return correlation also increases the bank's systemic risk contribution in all samples except for the American sample. The interaction terms between average correlation, risk-neutral probability and liability weight are positive on average whereas the interpretation of the results of regression 5 and 6 needs to be conducted with some caution due to the presence of multicollinearity.

### 5.4 Comparison with related research

As this is the first published study of systemic risk in the *global* financial sector, comparisons can be drawn only for sub-samples of our analysis. To this end we compare the analysis of systemic risk in the US financial sector by Huang/Zhou/Zhu (2010b) with our results for the

American sample and the analysis by Huang/Zhou/Zhu (2010a) of bank holding companies in the Asia-Pacific region with our results for the Asian-Pacific sub-sample.[47]

A comparison of the trajectory of the Distress Insurance Premium (DIP) systemic risk measure for the US financial system in Figure 2 of Huang/Zhou/Zhu (2010b) with the gradient of the ESS indicator of the American sample in Figure 9 between October 2005 and December 2009 exposes a consistency for *both* the peak points in time as well as for the ranking of the peak heights for the absolute and relative measures alike. With respect to the input factor determinants regression, the results for the American sub-sample in Table 10 are consistent with the regression results of Huang/Zhou/Zhu (2010b) in Table 2. As for the determinants of the systemic risk contributions by individual institutions, the results (in terms of estimated coefficients and coefficient rankings) from regressions 4 and 6 in Table 22 are consistent with the results of regression 1 and 3 in Table 5 of Huang/Zhou/Zhu (2010b).[48]

By comparing the gradient of the DIP measure for the Asian-Pacific banks in Figure 3 of Huang/Zhou/Zhu (2010a) with the ESS results for the Asian-Pacific sub-sample in Figure 11 between October 2005 and May 2009 we observe that the peaks are at the same points in time whereas the ranking of the peak heights differs slightly: the peaks in November and December 2008 of the ESS indicator are stronger than the DIP peaks in Huang/Zhou/Zhu (2010a). As regards the input factor determinants, our results for the Asian-Pacific sub-sample in Table 10 are consistent with the results in Table 3 of Huang/Zhou/Zhu (2010a) in terms of coefficient rankings.[49] With respect to the determinants of the relative systemic risk contributions by individual institutions we find that our results of regression 4 in Table 23 are consistent with regression 1 in Table 6 of Huang/Zhou/Zhu (2010a) whereas the results differ between our regression 6 and the relative-term DIP regression 3 (while the reasons cannot be explored further, multicollinearity in both regression equations is a likely cause[50]).

In summary we can state that the our ESS results for the American and Asian-Pacific sub-samples are consistent with the findings of Huang/Zhou/Zhu (2010b) and Huang/Zhou/Zhu

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[47] While there are also other studies of systemic risk in the American financial sector, Huang/Zhou/Zhu (2010b) provide the only comprehensive results which are comparable to our findings.

[48] Minor differences apply as Huang/Zhou/Zhu (2010b) also include the recovery rates in the regressions. Also, Huang/Zhou/Zhu (2010b) apply a different methodology to compute *marginal* risk contributions.

[49] As Huang/Zhou/Zhu (2010a) use the absolute DIP as dependent variable, the coefficients are naturally hardly comparable.

[50] Unfortunately Huang/Zhou/Zhu (2010a) do not provide variance inflation factors in their regressions in order to further analyze this claim.

(2010a), respectively. As the ESS indicator is computed on a daily basis whereas the DIP is computed on a weekly basis only, the gradient of the ESS indicator is more erratic and reacts faster to the financial crisis events then the DIP measure. Minor differences exist with respect to certain regression results which is not surprising as the methodologies and input parameters employed in the studies are different.

# 6 Regulatory Policy Implications and Recommendations

The recent financial crisis has exposed the need for macroprudential regulation, which seeks to enhance the stability of the overall financial system in addition to microprudential measures which focus on the stability of individual institutions. The Basel III regulatory framework released in December 2010 was devised bearing in mind this guiding principle. Therefore, the extended and new regulatory measures such as increased capital requirements, countercyclical capital buffers and the liquidity standard serve both macroprudential and microprudential purposes.[51] Regarding the treatment of systemically important banks, the new Basel III standard contains so far no specific provisions but states that the work on an "integrated approach" for the regulation of these entities will be completed in the first half of 2011.[52] The proposals currently under discussion comprise bail-in debt, capital surcharges, conditional capital and resolution mechanisms as potential measures for regulating systemically important banks.[53]

Irrespective of the precise measures taken to regulate SIFIs, the first step in regulating these entities is to adequately identify them. Among the current proposals for the identification of SIFIs one can discern an inclination to asses a bank's systemic importance based on its global ranking in terms of *size*. However, the use of a transparent, well-defined and accepted metric based on capital market data has obvious advantages. We suggest the use of the relative contribution to the ESS-indicator (or a comparable measure of systemic risk) in order to assess a bank's systemic importance. We consider the measure to be a suitable indicator for systemic importance as it directly incorporates the bank's size and also its interconnectedness and overall risk-profile are reflected as the ESS indicator is based on capital market data.[54]

The implementation could be conducted in a binary fashion by declaring all banking groups systemically important whose relative ESS contribution exceeds a certain threshold. For instance, by setting the relative ESS contribution threshold at 1 percent (3 percent) on the *global* level, our analysis in Table 13 shows that during Period 4 of the observation period 23

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[51] See BIS (2010), pp. 1-4.

[52] While specific provisions for systemically important financial institutions are yet pending, certain new capital requirements decrease the incentive of mutual exposures among global financial institutions.

[53] See BIS (2010), pp. 6-8.

[54] As the availability of capital market data is a precondition for the application of the ESS methodology our recommendation is based on the assumption that the relevant data is available for systemically important financial institutions.

(12) out of the 83 banking groups are globally systemically important.[55] Moreover, the ESS contribution could be translated into a discrete or continuous measure of systemic importance to facilitate the differentiation of degrees of systemic importance and a corresponding differentiation of regulatory measures, e. g. capital surcharges. Applying this concept to the empirical results for the global sample could mean, for instance, that the 12 banks whose systemic risk contribution exceeds 3 percent could be subjected to additional regulatory measures (discrete approach) or that the capital surcharges are scaled by the extent of which a bank's relative ESS contribution exceeds 1 percent (continuous approach). Under the latter approach, systemically important banks could take measures to mitigate their systemic importance, e. g. by reducing their balance sheet or overall risk profile, in order to achieve a more favorable regulatory treatment. As the continuous implementation approach would lead to efficient risk-taking incentives for the subjected financial institutions we consider this a particularly favorable implementation for regulating systemically important banks.

In assessing the systemic importance of banks we suggest to distinguish different layers of systemic importance and apply the ESS methodology to the geographical focus of interest in the way we analyzed the regional sub-samples. While the current regulatory discourse is focused on banking groups with systemic importance for the *global* financial system, *regional* and *national* systemically important banking groups should potentially be considered as well. The reasoning behind this proposal is that certain banks may be highly important for the functioning of regional or national financial sub-systems, while not being necessarily considered systemically important on a global scale.[56] Applying this proposal to our empirical results could take the following shape: while none of the banking groups from the Asian-Pacific region are systemically important on the global scale according to the above exemplary one percent threshold, Bank of China as well as Japan's Mizuho Financial Group and Sumitomo Mitsui Banking should be considered systemically important in the Asia-Pacific region and their countries of residence as their systemic loss contribution in the Asian-Pacific sub-sample lies above 15 percent.

Our analysis of the determinants of the relative risk contributions shows that a bank's size is the most important determinant of a bank's systemic importance. While the size is already

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[55] Period 4 ranges from January 1st, 2010 to April 30th, 2011.

[56] As our ESS-indicator can be implemented only for banks with publicly traded CDS spreads and equity the implementation of this proposal may require the use of additional metrics. This would be the case e. g. for state banks ("Landesbanken") in Germany.

captured in the bank's relative contribution to the ESS-indicator (and hence in our proposed approach for the assessment of systemic importance), regulators may want to consider additional limitations on the maximum size of banking groups. In fact, such a provision was made in the Dodd-Frank Act ("Wall Street Reform") by stating that an acquisition or merger of financial companies shall not be permitted if the resulting entity would have more than 10% of the total financial sector liabilities.[57]

The development of the ESS-indicator during the observation period shows that the aggregate level of risk in the financial system varies significantly over time. Consequently, central banks and regulators could use the ESS-indicator (globally or also for regional sub-samples) in order to enhance their ongoing financial stability monitoring and early warning systems.

[57] See SEC (2010), section 622 (b), p. 258.

# 7 Conclusion

In this paper we derive the expected systemic shortfall (ESS) indicator for the measurement of systemic financial sector risk. The ESS indicator is the product of the probability of a systemic default event and the expected loss in case this event occurs. It is a forward-looking risk-neutral measure which reflects the market judgment of aggregate systemic risk. We provide a methodology to determine the relative contribution of individual banks to the aggregate level of systemic risk as measured by the ESS indicator.

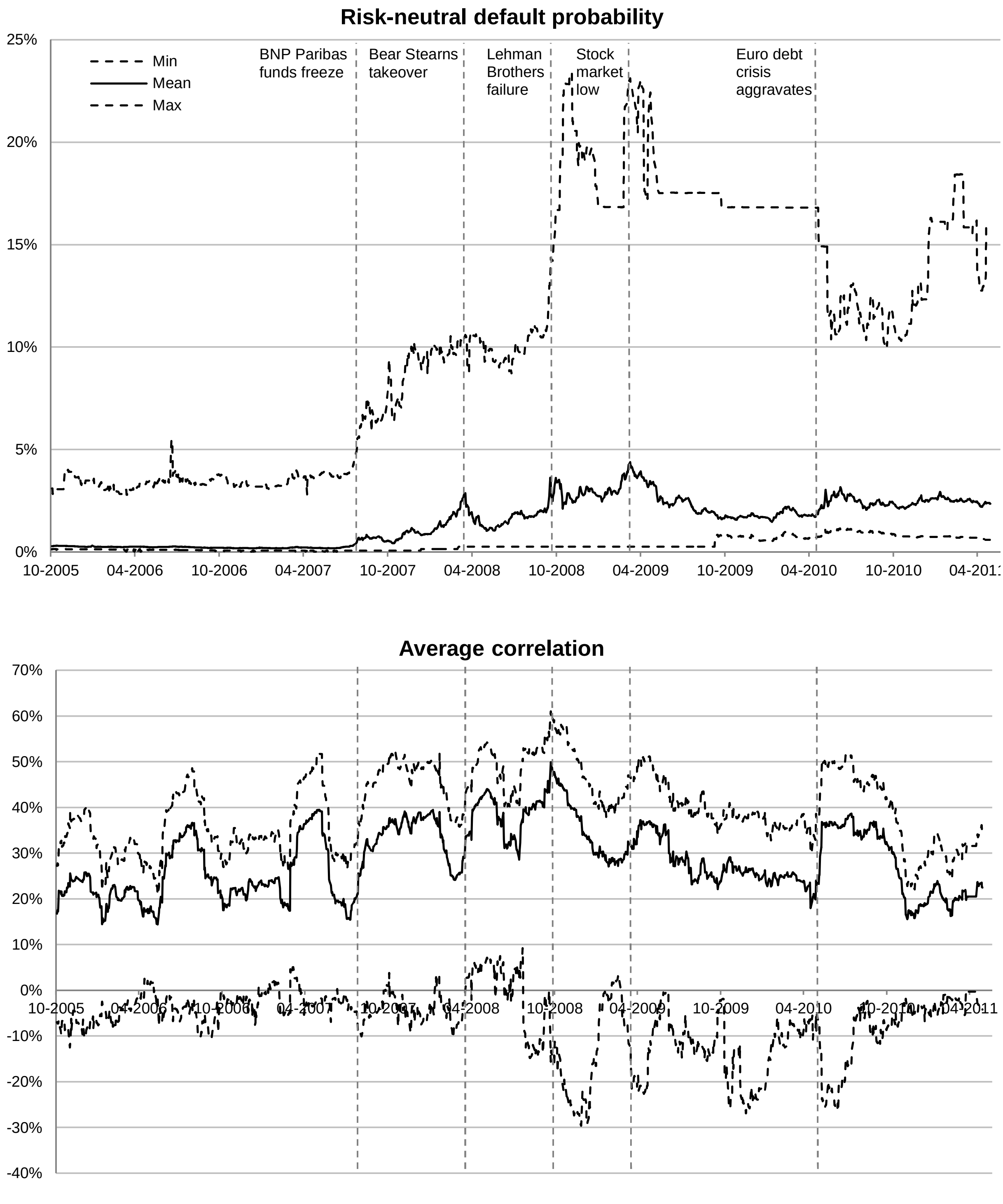
We apply the ESS methodology to a global sample and four regional sub-samples of banking groups and find that the indicator responds well to both the financial crisis events with global importance and also to region-specific events in the sub-samples. The ESS-indicator remains at an elevated level at the end of the observation period with respect to its pre-crisis level of all samples but particularly for the European sample due to the Euro sovereign debt crisis. The average risk-neutral default probability is the input factor with the highest explanatory power for the ESS indicator. By analyzing the risk premium determinants of the ESS indicator we find that the corporate default risk premium and the liquidity risk premium are the most important explanatory variables for the ESS indicator.

The relative systemic risk 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 systemic risk contribution threshold of 1 percent to the results for the global sample we find that there are *23 globally systemically important banks*. We recommend regional and national regulators to consider applying similar metrics to the banks under their responsibility. Additional effort needs to be undertaken in order to devise an operational policy framework for the regulation of systemically important financial institutions under the umbrella of the Basel III banking regulation.

## LIST OF FIGURES

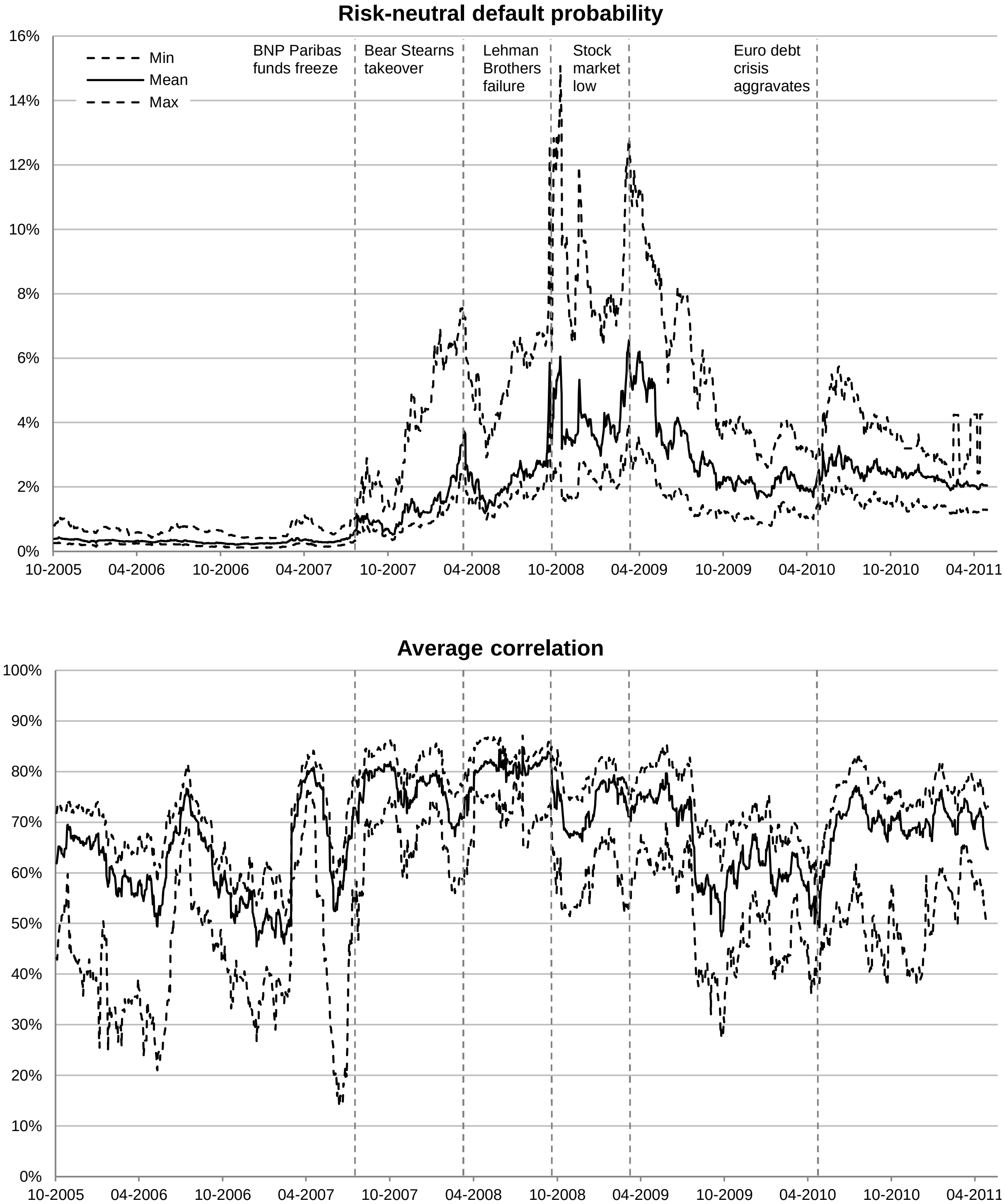
Figure 1 Input variables for the ESS-indicator (Global) .... 59
Figure 2 Input variables for the ESS-indicator (America) .... 60
Figure 3 Input variables for the ESS-indicator (Asia-Pacific) .... 61
Figure 4 Input variables for the ESS-indicator (Europe) .... 62
Figure 5 Input variables for the ESS-indicator (Middle East and Russia) .... 63
Figure 6 Input variables for the ESS-indicator (Comparative analysis) .... 64
Figure 7 Absolute and relative expected systemic shortfall (Global) .... 65
Figure 8 Probability of systemic default and expected tail loss (Global) .... 66
Figure 9 Absolute and relative expected systemic shortfall (America) .... 67
Figure 10 Probability of systemic default and expected tail loss (America) .... 68
Figure 11 Absolute and relative expected systemic shortfall (Asia-Pacific) .... 69
Figure 12 Probability of systemic default and expected tail loss (Asia-Pacific) .... 70
Figure 13 Absolute and relative expected systemic shortfall (Europe) .... 71
Figure 14 Probability of systemic default and expected tail loss (Europe) .... 72
Figure 15 Absolute and relative expected systemic shortfall (Middle East and Russia) .... 73
Figure 16 Probability of systemic default and expected tail loss (Middle East and Russia) ... 74
Figure 17 Absolute and relative expected systemic shortfall (Comparative analysis) .... 75
Figure 18 Probability of systemic default and expected tail loss (Comparative analysis) .... 76
Figure 19 Relative change of absolute and relative ESS indicator with respect to initial average (Comparative analysis) .... 77
Figure 20 Relative change of probability of systemic default (PSD) and expected tail loss (ETL) with respect to initial average (Comparative analysis) .... 78
Figure 21 Risk premium determinants of the relative ESS-indicator .... 79

*Figure 1 Input variables for the ESS-indicator (Global)*



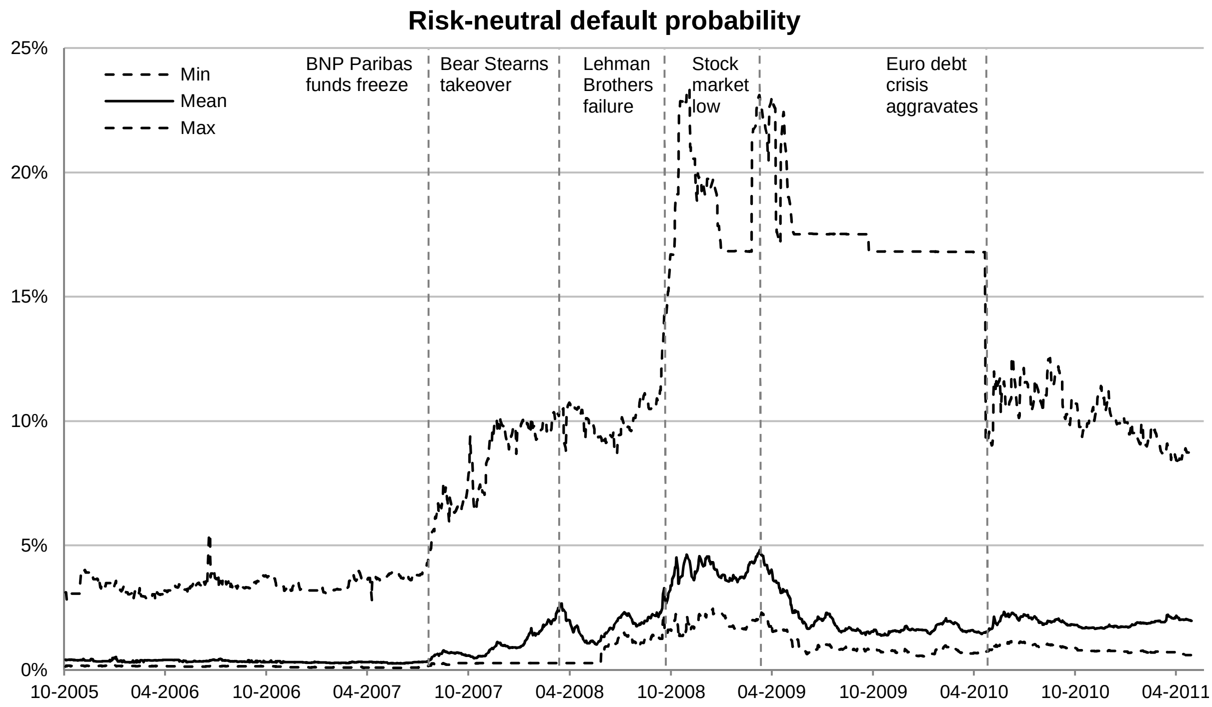

*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

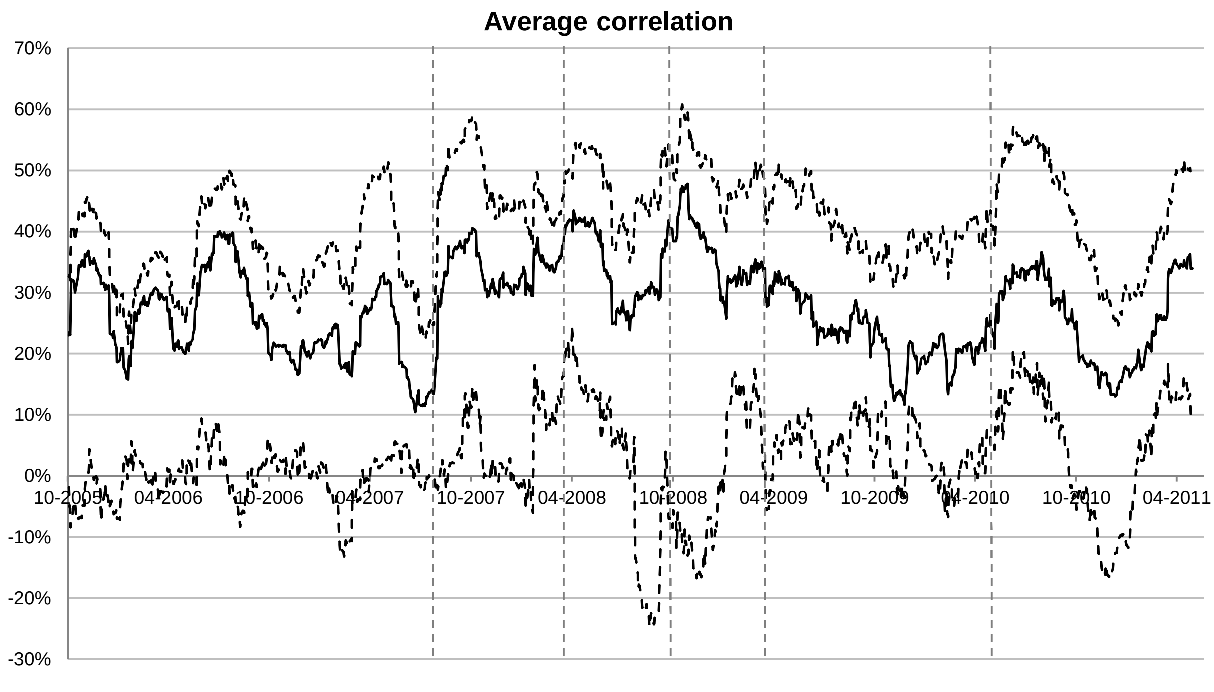
*Figure 2 Input variables for the ESS-indicator (America)*




*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

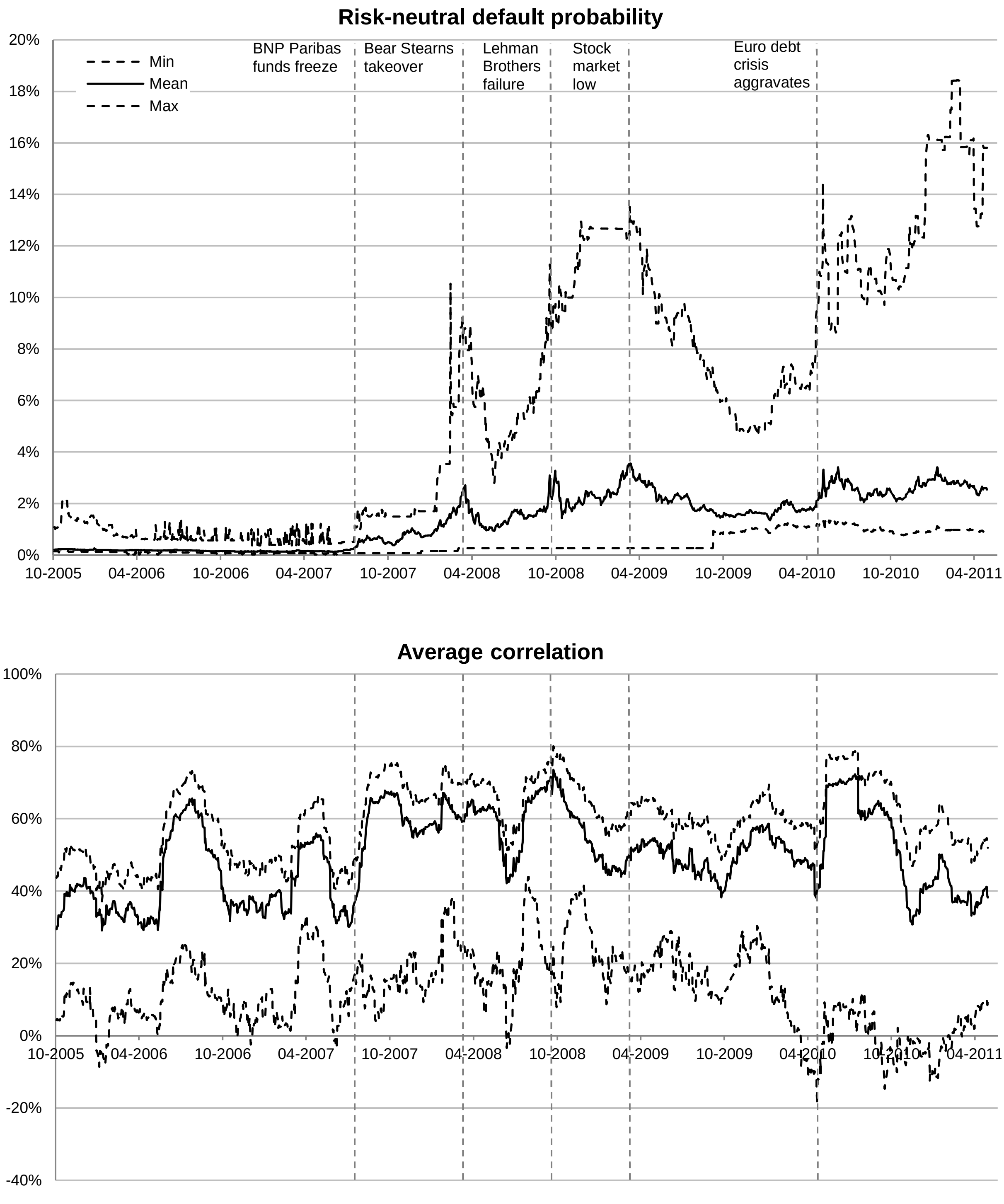
*Figure 3 Input variables for the ESS-indicator (<u>Asia-Pacific</u>)*



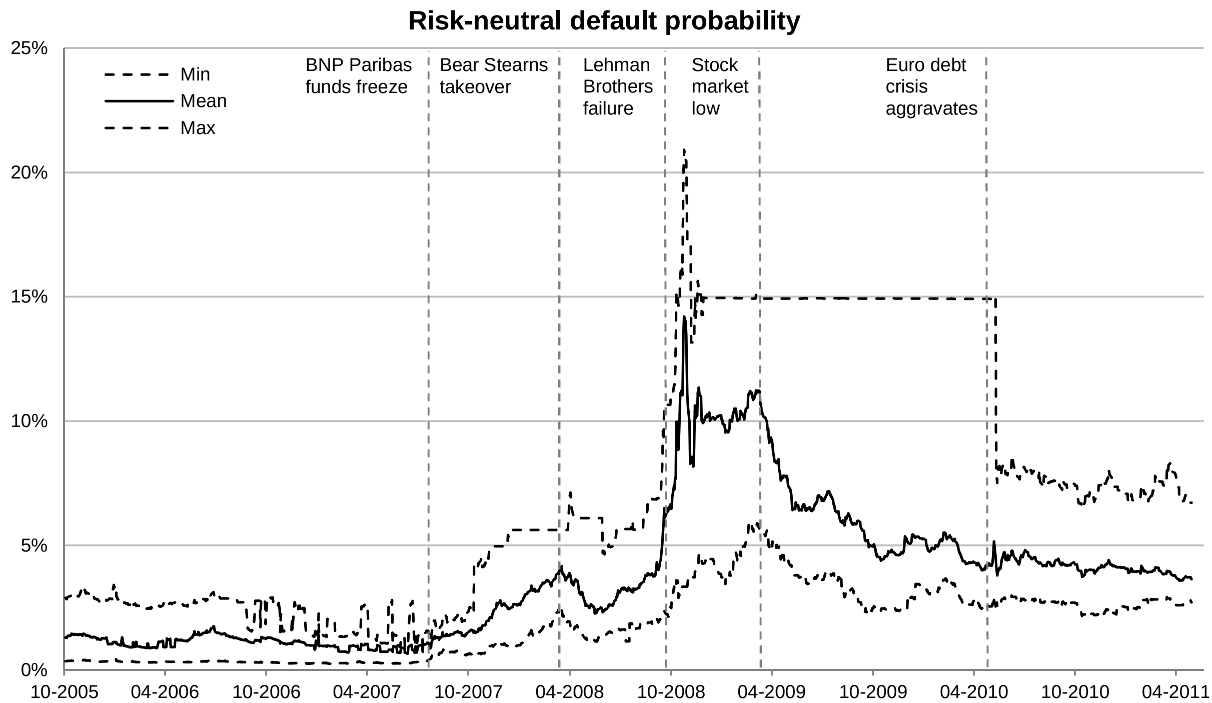

*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

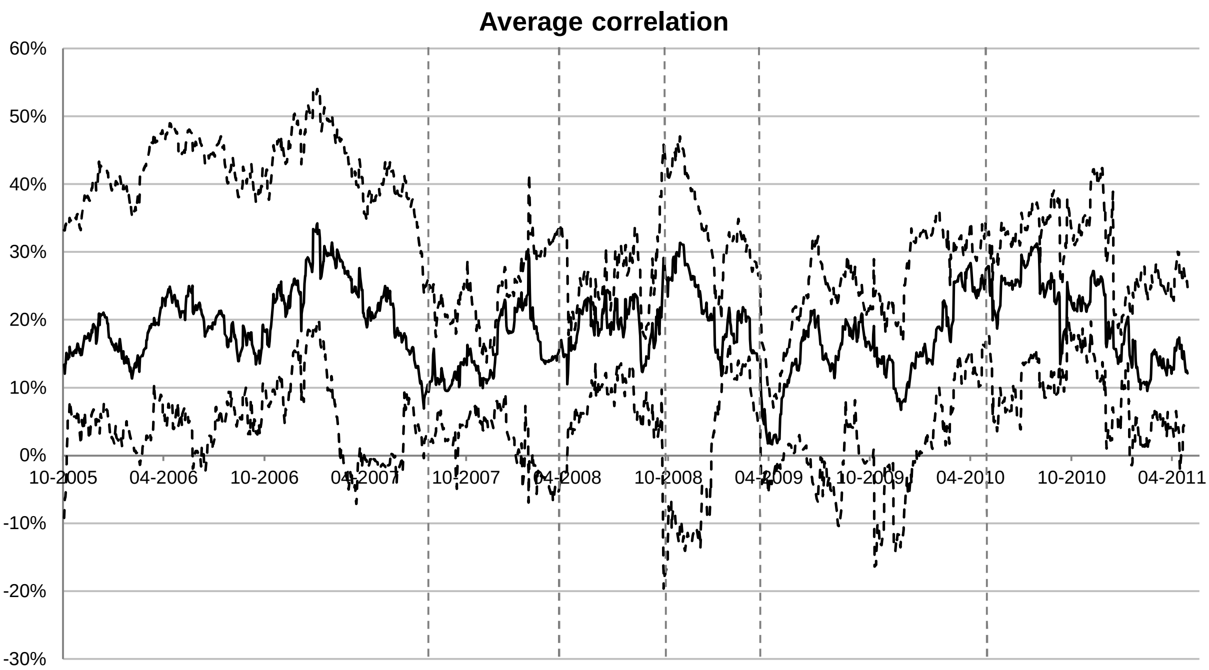
*Figure 4 Input variables for the ESS-indicator (Europe)*




*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

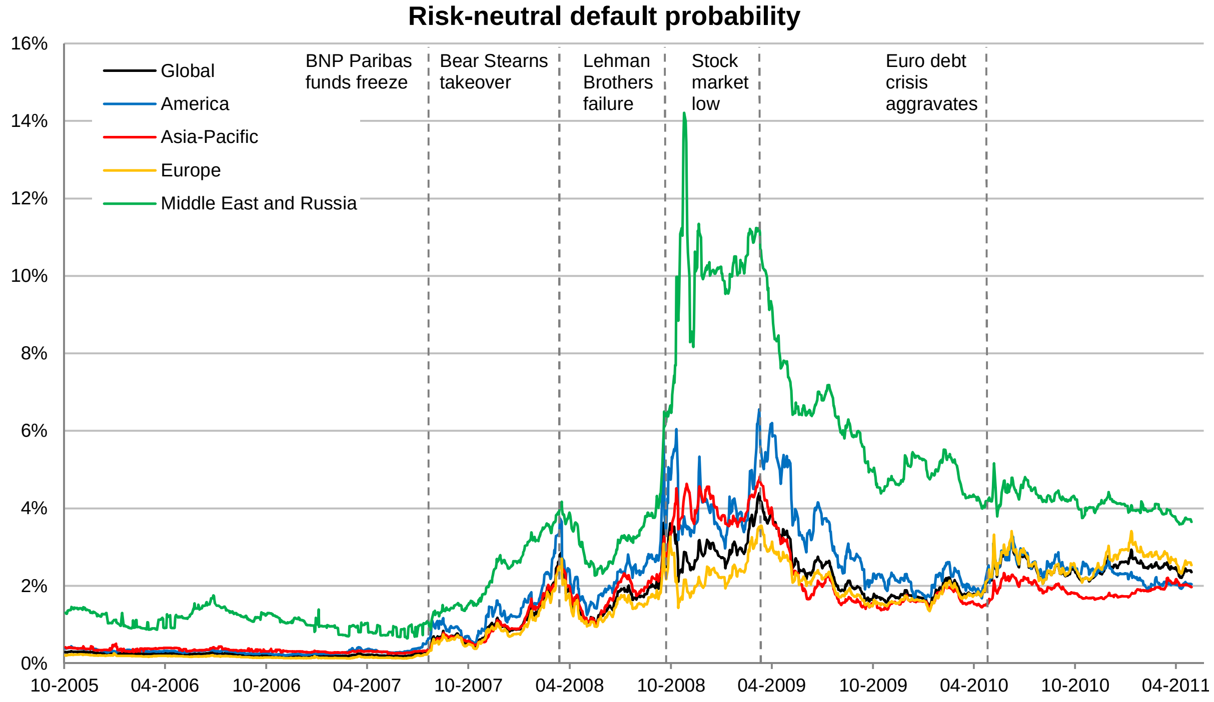
*Figure 5 Input variables for the ESS-indicator (Middle East and Russia)*

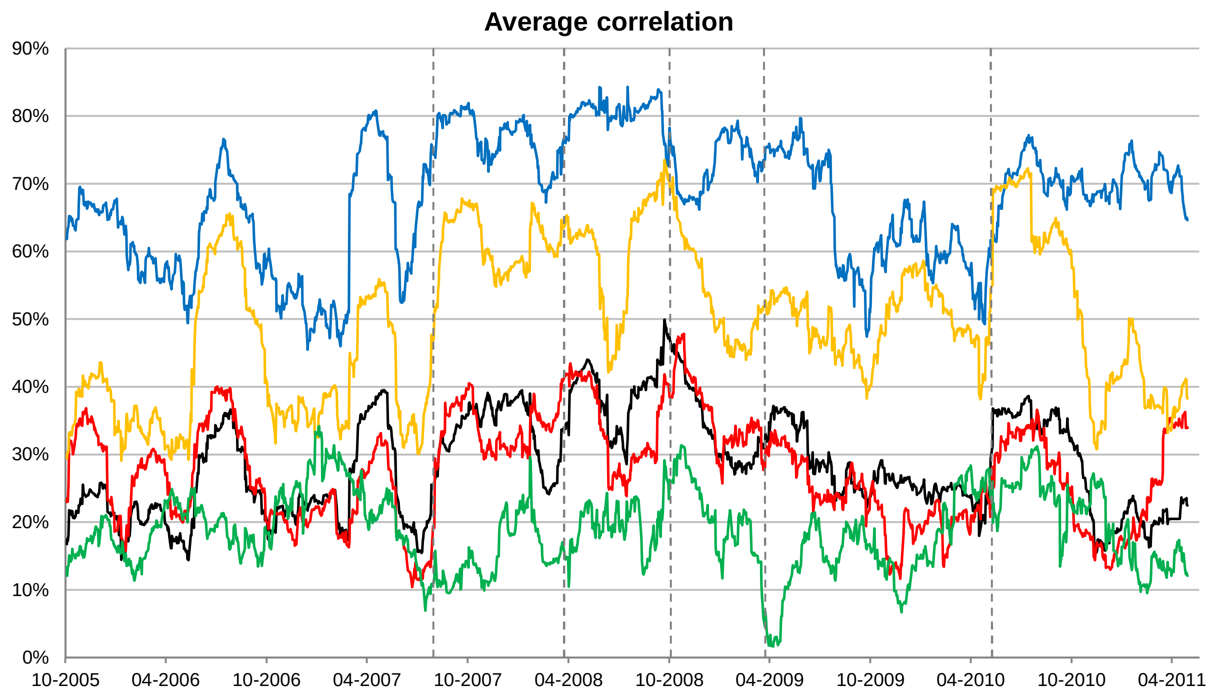



*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

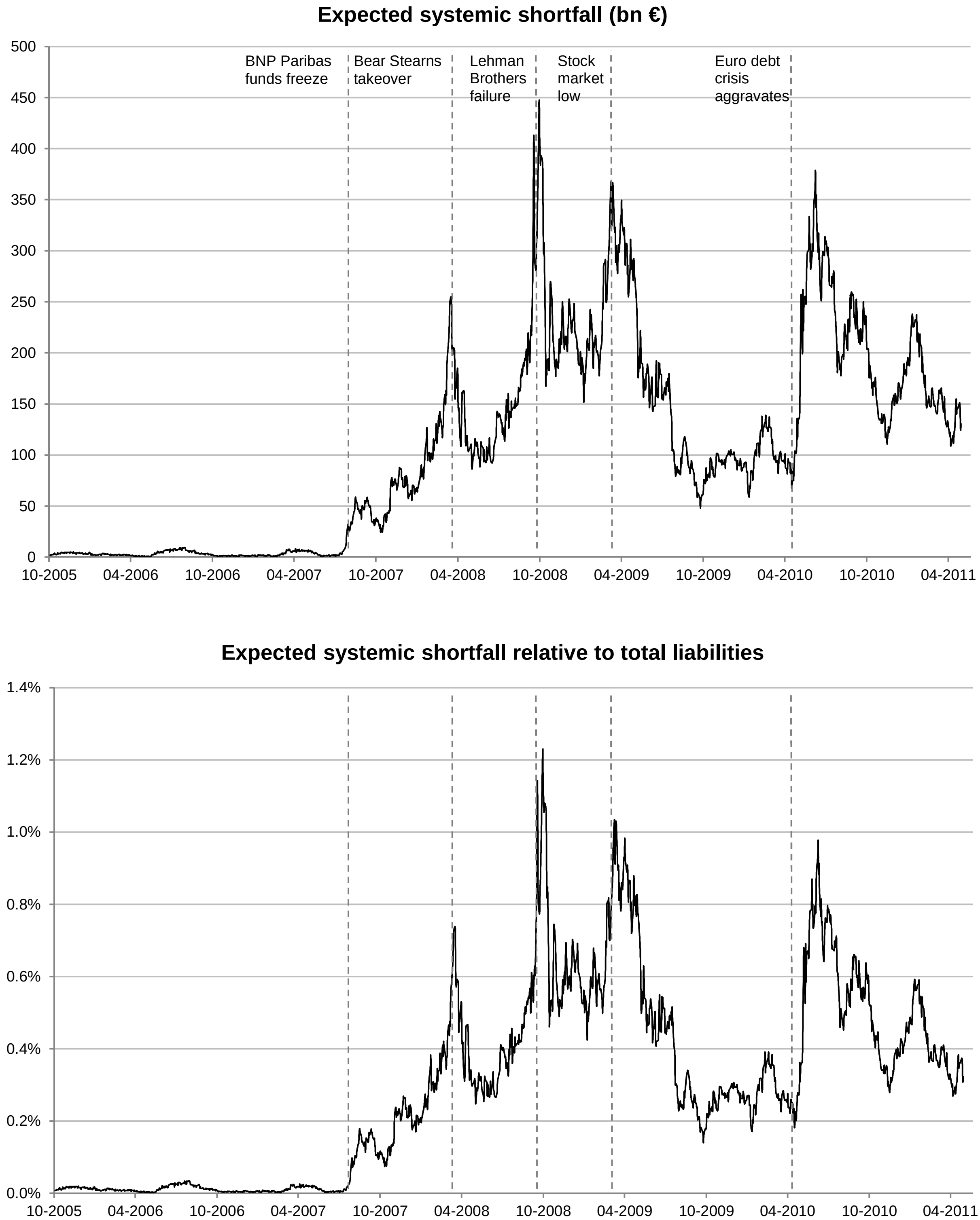
*Figure 6 Input variables for the ESS-indicator (Comparative analysis)*



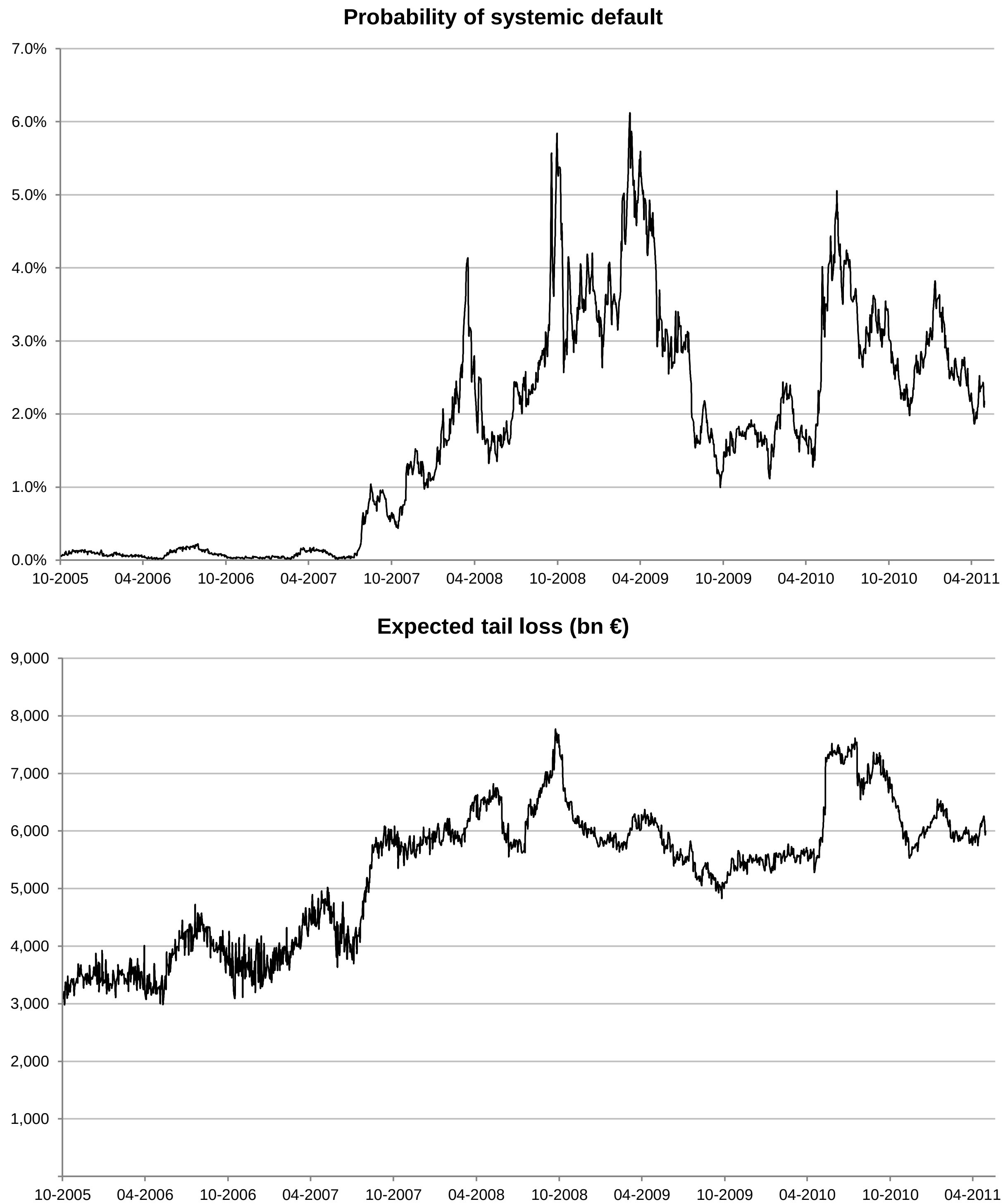

*Notes:* The upper panel shows the average risk-neutral default probabilities during the observation period (weighted by total liabilities). The lower panel shows the average correlations of the sample banks (computed from the correlations of one bank with all other banks, weighted by total liabilities). The dashed lines represent selected financial crisis events.

*Figure 7 Absolute and relative expected systemic shortfall (Global)*



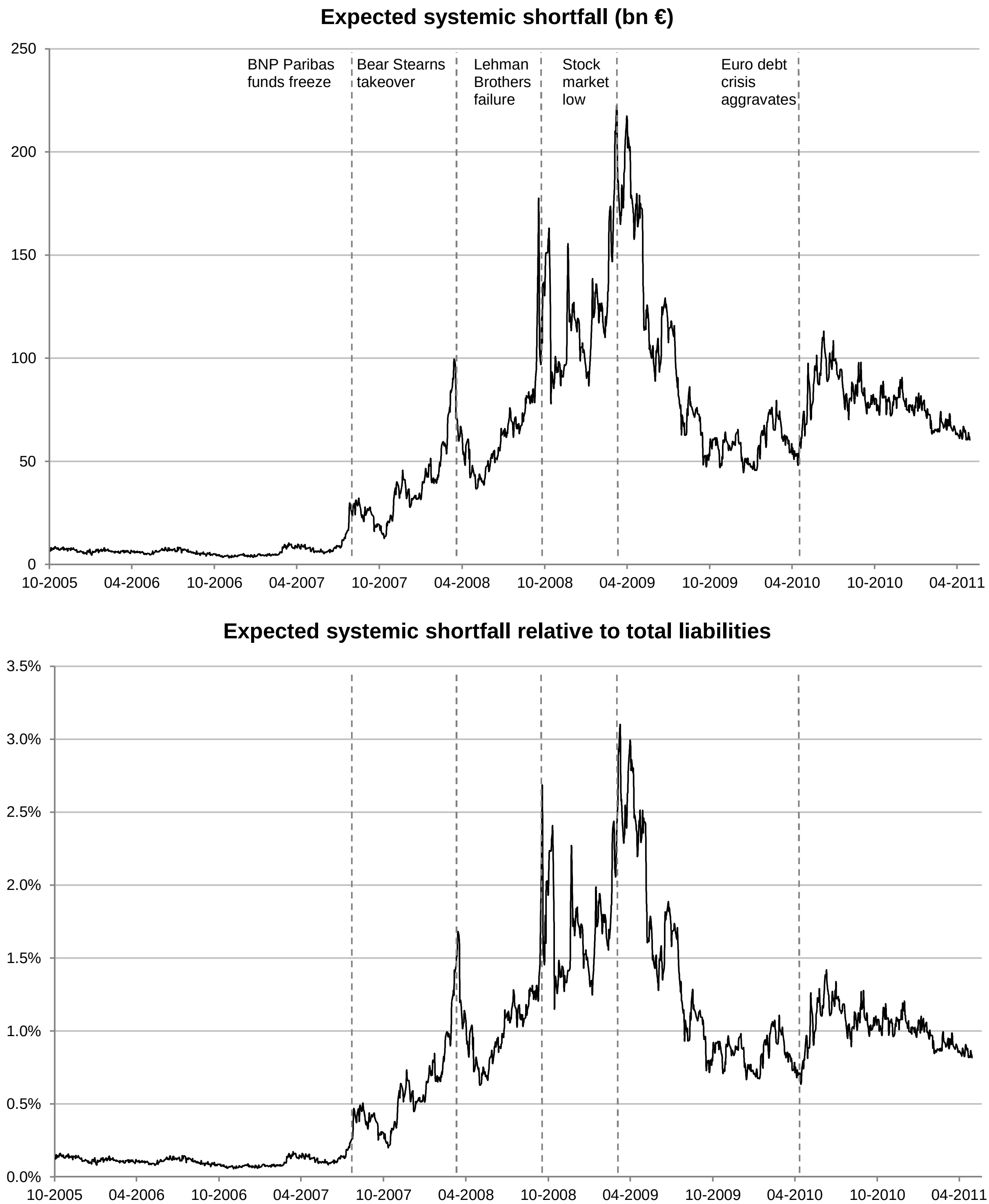

*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

*Figure 8 Probability of systemic default and expected tail loss (Global)*




*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 9 Absolute and relative expected systemic shortfall (America)*




*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

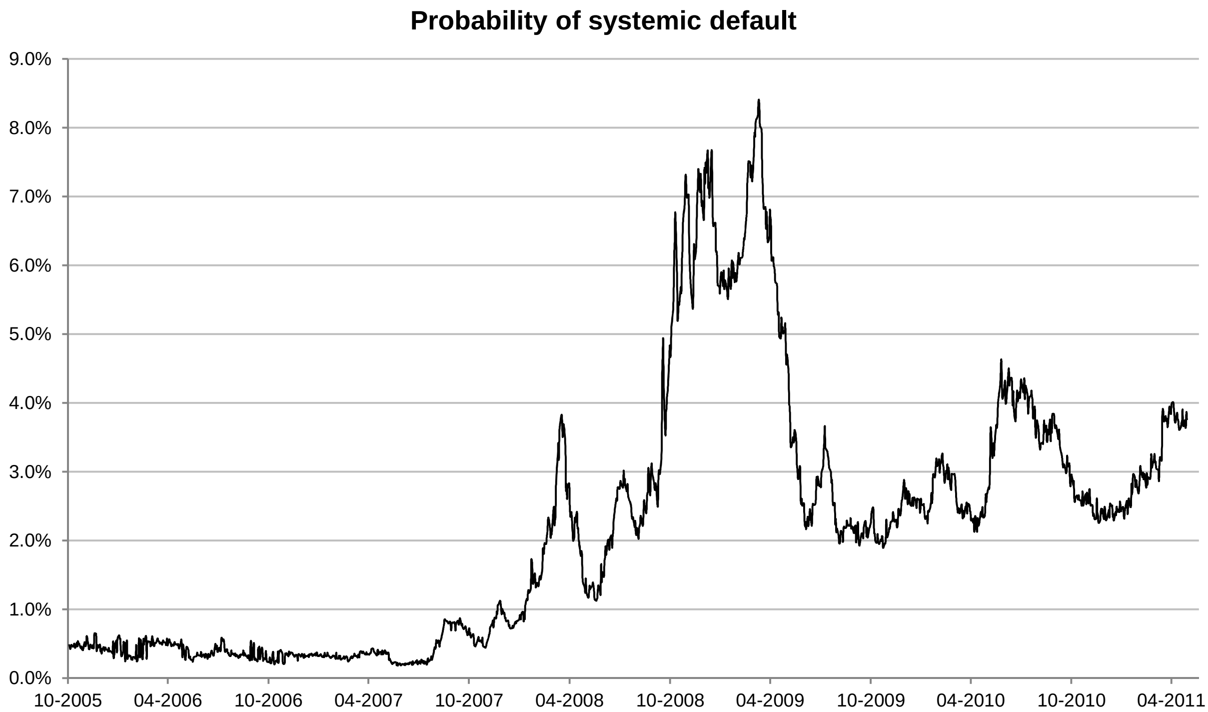
*Figure 10 Probability of systemic default and expected tail loss (America)*

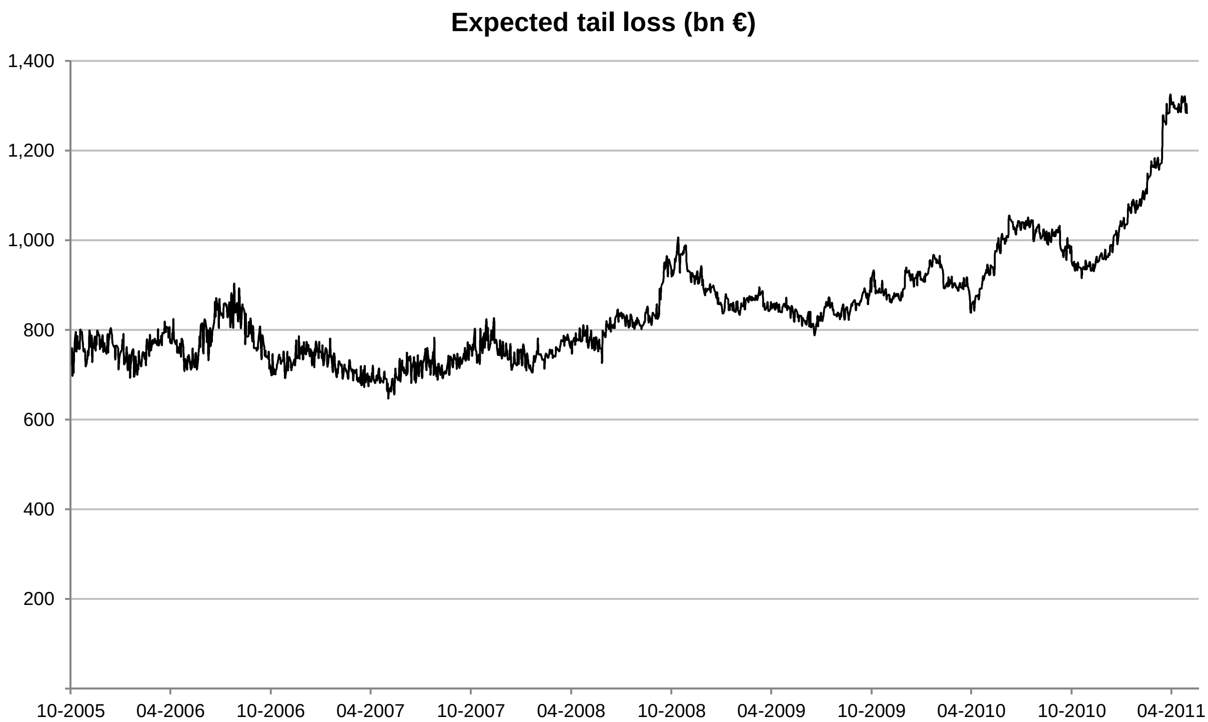

*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 11 Absolute and relative expected systemic shortfall (Asia-Pacific)*


*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

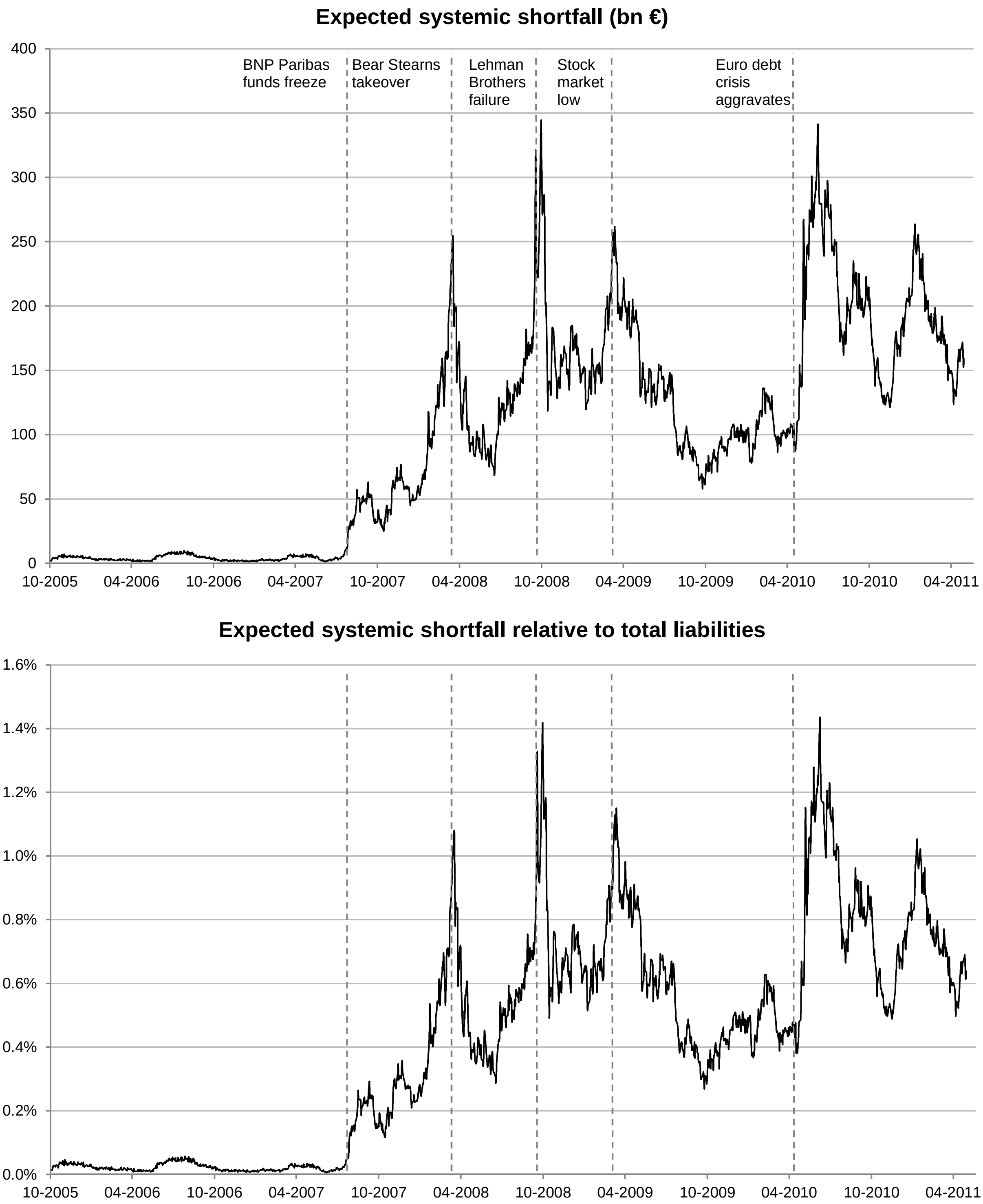
*Figure 12 Probability of systemic default and expected tail loss (Asia-Pacific)*



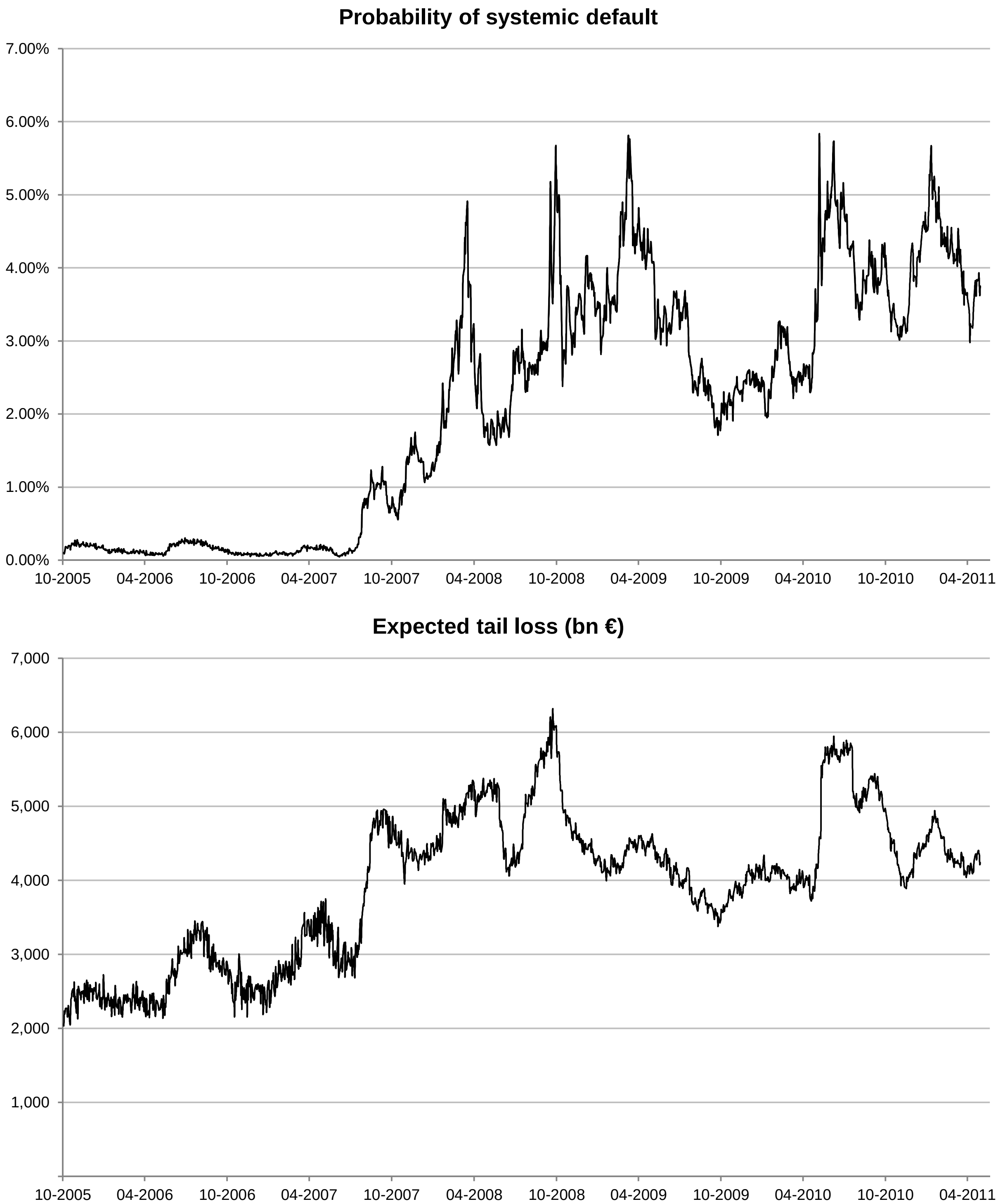

*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 13 Absolute and relative expected systemic shortfall (Europe)*



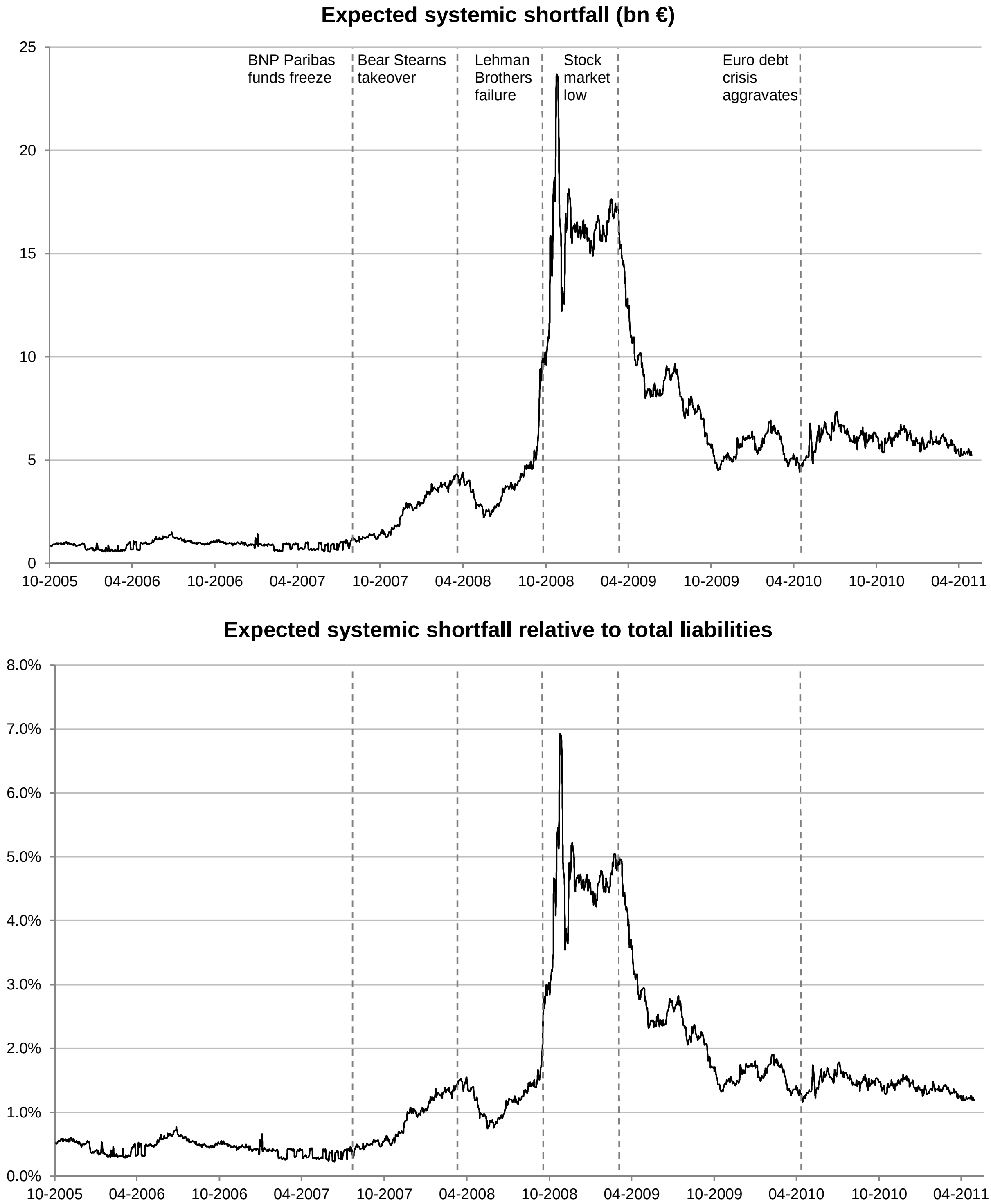

*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

*Figure 14 Probability of systemic default and expected tail loss (Europe)*




*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 15 Absolute and relative expected systemic shortfall (Middle East and Russia)*

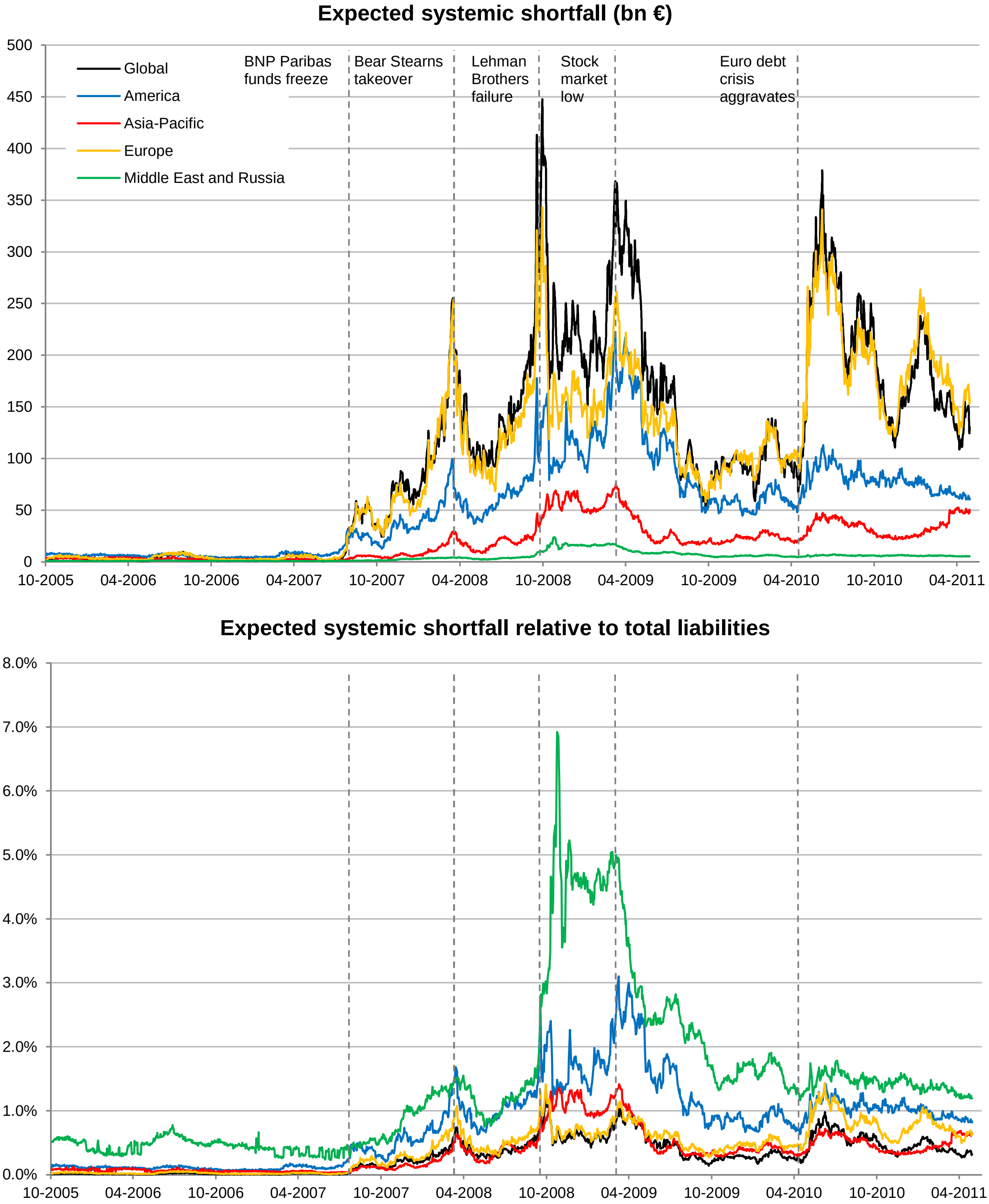



*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

*Figure 16 Probability of systemic default and expected tail loss (Middle East and Russia)*

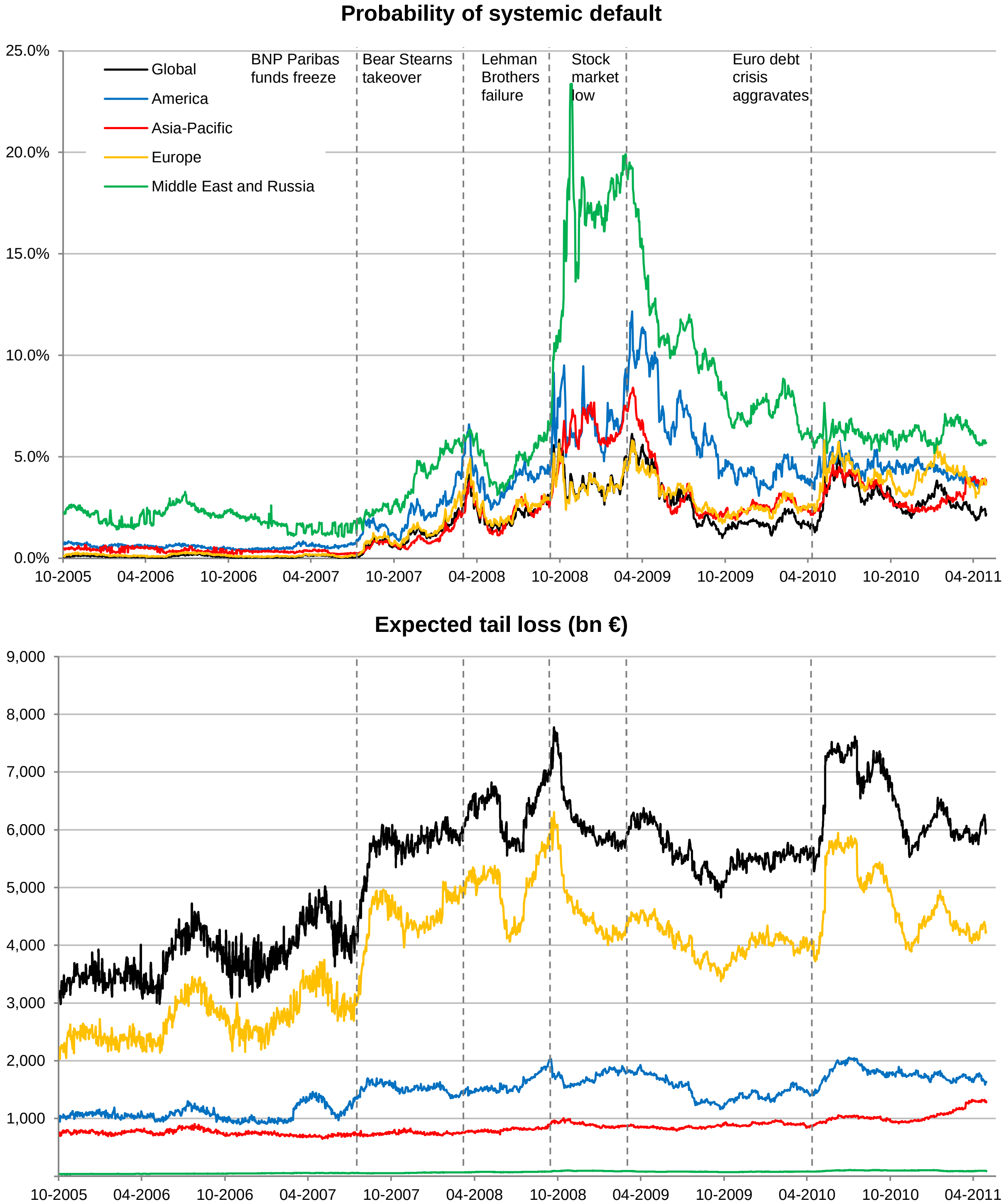

*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 17 Absolute and relative expected systemic shortfall (<u>Comparative analysis</u>)*



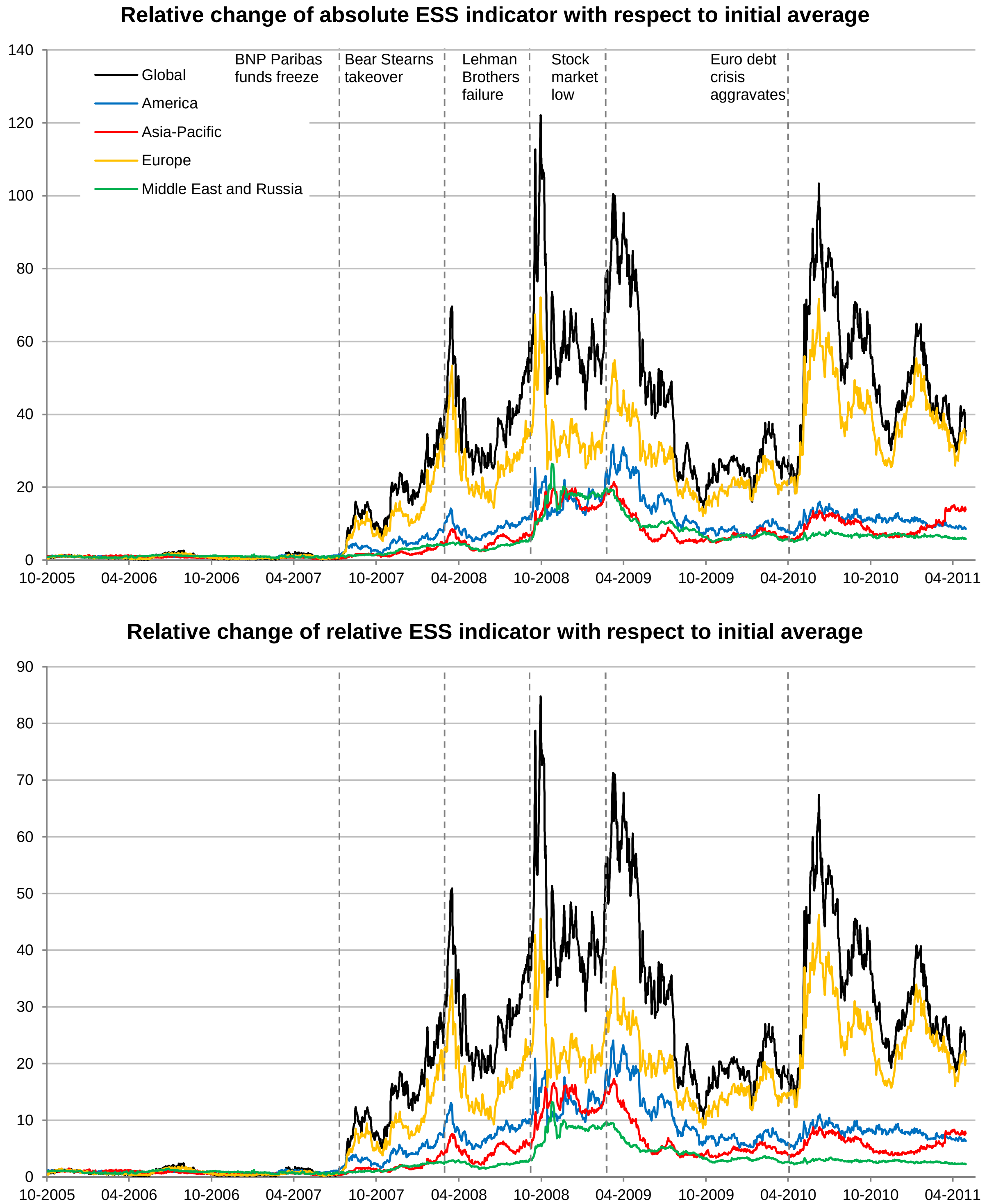

*Notes:* The upper panel shows the absolute expected systemic shortfall (ESS) indicator and the lower panel shows the relative ESS-indicator in the observation period. The dashed lines represent selected financial crisis events.

*Figure 18 Probability of systemic default and expected tail loss (<u>Comparative analysis</u>)*



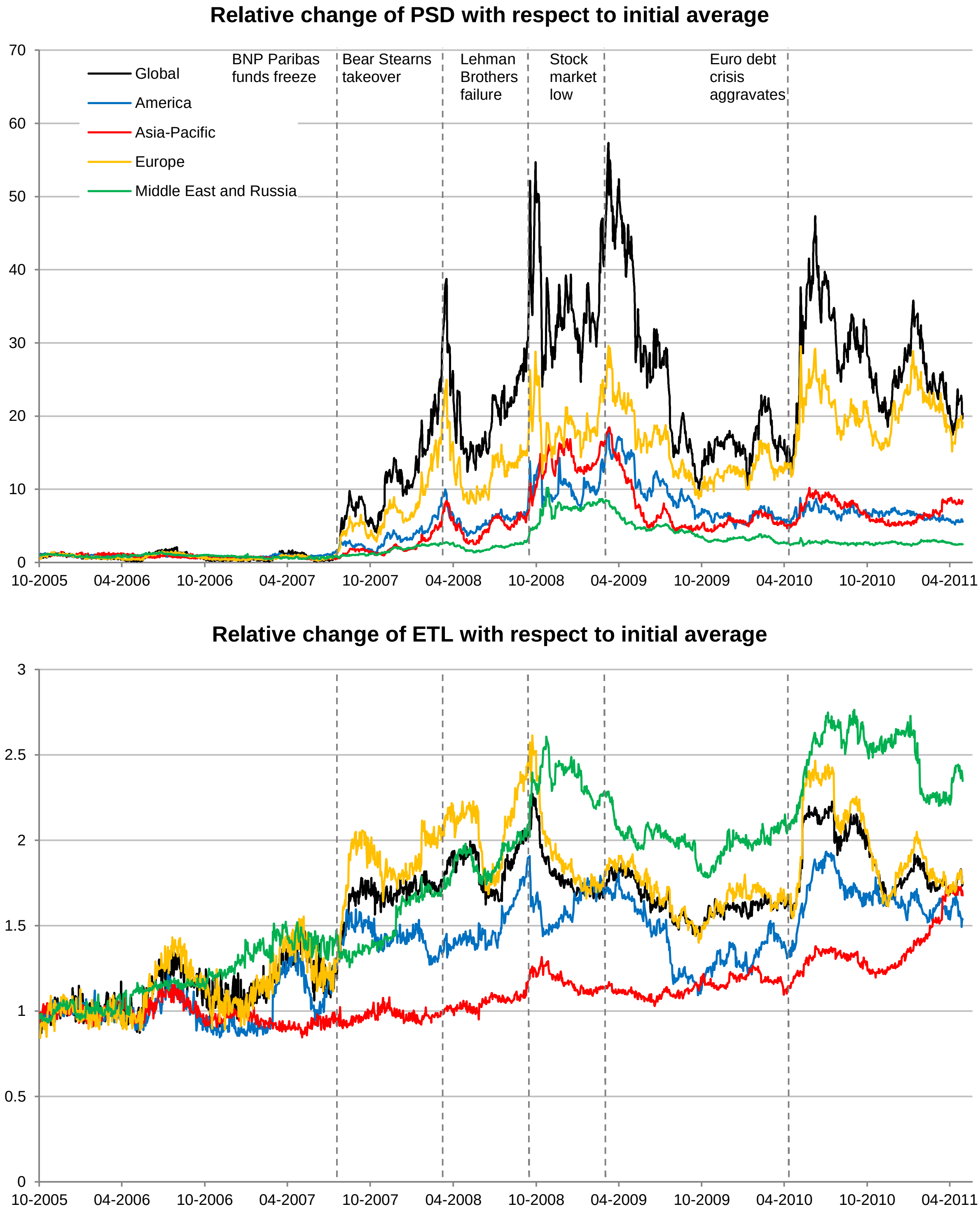

*Notes:* The upper panel shows the probability of the systemic default event and the lower panel shows the expected tail loss in case of a systemic default event during the observation period. The product of these two factors yields the expected systemic shortfall indicator.

*Figure 19 Relative change of absolute and relative ESS indicator with respect to initial average (Comparative analysis)*




*Notes:* The upper (lower) panel shows the relative change of the absolute ESS indicator (relative ESS indicator) with respect to its three-month average at the beginning of the observation period over time.

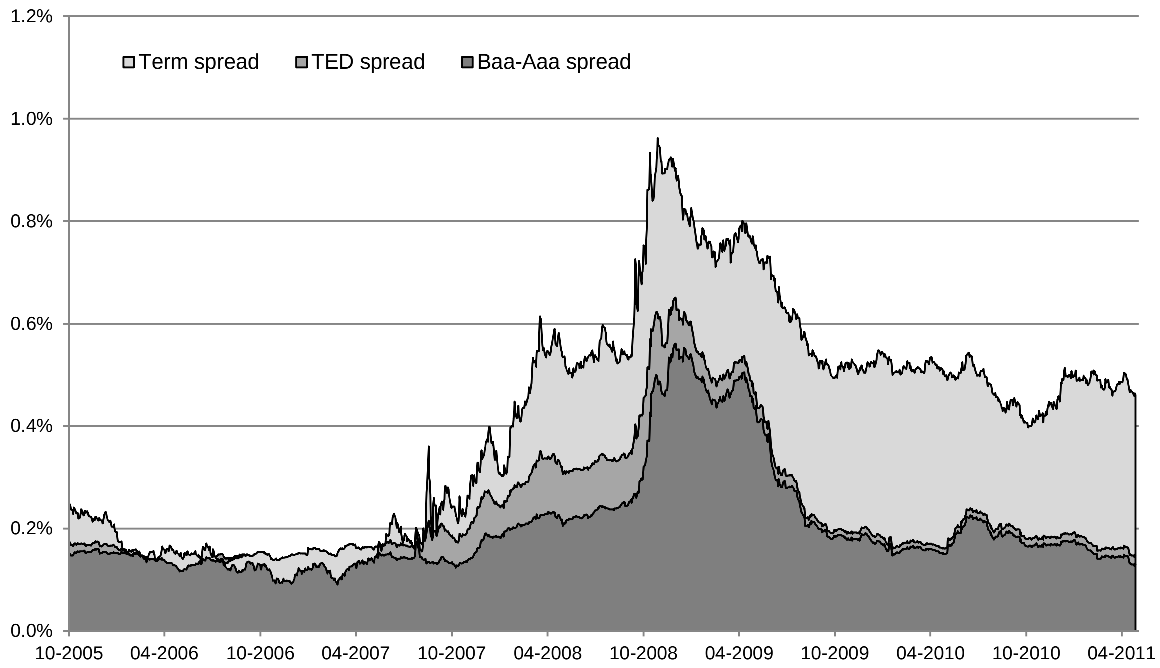
*Figure 20 Relative change of probability of systemic default (PSD) and expected tail loss (ETL) with respect to initial average (Comparative analysis)*



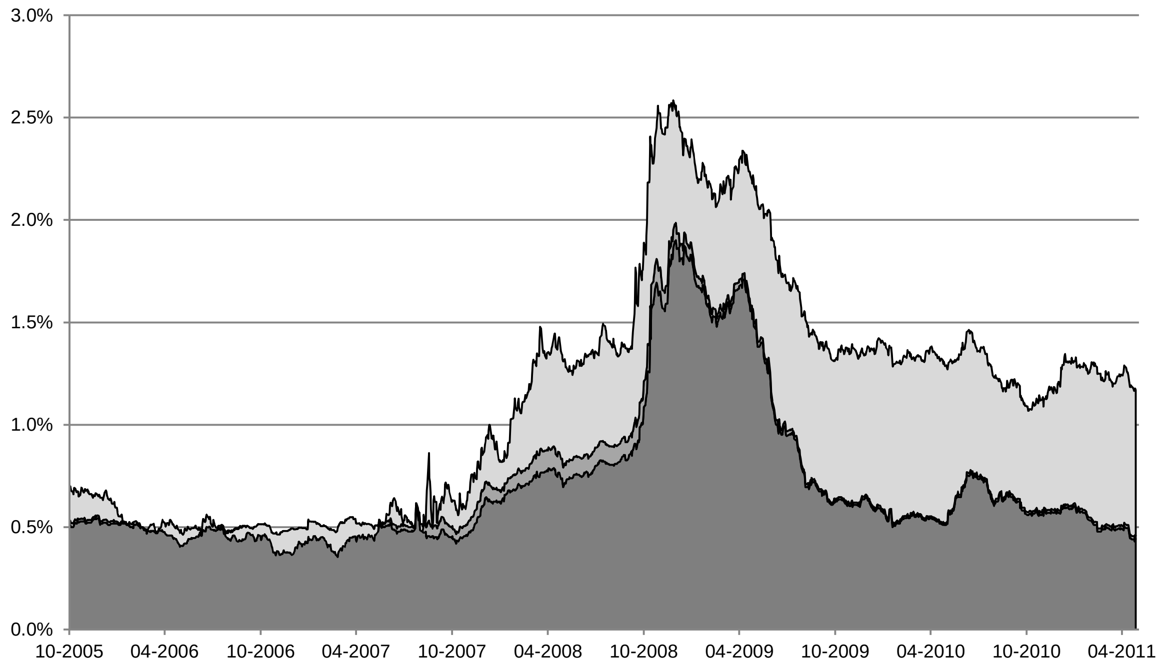

*Notes:* The upper (lower) panel shows the relative change of the probability of systemic default (expected tail loss) with respect to its three-month average at the beginning of the observation period over time.

*Figure 21 Risk premium determinants of the relative ESS-indicator*

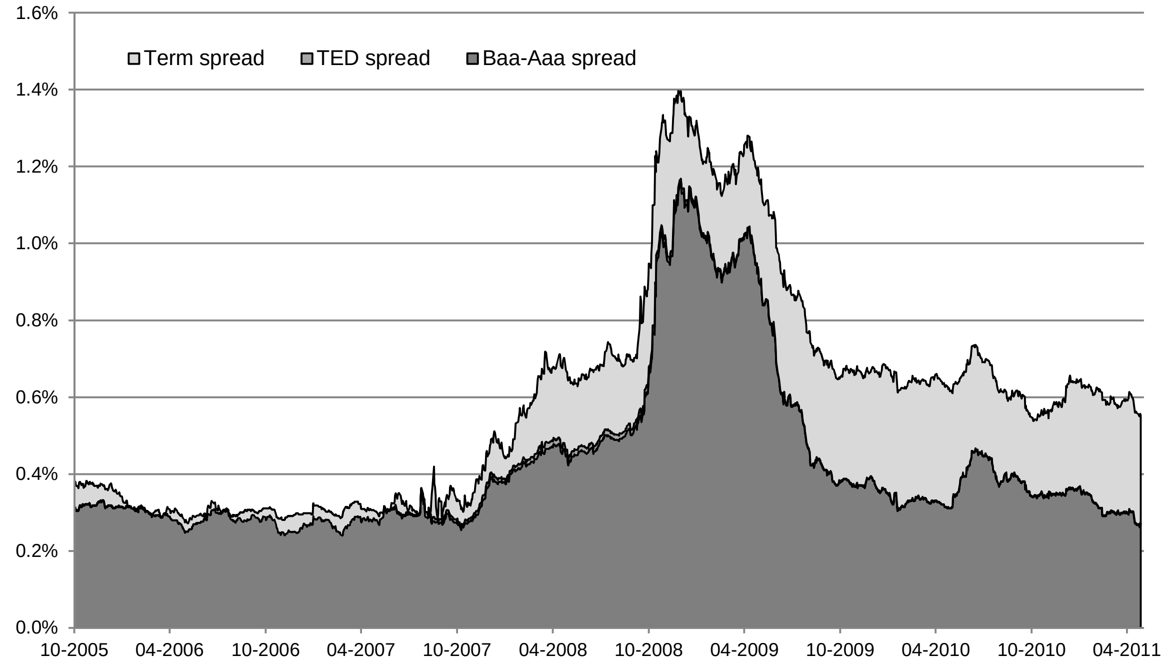
Global



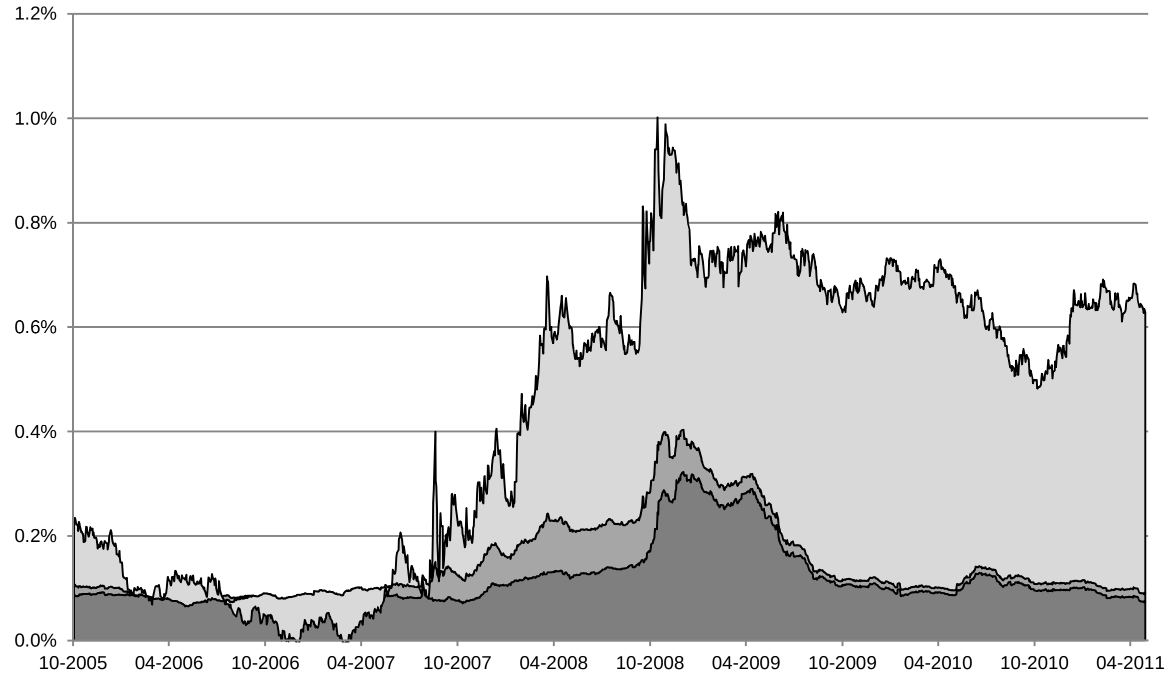

America



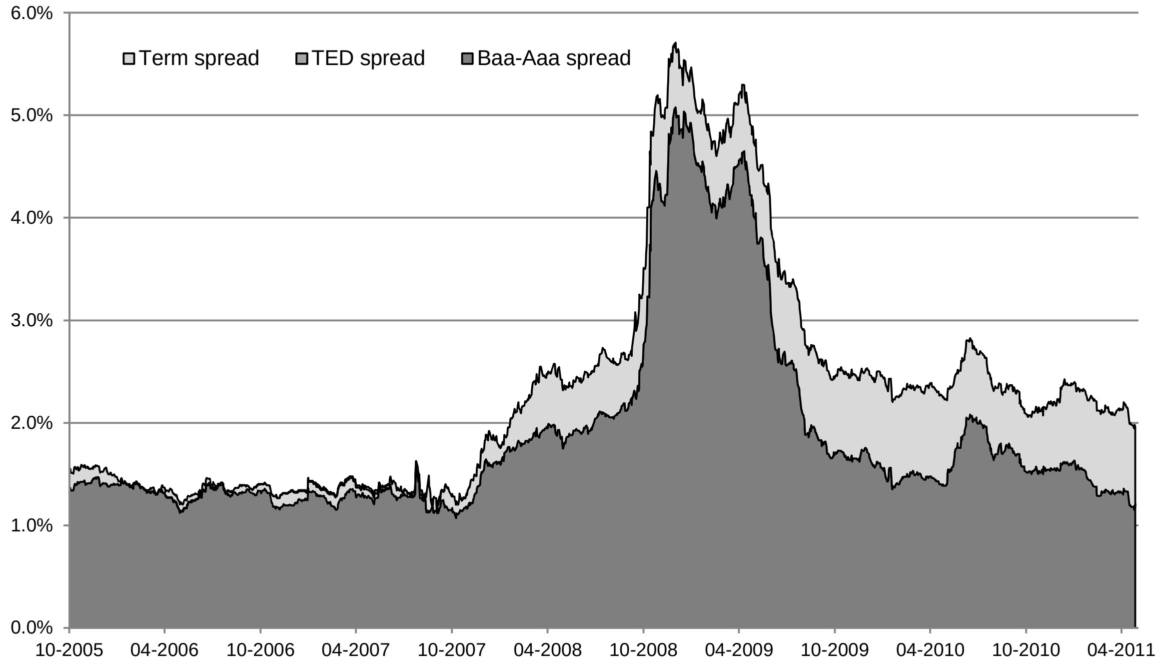
*Asia-Pacific*




*Europe*



*Middle East and Russia*




*Notes:* The graph shows the contribution of the risk premium proxy spreads to the relative expected systemic shortfall indicator. The graph is obtained by inserting the daily values of the respective spreads into the estimated respective regression equation from Regression 4 in Table 11 during the observation period.

## List of Tables

Table 1 Liabilities and CDS spreads by region and country .......... 83
Table 2 Liabilities and CDS spreads by bank .......... 84
Table 3 Equity and average equity return correlation by country (Global) .......... 86
Table 4 Equity and average equity return correlation by bank (Global) .......... 87
Table 5 Equity and average equity return correlation by bank (America) .......... 89
Table 6 Equity and average equity return correlation (Asia-Pacific) .......... 90
Table 7 Equity and average equity return correlation by country (Europe) .......... 91
Table 8 Equity and average equity return correlation by bank (Europe) .......... 92
Table 9 Equity and average equity return correlation by bank (Middle East and Russia) .......... 93
Table 10 Input variable determinants of the ESS-indicator .......... 94
Table 11 Risk premium determinants of the ESS-indicator .......... 96
Table 12 Relative systemic loss contribution by country (Global) .......... 98
Table 13 Relative systemic loss contribution by bank (Global) .......... 99
Table 14 Relative systemic loss contribution by bank (America) .......... 101
Table 15 Relative systemic loss contribution by country (Asia-Pacific) .......... 101
Table 16 Relative systemic loss contribution by bank (Asia-Pacific) .......... 102
Table 17 Relative systemic loss contribution by country (Europe) .......... 103
Table 18 Relative systemic loss contribution by bank (Europe) .......... 104
Table 19 Relative systemic loss contribution by country (Middle East and Russia) .......... 105
Table 20 Relative systemic loss contribution by bank (Middle East and Russia) .......... 105
Table 21 Determinants of the relative contributions to the ESS-indicator (Global) .......... 106
Table 22 Determinants of the relative contributions to the ESS-indicator (America) .......... 107
Table 23 Determinants of the relative contributions to the ESS-indicator (Asia-Pacific) .......... 108
Table 24 Determinants of the relative contributions to the ESS-indicator (Europe) .......... 109
Table 25 Determinants of the relative contributions to the ESS-indicator (Middle East and Russia) .......... 110

*Table 1 Liabilities and CDS spreads by region and country*

By region

| Region | Liabilities[1] Total | Mean³ | Average daily CDS spread[2] *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|
| America | 6,919.7 | 576.6 | 15.9 | 69.7 | 213.5 | 133.7 |
| Asia-Pacific | 5,222.6 | 217.6 | 19.2 | 57.3 | 168.6 | 108.3 |
| Europe | 23,287.7 | 612.8 | 9.6 | 47.1 | 124.4 | 145.1 |
| Middle East and Russia | 353.6 | 39.3 | 69.2 | 127.1 | 526.2 | 279.0 |
| Global | 35,783.5 | 431.1 | 12.8 | 53.8 | 152.1 | 138.8 |

By country

| Region | Country | Liability[1] | Average daily CDS spread[2] *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|
| America | US | 6,919.7 | 15.9 | 69.7 | 213.5 | 133.7 |
| Asia-Pacific | Australia | 1,204.7 | 8.7 | 47.3 | 125.3 | 110.3 |
| Asia-Pacific | China | 679.5 | 21.9 | 67.5 | 206.3 | 130.4 |
| Asia-Pacific | Hong Kong | 291.7 | 11.0 | 49.5 | 146.5 | 89.1 |
| Asia-Pacific | India | 247.0 | 65.7 | 148.4 | 314.8 | 183.4 |
| Asia-Pacific | Japan | 1,844.3 | 16.7 | 34.9 | 116.9 | 88.3 |
| Asia-Pacific | Kazakhstan | 22.4 | 192.8 | 449.0 | 1,509.9 | 762.5 |
| Asia-Pacific | Korea | 604.2 | 28.0 | 92.4 | 306.6 | 126.0 |
| Asia-Pacific | Malaysia | 48.1 | 20.2 | 49.2 | 138.6 | 75.9 |
| Asia-Pacific | Singapore | 280.7 | 9.6 | 44.8 | 98.6 | 47.2 |
| Europe | Austria | 189.5 | 21.5 | 52.4 | 208.2 | 148.3 |
| Europe | Belgium | 979.3 | 9.0 | 66.6 | 250.7 | 229.2 |
| Europe | Denmark | 462.8 | 6.0 | 22.1 | 122.4 | 87.9 |
| Europe | France | 4,700.4 | 7.2 | 41.1 | 83.4 | 114.0 |
| Europe | Germany | 2,810.2 | 13.0 | 51.8 | 113.8 | 112.0 |
| Europe | Greece | 139.9 | 21.2 | 20.7 | 71.8 | 777.7 |
| Europe | Ireland | 362.0 | 7.7 | 69.9 | 285.9 | 568.9 |
| Europe | Italy | 1,862.7 | 13.7 | 43.9 | 104.6 | 148.4 |
| Europe | Netherlands | 118.7 | 10.8 | 44.5 | 294.5 | 212.8 |
| Europe | Portugal | 199.4 | 13.0 | 50.7 | 110.2 | 462.7 |
| Europe | Spain | 1,740.4 | 10.9 | 46.0 | 119.1 | 203.0 |
| Europe | Sweden | 1,017.1 | 16.2 | 26.4 | 122.4 | 79.2 |
| Europe | Switzerland | 2,080.3 | 8.6 | 55.3 | 144.9 | 101.2 |
| Europe | UK | 6,625.1 | 7.6 | 49.3 | 127.6 | 133.1 |
| Middle East | Bahrain | 18.6 | 35.3 | 114.1 | 457.3 | 354.3 |
| Middle East | Qatar | 10.1 | 17.5 | 56.8 | 221.1 | 182.9 |
| Middle East | UAE | 87.2 | 22.5 | 72.3 | 345.7 | 315.1 |
| Russia | Russia | 237.6 | 91.1 | 151.2 | 610.9 | 263.9 |
| Mean | | 1,278.0 | 12.8 | 53.8 | 152.1 | 138.8 |
| Total | | 35,783.5 | | | | |

*Notes:* 1. Total liabilities as of 31.12.2008 in billion EUR. 2. Mean of daily CDS spread in basis points. 3. Mean computed per bank in region. 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. The mean of the CDS spreads is obtained by weighting the period CDS spreads with the liabilities as of 31.12.2008.

*Table 2 Liabilities and CDS spreads by bank*

| | | | | | Average daily CDS spread[2] | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Bank name | Region | Country | Liability[1] | *Period 1* | *Period 2* | *Period 3* | *Period 4* |
| 1 | American Express | America | US | 79.7 | 16.7 | 85.4 | 291.5 | 88.6 |
| 2 | Bank of America | America | US | 1,180.4 | 11.5 | 54.6 | 172.4 | 150.1 |
| 3 | Bank of New York Mellon | America | US | 150.7 | 14.5 | 80.3 | 221.0 | 133.9 |
| 4 | Capital One Financial | America | US | 100.2 | 34.4 | 205.7 | 267.1 | 116.5 |
| 5 | Citigroup | America | US | 1,292.6 | 11.0 | 72.0 | 298.0 | 161.8 |
| 6 | Goldman Sachs | America | US | 638.5 | 22.9 | 79.2 | 207.5 | 135.9 |
| 7 | JPMorgan Chase & Co. | America | US | 1,444.6 | 17.9 | 57.0 | 111.4 | 83.4 |
| 8 | MetLife | America | US | 331.1 | 20.2 | 64.3 | 451.4 | 208.3 |
| 9 | Morgan Stanley | America | US | 479.1 | 23.0 | 103.5 | 302.9 | 169.2 |
| 10 | PNC Financial Services | America | US | 189.5 | 22.8 | 119.0 | 257.5 | 137.9 |
| 11 | US Bancorp | America | US | 172.4 | 20.4 | 74.9 | 288.6 | 159.4 |
| 12 | Wells Fargo | America | US | 860.9 | 10.2 | 53.9 | 137.6 | 103.5 |
| 13 | ANZ Banking Group | Asia-Pacific | Australia | 249.4 | 8.0 | 43.2 | 109.9 | 103.0 |
| 14 | Commonwealth Bank | Asia-Pacific | Australia | 281.0 | 8.1 | 42.7 | 105.4 | 103.0 |
| 15 | Macquarie Bank | Asia-Pacific | Australia | 90.1 | 16.7 | 99.3 | 340.4 | 171.7 |
| 16 | National Australia Bank | Asia-Pacific | Australia | 348.8 | 8.1 | 43.6 | 110.6 | 104.9 |
| 17 | Westspac Banking Corp | Asia-Pacific | Australia | 235.4 | 7.9 | 42.6 | 104.8 | 111.2 |
| 18 | Bank of China | Asia-Pacific | China | 679.5 | 21.9 | 67.5 | 206.3 | 130.4 |
| 19 | Standard Chartered Bank | Asia-Pacific | Hong Kong | 291.7 | 11.0 | 49.5 | 146.5 | 89.1 |
| 20 | Bank of India | Asia-Pacific | India | 26.5 | 81.1 | 140.2 | 249.1 | 175.6 |
| 21 | ICICI Bank | Asia-Pacific | India | 68.9 | 71.9 | 191.6 | 446.0 | 213.7 |
| 22 | State Bank of India | Asia-Pacific | India | 151.5 | 60.1 | 130.2 | 266.6 | 171.1 |
| 23 | Mizuho Financial Group | Asia-Pacific | Japan | 939.1 | 18.5 | 24.4 | 101.9 | 94.8 |
| 24 | Resona Holdings | Asia-Pacific | Japan | 234.7 | 22.1 | 68.8 | 266.9 | 82.5 |
| 25 | Sumitomo Mitsui Banking | Asia-Pacific | Japan | 670.5 | 12.5 | 37.8 | 85.4 | 81.2 |
| 26 | Halyk Bank of Kazakhstan | Asia-Pacific | Kazakhstan | 8.7 | 180.3 | 336.5 | 1,369.1 | 481.8 |
| 27 | Kazkommertsbank | Asia-Pacific | Kazakhstan | 13.7 | 200.8 | 520.4 | 1,599.3 | 940.7 |
| 28 | Hana Bank | Asia-Pacific | Korea | 84.8 | 27.6 | 93.4 | 309.8 | 126.2 |
| 29 | Industrial Bank of Korea | Asia-Pacific | Korea | 78.1 | 23.1 | 74.1 | 279.1 | 118.2 |
| 30 | Kookmin Bank | Asia-Pacific | Korea | 143.6 | 24.0 | 81.3 | 292.4 | 120.9 |
| 31 | Shinhan Financial Group | Asia-Pacific | Korea | 140.1 | 27.7 | 94.9 | 308.0 | 124.2 |
| 32 | Woori Bank | Asia-Pacific | Korea | 157.7 | 34.4 | 108.8 | 330.1 | 135.9 |
| 33 | Malayan Banking Berhad | Asia-Pacific | Malaysia | 48.1 | 20.2 | 49.2 | 138.6 | 75.9 |
| 34 | DBS Bank | Asia-Pacific | Singapore | 116.1 | 9.0 | 44.9 | 98.8 | 46.5 |
| 35 | Oversea Chinese Banking | Asia-Pacific | Singapore | 81.3 | 9.5 | 44.7 | 98.0 | 46.2 |
| 36 | United Overseas Bank | Asia-Pacific | Singapore | 83.3 | 10.7 | 44.6 | 98.9 | 49.3 |
| 37 | Erste Group Bank | Europe | Austria | 189.5 | 21.5 | 52.4 | 208.2 | 148.3 |
| 38 | Dexia | Europe | Belgium | 641.4 | 9.1 | 67.7 | 274.6 | 269.0 |
| 39 | KBC Bank | Europe | Belgium | 337.9 | 9.0 | 64.5 | 205.4 | 153.6 |
| 40 | DANSKE Bank | Europe | Denmark | 462.8 | 6.0 | 22.1 | 122.4 | 87.9 |
| 41 | BNP Paribas | Europe | France | 2,012.6 | 7.0 | 35.1 | 69.6 | 96.4 |
| 42 | Crédit Agricole | Europe | France | 1,601.7 | 7.1 | 46.7 | 91.8 | 130.8 |
| 43 | Societé Generale | Europe | France | 1,086.2 | 7.6 | 43.9 | 96.9 | 121.7 |
| 44 | Commerzbank | Europe | Germany | 599.3 | 12.9 | 52.3 | 90.3 | 115.1 |
| 45 | Deutsche Bank | Europe | Germany | 2,162.0 | 12.7 | 49.1 | 107.9 | 105.2 |
| 46 | IKB - Deutsche Industriebank | Europe | Germany | 48.9 | 22.6 | 164.5 | 664.7 | 374.7 |
| 47 | Alpha Bank | Europe | Greece | 61.9 | 21.4 | 27.4 | 92.4 | 756.3 |
| 48 | EFG Eurobank | Europe | Greece | 78.0 | 21.1 | 15.4 | 55.6 | 794.6 |
| 49 | Allied Irish Banks | Europe | Ireland | 171.2 | 7.7 | 67.1 | 278.5 | 725.9 |

| No. | Bank name | Region | Country | Liability[1] | Average daily CDS spread[2] *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|---|
| 50 | ▪ └ 瀏嘌of Ireland | Europe | Ireland | 190.8 | 7.7 | 72.3 | 292.5 | 427.9 |
| 51 | Banca Monte d.P. die Siena | Europe | Italy | 195.1 | 12.6 | 46.5 | 89.5 | 185.4 |
| 52 | Banco Popolare | Europe | Italy | 109.3 | 37.8 | 68.2 | 151.9 | 202.2 |
| 53 | Intesa Sanpaolo | Europe | Italy | 581.3 | 11.0 | 36.3 | 82.5 | 126.2 |
| 54 | Unicredit Group | Europe | Italy | 976.9 | 12.8 | 45.1 | 115.5 | 148.1 |
| 55 | SNS REAAL Bank | Europe | Netherlands | 118.7 | 10.8 | 44.5 | 294.5 | 212.8 |
| 56 | Banco BPI | Europe | Portugal | 40.8 | 17.5 | 40.5 | 99.5 | 454.2 |
| 57 | Banco Comercial Portuges | Europe | Portugal | 87.6 | 11.5 | 50.2 | 104.4 | 463.1 |
| 58 | Espirito Santo Financial Group | Europe | Portugal | 71.0 | 12.4 | 57.3 | 123.5 | 467.1 |
| 59 | Banco de Sabadell | Europe | Spain | 75.1 | 24.6 | 83.4 | 239.1 | 304.7 |
| 60 | Banco Pastor | Europe | Spain | 25.5 | 21.1 | 27.3 | 372.8 | 428.2 |
| 61 | Banco Popular | Europe | Spain | 102.8 | 11.3 | 31.4 | 218.0 | 307.2 |
| 62 | Bankinter | Europe | Spain | 51.3 | 14.1 | 14.5 | 199.0 | 285.1 |
| 63 | Grupo BBVA | Europe | Spain | 510.7 | 9.5 | 46.1 | 98.4 | 204.7 |
| 64 | Grupo Santander | Europe | Spain | 975.0 | 10.2 | 46.7 | 99.4 | 173.0 |
| 65 | Nordea | Europe | Sweden | 450.1 | 10.7 | 29.3 | 95.4 | 74.7 |
| 66 | Skand Enskilda Banken | Europe | Sweden | 220.5 | 19.9 | 29.7 | 149.3 | 93.7 |
| 67 | Svenska Handelsbanken | Europe | Sweden | 189.5 | 13.7 | 20.4 | 90.2 | 58.1 |
| 68 | Swedbank | Europe | Sweden | 156.9 | 29.5 | 21.0 | 201.0 | 97.1 |
| 69 | Crédit Suisse | Europe | Switzerland | 751.9 | 13.1 | 55.1 | 119.4 | 96.1 |
| 70 | UBS | Europe | Switzerland | 1,328.4 | 6.0 | 55.4 | 159.3 | 104.1 |
| 71 | Barclay's | Europe | UK | 2,075.4 | 8.0 | 52.9 | 136.6 | 115.6 |
| 72 | HSBC | Europe | UK | 1,716.2 | 8.0 | 40.7 | 87.4 | 77.0 |
| 73 | Lloyds Banking Group | Europe | UK | 440.1 | 6.0 | 37.8 | 134.5 | 175.2 |
| 74 | Royal Bank of Scotland | Europe | UK | 2,393.4 | 7.2 | 54.3 | 147.2 | 180.7 |
| 75 | Arab Banking Corp | Middle East | Bahrain | 18.6 | 35.3 | 114.1 | 457.3 | 354.3 |
| 76 | Commercial Bank of Qatar | Middle East | Qatar | 10.1 | 17.5 | 56.8 | 221.1 | 182.9 |
| 77 | Abu Dhabi Commercial Bank | Middle East | UAE | 26.7 | 24.7 | 79.3 | 274.6 | 290.9 |
| 78 | Dubai Islamic Bank | Middle East | UAE | 14.9 | 25.7 | 83.4 | 507.8 | 450.6 |
| 79 | Mashreqbank | Middle East | UAE | 16.2 | 25.2 | 81.8 | 531.9 | 503.6 |
| 80 | National Bank of Abu Dhabi | Middle East | UAE | 29.4 | 17.5 | 55.2 | 226.0 | 165.1 |
| 81 | Bank of Moscow | Russia | Russia | 15.8 | 138.2 | 225.8 | 1,199.2 | 624.1 |
| 82 | Sberbank | Russia | Russia | 141.0 | 80.6 | 125.7 | 463.9 | 187.5 |
| 83 | WTB/VTB (Wneschtorgbank) | Russia | Russia | 80.7 | 100.4 | 181.1 | 752.2 | 326.8 |
| | Mean | | | 431.1 | 12.8 | 53.8 | 152.1 | 138.8 |
| | Total | | | 35,783.5 | | | | |

*Notes:* 1. Total liabilities as of 31.12.2008 in billion EUR. 2. Mean of daily CDS spread in basis points. 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. The mean of the CDS spreads is obtained by weighting the period CDS spreads with the liabilities as of 31.12.2008.

*Table 3 Equity and average equity return correlation by country (Global)*

| | | | Average equity return correlation[2] | | | |
|---|---|---|---|---|---|---|
| Region | Country | Equity[1] | *Period 1* | *Period 2* | *Period 3* | *Period 4* |
| America | US | 464.5 | 19.2% | 26.4% | 27.1% | 24.4% |
| Asia-Pacific | Australia | 60.3 | 17.5% | 23.9% | 28.5% | 22.0% |
| Asia-Pacific | China | 48.9 | 9.4% | 10.3% | 1.5% | 4.6% |
| Asia-Pacific | Hong Kong | 15.7 | 25.6% | 39.9% | 36.1% | 28.5% |
| Asia-Pacific | India | 18.3 | 13.3% | 21.5% | 24.7% | 16.2% |
| Asia-Pacific | Japan | 55.2 | 15.6% | 12.9% | 13.1% | 3.2% |
| Asia-Pacific | Kazakhstan | 3.0 | 6.3% | 8.3% | 7.6% | 5.6% |
| Asia-Pacific | Korea | 34.9 | 15.8% | 22.8% | 22.4% | 16.9% |
| Asia-Pacific | Malaysia | 3.7 | 10.4% | 19.0% | 20.1% | 10.7% |
| Asia-Pacific | Singapore | 23.5 | 19.2% | 28.2% | 28.5% | 18.5% |
| Europe | Austria | 8.1 | 19.0% | 34.0% | 36.4% | 28.5% |
| Europe | Belgium | 19.8 | 25.0% | 37.2% | 32.5% | 31.3% |
| Europe | Denmark | 13.2 | 20.5% | 35.8% | 36.2% | 22.3% |
| Europe | France | 132.5 | 28.8% | 39.8% | 39.4% | 34.1% |
| Europe | Germany | 51.7 | 29.0% | 39.1% | 37.7% | 32.5% |
| Europe | Greece | 6.6 | 15.2% | 25.5% | 30.0% | 18.8% |
| Europe | Ireland | 15.7 | 18.5% | 36.1% | 27.4% | 21.1% |
| Europe | Italy | 128.6 | 23.5% | 35.6% | 38.9% | 31.6% |
| Europe | Netherlands | 4.8 | 21.4% | 30.3% | 35.9% | 29.9% |
| Europe | Portugal | 11.4 | 10.5% | 26.1% | 30.5% | 27.0% |
| Europe | Spain | 97.9 | 26.5% | 34.0% | 37.1% | 30.1% |
| Europe | Sweden | 39.8 | 24.6% | 35.3% | 36.5% | 29.0% |
| Europe | Switzerland | 44.0 | 27.2% | 38.7% | 38.0% | 32.3% |
| Europe | UK | 169.5 | 27.4% | 38.8% | 36.0% | 30.3% |
| Middle East | Bahrain | 1.3 | 7.0% | 6.2% | -5.3% | 3.5% |
| Middle East | Qatar | 2.0 | 6.6% | 7.7% | 12.3% | 12.0% |
| Middle East | UAE | 8.7 | 3.3% | 8.0% | 10.7% | 4.3% |
| Russia | Russia | 28.7 | 17.2% | 25.2% | 29.7% | 23.9% |
| Mean | | 54.0 | 23.5% | 32.7% | 32.3% | 27.0% |
| Total | | 1,512.3 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 4 Equity and average equity return correlation by bank (Global)*

| | | | | | Average equity return correlation² | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Bank name | Region | Country | Equity[1] | *Period 1* | *Period 2* | *Period 3* | *Period 4* |
| 1 | American Express | America | US | 8.5 | 18.9% | 24.1% | 26.5% | 21.1% |
| 2 | Bank of America | America | US | 99.1 | 19.1% | 27.0% | 30.7% | 27.4% |
| 3 | Bank of New York Mellon | America | US | 20.2 | 18.6% | 25.3% | 23.0% | 22.7% |
| 4 | Capital One Financial | America | US | 16.6 | 18.1% | 23.5% | 26.7% | 22.4% |
| 5 | Citigroup | America | US | 51.1 | 20.4% | 29.4% | 27.7% | 22.9% |
| 6 | Goldman Sachs | America | US | 36.5 | 20.1% | 28.0% | 28.1% | 17.9% |
| 7 | JPMorgan Chase & Co. | America | US | 97.1 | 20.6% | 24.6% | 25.8% | 26.4% |
| 8 | MetLife | America | US | 24.6 | 15.6% | 25.5% | 27.1% | 26.6% |
| 9 | Morgan Stanley | America | US | 25.0 | 22.7% | 27.8% | 28.4% | 24.7% |
| 10 | PNC Financial Services | America | US | 18.3 | 15.4% | 23.9% | 20.8% | 21.8% |
| 11 | US Bancorp | America | US | 18.9 | 16.8% | 25.2% | 22.2% | 23.7% |
| 12 | Wells Fargo | America | US | 48.7 | 15.7% | 23.6% | 25.1% | 24.9% |
| 13 | ANZ Banking Group | Asia-Pacific | Australia | 14.4 | 14.4% | 21.2% | 27.3% | 20.7% |
| 14 | Commonwealth Bank | Asia-Pacific | Australia | 15.0 | 18.3% | 26.6% | 30.7% | 22.7% |
| 15 | Macquarie Bank | Asia-Pacific | Australia | 5.1 | 16.3% | 25.0% | 25.4% | 19.0% |
| 16 | National Australia Bank | Asia-Pacific | Australia | 15.8 | 18.9% | 22.6% | 28.1% | 22.7% |
| 17 | Westspac Banking Corp | Asia-Pacific | Australia | 10.0 | 18.2% | 24.9% | 29.1% | 22.4% |
| 18 | Bank of China | Asia-Pacific | China | 48.9 | 9.4% | 10.3% | 1.5% | 4.6% |
| 19 | Standard Chartered Bank | Asia-Pacific | Hong Kong | 15.7 | 25.6% | 39.9% | 36.1% | 28.5% |
| 20 | Bank of India | Asia-Pacific | India | 1.7 | 13.4% | 16.1% | 20.7% | 9.4% |
| 21 | ICICI Bank | Asia-Pacific | India | 7.0 | 13.7% | 23.1% | 27.8% | 17.1% |
| 22 | State Bank of India | Asia-Pacific | India | 9.6 | 13.2% | 21.7% | 24.0% | 16.9% |
| 23 | Mizuho Financial Group | Asia-Pacific | Japan | 18.5 | 16.6% | 13.2% | 13.9% | 2.6% |
| 24 | Resona Holdings | Asia-Pacific | Japan | 16.3 | 16.4% | 12.5% | 6.5% | 1.4% |
| 25 | Sumitomo Mitsui Banking | Asia-Pacific | Japan | 20.4 | 13.9% | 12.8% | 14.4% | 4.8% |
| 26 | Halyk Bank of Kazakhstan | Asia-Pacific | Kazakhstan | 1.1 | 6.9% | 8.4% | 13.2% | 5.7% |
| 27 | Kazkommertsbank | Asia-Pacific | Kazakhstan | 1.9 | 5.8% | 8.3% | 4.1% | 5.6% |
| 28 | Hana Bank | Asia-Pacific | Korea | 5.1 | 15.2% | 22.9% | 21.2% | 13.1% |
| 29 | Industrial Bank of Korea | Asia-Pacific | Korea | 4.0 | 14.6% | 22.2% | 23.7% | 16.4% |
| 30 | Kookmin Bank | Asia-Pacific | Korea | 9.0 | 16.6% | 24.1% | 22.0% | 18.9% |
| 31 | Shinhan Financial Group | Asia-Pacific | Korea | 9.8 | 15.4% | 24.1% | 22.9% | 16.4% |
| 32 | Woori Bank | Asia-Pacific | Korea | 7.0 | 16.5% | 20.6% | 22.3% | 17.7% |
| 33 | Malayan Banking Berhad | Asia-Pacific | Malaysia | 3.7 | 10.4% | 19.0% | 20.1% | 10.7% |
| 34 | DBS Bank | Asia-Pacific | Singapore | 9.9 | 20.4% | 29.0% | 28.3% | 18.4% |
| 35 | Oversea Chinese Banking | Asia-Pacific | Singapore | 7.0 | 19.0% | 28.6% | 29.2% | 17.0% |
| 36 | United Overseas Bank | Asia-Pacific | Singapore | 6.7 | 17.6% | 26.7% | 28.1% | 20.2% |
| 37 | Erste Group Bank | Europe | Austria | 8.1 | 19.0% | 34.0% | 36.4% | 28.5% |
| 38 | Dexia | Europe | Belgium | 14.2 | 25.2% | 36.1% | 30.2% | 30.3% |
| 39 | KBC Bank | Europe | Belgium | 5.6 | 24.5% | 39.3% | 36.8% | 33.3% |
| 40 | DANSKE Bank | Europe | Denmark | 13.2 | 20.5% | 35.8% | 36.2% | 22.3% |
| 41 | BNP Paribas | Europe | France | 53.2 | 29.8% | 40.9% | 39.3% | 34.4% |
| 42 | Crédit Agricole | Europe | France | 41.7 | 26.6% | 39.3% | 39.8% | 33.5% |
| 43 | Societé Generale | Europe | France | 37.5 | 30.1% | 38.4% | 38.9% | 34.3% |
| 44 | Commerzbank | Europe | Germany | 19.2 | 25.3% | 37.8% | 34.3% | 29.7% |
| 45 | Deutsche Bank | Europe | Germany | 30.7 | 30.2% | 39.9% | 39.1% | 34.0% |
| 46 | IKB - Deutsche Industriebank | Europe | Germany | 1.8 | 22.8% | 21.5% | 17.7% | 0.9% |
| 47 | Alpha Bank | Europe | Greece | 3.0 | 15.8% | 26.6% | 29.2% | 18.2% |
| 48 | EFG Eurobank | Europe | Greece | 3.6 | 14.7% | 24.6% | 30.6% | 19.2% |
| 49 | Allied Irish Banks | Europe | Ireland | 9.3 | 23.1% | 37.8% | 28.0% | 21.4% |

| No. | Bank name | Region | Country | Equity[1] | Average equity return correlation² *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|---|
| 50 | Bank of Ireland | Europe | Ireland | 6.4 | 14.5% | 34.6% | 26.9% | 20.8% |
| 51 | Banca Monte d.P. die Siena | Europe | Italy | 14.8 | 21.4% | 33.4% | 35.8% | 29.5% |
| 52 | Banco Popolare | Europe | Italy | 9.8 | 17.2% | 30.7% | 33.4% | 29.7% |
| 53 | Intesa Sanpaolo | Europe | Italy | 49.0 | 19.1% | 34.3% | 39.6% | 31.6% |
| 54 | Unicredit Group | Europe | Italy | 55.0 | 27.3% | 37.4% | 39.7% | 32.1% |
| 55 | SNS REAAL Bank | Europe | Netherlands | 4.8 | 21.4% | 30.3% | 35.9% | 29.9% |
| 56 | Banco BPI | Europe | Portugal | 1.5 | 8.0% | 19.8% | 33.2% | 26.2% |
| 57 | Banco Comercial Portuges | Europe | Portugal | 6.0 | 12.9% | 24.9% | 30.9% | 27.4% |
| 58 | Espirito Santo Financial Group | Europe | Portugal | 3.9 | 8.9% | 31.1% | 28.3% | 27.0% |
| 59 | Banco de Sabadell | Europe | Spain | 4.4 | 23.3% | 36.1% | 39.4% | 26.7% |
| 60 | Banco Pastor | Europe | Spain | 1.5 | 16.1% | 30.9% | 24.7% | 16.7% |
| 61 | Banco Popular | Europe | Spain | 6.8 | 23.8% | 37.6% | 41.2% | 28.3% |
| 62 | Bankinter | Europe | Spain | 2.0 | 22.8% | 36.2% | 29.2% | 29.2% |
| 63 | Grupo BBVA | Europe | Spain | 25.7 | 23.4% | 21.9% | 27.8% | 27.6% |
| 64 | Grupo Santander | Europe | Spain | 57.6 | 29.1% | 39.8% | 42.2% | 32.2% |
| 65 | Nordea | Europe | Sweden | 17.5 | 25.1% | 35.9% | 36.9% | 29.0% |
| 66 | Skand Enskilda Banken | Europe | Sweden | 7.6 | 24.8% | 37.0% | 37.4% | 30.0% |
| 67 | Svenska Handelsbanken | Europe | Sweden | 6.8 | 24.2% | 31.7% | 35.6% | 29.0% |
| 68 | Swedbank | Europe | Sweden | 7.8 | 23.3% | 35.4% | 35.1% | 27.6% |
| 69 | Crédit Suisse | Europe | Switzerland | 21.8 | 26.7% | 39.5% | 37.2% | 33.1% |
| 70 | UBS | Europe | Switzerland | 22.2 | 27.5% | 38.3% | 38.4% | 31.8% |
| 71 | Barclay's | Europe | UK | 34.1 | 26.9% | 39.8% | 36.8% | 34.3% |
| 72 | HSBC | Europe | UK | 64.8 | 31.0% | 38.3% | 40.3% | 30.1% |
| 73 | Lloyds Banking Group | Europe | UK | 9.7 | 26.4% | 39.3% | 31.9% | 26.9% |
| 74 | Royal Bank of Scotland | Europe | UK | 60.9 | 25.3% | 38.1% | 33.0% | 27.5% |
| 75 | Arab Banking Corp | Middle East | Bahrain | 1.3 | 7.0% | 6.2% | -5.3% | 3.5% |
| 76 | Commercial Bank of Qatar | Middle East | Qatar | 2.0 | 6.6% | 7.7% | 12.3% | 12.0% |
| 77 | Abu Dhabi Commercial Bank | Middle East | UAE | 2.2 | 4.5% | 9.5% | 11.5% | 7.2% |
| 78 | Dubai Islamic Bank | Middle East | UAE | 1.7 | 0.4% | 10.7% | 15.0% | 8.0% |
| 79 | Mashreqbank | Middle East | UAE | 2.0 | 6.0% | 6.7% | -4.9% | -5.5% |
| 80 | National Bank of Abu Dhabi | Middle East | UAE | 2.8 | 2.2% | 6.1% | 16.5% | 5.1% |
| 81 | Bank of Moscow | Russia | Russia | 1.6 | 10.3% | 20.6% | 21.2% | 11.7% |
| 82 | Sberbank | Russia | Russia | 17.6 | 20.2% | 28.4% | 30.5% | 25.5% |
| 83 | WTB/VTB (Wneschtorgbank) | Russia | Russia | 9.5 | 13.3% | 20.6% | 30.1% | 23.5% |
| | Mean | | | 18.2 | 23.5% | 32.7% | 32.3% | 27.0% |
| | Total | | | 1,512.3 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 5 Equity and average equity return correlation by bank (America)*

| No. | Bank name | Country | Equity[1] | Average equity return correlation² *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|
| 1 | American Express | US | 8.5 | 59.3% | 72.4% | 68.0% | 60.9% |
| 2 | Bank of America | US | 99.1 | 62.1% | 78.1% | 71.2% | 70.2% |
| 3 | Bank of New York Mellon | US | 20.2 | 53.5% | 72.3% | 68.5% | 65.4% |
| 4 | Capital One Financial | US | 16.6 | 50.1% | 66.4% | 67.8% | 65.2% |
| 5 | Citigroup | US | 51.1 | 61.4% | 76.0% | 62.3% | 60.4% |
| 6 | Goldman Sachs | US | 36.5 | 55.0% | 73.5% | 68.9% | 60.8% |
| 7 | JPMorgan Chase & Co. | US | 97.1 | 64.1% | 77.4% | 75.8% | 72.7% |
| 8 | MetLife | US | 24.6 | 50.1% | 70.4% | 67.9% | 63.1% |
| 9 | Morgan Stanley | US | 25.0 | 57.5% | 74.4% | 66.4% | 67.7% |
| 10 | PNC Financial Services | US | 18.3 | 53.5% | 74.1% | 68.9% | 67.8% |
| 11 | US Bancorp | US | 18.9 | 58.7% | 76.8% | 71.4% | 70.0% |
| 12 | Wells Fargo | US | 48.7 | 62.6% | 76.9% | 74.3% | 71.0% |
| | Mean | | 38.7 | 60.2% | 75.9% | 70.0% | 67.3% |
| | Total | | 464.5 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 6 Equity and average equity return correlation (Asia-Pacific)*

*By country*

| Region | Country | Equity[1] | Average equity return correlation[2] *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|
| Asia-Pacific | Australia | 60.3 | 28.6% | 35.6% | 35.1% | 35.5% |
| Asia-Pacific | China | 48.9 | 14.8% | 17.1% | 13.2% | 16.1% |
| Asia-Pacific | Hong Kong | 15.7 | 14.6% | 25.6% | 24.7% | 11.6% |
| Asia-Pacific | India | 18.3 | 22.1% | 27.3% | 29.3% | 22.9% |
| Asia-Pacific | Japan | 55.2 | 29.3% | 29.8% | 27.8% | 18.3% |
| Asia-Pacific | Kazakhstan | 3.0 | 7.1% | 8.7% | 13.5% | 15.2% |
| Asia-Pacific | Korea | 34.9 | 29.4% | 36.8% | 39.6% | 34.6% |
| Asia-Pacific | Malaysia | 3.7 | 16.5% | 27.0% | 27.2% | 25.3% |
| Asia-Pacific | Singapore | 23.5 | 28.5% | 38.1% | 39.2% | 33.6% |
| Mean | | 29.3 | 25.8% | 30.2% | 29.4% | 24.6% |
| Total | | 263.7 | | | | |

*By bank*

| No. | Bank name | Country | Equity[1] | Average equity return correlation[2] *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|
| 1 | ANZ Banking Group | Australia | 14.4 | 20.7% | 27.2% | 27.0% | 33.7% |
| 2 | Commonwealth Bank | Australia | 15.0 | 31.5% | 38.4% | 36.9% | 36.6% |
| 3 | Macquarie Bank | Australia | 5.1 | 26.5% | 40.1% | 35.8% | 36.1% |
| 4 | National Australia Bank | Australia | 15.8 | 32.2% | 36.9% | 37.7% | 36.1% |
| 5 | Westspac Banking Corp | Australia | 10.0 | 29.1% | 37.3% | 37.7% | 35.0% |
| 6 | Bank of China | China | 48.9 | 14.8% | 17.1% | 13.2% | 16.1% |
| 7 | Standard Chartered Bank | Hong Kong | 15.7 | 14.6% | 25.6% | 24.7% | 11.6% |
| 8 | Bank of India | India | 1.7 | 20.9% | 23.0% | 25.3% | 19.0% |
| 9 | ICICI Bank | India | 7.0 | 24.3% | 31.2% | 33.7% | 25.6% |
| 10 | State Bank of India | India | 9.6 | 21.4% | 26.2% | 27.9% | 22.3% |
| 11 | Mizuho Financial Group | Japan | 18.5 | 30.4% | 31.1% | 28.2% | 17.0% |
| 12 | Resona Holdings | Japan | 16.3 | 29.5% | 28.1% | 20.0% | 13.7% |
| 13 | Sumitomo Mitsui Banking | Japan | 20.4 | 27.6% | 28.5% | 30.0% | 21.7% |
| 14 | Halyk Bank of Kazakhstan | Kazakhstan | 1.1 | 8.5% | 9.9% | 19.9% | 15.3% |
| 15 | Kazkommertsbank | Kazakhstan | 1.9 | 6.2% | 8.0% | 9.5% | 15.2% |
| 16 | Hana Bank | Korea | 5.1 | 29.7% | 35.9% | 36.7% | 32.8% |
| 17 | Industrial Bank of Korea | Korea | 4.0 | 28.0% | 34.7% | 39.7% | 33.4% |
| 18 | Kookmin Bank | Korea | 9.0 | 31.2% | 39.0% | 40.9% | 36.7% |
| 19 | Shinhan Financial Group | Korea | 9.8 | 28.2% | 38.1% | 41.0% | 35.2% |
| 20 | Woori Bank | Korea | 7.0 | 29.3% | 35.1% | 38.6% | 33.9% |
| 21 | Malayan Banking Berhad | Malaysia | 3.7 | 16.5% | 27.0% | 27.2% | 25.3% |
| 22 | DBS Bank | Singapore | 9.9 | 31.1% | 40.3% | 40.1% | 34.5% |
| 23 | Oversea Chinese Banking | Singapore | 7.0 | 27.7% | 37.8% | 38.9% | 33.1% |
| 24 | United Overseas Bank | Singapore | 6.7 | 25.8% | 35.2% | 38.1% | 32.7% |
| | Mean | | 11.0 | 25.8% | 30.2% | 29.4% | 24.6% |
| | Total | | 263.7 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 7 Equity and average equity return correlation by country (Europe)*

| Region | Country | Equity[1] | Average equity return correlation² *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|
| Europe | Austria | 8.1 | 28.7% | 49.1% | 53.2% | 51.9% |
| Europe | Belgium | 19.8 | 40.6% | 54.8% | 46.5% | 54.7% |
| Europe | Denmark | 13.2 | 30.2% | 50.5% | 51.5% | 39.3% |
| Europe | France | 132.5 | 46.0% | 59.3% | 57.6% | 59.6% |
| Europe | Germany | 51.7 | 44.5% | 56.0% | 53.1% | 51.2% |
| Europe | Greece | 6.6 | 23.9% | 36.0% | 41.9% | 35.6% |
| Europe | Ireland | 15.7 | 32.0% | 51.2% | 40.1% | 35.0% |
| Europe | Italy | 128.6 | 38.1% | 53.5% | 55.1% | 57.3% |
| Europe | Netherlands | 4.8 | 19.6% | 44.5% | 51.9% | 46.3% |
| Europe | Portugal | 11.4 | 16.8% | 37.0% | 43.5% | 52.0% |
| Europe | Spain | 97.9 | 42.0% | 49.7% | 51.9% | 56.2% |
| Europe | Sweden | 39.8 | 40.3% | 54.0% | 54.7% | 47.9% |
| Europe | Switzerland | 44.0 | 42.5% | 56.7% | 55.1% | 48.5% |
| Europe | UK | 169.5 | 39.6% | 55.1% | 51.4% | 45.1% |
| Mean | | 53.1 | 41.1% | 55.1% | 53.2% | 51.2% |
| Total | | 743.5 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 8 Equity and average equity return correlation by bank (Europe)*

| No. | Bank name | Country | Equity[1] | Average equity return correlation² *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|
| 1 | Erste Group Bank | Austria | 8.1 | 28.7% | 49.1% | 53.2% | 51.9% |
| 2 | Dexia | Belgium | 14.2 | 40.6% | 53.6% | 44.4% | 53.7% |
| 3 | KBC Bank | Belgium | 5.6 | 40.5% | 57.1% | 50.7% | 56.5% |
| 4 | DANSKE Bank | Denmark | 13.2 | 30.2% | 50.5% | 51.5% | 39.3% |
| 5 | BNP Paribas | France | 53.2 | 47.9% | 61.3% | 57.6% | 60.2% |
| 6 | Crédit Agricole | France | 41.7 | 41.6% | 58.8% | 58.5% | 58.8% |
| 7 | Societé Generale | France | 37.5 | 49.1% | 56.4% | 56.3% | 59.7% |
| 8 | Commerzbank | Germany | 19.2 | 38.6% | 55.1% | 48.4% | 48.3% |
| 9 | Deutsche Bank | Germany | 30.7 | 46.4% | 56.9% | 55.0% | 53.1% |
| 10 | IKB - Deutsche Industriebank | Germany | 1.8 | 33.8% | 30.0% | 25.6% | 0.8% |
| 11 | Alpha Bank | Greece | 3.0 | 25.3% | 38.0% | 41.1% | 34.7% |
| 12 | EFG Eurobank | Greece | 3.6 | 22.9% | 34.4% | 42.7% | 36.3% |
| 13 | Allied Irish Banks | Ireland | 9.3 | 37.9% | 53.3% | 41.2% | 34.6% |
| 14 | Bank of Ireland | Ireland | 6.4 | 26.6% | 49.4% | 39.2% | 35.3% |
| 15 | Banca Monte d.P. die Siena | Italy | 14.8 | 34.4% | 50.3% | 50.8% | 54.7% |
| 16 | Banco Popolare | Italy | 9.8 | 29.7% | 47.0% | 47.4% | 52.7% |
| 17 | Intesa Sanpaolo | Italy | 49.0 | 32.9% | 51.2% | 55.7% | 57.8% |
| 18 | Unicredit Group | Italy | 55.0 | 42.9% | 56.3% | 56.5% | 58.0% |
| 19 | SNS REAAL Bank | Netherlands | 4.8 | 19.6% | 44.5% | 51.9% | 46.3% |
| 20 | Banco BPI | Portugal | 1.5 | 14.4% | 29.4% | 47.4% | 49.3% |
| 21 | Banco Comercial Portuges | Portugal | 6.0 | 19.3% | 35.4% | 43.5% | 52.9% |
| 22 | Espirito Santo Financial Group | Portugal | 3.9 | 15.0% | 43.3% | 41.1% | 52.5% |
| 23 | Banco de Sabadell | Spain | 4.4 | 37.6% | 53.6% | 57.0% | 54.1% |
| 24 | Banco Pastor | Spain | 1.5 | 26.5% | 46.0% | 35.3% | 32.9% |
| 25 | Banco Popular | Spain | 6.8 | 39.4% | 55.5% | 59.2% | 56.2% |
| 26 | Bankinter | Spain | 2.0 | 37.1% | 52.8% | 43.9% | 56.4% |
| 27 | Grupo BBVA | Spain | 25.7 | 36.1% | 29.8% | 35.2% | 48.2% |
| 28 | Grupo Santander | Spain | 57.6 | 46.4% | 59.1% | 60.3% | 61.1% |
| 29 | Nordea | Sweden | 17.5 | 41.0% | 54.3% | 55.7% | 49.6% |
| 30 | Skand Enskilda Banken | Sweden | 7.6 | 41.2% | 56.9% | 55.0% | 48.0% |
| 31 | Svenska Handelsbanken | Sweden | 6.8 | 39.6% | 49.7% | 54.0% | 45.5% |
| 32 | Swedbank | Sweden | 7.8 | 38.3% | 54.4% | 52.4% | 45.9% |
| 33 | Crédit Suisse | Switzerland | 21.8 | 40.7% | 57.2% | 53.1% | 49.3% |
| 34 | UBS | Switzerland | 22.2 | 43.5% | 56.4% | 56.3% | 48.1% |
| 35 | Barclay's | UK | 34.1 | 41.9% | 57.3% | 53.3% | 51.2% |
| 36 | HSBC | UK | 64.8 | 38.6% | 53.5% | 53.7% | 42.2% |
| 37 | Lloyds Banking Group | UK | 9.7 | 38.0% | 56.8% | 46.9% | 41.2% |
| 38 | Royal Bank of Scotland | UK | 60.9 | 38.6% | 54.1% | 48.8% | 42.6% |
| | Mean | | 19.6 | 41.1% | 55.1% | 53.2% | 51.2% |
| | Total | | 743.5 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 9 Equity and average equity return correlation by bank (Middle East and Russia)*

| No. | Bank name | Country | Equity[1] | Average equity return correlation² *Period 1* | *Period 2* | *Period 3* | *Period 4* |
|---|---|---|---|---|---|---|---|
| 1 | Arab Banking Corp | Bahrain | 1.3 | 13.9% | 7.1% | 5.0% | 17.0% |
| 2 | Commercial Bank of Qatar | Qatar | 2.0 | 12.4% | 12.3% | 18.7% | 21.5% |
| 3 | Abu Dhabi Commercial Bank | UAE | 2.2 | 24.6% | 19.1% | 22.9% | 19.4% |
| 4 | Dubai Islamic Bank | UAE | 1.7 | 19.4% | 17.9% | 22.4% | 20.7% |
| 5 | Mashreqbank | UAE | 2.0 | 11.0% | 11.3% | 3.2% | 18.6% |
| 6 | National Bank of Abu Dhabi | UAE | 2.8 | 21.7% | 19.3% | 24.8% | 24.2% |
| 7 | Bank of Moscow | Russia | 1.6 | 14.9% | 17.4% | 17.2% | 22.5% |
| 8 | Sberbank | Russia | 17.6 | 14.8% | 17.6% | 15.7% | 20.8% |
| 9 | WTB/VTB (Wneschtorgbank) | Russia | 9.5 | 43.4% | 22.8% | 17.4% | 20.7% |
| | Mean | | 4.5 | 22.6% | 18.0% | 16.7% | 20.7% |
| | Total | | 40.6 | | | | |

*Notes:* 1. Total equity as of 31.12.2008 in billion EUR. 2. Mean of daily pairwise stock return correlations between the bank and all other banks. 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. The mean of the correlations is obtained by weighting the period correlations with the liabilities as of 31.12.2008.

*Table 10 Input variable determinants of the ESS-indicator*

*Global*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 | |
|---|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | | 0.00 | | 0.00 |
| | (24.59) | (8.32) | | (32.50) | | (25.23) |
| Risk-neutral PD (average) | 0.23 | | | 0.21 | | 0.32 |
| | (101.29) | | *1.08* | (128.66) | *8.52* | (61.46) |
| Correlation (average) | | 0.02 | | 0.01 | | 0.01 |
| | | (20.35) | *1.08* | (30.80) | *3.10* | (16.90) |
| PD dispersion | | | | | | -0.11 |
| | | | | | *8.04* | (21.34) |
| Correlation dispersion | | | | | | 0.01 |
| | | | | | *3.29* | (8.17) |
| Adjusted-$R^2$ | 0.89 | 0.23 | | 0.94 | | 0.97 |

*America*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 | |
|---|---|---|---|---|---|---|
| Constant term | 0.00 | -0.01 | | 0.00 | | 0.00 |
| | (14.83) | (12.43) | | (28.90) | | (13.95) |
| Risk-neutral PD (average) | 0.45 | | | 0.44 | | 0.47 |
| | (237.30) | | *1.15* | (217.28) | *5.52* | (139.14) |
| Correlation (average) | | 0.03 | | 0.00 | | 0.00 |
| | | (19.89) | *1.15* | (25.24) | *1.81* | (17.76) |
| PD dispersion | | | | | | -0.08 |
| | | | | | *5.84* | (10.22) |
| Correlation dispersion | | | | | | 0.00 |
| | | | | | *1.59* | (5.93) |
| Adjusted-$R^2$ | 0.99 | 0.17 | | 0.99 | | 0.99 |

*Asia-Pacific*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 | |
|---|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | | 0.00 | | 0.00 |
| | (31.73) | (1.85) | | (22.25) | | (10.71) |
| Risk-neutral PD (average) | 0.28 | | | 0.28 | | 0.30 |
| | (187.17) | | *1.11* | (204.44) | *3.59* | (123.47) |
| Correlation (average) | | 0.01 | | 0.00 | | 0.00 |
| | | (13.04) | *1.11* | (10.17) | *1.46* | (5.21) |
| PD dispersion | | | | | | -0.03 |
| | | | | | *3.38* | (15.28) |
| Correlation dispersion | | | | | | 0.00 |
| | | | | | *1.37* | (0.04) |
| Adjusted-$R^2$ | 0.97 | 0.12 | | 0.97 | | 0.97 |

*Europe*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 | |
|---|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | | 0.00 | | 0.00 |
| | (12.31) | (8.65) | | (31.80) | | (22.92) |
| Risk-neutral PD (average) | 0.32 | | | 0.30 | | 0.34 |
| | (110.65) | | *1.09* | (157.02) | *11.28* | (46.81) |
| Correlation (average) | | 0.01 | | 0.01 | | 0.01 |
| | | (20.13) | *1.09* | (32.28) | *1.76* | (27.03) |
| PD dispersion | | | | | | -0.04 |
| | | | | | *11.25* | (6.06) |
| Correlation dispersion | | | | | | 0.01 |
| | | | | | *1.47* | (5.12) |
| Adjusted-$R^2$ | 0.92 | 0.22 | | 0.96 | | 0.96 |

*Middle East and Russia*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 | |
|---|---|---|---|---|---|---|
| Constant term | 0.00 | 0.01 | | 0.00 | | 0.00 |
| | (15.96) | (11.94) | | (13.66) | | (18.10) |
| Risk-neutral PD (average) | 0.43 | | | 0.43 | | 0.51 |
| | (122.64) | | *1.00* | (134.76) | *4.23* | (160.73) |
| Correlation (average) | | 0.00 | | 0.01 | | 0.00 |
| | | (0.28) | *1.00* | (9.31) | *1.15* | (5.49) |
| PD dispersion | | | | | | -0.20 |
| | | | | | *4.23* | (38.95) |
| Correlation dispersion | | | | | | 0.03 |
| | | | | | *1.15* | (18.07) |
| Adjusted-$R^2$ | 0.97 | 0.00 | | 0.97 | | 0.99 |

*Notes*: The dependent variable in the regression is the relative ESS-indicator of the banks in the sample. Average PD and average correlation denote the risk-neutral default probability of all banks and the correlation between the bank and all other banks at a particular point in time, respectively. Dispersion denotes the standard deviation of the respective variable at a particular point in time for all sample banks. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 11 Risk premium determinants of the ESS-indicator*

*Global*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 |
|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | 0.00 | | 0.00 |
| | (5.66) | (23.98) | (21.85) | | (16.00) |
| Baa-Aaa spread | 0.27 | | | | 0.16 |
| | (34.57) | | | *1.44* | (20.87) |
| Ted spread | | 0.08 | | | 0.02 |
| | | (21.72) | | *1.27* | (6.99) |
| Term spread | | | 0.13 | | 0.10 |
| | | | (45.19) | *1.20* | (38.93) |
| Adjusted-$R^2$ | 0.46 | 0.19 | 0.53 | | 0.72 |

*America*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 |
|---|---|---|---|---|---|
| Constant term | 0.00 | 0.01 | 0.00 | | 0.00 |
| | (7.45) | (30.91) | (32.36) | | (15.86) |
| Baa-Aaa spread | 0.76 | | | | 0.54 |
| | (33.67) | | | *1.44* | (23.43) |
| Ted spread | | 0.18 | | | 0.02 |
| | | (23.64) | | *1.27* | (3.26) |
| Term spread | | | 0.32 | | 0.22 |
| | | | (50.29) | *1.20* | (60.34) |
| Adjusted-$R^2$ | 0.62 | 0.18 | 0.55 | | 0.84 |

*Asia-Pacific*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 |
|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | 0.00 | | 0.00 |
| | (18.37) | (29.44) | (28.71) | | (31.80) |
| Baa-Aaa spread | 0.41 | | | | 0.33 |
| | (54.78) | | | *1.44* | (38.41) |
| Ted spread | | 0.09 | | | 0.00 |
| | | (16.46) | | *1.27* | (1.19) |
| Term spread | | | 0.15 | | 0.09 |
| | | | (42.35) | *1.20* | (38.64) |
| Adjusted-$R^2$ | 0.71 | 0.17 | 0.45 | | 0.84 |

*Europe*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 |
|---|---|---|---|---|---|
| Constant term | 0.00 | 0.00 | 0.00 | | 0.00 |
| | (4.26) | (26.35) | (22.92) | | (3.42) |
| Baa-Aaa spread | 0.26 | | | | 0.09 |
| | (28.11) | | | *1.44* | (11.74) |
| Ted spread | | 0.08 | | | 0.02 |
| | | (17.12) | | *1.27* | (5.29) |
| Term spread | | | 0.19 | | 0.16 |
| | | | (56.11) | *1.20* | (45.22) |
| Adjusted-$R^2$ | 0.26 | 0.11 | 0.65 | | 0.69 |

*Middle East and Russia*

| Independent variables | Regression 1 | Regression 2 | Regression 3 | | Regression 4 |
|---|---|---|---|---|---|
| Constant term | -0.01 | 0.01 | 0.01 | | -0.01 |
| | (21.25) | (36.22) | (43.04) | | (28.58) |
| Baa-Aaa spread | 1.67 | | | | 1.49 |
| | (55.05) | | | *1.44* | (43.83) |
| Ted spread | | 0.31 | | | -0.04 |
| | | (13.61) | | *1.27* | (3.58) |
| Term spread | | | 0.50 | | 0.24 |
| | | | (38.00) | *1.20* | (57.77) |
| Adjusted-$R^2$ | 0.83 | 0.15 | 0.37 | | 0.90 |

*Notes:* The dependent regression variable is the relative ESS-indicator of the European banks in the sample during the observation period. Baa-Aaa spread is the spread between Moody's Baa and Aaa bond indices, Ted spread is the spread between the 3-month LIBOR and the yield of a 3-month T-Bill, Term spread is the spread between the yields of 10-year and 3-month maturity T-Bills. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 12 Relative systemic loss contribution by country (Global)*

| | | Relative systemic loss contribution | | | | |
|---|---|---|---|---|---|---|
| Region | Country | *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
| America | US | 20.8% | 19.0% | 22.1% | 16.5% | 19.6% |
| Asia-Pacific | Australia | 0.4% | 0.6% | 1.6% | 1.4% | 1.0% |
| Asia-Pacific | China | 0.2% | 0.2% | 0.3% | 0.4% | 0.3% |
| Asia-Pacific | Hong Kong | 0.5% | 0.7% | 0.8% | 0.7% | 0.7% |
| Asia-Pacific | India | 0.2% | 0.3% | 0.5% | 0.3% | 0.3% |
| Asia-Pacific | Japan | 1.8% | 0.4% | 1.1% | 0.6% | 1.0% |
| Asia-Pacific | Kazakhstan | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Asia-Pacific | Korea | 0.4% | 0.5% | 0.9% | 0.4% | 0.5% |
| Asia-Pacific | Malaysia | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Asia-Pacific | Singapore | 0.1% | 0.2% | 0.3% | 0.1% | 0.2% |
| Europe | Austria | 0.3% | 0.3% | 0.7% | 0.5% | 0.4% |
| Europe | Belgium | 2.4% | 2.9% | 3.1% | 3.6% | 3.0% |
| Europe | Denmark | 0.3% | 0.5% | 1.1% | 0.5% | 0.6% |
| Europe | France | 19.3% | 15.2% | 14.5% | 18.9% | 17.0% |
| Europe | Germany | 10.1% | 11.8% | 9.0% | 8.1% | 9.8% |
| Europe | Greece | 0.1% | 0.1% | 0.1% | 0.5% | 0.2% |
| Europe | Ireland | 0.4% | 0.9% | 1.0% | 0.9% | 0.8% |
| Europe | Italy | 5.0% | 4.7% | 5.3% | 6.7% | 5.4% |
| Europe | Netherlands | 0.1% | 0.1% | 0.5% | 0.4% | 0.3% |
| Europe | Portugal | 0.1% | 0.2% | 0.3% | 0.9% | 0.4% |
| Europe | Spain | 6.2% | 3.8% | 5.2% | 7.3% | 5.6% |
| Europe | Sweden | 2.6% | 1.6% | 2.9% | 2.0% | 2.3% |
| Europe | Switzerland | 9.8% | 8.5% | 6.6% | 4.5% | 7.4% |
| Europe | UK | 18.5% | 27.2% | 21.4% | 24.3% | 22.9% |
| Middle East | Bahrain | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Middle East | Qatar | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Middle East | UAE | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% |
| Russia | Russia | 0.3% | 0.3% | 0.9% | 0.5% | 0.5% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 13 Relative systemic loss contribution by bank (Global)*

| No. | Bank name | Region | Country | Relative systemic loss contribution *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
|---|---|---|---|---|---|---|---|---|
| 1 | American Express | America | US | 0.2% | 0.2% | 0.2% | 0.1% | 0.2% |
| 2 | Bank of America | America | US | 3.6% | 3.0% | 4.8% | 4.3% | 3.9% |
| 3 | Bank of New York Mellon | America | US | 0.1% | 0.2% | 0.3% | 0.3% | 0.2% |
| 4 | Capital One Financial | America | US | 0.2% | 0.3% | 0.3% | 0.2% | 0.2% |
| 5 | Citigroup | America | US | 4.8% | 5.0% | 4.8% | 3.0% | 4.4% |
| 6 | Goldman Sachs | America | US | 2.0% | 2.3% | 2.0% | 1.0% | 1.8% |
| 7 | JPMorgan Chase & Co. | America | US | 4.1% | 2.9% | 3.4% | 3.0% | 3.4% |
| 8 | MetLife | America | US | 0.8% | 0.8% | 1.4% | 1.1% | 1.0% |
| 9 | Morgan Stanley | America | US | 3.6% | 2.9% | 1.9% | 1.4% | 2.4% |
| 10 | PNC Financial Services | America | US | 0.1% | 0.2% | 0.5% | 0.3% | 0.3% |
| 11 | US Bancorp | America | US | 0.4% | 0.4% | 0.5% | 0.4% | 0.4% |
| 12 | Wells Fargo | America | US | 0.9% | 0.8% | 2.0% | 1.6% | 1.3% |
| 13 | ANZ Banking Group | Asia-Pacific | Australia | 0.1% | 0.1% | 0.3% | 0.2% | 0.2% |
| 14 | Commonwealth Bank | Asia-Pacific | Australia | 0.1% | 0.2% | 0.4% | 0.3% | 0.2% |
| 15 | Macquarie Bank | Asia-Pacific | Australia | 0.0% | 0.1% | 0.2% | 0.1% | 0.1% |
| 16 | National Australia Bank | Asia-Pacific | Australia | 0.1% | 0.1% | 0.4% | 0.4% | 0.3% |
| 17 | Westspac Banking Corp | Asia-Pacific | Australia | 0.1% | 0.1% | 0.3% | 0.3% | 0.2% |
| 18 | Bank of China | Asia-Pacific | China | 0.2% | 0.2% | 0.3% | 0.4% | 0.3% |
| 19 | Standard Chartered Bank | Asia-Pacific | Hong Kong | 0.5% | 0.7% | 0.8% | 0.7% | 0.7% |
| 20 | Bank of India | Asia-Pacific | India | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 21 | ICICI Bank | Asia-Pacific | India | 0.0% | 0.1% | 0.2% | 0.1% | 0.1% |
| 22 | State Bank of India | Asia-Pacific | India | 0.1% | 0.2% | 0.2% | 0.2% | 0.2% |
| 23 | Mizuho Financial Group | Asia-Pacific | Japan | 1.1% | 0.2% | 0.5% | 0.3% | 0.6% |
| 24 | Resona Holdings | Asia-Pacific | Japan | 0.3% | 0.1% | 0.2% | 0.1% | 0.1% |
| 25 | Sumitomo Mitsui Banking | Asia-Pacific | Japan | 0.4% | 0.1% | 0.3% | 0.2% | 0.3% |
| 26 | Halyk Bank of Kazakhstan | Asia-Pacific | Kazakhstan | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 27 | Kazkommertsbank | Asia-Pacific | Kazakhstan | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 28 | Hana Bank | Asia-Pacific | Korea | 0.0% | 0.1% | 0.1% | 0.0% | 0.1% |
| 29 | Industrial Bank of Korea | Asia-Pacific | Korea | 0.0% | 0.1% | 0.1% | 0.0% | 0.1% |
| 30 | Kookmin Bank | Asia-Pacific | Korea | 0.1% | 0.1% | 0.2% | 0.1% | 0.1% |
| 31 | Shinhan Financial Group | Asia-Pacific | Korea | 0.1% | 0.1% | 0.2% | 0.1% | 0.1% |
| 32 | Woori Bank | Asia-Pacific | Korea | 0.1% | 0.2% | 0.2% | 0.1% | 0.2% |
| 33 | Malayan Banking Berhad | Asia-Pacific | Malaysia | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 34 | DBS Bank | Asia-Pacific | Singapore | 0.0% | 0.1% | 0.1% | 0.0% | 0.1% |
| 35 | Oversea Chinese Banking | Asia-Pacific | Singapore | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% |
| 36 | United Overseas Bank | Asia-Pacific | Singapore | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% |
| 37 | Erste Group Bank | Europe | Austria | 0.3% | 0.3% | 0.7% | 0.5% | 0.4% |
| 38 | Dexia | Europe | Belgium | 1.6% | 1.8% | 1.9% | 2.6% | 2.0% |
| 39 | KBC Bank | Europe | Belgium | 0.9% | 1.1% | 1.2% | 1.1% | 1.0% |
| 40 | DANSKE Bank | Europe | Denmark | 0.3% | 0.5% | 1.1% | 0.5% | 0.6% |
| 41 | BNP Paribas | Europe | France | 8.8% | 6.5% | 6.0% | 7.7% | 7.2% |
| 42 | Crédit Agricole | Europe | France | 5.0% | 5.3% | 5.3% | 6.8% | 5.6% |
| 43 | Societé Generale | Europe | France | 5.5% | 3.4% | 3.3% | 4.4% | 4.1% |
| 44 | Commerzbank | Europe | Germany | 2.0% | 2.1% | 1.8% | 2.0% | 1.9% |
| 45 | Deutsche Bank | Europe | Germany | 8.0% | 9.6% | 7.1% | 6.1% | 7.8% |
| 46 | IKB - Deutsche Industriebank | Europe | Germany | 0.1% | 0.1% | 0.1% | 0.0% | 0.1% |
| 47 | Alpha Bank | Europe | Greece | 0.1% | 0.0% | 0.1% | 0.2% | 0.1% |
| 48 | EFG Eurobank | Europe | Greece | 0.0% | 0.0% | 0.1% | 0.3% | 0.1% |
| 49 | Allied Irish Banks | Europe | Ireland | 0.3% | 0.5% | 0.5% | 0.5% | 0.4% |

| No. | Bank name | Region | Country | Relative systemic loss contribution *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
|---|---|---|---|---|---|---|---|---|
| 50 | Bank of Ireland | Europe | Ireland | 0.1% | 0.4% | 0.5% | 0.4% | 0.4% |
| 51 | Banca Monte d.P. die Siena | Europe | Italy | 0.3% | 0.4% | 0.4% | 0.8% | 0.5% |
| 52 | Banco Popolare | Europe | Italy | 0.2% | 0.2% | 0.3% | 0.4% | 0.3% |
| 53 | Intesa Sanpaolo | Europe | Italy | 0.5% | 1.1% | 1.4% | 2.1% | 1.3% |
| 54 | Unicredit Group | Europe | Italy | 4.0% | 2.9% | 3.2% | 3.4% | 3.4% |
| 55 | SNS REAAL Bank | Europe | Netherlands | 0.1% | 0.1% | 0.5% | 0.4% | 0.3% |
| 56 | Banco BPI | Europe | Portugal | 0.0% | 0.0% | 0.1% | 0.2% | 0.1% |
| 57 | Banco Comercial Portuges | Europe | Portugal | 0.0% | 0.1% | 0.1% | 0.4% | 0.2% |
| 58 | Espirito Santo Financial Group | Europe | Portugal | 0.0% | 0.1% | 0.1% | 0.3% | 0.1% |
| 59 | Banco de Sabadell | Europe | Spain | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| 60 | Banco Pastor | Europe | Spain | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% |
| 61 | Banco Popular | Europe | Spain | 0.2% | 0.2% | 0.5% | 0.5% | 0.3% |
| 62 | Bankinter | Europe | Spain | 0.1% | 0.1% | 0.1% | 0.2% | 0.1% |
| 63 | Grupo BBVA | Europe | Spain | 0.7% | 0.4% | 0.7% | 1.4% | 0.8% |
| 64 | Grupo Santander | Europe | Spain | 4.8% | 2.9% | 3.5% | 4.8% | 4.0% |
| 65 | Nordea | Europe | Sweden | 0.9% | 0.7% | 1.2% | 0.9% | 0.9% |
| 66 | Skand Enskilda Banken | Europe | Sweden | 0.7% | 0.4% | 0.7% | 0.4% | 0.6% |
| 67 | Svenska Handelsbanken | Europe | Sweden | 0.5% | 0.2% | 0.4% | 0.3% | 0.4% |
| 68 | Swedbank | Europe | Sweden | 0.5% | 0.3% | 0.5% | 0.3% | 0.4% |
| 69 | Crédit Suisse | Europe | Switzerland | 4.0% | 3.1% | 2.2% | 1.9% | 2.8% |
| 70 | UBS | Europe | Switzerland | 5.8% | 5.4% | 4.4% | 2.5% | 4.6% |
| 71 | Barclay's | Europe | UK | 7.2% | 8.7% | 6.6% | 6.0% | 7.2% |
| 72 | HSBC | Europe | UK | 5.6% | 5.5% | 4.9% | 4.3% | 5.1% |
| 73 | Lloyds Banking Group | Europe | UK | 1.1% | 1.5% | 2.5% | 7.7% | 3.1% |
| 74 | Royal Bank of Scotland | Europe | UK | 4.7% | 11.6% | 7.4% | 6.2% | 7.5% |
| 75 | Arab Banking Corp | Middle East | Bahrain | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 76 | Commercial Bank of Qatar | Middle East | Qatar | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 77 | Abu Dhabi Commercial Bank | Middle East | UAE | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 78 | Dubai Islamic Bank | Middle East | UAE | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 79 | Mashreqbank | Middle East | UAE | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 80 | National Bank of Abu Dhabi | Middle East | UAE | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 81 | Bank of Moscow | Russia | Russia | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% |
| 82 | Sberbank | Russia | Russia | 0.3% | 0.3% | 0.5% | 0.3% | 0.3% |
| 83 | WTB/VTB (Wneschtorgbank) | Russia | Russia | 0.0% | 0.1% | 0.3% | 0.2% | 0.1% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 14 Relative systemic loss contribution by bank (America)*

| No. | Bank name | Country | Relative systemic loss contribution *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:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 15 Relative systemic loss contribution by country (Asia-Pacific)*

| Region | Country | Relative systemic loss contribution *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
|---|---|---|---|---|---|---|
| Asia-Pacific | Australia | 2.5% | 16.9% | 16.4% | 20.9% | 14.1% |
| Asia-Pacific | China | 3.0% | 8.0% | 17.7% | 24.5% | 13.1% |
| Asia-Pacific | Hong Kong | 0.2% | 1.5% | 2.2% | 1.1% | 1.3% |
| Asia-Pacific | India | 0.9% | 2.5% | 2.9% | 1.8% | 2.0% |
| Asia-Pacific | Japan | 88.4% | 58.6% | 46.2% | 44.8% | 59.7% |
| Asia-Pacific | Kazakhstan | 0.1% | 0.3% | 0.4% | 0.2% | 0.2% |
| Asia-Pacific | Korea | 4.4% | 9.7% | 11.5% | 5.3% | 7.8% |
| Asia-Pacific | Malaysia | 0.1% | 0.3% | 0.3% | 0.2% | 0.2% |
| Asia-Pacific | Singapore | 0.4% | 2.4% | 2.4% | 1.2% | 1.6% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 16 Relative systemic loss contribution by bank (Asia-Pacific)*

| No. | Bank name | Country | Relative systemic loss contribution *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
|---|---|---|---|---|---|---|---|
| 1 | ANZ Banking Group | Australia | 0.2% | 2.1% | 2.2% | 3.2% | 1.9% |
| 2 | Commonwealth Bank | Australia | 0.7% | 4.2% | 3.9% | 5.3% | 3.5% |
| 3 | Macquarie Bank | Australia | 0.2% | 1.5% | 1.6% | 1.0% | 1.1% |
| 4 | National Australia Bank | Australia | 1.0% | 5.6% | 5.1% | 6.1% | 4.4% |
| 5 | Westspac Banking Corp | Australia | 0.4% | 3.5% | 3.6% | 5.2% | 3.2% |
| 6 | Bank of China | China | 3.0% | 8.0% | 17.7% | 24.5% | 13.1% |
| 7 | Standard Chartered Bank | Hong Kong | 0.2% | 1.5% | 2.2% | 1.1% | 1.3% |
| 8 | Bank of India | India | 0.1% | 0.2% | 0.2% | 0.2% | 0.2% |
| 9 | ICICI Bank | India | 0.2% | 1.0% | 1.1% | 0.4% | 0.7% |
| 10 | State Bank of India | India | 0.5% | 1.3% | 1.6% | 1.1% | 1.2% |
| 11 | Mizuho Financial Group | Japan | 58.1% | 35.1% | 27.4% | 27.1% | 37.1% |
| 12 | Resona Holdings | Japan | 8.5% | 5.8% | 4.5% | 2.2% | 5.3% |
| 13 | Sumitomo Mitsui Banking | Japan | 21.8% | 17.7% | 14.3% | 15.5% | 17.3% |
| 14 | Halyk Bank of Kazakhstan | Kazakhstan | 0.0% | 0.1% | 0.2% | 0.1% | 0.1% |
| 15 | Kazkommertsbank | Kazakhstan | 0.1% | 0.2% | 0.2% | 0.1% | 0.1% |
| 16 | Hana Bank | Korea | 1.0% | 1.1% | 1.4% | 0.7% | 1.1% |
| 17 | Industrial Bank of Korea | Korea | 0.4% | 1.0% | 1.4% | 0.7% | 0.9% |
| 18 | Kookmin Bank | Korea | 1.1% | 2.4% | 2.8% | 1.3% | 1.9% |
| 19 | Shinhan Financial Group | Korea | 0.8% | 2.4% | 2.9% | 1.2% | 1.8% |
| 20 | Woori Bank | Korea | 1.0% | 2.8% | 3.0% | 1.5% | 2.1% |
| 21 | Malayan Banking Berhad | Malaysia | 0.1% | 0.3% | 0.3% | 0.2% | 0.2% |
| 22 | DBS Bank | Singapore | 0.2% | 1.1% | 1.1% | 0.5% | 0.7% |
| 23 | Oversea Chinese Banking | Singapore | 0.1% | 0.7% | 0.7% | 0.4% | 0.5% |
| 24 | United Overseas Bank | Singapore | 0.1% | 0.6% | 0.7% | 0.3% | 0.5% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 17 Relative systemic loss contribution by country (Europe)*

| | Relative systemic loss contribution | | | | |
|---|---|---|---|---|---|
| Country | *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
| Austria | 0.4% | 0.4% | 0.9% | 0.7% | 0.6% |
| Belgium | 3.2% | 3.7% | 4.3% | 4.7% | 4.0% |
| Denmark | 0.4% | 0.6% | 1.5% | 0.6% | 0.8% |
| France | 25.7% | 19.6% | 20.2% | 23.2% | 22.2% |
| Germany | 13.5% | 13.5% | 11.9% | 9.4% | 12.1% |
| Greece | 0.1% | 0.1% | 0.2% | 0.6% | 0.3% |
| Ireland | 0.5% | 1.1% | 1.3% | 1.4% | 1.0% |
| Italy | 6.7% | 5.9% | 7.0% | 8.7% | 7.0% |
| Netherlands | 0.1% | 0.1% | 0.7% | 0.5% | 0.3% |
| Portugal | 0.1% | 0.3% | 0.5% | 1.2% | 0.5% |
| Spain | 8.0% | 4.8% | 7.1% | 9.8% | 7.4% |
| Sweden | 3.5% | 2.1% | 3.9% | 2.4% | 3.0% |
| Switzerland | 13.7% | 11.1% | 9.1% | 5.3% | 9.9% |
| UK | 24.3% | 36.8% | 31.6% | 31.4% | 31.1% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 18 Relative systemic loss contribution by bank (Europe)*

| No. | Bank name | Country | Relative systemic loss contribution *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
|---|---|---|---|---|---|---|---|
| 1 | Erste Group Bank | Austria | 0.4% | 0.4% | 0.9% | 0.7% | 0.6% |
| 2 | Dexia | Belgium | 2.1% | 2.3% | 2.7% | 3.4% | 2.6% |
| 3 | KBC Bank | Belgium | 1.1% | 1.5% | 1.6% | 1.3% | 1.4% |
| 4 | DANSKE Bank | Denmark | 0.4% | 0.6% | 1.5% | 0.6% | 0.8% |
| 5 | BNP Paribas | France | 11.9% | 8.2% | 8.4% | 9.3% | 9.4% |
| 6 | Crédit Agricole | France | 6.4% | 6.9% | 7.3% | 8.6% | 7.3% |
| 7 | Societé Generale | France | 7.4% | 4.5% | 4.5% | 5.4% | 5.5% |
| 8 | Commerzbank | Germany | 2.6% | 2.4% | 2.4% | 2.4% | 2.4% |
| 9 | Deutsche Bank | Germany | 10.7% | 11.0% | 9.3% | 7.1% | 9.6% |
| 10 | IKB - Deutsche Industriebank | Germany | 0.1% | 0.1% | 0.2% | 0.0% | 0.1% |
| 11 | Alpha Bank | Greece | 0.1% | 0.1% | 0.1% | 0.3% | 0.1% |
| 12 | EFG Eurobank | Greece | 0.1% | 0.0% | 0.1% | 0.4% | 0.1% |
| 13 | Allied Irish Banks | Ireland | 0.3% | 0.6% | 0.7% | 0.6% | 0.5% |
| 14 | Bank of Ireland | Ireland | 0.1% | 0.5% | 0.7% | 0.6% | 0.5% |
| 15 | Banca Monte d.P. die Siena | Italy | 0.4% | 0.4% | 0.5% | 1.0% | 0.6% |
| 16 | Banco Popolare | Italy | 0.2% | 0.3% | 0.4% | 0.5% | 0.4% |
| 17 | Intesa Sanpaolo | Italy | 0.7% | 1.4% | 1.9% | 2.7% | 1.7% |
| 18 | Unicredit Group | Italy | 5.3% | 3.8% | 4.2% | 4.4% | 4.4% |
| 19 | SNS REAAL Bank | Netherlands | 0.1% | 0.1% | 0.7% | 0.5% | 0.3% |
| 20 | Banco BPI | Portugal | 0.0% | 0.0% | 0.1% | 0.2% | 0.1% |
| 21 | Banco Comercial Portuges | Portugal | 0.0% | 0.1% | 0.2% | 0.5% | 0.2% |
| 22 | Espirito Santo Financial Group | Portugal | 0.0% | 0.1% | 0.2% | 0.4% | 0.2% |
| 23 | Banco de Sabadell | Spain | 0.3% | 0.3% | 0.4% | 0.5% | 0.4% |
| 24 | Banco Pastor | Spain | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% |
| 25 | Banco Popular | Spain | 0.3% | 0.2% | 0.7% | 0.7% | 0.5% |
| 26 | Bankinter | Spain | 0.1% | 0.1% | 0.2% | 0.3% | 0.2% |
| 27 | Grupo BBVA | Spain | 1.0% | 0.5% | 0.9% | 1.9% | 1.1% |
| 28 | Grupo Santander | Spain | 6.3% | 3.7% | 4.8% | 6.4% | 5.3% |
| 29 | Nordea | Sweden | 1.2% | 0.9% | 1.6% | 1.1% | 1.2% |
| 30 | Skand Enskilda Banken | Sweden | 1.0% | 0.5% | 1.0% | 0.5% | 0.7% |
| 31 | Svenska Handelsbanken | Sweden | 0.7% | 0.3% | 0.6% | 0.4% | 0.5% |
| 32 | Swedbank | Sweden | 0.7% | 0.3% | 0.7% | 0.4% | 0.5% |
| 33 | Crédit Suisse | Switzerland | 5.5% | 4.0% | 2.9% | 2.2% | 3.7% |
| 34 | UBS | Switzerland | 8.2% | 7.0% | 6.1% | 3.0% | 6.2% |
| 35 | Barclay's | UK | 10.2% | 11.3% | 9.7% | 7.3% | 9.7% |
| 36 | HSBC | UK | 6.5% | 7.0% | 6.6% | 5.1% | 6.3% |
| 37 | Lloyds Banking Group | UK | 1.3% | 1.8% | 3.8% | 10.5% | 4.3% |
| 38 | Royal Bank of Scotland | UK | 6.3% | 16.6% | 11.5% | 8.6% | 10.8% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 19 Relative systemic loss contribution by country (Middle East and Russia)*

| | Relative systemic loss contribution | | | | |
|---|---|---|---|---|---|
| Country | *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
| Bahrain | 0.8% | 0.7% | 1.0% | 1.3% | 1.0% |
| Qatar | 0.1% | 0.2% | 0.5% | 0.6% | 0.3% |
| UAE | 3.5% | 3.0% | 8.0% | 10.2% | 6.1% |
| Russia | 95.6% | 96.1% | 90.5% | 88.0% | 92.6% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 20 Relative systemic loss contribution by bank (Middle East and Russia)*

| | | | Relative systemic loss contribution | | | | |
|---|---|---|---|---|---|---|---|
| No. | Bank name | Country | *Period 1* | *Period 2* | *Period 3* | *Period 4* | *Average* |
| 1 | Arab Banking Corp | Bahrain | 0.8% | 0.7% | 1.0% | 1.3% | 1.0% |
| 2 | Commercial Bank of Qatar | Qatar | 0.1% | 0.2% | 0.5% | 0.6% | 0.3% |
| 3 | Abu Dhabi Commercial Bank | UAE | 1.1% | 0.9% | 2.5% | 3.4% | 1.9% |
| 4 | Dubai Islamic Bank | UAE | 0.8% | 0.5% | 1.7% | 1.7% | 1.2% |
| 5 | Mashreqbank | UAE | 0.2% | 0.5% | 0.9% | 1.4% | 0.7% |
| 6 | National Bank of Abu Dhabi | UAE | 1.4% | 1.1% | 2.9% | 3.7% | 2.3% |
| 7 | Bank of Moscow | Russia | 1.4% | 2.6% | 4.6% | 4.5% | 3.2% |
| 8 | Sberbank | Russia | 73.5% | 67.3% | 49.3% | 53.3% | 61.0% |
| 9 | WTB/VTB (Wneschtorgbank) | Russia | 20.7% | 26.2% | 36.6% | 30.2% | 28.4% |

*Notes:* Relative systemic loss contribution is defined as the relative loss share of a bank when the total portfolio loss exceeds the systemic loss threshold. 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.

*Table 21 Determinants of the relative contributions to the ESS-indicator (Global)*

| Independent variables | | Regression 1 | | Regression 2 | | Regression 3 |
|---|---|---|---|---|---|---|
| Constant term | | 0.01 | | 0.00 | | 0.00 |
| | | (172.74) | | (105.11) | | (119.41) |
| Risk-neutral PD | | -0.11 | | | | 0.05 |
| | | (75.77) | | | *1.05* | (80.01) |
| Liability weight | | | | 1.26 | | 1.28 |
| | | | | (302.20) | *1.05* | (307.16) |
| Average correlation | | | | | | |
| | | | | | | |
| Adjusted-$R^2$ | | 0.02 | | 0.77 | | 0.78 |
| | | **Regression 4** | | **Regression 5** | | **Regression 6** |
| Constant term | | -0.01 | | 0.00 | | 0.00 |
| | | (135.50) | | (82.15) | | (52.66) |
| Risk-neutral PD | | 0.06 | | | | 0.04 |
| | *1.05* | (86.93) | | | *1.29* | (43.23) |
| Liability weight | | 1.23 | | 0.59 | | 0.63 |
| | *1.16* | (282.42) | *6.28* | (58.55) | *8.20* | (54.76) |
| Average correlation | | 0.02 | | | | 0.00 |
| | *1.12* | (80.50) | | | *1.64* | (4.24) |
| Risk-neutral PD*liability weight | | | | 2.06 | | 0.38 |
| | | | *1.75* | (7.81) | *2.11* | (1.25) |
| Average correlation*liability weight | | | | 1.98 | | 1.99 |
| | | | *5.97* | (81.40) | *8.66* | (70.22) |
| Adjusted-$R^2$ | | 0.79 | | 0.81 | | 0.82 |

*Notes*: The dependent regression variable is the relative contribution to the ESS-indicator of each bank i (in percentage terms) over time. Independent variables are the risk-neutral default probability, the percentage weight (share) of total liabilities, the bank-specific correlations (average of bilateral correlations of one bank with all other banks) as well as interaction terms of each bank *i* over time. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 22 Determinants of the relative contributions to the ESS-indicator (America)*

| Independent variables | | Regression 1 | | Regression 2 | | Regression 3 |
|---|---|---|---|---|---|---|
| Constant term | | 0.09 | | -0.01 | | -0.02 |
| | | (90.89) | | (53.60) | | (54.11) |
| Risk-neutral PD | | -0.17 | | | | 0.40 |
| | | (4.86) | | | *1.02* | (33.93) |
| Liability weight | | | | 1.13 | | 1.14 |
| | | | | (258.94) | *1.02* | (265.76) |
| Average correlation | | | | | | |
| Adjusted-$R^2$ | | 0.00 | | 0.87 | | 0.87 |
| | | Regression 4 | | Regression 5 | | Regression 6 |
| Constant term | | 0.00 | | -0.01 | | -0.05 |
| | | (1.17) | | (67.50) | | (41.44) |
| Risk-neutral PD | | 0.46 | | | | -0.07 |
| | *1.10* | (35.19) | | | *2.56* | (7.27) |
| Liability weight | | 1.15 | | 1.52 | | 1.81 |
| | *1.05* | (263.91) | *18.78* | (77.47) | *38.44* | (75.61) |
| Average correlation | | -0.04 | | | | 0.06 |
| | *1.10* | (14.68) | | | *2.58* | (32.53) |
| Risk-neutral PD*liability weight | | | | 6.31 | | 6.74 |
| | | | *1.47* | (36.90) | *3.37* | (29.29) |
| Average correlation*liability weight | | | | -0.70 | | -1.15 |
| | | | *18.95* | (25.64) | *43.79* | (33.68) |
| Adjusted-$R^2$ | | 0.88 | | 0.89 | | 0.89 |

*Notes*: The dependent regression variable is the relative contribution to the ESS-indicator of each bank i (in percentage terms) over time. Independent variables are the risk-neutral default probability, the percentage weight (share) of total liabilities, the bank-specific correlations (average of bilateral correlations of one bank with all other banks) as well as interaction terms of each bank *i* over time. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 23 Determinants of the relative contributions to the ESS-indicator (Asia-Pacific)*

| Independent variables | | Regression 1 | | Regression 2 | | Regression 3 |
|---|---|---|---|---|---|---|
| Constant term | | 0.05 | | -0.03 | | -0.04 |
| | | (73.16) | | (61.81) | | (72.04) |
| Risk-neutral PD | | -0.36 | | | | 0.32 |
| | | (36.57) | | | *1.07* | (75.92) |
| Liability weight | | | | 1.70 | | 1.75 |
| | | | | (105.67) | *1.07* | (107.59) |
| Average correlation | | | | | | |
| | | | | | | |
| Adjusted-$R^2$ | | 0.01 | | 0.74 | | 0.75 |
| | | Regression 4 | | Regression 5 | | Regression 6 |
| Constant term | | -0.05 | | -0.03 | | -0.06 |
| | | (62.92) | | (74.04) | | (45.33) |
| Risk-neutral PD | | 0.34 | | | | 0.46 |
| | *1.08* | (79.40) | | | *1.35* | (38.45) |
| Liability weight | | 1.75 | | 1.68 | | 2.02 |
| | *1.07* | (107.99) | *4.18* | (53.29) | *7.83* | (47.94) |
| Average correlation | | 0.03 | | | | 0.06 |
| | *1.02* | (16.98) | | | *1.95* | (17.04) |
| Risk-neutral PD*liability weight | | | | -2.19 | | -10.91 |
| | | | *1.49* | (3.02) | *1.89* | (11.96) |
| Average correlation*liability weight | | | | 0.18 | | -0.52 |
| | | | *3.53* | (2.31) | *6.62* | (4.70) |
| Adjusted-$R^2$ | | 0.75 | | 0.74 | | 0.76 |

*Notes*: The dependent regression variable is the relative contribution to the ESS-indicator of each bank i (in percentage terms) over time. Independent variables are the risk-neutral default probability, the percentage weight (share) of total liabilities, the bank-specific correlations (average of bilateral correlations of one bank with all other banks) as well as interaction terms of each bank *i* over time. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 24 Determinants of the relative contributions to the ESS-indicator (<u>Europe</u>)*

| Independent variables | Regression 1 | | Regression 2 | | Regression 3 | |
|---|---|---|---|---|---|---|
| Constant term | | 0.03 | | 0.00 | | -0.01 |
| | | (153.83) | | (76.04) | | (86.89) |
| Risk-neutral PD | | -0.22 | | | | 0.08 |
| | | (52.40) | | | *1.04* | (54.93) |
| Liability weight | | | | 1.17 | | 1.18 |
| | | | | (313.41) | *1.04* | (319.04) |
| Average correlation | | | | | | |
| Adjusted-$R^2$ | | 0.02 | | 0.85 | | 0.85 |
| | Regression 4 | | Regression 5 | | Regression 6 | |
| Constant term | | -0.01 | | 0.00 | | -0.01 |
| | | (72.23) | | (74.41) | | (39.30) |
| Risk-neutral PD | | 0.08 | | | | 0.07 |
| | *1.04* | (57.53) | | | *1.36* | (37.40) |
| Liability weight | | 1.16 | | 0.85 | | 0.90 |
| | *1.11* | (297.29) | *9.05* | (62.55) | *12.84* | (56.95) |
| Average correlation | | 0.01 | | | | 0.00 |
| | *1.07* | (36.78) | | | *1.69* | (6.79) |
| Risk-neutral PD*liability weight | | | | 2.07 | | 0.13 |
| | | | *1.76* | (8.23) | *2.30* | (0.44) |
| Average correlation*liability weight | | | | 0.57 | | 0.53 |
| | | | *9.24* | (26.31) | *14.40* | (20.40) |
| Adjusted-$R^2$ | | 0.86 | | 0.86 | | 0.86 |

*Notes*: The dependent regression variable is the relative contribution to the ESS-indicator of each bank i (in percentage terms) over time. Independent variables are the risk-neutral default probability, the percentage weight (share) of total liabilities, the bank-specific correlations (average of bilateral correlations of one bank with all other banks) as well as interaction terms of each bank *i* over time. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

*Table 25 Determinants of the relative contributions to the ESS-indicator (Middle East and Russia)*

| Independent variables | | Regression 1 | | Regression 2 | | Regression 3 |
|---|---|---|---|---|---|---|
| Constant term | | 0.10 | | -0.07 | | -0.08 |
| | | (38.92) | | (125.11) | | (124.05) |
| Risk-neutral PD | | 0.26 | | | | 0.35 |
| | | (6.17) | | | *1.00* | (36.21) |
| Liability weight | | | | 1.59 | | 1.59 |
| | | | | (251.10) | *1.00* | (242.64) |
| Average correlation | | | | | | |
| Adjusted-$R^2$ | | 0.00 | | 0.94 | | 0.94 |
| | | Regression 4 | | Regression 5 | | Regression 6 |
| Constant term | | -0.08 | | -0.07 | | -0.10 |
| | | (96.00) | | (127.95) | | (82.77) |
| Risk-neutral PD | | 0.35 | | | | 0.58 |
| | *1.00* | (36.44) | | | *1.94* | (52.43) |
| Liability weight | | 1.59 | | 1.61 | | 1.76 |
| | *1.00* | (240.37) | *3.83* | (121.00) | *6.29* | (112.73) |
| Average correlation | | 0.02 | | | | 0.07 |
| | *1.01* | (4.99) | | | *2.12* | (11.33) |
| Risk-neutral PD*liability weight | | | | 0.41 | | -2.44 |
| | | | *1.72* | (2.97) | *3.34* | (16.43) |
| Average correlation*liability weight | | | | -0.21 | | -0.50 |
| | | | *3.11* | (3.94) | *6.58* | (6.73) |
| Adjusted-$R^2$ | | 0.94 | | 0.94 | | 0.94 |

*Notes*: The dependent regression variable is the relative contribution to the ESS-indicator of each bank i (in percentage terms) over time. Independent variables are the risk-neutral default probability, the percentage weight (share) of total liabilities, the bank-specific correlations (average of bilateral correlations of one bank with all other banks) as well as interaction terms of each bank *i* over time. Variance inflation factors are provided in italics. Heteroskedacity-consistent t-statistics are shown in parenthesis.

# APPENDIX

*Appendix 1 Relationship between asset and equity correlations*[58]

In the Merton (1974) framework, the market value of the firm's assets are characterized by the following stochastic process:

$$dV = \mu V dt + \sigma V dW$$

with $V$ denoting the firm's asset value, $\mu$ and $\sigma$ are the drift rate and volatility of the stochastic process, respectively. $W$ denotes a Wiener process. The liability side of the firm's balance sheet consists of only two liabilities, namely equity and debt. The debt has a book value of $X$ and a matures at time $T$. By interpreting the equity as a call option on the firm's assets, Merton (1974) applies the well-known Black-Scholes-Merton equation for pricing European options to show that he equity value is determined by

$$E = VN\left(d_1\right) - e^{-rT} XN\left(d_2\right)$$

where $d_1 \equiv \frac{\ln\left(V/X\right) + \left(r + \sigma^2/2\right)T}{\sigma\sqrt{T}}$, $d_2 = d1 - \sigma\sqrt{T} = \frac{\ln\left(V/X\right) + \left(r - \sigma^2/2\right)T}{\sigma\sqrt{T}}$ and $r$ denotes the risk-free interest rate.

Under the assumption of constant risk-free interest rate, volatility and constant leverage $V/X$ it can be easily seen that the value of the equity is proportional to the asset value since $d_1$ and $d_2$ are constant and $V$ is proportional to $X$. Consequently, it must hold that $fd\left(\ln\left(E\right)\right) = fd\left(\ln\left(V\right)\right)$ with $fd$ denoting the first difference. Under this condition the equity return correlation is equal to the asset return correlation:

$$cor\left[fd\left(\ln\left(E_1\right)\right), fd\left(\ln\left(E_2\right)\right)\right] = cor\left[fd\left(\ln\left(V_1\right)\right), fd\left(\ln\left(V_2\right)\right)\right].$$

[58] This appendix is based on Huang/Zhou/Zhu (2009), p. 2047 (Appendix A).

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