Basis Risk, Procyclicality, and Systemic Risk in the Solvency II Equity Risk Module

Martin Eling
David Pankoke
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Basis Risk, Procyclicality, and Systemic Risk in the Solvency II Equity Risk Module

Martin Eling*
David Pankoke**

Abstract

This paper analyzes the equity risk module of Solvency II, the new regulatory framework for insurance companies in the European Union. The equity risk module contains a symmetric adjustment mechanism called equity dampener that is meant to reduce procyclicality of capital requirements and thus systemic risk in the insurance sector. We critique the equity risk module in three steps: we first analyze the sensitivities of the equity risk module with respect to the underlying technical basis, then work out potential basis risk (i.e., deviations of insurers’ actual equity risk from the Solvency II equity risk) and, based on these results, measure the impact of the symmetric adjustment mechanism on the goals of Solvency II. The equity risk module is backward-looking in nature and a substantial degree of basis risk exists if realistic equity portfolios are considered. Both of these aspects underline the importance of the Own Risk and Solvency Assessment (ORSA) under Solvency II. Moreover, we show that the equity dampener leads to substantial deviations from the proposed 99.5% confidence level and thereby reduces procyclicality of capital requirements. Our results are of interest to academics who study regulation and risk management and of practical relevance to practitioners and regulators working on the implementation of such models.

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1. Purpose and Motivation

In light of the ongoing financial crisis, the scope and structure of insurance regulation is the subject of intense discussion, both in academia and practice. Regulators around the world are revising their regulatory frameworks, including in the United States (Federal Insurance Office (FIO), 2013), the European Union (Eling et al., 2007), and Switzerland (Filipović and Vogelpoth, 2008). A new and important issue on the regulatory agenda is whether the insurance industry poses systemic risk and, if so, how regulation might mitigate undesired outcomes arising from such risk (Klein, 2011; Cummins and Weiss, 2011; Harrington, 2009; Harrington and Miller, 2011; Grace, 2011).

This paper contributes to the insurance regulation discussion by focusing on the equity risk module of Solvency II. The module consists of capital requirements for equity based on a standard capital stress scenario, which is the 0.5% quantile of past returns and an additional adjustment term to counteract systemic risk (CEIOPS, 2010a). The adjustment term is intended as a mechanism that can either tighten or relax capital requirements depending on the market environment. Due to the “one-size-fits-all” approach of the standard formula, it is likely that the capital requirements for equity will not precisely match insurers’ risk. Neither this potential deviation nor the proposed mechanisms for counteracting systemic risk have been the subject of academic insurance research to date.

The design of Solvency II has been the subject of a fair amount of research during the past few years, with the insurer’s option to choose between a regulatory standard model and an internal risk model one of the features that has attracted much attention. Liebwein (2006) and Albarrán et al. (2011), as well as Gatzert and Martin (2012), argue that companies should use internal risk models because these will better reflect the company’s actual risk than will the standard formula. Christiansen et al. (2012) review the aggregation formula used to sum up the capital requirements for different risk classes and find that the aggregation formula is theoretically supportable, but that the underlying correlation matrix is highly questionable. Pfeifer and Strassburger (2008) show that if the individual risks are skewed, then the solvency capital requirements can be largely under- or overestimated. According to Savelli and Clemente (2011), the proposed aggregation formula produces correct results for only a restricted class of independent distributions and can lead to an underestimation of the diversification effect. As an alternative, the authors propose using copula functions to model the dependencies of distributions and thus derive more appropriate capital requirements. Van Laere and Baesens (2010) discuss the calculation of the capital

1. In 2011, CEIOPS (Committee of European Insurance and Occupational Pensions Supervisors) was renamed EIOPA (European Insurance and Occupational Pensions Authority).
2. Our paper contributes to this discussion by empirically showing the differences between the actual risk and the standard model risk for the equity risk module of Solvency II.
3. Our results also contribute to this discussion in that we empirically analyze the time-varying nature of the correlations between asset classes considered in the equity risk module.
requirements for credit risk and suggest an approach similar to that used by Basel II to predict credit ratings for nonrated companies. Mittnik (2011) analyzes the calibration of the equity risk module and points out flaws in the return definition based on a rolling window of daily measured annual returns. Braun et al. (2013) show that private equity investments are overly penalized by the standard formula for equity risk.

Some authors claim that regulation can increase systemic risk (see, with regard to Solvency II, Keller, 2011; Huerta de Soto, 2009; more generally, see Vaughan, 2009), which is the motivation behind introducing an additional adjustment term in the equity risk module. A frequently heard argument in support of the adjustment term is that in the event of an economic downturn or a stock market crash, risk-based capital standards might force insurers to sell risky assets, which could cause a run in the market and thus intensify the crisis (Eling et al., 2007). In the case of Basel II, this possibility has been analyzed; however, to our knowledge, Solvency II’s symmetric adjustment feature of its equity risk module has not been analyzed in the academic literature.

The goal of this paper is to thoroughly analyze the equity risk module of Solvency II in three steps. We first analyze the sensitivities of the equity risk module based on the empirical data used to calibrate the model. Then, we consider more realistic insurance company investment portfolios in order to identify potential basis risk in the Solvency II model. For our context, we define basis risk as the risk that the Solvency II risk measure deviates from the insurance company’s actual risk due to the simplified portfolio construction used in the standard formula. Finally, we analyze whether the symmetric adjustment mechanism reduces procyclicality of capital requirements.

We are interested in whether the proposed mechanisms of Solvency II further its stated goals, which are the protection of policyholders and financial stability. To this end, we empirically backtest the equity risk module. Our work contributes to the academic discussion on the optimal design of insurance regulation and will also aid practitioners in their efforts to develop a framework for a safe and sound insurance industry. Table 1 summarizes the two main goals of Solvency II, the analysis done in this paper with respect to these goals, the results, and the conclusion that we derive from the results.

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4. According to Article 16 and Article 64 of the directive written by the European Parliament and the European Council (2009), the primary goal of Solvency II is to protect policyholders and guarantee a solvency probability of 99.5% for insurers. In addition, Article 16 calls for “[f]inancial stability and fair and stable markets.”
Table 1: Summary of Main Findings

<table>
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<tr>
<th>Goal of Solvency II</th>
<th>Contribution of this paper</th>
<th>Result</th>
<th>Conclusion</th>
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<tr>
<td>1. Safety at confidence level of 99.5%</td>
<td>Analysis of sensitivities and of basis risk with respect to the confidence level</td>
<td>Substantial deviations from the 99.5% confidence level depending on the data (e.g., time horizon) and portfolio composition</td>
<td>Need for thorough ORSA and internal risk models</td>
</tr>
<tr>
<td>2. Financial stability</td>
<td>Analysis of procyclicality</td>
<td>Symmetric adjustment mechanism reduces procyclicality of capital requirements</td>
<td>Equity dampener helps avoid a fire sale in the market</td>
</tr>
</tbody>
</table>

Our results complement previous work on the deficiencies of the Solvency II standard formula (Lorson et al., 2013; Christiansen et al., 2012; Savelli and Clemente, 2011; Sproule, 2009; Pfeifer and Strassburger, 2008) with a detailed empirical analysis of the equity risk module. The sensitivity analysis of the equity risk module illustrates the backward-looking nature of the new Solvency II capital requirements because the capital charges reflect only past crises. Our analysis of the basis risk shows that the proposed standard capital stress for equity risk can deviate substantially from individual insurers’ portfolio risk; for example, we find that the actual capital stress as measured with more realistic empirical data can be 29.7 percentage points lower or 11.6 percentage points higher than the standard capital stress. All these results emphasize the need for an Own Risk and Solvency Assessment (ORSA) under Solvency II.5 Finally, we show how the symmetric adjustment mechanism defeats the regulators’ goal of setting a 99.5% confidence level, but does contribute to financial stability by reducing procyclicality of capital requirements.

Our findings are relevant not only for Solvency II, but also at the international level. The International Association of Insurance Supervisors (IAIS) (2013a) is currently working on international insurance capital standards and is planning to implement them by 2019. The initial idea for internationally active insurance groups (IAIGs) is to establish an individual capital benchmark based on a scenario approach (IAIS, 2013b, p. 64, pp. 80–90). In addition, there are several upcoming insurance regulation reforms in the United States, including solvency requirements (see NAIC, 2012; FIO, 2013, especially recommendation #4). In the literature, Solvency II is seen as a positive example of such regulation (see, e.g., Holzmüller, 5. ORSA requires the insurers to document deviations of the actual risk from the risk shown under the Solvency II standard model. Although ORSA is still based on an insurer’s actual risk profile, it might provide an opportunity to implement stress tests which do not solely reflect past crisis. An example might be to analyze the potential effects of a cure of cancer or a drastic drop in interest rates. For another positive assessment of ORSA see Cummins and Phillips (2009).
2009; Klein and Wang, 2009 and Ashby, 2011) and can be expected to have an impact on U.S. policy decisions, as well as those of other countries (see FIO, 2013, p. 25).

The remainder of this paper is structured as follows. In Section 2, we briefly explain the calculations behind the capital requirements of the equity risk module, i.e., the standard capital stress and the symmetric adjustment mechanism. In Section 3, we discuss the results of the sensitivity analyses of the capital requirements with respect to their technical basis. The basis risk is then evaluated in Section 4 and Section 5 focuses on procyclicality and systemic risk. Section 6 concludes and outlines several suggestions for future research.

2. Capital Requirements for Equity Risk and the Symmetric Adjustment Mechanism

The calculation of the capital requirement for the Solvency II equity risk module is set out in three publications. Directive 2009/138/EC, the bill passed by the European Parliament and European Council (2009), sets the general outline of Solvency II. It determines the 0.5% risk level for capital requirements and the cap for the symmetric adjustment mechanism. The symmetric adjustment mechanism is the algorithm which determines the capital requirements according to the market environment. The QIS5 Technical Specifications (CEIOPS, 2010b) set out the guidelines for the fifth test run of Solvency II which took place in 2010. The Solvency II Calibration Paper (CEIOPS, 2010a) presents the reasoning behind algorithms set out in the specifications. The three mentioned publications are the latest publically available information about the application of Solvency II. However, discussions between European institutions are ongoing and further changes in the specifications as well as in the directive itself are likely (e.g., see proposed changes in the directive by the European Commission, 2011, called Omnibus II or the new time schedule for the introduction of Solvency II suggested by the European Commission, 2012).

The standard capital stress is calibrated according to a Value at Risk measure with a confidence level of 99.5% (European Parliament and European Council, 2009, Article 104(4)). It differentiates between two classes of equities. Equities listed in EEA or OECD countries are considered under the class “global.” Equities not listed in EEA or OECD countries, hedge funds, commodities, private equities and other alternative investments are categorized as “other” equities. Thus, the 0.5% quantile of annual returns from different benchmark indices are taken into account. For “global” equities the MSCI World Price Index is used and for

6. In addition, CEIOPS presents results for the MSCI Americas, MSCI Europe, and MSCI Pacific Price Index. Also, the historical quantiles are compared with quantiles assuming a normal distribution. For a critical discussion of assuming normal distributions, see, e.g., Sandström (2007).
“other” equities the LPX 50 Total Return Index, the HFRX Hedge Fund Total Return Index, the MSCI BRIC Price Index and the S&P GSCI Commodities Total Return Index are considered. The calculations done by CEIOPS are based on a rolling window of daily measured annual returns for the longest period from which data are available.7

The capital requirements for equity risk (Mkt_eq) are calculated per equity category as follows:

\[
Mkt_{eq} = \max(\Delta NAV| \text{equity shock}; 0)
\] (1)

where

- \(Mkt_g\) = capital requirements for the equity category “global”
- \(Mkt_o\) = capital requirements for the equity category “other”
- \(NAV\) = net value of assets minus liabilities
- \(\text{equity shock}\) = prescribed fall in the value of equities

The symmetric adjustment mechanism is the algorithm determining the adjusted capital stress.

\[
\text{equity shock} = \text{adjusted capital stress} = \text{standard capital stress} + \text{adjustment term}
\] (2)

\[
\text{adjustment term} = \min \left\{ \max \left\{ \frac{I_t - \frac{1}{n} \sum_{s=t-n+1}^{t} I_s}{\frac{1}{n} \sum_{s=t-n+1}^{t} I_s} - \beta - 0.1 \right\}, 0.1 \right\}
\] (3)

where

- \(I_t\) = value of the MSCI World Price Index at time \(t\)
- \(n\) = number of days of the reference period
- \(\beta\) = regression coefficient in the OLS regression of the MSCI World Price Index on its average8
- \(\text{standard capital stress} = 39\%\), for equities listed in EEA/ OECD countries,
- \(49\%\), for other equities

7. The capital requirements for the equity risk class “global” are based on the MSCI World Price Index. For this index, daily data is available from January 1970 until January 2012. Capital requirements for “other” equities consider four indices approximating alternative investments: the LPX 50 Total Return Index (Private Equity) from January 1994 to January 2012, the HFRX Hedge Fund Total Return Index (Hedge Funds) from April 2003 until January 2012, the MSCI BRIC Price Index (Emerging Markets) from June 1994 until January 2012 and the S&P GSCI Total Return Index (Commodities) from January 1970 until January 2012. All data can be obtained via Datastream.

8. The regression equation is as follows: \(I_t = \alpha + \beta \cdot \frac{\sum_{s=t-n+1}^{t} I_s}{n} + \varepsilon_t\). For the regression analysis the time period from January 1971 until January 2012 is considered. If not otherwise indicated, we assume a \(\beta\) of one in this paper for further analysis, because, in all regressions, it is close to one regardless of the reference period. For more details see the analysis about the length of the reference period and its impact on the symmetric adjustment mechanism in Appendix A.
It is important to mention that the final standard capital stress is not exactly the result of the 0.5% quantile of historical returns, but is determined by CEIOPS in a political decision making process. CEIOPS proposes a standard capital stress of 39% for “global” equities and 49% for “other” equities as mentioned in QIS5. Looking at the empirical data would result in a standard capital stress of 45% for “global” equities (CEIOPS, 2010a, p. 41). For “other” equities several indices are considered so an exact result based on historical returns should contain diversification effects. However, these effects are considered to be small and therefore neglected. A correlation of one between the indices is assumed (CEIOPS, 2010a, p. 52).

Procyclicality and the risk of asset price contagion in the equity risk module are addressed by an adjustment term (Eq. (3)), which increases or decreases the capital requirements by up to 10% depending on the market environment. The standard capital stress and the adjustment term together constitute the adjusted capital stress, which determines the stress scenario and thus the capital requirements. These calculations have to be done separately for “global” equities and “other” equities. In order to derive the capital requirements for the equity risk module, the capital requirements for “global” and “other” equities are aggregated as follows:

$$Mkt_{eq} = \sqrt{Mkt_g^2 + 2 \cdot c \cdot Mkt_g \cdot Mkt_o + Mkt_o^2} \quad (4)$$

where

- $Mkt_{eq}$ = overall capital requirements for the equity risk module
- $c$ = constant for approximating the diversification effect, set to 0.75 by CEIOPS

A constant is used to consider the diversification effect between the two equity categories. It is based on the tail correlations between the different benchmark indices, but finally determined by CEIOPS. Diversification effects within an equity category are not considered.

### 3. Sensitivity Analyses

The purpose of this section is to review the calculation of the equity risk module. We, therefore, look at the assumptions behind the standard capital stress (Eq. (2)), the symmetric adjustment mechanism (Eq. (3)), and the aggregation formula (Eq. (4)). Numerous other aspects could be looked at. We restrict ourselves to the above mentioned three aspects, while results for other tests (e.g., definition of returns, risk measures, β calculation) are given in Appendix A.

The calculation of the standard capital stress is based on a predefined time period. CEIOPS uses the full period of data currently (as of December 2009) available as basis for the setting of the standard capital stress, which is a constant.

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We analyze the impact of the chosen time horizon in Figure 1 and evaluate the effects if the standard capital stress would have been set at a different point in time. That is, for each trading day from January 1971 to January 2012 the hypothetical standard capital stress based on the longest time period available on that specific date is given. An important result from Figure 1 is that the recent financial crisis significantly increased the standard capital stress which would have been much lower if Solvency II would have been introduced before 2008. This emphasizes the backward-looking nature of the model because only past risks are considered. Furthermore, it illustrates the shortcomings of the VaR approach for regulatory purposes, as already widely discussed in literature (see, e.g., Danielsson, 2008).

Figure 1: Hypothetical Standard Capital Stress Over Time

Notes: The standard capital stress is fixed by CEIOPS at 39% for “global” equities and at 49% for “other” equities. We refer to hypothetical standard capital stress when the same calibration method used by CEIOPS is employed, but to different points in time and different equities. This figure is based on the same equities as CEIOPS calibration but different reference dates are used.

9. In the following, we use the term “standard capital stress” if we refer to the constant requirements of 39% and 49% as fixed by CEIOPS. We use the term “hypothetical standard capital stress” if we use the same calibration method as CEIOPS but apply it over time or to different equities.

10. In the graph, we neglect the first three years because too few data points would result in misleading insights. Moreover, for private equity, hedge funds and emerging markets, less data is available and, therefore, these start later in Figure 1.

11. The Quantitative Impact Studies (QIS) done for Solvency II exactly reflect this problem. In QIS 4, the capital stress for “global” equities was set to 32% and for QIS 5 it was already set to 39%. The capital stress for QIS 4 was published in March 2008, the one for QIS 5 in March 2010. Further information regarding the results of this analysis, if time windows are considered instead of increasing time horizons, can be found in Table A1 in the first row in Appendix A.
We empirically compare the proposed correlations within the **aggregation formula** with actual correlations of the different asset classes. In QIS5 a correlation between “global” and “other” equities of 0.75 is considered. Empirically we find that the correlations range from 0.09 to 0.95 if the maximum time period is considered. In order to illustrate the time-varying nature of the correlation, Figure 2 shows the correlations between the MSCI World Price Index and the other four indices used to define the standard capital stress. Returns are calculated annually based on a one-year rolling window with daily data; the correlation coefficients are based on a five-year rolling window. The horizontal line indicates the assumed correlation of 0.75 between the equity class “global” and “others” in the aggregation formula. Notable is the extreme variation for the commodity index and the MSCI World Index. From July 1990 to July 1995 the correlation has been lowest with a coefficient of -0.69 and it has been highest from March 1977 to March 1982 with a coefficient of 0.64. These results clearly illustrate that the assumption of a fixed correlation of 0.75 which is not time-varying is not an optimal solution. Another important aspect which can be observed in Figure 2 is that in times of crisis the correlations are higher.\(^\text{12}\)

![Figure 2: Correlations Between the MSCI World Index and Indices of the Category “Other”](image)

**Figure 2:** Correlations Between the MSCI World Index and Indices of the Category “Other”

Notes: Pearson-correlations over time between the MSCI World Price Index and indices considered for the “other” equity category for five-year rolling windows.

\(^{12}\) For this reason, CEIOPS (2010a) focuses on tail correlations in QIS 5; i.e., conditional correlations are calculated. We also repeated the analysis shown in Figure 2 for tail correlations (see Appendix A). They show the same result (correlations are time-varying and typically far away from the proposed 0.75), but are more difficult to interpret because there are jumps. For this reason, we present the unconditional correlations in the main part of the analysis.

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Another crucial part of the equity risk module is the length of the reference period in the **symmetric adjustment mechanism**. We analyze the impact of different reference periods on overall capital requirements. This analysis is motivated by ongoing discussions between regulators as to which reference period is most appropriate. In Figure 3, we compare the most discussed reference periods (one year and three years) and analyze their impact on the capital requirements.\(^{13}\) The adjustment term and the standard capital stress are calibrated based on the MSCI World Price Index. It can be seen that a longer reference period of three years has two effects. First, on average, higher adjusted capital stresses are applied; and second, the adjusted capital stress becomes binominal — either the highest or the lowest possible adjusted capital stress is applied. For example, if a three-year reference period is applied and the MSCI World Price Index is considered, in 56.6% of the time, an adjusted capital stress of 49% is applied and only 13.0% of the time an adjusted capital stress of 29%.

The sensitivity analysis presented in this section are not more than a “what if” sensitivity analysis, but we believe that the results are important especially to empirically backtest and illustrate the dynamics of the modeling approach chosen for Solvency II. One of the drawbacks of the new Solvency II regime is that it has not been tested over time. Our results illustrate how the equity risk model would behave over time if Solvency II was already running for years. First, the model would result in a backward-looking adaption to historical crisis. Second, true correlations would be insufficiently approximated, with risk being particularly underestimated in crises. Third, capital requirements would be risk insensitive and binomial if the chosen reference period is three years.

\(^{13}\) CEIOPS (2010a) points out in its calibration paper that the longer the reference period, the more frequently the 10% band is hit and the risk sensitivity is reduced. CEIOPS concludes that a longer reference period on the one hand alters the empirical default probability and on the other hand leads to lower capital requirements in falling markets, which could create moral hazard. Insurance companies might shift their investments from asset classes without an adjustment mechanism to equities. Therefore, the majority of regulators propose a one-year reference period. However, a minority still argue that a three-year reference horizon is more appropriate, because capital requirements fluctuate a lot if a short reference period is chosen and argue that it is not the goal of the symmetric adjustment mechanism to respond to temporary market movements.
4. Solvency II Basis Risk

Under Solvency II, a uniform standard capital stress must be applied by all insurance companies, regardless of their actual portfolio composition. This requirement raises the question of how good this approximation is and how substantial deviations from this proxy are if we consider more realistic portfolios. Depending on the true portfolio composition of the individual insurer the standard capital stress might substantially deviate from the hypothetical one based on a 99.5% confidence level and thus basis risk emerges. Our interpretation of basis risk in a Solvency II context is thus deviations of the actual insurer’s portfolio risk from the risk measured by the standard regulatory model.

To analyze basis risk, we model the investment portfolio of 16 insurance companies from 16 European countries. Rather than analyzing 16 real portfolios, we have set up 16 stylized country portfolios which proxy the typical allocation of insurers from these countries. To keep the analysis simple and comprehensible, the 16 country portfolios are equally composed of the MSCI country index, the MSCI Europe Index excluding the respective country and the MSCI World Index excluding Europe (only price indices are considered). 33.3% of each portfolio is thus invested in the home market, 33.3% in Europe outside the home market and 33.3% worldwide outside Europe. This approach follows Gatzert and Martin (2012) who use a stylized portfolio consisting of indices to approximate the stock...
portfolio of a typical insurance company as well and calculate a hypothetical
standard capital stress of the equity risk module.\textsuperscript{14} Due to the home bias for
investment decisions (see, e.g., Tesar and Werner, 1995) we believe these
portfolios might better approximate the actual equity allocation of insurers in
Europe than the MSCI World Price Index.\textsuperscript{15} Table 2 gives some descriptive
information on the MSCI World Price Index and the 16 country portfolios.

\textsuperscript{14} Stylized portfolios consisting of indices are also used by Eling and Schuhmacher (2007)
as representative investment portfolios of a typical institutional investor. The composition of
country portfolios is based on representative investment opportunities, as described by Eling
et al. (2009).

\textsuperscript{15} We also calculated the basis risk for country portfolios with different weightings.
Alternatives are: 50\% (25\%, 25\%) are invested in the MSCI World Index excluding Europe, 25\%
(50\%, 25\%) in the MSCI Europe Index excluding the respective country, and 25\% (25\%, 50\%) in
the MSCI home market index. The results are basically the same, but basis risk increases if home
market share increases. These results are available upon request.
Table 2:
Structure of Country Portfolios

<table>
<thead>
<tr>
<th>Portfolio Constituents</th>
<th>MSCI World</th>
<th>MSCI Europe</th>
<th>MSCI Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSCI</td>
<td>ex Europe</td>
<td>ex Country</td>
</tr>
<tr>
<td>MSCI World</td>
<td>100.00%</td>
<td>0.00%</td>
<td>0.00%</td>
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</tbody>
</table>

Descriptive Statistics of Returns

<table>
<thead>
<tr>
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<th>Standard Deviation</th>
<th>VaR_0.05</th>
<th>VaR_0.005</th>
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<tbody>
<tr>
<td>8.21%</td>
<td>17.80%</td>
<td>21.92%</td>
<td>44.24%</td>
</tr>
</tbody>
</table>

Country Portfolios

- Austria: 0.00% 33.33% 33.33% 33.33%
- Belgium: 0.00% 33.33% 33.33% 33.33%
- Denmark: 0.00% 33.33% 33.33% 33.33%
- Finland: 0.00% 33.33% 33.33% 33.33%
- France: 0.00% 33.33% 33.33% 33.33%
- Germany: 0.00% 33.33% 33.33% 33.33%
- Greece: 0.00% 33.33% 33.33% 33.33%
- Ireland: 0.00% 33.33% 33.33% 33.33%
- Italy: 0.00% 33.33% 33.33% 33.33%
- Netherlands: 0.00% 33.33% 33.33% 33.33%
- Norway: 0.00% 33.33% 33.33% 33.33%
- Portugal: 0.00% 33.33% 33.33% 33.33%
- Spain: 0.00% 33.33% 33.33% 33.33%
- Sweden: 0.00% 33.33% 33.33% 33.33%
- Switzerland: 0.00% 33.33% 33.33% 33.33%
- UK: 0.00% 33.33% 33.33% 33.33%

Notes: Returns are calculated by using a rolling window of daily measured annual returns. VaR_0.05 and VaR_0.005 correspond to a value at risk at a confidence level of 95.0% and 99.5%, respectively. The time horizon is January 1971 to January 2012 except for Finland (January 1989–January 2012), Greece (May 2002–January 2012), Ireland (May 1994–January 2012), and Portugal (December 1998–January 2012).

For these 16 country portfolios, we calculate a hypothetical standard capital stress over time and compare it with the Solvency II capital stress. In this case, the capital stress only considers the MSCI World Index because all equities in the 16 country portfolios can be classified as “global” equities (see Section 2 of this article). Figure 4 illustrates the results of this analysis for the German, Greek, Irish and Austrian country portfolios for the years 2000 to 2012. The black thick line illustrates the capital stress over time based on the MSCI World Price Index (it corresponds to the line “global” in Figure 1). The other lines represent the results, if the hypothetical capital stress is based on the country portfolios. We see that the risk of the country portfolios can substantially deviate from the one proposed by Solvency II. For example, the capital stress based on the MSCI overestimates the risk of the German portfolio, but underestimates the one of the Greek portfolio.
We also see that for all portfolios the risk significantly increased after 2008. As illustrated in Figure 4, these effects can be very substantial and they can occur in both directions (overestimation and underestimation of the actual risk). For example, on the Dec. 19, 2000, the proposed capital stress is 29.7 percentage points higher than the capital stress of the Irish portfolio. On the Oct. 30, 2008, the Greek portfolio was underestimated by 10.97 percentage points. In general the capital stress based on the MSCI World Index seems to overestimate the risk in normal market conditions and underestimates it in times of crisis. This is a meaningful finding, because the MSCI World Index is more diversified than the individual country portfolios. In contrast, individual country portfolios rely more on a specific geographic area and thus inhibit idiosyncratic risks attached to single European countries, which were subject to specific crisis during the investigation period (especially Ireland and Greece). A regulatory question that thus arises is which of these two alternatives — a global standardized view or the more country specific one — is more adequate to account for the equity risk of insurance companies. Moreover, the findings emphasize the need for a careful ORSA. Under this provision, insurance companies are obliged to report systematic deviations of their true risk from the Solvency II standard model. Our results emphasize that the deviations can be very substantial.

Figure 4:  
Hypothetical Standard Capital Stress Over Time (Country Portfolios)

Notes: The standard capital stress is fixed by CEIOPS at 39% for “global” equities. We refer to hypothetical standard capital stress when the same calibration method used by CEIOPS is employed, but to different points in time and different equities. This figure is based on different reference dates. In addition, results for CEIOPS equities (MSCI World Price Index) are compared to more realistic portfolios (country portfolios).
Table 3 shows the corresponding results for all 16 country portfolios. The second column shows the standard capital stress set by CEIOPS as described in QIS5. Because all country portfolios only invest in OECD countries, for all portfolios a standard capital stress of 39% would apply. The third column shows the hypothetical standard capital stress based on the 0.5% quantile of the returns based on the MSCI World Index. In the fourth column, the capital stresses are shown calibrated according to the country portfolios. The maximal positive and negative deviation of the capital stress of a country portfolio from the capital stress based on the MSCI index over time are shown in column five and seven. A positive deviation means that the standard capital stress of the MSCI index underestimates the risk of the country portfolio and a negative one that the risk is overestimated. Looking at the results we see that the maximum deviation is –29.7 percentage points for the Irish country portfolio.

Table 3: Basis Risk of Country Portfolios

<table>
<thead>
<tr>
<th>Country</th>
<th>Proposed CEIOPS Standard Capital Stress</th>
<th>Standard Capital Stress based on MSCI World Index</th>
<th>Minimal Positive Deviation of Country Portfolio Stress from MSCI World Stress in Percentage Points</th>
<th>Period of Minimal Positive Deviation</th>
<th>Minimal Negative Deviation of Country Portfolio Stress from MSCI World Stress in Percentage Points</th>
<th>Period of Minimal Negative Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>39%</td>
<td>44.29%</td>
<td>5.88</td>
<td>February 2000</td>
<td>-11.1</td>
<td>January 1977 - November 1987</td>
</tr>
<tr>
<td>Belgium</td>
<td>39%</td>
<td>44.29%</td>
<td>5.88</td>
<td>December 2008</td>
<td>-3.46</td>
<td>November 2008 - December 2008</td>
</tr>
<tr>
<td>Denmark</td>
<td>39%</td>
<td>44.29%</td>
<td>3.02</td>
<td>October 2007</td>
<td>-2.78</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Finland</td>
<td>39%</td>
<td>44.29%</td>
<td>6.31</td>
<td>October 2007</td>
<td>-5.10</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>France</td>
<td>39%</td>
<td>44.29%</td>
<td>5.58</td>
<td>January 2007</td>
<td>-5.10</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Germany</td>
<td>39%</td>
<td>44.29%</td>
<td>1.07</td>
<td>October 2007</td>
<td>-8.18</td>
<td>January 2003</td>
</tr>
<tr>
<td>Greece</td>
<td>39%</td>
<td>44.29%</td>
<td>10.97</td>
<td>October 2008</td>
<td>-20.70</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Ireland</td>
<td>39%</td>
<td>44.29%</td>
<td>11.63</td>
<td>November 2008</td>
<td>-20.70</td>
<td>January 2003</td>
</tr>
<tr>
<td>Italy</td>
<td>39%</td>
<td>44.29%</td>
<td>2.74</td>
<td>October 2007</td>
<td>-3.95</td>
<td>November 2008 - December 2008</td>
</tr>
<tr>
<td>Netherlands</td>
<td>39%</td>
<td>44.29%</td>
<td>3.00</td>
<td>October 2008</td>
<td>-2.14</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Norway</td>
<td>39%</td>
<td>44.29%</td>
<td>3.81</td>
<td>October 2008</td>
<td>-3.17</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Portugal</td>
<td>39%</td>
<td>44.29%</td>
<td>7.44</td>
<td>November 2008</td>
<td>-2.57</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Spain</td>
<td>39%</td>
<td>44.29%</td>
<td>-</td>
<td>-</td>
<td>-2.14</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Sweden</td>
<td>39%</td>
<td>44.29%</td>
<td>0.05</td>
<td>October 2008</td>
<td>-12.08</td>
<td>January 1975 - November 1987</td>
</tr>
<tr>
<td>Switzerland</td>
<td>39%</td>
<td>44.29%</td>
<td>1.79</td>
<td>August 1988</td>
<td>-3.73</td>
<td>November 2008</td>
</tr>
<tr>
<td>UK</td>
<td>39%</td>
<td>44.29%</td>
<td>5.07</td>
<td>August 1988</td>
<td>-1.44</td>
<td>April 2009</td>
</tr>
</tbody>
</table>

Notes: Analyses over time means that, in order to calculate a hypothetical standard capital stress based on the MSCI World Price Index/country portfolios, for each point in time the maximal time period is considered up to this date. For example, for the Nov. 25, 2002, data, Jan. 1, 1971, until Nov. 25, 2002, is considered and, for the April 15, 2005, data, from Jan. 1 1971, until April 15, 2005.


17. Deviations would be even larger if we would compare the results for the country portfolios with the standard capital stress of 39% set by CEIOPS instead of the one based on the 0.5% quantile of the MSCI World Price Index.
5. Procyclicality and Systemic Risk

5.1 Impact of the Symmetric Adjustment Mechanism on the Confidence Level of Capital Requirements

In this section, we analyze the extent to which the symmetric adjustment mechanism affects the predefined goal of Solvency II of a 99.5% confidence level. Relaxing capital requirements in bad markets will systematically decrease the confidence level, while raising capital requirements in good markets should systematically increase the confidence level. We are especially interested in the possible range of outcomes; for the overall goals of Solvency II (e.g., creating a safe industry) it might be relevant to know if this range is between 99% and 99.9% or between 90% and 99.99%.

We calculate the impact of the symmetric adjustment mechanism on the confidence level as follows. First, we take the standard capital stress, which is calibrated according to a 99.5% confidence level based on the MSCI World Price Index and set to 39% by CEIOPS. Second, we calculate the adjusted capital stress according to the symmetric adjustment mechanism as described in Eq. (2) and Eq. (3) in Section 2. Third, we derive the confidence level based on this adjusted capital stress. For each point in time, the confidence level is simply the percentage of annual returns of the benchmark portfolio which would have been lower than the negative adjusted capital stress. Put differently: the confidence level indicates the percentage of historical annual returns for which the capital requirements based on the adjusted capital stress would have been sufficient. Figure 5 shows the confidence level of the adjusted capital stress for the MSCI World Price Index over time.
It can be seen in Figure 5 that, most of the time, a confidence level of 1 is reached with temporary deviations from this level. The lowest confidence level is 97.26%. After 2008, the confidence level of 1 is not reached anymore, which can be explained by the characteristics of the adjustment term. Before 2008, there is no incident where the MCSI portfolio exceeds an annual loss of 49%. So, when the maximum adjusted capital stress of 49% is employed, the confidence level is 1 per definition. Only when the adjusted capital stress turns out to be below the maximum, the confidence level sometimes cannot meet the 99.5% threshold. After 2008, the maximal loss exceeds 49% and consequently, as seen in Figure 5, a confidence level of 1 cannot be reached anymore.\footnote{We also repeated the analysis from Figure 5 for all 16 country portfolios. The results are available upon request.}

The confidence level thus from time to time substantially deviates from the required confidence level when capital requirements are relaxed. Especially, during the financial crisis the goal of Solvency II to ensure that insurers can meet their obligations with a 99.5% confidence level would have been violated. The symmetric adjustment mechanism thus reduces the capital requirements in times of financial distress and thus reduces procyclical behavior.
5.2 Alignment of the Symmetric Adjustment Mechanism with Systemic Risk

Besides the protection of policyholders and beneficiaries, Solvency II has the objective to maintain financial stability and fair and stable markets as stated in Article 16 of the directive from the European Parliament and the European Council (2009). In this section we analyze if the symmetric adjustment mechanism is contributing to this second goal of stability. Therefore we employ two systemic risk measures — CoVaR (Adrian and Brunnermeier, 2011) and Marginal Expected Shortfall (MES; Acharya et al., 2012) — to our country portfolios and review if the symmetric adjustment mechanism is procyclical or anticyclical in regard to systemic risk.

CoVaR can be used to measure the VaR of a system conditional on an institution being at its VaR level. Thus, basically it is a measure to what extent the distress of the whole system coincides with the distress of a single institution. CoVaR can be calculated as time-invariant, time-variant or forward-looking measure. Because we want to compare current systemic risk with the current capital requirements of the equity risk module over time we use the time-variant version in this paper. In contrast to Adrian and Brunnermeier (2011) we adopt the CoVaR for the European market by using state variables fitting to a European environment. As Adrian and Brunnermeier (2011) we use weekly data for our evaluation. The time period ranges from May 1999 to January 2012. For further details about the calculation of the CoVaR measure in this paper we refer to Appendix B.

MES is the average return of a company during the 5% worst days of the whole market. Acharya et al. (2012) show that it can be used to approximate the losses of a company if a crisis occurs and, therefore, indicates its potential systemic risk. As Acharya et al. (2012), we use daily data to calculate the time-variant MES version. After transforming the daily time series into a weekly one, MES and CoVaR can be compared. The time period we use for the MES ranges from April 1999 to January 2012. Further details regarding the calculation of MES can be found in Appendix C.

A wide variety of systemic risk measures are currently under discussion by academics and regulators. In this paper, we employ MES and CoVaR due to their relevance and their applicability. Regarding MES and CoVaR, Benoit et al. (2013, p. 2) state that “very few crisis-related papers made a higher impact both in the academia and on the regulatory debate...” In addition, both measures are based on publicly available market data and therefore are applicable to the setting in this paper. In general, as mentioned by Drehmann and Tarashev (2011, p. 25), and in

19. For an overview, see Bisias et al. (2012).
20. Several publications already use these systemic risk measures. Examples are Zhou (2010), Huang (2012), López-Espinosa et al. (2012), and Rodríguez-Moreno and Peña (2013). Furthermore, as of April 1, 2014, google scholar lists 723 and 483 citations referring to Adrian and Brunnermeier (2011) and Acharya et al. (2012), respectively.
particular for our setting of stylized country portfolios, it is problematic to apply measures that require non-public, non-market information. Indeed, approximating these inputs would increase the arbitrariness of our evaluation.

However, this does not mean that these measures are free from shortcomings. Acharya et al. (2012, p. 12) point out that MES can only estimate the impact of a crisis on an institution, not the probability that a crisis will occur. Benoit et al. (2013) show that CoVaR and MES can be understood as transformations of market risk measures and conclude that these measures “fall short in capturing the multiple facets of systemic risk.” Three further shortcomings are identified by Löffler and Raupach (2013). First, the authors show, in a linear market model, that an institution can decrease its systemic risk as measured by CoVaR simply by increasing its idiosyncratic risk. Therefore, they argue, CoVaR sets the wrong incentives. Second, they show that when contagion is considered, CoVaR attributes higher systemic risk to the institutions causing contagious effects than to the ones being affected. MES leads to opposite result. Third, using simulations, they show that it is possible for institutions to have large tail risks, which have nearly no effect on either risk measure. We agree with the authors that naively applying these measures for regulatory purposes would not be wise. In our case, though, the measures are appropriate because historical data are used and the measures have been developed only recently, meaning that no institution could have anticipated the measure’s reaction in its risk and portfolio management.

Figure 6 shows the capital requirements of the equity risk module in comparison with the average CoVaR and the average MES. We first calculate the CoVaR and MES for each country portfolio over time. In this way we approximate the contribution of a typical insurance company in a country to systemic risk of the whole system. Second, we derive the systemic risk of the whole system according to both risk measures by calculating the arithmetic average of the individual results for the 16 country portfolios at each point in time.21

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21. We consider the capital requirements based on the adjusted capital stress, which includes the symmetric adjustment mechanism. If the symmetric adjustment mechanism is omitted and only the standard capital stress is considered, capital requirements are 39% for all portfolios at all times. Thus, correlations between the systemic risk measures and the capital requirements cannot be calculated.
Figure 6:
Capital Requirements in Comparison with Systemic Risk Measures

Notes: Capital requirements according to the equity risk module of Solvency II compared to the average MES and CoVaR risk measure based on the 16 country portfolios over time.

It can be seen that low capital requirements coincide with a strongly negative average CoVaR and high capital requirements appear synchronously with a high average CoVaR. This impression is confirmed by the correlation coefficient of 0.43 between the capital requirements and the CoVaR measure and a correlation of 0.46 if the capital requirements are lagged by one week. The same is true for MES. The correlation between the capital requirements and the risk measure is 0.36 and increases to 0.38 if capital requirements are lagged as well. All coefficients are significant at a 1% confidence level.
Table 4 shows that this relationship also holds for each country portfolio. The CoVaR conditional of the Greece country portfolio has the lowest correlation coefficient (0.35) and the Portuguese one the highest (0.48) with regard to the capital requirements. For the MES, Finland and Sweden show the highest correlation with the capital requirements (0.42) and the coefficient of Greece is the smallest (0.27). In this paper only the Pearson-correlation coefficients are shown. However, we also use the Spearman rank-order correlation in order to check if the correlation is heavily influenced by outliers, which is not the case.\footnote{22}

<table>
<thead>
<tr>
<th>Country Portfolio</th>
<th>CoVaR Correlation</th>
<th>MES Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0.403***</td>
<td>0.290***</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.461***</td>
<td>0.345***</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.444***</td>
<td>0.391***</td>
</tr>
<tr>
<td>Finland</td>
<td>0.419***</td>
<td>0.419***</td>
</tr>
<tr>
<td>France</td>
<td>0.405***</td>
<td>0.373***</td>
</tr>
<tr>
<td>Germany</td>
<td>0.421***</td>
<td>0.373***</td>
</tr>
<tr>
<td>Greece</td>
<td>0.354***</td>
<td>0.274***</td>
</tr>
</tbody>
</table>

Notes: Pearson-correlation coefficients between capital requirements and systemic risk measures are shown. CoVaR considers the 1% VaR level. ***, **, * indicate a significance level of 1%, 5%, and 10%, respectively.

We further analyze the relationship between the systemic risk measures and capital requirements with statistical tests and regressions (see Appendix D). We report only the results for the average CoVaR and average MES. We do not report the risk measures for each country portfolio individually, because we are interested in the relationship between capital requirements and the systemic risk of the whole system.

\footnote{22. When interpreting the results, one has to keep in mind that by construction there is a relation between the CoVaR of the system and the VaR of the country portfolios, because the system is defined as the average return of the country portfolios. Moreover, the capital requirements are based on the MSCI World Price Index, which has a significant impact on the country portfolios. The same is true for the MES measure.}
The additional tests include \( \chi^2 \) tests for independence, unit root tests, Granger causality tests, and OLS regressions. Also, we employ a vector autoregressive (VAR) model in the case of CoVaR. For the MES analysis, we build a vector error correction (VEC) model, because capital requirements and MES are non-stationary and seem to be cointegrated. Our results show that capital requirements are low when CoVaR indicates increased systemic risk, and high when systemic risk is relatively low. For MES, the results are mixed. This pattern is an indication that the equity dampener in fact reduces procyclicality with respect to systemic risk. We can thus conclude that according to the time-variant CoVaR the symmetric adjustment mechanism indeed contributes to stability of the financial system. According to our analysis it seems that in times of crisis capital requirements are low and in times of low systemic risk high. Also, the symmetric adjustment mechanism is more sensitive to equity market changes than the risk measures and therefore seems to lead them.

6. Conclusion and Future Research

The main goal of Solvency II is to protect insurance policyholders (European Parliament and European Council, 2009, Article 16). Therefore, capital requirements should ensure that insurance companies have enough economic capital to meet their obligations to policyholders over the next 12 months with a probability of at least 99.5% (European Parliament and European Council, 2009, Article 64). Additional objectives include financial stability and fair and stable markets (European Parliament and European Council, 2009, Article 16). In light of these goals of Solvency II, the aim of this paper is to critically analyze the equity risk module.

By backtesting Solvency II using historical data we find that the hypothetical standard capital stress is highly sensitive to the considered time period and the underlying definition of returns. To guarantee a confidence level of 99.5% for European insurers, the standard capital stress should be substantially higher. Specifically, after 2008, a standard capital stress of 39% is not sufficient. In addition, there are large deviations between individual insurers’ risk situation and the risk implications of Solvency II. Furthermore, the aggregation formula might underestimate the true risk due to the fixed time-invariant correlations. Fixed correlation coefficients are problematic in general because equity correlations are not stable over time. The symmetric adjustment mechanism further decreases the confidence level when the capital requirements are relaxed.

We conclude that applying the standard model will lead to systematic deviations from the proposed 99.5% confidence level and that it is therefore not guaranteed that Solvency II’s chief goal will be achieved. This result makes a strong argument for using internal models and emphasizes the importance of a thorough ORSA. We thus urge insurers to evaluate whether the standard model is appropriate to their situation and to use an internal model if necessary. This
implies that when evaluating internal models, regulators, also, should take into consideration the standard model’s flaws. Generally, the basis risk and calibration issues of the standard formula apply to internal models as well. However, the requirements for internal models should not surpass the quality of the standard formula. Moreover, regarding systemic risk, flaws in the standard formula affect many more companies than flaws in individual internal models. As an alternative to using an internal model, insurance companies should undertake sensitivity analyses for the ORSA so as to document potential deviations of their own risk from the results of the standard model. For the regulator it will be important to pay attention to the depth and width of these sensitivity analyses; otherwise, the full extent of basis risk can be concealed by employing only very narrow analyses.

These implications are not only applicable to Solvency II, but should be considered in the design of other capital standards as well. For example, these findings support, as currently under discussion by the IAIS, the use of an individual scenario-based approach for insurance capital standards if a global regulation framework is indeed realized. For the United States, the results underline the importance of ORSA assessments, expected to be required by 2015, and the regulation reforms recommended by the FIO.23

We employ CoVaR and MES as systemic risk measures and find that capital requirements have explanatory power to anticipate systemic risk. Furthermore, they are more sensitive to stock market movements. These results indicate that the symmetric adjustment mechanism does indeed reduce procyclicality.

In future research it would be valuable to more closely analyze the basis risk and the symmetric adjustment mechanism. It would be interesting to focus on the explanatory factors behind the basis risk by focusing on the dependencies between and within the different equity categories. For the symmetric adjustment mechanism, one could distinguish between booming and falling markets. Also, to further analyze the potential procyclical nature of the adjusted capital stress, it might be beneficial to model not only the effect of markets on insurer capital requirements, but also the vice versa effects. Analyses with historical data ignore how markets are affected by the changed behavior of insurers following the introduction of new regulatory regimes. Another path of research could be to analyze ORSA information when it becomes available after the introduction of Solvency II. It would be interesting to evaluate if deviations from the standard model of the same magnitude found here really do occur in practice. And finally, research should investigate whether it is possible to calibrate capital requirements using factors other than historical data in order to mitigate backward-looking characteristics. Insurers should not only be ready for the last, but also for the next, crisis.

Appendix A – Further Sensitivity Analysis

Table A1:
Sensitivity Analysis of the Equity Risk Module

<table>
<thead>
<tr>
<th></th>
<th>MSCI World Price index</th>
<th>LPX 50 TR index</th>
<th>HFRX Global Hedge Fund TR index</th>
<th>MSCI BRIC Price index</th>
<th>S&amp;P GSCI TR index</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Capital</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress based on Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1971-1980</td>
<td>40.49%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>23.74%</td>
<td></td>
</tr>
<tr>
<td>1980-1990</td>
<td>19.30%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>24.09%</td>
<td></td>
</tr>
<tr>
<td>1990-2000</td>
<td>19.14%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>38.38%</td>
<td></td>
</tr>
<tr>
<td>2000-2011</td>
<td>47.84%</td>
<td>74.82%</td>
<td>n.a.</td>
<td>62.81%</td>
<td>61.80%</td>
</tr>
<tr>
<td><strong>Standard Capital</strong></td>
<td>Daily Data</td>
<td>44.39%</td>
<td>73.34%</td>
<td>23.18%</td>
<td>62.56%</td>
</tr>
<tr>
<td>Stress based on</td>
<td>Monthly Data</td>
<td>43.79%</td>
<td>72.76%</td>
<td>22.98%</td>
<td>62.09%</td>
</tr>
<tr>
<td>Return Definition</td>
<td>Yearly Data</td>
<td>39.52%</td>
<td>63.68%</td>
<td>22.60%</td>
<td>59.77%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tail Correlations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>between MSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>World Price and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other Indices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposed</td>
<td>1.00</td>
<td>0.84</td>
<td>0.45</td>
<td>0.77</td>
<td>-0.53</td>
</tr>
<tr>
<td>0.005 Quantile</td>
<td>1.00</td>
<td>0.78</td>
<td>-</td>
<td>0.51</td>
<td>0.21</td>
</tr>
<tr>
<td>0.01 Quantile</td>
<td>1.00</td>
<td>0.48</td>
<td>-0.84</td>
<td>0.11</td>
<td>0.30</td>
</tr>
<tr>
<td>0.05 Quantile</td>
<td>1.00</td>
<td>0.85</td>
<td>0.27</td>
<td>0.45</td>
<td>0.08</td>
</tr>
<tr>
<td>0.1 Quantile</td>
<td>1.00</td>
<td>0.95</td>
<td>0.78</td>
<td>0.81</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Linear Return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Correlation between</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Period</td>
<td>0.96</td>
<td>0.95</td>
<td>1.00</td>
<td>0.91</td>
<td>0.97</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.99</td>
<td>0.98</td>
<td>n.a.</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.00</td>
<td>0.61</td>
<td>n.a.</td>
<td>0.75</td>
<td>0.06</td>
</tr>
<tr>
<td>Frequency of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted Capital</td>
<td>Max. (22 days)</td>
<td>0.09%</td>
<td>1.64%</td>
<td>0.00%</td>
<td>1.81%</td>
</tr>
<tr>
<td>Stress reaching the</td>
<td>Min. (22 days)</td>
<td>0.47%</td>
<td>2.73%</td>
<td>0.00%</td>
<td>4.10%</td>
</tr>
<tr>
<td>Maximum and</td>
<td>Max. (90 days)</td>
<td>4.12%</td>
<td>5.66%</td>
<td>0.00%</td>
<td>9.16%</td>
</tr>
<tr>
<td>Minimum according to</td>
<td>Min. (260 days)</td>
<td>22.66%</td>
<td>18.13%</td>
<td>0.00%</td>
<td>17.07%</td>
</tr>
<tr>
<td>Reference Period</td>
<td>Max. (780 days)</td>
<td>56.61%</td>
<td>21.67%</td>
<td>2.04%</td>
<td>18.13%</td>
</tr>
<tr>
<td>Min. (780 days)</td>
<td>12.98%</td>
<td>11.25%</td>
<td>2.23%</td>
<td>10.30%</td>
<td>12.53%</td>
</tr>
</tbody>
</table>

The first row of Table A1 shows the capital requirements without the adjustment term based on different indices according to different time periods. It can be seen that a hypothetical standard capital stress is not constant over time and the deviation can be up to 38.1 percentage points in case for commodities.

The second row of Table A1 considers the definition of returns. The calculations done by CEIOPS are based on a rolling window of daily measured annual returns; i.e., \( r_d = \frac{I_d}{I_{d-260}} - 1 \). We analyze whether different definitions of returns lead to alternative outcomes. We look at a rolling window of monthly measured annual returns \( r_m = \frac{I_m}{I_{m-12}} - 1 \) and yearly data \( r_y = \frac{I_y}{I_{y-1}} - 1 \). \( I_d, I_m \)
and \( I_p \) denote the current index value at a specific date, month or year. For all indices, fewer data points would lead to a reduced capital stress. The maximum difference is observed for the LPX 50 Index. A one-year rolling window of daily data leads to a capital stress of 73.3% and yearly data leads to 63.7%. We suppose this is due to the calculating method used by CEIOPS. Annual returns are calculated based on a one-year rolling window of daily index values. In this way all fluctuations are considered, whereas by using only annual data points fluctuations within a certain year are ignored. So, the method used by CEIOPS seems to be appropriate because neglecting fluctuations within a year and within a month would mean underestimating the volatility of equity prices.

The standard formula recognizes a diversification effect between “global” and “other” equities by introducing a constant of 0.75 into the aggregation formula, as shown in Eq. (4). We calculate tail correlation coefficients between the MSCI World Price Index and all other employed indices as in CEIOPS (2010a). Results are shown in the third row of Table A1. We use not only the 0.5% quantile to determine which returns to consider in our analysis, but also the 1%, 5%, and 10% quantiles. Mathematically, a 99.5% confidence level does not imply that any specific quantile must be used to determine tail correlations and therefore the decision is arbitrary. However, our results show that the impact of the chosen quantile is substantial.

Solvency II considers a 0.5% quantile for the risk factors, which corresponds to the Value at Risk (VaR) at a 99.5% confidence level as a risk measure. We are motivated to look further at this issue by other regulatory approaches using different risk measures. For example, the Swiss Solvency Test employs the Expected Shortfall at a 99% confidence level. Also, the fact that companies might use other risk measures for their internal decision making makes the issue worth to consider. We test whether the Expected Shortfall (ES) at a 99.5% confidence level leads to comparable results. We calculate the differences in the hypothetical standard capital stress for each index by using the ES and VaR measure for the time period from December 1975 until January 2012. The capital stress is calculated according to a five-year rolling period. Our results show that using Expected Shortfall (ES) as a risk measure instead of Value at Risk (VaR) leads to very comparable results (see Figure A1). The capital stress increases about 6.5 percentage points on average and extreme stock price movements are anticipated more quickly. Both could be expected due to the fact that ES considers all tail values and not, like VaR, only the threshold. For all equity classes the correlation over time between VaR and ES are close to 1 over the total period as shown in the fourth row of Table A1.

24. For the MSCI World Price Index, as well as the S&P GSCI Commodities TR Index, data from January 1973 until December 2009 is used. For the LPX 50 Total Return Index, data from January 2000 until December 2009 is used. Calculations regarding the HFRX Global Hedge Fund Total Return Index take the period from April 2004 until December 2009 into account. For the MSCI Emerging Markets BRIC Price Index the period from June 1995 until December 2009 is considered.
The last row of Table A1 shows the effect of considering different reference periods in calculating the symmetric adjustment mechanism. We compare the most discussed time horizons as mentioned by CEIOPS (2010c). It can be seen that the minimum and maximum of the symmetric adjustment mechanism are more likely to be reached the longer the reference period.

We analyze the impact of the reference period on $\beta$ of the adjustment term, which is derived by a regression of the actual index level on the weighted average index level. Table A2 shows the results. As CEIOPS reports, we find betas for the MSCI world indices and the S&P GSCI commodities Total Return indices are for all reference periods close to 1. Therefore, we approximate beta in this paper by one.

<table>
<thead>
<tr>
<th>Reference period</th>
<th>MSCI World Price</th>
<th>MSCI World TR</th>
<th>GSCI TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month (22 days)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>4 months (90 days)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>1 year (260 days)</td>
<td>0.99</td>
<td>1.01</td>
<td>0.98</td>
</tr>
<tr>
<td>3 years (780 days)</td>
<td>0.98</td>
<td>1.02</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Notes: Comparison of hypothetical standard capital stress employing VaR and ES. In both cases, the calculations are based on the MSCI World Price Index.
We empirically compare the proposed correlations within the **aggregation formula** with actual correlations of the different asset classes. In QIS5, a tail correlation between “global” and “other” equities of 0.75 is considered. CEIOPS (2010a) defines tail correlation as the Pearson-correlation of values below a certain quantile. Thus, the only returns considered are those that are simultaneously below the 0.5% quantile of the indices at hand. Empirically, we find that the correlations range from –1 to 1 depending on the indices and time period being considered. To illustrate the time-varying nature of the correlations, Figure A2 shows the correlations between the MSCI World Price Index and the other four indices used to define the standard capital stress. Returns are calculated annually based on a one-year rolling window with daily data; the correlation coefficients over time are based on the longest time period available on each specific date. In our analysis, only data below the 0.5% quantile are chosen, except for the HFRX Global Hedge Fund TR Index, because there are not enough overlapping data points below this quantile. Instead, we chose the 1% quantile.

Figure A2 only shows the results for January 2000 to January 2012 because, previous to this period, returns from the different indices that are below the 0.5% quantile do not occur at the same time. As described by Mittnik (2011) the small number of data points is a general flaw of the CEIOPS method for calculating tail correlations. The horizontal line indicates the assumed correlation of 0.75 between the equity class “global” and “others” in the aggregation formula. Note the extreme variations during 2001 and 2009. In 2001, the tail correlation between the private equity index and the MSCI World Price Index reached both its minimum and maximum. The same is true for the commodity and the emerging markets indices. These results clearly illustrate that the assumption of a fixed correlation of 0.75 that is not time-varying is not an optimal solution. Also, the figure illustrates that tail correlations fluctuate especially in times of crisis.
**Figure A2:**
Tail correlations between the MSCI World Index and indices of the category “Other”

Notes: Tail correlations over time between the MSCI World Price Index and indices considered for the “other” equity category. The correlation coefficients are based on the longest time period available on each specific date. Tail correlations do not exist at each point in time because overlapping quantiles are required for calculation.
Appendix B – CoVaR Calculation

In order to project the time-variant CoVaR measure, we use quantile regressions and seven state variables as Adrian and Brunnermeier (2011). We employ the following quantile regressions to estimate the joint distribution of $X^i_t$ and $X^{system}_t$ (see Eq. (5) and Eq. (6)), whereas $X^i_t$ stands for the returns of the country portfolio $i$ and $X^{system}_t$ for the returns of the whole system. In contrast to Adrian and Brunnermeier (2011) a conversion of asset book-values into asset market-values before calculating the return series is omitted, because, in our setting, the portfolios are not leveraged and the values of the stylized insurance companies are equal to the values of their constitutive market-valued assets. We estimate the returns of the whole system as in the original paper by taking the arithmetic average over $i$.

\[ X^i_t = \alpha^i + \gamma^i M_{t-1} + \varepsilon^i_t \]  
\[ X^{system}_t = \alpha^{system|i} + \beta^{system|i} X^i_t + \gamma^{system|i} M_{t-1} + \varepsilon^{system|i}_t \tag{6} \]

$\alpha^i$ and $\alpha^{system|i}$ are the constants in both regressions and $\varepsilon^i_t$ and $\varepsilon^{system|i}_t$ are the error terms. System|i indicates that the system variable is conditional on $i$’s return. $\gamma^i$ and $\gamma^{system|i}$ are vectors and indicate regression coefficients as well as $\beta^{system|i}$. $M_{t-1}$ is a vector of state variables lagged by one week. The estimated coefficients are used to predict the time-variant risk measures as shown in Eq. (7) and Eq. (8).

\[ VaR^i_t(q) = \hat{\alpha}^i + \hat{\gamma}^i M_{t-1} \]  
\[ CoVaR^{system|i}_t(q) = \hat{\alpha}^{system|i} + \hat{\beta}^{system|i} X^i_t + \hat{\gamma}^{system|i} M_{t-1} \tag{8} \]

$q$ indicates the quantile which is used in the regressions and to which the VaR and CoVaR are referring to.

In this paper, the following state variables are used.

- **Volatility of the stock markets.** Adrian and Brunnermeier (2011) use the VIX Index, but we use the VSTOXX Index in order to adjust to a European setting. The index is obtained from Datastream.
- **Liquidity spread,** which is defined as the difference between the three-month general collateral repo rate and the three-month U.S. T-bill rate. For the repo rate, we use the Euro Repo Benchmark from Datastream and, for the T-bill rate, the three-month rate of German government bonds from Bloomberg.
- **Tails of market-valued asset returns**, which are explained in the original paper by the change in the three-month U.S. T-bill rate. In contrast, we use the change in the three-month T-bill rate of German government bonds.

- **Change in the slope of the yield curve.** Originally, the variable is measured by the yield spread between 10-year U.S. government bonds and three-month U.S. T-bills. We use the change in the yield spread between 10-year and three-month German government bonds.

- **Change in the credit spread.** We use the change in the difference between the yield to maturity of bonds represented by the Barclays Euro Aggregate 7–10Y Corporate Index and the yield to maturity of bonds represented by the Bank of America Merrill Lynch German Government 7–10Y Index. Both indices are obtained from Datastream. Adrian and Brunnermeier (2011) use BAA-rated bonds and the U.S. Treasury rate.

- **Equity market return.** Adrian and Brunnermeier (2011) use the equity market return from CRSP. We use the MSCI Europe Price Index obtained from Datastream in order to approximate the equity market return.

- **Real estate sector return.** Originally, the excess return above the market return of companies with a SIC code of 65 and 66 is used. In contrast, we simply employ the excess return of the MSCI Europe Real Estate Price Index over the return of the MSCI Europe Price Index.
Appendix C – MES Calculation

According to Acharya et al. (2012), the marginal expected shortfall of a company is defined as follows in Eq. (9).

\[
MES^i_{5\%} = -E \left[ \frac{w^i_t}{w^i_{t-1}} - 1 | I_{5\%} \right] \tag{9}
\]

\( MES^i_{5\%} \) indicates the marginal expected shortfall of company \( i \) conditional on the 5% worst trading days of the market. \( w^i_t \) stands for the equity value of company \( i \) at time \( t \) and \( I_{5\%} \) denotes the 5% worst market outcomes. The time variant MES in this paper is following the same logic, but considers only the last year and is, therefore, more sensitive to recent stock market movements. The applied calculation is shown in Eq. (10).

\[
MES(t)^i_{5\%} = \frac{1}{261} \sum_{t-261}^t \left[ \frac{w^i_t}{w^i_{t-1}} - 1 | I_{5\%261} \right] \tag{10}
\]

\( MES(t)^i_{5\%} \) indicates the marginal expected shortfall at time \( t \) and \( I_{5\%261} \) the 5% worst market returns during the last 261 trading days. As a reference for the equity market, we use the MSCI World Price Index.

As an alternative (not reported in this paper), we calculate the measure based on daily, annual rolling returns as used in the calculations for the symmetric adjustment mechanism CEIOPS (2010a). In this case, \( w^i_{t-1} \) in Eq. (9) and Eq. (10) changes to \( w^i_{t-261} \). Our key results are the same for this version. However, due to a loss of intra-year variations, the MES is reacting less sensitive and looks more smoothly over time.

Acharya et al. (2012) use leverage in addition to MES to predict expected losses. Because the country portfolios are not leveraged, we omit the measure for leverage.
Appendix D – Relationship Between CoVaR/MES and Capital Requirements

In the following, we report the results of additional statistical tests of the relationship between systemic risk measures and capital requirements. Table A3 shows the results for tests of independence, unit root tests, Granger causality tests, and OLS regressions. Table A4 and Table A5 report the results of a vector autoregressive (VAR) model and a vector error correction (VEC) model, respectively.

Table A3:
Statistical Tests Regarding Capital Requirements and Systemic Risk Measures

<table>
<thead>
<tr>
<th>Chi^2 Test for Independence</th>
<th>Unit Root Test</th>
<th>OLS Regression Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Requirements &amp; CoVaR</td>
<td>-2.72**</td>
<td>CoVaR &lt;- Capital Requirements</td>
</tr>
<tr>
<td>Capital Requirements &amp; MES</td>
<td>-5.34***</td>
<td>MES</td>
</tr>
<tr>
<td>ΔCapital Requirements</td>
<td>-1.78</td>
<td>ΔCapital Requirements</td>
</tr>
<tr>
<td>ΔMES</td>
<td>-27.49***</td>
<td>ΔMES</td>
</tr>
<tr>
<td>ΔMES &lt;- ΔCapital Requirements</td>
<td>1.30</td>
<td>ΔMES &lt;- ΔCapital Requirements (lag)</td>
</tr>
<tr>
<td>ΔMES &lt;- CoVaR</td>
<td>0.37</td>
<td>ΔMES &lt;- ΔCapital Requirements (lag)</td>
</tr>
</tbody>
</table>

Notes: Chi^2 test statistics for H_0: stochastic independence. Unit root t-test statistics for H_0: unit root. Granger causality f-test statistics for H_0: no Granger causation. (lag) indicates a variable lagged by one week. Δ indicates the first difference in the time series and ***, **, * the 1%, 5%, and 10% significance level, respectively.

Chi^2 tests for independence reveal that stochastic independence between the risk measures and the capital requirements can be rejected at a 1% significance level. Augmented Dickey-Fuller tests (unit root tests) show that the capital requirements and CoVaR are not non-stationary at a significance level of 10% and 1%. For MES non-stationarity cannot be rejected. In order to avoid spurious regressions we use the first difference in the time series for MES analysis. Granger causality tests show that capital requirements seem to Granger cause CoVaR, because the null hypothesis of no Granger causality can be rejected at a 1% significance level. However, CoVaR does not Granger cause capital requirements. With regard to MES, neither changes in capital requirements Granger cause changes in the systemic risk measure, nor changes in MES Granger cause changes in capital requirements. OLS regressions of the systemic risk measures on capital...
requirements show that there is a relationship between contemporary as well as lagged capital requirements by one week and the systemic risk measures. Especially, there appears to be a deferred relationship between CoVaR and capital requirements.\(^{25}\)

We model the interrelation between capital requirements and the average CoVaR in an autoregressive model as specified in Eq. (11). As endogenous variables, we use capital requirements and CoVaR. A constant is the only exogenous variable.

\[
y_t = A_1 y_{t-1} + A_2 y_{t-2} + A_3 y_{t-3} + c + \varepsilon_t
\]

\(y_t\) is a column vector and denotes the capital requirements and CoVaR at time \(t\). \(A_1, A_2, A_3\) are the coefficient matrices that are to be estimated. \(c\) is a column vector and stands for the constants. \(\varepsilon_t\) is a column vector and stands for the error terms at time \(t\). The lag length of three is estimated by the Hannan-Quinn and Schwarz criterion. Results of the coefficient matrices, \(R^2\) figures and F-Statistics are shown in Table A4.\(^{26}\)

\(^{25}\) This deferred relationship can be explained by the construction of the risk measures, which are not as sensitive as the symmetric adjustment mechanism. For example, CoVaR is based on state variables, which are lagged by one week, and, therefore, reacts not instantaneously to equity market changes, but the symmetric adjustment mechanism does. The deferred relationship should thus not be interpreted as a forecasting capability of the symmetric adjustment mechanism to anticipate future systemic risk.

\(^{26}\) Note that single coefficients should be interpreted with caution and can be misleading. Freeman et al. (1989) argue that only sets of coefficients should be considered. Also, Brandt and Williams (2007, p. 14) point out that VAR models are only “…an approach to modeling dynamics among a set of (endogenous) variables.” Therefore, we put no emphasis on the highly significant and negative coefficient of Capital Requirements \((-2)\) of \(-0.430\) with regard to the CoVaR measure. In our view, the coefficient is negative out of technical reasons because, without it, the model would include a positive trend. For interpreting explanatory relationships on the level of individual variables, for example, the Granger causality tests as reported in Table A3 are more suitable.
Table A4: Vector Autoregressive Model

<table>
<thead>
<tr>
<th></th>
<th>Capital Requirements</th>
<th>CoVaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Requirements (-1)</td>
<td>0.921***</td>
<td>0.472***</td>
</tr>
<tr>
<td>Capital Requirements (-2)</td>
<td>0.072</td>
<td>-0.430***</td>
</tr>
<tr>
<td>Capital Requirements (-3)</td>
<td>-0.019</td>
<td>-0.024</td>
</tr>
<tr>
<td>CoVaR (-1)</td>
<td>0.062**</td>
<td>0.368***</td>
</tr>
<tr>
<td>CoVaR (-2)</td>
<td>-0.004</td>
<td>0.202***</td>
</tr>
<tr>
<td>CoVaR (-3)</td>
<td>-0.019</td>
<td>0.244***</td>
</tr>
<tr>
<td>R^2</td>
<td>0.958</td>
<td>0.637</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>2505.692***</td>
<td>191.059***</td>
</tr>
</tbody>
</table>

Notes: (-1), (-2) and (-3) indicate a lag of one, two, and three weeks of the variables and ***., **., * the 1%, 5%, and 10% significance level of the coefficients, respectively.

We cannot apply a normal VAR model to evaluate the dynamics between capital requirements and MES, because MES is a non-stationary time series. However, the Johansen cointegration test shows that capital requirements and MES are cointegrated. Therefore, we employ a vector error correction model as specified in Eq. (12). The model is based on the third deterministic trend case as described by Johansen (1995, p. 81).

\[
\Delta y_t = \alpha \beta' (y_{t-1} - c) + A_1 \Delta y_{t-1} + A_2 \Delta y_{t-2} + A_3 \Delta y_{t-3} + \varepsilon_t \quad (12)
\]

\( \alpha \) is a column vector and \( \beta = \begin{bmatrix} 1 \\ -\beta_1 \end{bmatrix} \), whereas \( \beta_1 \) is the coefficient denoting the linear relationship between the capital requirements and MES. \( c \) is a column vector of constants. Results of the coefficient matrices \( A_1, A_2, \) and \( A_3, \) as well as \( R^2 \) figures and F-Statistics regarding the differences in capital requirements and MES, are shown in Table A5.
Table A5: Error Correction Model

<table>
<thead>
<tr>
<th></th>
<th>ΔCapital Requirements</th>
<th>ΔMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔCapital Requirements (-1)</td>
<td>-0.055*</td>
<td>0.002*</td>
</tr>
<tr>
<td>ΔCapital Requirements (-2)</td>
<td>0.056*</td>
<td>-0.001</td>
</tr>
<tr>
<td>ΔCapital Requirements (-3)</td>
<td>0.068*</td>
<td>-0.003*</td>
</tr>
<tr>
<td>ΔMES (-1)</td>
<td>-0.561</td>
<td>0.220***</td>
</tr>
<tr>
<td>ΔMES (-2)</td>
<td>-0.377</td>
<td>0.220***</td>
</tr>
<tr>
<td>ΔMES (-3)</td>
<td>0.659</td>
<td>0.061*</td>
</tr>
<tr>
<td>R²</td>
<td>0.014</td>
<td>0.246</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>1.357**</td>
<td>30.372***</td>
</tr>
</tbody>
</table>

Notes: Δ stands for the first difference regarding the time series. (-1), (-2) and (-3) indicate a lag of one, two, and three weeks of the variables and ***, **, * the 1%, 5%, and 10% significance level of the coefficients, respectively.

Results of both models show that the optimal lag length is three. F-statistics at a 1% confidence level show that lagged capital requirements and lagged CoVaR variables can explain current CoVaR levels. In the case of the VEC model, the F-statistics show at a 1% and 5% confidence level that MES and capital requirements can be explained by lagged variables. However, in the VEC model, the significance of the coefficients is very low, thus making the explanatory relationship doubtful. Furthermore, in contrast to the R² (0.63) of the CoVaR equation in the VAR model, the one (0.01) of the MES equation in the VEC model is very low. This contributes to the previous findings shown in Table A3. Lagged capital requirements can significantly explain CoVaR, but the evidence for MES is weak.
References


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References to published literature should be inserted into the text using the “author, date” format. Examples are: (1) “Manders et al. (1994) have shown. . .” and (2) “Interstate compacts have been researched extensively (Manders et al., 1994).” Cited literature should be shown in a “References” section, containing an alphabetical list of authors as shown below.


Footnotes should be used to supply useful background or technical information that might distract or disinterest the general readership of insurance professionals. Footnotes should not simply cite published literature — use instead the “author, date” format above.

Tables and charts should be used only if needed to directly support the thesis of the paper. They should have descriptive titles and helpful explanatory notes included at the foot of the exhibit.
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Cassandra Cole and Kathleen McCullough
jireditor@gmail.com

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