



**WP/17/107**

# IMF Working Paper

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## Variance Decomposition Networks: Potential Pitfalls and a Simple Solution

by Jorge A. Chan-Lau

***IMF Working Papers* describe research in progress by the author(s) and are published to elicit comments and to encourage debate.** The views expressed in IMF Working Papers are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

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**IMF Working Paper**

Institute for Capacity and Development

**Variance Decomposition Networks: Potential Pitfalls and a Simple Solution**

**Prepared by Jorge A. Chan-Lau**

Authorized for distribution by Ralph Chami

May 2017

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**Abstract**

Diebold and Yilmaz (2015) recently introduced variance decomposition networks as tools for quantifying and ranking the systemic risk of individual firms. The nature of these networks and their implied rankings depend on the choice decomposition method. The standard choice is the order invariant generalized forecast error variance decomposition of Pesaran and Shin (1998). The shares of the forecast error variation, however, do not add to unity, making difficult to compare risk ratings and risks contributions at two different points in time. As a solution, this paper suggests using the Lanne-Nyberg (2016) decomposition, which shares the order invariance property. To illustrate the differences between both decomposition methods, I analyzed the global financial system during 2001 – 2016. The analysis shows that different decomposition methods yield substantially different systemic risk and vulnerability rankings. This suggests caution is warranted when using rankings and risk contributions for guiding financial regulation and economic policy.

JEL Classification Numbers: C32, C39, G21

Keywords: networks, interconnectedness, systemic risk, regularization techniques, global financial system, variance decomposition, VAR

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## 1. Motivation<sup>1</sup>

Following the global financial crisis in 2008, attention has focused on enhancing our understanding of systemic risk, and in particular, on how financial networks propagate and amplify adverse shocks. In the pursuit of these goals, the economics profession has built up on the rapid advances in network theory initially developed in biology and the computational social sciences, as illustrated in recent textbooks by Easley and Kleinberg (2010), and Jackson (2010).

Lessons and insights learned from the analysis of financial networks have already started to influence economic policy. The identification of systemic financial institutions, which are subject to higher capital requirements and enhanced oversight, incorporates interconnectedness as one of the assessment criteria (FSB, 2009). Central banks around the world are analyzing financial networks to assess contagion in the financial system, e.g. Banco de Mexico (2015), or the resilience of the banking sector to adverse shocks accounting for network spillovers, e.g. Anand, Bedard-Page, and Traclet (2014). From a multilateral perspective, Demekas et al (2013) apply clique percolation (Derenyi, Palla, and Vicsek, 2005) to identify the community of systemic financial jurisdictions using banking and portfolio exposures data.

Diebold and Yilmaz (2014) have recently proposed constructing variance decomposition networks that allow ranking firms by their systemic importance. For a group of firms, the construction of the network requires first estimating a vector autoregressive (VAR) model for their equity returns or other observable market-based measures. The impact of one firm on the network, or its systemic importance, is proportional to its contribution to the generalized forecast error variance decomposition (GFEVD) of the other firms. Two edges, hence, connect any two firms in the network. One edge measures the impact of the first firm on the GFEVD of the second firm, and the second edge measures the opposite.

One advantage of using the GFEVD as an interconnectedness measure is that the ordering of the variables in the VAR does not matter (Koop, Pesaran, and Potter, 1996). This is important when handling networks comprising a large number of firms for which it is unfeasible to specify a structural VAR model.

The order invariance comes at a cost though. Compared with the forecast error variance decomposition (FEVD) in a structural VAR, the GFEVD contributions do not add to unity since the error terms are correlated. This creates two potential pitfalls. The first one relates to the economic interpretation shocks to the system, a problem acknowledged in Koop et al (1996). The second one relates to how best to assess changes in the systemic contribution (or importance) of an individual firm over time.

To illustrate the last point, suppose that in one period firm A explains one fifth of the GFEVD of firm B while the sum of all the firms' contributions amounts to two. In another period, firm A explains one half of the GFEVD of firm B but contributions only add to one half. On the one hand, firm A seems more systemic in the second period since its contribution increased to fifty percent from twenty percent. On the other hand, firm A might be less systemic since it

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<sup>1</sup> The paper benefits from discussions with Henri Nyberg on the statistical methodology, and the data collection work of Christina Daniels and Dulani Seneviratne. Any errors or omissions are the author's sole responsibility.

contribution only accounts for one quarter (fifty percent of one half), down from forty percent (twenty percent of two).

In this paper, I point out that these pitfalls disappear when one uses the GFEVD of Lanne and Nyberg (2016) rather than the Koop-Pesaran-Potter GFEVD in an otherwise standard Diebold-Yilmaz (DY) variance decomposition network. In the modified network, i.e. the corrected Lanne-Nyberg (CLNDY) variance decomposition network, the GFEVD contributions sum to unity. Hence, shocks to individual equations have an economic interpretation similar to those in a structural VAR. It also becomes possible to compare the systemic importance of a firm, or systemic risk-based rankings, in two different periods of time in a consistent manner.

For comparison purposes, both DY and CLNDY networks were estimated for a large sample of publicly listed financial firms in advanced and emerging market economies during 2001 – 2016. The high dimensionality of the underlying VAR required using regularization techniques for estimating the coefficients and the variance-covariance matrix of the error terms. There is only weak correlation between systemic and vulnerability risk rankings implied from DY and CLNDY networks, indicating caution is warranted when risk ratings serve to guide policy.

The roadmap to the remainder of the paper is as follows. Section 2 reviews the literature on network interconnectedness and systemic risk in the financial system. Since research on this topic is accumulating at a rapid pace, the review would be, by necessity, brief and selective. Section 3 presents side by side the Koop-Pesaran-Potter and Lanne and Nyberg GFEVD methodologies, and argues why the latter might be more advantageous for constructing variance decomposition networks as first proposed by Diebold and Yilmaz (2014). This section also introduces the Lasso regularization and variance-covariance shrinking methods used to build the networks. Section IV puts the methodology to work by building both DY and CLNDY equity-return networks and comparing their systemic risk rankings. Section V concludes.

## **2. Network Interconnectedness and Systemic Risk: A Brief Literature Review**

Efforts towards understanding financial networks and its systemic implications have progressed rapidly along two different tracks. In the first track, networks emerge naturally from direct bilateral exposures between financial institutions and other market participants. Systemic risk in these networks arise from the potential realization of cascades of failures triggered by the inability of one firm to honor its obligations to other firms, as first advanced in Eisenberg and Noe (2001). Once a firm defaults subsequent failures arise from credit losses, forced sale of assets, funding withdrawals, and liquidity shortages (Brunnermeier and Pedersen, 2009).

Systemic risk rankings in these networks correspond to the total impact of a firms' failure on the system, measured as the losses their failure generate, weighted for instance by the centrality of the firms in the network as in Battiston et al (2012) for U.S. banks, and D'Errico, Battiston, and Gurciullo (2016) for European banks. In recent work, Jo (2012) captures the impact of counterparty risk, funding costs, and liquidity shortages in a direct exposures network, which, as in related models, must be solved numerically (Upper, 2011).

Networks based on direct exposures can capture the strategic and adaptive behavior of firms in the system, as done by Gai and Kapadia (2010) and Jo (2012) using numerical simulations; or

Elliott et al (2014), and Acemoglu et al (2015) at a theoretical level. More recently, these networks arise endogenously in agent-based models incorporating complexity and real world constraints, such as margin calls or regulatory requirements, as in Montagna and Kok, (2013), Bookstaber and Maddrik (2015), and Chan-Lau (2015) among others.

Constructing direct exposures networks requires detailed counterparty exposure data. In many instances, the data would be available only for the aggregate counterparty exposure of an individual firm. There are methods available to reconstruct the bilateral exposures from aggregate data, but the reconstructed data is likely to differ substantially from the actual exposures (Anand, Craig, and Peter, 2015). Even if data on bilateral exposures are available, absent information on the characteristics of the bilateral exposures makes difficult to assess the extent of losses in the case of counterparty default. Lastly, the network may not be able to capture completely the transmission of shocks arising from common exposures to risk factors rather than bilateral exposures.

The second track of analytical work on financial networks bypasses these problems by relying on the comovement of firms' security prices. With efficient markets, prices would capture the risks from bilateral exposures as well as from indirect exposures, such as similarity in business models and common exposures to risk factors owing to similar trading, investment, and risk management strategies. In the network, the links between firms are proportional to the comovement of their security prices. While easier to build than direct exposures network, comovement networks cannot accommodate the strategic behavior of firms.

Mantegna (1999) pioneered the work on comovement networks, setting the strength of the link between two firms, or distance, proportional to the inverse of their stock price correlation. More recently, Billio et al (2012) built Granger-causality networks based on monthly asset returns for publicly listed financial firms and hedge funds. In these networks, the strength and directionality of the link between two firms is determined by the degree of their pair-wise Granger causality measures. The pair-wise estimation of these measures allows constructing networks with a large number of constituent firms. Nevertheless, pairwise effects are local in nature, ignoring the effects of other firms and neglecting the global aspect of the network. Indeed, pairwise Granger causality measure may be significant owing to the unobserved effect of a third firm.

Partial correlation analysis, a statistical technique introduced by Baba, Shibata, and Sibuya (2004), bypass the limitations of pairwise Granger-causality networks and earlier work on correlation networks. In simple words, the partial correlation is the residual correlation between two firms after subtracting the correlation with a third firm. The application of partial correlation analysis, therefore, isolates the link between two firms. What is lost, compared to Granger-causality networks, is the directionality of the link. Examples include Kennet et al (2010), who introduced partial correlation analysis in financial networks of stock returns, and those surveyed in Kennet et al (2014). Partial correlation analysis, however, could yield a network with all firms directly connected to each other, or in other words, the financial network reduces to a single giant component.

To trim the partial correlation network, Chan-Lau, Chuang, Duan, and Sun (2016) propose using a Lasso penalty restriction based on the CONCORD algorithm (Khare et al, 2015; Oh et al,



2014) such that the partial correlation of weakly connected firms, i.e. low partial correlation values, is set equal to zero. If the penalty is too large, the network may generate a substantial number of orphan firms, i.e. firms completely disconnected from the network, which is at odds with the prior that the financial system is fully integrated. To avoid this situation, the value of the Lasso penalty is set to the maximum value such that all firms belong to the network. This restriction is consistent with the prior that the financial system is fully integrated albeit not fully connected. The authors apply these techniques to build networks based on the partial correlation of projected probabilities of default.

Diebold and Yilmaz (2014) propose to summarize the interconnectedness between firms using the variance decomposition in a VAR model of the financial system. Specifically, the contribution of one firm to the GFEVD of another firm is a directed measure of their interconnectedness to rule out the effect of the order of variables in the VAR (Koop, Pesaran, and Potter, 1996). Compared with plain correlation networks, there are two separate weighted edges connecting two firms in a variance decomposition network. One edge measures the effect of the first firm on the second, and the other measuring the reverse effect. As in the case of Granger causality networks, the notion of firms as sources and recipients of risk arise naturally in the Diebold-Yilmaz framework. The authors analyze the interconnectedness between ten U.S. financial firms using a VAR model for realized equity return volatility. Demirer, Diebold, Liu, and Yilmaz (2015), by leveraging on dimensionality reduction methods, are able to extend Diebold-Yilmaz original framework to a global bank network comprising the top one hundred banks worldwide.

Despite the positive features of Diebold-Yilmaz financial networks, weaknesses in the economic interpretation of the shocks remain, which have implications for systemic risk rankings based on the GFEVD, as pointed in the introductory section. I explain next why a simple modification based on the variance decomposition method proposed by Lanne and Nyberg (2016) goes a long way towards enhancing the original Diebold-Yilmaz analytical framework.

### **3. Methodology**

The construction of variance decomposition networks requires three steps. First, it is necessary to estimate the VAR model, which requires the use of regularization techniques when the number of endogenous variables is large. Second, the estimates of the VAR coefficients serve to generate the GFEVD. Two options are available for performing the decomposition, one proposed by Pesaran and Shin (1998) and another proposed by Lanne and Nyberg (2016). In the third step, the GFEVD determines the network structure and the systemic importance of the firms. This section reviews the three steps.

#### **A. High-Dimensional VAR estimation**

Realizing the power of networks to uncover interconnectedness in the financial system requires including a large number of firms in the analysis. In variance decomposition networks, it demands estimating a high dimensional VAR model. Such estimation is challenging, with the

number of autoregressive coefficients for each equation increasing quadratically in the number of lags, i.e. for  $n$  variables and  $p$  lags, the total number of coefficients equal to  $n + n \times p^2$ .

Bayesian VAR methods, surveyed in Koop (2013), are useful for estimating large VARs, and have proven better at forecasting than factor models when combining the use of Minnesota priors and stochastic search variable selection. But these methods could be computationally expensive relative to shrinkage methods incorporating the least absolute shrinkage and selection operator (lasso) of Tibshirani (1996), a widely used penalized least squares estimator for dealing with sparse high dimensional systems in economics (Fan, Ly, and Qi, 2011). Work exploring the application of lasso to VARs include Song and Bickel (2011), Li and Chen (2014), and Davis, Zang, and Zheng (2015). Nicholson, Matteson and Bien (2016) introduce the VARX-L to account for exogenous variables.

This study uses the Lasso to estimate each single equation in the VAR. The minimization of the penalized residual sum of squares in an otherwise least squares regression, i.e.

$$(1) \quad \min_{\beta_{i,0}, \beta_{i,kj}} \sum_{t=1}^T \left( y_{i,t} - \beta_{i,0} - \sum_{k=1}^p \sum_{j=1}^n \beta_{i,kj} y_{j,t-k} \right)^2 + \lambda \sum_{k=1}^p \sum_{j=1}^n |\beta_{i,kj}|$$

yields the lasso coefficients  $\beta_{i,kj}^\lambda$  in the  $i$ -th equation of the VAR model, where  $T$  is the number of observations, and  $p$  the number of lags. Note that the coefficients depend on the value of the penalty parameter,  $\lambda$ . The larger the parameter value, the larger the number of coefficients shrunk towards the value of zero.

Typically,  $k$ -fold cross-validation serves to choose the penalty parameter. The validation process divides the set of observation into  $k$  groups or folds. Each fold serves successively as a validation set, with the model estimated using the remaining  $k-1$  folds. The average cross-validation error is the average of the mean square error over the  $k$  estimations. There are two commonly used criteria for parameter selection. The first one is to choose the parameter that yields the minimum cross-validation error. The second one, the one standard error rule, is to choose the minimum parameter with an associated error not exceeding the minimum cross-validation error by more than one standard deviation (see James et al, 2013, for a textbook exposition).

When estimating VAR models for weekly equity returns, the minimum the minimum cross-validation error and one standard error criteria performed aggressively. In some instances, they shrank all autoregressive coefficients to zero, implying equity returns followed a random walk. The estimation also used the elastic net (Zou and Hastie, 2005) and the adaptive elastic net estimators (Zou and Zhang, 2009) as suggested by Demirer et al (2015), who showed it performed well when analyzing VAR models of daily equity return volatility. Both estimators, however, exhibited a behavior similar to the Lasso models under the minimum cross validation error and the one standard error rule, aggressively shrinking the coefficients to zero.

Therefore, I adopted a simpler, somewhat ad hoc rule that set the penalty parameter equal to the maximum value such that the number of non-zero coefficients exceeds an arbitrary minimum threshold. The numerical results reported below correspond to a threshold value of twenty. After selecting the penalty parameter and the number of lagged values in the VAR, it is straightforward to estimate the individual equations.

### B. The Pesaran-Shin and Lanne-Nyberg GFEVDs

Upon estimation of the VAR, it is possible to calculate the GFEVD of the system using either the Pesaran and Shin (1998) or Lanne and Nyberg (2016) decompositions. Both build on the generalized impulse response function (GIRF) proposed by Koop, Pesaran and Potter (1996).

To obtain the Pesaran-Shin GFEVD, start with the moving average representation of the VAR (Hamilton, 1994):

$$(2) \quad \mathbf{Y}_t = \sum_{j=0}^{\infty} \mathbf{A}_j \boldsymbol{\varepsilon}_{t-j},$$

where  $\mathbf{Y}_t$  is the  $n \times 1$  vector of the realization of the endogenous variables at time  $t$ ,  $\mathbf{A}_j$  are  $n \times n$  matrices, and  $\boldsymbol{\varepsilon}_t$  is an independent and identically distributed error term with zero mean and covariance matrix  $\boldsymbol{\Sigma} = \{\sigma_{ij}, i, j = 1, \dots, n\}$ . Koop et al (1996) specify the order-invariant generalized impulse response function  $h$  periods ahead,  $GI$ , to a shock  $\boldsymbol{\delta}$  at time  $t$  given the past history of the economy at time  $t-1$ ,  $\boldsymbol{\Omega}_{t-1}$ , as:

$$(3) \quad GI(h, \boldsymbol{\delta}_t, \boldsymbol{\Omega}_{t-1}) = E(\mathbf{Y}_{t+h} | \boldsymbol{\varepsilon}_t = \boldsymbol{\delta}_t, \boldsymbol{\Omega}_{t-1}) - E(\mathbf{Y}_{t+h} | \boldsymbol{\Omega}_{t-1}).$$

In a linear model, the GIRF is independent of the past history of shocks. Pesaran and Shin (1998) simplify the GIRF by restricting the shock to a single element, i.e. the  $j$ -th element,  $\delta_j$ :

$$(4) \quad GI(h, \boldsymbol{\delta}_t, \boldsymbol{\Omega}_{t-1}) = \mathbf{A}_h \boldsymbol{\Sigma} \mathbf{e}_j \sigma_{jj}^{-1} \delta_j,$$

where  $\mathbf{e}_j$  is a  $n \times 1$  vector with all entries set to zero except for the  $j$ -th entry. The corresponding Pesaran-Shin GFEVD from variable  $j$  to variable  $i$  at horizon  $h$ ,  $\theta_{ij}(h)$ , follows after setting the shock  $\delta_j$  equal to  $\sqrt{\sigma_{jj}}$ :

$$(5) \quad \theta_{ij}(h) = \frac{\sigma_{ii}^{-1} \sum_{k=0}^h (\mathbf{e}_j' \mathbf{A}_k \boldsymbol{\Sigma} \mathbf{e}_j)^2}{\sum_{k=0}^h \mathbf{e}_j' \mathbf{A}_k \boldsymbol{\Sigma} \mathbf{A}_k' \mathbf{e}_i}, \quad i, j = 1, \dots, n.$$

Compared with impulse responses obtained from a Cholesky decomposition, the GIRFs are unique and independent from the ordering of the variables in the VAR, and exactly equivalent if shocks are orthogonal. The invariance property extends to the Pesaran-Shin GFEVDs, but there is a cost to pay: they do not add to unity, i.e.  $\sum_{j=1}^n \theta_{ij}(h) \neq 1$ , unless the shocks are orthogonal

to start with. Because of this feature, the interpretation of the Pesaran-Shin GFEVD as the partial contribution of a variable is at best ambiguous. To deal with this issue, Diebold and Yilmaz (2015) propose a standardized GFEVD given by:

$$(6) \quad \tilde{\theta}_{ij}(h) = \frac{\theta_{ij}(h)}{\sum_{k=1}^n \theta_{ik}(h)}, \quad i, j = 1, \dots, n.$$

Lanne and Nyberg (2016) introduce an alternative GFEVD,  $\lambda_{ij}(h)$ , based on the partial contribution of variable  $j$  to the total GIRF of variable  $i$ :

$$(7) \quad \lambda_{ij}(h) = \frac{\sum_{k=0}^h GI(h, \delta_{jt}, \boldsymbol{\Omega}_{t-1})}{\sum_{j=1}^n \sum_{k=0}^h GI(h, \delta_{jt}, \boldsymbol{\Omega}_{t-1})}, \quad i, j = 1, \dots, n.$$

The Lanne-Nyberg GFEVD adds to unity, and its interpretation as the relative contribution of a variable is straightforward and analogous to that of the Cholesky decomposition.

Calculating the GFEVDs requires estimates of the variance-covariance matrix  $\boldsymbol{\Sigma}$  to obtain the GIRFs. In large dimensional systems, a simple empirical estimate may fail to be positive definite. To avoid this problem, the estimation in this analysis uses the shrinkage methods proposed by Schafer and Strimmer (2005) and Opgen-Rhein and Strimmer (2007).

### C. Variance Decomposition Networks

Following Diebold and Yilmaz (2015), the pairwise directional connectedness from firm  $j$  to firm  $i$ , is equal to its contribution to the  $h$ -step ahead GFEVD of equity returns:

$$(8) \quad C_{ij}(h) = \begin{cases} \tilde{\theta}_{ij}(h) & \text{if using Pesaran-Shin GFEVD} \\ \lambda_{ij}(h) & \text{if using Lanne-Nyberg GFEVD} \end{cases}, \quad i, j = 1, \dots, n.$$

where the decompositions correspond to equations (5) and (6) respectively. The Pesaran-Shin GFEVD yields the Diebold-Yilmaz (DY) network, and the Lanne and Nyberg GFEVD yields the corrected Lanne-Nyberg-Diebold-Yilmaz (CLNDY) network.

The total directional connectedness from a firm  $j$ , is defined as the sum of its contribution to the  $h$ -step ahead GFEVD of the other firms' equity returns:

$$(9) \quad C_j(h) = \frac{\sum_{i \neq j, i=1}^n C_{ij}(h)}{\sum_{i,j=1}^n C_{ij}(h)} \times 100, \quad i, j = 1, \dots, n.$$

This measure captures the systemic risk of the firm, i.e. its total contribution to the forecast error variance of other firms in the system. Higher values correspond to higher systemic risk, making possible to rank firms by their systemic risk. Similarly, the systemic vulnerability of firm  $i$  is

simply the total contribution of other firms in the system to its forecast error variance, and is given by:

$$(10) \quad V_i(h) = \frac{\sum_{i \neq j, j=1}^n C_{ij}(h)}{\sum_{i,j=1}^n C_{ij}(h)} \times 100, \quad i, j = 1, \dots, n.$$

This measure helps us build a systemic vulnerability ranking, with more vulnerable firms characterized by higher values of  $V_i(h)$ . As in any statistical model, these risk and vulnerability measures assume that statistical causality implies economic causality. Even if this were not the case, however, the systemic risk and vulnerability measures would capture the role firms play in the amplification of shocks.

#### 4. A Case Study: Systemic Risk in the Global Financial Network

To evaluate the similarities and differences between the systemic risk and vulnerability rankings implied by the DY and CLNDY networks, I estimated them using weekly equity price returns in U.S. dollars of publicly traded financial firms. The data sample comprised 402 firms headquartered in 34 advanced and emerging market economies and covered the period January 1, 2001 – July 31, 2016. The sample of firms included those publicly traded as of mid-July 2015, which could introduce survivorship bias since it omits firms that merged or went into liquidation during the 2008 financial crisis, such as Lehman Brothers, Merrill Lynch and Dexia. The firms fall in one of the following categories: (1) property/casualty/health insurers; (2) life insurers; (3) banks, and savings and loan associations; and (4) security brokers and dealers.

The analysis relied on systemic rankings estimated on the full sample as well as on four distinct periods. The periods were: (1) the pre-crisis period, i.e. January 1, 2001 to December 31, 2004; (2) the Lehman Brothers period, i.e. January 1, 2005 to December 31, 2008; (3) the European sovereign debt crisis period, i.e. January 1, 2009 to December 31, 2012; and (4) the secular stagnation period, January 1, 2013 to July 31, 2016. In each sub-period, the number of firms was 275, 331, 380, and 402 respectively. To avoid thinly traded firms, the analysis included only firms for which at least 80 percent of the observations in the subsample were different from zero. The horizon for the variance decompositions was one year (52 weeks).

Table 1 presents detailed information on the sample composition by country in each sub-sample period. The United States and emerging market economies headquartered one quarter of the firms each. Banks and property/casualty/health insurance firms each account for roughly forty percent of the firms in the sample. Life insurance companies account for most of the remaining twenty percent, with a few securities brokers and dealers making up for the rest.

Table 1. Distribution of firms per country

Panel A: Sample period: Jan. 1, 2001 - Dec. 31 - 2004

Country	Type of firm				Total, per country
	Insurance: Property and Casualty; Health	Life Insurance	Banks and Savings&Loans	Security brokers and dealers	
UNITED STATES	48	9	18	2	77
CANADA	3	6	6	0	15
UNITED KINGDOM	5	4	5	0	14
JAPAN	0	0	11	2	13
SOUTH AFRICA	4	3	4	1	12
ITALY	3	3	5	0	11
TURKEY	4	2	5	0	11
AUSTRALIA	3	1	4	1	9
SWITZERLAND	2	4	3	0	9
FRANCE	1	3	4	0	8
GERMANY	1	5	2	0	8
TAIWAN	4	3	1	0	8
INDIA	0	1	6	0	7
INDONESIA	3	3	1	0	7
BERMUDA	6	0	0	0	6
SPAIN	1	1	4	0	6
SINGAPORE	1	2	3	0	6
IRELAND	2	1	2	0	5
HONG KONG	1	2	2	0	5
GREECE	0	1	4	0	5
DENMARK	2	0	2	0	4
SWEDEN	0	0	4	0	4
CHINA	0	0	3	1	4
BELGIUM	1	0	2	0	3
AUSTRIA	0	2	1	0	3
BRAZIL	0	0	3	0	3
NORWAY	0	1	1	0	2
NETHERLANDS	0	1	1	0	2
FINLAND	1	0	1	0	2
PORTUGAL	0	0	2	0	2
NEW ZEALAND	0	2	0	0	2
MEXICO	0	0	1	0	1
RUSSIAN FEDERATION	0	0	1	0	1
Total	96	60	112	7	275

Source: Bloomberg LLP and author's calculations.

Table 1 (continued). Distribution of firms per country

Panel B: Sample period: Jan. 1, 2005 - Dec. 31 - 2008

Country	Type of firm				Total, per country
	Insurance: Property and Casualty; Health	Life Insurance	Banks and Savings&Loans	Security brokers and dealers	
UNITED STATES	59	14	18	2	93
JAPAN	2	1	17	2	22
UNITED KINGDOM	8	4	5	0	17
CANADA	4	6	6	0	16
TAIWAN	4	6	4	0	14
SOUTH AFRICA	4	4	4	1	13
ITALY	3	3	6	0	12
BERMUDA	11	0	0	0	11
TURKEY	4	2	5	0	11
GERMANY	1	5	4	0	10
CHINA	1	2	5	2	10
AUSTRALIA	3	1	4	1	9
SWITZERLAND	2	4	3	0	9
FRANCE	1	3	5	0	9
INDIA	0	1	8	0	9
SPAIN	1	1	5	0	7
IRELAND	3	1	2	0	6
HONG KONG	1	2	3	0	6
SINGAPORE	1	2	3	0	6
INDONESIA	1	2	3	0	6
GREECE	0	1	4	0	5
DENMARK	2	0	2	0	4
SWEDEN	0	0	4	0	4
BRAZIL	1	0	3	0	4
BELGIUM	1	0	2	0	3
AUSTRIA	0	2	1	0	3
NORWAY	0	1	1	0	2
NETHERLANDS	0	1	1	0	2
FINLAND	1	0	1	0	2
PORTUGAL	0	0	2	0	2
NEW ZEALAND	0	2	0	0	2
MEXICO	0	0	1	0	1
RUSSIAN FEDERATION	0	0	1	0	1
Total	119	71	133	8	331

Source: Bloomberg LLP and author's calculations.

Table 1 (continued). Distribution of firms per country

Panel C: Sample period: Jan. 1, 2009 - Jul. 31 - 2012

Country	Type of firm				Total, per country
	Insurance: Property and Casualty; Health	Life Insurance	Banks and Savings&Loans	Security brokers and dealers	
UNITED STATES	65	14	18	4	101
JAPAN	3	2	19	2	26
UNITED KINGDOM	10	7	5	0	22
CHINA	1	3	14	2	20
CANADA	5	6	6	0	17
BERMUDA	15	0	0	0	15
SOUTH AFRICA	4	5	4	1	14
TAIWAN	4	6	4	0	14
ITALY	3	3	7	0	13
TURKEY	4	2	5	0	11
AUSTRALIA	4	1	4	1	10
SWITZERLAND	3	4	3	0	10
GERMANY	1	5	4	0	10
INDIA	0	2	8	0	10
FRANCE	1	3	5	0	9
INDONESIA	4	2	3	0	9
SPAIN	1	1	6	0	8
IRELAND	3	1	2	0	6
HONG KONG	1	2	3	0	6
SINGAPORE	1	2	3	0	6
BRAZIL	2	0	4	0	6
DENMARK	3	0	2	0	5
SWEDEN	1	0	4	0	5
GREECE	0	1	4	0	5
AUSTRIA	0	2	2	0	4
NORWAY	0	2	1	0	3
BELGIUM	1	0	2	0	3
NETHERLANDS	0	1	1	0	2
FINLAND	1	0	1	0	2
PORTUGAL	0	0	2	0	2
RUSSIAN FEDERATION	0	0	2	0	2
NEW ZEALAND	0	2	0	0	2
CAYMAN ISLANDS	1	0	0	0	1
MEXICO	0	0	1	0	1
Total	142	79	149	10	380

Source: Bloomberg LLP and author's calculations.



Table 1 (continued). Distribution of firms per country

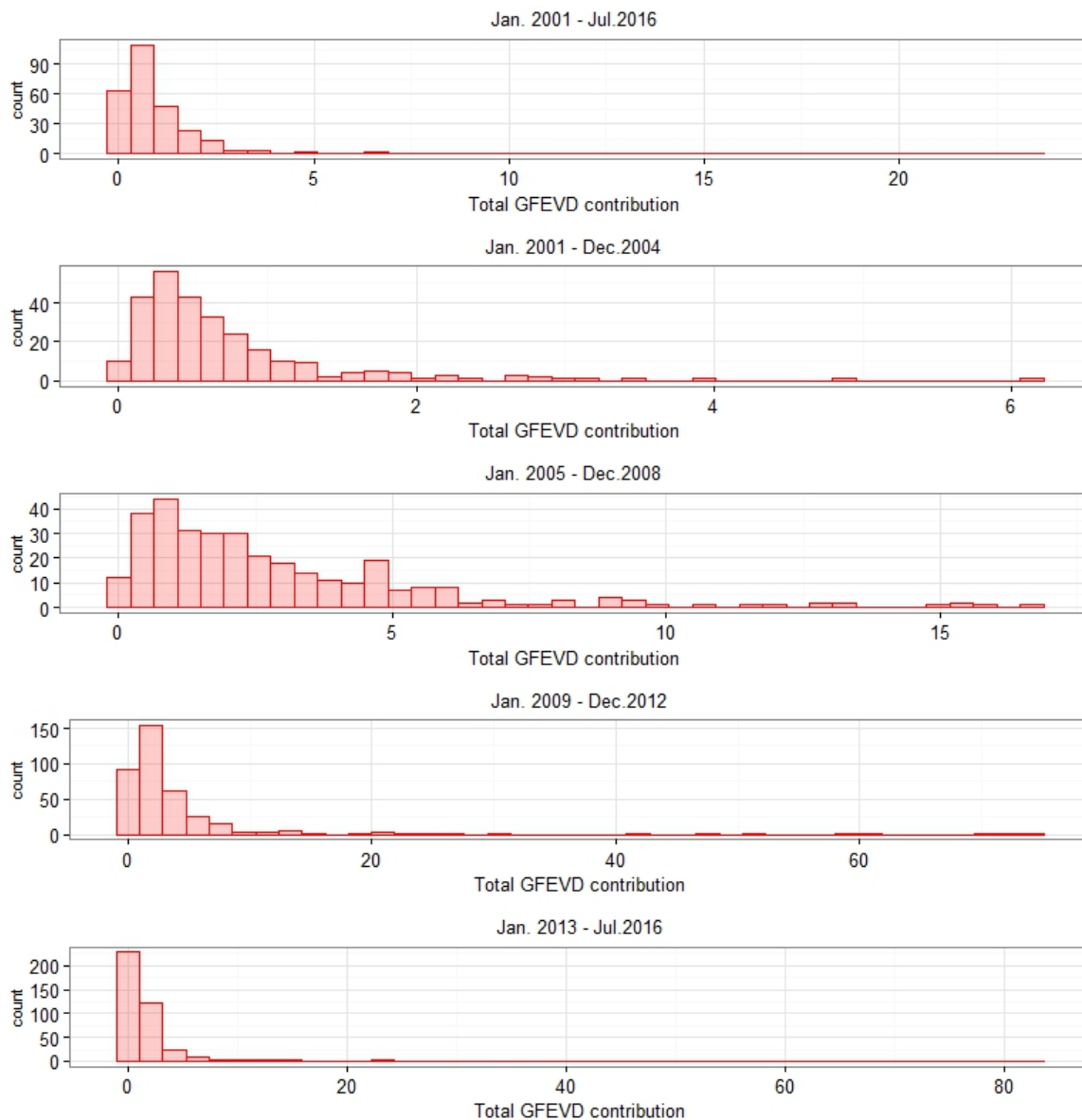
Panel D: Sample period: Jan. 1, 2013 - Jul. 31 - 2016

Country	Type of firm				Total, per country
	Insurance: Property and Casualty; Health	Life Insurance	Banks and Savings&Loans	Security brokers and dealers	
UNITED STATES	65	16	19	4	104
JAPAN	5	4	20	2	31
CHINA	2	4	17	3	26
UNITED KINGDOM	12	7	5	0	24
CANADA	6	6	6	0	18
TAIWAN	4	6	5	0	15
BERMUDA	13	0	0	0	13
ITALY	3	3	7	0	13
SOUTH AFRICA	4	4	4	1	13
TURKEY	4	2	5	0	11
AUSTRALIA	4	1	4	1	10
GERMANY	2	4	4	0	10
SWITZERLAND	3	4	3	0	10
INDIA	0	2	8	0	10
SPAIN	1	1	7	0	9
FRANCE	1	3	5	0	9
BRAZIL	3	0	4	1	8
INDONESIA	3	2	3	0	8
HONG KONG	1	3	3	0	7
SINGAPORE	2	2	3	0	7
IRELAND	3	1	2	0	6
GREECE	1	1	4	0	6
DENMARK	3	0	2	0	5
SWEDEN	1	0	4	0	5
NORWAY	1	2	1	0	4
NETHERLANDS	0	3	1	0	4
AUSTRIA	0	2	2	0	4
BELGIUM	1	0	2	0	3
MEXICO	0	0	2	0	2
RUSSIAN FEDERATION	0	0	2	0	2
NEW ZEALAND	0	2	0	0	2
FINLAND	1	0	0	0	1
CAYMAN ISLANDS	1	0	0	0	1
PORTUGAL	0	0	1	0	1
Total	150	85	155	12	402

Source: Bloomberg LLP and author's calculations.

The calculation of the DY and CLNDY systemic rankings built on the estimation of three VAR specifications differing in the number of lags: 4, 8, and 12. For a given variance decomposition method, the number of lags did not affect much the systemic risk and vulnerability rankings. The Spearman rank correlations ranged from 0.95 to 0.99, and the Kendal rank correlations from 0.85 to 0.90. Figure 1 shows the distribution of the Pesaran-Shin total GFEVD contribution to the equity returns of single firms generated from a VAR(8) specification. After normalization, these GFEVDs serve to construct the DY network and its systemic rankings. However, the wide dispersion of the total GFEVD, with many observations below one hundredth or above one, makes the interpretation of the DY ranking ambiguous as discussed earlier (Figure 1).

Figure 1. Distribution of Pesaran-Shin total GFEVD contributions to the equity returns of individual firms. Full sample and sub-sample periods



Source: Bloomberg LLP and author's calculations.

To highlight the differences between the DY and CLNDY systemic rankings, Table 2 presents their nonparametric Spearman and Kendall rank correlations. The low sensitivity of the DY and CLNDY systemic rankings to the lag specification is also evident in the low sensitivity of the cross-systemic ranking correlation across different lags.

Table 2. Rank correlations, Diebold-Yilmaz and corrected Lanne-Nyberg-Diebold-Yilmaz rankings\*

Correlation measure	Spearman			Kendall		
	4	8	12	4	8	12
Number of lags in VAR						
Panel A: Systemic Risk Rankings						
<i>All firms</i>						
Jan. 2001 - Jul. 2016	0.72	0.74	0.74	0.54	0.56	0.56
Jan. 2001 - Dec. 2004	0.68	0.64	0.65	0.50	0.46	0.47
Jan. 2005 - Dec. 2008	0.66	0.69	0.73	0.48	0.52	0.54
Jan. 2009 - Dec. 2012	0.74	0.77	0.73	0.56	0.59	0.54
Jan. 2013 - Jul. 2016	0.54	0.54	0.56	0.38	0.39	0.40
<i>Top 100 firms in Diebold-Yilmaz network</i>						
Jan. 2001 - Jul. 2016	0.17	0.32	0.34	0.11	0.22	0.23
Jan. 2001 - Dec. 2004	0.16	0.12	0.15	0.12	0.08	0.11
Jan. 2005 - Dec. 2008	0.17	0.29	0.28	0.12	0.20	0.20
Jan. 2009 - Dec. 2012	0.06	0.05	0.01	0.04	0.04	0.01
Jan. 2013 - Jul. 2016	-0.09	-0.15	-0.23	-0.07	-0.09	-0.16
<i>Top 100 firms in corrected Lanne-Nyberg-Diebold-Yilmaz network</i>						
Jan. 2001 - Jul. 2016	0.24	0.42	0.44	0.16	0.29	0.30
Jan. 2001 - Dec. 2004	0.69	0.64	0.63	0.50	0.44	0.44
Jan. 2005 - Dec. 2008	0.39	0.44	0.45	0.28	0.31	0.31
Jan. 2009 - Dec. 2012	0.10	0.22	0.04	0.07	0.15	0.03
Jan. 2013 - Jul. 2016	0.22	0.34	0.32	0.15	0.23	0.21
Panel B: Systemic Vulnerability Rankings						
<i>All firms</i>						
Jan. 2001 - Jul. 2016	0.80	0.82	0.79	0.63	0.63	0.62
Jan. 2001 - Dec. 2004	0.84	0.80	0.82	0.67	0.62	0.65
Jan. 2005 - Dec. 2008	0.81	0.85	0.84	0.63	0.66	0.66
Jan. 2009 - Dec. 2012	0.81	0.80	0.77	0.63	0.62	0.59
Jan. 2013 - Jul. 2016	0.79	0.76	0.75	0.61	0.59	0.57
<i>Top 100 firms in Diebold-Yilmaz network</i>						
Jan. 2001 - Jul. 2016	0.62	0.63	0.71	0.47	0.47	0.53
Jan. 2001 - Dec. 2004	0.71	0.73	0.71	0.54	0.55	0.52
Jan. 2005 - Dec. 2008	0.54	0.27	0.15	0.41	0.20	0.11
Jan. 2009 - Dec. 2012	0.61	0.62	0.46	0.46	0.47	0.34
Jan. 2013 - Jul. 2016	0.63	0.60	0.47	0.46	0.44	0.33
<i>Top 100 firms in corrected Lanne-Nyberg-Diebold-Yilmaz network</i>						
Jan. 2001 - Jul. 2016	0.78	0.77	0.79	0.59	0.58	0.61
Jan. 2001 - Dec. 2004	0.77	0.73	0.65	0.59	0.55	0.49
Jan. 2005 - Dec. 2008	0.55	0.26	0.20	0.39	0.18	0.13
Jan. 2009 - Dec. 2012	0.62	0.51	0.43	0.45	0.36	0.30
Jan. 2013 - Jul. 2016	0.51	0.41	0.38	0.36	0.28	0.25

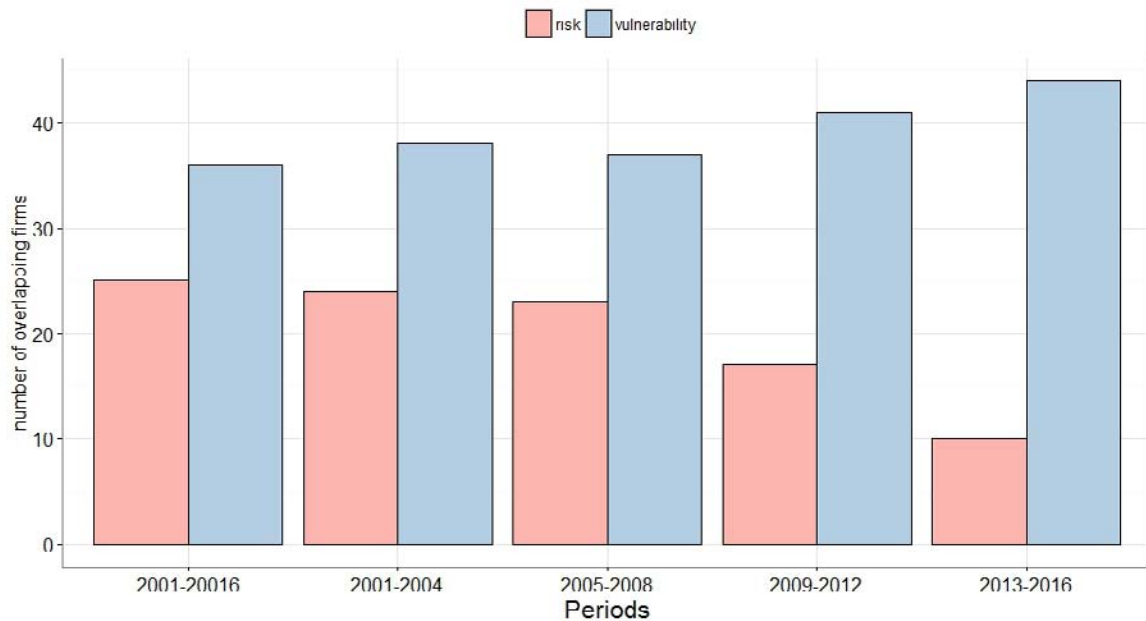
\* All correlations significantly different from zero, except in the January 2009 – December 2012 and the January 2013 – July 2016 periods for the top 100 firms in the Diebold-Yilmaz network. Source: Bloomberg LLP and author's calculations.

Although there is a positive correlation between the DY and CLNDY systemic rankings comprising all firms, the correlation is weaker for risk rankings (Table 2, Panel A) than for vulnerability rankings (Table 2, Panel B). Moreover, the systemic risk ranking correlations dropped in the last subsample period; on the contrary, systemic vulnerability ranking correlations were in line with the values observed in earlier periods or in the full sample period.

The differences in systemic risk rankings introduced by the choice of variance decomposition become more evident in a correlation analysis restricted only to rankings of the top one hundred riskiest firms. In the first exercise, the top one hundred firms correspond to those identified by the DY network. The correlations with the corresponding rankings in the CLNDY network are very low, and in some instances, statistically insignificant. In the second exercise, the top one hundred firms correspond to those identified by the CLNDY network. In this case, the rankings appeared quite correlated in the pre-crisis period of January 2001 to December 2004, but have decoupled since then. As for the top one hundred vulnerable firms, regardless of whether the DY or the CLNDY network guide their selection, rank correlations are higher than for the top one hundred riskiest firms, but they declined sharply in the run up to the Lehman Brothers bankruptcy and global financial crisis during the period of January 2005 – December 2008.

Figure 2, which shows the number of overlapping firms in the DY and CLNDY rankings of the top fifty riskiest and most vulnerable firms, reinforces the analysis. The overlap is considerable for the vulnerability rankings, ranging from 70 to 90 percent depending on the sample period. In the risk rankings, however, the overlap does not exceed 50 percent and has declined in the most recent sub-period. Tables 3 and 4, listing the top firms, provide more details.

Figure 2. Number of overlapping firms in the top fifty DY and CLNDY rankings (ranking based on a VAR(8) specification)



Source: Bloomberg LLP and author's calculations.

Table 3a. Systemic risk rankings, all firms: January 2001 – December 2004  
(ranking based on a VAR(8) specification)

Ranking	Systemic risk ranking			
	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	NOVAE GROUP PLC	UNITED KINGDOM	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY
2	SCOR SE	FRANCE	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN
3	MEDIOLANUM S.P.A	ITALY	SOCIETE GENERALE	FRANCE
4	YAPI VE KREDI BANKASI AS	TURKEY	AXA SA	FRANCE
5	ZURICH INSURANCE GROUP LIMITED	SWITZERLAND	MEDIOLANUM S.P.A	ITALY
6	AXA SA	FRANCE	BANCO SANTANDER SA	SPAIN
7	TURKIYE IS BANKASI A.S.	TURKEY	ING GROEP N.V.	NETHERLANDS
8	SMSS LIFE HOLDING AG	SWITZERLAND	BNP PARIBAS SA	FRANCE
9	RSA INSURANCE GROUP PLC	UNITED KINGDOM	BANKINTER, S.A.	SPAIN
10	COMMERZBANK AKTIENGESELLSCHAFT	GERMANY	STANDARD CHARTERED PLC	UNITED KINGDOM
11	AEGON N.V.	NETHERLANDS	CREDIT SUISSE GROUP AG	SWITZERLAND
12	ING GROEP N.V.	NETHERLANDS	ALLIANZ SE	GERMANY
13	GUNES SIGORTA A.S.	TURKEY	MEDIOBANCA SPA	ITALY
14	ALLIANZ SE	GERMANY	COMMERZBANK AKTIENGESELLSCHAFT	GERMANY
15	SINAR MAS MULTIARTHA TBK PT	INDONESIA	UBS AG	SWITZERLAND
16	TURKIYE GARANTI BANKASI A.S.	TURKEY	UNICREDIT SPA	ITALY
17	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY	UBS GROUP AG	SWITZERLAND
18	RAY SIGORTA A.S.	TURKEY	PRUDENTIAL PLC	UNITED KINGDOM
19	MUENCHENER RUCKVERSICHERUNGS-GESELLSCHAFT	GERMANY	NORTHERN TRUST CORP	UNITED STATES
20	CNP ASSURANCES	FRANCE	ASSICURAZIONI GENERALI SPA	ITALY
21	ANADOLU HAYAT EMEKLILIK A.S.	TURKEY	HARTFORD FINANCIAL SERVICES	UNITED STATES
22	PRUDENTIAL PLC	UNITED KINGDOM	TORCHMARK CORP	UNITED STATES
23	CREDIT SUISSE GROUP AG	SWITZERLAND	ZURICH INSURANCE GROUP LIMITED	SWITZERLAND
24	PANIN FINANCIAL TBK PT	INDONESIA	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM
25	SOCIETE GENERALE	FRANCE	MUENCHENER RUCKVERSICHERUNGS-GESELLSCHAFT	GERMANY
26	HANNOVER RUECK SE	GERMANY	SWEDBANK AB	SWEDEN
27	AKSIGORTA ANONIM SIRKETI	TURKEY	HSBC HOLDINGS PLC	UNITED KINGDOM
28	AKBANK TAS	TURKEY	BANCA MONTE DEI PASCHI DI SIENA SPA	ITALY
29	HANOVER INSURANCE GROUP INC	UNITED STATES	SUN LIFE FINANCIAL INC	CANADA
30	AMLIN PLC	UNITED KINGDOM	MBIA INC	UNITED STATES
31	BANCO DO BRASIL SA	BRAZIL	LINCOLN NATIONAL CORP	UNITED STATES
32	BNP PARIBAS SA	FRANCE	KBC GROUP NV	BELGIUM
33	CHUBB CORP	UNITED STATES	SWISS RE AG	SWITZERLAND
34	BALOISE HOLDING AG	SWITZERLAND	AEGON N.V.	NETHERLANDS
35	HISCOX PLC	UNITED KINGDOM	DEXIA SA	BELGIUM
36	BANCO BRADESCO S.A.	BRAZIL	HANNOVER RUECK SE	GERMANY
37	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN	METLIFE INC	UNITED STATES
38	HACI OMER SABANCI HOLDING A.S.	TURKEY	CITIGROUP INC	UNITED STATES
39	JPMORGAN CHASE & CO	UNITED STATES	BALOISE HOLDING AG	SWITZERLAND
40	DEXIA SA	BELGIUM	STATE STREET CORP	UNITED STATES
41	BANCO SANTANDER SA	SPAIN	BARCLAYS PLC	UNITED KINGDOM
42	MORGAN STANLEY	UNITED STATES	JPMORGAN CHASE & CO	UNITED STATES
43	AVIVA PLC	UNITED KINGDOM	AMLIN PLC	UNITED KINGDOM
44	ITAU UNIBANCO HOLDING S.A.	BRAZIL	MANULIFE FINANCIAL CORP	CANADA
45	SMSS RE AG	SWITZERLAND	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN
46	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN	BANCA POPOLARE DELL'EMILIA ROMAGNA SC	ITALY
47	FEDERATED NATIONAL HLDG CO	UNITED STATES	VITTORIA ASSICURAZIONI SPA	ITALY
48	INTESA SANPAOLO SPA	ITALY	WELLS FARGO & CO	UNITED STATES
49	BANCA MONTE DEI PASCHI DI SIENA SPA	ITALY	OLD MUTUAL PLC	UNITED KINGDOM
50	STANDARD CHARTERED PLC	UNITED KINGDOM	BANCO COMERCIAL PORTUGUES, S.A.	PORTUGAL

Source: Bloomberg LLP and author's calculations.

Table 3b. Systemic risk rankings, all firms: January 2005 – December 2008  
(ranking based on a VAR(8) specification)

Systemic risk ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	AMERICAN INTERNATIONAL GROUP	UNITED STATES	AMERICAN INTERNATIONAL GROUP	UNITED STATES
2	RADIAN GROUP INC	UNITED STATES	MORGAN STANLEY	UNITED STATES
3	MBIA INC	UNITED STATES	REGIONS FINANCIAL CORP	UNITED STATES
4	MGIC INVESTMENT CORP/ WM	UNITED STATES	COMERICA INC	UNITED STATES
5	GENWORTH FINANCIAL INC	UNITED STATES	CHUBB CORP	UNITED STATES
6	XL GROUP PLC – ADR	IRELAND	WELLS FARGO & CO	UNITED STATES
7	REGIONS FINANCIAL CORP	UNITED STATES	SUNTRUST BANKS INC	UNITED STATES
8	MORGAN STANLEY	UNITED STATES	HUMANA INC	UNITED STATES
9	ASSURED GUARANTY LTD	BERMUDA	CNA FINANCIAL CORP	UNITED STATES
10	HUMANA INC	UNITED STATES	MERCURY GENERAL CORP	UNITED STATES
11	COMERICA INC	UNITED STATES	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY
12	PERMANENT TSB GROUP HOLDINGS PLC	IRELAND	GENWORTH FINANCIAL INC	UNITED STATES
13	UTG INC	UNITED STATES	MARKEL CORP	UNITED STATES
14	CITIGROUP INC	UNITED STATES	AMERICAN FINANCIAL GROUP INC	UNITED STATES
15	ITAU UNIBANCO HOLDING S.A.	BRAZIL	GOLDMAN SACHS GROUP INC	UNITED STATES
16	ZIONS BANCORPORATION	UNITED STATES	PRUDENTIAL FINANCIAL INC	UNITED STATES
17	CNO FINANCIAL GROUP INC	UNITED STATES	BANK OF AMERICA CORP	UNITED STATES
18	HARTFORD FINANCIAL SERVICES	UNITED STATES	ZIONS BANCORPORATION	UNITED STATES
19	SUNTRUST BANKS INC	UNITED STATES	OLD REPUBLIC INTL CORP	UNITED STATES
20	RAY SIGORTA A.S.	TURKEY	METLIFE INC	UNITED STATES
21	BANCO DO BRASIL SA	BRAZIL	ALLSTATE CORP	UNITED STATES
22	WELLS FARGO & CO	UNITED STATES	CREDIT SUISSE GROUP AG	SWITZERLAND
23	BANCO BRADESCO S.A.	BRAZIL	LINCOLN NATIONAL CORP	UNITED STATES
24	BARCLAYS PLC	UNITED KINGDOM	ALLEGHANY CORP	UNITED STATES
25	AKSIGORTA ANONIM SIRKETI	TURKEY	XL GROUP PLC – ADR	IRELAND
26	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM	HORACE MANN EDUCATORS CORP	UNITED STATES
27	PRUDENTIAL FINANCIAL INC	UNITED STATES	CITIGROUP INC	UNITED STATES
28	LINCOLN NATIONAL CORP	UNITED STATES	BB&T CORP	UNITED STATES
29	KEYCORP	UNITED STATES	TRAVELERS COS INC	UNITED STATES
30	TURNERS LTD	NEW ZEALAND	KBC GROUP NV	BELGIUM
31	CREDIT SUISSE GROUP AG	SWITZERLAND	PROASSURANCE CORP	UNITED STATES
32	MACQUARIE GROUP LIMITED	AUSTRALIA	CNO FINANCIAL GROUP INC	UNITED STATES
33	GOLDMAN SACHS GROUP INC	UNITED STATES	SUN LIFE FINANCIAL INC	CANADA
34	STANDARD CHARTERED PLC	UNITED KINGDOM	AXA SA	FRANCE
35	BANK OF AMERICA CORP	UNITED STATES	ARCH CAPITAL GROUP LTD	BERMUDA
36	AKBANK TAS	TURKEY	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN
37	HORACE MANN EDUCATORS CORP	UNITED STATES	KEMPER CORP/ DE	UNITED STATES
38	TURKIYE IS BANKASI A.S.	TURKEY	BANCO SANTANDER SA	SPAIN
39	LLOYDS BANKING GROUP PLC	UNITED KINGDOM	EVEREST RE GROUP LTD	BERMUDA
40	BANK OF IRELAND	IRELAND	CANADIAN IMPERIAL BANK	CANADA
41	SBERBANK ROSSII OAO	RUSSIAN FEDERATION	ALLIANZ SE	GERMANY
42	TURKIYE GARANTI BANKASI A.S.	TURKEY	CINCINNATI FINANCIAL CORP	UNITED STATES
43	SOCIETE GENERALE	FRANCE	LLOYDS BANKING GROUP PLC	UNITED KINGDOM
44	ALLIED IRISH BANKS PLC	IRELAND	UBS AG	SWITZERLAND
45	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY	STATE AUTO FINANCIAL CORP	UNITED STATES
46	STATE AUTO FINANCIAL CORP	UNITED STATES	AEGON N.V.	NETHERLANDS
47	CNA FINANCIAL CORP	UNITED STATES	U S BANCORP	UNITED STATES
48	FIFTH THIRD BANCORP	UNITED STATES	UBS GROUP AG	SWITZERLAND
49	CHALLENGER FINANCIAL SERVICES GROUP LTD	AUSTRALIA	STANDARD CHARTERED PLC	UNITED KINGDOM
50	AAREAL BANK AG	GERMANY	M & T BANK CORP	UNITED STATES

Source: Bloomberg LLP and author's calculations.

Table 3c. Systemic risk rankings, all firms: January 2009 – December 2012  
(ranking based on a VAR(8) specification)

Systemic risk ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	RADIAN GROUP INC	UNITED STATES	AEGON N.V.	NETHERLANDS
2	KBC GROUP NV	BELGIUM	ING GROEP N.V.	NETHERLANDS
3	BANK OF IRELAND	IRELAND	ALLIANZ SE	GERMANY
4	ALLIED IRISH BANKS PLC	IRELAND	AFLAC INC	UNITED STATES
5	MGIC INVESTMENT CORP/ WM	UNITED STATES	LOEWS CORP	UNITED STATES
6	ING GROEP N.V.	NETHERLANDS	SAMPO OYJ	FINLAND
7	SOCIETE GENERALE	FRANCE	METLIFE INC	UNITED STATES
8	PHOENIX COMPANIES INC	UNITED STATES	UNUM GROUP	UNITED STATES
9	BARCLAYS PLC	UNITED KINGDOM	AXA SA	FRANCE
10	CREDIT AGRICOLE SA	FRANCE	AVIVA PLC	UNITED KINGDOM
11	AMERICAN INTERNATIONAL GROUP	UNITED STATES	BNP PARIBAS SA	FRANCE
12	AEGON N.V.	NETHERLANDS	POWER CORP CANADA	CANADA
13	NATIXIS	FRANCE	HSBC HOLDINGS PLC	UNITED KINGDOM
14	AAREAL BANK AG	GERMANY	BARCLAYS PLC	UNITED KINGDOM
15	CNO FINANCIAL GROUP INC	UNITED STATES	CREDIT AGRICOLE SA	FRANCE
16	UNICREDIT SPA	ITALY	POWER FINANCIAL CORP	CANADA
17	LLOYDS BANKING GROUP PLC	UNITED KINGDOM	SOCIETE GENERALE	FRANCE
18	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY
19	GENWORTH FINANCIAL INC	UNITED STATES	HARTFORD FINANCIAL SERVICES	UNITED STATES
20	COMMERZBANK AKTIENGESELLSCHAFT	GERMANY	BANK OF MONTREAL	CANADA
21	HARTFORD FINANCIAL SERVICES	UNITED STATES	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN
22	ERSTE GROUP BANK AG	AUSTRIA	NORDEA BANK AB	SWEDEN
23	EUROBANK ERGASIAS SA	GREECE	AMERICAN FINANCIAL GROUP INC	UNITED STATES
24	AXA SA	FRANCE	TORONTO DOMINION BANK	CANADA
25	BNP PARIBAS SA	FRANCE	COMMONWEALTH BANK OF AUSTRALIA	AUSTRALIA
26	RAIFFEISEN BANK INTERNATIONAL AG	AUSTRIA	PRUDENTIAL FINANCIAL INC	UNITED STATES
27	ALPHA BANK SA	GREECE	SWISS RE AG	SWITZERLAND
28	INTESA SANPAOLO SPA	ITALY	ZURICH INSURANCE GROUP LIMITED	SWITZERLAND
29	MBIA INC	UNITED STATES	SVENSKA HANDELSBANKEN AB	SWEDEN
30	CITIGROUP INC	UNITED STATES	ASSICURAZIONI GENERALI SPA	ITALY
31	STOREBRAND ASA	NORWAY	TORCHMARK CORP	UNITED STATES
32	ASSURED GUARANTY LTD	BERMUDA	POHJOLA BANK PLC	FINLAND
33	BANCO POPOLARE	ITALY	BANK OF NOVA SCOTIA	CANADA
34	REGIONS FINANCIAL CORP	UNITED STATES	CANADIAN IMPERIAL BANK	CANADA
35	FIFTH THIRD BANCORP	UNITED STATES	LLOYDS BANKING GROUP PLC	UNITED KINGDOM
36	ZIONS BANCORPORATION	UNITED STATES	NATIONAL AUSTRALIA BANK LIMITED	AUSTRALIA
37	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN	SWISS LIFE HOLDING AG	SWITZERLAND
38	BANK OF PIRAEUS S.A.	GREECE	BALOISE HOLDING AG	SWITZERLAND
39	DEXIA SA	BELGIUM	HELVETIA HOLDING AG	SWITZERLAND
40	LINCOLN NATIONAL CORP	UNITED STATES	AAREAL BANK AG	GERMANY
41	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM
42	BANK OF AMERICA CORP	UNITED STATES	KBC GROUP NV	BELGIUM
43	UNIPOLSAI ASSICURAZIONI SPA	ITALY	DNB ASA	NORWAY
44	SWEDBANK AB	SWEDEN	MANULIFE FINANCIAL CORP	CANADA
45	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN	VIENNA INSURANCE GROUP	AUSTRIA
46	NATIONAL BANK OF GREECE, S.A.	GREECE	INTESA SANPAOLO SPA	ITALY
47	AVIVA PLC	UNITED KINGDOM	OLD MUTUAL PLC	UNITED KINGDOM
48	PERMANENT TSB GROUP HOLDINGS PLC	IRELAND	ACKERMANS & VAN HAAREN	BELGIUM
49	HUMANA INC	UNITED STATES	ROYAL BANK OF CANADA	CANADA
50	SUNTRUST BANKS INC	UNITED STATES	ERSTE GROUP BANK AG	AUSTRIA

Source: Bloomberg LLP and author's calculations.

Table 3d. Systemic risk rankings, all firms: January 2013 – July 2016  
(ranking based on a VAR(8) specification)

Systemic risk ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	BANK OF PIRAEUS S.A.	GREECE	OLD MUTUAL PLC	UNITED KINGDOM
2	NATIONAL BANK OF GREECE, S.A.	GREECE	AMERIPRISE FINANCIAL INC	UNITED STATES
3	EUROBANK ERGASIAS SA	GREECE	PRUDENTIAL PLC	UNITED KINGDOM
4	BANKIA SAU	SPAIN	METLIFE INC	UNITED STATES
5	ALPHA BANK SA	GREECE	PRUDENTIAL FINANCIAL INC	UNITED STATES
6	GENWORTH FINANCIAL INC	UNITED STATES	MANULIFE FINANCIAL CORP	CANADA
7	SANLAM LIMITED	SOUTH AFRICA	CITIGROUP INC	UNITED STATES
8	CPFGROUP PLC	UNITED KINGDOM	AMERICAN INTERNATIONAL GROUP	UNITED STATES
9	BANCO COMERCIAL PORTUGUES, S.A.	PORTUGAL	SOCIETE GENERALE	FRANCE
10	BANCO DO BRASIL SA	BRAZIL	LINCOLN NATIONAL CORP	UNITED STATES
11	BANCA MONTE DEI PASCHI DI SIENA SPA	ITALY	GOLDMAN SACHS GROUP INC	UNITED STATES
12	OLD MUTUAL PLC	UNITED KINGDOM	TORCHMARK CORP	UNITED STATES
13	MMI HOLDINGS LIMITED	SOUTH AFRICA	LOEWS CORP	UNITED STATES
14	BANCO POPOLARE	ITALY	SANLAM LIMITED	SOUTH AFRICA
15	DISCOVERY LTD	SOUTH AFRICA	AMERICAN FINANCIAL GROUP INC	UNITED STATES
16	SOCIETE GENERALE	FRANCE	U S BANCORP	UNITED STATES
17	FIRSTRAND LIMITED	SOUTH AFRICA	POWER FINANCIAL CORP	CANADA
18	STANDARD BANK GROUP LIMITED	SOUTH AFRICA	UBS GROUP AG	SWITZERLAND
19	BANCO POPULAR ESPANOL	SPAIN	OLD REPUBLIC INTL CORP	UNITED STATES
20	BANCO SABADELL	SPAIN	ST. JAMES'S PLACE PLC	UNITED KINGDOM
21	BANCO BRADESCO S.A.	BRAZIL	AXA SA	FRANCE
22	BANCA POPOLARE DELL'EMILIA ROMAGNA SC	ITALY	SUN LIFE FINANCIAL INC	CANADA
23	ALLIED IRISH BANKS PLC	IRELAND	CNO FINANCIAL GROUP INC	UNITED STATES
24	RMB HOLDINGS LIMITED	SOUTH AFRICA	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN
25	LINCOLN NATIONAL CORP	UNITED STATES	SUNTRUST BANKS INC	UNITED STATES
26	UBI BANCA	ITALY	HUMANA INC	UNITED STATES
27	MBIA INC	UNITED STATES	AFLAC INC	UNITED STATES
28	BARCLAYS AFRICA GROUP LTD	SOUTH AFRICA	POWER CORP CANADA	CANADA
29	PORTO SEGURO SA	BRAZIL	HSBC HOLDINGS PLC	UNITED KINGDOM
30	DELTA LLOYD NV	NETHERLANDS	BANCO SANTANDER SA	SPAIN
31	BANCO SANTANDER BRASIL SA	BRAZIL	ALLIANZ SE	GERMANY
32	CREDIT AGRICOLE SA	FRANCE	CREDIT AGRICOLE SA	FRANCE
33	ST. JAMES'S PLACE PLC	UNITED KINGDOM	PNC FINANCIAL SVCS GROUP INC	UNITED STATES
34	AMERICAN EQTY INVT LIFE HLDG	UNITED STATES	JPMORGAN CHASE & CO	UNITED STATES
35	STOREBRAND ASA	NORWAY	MMI HOLDINGS LIMITED	SOUTH AFRICA
36	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY	STATE STREET CORP	UNITED STATES
37	NEDBANK GROUP LIMITED	SOUTH AFRICA	FIFTH THIRD BANCORP	UNITED STATES
38	LIBERTY HOLDINGS LIMITED	SOUTH AFRICA	MORGAN STANLEY	UNITED STATES
39	HUATAI SECURITIES COMPANY LIMITED	CHINA	BANK OF NEW YORK MELLON CORP	UNITED STATES
40	UNICREDIT SPA	ITALY	BB&T CORP	UNITED STATES
41	BANCO SANTANDER SA	SPAIN	NORTHERN TRUST CORP	UNITED STATES
42	PRUDENTIAL PLC	UNITED KINGDOM	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY
43	NATIXIS	FRANCE	AVIVA PLC	UNITED KINGDOM
44	STANDARD CHARTERED PLC	UNITED KINGDOM	MAFFRE SA	SPAIN
45	MACQUARIE GROUP LIMITED	AUSTRALIA	BANK OF NOVA SCOTIA	CANADA
46	AKBANK TAS	TURKEY	ROYAL BANK OF CANADA	CANADA
47	TURKIYE IS BANKASI A.S.	TURKEY	BNP PARIBAS SA	FRANCE
48	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM	ING GROEP N.V.	NETHERLANDS
49	MEDIOBANCA SPA	ITALY	AUSTRALIA AND NEW ZEALAND BANKING GROUP	AUSTRALIA
50	SUL AMERICA S.A.	BRAZIL	BANK OF MONTREAL	CANADA

Source: Bloomberg LLP and author's calculations.



Table 3e. Systemic risk rankings, all firms: January 2001 – July 2016  
(ranking based on a VAR(8) specification)

Systemic risk ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	RADIAN GROUP INC	UNITED STATES	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM
2	ROYAL BANK OF SCOTLAND GROUP PLC	UNITED KINGDOM	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY
3	MGIC INVESTMENT CORP/ WI	UNITED STATES	METLIFE INC	UNITED STATES
4	MBIA INC	UNITED STATES	XL GROUP PLC – ADR	IRELAND
5	BANK OF IRELAND	IRELAND	BANK OF AMERICA CORP	UNITED STATES
6	KBC GROUP NV	BELGIUM	ING GROEP N.V.	NETHERLANDS
7	BARCLAYS PLC	UNITED KINGDOM	AXA SA	FRANCE
8	XL GROUP PLC – ADR	IRELAND	BARCLAYS PLC	UNITED KINGDOM
9	AMERICAN INTERNATIONAL GROUP	UNITED STATES	TORCHMARK CORP	UNITED STATES
10	HARTFORD FINANCIAL SERVICES	UNITED STATES	AMERICAN FINANCIAL GROUP INC	UNITED STATES
11	ING GROEP N.V.	NETHERLANDS	KBC GROUP NV	BELGIUM
12	ALLIED IRISH BANKS PLC	IRELAND	MORGAN STANLEY	UNITED STATES
13	CITIGROUP INC	UNITED STATES	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN
14	AEGON N.V.	NETHERLANDS	SUN LIFE FINANCIAL INC	CANADA
15	MORGAN STANLEY	UNITED STATES	CREDIT SUISSE GROUP AG	SWITZERLAND
16	LLOYDS BANKING GROUP PLC	UNITED KINGDOM	HSBC HOLDINGS PLC	UNITED KINGDOM
17	SOCIETE GENERALE	FRANCE	ALLIANZ SE	GERMANY
18	FIFTH THIRD BANCORP	UNITED STATES	CNA FINANCIAL CORP	UNITED STATES
19	DEUTSCHE BANK AKTIENGESELLSCHAFT	GERMANY	MANULIFE FINANCIAL CORP	CANADA
20	BANK OF AMERICA CORP	UNITED STATES	AEGON N.V.	NETHERLANDS
21	LINCOLN NATIONAL CORP	UNITED STATES	ROYAL BANK OF CANADA	CANADA
22	COMMERZBANK AKTIENGESELLSCHAFT	GERMANY	CITIGROUP INC	UNITED STATES
23	AXA SA	FRANCE	SOCIETE GENERALE	FRANCE
24	BANK OF PIRAEUS S.A.	GREECE	LINCOLN NATIONAL CORP	UNITED STATES
25	UNICREDIT SPA	ITALY	SUNTRUST BANKS INC	UNITED STATES
26	REGIONS FINANCIAL CORP	UNITED STATES	LLOYDS BANKING GROUP PLC	UNITED KINGDOM
27	NATIONAL BANK OF GREECE, S.A.	GREECE	LOEWS CORP	UNITED STATES
28	ERSTE GROUP BANK AG	AUSTRIA	UBS GROUP AG	SWITZERLAND
29	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN	SKANDINAVISKA ENSKILDA BANKEN	SWEDEN
30	SUNTRUST BANKS INC	UNITED STATES	CINCINNATI FINANCIAL CORP	UNITED STATES
31	HUMANA INC	UNITED STATES	BANK OF NOVA SCOTIA	CANADA
32	KEYCORP	UNITED STATES	AFLAC INC	UNITED STATES
33	CREDIT SUISSE GROUP AG	SWITZERLAND	ALLSTATE CORP	UNITED STATES
34	EUROBANK ERGASIAS SA	GREECE	CANADIAN IMPERIAL BANK	CANADA
35	AVIVA PLC	UNITED KINGDOM	REINSURANCE GROUP AMER INC	UNITED STATES
36	PERMANENT TSB GROUP HOLDINGS PLC	IRELAND	OLD REPUBLIC INTL CORP	UNITED STATES
37	STOREBRAND ASA	NORWAY	HORACE MANN EDUCATORS CORP	UNITED STATES
38	ZIONS BANCORPORATION	UNITED STATES	BANCO SANTANDER SA	SPAIN
39	METLIFE INC	UNITED STATES	KEYCORP	UNITED STATES
40	PRUDENTIAL PLC	UNITED KINGDOM	UBS AG	SWITZERLAND
41	INTESA SANPAOLO SPA	ITALY	TORONTO DOMINION BANK	CANADA
42	BNP PARIBAS SA	FRANCE	PRUDENTIAL PLC	UNITED KINGDOM
43	BANCO BILBAO VIZCAYA ARGENTARIA SA	SPAIN	BNP PARIBAS SA	FRANCE
44	ALLIANZ SE	GERMANY	POWER FINANCIAL CORP	CANADA
45	NATIXIS	FRANCE	NORDEA BANK AB	SWEDEN
46	BANCO DO BRASIL SA	BRAZIL	AVIVA PLC	UNITED KINGDOM
47	DNB ASA	NORWAY	POWER CORP CANADA	CANADA
48	SWISS LIFE HOLDING AG	SWITZERLAND	KEMPER CORP/ DE	UNITED STATES
49	STANDARD CHARTERED PLC	UNITED KINGDOM	GOLDMAN SACHS GROUP INC	UNITED STATES
50	BANCO SANTANDER SA	SPAIN	U S BANCORP	UNITED STATES

Source: Bloomberg LLP and author's calculations.

Table 4a. Systemic vulnerability rankings, all firms: January 2001 – December 2004  
(ranking based on a VAR(8) specification)

Systemic vulnerability ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	CHINA MINSHENG BANKING CORPORATION LIMITED	CHINA	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN
2	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN	ICICI BANK LIMITED	INDIA
3	ICICI BANK LIMITED	INDIA	CHINA MINSHENG BANKING CORPORATION LIMITED	CHINA
4	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG	AXIS BANK LIMITED	INDIA
5	NATIONAL SEC GROUP INC	UNITED STATES	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG
6	STATE BANK OF INDIA	INDIA	STATE BANK OF INDIA	INDIA
7	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE	ASURANSI BINTANG TBK PT	INDONESIA
8	PING AN BANK COMPANY LIMITED	CHINA	NATIONAL SEC GROUP INC	UNITED STATES
9	AXIS BANK LIMITED	INDIA	ADITYA BIRLA NUVO LIMITED	INDIA
10	INDEQUITY GROUP LIMITED	SOUTH AFRICA	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN
11	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN	PING AN BANK COMPANY LIMITED	CHINA
12	HAITONG SECURITIES CO. LIMITED	CHINA	INDEQUITY GROUP LIMITED	SOUTH AFRICA
13	SHANGHAI PUDONG DEVELOPMENT BANK	CHINA	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN
14	ASURANSI BINTANG TBK PT	INDONESIA	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN
15	ADITYA BIRLA NUVO LIMITED	INDIA	PANINVEST TBK PT	INDONESIA
16	CENTRAL REINSURANCE CORPORATION	TAIWAN	PANIN FINANCIAL TBK PT	INDONESIA
17	BANCA POPOLARE DELL'EMILIA ROMAGNA SC	ITALY	HAITONG SECURITIES CO. LIMITED	CHINA
18	NUERNBERGER BETEILIGUNGS-AG	GERMANY	SHANGHAI PUDONG DEVELOPMENT BANK	CHINA
19	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO
20	NAVIGATORS GROUP INC	UNITED STATES	NAVIGATORS GROUP INC	UNITED STATES
21	HCC INSURANCE HOLDINGS INC	UNITED STATES	ANADOLU ANONIM TURK SIGORTA SIRKETI	TURKEY
22	GRUPO CATALANA OCCIDENTE SA	SPAIN	YAPI VE KREDI BANKASI AS	TURKEY
23	ANADOLU ANONIM TURK SIGORTA SIRKETI	TURKEY	CHINA TAIPING INSURANCE HOLDINGS COMPANY LIMITED	HONG KONG
24	UNIQA INSURANCE GROUP AG	AUSTRIA	CENTRAL REINSURANCE CORPORATION	TAIWAN
25	FIRST ACCEPTANCE CORP	UNITED STATES	EMC INSURANCE GROUP INC	UNITED STATES
26	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY	MEADOWBROOK INS GROUP INC	UNITED STATES
27	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN	MIN XIN HOLDINGS LTD.	HONG KONG
28	TURNERS LTD	NEW ZEALAND	SBERBANK ROSSII OAO	RUSSIAN FEDERATI
29	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN	FIRST ACCEPTANCE CORP	UNITED STATES
30	KANSAS CITY LIFE INS CO	UNITED STATES	MASKAPAI REASURANSI INDONESIA TBK PT	INDONESIA
31	POHJOLA BANK PLC	FINLAND	NUERNBERGER BETEILIGUNGS-AG	GERMANY
32	HANG SENG BANK LIMITED	HONG KONG	BANK OF INDIA	INDIA
33	WHITE MTNS INS GROUP LTD	BERMUDA	BANK OF BARODA	INDIA
34	HDFC BANK LIMITED	INDIA	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE
35	AMERICAN NATIONAL INSURANCE	UNITED STATES	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY
36	CHINA TAIPING INSURANCE HOLDINGS COMPANY LIMITED	HONG KONG	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN
37	NATIONAL WESTERN LIFE -CL A	UNITED STATES	ASURANSI DAYIN MITRA TBK PT	INDONESIA
38	RENAISSANCERE HOLDINGS LTD	BERMUDA	HCC INSURANCE HOLDINGS INC	UNITED STATES
39	MIN XIN HOLDINGS LTD.	HONG KONG	TURNERS LTD	NEW ZEALAND
40	EMC INSURANCE GROUP INC	UNITED STATES	TOWER LIMITED	NEW ZEALAND
41	MERCURY GENERAL CORP	UNITED STATES	SELECTIVE INS GROUP INC	UNITED STATES
42	WESTPAC BANKING CORPORATION	AUSTRALIA	HDFC BANK LIMITED	INDIA
43	VAUDOISE ASSURANCES HOLDING	SWITZERLAND	VAUDOISE ASSURANCES HOLDING	SWITZERLAND
44	KEMPER CORP DE	UNITED STATES	UNIQA INSURANCE GROUP AG	AUSTRIA
45	COMMONWEALTH BANK OF AUSTRALIA	AUSTRALIA	BANCA POPOLARE DELL'EMILIA ROMAGNA SC	ITALY
46	SELECTIVE INS GROUP INC	UNITED STATES	CITIZENS INC	UNITED STATES
47	MARKEL CORP	UNITED STATES	RENAISSANCERE HOLDINGS LTD	BERMUDA
48	ALLEGHANY CORP	UNITED STATES	KANSAS CITY LIFE INS CO	UNITED STATES
49	PERSONAL GROUP HOLDINGS PLC	UNITED KINGDOM	WHITE MTNS INS GROUP LTD	BERMUDA
50	FIFTH THIRD BANCORP	UNITED STATES	NATIONAL WESTERN LIFE -CL A	UNITED STATES

Source: Bloomberg LLP and author's calculations.

Table 4b. Systemic vulnerability rankings, all firms: January 2005 – December 2008  
(rankings based on a VAR(8) specification)

Systemic vulnerability ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	SHINKONG INSURANCE CO LTD	TAIWAN	SHINKONG INSURANCE CO LTD	TAIWAN
2	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN
3	ADITYA BIRLA NUVO LIMITED	INDIA	ADITYA BIRLA NUVO LIMITED	INDIA
4	PUNJAB NATIONAL BANK LTD	INDIA	PUNJAB NATIONAL BANK LTD	INDIA
5	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	ICICI BANK LIMITED	INDIA
6	ICICI BANK LIMITED	INDIA	BANK OF BARODA	INDIA
7	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
8	BANK OF BARODA	INDIA	CANARA BANK	INDIA
9	CANARA BANK	INDIA	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY
10	INDEQUITY GROUP LIMITED	SOUTH AFRICA	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
11	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY	INDEQUITY GROUP LIMITED	SOUTH AFRICA
12	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN	AXIS BANK LIMITED	INDIA
13	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	SBERBANK ROSSII OAO	RUSSIA
14	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	SHIN KONG FINANCIAL HOLDING COMPANY LIMI	TAIWAN
15	HDFC BANK LIMITED	INDIA	HDFC BANK LIMITED	INDIA
16	AXIS BANK LIMITED	INDIA	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN
17	SHIN KONG FINANCIAL HOLDING COMPANY LIMI	TAIWAN	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
18	CENTRAL REINSURANCE CORPORATION	TAIWAN	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN
19	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
20	INVESTEC LIMITED	SOUTH AFRICA	UTG INC	UNITED STATES
21	STATE BANK OF INDIA	INDIA	ARGO GROUP INTL HOLDINGS LTD	BERMUDA
22	NUERNBERGER BETELIGUNGS-AG	GERMANY	STATE BANK OF INDIA	INDIA
23	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO
24	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN	BANK OF INDIA	INDIA
25	GREAT EASTERN HOLDINGS LTD	SINGAPORE	CENTRAL REINSURANCE CORPORATION	TAIWAN
26	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN	UNION INSURANCE COMPANY LIMITED	TAIWAN
27	NOVAE GROUP PLC	UNITED KINGDOM	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN
28	ARGO GROUP INTL HOLDINGS LTD	BERMUDA	WELLCARE HEALTH PLANS INC	UNITED STATES
29	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN
30	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN
31	BANK OF INDIA	INDIA	INVESTEC LIMITED	SOUTH AFRICA
32	CHUGOKU BANK LIMITED (THE)	JAPAN	CITIC SECURITIES CO., LTD.	CHINA
33	SINGAPORE REINSURANCE CORPORATION LIMITE	SINGAPORE	DREAM INCUBATOR INCORPORATED	JAPAN
34	PERSONAL GROUP HOLDINGS PLC	UNITED KINGDOM	RAY SIGORTA A.S.	TURKEY
35	GLOBAL INDEMNITY PLC-ADR	IRELAND	PANINVEST TBK PT	INDONESIA
36	CHESNARA PLC	UNITED KINGDOM	NOVAE GROUP PLC	UNITED KINGDOM
37	E.L. FINANCIAL CORP LTD	CANADA	ATLANTIC AMERICAN CORP	UNITED STATES
38	SBERBANK ROSSII OAO	RUSSIAN FEDERATION	PING AN BANK COMPANY LIMITED	CHINA
39	HISCOX PLC	UNITED KINGDOM	TURNERS LTD	NEW ZEALAND
40	VITTORIA ASSICURAZIONI SPA	ITALY	PING AN INSURANCE (GROUP) COMPANY OF CHINA LTD	CHINA
41	UNICO AMERICAN CORP	UNITED STATES	GLOBAL INDEMNITY PLC-ADR	IRELAND
42	TRAVELERS COS INC	UNITED STATES	NUERNBERGER BETELIGUNGS-AG	GERMANY
43	INFINITY PROPERTY & CAS CORP	UNITED STATES	CENTENE CORP	UNITED STATES
44	PANINVEST TBK PT	INDONESIA	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG
45	PING AN INSURANCE (GROUP) COMPANY OF CHINA LTD	CHINA	PICC PROPERTY AND CASUALTY COMPANY LTD	CHINA
46	VAUDOISE ASSURANCES HOLDING	SWITZERLAND	PANIN FINANCIAL TBK PT	INDONESIA
47	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG	KINGSTONE COS INC	UNITED STATES
48	PICC PROPERTY AND CASUALTY COMPANY LTD	CHINA	SHANGHAI PUJONG DEVELOPMENT BANK	CHINA
49	LIBERTY HOLDINGS LIMITED	SOUTH AFRICA	FEDERATED NATIONAL HLDG CO	UNITED STATES
50	UNION INSURANCE COMPANY LIMITED	TAIWAN	HISCOX PLC	UNITED KINGDOM

Source: Bloomberg LLP and author's calculations.

Table 4c. Systemic vulnerability rankings, all firms: January 2009 – December 2012  
(rankings based on a VAR(8) specification)

Systemic vulnerability ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
2	HDFC BANK LIMITED	INDIA	HDFC BANK LIMITED	INDIA
3	SHINKONG INSURANCE CO LTD	TAIWAN	SHINKONG INSURANCE CO LTD	TAIWAN
4	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN	.JSC VTB BANK	RUSSIA
5	.JSC VTB BANK	RUSSIA	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN
6	SHIN KONG FINANCIAL HOLDING COMPANY LIM	TAIWAN	SHIN KONG FINANCIAL HOLDING COMPANY LIM	TAIWAN
7	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN	STATE BANK OF INDIA	INDIA
8	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN
9	STATE BANK OF INDIA	INDIA	BANK OF INDIA	INDIA
10	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN
11	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN
12	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
13	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
14	BANK OF INDIA	INDIA	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
15	UNICO AMERICAN CORP	UNITED STATES	PUNJAB NATIONAL BANK LTD	INDIA
16	GUNMA BANK LTD	JAPAN	CANARA BANK	INDIA
17	PUNJAB NATIONAL BANK LTD	INDIA	AXIS BANK LIMITED	INDIA
18	CENTRAL REINSURANCE CORPORATION	TAIWAN	BAJAJFINSERV LIMITED	INDIA
19	AXIS BANK LIMITED	INDIA	INDEQUITY GROUP LIMITED	SOUTH AFRICA
20	CANARA BANK	INDIA	CENTRAL REINSURANCE CORPORATION	TAIWAN
21	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN	UNICO AMERICAN CORP	UNITED STATES
22	INDEQUITY GROUP LIMITED	SOUTH AFRICA	GUNMA BANK LTD	JAPAN
23	BANK OF BARODA	INDIA	ADITYA BIRLA NUVO LIMITED	INDIA
24	ADITYA BIRLA NUVO LIMITED	INDIA	NATIONAL SEC GROUP INC	UNITED STATES
25	ICICI BANK LIMITED	INDIA	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN
26	BAJAJFINSERV LIMITED	INDIA	ICICI BANK LIMITED	INDIA
27	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN	BANK OF BARODA	INDIA
28	NATIONAL SEC GROUP INC	UNITED STATES	UNION INSURANCE COMPANY LIMITED	TAIWAN
29	HACHIJUNI BANK LIMITED (THE)	JAPAN	KINGSWAY FINANCIAL SVCS INC	CANADA
30	RESONA HOLDINGS INC	JAPAN	RESONA HOLDINGS INC	JAPAN
31	UNION INSURANCE COMPANY LIMITED	TAIWAN	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN
32	CHIBA BANK LTD (THE)	JAPAN	UNIVERSAL AMERICAN CORP	UNITED STATES
33	77 BANK LIMITED (THE)	JAPAN	ASURANSI MULTI ARTHA GUNA TBK PT	INDONESIA
34	.JOYO BANK LIMITED (THE)	JAPAN	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO
35	RANDALL AND QUILTER INVESTMENT HOLDINGS	UNITED KINGDOM	77 BANK LIMITED (THE)	JAPAN
36	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE	HACHIJUNI BANK LIMITED (THE)	JAPAN
37	ECHELON FINANCIAL HLDGS INC	CANADA	WURTEMBERGISCHE LEBENSVERSICHERUNG AG	GERMANY
38	NISHI-NIPPON CITY BANK LTD	JAPAN	INSPANET AB	SWEDEN
39	HIROSHIMA BANK LIMITED (THE)	JAPAN	MIZUHO FINANCIAL GROUP INC	JAPAN
40	MIZUHO FINANCIAL GROUP INC	JAPAN	PERMANENT TSB GROUP HOLDINGS PLC	IRELAND
41	HANSARD GLOBAL PLC	UNITED KINGDOM	CHIBA BANK LTD (THE)	JAPAN
42	BANK OF BEIJNG CO., LIMITED.	CHINA	ECHELON FINANCIAL HLDGS INC	CANADA
43	SHANGHAI PUJONG DEVELOPMENT BANK	CHINA	BANK OF BEIJNG CO., LIMITED.	CHINA
44	WUESTENROT & WUERTEMBERGISCHE AKTIENGES	GERMANY	SHANGHAI PUJONG DEVELOPMENT BANK	CHINA
45	CHUGOKU BANK LIMITED (THE)	JAPAN	TURNERS LTD	NEW ZEALAND
46	ALLEGHANY CORP	UNITED STATES	HANSARD GLOBAL PLC	UNITED KINGDOM
47	CHINA MINSHENG BANKING CORPORATION LIMITED	CHINA	NISHI-NIPPON CITY BANK LTD	JAPAN
48	FUKUOKA FINANCIAL GROUP, INC	JAPAN	SBERBANK ROSSII OAO	RUSSIA
49	SHIZUOKA BANK LTD (THE)	JAPAN	CNP ASSURANCES	FRANCE
50	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO	RANDALL AND QUILTER INVESTMENT HOLDINGS	UNITED KINGDOM

Source: Bloomberg LLP and author's calculations.

Table 4d. Systemic vulnerability rankings, all firms: January 2013 – July 2016  
(rankings based on a VAR(8) specification)

Systemic vulnerability ranking				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	TAIWAN COOPERATIVE BANK	TAIWAN	CPPGROUP PLC	UNITED KINGDOM
2	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN	TAIWAN COOPERATIVE BANK	TAIWAN
3	SHIN KONG FINANCIAL HOLDING COMPANY LIM	TAIWAN	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN
4	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN	SHIN KONG FINANCIAL HOLDING COMPANY LIM	TAIWAN
5	CPPGROUP PLC	UNITED KINGDOM	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN
6	SHINKONG INSURANCE CO LTD	TAIWAN	INDEQUITY GROUP LIMITED	SOUTH AFRICA
7	MERCURIES LIFE INSURANCE CO LTD	TAIWAN	.JSC VTB BANK	RUSSIA
8	INDEQUITY GROUP LIMITED	SOUTH AFRICA	BANK OF INDIA	INDIA
9	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	STATE BANK OF INDIA	INDIA
10	STATE BANK OF INDIA	INDIA	SHINKONG INSURANCE CO LTD	TAIWAN
11	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	AXIS BANK LIMITED	INDIA
12	.JSC VTB BANK	RUSSIA	PUNJAB NATIONAL BANK LTD	INDIA
13	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN	FUBON FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
14	CENTRAL REINSURANCE CORPORATION	TAIWAN	FBD HOLDINGS PLC	IRELAND
15	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	CANARA BANK	INDIA
16	FBD HOLDINGS PLC	IRELAND	MERCURIES LIFE INSURANCE CO LTD	TAIWAN
17	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN
18	BANK OF INDIA	INDIA	UNION INSURANCE COMPANY LIMITED	TAIWAN
19	AXIS BANK LIMITED	INDIA	MEGA FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
20	HDFC BANK LIMITED	INDIA	HDFC BANK LIMITED	INDIA
21	UNION INSURANCE COMPANY LIMITED	TAIWAN	LIFENET INSURANCE COMPANY	JAPAN
22	PUNJAB NATIONAL BANK LTD	INDIA	BANK OF BARODA	INDIA
23	CANARA BANK	INDIA	FIRST FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
24	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE	ADITYA BIRLA NUVO LIMITED	INDIA
25	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN	PHOENIX COMPANIES INC	UNITED STATES
26	INDEPENDENCE HOLDING CO	UNITED STATES	LIFPO GENERAL INSURANCE TBK PT	INDONESIA
27	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN	BAJAJFINSERV LIMITED	INDIA
28	WHITE MTNS INS GROUP LTD	BERMUDA	INDEPENDENCE HOLDING CO	UNITED STATES
29	LIFENET INSURANCE COMPANY	JAPAN	CENTRAL REINSURANCE CORPORATION	TAIWAN
30	ADITYA BIRLA NUVO LIMITED	INDIA	HUA NAN FINANCIAL HOLDINGS COMPANY LIMIT	TAIWAN
31	NUERNBERGER BETEILIGUNGS-AG	GERMANY	FEDERATED NATIONAL HLDG CO	UNITED STATES
32	BAJAJFINSERV LIMITED	INDIA	CATHAY FINANCIAL HOLDING COMPANY LIMITED	TAIWAN
33	WUESTENROT & WUERTTEMBERGISCHE AKTIENGES	GERMANY	FIRST ACCEPTANCE CORP	UNITED STATES
34	KINGSTONE COS INC	UNITED STATES	KINGSTONE COS INC	UNITED STATES
35	GREAT EASTERN HOLDINGS LTD	SINGAPORE	ICICI BANK LIMITED	INDIA
36	CREDIT INDUSTRIEL ET COMMERCIAL SA	FRANCE	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE
37	RANDALL AND QUILTER INVESTMENT HOLDINGS	UNITED KINGDOM	RANDALL AND QUILTER INVESTMENT HOLDINGS	UNITED KINGDOM
38	PARTNERRE LTD	BERMUDA	TOWER LIMITED	NEW ZEALAND
39	BANK OF BARODA	INDIA	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO
40	HELIOS UNDERWRITING PLC	UNITED KINGDOM	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN
41	FEDERATED NATIONAL HLDG CO	UNITED STATES	INDUSTRIAL BANK CO LTD	CHINA
42	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO	WUESTENROT & WUERTTEMBERGISCHE AKTIENGES	GERMANY
43	AXIS CAPITAL HOLDINGS LTD	BERMUDA	INTERLIFE GENERAL INSURANCE COMPANY SA	GREECE
44	DONEGAL GROUP INC	UNITED STATES	HELIOS UNDERWRITING PLC	UNITED KINGDOM
45	TOWER LIMITED	NEW ZEALAND	WHITE MTNS INS GROUP LTD	BERMUDA
46	DEUTSCHE POSTBANK AG	GERMANY	ALLIED IRISH BANKS PLC	IRELAND
47	KANSAS CITY LIFE INS CO	UNITED STATES	NUERNBERGER BETEILIGUNGS-AG	GERMANY
48	ICICI BANK LIMITED	INDIA	GREAT EASTERN HOLDINGS LTD	SINGAPORE
49	FIRST ACCEPTANCE CORP	UNITED STATES	CREDIT INDUSTRIEL ET COMMERCIAL SA	FRANCE
50	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG	KINGSWAY FINANCIAL SVCS INC	CANADA

Source: Bloomberg LLP and author's calculations.

Table 4e. Systemic vulnerability rankings, all firms: January 2001 – July 2016  
(rankings based on a VAR(8) specification)

Systemic vulnerability rankings				
Ranking	Diebold-Yilmaz network		Corrected Lanne-Nyberg-Diebold-Yilmaz network	
1	INDEQUITY GROUP LIMITED	SOUTH AFRICA	INDEQUITY GROUP LIMITED	SOUTH AFRICA
2	AXIS BANK LIMITED	INDIA	AXIS BANK LIMITED	INDIA
3	BANK OF BARODA	INDIA	BANK OF BARODA	INDIA
4	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN	CHANG HWA COMMERCIAL BANK LIMITED	TAIWAN
5	HDFC BANK LIMITED	INDIA	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN
6	TAIWAN LIFE INSURANCE COMPANY LIMITED	TAIWAN	SHINKONG INSURANCE CO LTD	TAIWAN
7	SHINKONG INSURANCE CO LTD	TAIWAN	HDFC BANK LIMITED	INDIA
8	CENTRAL REINSURANCE CORPORATION	TAIWAN	STATE BANK OF INDIA	INDIA
9	STATE BANK OF INDIA	INDIA	BANK OF INDIA	INDIA
10	BANK OF INDIA	INDIA	CENTRAL REINSURANCE CORPORATION	TAIWAN
11	ADITYA BIRLA NUVO LIMITED	INDIA	ADITYA BIRLA NUVO LIMITED	INDIA
12	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN	CHINA LIFE INSURANCE COMPANY LIMITED	TAIWAN
13	ICICI BANK LIMITED	INDIA	ICICI BANK LIMITED	INDIA
14	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN	FIRST INSURANCE COMPANY LIMITED (THE)	TAIWAN
15	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN	TURNERS LTD	NEW ZEALAND
16	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY	UNION INSURANCE COMPANY LIMITED	TAIWAN
17	UNION INSURANCE COMPANY LIMITED	TAIWAN	WURTTENBERGISCHE LEBENSVERSICHERUNG AG	GERMANY
18	NUERNBERGER BETEILIGUNGS-AG	GERMANY	TAIWAN FIRE & MARINE INSURANCE COMPANY L	TAIWAN
19	PERSONAL GROUP HOLDINGS PLC	UNITED KINGDOM	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO
20	TURNERS LTD	NEW ZEALAND	SHANGHAI PUDONG DEVELOPMENT BANK	CHINA
21	SINGAPORE REINSURANCE CORPORATION LIMITE	SINGAPORE	NISHI-NIPPON CITY BANK LTD	JAPAN
22	VAUDOISE ASSURANCES HOLDING	SWITZERLAND	SBERBANK ROSSII OAO	RUSSIA
23	SHANGHAI PUDONG DEVELOPMENT BANK	CHINA	NUERNBERGER BETEILIGUNGS-AG	GERMANY
24	GRUPO FINANCIERO BANORTE S.A.B. DE C.V.	MEXICO	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG
25	NISHI-NIPPON CITY BANK LTD	JAPAN	FEDERATED NATIONAL HLDG CO	UNITED STATES
26	UNITED OVERSEAS INSURANCE LIMITED	SINGAPORE	VAUDOISE ASSURANCES HOLDING	SWITZERLAND
27	ASIA FINANCIAL HOLDINGS LTD.	HONG KONG	PERSONAL GROUP HOLDINGS PLC	UNITED KINGDOM
28	INVESTEC LIMITED	SOUTH AFRICA	SINGAPORE REINSURANCE CORPORATION LIMITE	SINGAPORE
29	GREAT EASTERN HOLDINGS LTD	SINGAPORE	PANIN FINANCIAL TBK PT	INDONESIA
30	SHIZUOKA BANK LTD (THE)	JAPAN	TOWER LIMITED	NEW ZEALAND
31	BANK OF YOKOHAMA LTD	JAPAN	AVIVA SIGORTA AS	TURKEY
32	HIROSHIMA BANK LIMITED (THE)	JAPAN	HUNTINGTON BANCSHARES	UNITED STATES
33	UNIQA INSURANCE GROUP AG	AUSTRIA	PANINVEST TBK PT	INDONESIA
34	TOWER LIMITED	NEW ZEALAND	PING AN BANK COMPANY LIMITED	CHINA
35	MARKEL CORP	UNITED STATES	KINGSWAY FINANCIAL SVCS INC	CANADA
36	HUNTINGTON BANCSHARES	UNITED STATES	INVESTEC LIMITED	SOUTH AFRICA
37	KANSAS CITY LIFE INS CO	UNITED STATES	HAITONG SECURITIES CO. LIMITED	CHINA
38	FAIRFAX FINANCIAL HOLDINGS	CANADA	CHINA TAIPING INSURANCE HOLDINGS COMPANY LIMITED	HONG KONG
39	FBD HOLDINGS PLC	IRELAND	FAIRFAX FINANCIAL HOLDINGS	CANADA
40	ANADOLU ANONIM TURK SIGORTA SIRKETI	TURKEY	FBD HOLDINGS PLC	IRELAND
41	VITTORIA ASSICURAZIONI SPA	ITALY	TORONTO DOMINION BANK	CANADA
42	WUESTENROT & WURTTENBERGISCHE AKTIENGENES	GERMANY	PRUDENTIAL PLC	UNITED KINGDOM
43	77 BANK LIMITED (THE)	JAPAN	BNP PARIBAS SA	FRANCE
44	EL FINANCIAL CORP LTD	CANADA	POWER FINANCIAL CORP	CANADA
45	PING AN BANK COMPANY LIMITED	CHINA	NORDEA BANK AB	SWEDEN
46	CHIBA BANK LTD (THE)	JAPAN	AVIVA PLC	UNITED KINGDOM
47	RLI CORP	UNITED STATES	POWER CORP CANADA	CANADA
48	CHINA MINSHENG BANKING CORPORATION LIMITED	CHINA	KEMPER CORP DE	UNITED STATES
49	HANG SENG BANK LIMITED	HONG KONG	GOLDMAN SACHS GROUP INC	UNITED STATES
50	ERIE INDEMNITY CO -CL A	UNITED STATES	U S BANCORP	UNITED STATES

Source: Bloomberg LLP and author's calculations.

Only a handful of institutions are simultaneously in the top risk and vulnerability rankings. In the case of the DY rankings, it is Sberbank, a Russian bank, during the 2005 – 2008, and CPP Group, a British insurer, during 2013 – 2016. In the case of the CLNDY rankings, it is only Banca Popolare, an Italian bank, during 2001 – 2004. A glance at Tables 3 and 4 reveals that the headquarters of the riskiest firms are mainly in advanced economies. U.S. firms dominate the top rankings during 2005–2008, coinciding with the subprime crisis in the United States, and European firms dominate during 2009 – 2012, coinciding with the sovereign debt crisis.

Table 5 provides further confirmation, with firms in emerging economies losing systemic importance during 2005 – 2012 in the DY rankings. The CLNDY ranking, however, suggests that these firms are not systemic at all. In regards to vulnerability, emerging market firms appear over-represented relative to their share in the sample. It is worth highlighting that in advanced economies, the risky firms tend to be in North America and Europe, and the vulnerable firms in Asia and Oceania.

Table 5. Top fifty systemic firms, by headquarter location  
(ranking based on a VAR (8) specification)

	Period				
	2001 to 2004	2005 to 2008	2009 - 2012	2013 - 2016	2001 - 2016
Panel A: Systemic risk ranking					
<i>Diebold - Yilmaz</i>					
Advanced economies	36	41	50	33	49
Emerging economies	14	9	0	17	1
<i>Corrected Lanne-Nyberg-Diebold-Yilmaz</i>					
Advanced economies	50	50	50	48	50
Emerging economies	0	0	0	2	0
Panel B: Systemic vulnerability ranking					
<i>Diebold - Yilmaz</i>					
Advanced economies	38	33	34	33	32
Emerging economies	12	17	6	7	18
<i>Corrected Lanne-Nyberg-Diebold-Yilmaz</i>					
Advanced economies	29	29	33	35	32
Emerging economies	21	21	7	5	18

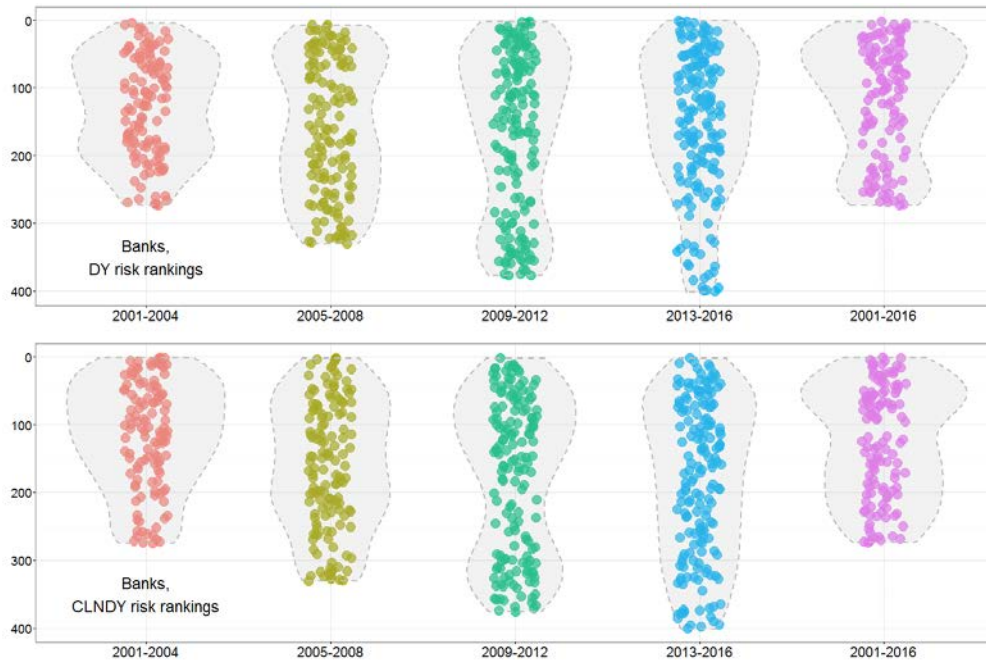
Source: Bloomberg LLP and author's calculations.

While the DY and CLNDY rankings can be strikingly different at the individual firm level, they convey roughly the same information on how the probability distribution of rankings evolves over time, as Figure 3 and 4 indicate. Figure 3 shows the distribution of systemic risk rankings for different categories of firms, with the bank category including not only banks but also



securities and broker dealers. During the pre-crisis period of 2001 to 2004, the distribution of systemic risk rankings in the banking sector was highly skewed towards the top one hundred rankings, especially visible in the inverted pear-shaped CLNDY distribution (bottom panel, Figure 3a). During the crisis period, 2005 to 2008, the rankings of the banks were roughly uniformly distributed but still slightly concentrated in the upper range of values. At the time of the European sovereign debt crisis, 2009 to 2012, bank ranking skewed towards the upper end, and they have remained highly skewed during the secular stagnation period, 20013 to 2016.

Figure 3a. Banks: systemic risk rankings, probability distribution evolution (ranking based on a VAR(8) specification)



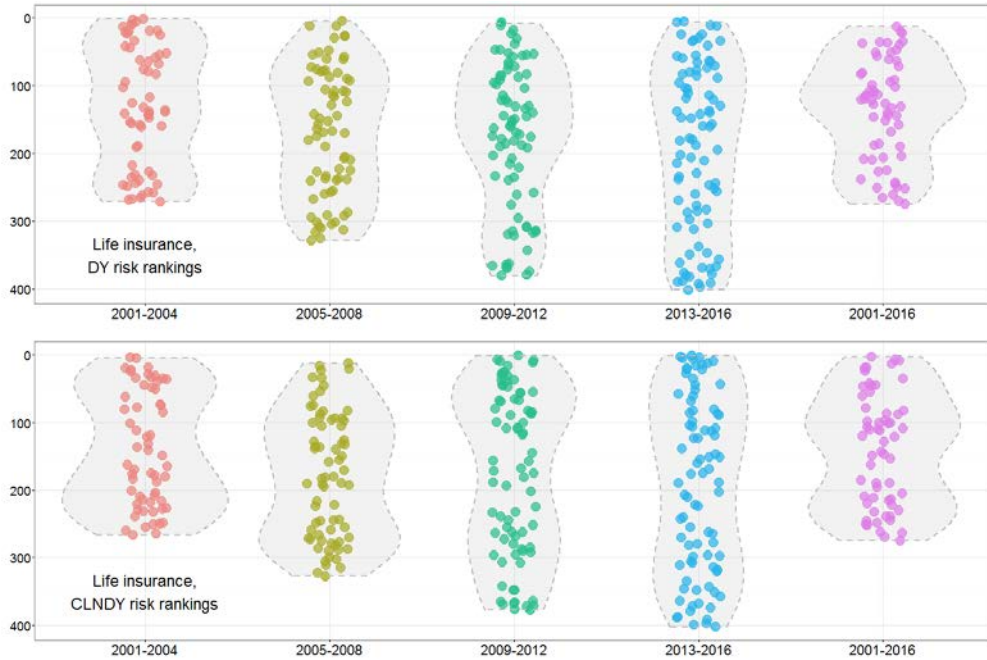
Rankings in reverse order, right axis. A lower ranking corresponds to higher risk  
Source: Bloomberg LLP and author's calculations.

The distributions of risk rankings of life insurance and property/casualty/health insurance firms have evolved quite differently. In the earlier part of the sample, quite a large proportion of large insurers rank among the top hundred firms (Figure 3b). The situation reversed during the crisis period but the industry risk rankings rose during the 2009 – 2012 period. More recently, the distribution of risk rankings in the industry appears uniform.

Systemic risk in the property/casualty/health insurance sector has never been high despite an upward migration in the crisis period of 2005 – 2008 (Figure 3c). Finally, if the whole sample period of 2001 – 2016 is considered, the emerging picture is one that places banks at the top of the risk rankings, followed in descending order by life insurers and property/casualty/health insurers. This is consistent with conclusions reached by the International Monetary Fund (IMF, 2016) using quite a different set of analytical methods.

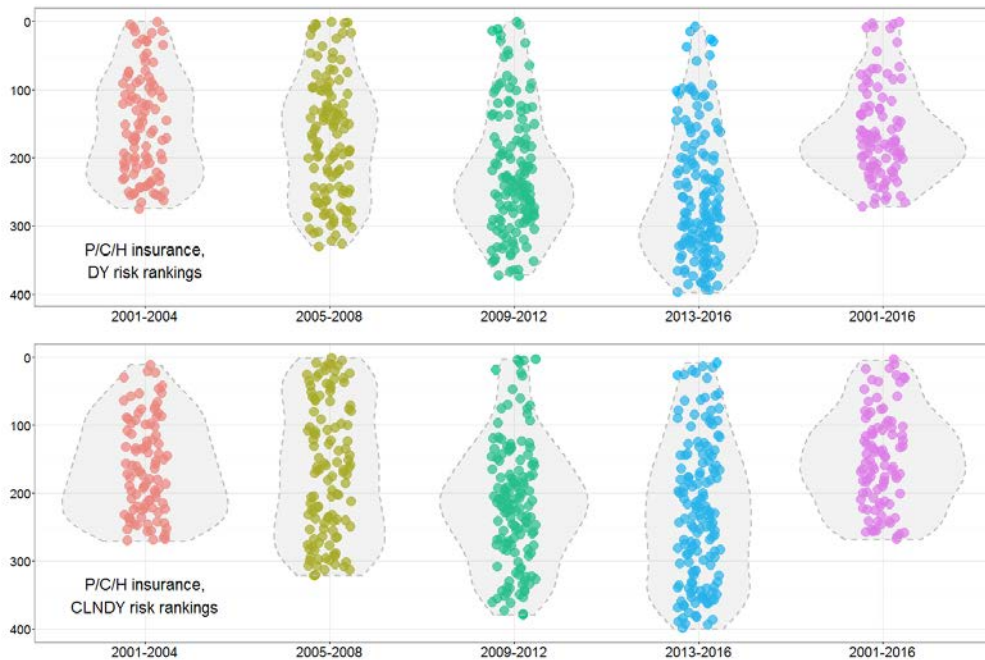


Figure 3b. Life insurers: systemic risk rankings, probability distribution evolution (ranking based on a VAR(8) specification)



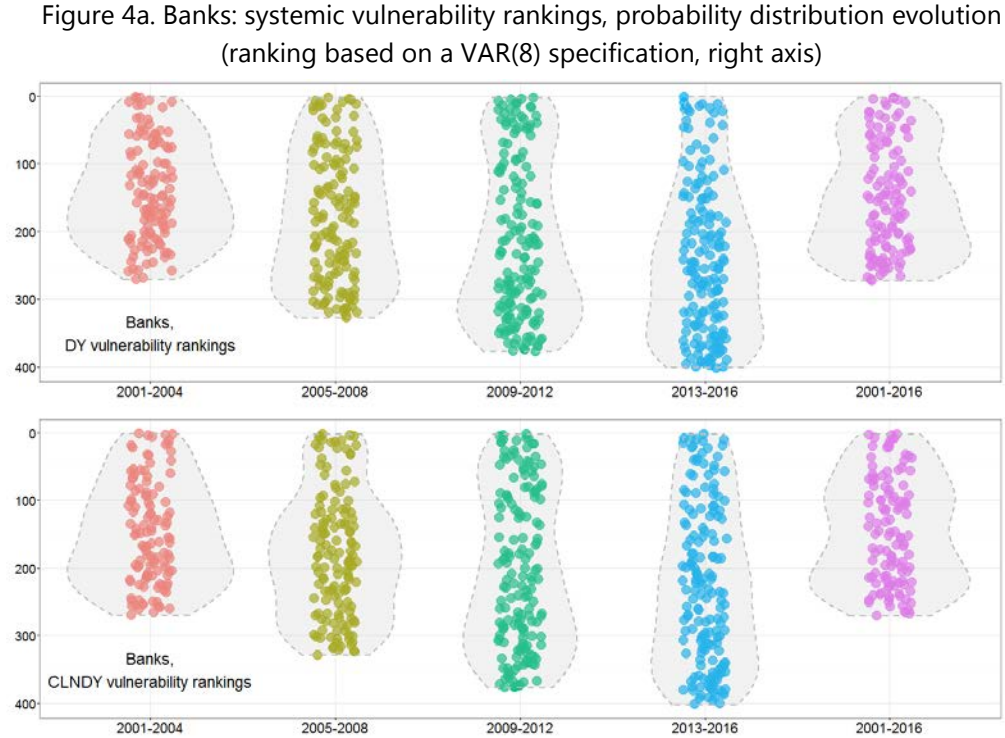
Rankings in reverse order, right axis. A lower ranking corresponds to higher risk  
 Source: Bloomberg LLP and author's calculations.

Figure 3c. Property/casualty/health insurers: systemic risk rankings, probability distribution evolution (ranking based on a VAR(8) specification)



Rankings in reverse order, right axis. A lower ranking corresponds to higher risk  
 Source: Bloomberg LLP and author's calculations.

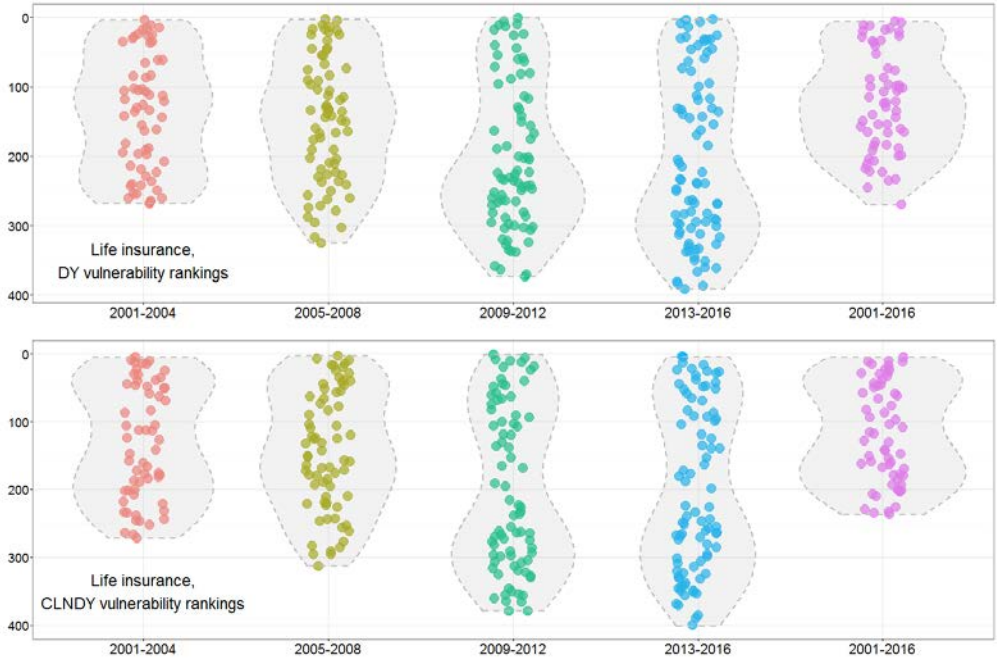
The analysis of vulnerability distributions in the banking sector is a mirror image of its risk distributions (Figure 4a). In the earlier part of the sample, most banks ranked in the bottom two thirds of the distribution and have remained there since then despite a slight upward shift during 2009 – 2012.



Rankings in reverse order, right axis. A lower ranking corresponds to higher vulnerability  
Source: Bloomberg LLP and author's calculations.

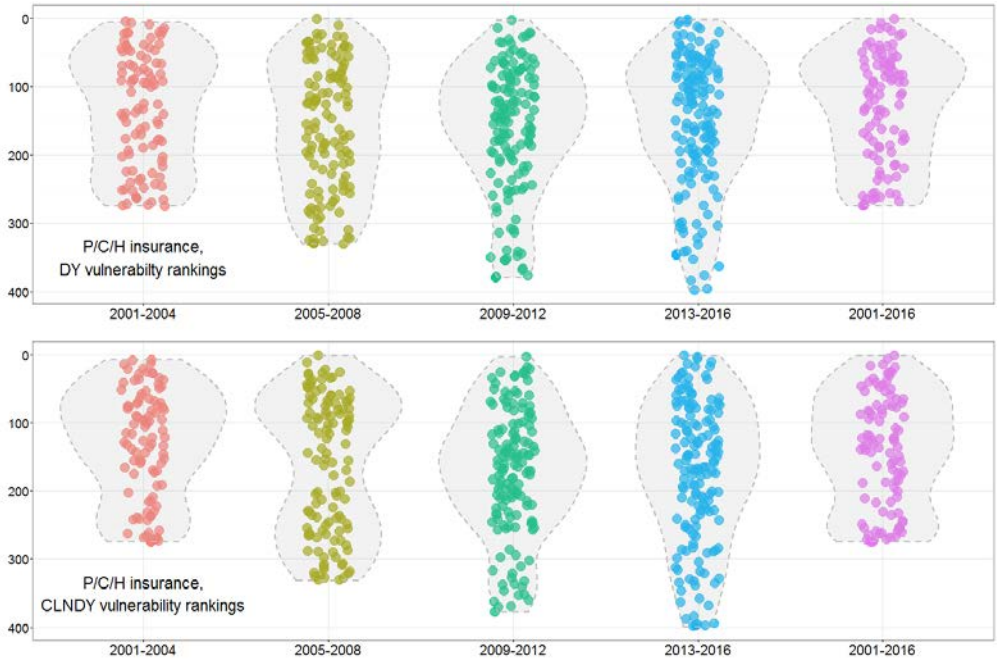
In contrast, the vulnerability rankings of life insurance firms were concentrated in the upper region up to the 2008 global financial crisis, but they have declined since then. The current distribution in 2013-2016, however, is bimodal with a peak in the top quarter of the distribution, and the other peak in the bottom quarter (Figure 4b). While property/casualty/health insurance firms have not ranked among the riskiest firms in the system, the opposite is true regarding their vulnerability, with many firms in the sector concentrated in the top rankings, regardless of whether the DY or CLNDY ranking is used, during 2001 – 2008. Although the concentration of vulnerability rankings has become wider since 2008, property/casualty/health insurance firms remain more vulnerable vis-a-vis banks and the life insurance firms. The full sample analysis also supports this fact.

Figure 4b. Life insurers: systemic vulnerability rankings, probability distribution evolution (ranking based on a VAR(8) specification, right axis)



Rankings in reverse order, right axis. A lower ranking corresponds to higher vulnerability  
 Source: Bloomberg LLP and author's calculations.

Figure 4c. Property/casualty/health insurers: systemic vulnerability rankings, probability distribution evolution (ranking based on a VAR(8) specification, right axis)



Rankings in reverse order, right axis. A lower ranking corresponds to higher vulnerability  
 Source: Bloomberg LLP and author's calculations.

To complement the analysis above, Table 6 shows the industry share in the top fifty systemic firms. In general, the DY rankings weight bank, which represent more than sixty percent of the riskiest firms since 2009, more heavily than the CLNDY rankings. In both rankings, banks are the riskiest, followed by life insurance firms, and then property/casualty/health insurance firms. There was a reversal, however, during the crisis period in 2005 – 2008, when the importance of the property/casualty/health insurance sector increased. The share of vulnerabilities is more evenly distributed in the CLNDY rankings than in the DY rankings.

Table 6. Top fifty systemic firms, by industry, in percent  
(ranking based on a VAR (8) specification)

	Banks	Life insurance	Insurance: Property and Casualty; Health	Security brokers and dealers
<i>Diebold-Yilmaz, risk rankings</i>				
2001 - 2004	44	30	24	2
2005 - 2008	52	14	28	6
2009 - 2012	66	16	18	0
2013 - 2016	62	22	12	4
2001 - 2016	64	18	16	2
<i>Corrected Lanne-Nyberg-Diebold-Yilmaz, risk rankings</i>				
2001 - 2004	58	30	12	0
2005 - 2008	40	14	42	4
2009 - 2012	50	32	18	0
2013 - 2016	46	32	16	6
2001 - 2016	50	24	22	4
<i>Diebold-Yilmaz, vulnerability rankings</i>				
2001 - 2004	28	26	44	2
2005 - 2008	30	28	40	2
2009 - 2012	58	20	22	0
2013 - 2016	34	32	34	0
2001 - 2016	38	28	32	2
<i>Corrected Lanne-Nyberg-Diebold-Yilmaz, vulnerability rankings</i>				
2001 - 2004	28	34	36	2
2005 - 2008	32	30	34	4
2009 - 2012	48	26	26	0
2013 - 2016	36	30	34	0
2001 - 2016	30	34	32	4

Source: Bloomberg LLP and author's calculations.

## 5. Conclusions

Analyzing systemic risk in financial networks has become increasingly important in the aftermath of the financial crisis. To complement network analysis based on bilateral exposures, academics and policy practitioners have developed techniques for constructing financial networks based on the comovement of securities prices. In particular, Diebold and Yilmaz (2015) propose using variance decomposition networks, which can capture the directionality of spillovers between firms.

One disadvantage in Diebold and Yilmaz original methodology, however, is its reliance on Pesaran-Shin (1998) GFEVDs, which do not add to unity. This makes difficult to compare the risk contribution and ranking of a firm at two different points in time. It is possible, however, to enhance the Diebold-Yilmaz methodology while preserving its intuition by simply replacing the the Lanne-Nyberg (2016) decomposition, which adds to unity, for the Pesaran-Shin decomposition.

Different variance decompositions, however, could produce substantially different systemic risk rankings. In a global financial network comprising a large number of financial firms in advanced and emerging market economies, the DY and CLNDY systemic risk rankings differed markedly. When comparing the top fifty firms, less than half of the firms were in both rankings. The choice decomposition method, however, did not affect systemic vulnerability rankings to the same extent. While the rankings of individual firms may be different, the evolution of the distribution of rankings over time was quite similar using either of the two methods.

This paper favors the use of the CLNDY rather than the original DY network for assessing the systemic risk contribution of firms, and assessing their systemic importance in the financial system. From an anecdotal perspective, the CLNDY risk ranking appears to do a better job than the DY risk ranking in selecting the top riskiest firms in the 2005 – 2008 and the 2013 – 2016 periods. Survivorship bias, however, may have influenced this result since the analysis did not include delisted firms such as Lehman Brothers and Merrill Lynch that had a major role during the 2008 crisis. Regardless of this paper preference, however, the differences induced by the choice of decomposition suggest caution when using systemic risk rankings for guiding financial regulation and policy recommendations.

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## Appendix. Selected Tables, January 2001 – July 2016

Table A1. Advanced Asia – systemic risk ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Macquarie Group Limited	Australia	Security Brokers & Dealers	1	Australia And New Zealand Banking Group	Australia	Banks And S&Ls
2	Dai-Ichi Life Insurance Company, Ltd (Th	Japan	Insurance - Life	2	Macquarie Group Limited	Australia	Security Brokers & Dealers
3	China Taiping Insurance Holdings Company Limited	Hong Kong	Insurance - Life	3	Commonwealth Bank Of Australia	Australia	Banks And S&Ls
4	Australia And New Zealand Banking Group	Australia	Banks And S&Ls	4	National Australia Bank Limited	Australia	Banks And S&Ls
5	Nomura Holdings Incorporated	Japan	Security Brokers & Dealers	5	Westpac Banking Corporation	Australia	Banks And S&Ls
6	T&D Holdings Incorporated	Japan	Insurance - Life	6	Oversea-Chinese Banking Corporation Limi	Singapore	Banks And S&Ls
7	National Australia Bank Limited	Australia	Banks And S&Ls	7	United Overseas Bank Limited	Singapore	Banks And S&Ls
8	Bank Of Kyoto Ltd	Japan	Banks And S&Ls	8	Dbz Group Holdings Ltd	Singapore	Banks And S&Ls
9	Sony Financial Holdings Inc.	Japan	Insurance - Life	9	Bank Of East Asia Limited (The)	Hong Kong	Banks And S&Ls
10	Qbe Insurance Group Limited	Australia	Insurance - Prop/Cas/Health	10	Suncorp Group Limited	Australia	Insurance - Prop/Cas/Health
11	Anicom Holdings Incorporation	Japan	Insurance - Prop/Cas/Health	11	Shizuoka Bank Ltd (The)	Japan	Banks And S&Ls
12	Westpac Banking Corporation	Australia	Banks And S&Ls	12	Mitsubishi Ufj Financial Group Incorpora	Japan	Banks And S&Ls
13	Dream Incubator Incorporated	Japan	Insurance - Prop/Cas/Health	13	Aia Group Limited	Hong Kong	Insurance - Life
14	Fukuoka Financial Group, Inc	Japan	Banks And S&Ls	14	Hang Seng Bank Limited	Hong Kong	Banks And S&Ls
15	Shinsei Bank Limited	Japan	Banks And S&Ls	15	Dai-Ichi Life Insurance Company, Ltd (Th	Japan	Insurance - Life
16	Shizuoka Bank Ltd (The)	Japan	Banks And S&Ls	16	Challenger Financial Services Group Ltd	Australia	Insurance - Life
17	Sumitomo Mitsui Financial Group Inc	Japan	Banks And S&Ls	17	Sumitomo Mitsui Financial Group Inc	Japan	Banks And S&Ls
18	Challenger Financial Services Group Ltd	Australia	Insurance - Life	18	Boc Hong Kong (Holdings) Ltd	Hong Kong	Banks And S&Ls
19	Commonwealth Bank Of Australia	Australia	Banks And S&Ls	19	Nomura Holdings Incorporated	Japan	Security Brokers & Dealers
20	Mitsubishi Ufj Financial Group Incorpora	Japan	Banks And S&Ls	20	Insurance Australia Group Limited	Australia	Insurance - Prop/Cas/Health
21	Chiba Bank Ltd (The)	Japan	Banks And S&Ls	21	Sony Financial Holdings Inc.	Japan	Insurance - Life
22	Nishi-Nippon City Bank Ltd	Japan	Banks And S&Ls	22	Bank Of Kyoto Ltd	Japan	Banks And S&Ls
23	Hokuhoku Financial Group Incorporated	Japan	Banks And S&Ls	23	T&D Holdings Incorporated	Japan	Insurance - Life
24	Sompo Japan Nipponkoa Holdings Inc	Japan	Insurance - Prop/Cas/Health	24	Chiba Bank Ltd (The)	Japan	Banks And S&Ls
25	Chugoku Bank Limited (The)	Japan	Banks And S&Ls	25	Hokuhoku Financial Group Incorporated	Japan	Banks And S&Ls
26	Hiroshima Bank Limited (The)	Japan	Banks And S&Ls	26	Joyo Bank Limited (The)	Japan	Banks And S&Ls
27	Hachijuni Bank Limited (The)	Japan	Banks And S&Ls	27	Chugoku Bank Limited (The)	Japan	Banks And S&Ls
28	77 Bank Limited (The)	Japan	Banks And S&Ls	28	Fukuoka Financial Group, Inc	Japan	Banks And S&Ls
29	Gunma Bank Ltd	Japan	Banks And S&Ls	29	Resona Holdings Inc	Japan	Banks And S&Ls
30	Joyo Bank Limited (The)	Japan	Banks And S&Ls	30	Qbe Insurance Group Limited	Australia	Insurance - Prop/Cas/Health

Source: Bloomberg LLP and author's calculations.

Table A2. Emerging markets economies – systemic risk ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Sanlam Limited	South Africa	Insurance - Life	1	Sanlam Limited	South Africa	Insurance - Life
2	Banco Do Brasil Sa	Brazil	Banks And S&Ls	2	Mmi Holdings Limited	South Africa	Insurance - Life
3	Mmi Holdings Limited	South Africa	Insurance - Life	3	Discovery Ltd	South Africa	Insurance - Prop/Cas/Health
4	Discovery Ltd	South Africa	Insurance - Prop/Cas/Health	4	Standard Bank Group Limited	South Africa	Banks And S&Ls
5	Firststrand Limited	South Africa	Banks And S&Ls	5	Rmb Holdings Limited	South Africa	Insurance - Life
6	Standard Bank Group Limited	South Africa	Banks And S&Ls	6	Liberty Holdings Limited	South Africa	Insurance - Prop/Cas/Health
7	Banco Bradesco S.A.	Brazil	Banks And S&Ls	7	Nedbank Group Limited	South Africa	Banks And S&Ls
8	Rmb Holdings Limited	South Africa	Insurance - Life	8	Firststrand Limited	South Africa	Banks And S&Ls
9	Barclays Africa Group Ltd	South Africa	Banks And S&Ls	9	Barclays Africa Group Ltd	South Africa	Banks And S&Ls
10	Porto Seguro Sa	Brazil	Insurance - Prop/Cas/Health	10	Porto Seguro Sa	Brazil	Insurance - Prop/Cas/Health
11	Banco Santander Brasil Sa	Brazil	Banks And S&Ls	11	Santander Mexico Financial Group Sab De Cv	Mexico	Banks And S&Ls
12	Nedbank Group Limited	South Africa	Banks And S&Ls	12	China Construction Bank Corp	China	Banks And S&Ls
13	Liberty Holdings Limited	South Africa	Insurance - Prop/Cas/Health	13	Picc Property And Casualty Company Ltd	China	Insurance - Prop/Cas/Health
14	Huatai Securities Company Limited	China	Security Brokers & Dealers	14	Bank Of China Limited	China	Banks And S&Ls
15	Akbank Tas	Turkey	Banks And S&Ls	15	Banco Bradesco S.A.	Brazil	Banks And S&Ls
16	Turkiye Is Bankasi A.S.	Turkey	Banks And S&Ls	16	China Citic Bank Corporation Limited	China	Banks And S&Ls
17	Sul America S.A.	Brazil	Insurance - Prop/Cas/Health	17	Bank Of Communications Co Ltd	China	Banks And S&Ls
18	Itau Unibanco Holding S.A.	Brazil	Banks And S&Ls	18	Ping An Insurance (Group) Company Of China Ltd	China	Insurance - Life
19	Haci Omer Sabanci Holding A.S.	Turkey	Banks And S&Ls	19	Chongqing Rural Commercial Bank Co Ltd	China	Banks And S&Ls
20	Turkiye Garanti Bankasi A.S.	Turkey	Banks And S&Ls	20	Santam Limited	South Africa	Insurance - Prop/Cas/Health
21	Yapi Ve Kredi Bankasi As	Turkey	Banks And S&Ls	21	Sul America S.A.	Brazil	Insurance - Prop/Cas/Health
22	Grupo Btg Pactual	Brazil	Security Brokers & Dealers	22	Agricultural Bank Of China Limited	China	Banks And S&Ls
23	Santander Mexico Financial Group Sab De Cv	Mexico	Banks And S&Ls	23	Itau Unibanco Holding S.A.	Brazil	Banks And S&Ls
24	Picc Property And Casualty Company Ltd	China	Insurance - Prop/Cas/Health	24	China Life Insurance Co Ltd	China	Insurance - Life
25	China Life Insurance Co Ltd	China	Insurance - Life	25	The People S Insurance Co (Group) Of Chi	China	Insurance - Prop/Cas/Health
26	Qualicorp Sa	Brazil	Insurance - Prop/Cas/Health	26	Haci Omer Sabanci Holding A.S.	Turkey	Banks And S&Ls
27	Haitong Securities Co. Limited	China	Security Brokers & Dealers	27	Turkiye Is Bankasi A.S.	Turkey	Banks And S&Ls
28	Ping An Insurance (Group) Company Of China Ltd	China	Insurance - Life	28	New China Life Insurance Co Ltd	China	Insurance - Life
29	Citic Securities Co., Ltd.	China	Security Brokers & Dealers	29	Akbank Tas	Turkey	Banks And S&Ls
30	New China Life Insurance Co Ltd	China	Insurance - Life	30	Yapi Ve Kredi Bankasi As	Turkey	Banks And S&Ls

Source: Bloomberg LLP and author's calculations.

Table A3. Europe – systemic risk ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Bank Of Piraeus S.A.	Greece	Banks And S&Ls	1	Old Mutual Plc	United Kingdom	Insurance - Life
2	National Bank Of Greece, S.A.	Greece	Banks And S&Ls	2	Prudential Plc	United Kingdom	Insurance - Life
3	Eurobank Ergasias Sa	Greece	Banks And S&Ls	3	Societe Generale	France	Banks And S&Ls
4	Bankia Sau	Spain	Banks And S&Ls	4	Ubs Group Ag	Switzerland	Banks And S&Ls
5	Alpha Bank Sa	Greece	Banks And S&Ls	5	St. James'S Place Plc	United Kingdom	Insurance - Life
6	Cppgroup Plc	United Kingdom	Insurance - Prop/Cas/Health	6	Axa Sa	France	Insurance - Life
7	Banco Comercial Portugues, S.A.	Portugal	Banks And S&Ls	7	Banco Bilbao Vizcaya Argentaria Sa	Spain	Banks And S&Ls
8	Banca Monte Dei Paschi Di Siena Spa	Italy	Banks And S&Ls	8	Hsbc Holdings Plc	United Kingdom	Banks And S&Ls
9	Old Mutual Plc	United Kingdom	Insurance - Life	9	Banco Santander Sa	Spain	Banks And S&Ls
10	Banco Popolare	Italy	Banks And S&Ls	10	Allianz Se	Germany	Insurance - Prop/Cas/Health
11	Societe Generale	France	Banks And S&Ls	11	Credit Agricole Sa	France	Banks And S&Ls
12	Banco Popular Espanol	Spain	Banks And S&Ls	12	Deutsche Bank Aktiengesellschaft	Germany	Banks And S&Ls
13	Banco Sabadell	Spain	Banks And S&Ls	13	Aviva Plc	United Kingdom	Insurance - Life
14	Banca Popolare Dell'Emilia Romagna Sc	Italy	Banks And S&Ls	14	Mapfre Sa	Spain	Insurance - Life
15	Allied Irish Banks Plc	Ireland	Banks And S&Ls	15	Bnp Paribas Sa	France	Banks And S&Ls
16	Ubi Banca	Italy	Banks And S&Ls	16	Ing Groep N.V.	Netherlands	Banks And S&Ls
17	Delta Lloyd Nv	Netherlands	Insurance - Life	17	European Reliance General Insurance Co.	Greece	Insurance - Life
18	Credit Agricole Sa	France	Banks And S&Ls	18	Credit Suisse Group Ag	Switzerland	Banks And S&Ls
19	St. James'S Place Plc	United Kingdom	Insurance - Life	19	Standard Life Plc	United Kingdom	Insurance - Life
20	Storebrand Asa	Norway	Insurance - Life	20	Natixis	France	Banks And S&Ls
21	Deutsche Bank Aktiengesellschaft	Germany	Banks And S&Ls	21	Hannover Rueck Se	Germany	Insurance - Life
22	Unicredit Spa	Italy	Banks And S&Ls	22	Barclays Plc	United Kingdom	Banks And S&Ls
23	Banco Santander Sa	Spain	Banks And S&Ls	23	Julius Baer Group Ag	Switzerland	Banks And S&Ls
24	Prudential Plc	United Kingdom	Insurance - Life	24	Aareal Bank Ag	Germany	Banks And S&Ls
25	Natixis	France	Banks And S&Ls	25	Dnb Asa	Norway	Banks And S&Ls
26	Standard Chartered Plc	United Kingdom	Banks And S&Ls	26	Xi Group Plc -- Adr	Ireland	Insurance - Prop/Cas/Health
27	Royal Bank Of Scotland Group Plc	United Kingdom	Banks And S&Ls	27	Baloise Holding Ag	Switzerland	Insurance - Life
28	Mediobanca Spa	Italy	Banks And S&Ls	28	Kbc Group Nv	Belgium	Banks And S&Ls
29	Barclays Plc	United Kingdom	Banks And S&Ls	29	Nordea Bank Ab	Sweden	Banks And S&Ls
30	Banco Bilbao Vizcaya Argentaria Sa	Spain	Banks And S&Ls	30	Swiss Life Holding Ag	Switzerland	Insurance - Life

Source: Bloomberg LLP and author's calculations.

Table A4. North America – systemic risk ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Genworth Financial Inc	United States	Insurance - Life	1	Ameriprise Financial Inc	United States	Security Brokers & Dealers
2	Lincoln National Corp	United States	Insurance - Life	2	Metlife Inc	United States	Insurance - Life
3	MBIA Inc	United States	Insurance - Prop/Cas/Health	3	Prudential Financial Inc	United States	Insurance - Life
4	American Eqty Invnt Life Hldg	United States	Insurance - Life	4	Manulife Financial Corp	Canada	Insurance - Life
5	UTG Inc	United States	Insurance - Life	5	Citigroup Inc	United States	Finance Nec
6	Metlife Inc	United States	Insurance - Life	6	American International Group	United States	Insurance - Prop/Cas/Health
7	CNO Financial Group Inc	United States	Insurance - Prop/Cas/Health	7	Lincoln National Corp	United States	Insurance - Life
8	Manulife Financial Corp	Canada	Insurance - Life	8	Goldman Sachs Group Inc	United States	Security Brokers & Dealers
9	Citigroup Inc	United States	Finance Nec	9	Torchmark Corp	United States	Insurance - Life
10	Ameriprise Financial Inc	United States	Security Brokers & Dealers	10	Loews Corp	United States	Insurance - Prop/Cas/Health
11	Prudential Financial Inc	United States	Insurance - Life	11	American Financial Group Inc	United States	Insurance - Prop/Cas/Health
12	Morgan Stanley	United States	Security Brokers & Dealers	12	U S Bancorp	United States	Banks And S&Ls
13	State Street Corp	United States	Banks And S&Ls	13	Power Financial Corp	Canada	Insurance - Life
14	United Insurance Holdings Co	United States	Insurance - Prop/Cas/Health	14	Old Republic Intl Corp	United States	Insurance - Prop/Cas/Health
15	Zions Bancorporation	United States	Banks And S&Ls	15	Sun Life Financial Inc	Canada	Insurance - Life
16	Mgic Investment Corp/Wi	United States	Insurance - Prop/Cas/Health	16	CNO Financial Group Inc	United States	Insurance - Prop/Cas/Health
17	Industrial Alliance Ins &Fin	Canada	Insurance - Life	17	Suntrust Banks Inc	United States	Banks And S&Ls
18	Universal American Corp	United States	Insurance - Prop/Cas/Health	18	Humana Inc	United States	Insurance - Prop/Cas/Health
19	Radian Group Inc	United States	Insurance - Prop/Cas/Health	19	Aflac Inc	United States	Insurance - Prop/Cas/Health
20	Regions Financial Corp	United States	Banks And S&Ls	20	Power Corp Canada	Canada	Insurance - Life
21	Suntrust Banks Inc	United States	Banks And S&Ls	21	Pnc Financial Svcs Group Inc	United States	Banks And S&Ls
22	Bank Of America Corp	United States	Banks And S&Ls	22	JPMorgan Chase & Co	United States	Banks And S&Ls
23	Sun Life Financial Inc	Canada	Insurance - Life	23	State Street Corp	United States	Banks And S&Ls
24	Comerica Inc	United States	Banks And S&Ls	24	Fifth Third Bancorp	United States	Banks And S&Ls
25	HCI Group Inc	United States	Insurance - Prop/Cas/Health	25	Morgan Stanley	United States	Security Brokers & Dealers
26	Fifth Third Bancorp	United States	Banks And S&Ls	26	Bank Of New York Mellon Corp	United States	Banks And S&Ls
27	Unum Group	United States	Insurance - Prop/Cas/Health	27	BB&T Corp	United States	Banks And S&Ls
28	Keycorp	United States	Banks And S&Ls	28	Northern Trust Corp	United States	Banks And S&Ls
29	Goldman Sachs Group Inc	United States	Security Brokers & Dealers	29	Bank Of Nova Scotia	Canada	Banks And S&Ls
30	National Bank Canada	Canada	Banks And S&Ls	30	Royal Bank Of Canada	Canada	Banks And S&Ls

Source: Bloomberg LLP and author's calculations.

Table A5. Advanced Asia – systemic vulnerability ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Taiwan Cooperative Bank	Taiwan	Banks And S&Ls	1	Taiwan Cooperative Bank	Taiwan	Banks And S&Ls
2	Taiwan Fire & Marine Insurance Company L	Taiwan	Insurance - Prop/Cas/Health	2	Taiwan Fire & Marine Insurance Company L	Taiwan	Insurance - Prop/Cas/Health
3	Shin Kong Financial Holding Company Limi	Taiwan	Insurance - Life	3	Shin Kong Financial Holding Company Limi	Taiwan	Insurance - Life
4	China Life Insurance Company Limited	Taiwan	Insurance - Life	4	China Life Insurance Company Limited	Taiwan	Insurance - Life
5	Shinkong Insurance Co Ltd	Taiwan	Insurance - Prop/Cas/Health	5	Shinkong Insurance Co Ltd	Taiwan	Insurance - Prop/Cas/Health
6	Mercuries Life Insurance Co Ltd	Taiwan	Insurance - Life	6	Fubon Financial Holding Company Limited	Taiwan	Insurance - Life
7	Fubon Financial Holding Company Limited	Taiwan	Insurance - Life	7	Mercuries Life Insurance Co Ltd	Taiwan	Insurance - Life
8	First Financial Holding Company Limited	Taiwan	Banks And S&Ls	8	First Insurance Company Limited (The)	Taiwan	Insurance - Prop/Cas/Health
9	First Insurance Company Limited (The)	Taiwan	Insurance - Prop/Cas/Health	9	Union Insurance Company Limited	Taiwan	Insurance - Prop/Cas/Health
10	Central Reinsurance Corporation	Taiwan	Insurance - Life	10	Mega Financial Holding Company Limited	Taiwan	Banks And S&Ls
11	Mega Financial Holding Company Limited	Taiwan	Banks And S&Ls	11	Lifenet Insurance Company	Japan	Insurance - Life
12	Hua Nan Financial Holdings Company Limit	Taiwan	Banks And S&Ls	12	First Financial Holding Company Limited	Taiwan	Banks And S&Ls
13	Union Insurance Company Limited	Taiwan	Insurance - Prop/Cas/Health	13	Central Reinsurance Corporation	Taiwan	Insurance - Life
14	United Overseas Insurance Limited	Singapore	Insurance - Prop/Cas/Health	14	Hua Nan Financial Holdings Company Limit	Taiwan	Banks And S&Ls
15	Chang Hwa Commercial Bank Limited	Taiwan	Banks And S&Ls	15	Cathay Financial Holding Company Limited	Taiwan	Insurance - Life
16	Cathay Financial Holding Company Limited	Taiwan	Insurance - Life	16	United Overseas Insurance Limited	Singapore	Insurance - Prop/Cas/Health
17	Lifenet Insurance Company	Japan	Insurance - Life	17	Tower Limited	New Zealand	Insurance - Life
18	Great Eastern Holdings Ltd	Singapore	Insurance - Life	18	Chang Hwa Commercial Bank Limited	Taiwan	Banks And S&Ls
19	Tower Limited	New Zealand	Insurance - Life	19	Great Eastern Holdings Ltd	Singapore	Insurance - Life
20	Asia Financial Holdings Ltd.	Hong Kong	Insurance - Life	20	Asia Financial Holdings Ltd.	Hong Kong	Insurance - Life
21	Hang Seng Bank Limited	Hong Kong	Banks And S&Ls	21	China Taiping Insurance Holdings Company Limited	Hong Kong	Insurance - Life
22	Min Xin Holdings Ltd.	Hong Kong	Insurance - Prop/Cas/Health	22	Min Xin Holdings Ltd.	Hong Kong	Insurance - Prop/Cas/Health
23	Insurance Australia Group Limited	Australia	Insurance - Prop/Cas/Health	23	77 Bank Limited (The)	Japan	Banks And S&Ls
24	Aia Group Limited	Hong Kong	Insurance - Life	24	Chiba Bank Ltd (The)	Japan	Banks And S&Ls
25	Oversea-Chinese Banking Corporation Limi	Singapore	Banks And S&Ls	25	Nishi-Nippon City Bank Ltd	Japan	Banks And S&Ls
26	77 Bank Limited (The)	Japan	Banks And S&Ls	26	Insurance Australia Group Limited	Australia	Insurance - Prop/Cas/Health
27	Dbs Group Holdings Ltd	Singapore	Banks And S&Ls	27	Fukuoka Financial Group, Inc	Japan	Banks And S&Ls
28	Chiba Bank Ltd (The)	Japan	Banks And S&Ls	28	Anicom Holdings Incorporation	Japan	Insurance - Prop/Cas/Health
29	Bank Of East Asia Limited (The)	Hong Kong	Banks And S&Ls	29	Hiroshima Bank Limited (The)	Japan	Banks And S&Ls
30	Boc Hong Kong (Holdings) Ltd	Hong Kong	Banks And S&Ls	30	Shc Insurance Pte Limited	Singapore	Insurance - Prop/Cas/Health

Source: Bloomberg LLP and author's calculations.

Table A6. Emerging markets economies – systemic vulnerability ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Indequity Group Limited	South Africa	Insurance - Prop/Cas/Health	1	Indequity Group Limited	South Africa	Insurance - Prop/Cas/Health
2	Jsc Vtb Bank	Russian Federation	Banks And S&Ls	2	State Bank Of India	India	Banks And S&Ls
3	Bank Of India	India	Banks And S&Ls	3	Jsc Vtb Bank	Russian Federation	Banks And S&Ls
4	State Bank Of India	India	Banks And S&Ls	4	Bank Of India	India	Banks And S&Ls
5	Axis Bank Limited	India	Banks And S&Ls	5	Axis Bank Limited	India	Banks And S&Ls
6	Punjab National Bank Ltd	India	Banks And S&Ls	6	Hdfc Bank Limited	India	Banks And S&Ls
7	Canara Bank	India	Banks And S&Ls	7	Punjab National Bank Ltd	India	Banks And S&Ls
8	Hdfc Bank Limited	India	Banks And S&Ls	8	Canara Bank	India	Banks And S&Ls
9	Bank Of Baroda	India	Banks And S&Ls	9	Aditya Birla Nuvo Limited	India	Insurance - Life
10	Aditya Birla Nuvo Limited	India	Insurance - Life	10	Bajaj Finserv Limited	India	Insurance - Life
11	Lippo General Insurance Tbk Pt	Indonesia	Insurance - Prop/Cas/Health	11	Bank Of Baroda	India	Banks And S&Ls
12	Bajaj Finserv Limited	India	Insurance - Life	12	Grupo Financiero Banorte S.A.B. De C.V.	Mexico	Banks And S&Ls
13	Icici Bank Limited	India	Banks And S&Ls	13	Icici Bank Limited	India	Banks And S&Ls
14	Grupo Financiero Banorte S.A.B. De C.V.	Mexico	Banks And S&Ls	14	Lippo General Insurance Tbk Pt	Indonesia	Insurance - Prop/Cas/Health
15	Industrial Bank Co Ltd	China	Banks And S&Ls	15	Anadolu Anonim Turk Sigorta Sirketi	Turkey	Insurance - Prop/Cas/Health
16	Asuransi Harta Aman Pratama Tbk Pt	Indonesia	Insurance - Prop/Cas/Health	16	Industrial Bank Co Ltd	China	Banks And S&Ls
17	Sberbank Rossii Oao	Russian Federation	Banks And S&Ls	17	Paninvest Tbk Pt	Indonesia	Insurance - Life
18	Aviva Sigorta As	Turkey	Insurance - Prop/Cas/Health	18	Sberbank Rossii Oao	Russian Federation	Banks And S&Ls
19	Anadolu Anonim Turk Sigorta Sirketi	Turkey	Insurance - Prop/Cas/Health	19	Picc Property And Casualty Company Ltd	China	Insurance - Prop/Cas/Health
20	Bank Rakyat Indonesia (Persero) Tbk Pt	Indonesia	Banks And S&Ls	20	Aviva Sigorta As	Turkey	Insurance - Prop/Cas/Health
21	Bank Mandiri (Persero) Tbk Pt	Indonesia	Banks And S&Ls	21	Investec Limited	South Africa	Security Brokers & Dealers
22	Picc Property And Casualty Company Ltd	China	Insurance - Prop/Cas/Health	22	Anadolu Hayat Emeklilik A.S.	Turkey	Insurance - Life
23	Paninvest Tbk Pt	Indonesia	Insurance - Life	23	Bank Mandiri (Persero) Tbk Pt	Indonesia	Banks And S&Ls
24	Anadolu Hayat Emeklilik A.S.	Turkey	Insurance - Life	24	Bank Central Asia Tbk Pt	Indonesia	Banks And S&Ls
25	Turkiye Garanti Bankasi A.S.	Turkey	Banks And S&Ls	25	Agricultural Bank Of China Limited	China	Banks And S&Ls
26	Aksigorta Anonim Sirketi	Turkey	Insurance - Prop/Cas/Health	26	Aksigorta Anonim Sirketi	Turkey	Insurance - Prop/Cas/Health
27	New China Life Insurance Co Ltd	China	Insurance - Life	27	Bank Rakyat Indonesia (Persero) Tbk Pt	Indonesia	Banks And S&Ls
28	Yapi Ve Kredi Bankasi As	Turkey	Banks And S&Ls	28	New China Life Insurance Co Ltd	China	Insurance - Life
29	Bank Central Asia Tbk Pt	Indonesia	Banks And S&Ls	29	Ray Sigorta A.S.	Turkey	Insurance - Prop/Cas/Health
30	Akbank Tas	Turkey	Banks And S&Ls	30	China Construction Bank Corp	China	Banks And S&Ls

Source: Bloomberg LLP and author's calculations.

Table A7. Europe – systemic vulnerability ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	CPPgroup Plc	United Kingdom	Insurance - Prop/Cas/Health	1	CPPgroup Plc	United Kingdom	Insurance - Prop/Cas/Health
2	FBD Holdings Plc	Ireland	Insurance - Prop/Cas/Health	2	FBD Holdings Plc	Ireland	Insurance - Prop/Cas/Health
3	Nuernberger Beteiligungs-Ag	Germany	Insurance - Life	3	Randall And Quilter Investment Holdings	United Kingdom	Insurance - Prop/Cas/Health
4	Wuestenrot & Wuerttembergische Aktienges	Germany	Insurance - Life	4	Wuestenrot & Wuerttembergische Aktienges	Germany	Insurance - Life
5	Credit Industriel Et Commercial Sa	France	Banks And S&Ls	5	Interlife General Insurance Company Sa	Greece	Insurance - Prop/Cas/Health
6	Randall And Quilter Investment Holdings	United Kingdom	Insurance - Prop/Cas/Health	6	Helios Underwriting Plc	United Kingdom	Insurance - Life
7	Helios Underwriting Plc	United Kingdom	Insurance - Life	7	Allied Irish Banks Plc	Ireland	Banks And S&Ls
8	Deutsche Postbank Ag	Germany	Banks And S&Ls	8	Nuernberger Beteiligungs-Ag	Germany	Insurance - Life
9	Personal Group Holdings Plc	United Kingdom	Insurance - Prop/Cas/Health	9	Credit Industriel Et Commercial Sa	France	Banks And S&Ls
10	Amlin Plc	United Kingdom	Insurance - Prop/Cas/Health	10	Eurobank Ergasias Sa	Greece	Banks And S&Ls
11	Admiral Group Plc	United Kingdom	Insurance - Prop/Cas/Health	11	Deutsche Postbank Ag	Germany	Banks And S&Ls
12	Novae Group Plc	United Kingdom	Insurance - Prop/Cas/Health	12	Admiral Group Plc	United Kingdom	Insurance - Prop/Cas/Health
13	Phoenix Group Holdings	Netherlands	Insurance - Life	13	Amlin Plc	United Kingdom	Insurance - Prop/Cas/Health
14	Allied World Assurance Co Ag-Adr	Switzerland	Insurance - Prop/Cas/Health	14	Personal Group Holdings Plc	United Kingdom	Insurance - Prop/Cas/Health
15	Euler Hermes Group Sa	France	Insurance - Prop/Cas/Health	15	Hansard Global Plc	United Kingdom	Insurance - Life
16	Ackermans & Van Haaren	Belgium	Insurance - Prop/Cas/Health	16	Novae Group Plc	United Kingdom	Insurance - Prop/Cas/Health
17	Global Indemnity Plc-Adr	Ireland	Insurance - Prop/Cas/Health	17	Phoenix Group Holdings	Netherlands	Insurance - Life
18	Hiscox Plc	United Kingdom	Insurance - Prop/Cas/Health	18	Unicredit Spa	Italy	Banks And S&Ls
19	Hansard Global Plc	United Kingdom	Insurance - Life	19	Alpha Bank Sa	Greece	Banks And S&Ls
20	Swiss Re Ag	Switzerland	Insurance - Life	20	Bank Of Ireland	Ireland	Banks And S&Ls
21	Interlife General Insurance Company Sa	Greece	Insurance - Prop/Cas/Health	21	Unipolsai Assicurazioni Spa	Italy	Insurance - Prop/Cas/Health
22	Vittoria Assicurazioni Spa	Italy	Insurance - Prop/Cas/Health	22	Delta Lloyd Nv	Netherlands	Insurance - Life
23	Beazley Plc	United Kingdom	Insurance - Prop/Cas/Health	23	Permanent Tsb Group Holdings Plc	Ireland	Insurance - Life
24	Helvetia Holding Ag	Switzerland	Insurance - Life	24	Intesa Sanpaolo Spa	Italy	Banks And S&Ls
25	Chesnara Plc	United Kingdom	Insurance - Prop/Cas/Health	25	Beazley Plc	United Kingdom	Insurance - Prop/Cas/Health
26	Uniqa Insurance Group Ag	Austria	Insurance - Life	26	Euler Hermes Group Sa	France	Insurance - Prop/Cas/Health
27	Zurich Insurance Group Limited	Switzerland	Insurance - Prop/Cas/Health	27	Chesnara Plc	United Kingdom	Insurance - Prop/Cas/Health
28	Direct Line Insurance Group Plc	United Kingdom	Insurance - Prop/Cas/Health	28	Uniqa Insurance Group Ag	Austria	Insurance - Life
29	Baloise Holding Ag	Switzerland	Insurance - Life	29	Hiscox Plc	United Kingdom	Insurance - Prop/Cas/Health
30	Danske Bank As	Denmark	Banks And S&Ls	30	Lloyds Banking Group Plc	United Kingdom	Banks And S&Ls

Source: Bloomberg LLP and author's calculations.



Table A8. North America – systemic vulnerability ranking  
(ranking based on a VAR (8) specification)

Ranking	Firm	Country	Industry	Ranking	Firm	Country	Industry
<i>DY rankings</i>				<i>CLNDY rankings</i>			
1	Independence Holding Co	United States	Insurance - Prop/Cas/Health	1	Phoenix Companies Inc	United States	Insurance - Life
2	White Mtns Ins Group Ltd	Bermuda	Insurance - Prop/Cas/Health	2	Independence Holding Co	United States	Insurance - Prop/Cas/Health
3	Kingstone Cos Inc	United States	Insurance - Prop/Cas/Health	3	Federated National Hldg Co	United States	Insurance - Prop/Cas/Health
4	Partnerre Ltd	Bermuda	Insurance - Prop/Cas/Health	4	First Acceptance Corp	United States	Insurance - Prop/Cas/Health
5	Federated National Hldg Co	United States	Insurance - Prop/Cas/Health	5	Kingstone Cos Inc	United States	Insurance - Prop/Cas/Health
6	Axis Capital Holdings Ltd	Bermuda	Insurance - Prop/Cas/Health	6	White Mtns Ins Group Ltd	Bermuda	Insurance - Prop/Cas/Health
7	Donegal Group Inc	United States	Insurance - Prop/Cas/Health	7	Kingsway Financial Svcs Inc	Canada	Insurance - Prop/Cas/Health
8	Kansas City Life Ins Co	United States	Insurance - Life	8	Kansas City Life Ins Co	United States	Insurance - Life
9	First Acceptance Corp	United States	Insurance - Prop/Cas/Health	9	Stancorp Financial Group Inc	United States	Insurance - Prop/Cas/Health
10	Proassurance Corp	United States	Insurance - Prop/Cas/Health	10	Donegal Group Inc	United States	Insurance - Prop/Cas/Health
11	Markel Corp	United States	Insurance - Prop/Cas/Health	11	Hallmark Financial Services	United States	Insurance - Prop/Cas/Health
12	Stancorp Financial Group Inc	United States	Insurance - Prop/Cas/Health	12	Cigna Corp	United States	Insurance - Prop/Cas/Health
13	Fairfax Financial Holdings	Canada	Insurance - Prop/Cas/Health	13	National Sec Group Inc	United States	Insurance - Prop/Cas/Health
14	Arch Capital Group Ltd	Bermuda	Insurance - Prop/Cas/Health	14	National Interstate Corp	United States	Insurance - Prop/Cas/Health
15	Phoenix Companies Inc	United States	Insurance - Life	15	Mbia Inc	United States	Insurance - Prop/Cas/Health
16	Anthem Inc	United States	Insurance - Prop/Cas/Health	16	Anthem Inc	United States	Insurance - Prop/Cas/Health
17	Kingsway Financial Svcs Inc	Canada	Insurance - Prop/Cas/Health	17	Partnerre Ltd	Bermuda	Insurance - Prop/Cas/Health
18	Renaissancere Holdings Ltd	Bermuda	Insurance - Prop/Cas/Health	18	Interactive Brokers Group	United States	Security Brokers & Dealers
19	Cigna Corp	United States	Insurance - Prop/Cas/Health	19	Fairfax Financial Holdings	Canada	Insurance - Prop/Cas/Health
20	Baldwin & Lyons -CI B	United States	Insurance - Prop/Cas/Health	20	Axis Capital Holdings Ltd	Bermuda	Insurance - Prop/Cas/Health
21	Onebeacon Insurance Group	Bermuda	Insurance - Prop/Cas/Health	21	Emc Insurance Group Inc	United States	Insurance - Prop/Cas/Health
22	Infinity Property & Cas Corp	United States	Insurance - Prop/Cas/Health	22	United Insurance Holdings Co	United States	Insurance - Prop/Cas/Health
23	Interactive Brokers Group	United States	Security Brokers & Dealers	23	Utg Inc	United States	Insurance - Life
24	National Western Life -CI A	United States	Insurance - Life	24	Triple-S Management Corp	United States	Insurance - Prop/Cas/Health
25	Erie Indemnity Co -CI A	United States	Insurance - Prop/Cas/Health	25	National Western Life -CI A	United States	Insurance - Life
26	Hallmark Financial Services	United States	Insurance - Prop/Cas/Health	26	Universal American Corp	United States	Insurance - Prop/Cas/Health
27	Echelon Financial Hldgs Inc	Canada	Insurance - Prop/Cas/Health	27	Echelon Financial Hldgs Inc	Canada	Insurance - Prop/Cas/Health
28	Emc Insurance Group Inc	United States	Insurance - Prop/Cas/Health	28	Proassurance Corp	United States	Insurance - Prop/Cas/Health
29	Endurance Specialty Holdings	Bermuda	Insurance - Prop/Cas/Health	29	Wmih Corp	United States	Insurance - Prop/Cas/Health
30	Everest Re Group Ltd	Bermuda	Insurance - Prop/Cas/Health	30	Wellcare Health Plans Inc	United States	Insurance - Prop/Cas/Health

Source: Bloomberg LLP and author's calculations.