



# Article The Leaders, the Laggers, and the "Vulnerables"

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**Abstract:** We examine the lead-lag effect between the large and the small capitalization financial institutions by constructing two global weekly rebalanced indices. We focus on the 10% of stocks that "survived" all the rebalancings by remaining constituents of the indices. We sort them according to their systemic importance using the marginal expected shortfall (MES), which measures the individual institutions' vulnerability over the market, the network based MES, which captures the vulnerability of the risks generated by institutions' interrelations, and the Bayesian network based MES, which takes into account different network structures among institutions' interrelations. We also check if the lead-lag effect holds in terms of systemic risk implying systemic risk transmission from the large to the small capitalization, concluding a mixed behavior compared to the index returns. Additionally, we find that all the systemic risk indicators increase their magnitude during the financial crisis.

Keywords: financial networks; lead-lag effect; systemic risk; VAR

## 1. Introduction

Seeking for positive expected return and managing portfolio risk are two sides of the same coin, accompanied by a risk-return trade-off that depends on the risk appetite of the market participants. The early literature includes many studies that focus on the behavior of asset returns and the possibility of significant profits due to information diffusion. One of the major financial economic concerns is to understand how firms transmit information to markets and how markets impose this information on stock prices. Traditional asset-pricing theories assume that information is disseminated instantaneously in a complete and frictionless market. However, there is a considerable empirical reason to believe that investors are facing significant frictions, and information can sometimes be slowly transmitted to the market. Specifically, there is ample evidence pointing to a lead-lag effect on equity markets where the stock prices of some firms show a delayed reaction to other firms' price innovations. Lo and MacKinlay (1990) mentioned that the forecasting ability of stock returns can be attributed to what is known as the "stock market overreaction" hypothesis, based on the waves of optimism or pessimism of investors creating a "momentum". Hou (2007) primarily focused on explaining the lead-lag effect as a sluggish reaction of certain firms to common information compared to others. The author conditioned on the industry membership, because slow diffusion of common information should be more prevalent among firms from the same industry, and he showed that within the same industry, large firms lead small firms. DeMiguel et al. (2014) studied whether investors can exploit serial dependence in stock returns to improve out-of-sample portfolio performance. Using raw returns rather than returns in excess of the risk-free rate and a rolling-horizon procedure, they estimated a VAR model of a small and large stock portfolio and verified a lead-lag relationship with large stock returns leading small stock returns.

In this study, we also restricted to a single industry, that is financial institutions. Why financial institutions? The fact that a healthy financial system is the backbone of economic progress is addressed by many papers<sup>1</sup>. Additionally, the waves of optimism or pessimism are not limited to one institution as the financial system's structure is comprised of many financial institutions with linkages between them that may transfer and magnify financial stress during times of crisis (e.g., Billio et al. 2012). The financial institutions' connectivity is investigated in many works focusing on the systemic risk<sup>2</sup>, emphasizing the importance of the financial system's structure during systemic events and the homogeneity or asset commonality between financial institutions<sup>3</sup>. The works in Wagner (2010) and Allen et al. (2012) pointed out that an increasing homogeneity between financial institutions makes them vulnerable to the same risks, as they become more similar to each other. The former Fed Chairman, Paul Volcker, supported imposing restrictions on the risk level of large banks, on their size, their interconnections, and activities (Volcker 2012).

The systemic risk as a function of the financial system's architecture and the size of the financial institutional participants is still under debate among regulators and researchers, especially that large banks were found to have an integral role at the center of the recent financial crisis; see Laeven et al. (2016). The authors studied the significant variation in the cross-section of systemic risk measures of large banks during the recent financial crisis in a broad sample of countries, intending to identify bank-specific factors, like banks size, capital, funding, and activities, that determine systemic risk and shed light on the ongoing debate on the merits of restricting bank size, imposing capital surcharges on large banks, and/or restricting their unstable funding and risky activities. Several theories support the view that large and complex banks contribute to systemic risk. According to one view, which the authors named "the unstable banking hypothesis", large banks tend to engage in risky activities more (e.g., trading) and to be financed more by short-term debt, which makes them more vulnerable to generalized liquidity shocks and market failures such as liquidity shortages and fire sales (Kashyap et al. 2002; Shleifer and Vishny 2010; Gennaioli et al. 2013). In our view, the importance and the implications of this "hypothesis" are not addressed much by the literature. We chose to expand the sample of financial institutions to a broader one because the results of a shock and its dissemination have not been studied or highlighted so far. For example, the removal of the floor of the Euro/Swiss franc exchange rate from the Swiss National Bank was at a time when the markets were not turbulent. However, some financial services companies have been insolvent due to poorly, for such an event, margined positions. The questions that arise are: How much can the insolvency of small financial institutions become a problem? Who are the "vulnerable" portfolio constituents? Can a financial institution be vulnerable, but at the same time a leader in terms of returns?

The literature discussing measures of banks' systemic risk is vast, and Benoit et al. (2017) provided an excellent survey of systemic risk measures. The literature either uses only market data, i.e, financial returns or credit default swaps (CDS) (e.g., Billio et al. 2012; Acharya et al. 2012; Allen et al. 2012; Adrian and Brunnermeier 2016), or enriches the dataset with balance sheet data (among others, Brownlees and Engle (2017)) to measure systemic risk. A combination of both microeconomic and macroeconomic data was used by Calabrese and Giudici (2015), who built a statistical model of bank distress, based on the balance sheet of a bank, and on macroeconomic information on the country where the bank operated. Several authors discussed the systemic risk vulnerability in the context of financial networks facing the challenge to provide not only a good fit,

<sup>&</sup>lt;sup>1</sup> The literature is vast. We refer to some papers that can navigate the reader who is interested in the literature of financial intermediation and the related topics, e.g., Santomero (1984), Bhattacharya and Thakor (1993), Allen and Santomero (2001), and Berger and Bouwman (2009).

<sup>&</sup>lt;sup>2</sup> The literature is vast. Among others, see Eisenberg and Noe (2001), Lehar (2005), Bartram et al. (2007), and Gofman (2017).

<sup>&</sup>lt;sup>3</sup> The homogeneity could be empowered by the tendency of financial institutions to hold the market portfolio as inclined by the modern portfolio theory Markowitz (1952) and by the deregulation following the Second Banking Directive of 1989 and the Gramm-Leach-Bliley Act (1999) (https://www.govinfo.gov/content/pkg/PLAW-106publ102/pdf/PLAW-106publ102.pdf) in Europe and the US.

but also a good interpretation. This may result in choosing a model that has little support from the data, leading to predictions worse than could be obtained with other models. Additionally, the graphical models are essentially static, photographing a situation in a given period. This assumption seems to be restrictive in economics, in the case of variables that change over time, for example during periods of financial stress. Giudici and Green (1999) and recently in Ahelegbey et al. (2016) proposed more advanced, Bayesian, graphical models to overcome this limitation. Battiston et al. (2012) contributed to the debate on the resilience of financial networks by introducing a dynamic model for the evolution of financial robustness, showing that, in the presence of financial acceleration and persistence, the probability of default did not decrease monotonically with diversification. As a result, the financial network was most resilient for an intermediate level of connectivity. Diebold and Yilmaz (2014) proposed several connectedness measures built from pieces of variance decompositions, and they argued that they provided natural and insightful measures of connectedness. They also showed that variance decompositions define weighted, directed networks, so that our connectedness measures are intimately related to key measures of connectedness used in the network literature. Building on these insights, they tracked daily time-varying connectedness of major U.S. financial institutions' stock return volatilities in recent years, with emphasis on the financial crisis of 2007–2008. Abedifar et al. (2017) compared the results of three different measures to gauge systemic risk, employing an application of the graphical network model described by Giudici and Spelta (2016) to identify the most interconnected banking sector. Avdjiev et al. (2019), based on a tensor decomposition method that extracted an adjacency matrix from a multi-layer network, proposed a distress measure for national banking systems that incorporated not only banks' CDS spreads, but also how they interacted with the rest of the global financial system via multiple linkage types, using banks' foreign exposures. Despite the vast amount of literature, there is no widely accepted methodology to determine the systemically important nodes in a network. To answer this, Battiston et al. (2012) introduced the DebtRank metric to determine the impact of the distress of one or several financial institutions through their counterparties' network. Soramaki and Cook (2013) introduced SinkRank to predict the influence of disturbance caused by the collapse of a bank and identify most affected banks in the system, and Brunnermeier and Cheridito (2019) developed SystRiskto capture the a priori cost to society for providing tail-risk insurance to the financial system. In addition, Elliott et al. (2014) proposed a simple model of cross-holdings to analyze cascades in financial networks; they concluded that diversification and integration of financial institutions had non-monotonic effects on financial contagions, whereas Amini et al. (2016) considered the magnitude of contagion in large counterparty network, giving analytical expression for the asymptotic fraction of defaults, emphasizing in this way the key role of contagious links via the institutions with large connectivity and a large fraction of contagious links.

To measure systemic risk, we used the marginal expected shortfall (MES) of Acharya et al. (2017) and its alternatives proposed by Hashem and Giudici (2016). MES is simply calculated by each firm's average return during the C% worst days for the market. It measures how exposed a firm is to the aggregate tail shocks, and together with leverage, it has a significant explanatory power for which firms contribute to a potential crisis (see, Acharya et al. 2017). Additionally and for the portfolio allocation, we used MES because, under the assumption that the individual financial institution and the index returns are driven by a bivariate GARCH, the MES of the financial institution is proportional to its systematic risk, as measured by its time-varying beta (see Benoit et al. 2017). On the other hand, there is much criticism of the systemic risk measures, and various papers have presented their shortcomings (among others, Danielsson et al. 2016; Benoit et al. 2019; Idier et al. 2014). The discussion of the adequacy of the systemic risk measures is out of the scope of this paper, and we chose to use MES and its two alternatives, for three main reasons: First, the stock returns used for its calculation are easily obtained and updated, contrary to the balance sheet data used in other measures that are updated at a quarterly frequency. Second, MES provides a clear measure of the expected loss of financial institutions when an extreme event occurs. Third is its additive property. The sum of MES from all banks is equal to a measure of the total systemic risk, allowing for macroprudential tools to be

implemented at the bank level (see Tarashev et al. 2010; Qin and Zhou 2013). The disadvantage of this method is that it does not reflect characteristics like the size and the leverage. However, we would like to address that MES is based on historical data like measures of risks built on the covariance matrix. Given the uniqueness of each crisis, the assumption that the risk measures or the parameters involved in their calculation are sufficiently invariant makes these measures "forensic" tools, as Malevergne and Sornette (2006) pointed out. Therefore, MES complements other forensic approaches without being a forward-looking indicator for an upcoming crisis.

This paper contributes to the size and interconnectedness debates in three ways:

First, we examine the lead-lag effect reported by Lo and MacKinlay (1990) between large and small capitalization financial index returns. To obtain the two indexes, we divide the financial institutions based on their market capitalization into top ones that are the largest until reaching the top 50th percentile of market capitalization and the remaining bottom ones, repeating this procedure on a weekly basis over the pre- and post-financial crisis period of 2007. We choose to use market capitalization (market cap), as it is widely used to create a context for judging company financial performance and business outlook. Larger cap tend to have more broadly diversified business structures than smaller firms. This may give them more stable business performance from year-to-year, with relatively less variable earnings and revenue streams. As a result, large companies may have less volatile share prices than smaller firms in many circumstances. Large companies, on the other hand, tend to have a tighter business focus. They may have the potential for more rapid revenue and profit growth, but this potential is often more variable. As a result, small-company shares may be, on average, more volatile and more sensitive to macroeconomic shifts than the shares of larger companies.

Second, we form a large and a small cap portfolio of the stocks that remained as index constituents in every rebalance (named "survived" large and small cap stocks), and we test whether the lead-lag effect is sustained within the systemic risk measures of those. For this purpose, we use a non-directional systemic risk measure, which does not take size into account upon its construction. This allows us to control for the contemporaneous size effect that results from the systemic risk measure specification. Thus, we use the bivariate marginal expected shortfall (MES) systemic risk measure of Acharya et al. (2017) to estimate the risk exposure of an individual institution to the market.

Third, we test if the size impact holds upon taking into consideration the financial system structure. The use of network analysis gives insightful information about important players in terms of network connectivity. For this purpose, we use two alternatives of MES that take the interconnectedness relations into account: the network based MES (NetMES), which extends MES by taking multivariate dependencies into its estimation; and the Bayesian NetMES, which further accounts for the network model uncertainty.

We further investigate the size impact at the individual institution level. Upon the estimation of MES, NetMES, and Bayesian NetMES, we rank the institutions based on the systemic risk indicators in descending order for the systemic risk level. We select the top six ranking institutions across the different systemic risk measures, and we evaluate their network connectedness.

The paper is organized as follows: Section 2 describes in detail the dataset and the construction of the large and the small capitalization indices. Section 3 states the VAR model, which explains the lead-lag relation between the large and the small cap index returns and tests its statistical significance to identify the origin of the predictability in index returns. Section 4 discusses the systemic risk indicators, and Section 5 presents the results of the lead-lag relations between the systemic risk indicators. We also give details about the systemically important financial institutions derived from the previous analysis. Section 6 concludes.

#### 2. Data and Market Indices

We examined the interrelations between the large and small capitalization financial stocks by constructing our own indices, instead of using an existing benchmark market index. An already available index would be like a black box, as details like the constituents of the index, the weights in each distinct point of time, and the re-balancing dates are unknown. Indeed, comparing the available benchmark market indices, three separate causative influences can be uncovered. First, the behavior of equity indices is partly attributable to the technical procedures of its construction. Some indices have a small number of stocks, while others have a large number<sup>4</sup>. Some local benchmark market indices are industrially concentrated, while others are very diversified. These diversification elements explain part of the observed inter-market differences in price indices' behavior, which do not correspond to differences in the individual stocks behaviors. Second, local indices may vary in their industrial composition and have industries that are inherently more or less volatile. We can think of a local index as a country-specific managed portfolio with particular industry sector "bets". In this context, even a large portfolio can be influenced by disproportionate investments in certain industries. Third, exchange rates play a significant role. With returns expressed in a local currency, part of a stock index's return volatility is induced by monetary phenomena such as changes in anticipated and actual local inflation rates. Converting local currency returns into common currency returns (e.g., the U.S. dollar) does not entirely eliminate the exchange rate's influence.

The steps followed to construct our indices were: First, we collected stocks across the globe, which according to the Global Industry Classification Standard (GICS) were classified as banks and diversified financial institutions, excluding consumer finance, diversified financial services, insurance, and real estate companies. The fact that our sample contained a wide range of financial institutions and not only banks allowed us to take into account other sources of risks. In particular, our sample contained financial institutions exposed to sovereign systemic risk (the case of Greece during the debt crisis), to geographic risk (for example, periods of turmoil in Middle Eastern countries), and/or to risks driven by different banking business models (e.g., banks, asset management and custody banks, etc.). We remark that, as the GICS was applied to companies around the world and it was annually revised, the universe was continuously up-to-date and, therefore, so were our results. Second, we divided them into two tiers: the top 50 sequential percentile rank and the bottom 50 sequential percentile rank, obtaining the large and the small capitalization groups, respectively. The sample was free of survivorship, restatement, and lagging bias and contained the five largest world companies, which accounted for 63.02% of the 2010 world banking sector and represented the fundamentals as they were known in the market at each observation point. Then, all the stock prices were converted into U.S. dollars, since according to Roll (1992), the best way to combine stocks in the same industry, but traded in different currencies was to convert all first to a common currency and then construct the industry index. Beginning from 31 December 2014, and going back to 1 January 2005, our portfolio was weekly rebalanced, ending up with 522 different groups of large and small capitalization financial stocks. During the coverage period, the indices covered 2590 stocks; 1361 appeared in the weekly large cap portfolios and 2064 in the small cap portfolios, and 835 stocks moved between the two groups. The set of large cap stocks spanned 98 countries, 3 industry groups (Banks, Capital Markets, Thrifts & Mortgage), 6 sub-industries (Asset Management & Custody Banks, Diversified Banks, Diversified Capital Markets, Investment Banking & Brokerage, Regional Banks, Thrifts & Mortgage Finance)<sup>5</sup>, and 103 primary exchanges. For the small cap stocks group, there were 108 countries and 118 primary exchanges. The number of industry and sub-industry groups was the same. Only 321 out of 1361 large

<sup>&</sup>lt;sup>4</sup> For example, the Deutsche Boerse AG German Stock Index, DAX, is composed of 30 selected German blue-chip stocks, while the Russell 1000 Index is composed of the largest 1000 companies of Russell 3000, representing the universe of the large capitalization stocks from which most active money managers typically select.

<sup>&</sup>lt;sup>5</sup> Appendix A Table A1 contains the definitions of the groups according to GICS obtained from https://www.msci.com/gics and some examples.

cap stocks "survived" through the years in each rebalance, having a positive weight in the indices. On the other hand, 193 out of the 2064 small cap stocks survived. In both cases, we called these groups as "survived". Following the sub-industry classifications, from the 321 large cap survived financial institutions, 39 belonged to the Asset Management & Custody Banks (AMC), 131 to the Diversified Banks (DB), 8 to the Diversified Capital Markets (DCM), 19 to the Investment Banking & Brokerage (IBB), 98 to the Regional Banks (RB), and 11 to the Thrifts & Mortgage Finance (TMF) sub-industry. Accordingly, from the 193 small cap survived financial institutions, 23 belonged to the Asset Management & Custody Banks (AMC), 18 to the Diversified Banks (DB), 32 to the Investment Banking & Brokerage (IBB), 87 to the Regional Banks (RB), and 14 to the Thrifts & Mortgage Finance (TMF) sub-industry. Unlike the large cap survived group, the Diversified Capital Markets sub-industry for the small cap survived financial institutions.

The descriptive statistics (Table A2) of the weekly returns of the indices showed a departure from normality. Both the skewness and the excess kurtosis statistics were significantly higher than those of the normal distribution at all meaningful significance levels, and these suggested that both series were negatively skewed and leptokurtic. For the large cap index returns, the maximum positive change was 13.605% in November 2008 and the maximum drop -17.78% in October 2008. For the small cap index returns, the maximum positive change was 8.25% in May 2009 and the maximum drop -13.67% in October 2008. For both series, the worst weekly change took place at the end of the second week of October 2008, when UniCredit, Italy's second biggest bank by market capitalization, was rumored to be insolvent and a large International Monetary Fund (IMF)-EU rescue package was needed to stabilize the situation in Hungary, where the short-term swap and bond markets were frozen. The period with the highest increases was in April 2009, when the G20 and Japan announced a U.S.\$1-trillion and a U.S.\$150-billion economic stimulus package, respectively, against the financial crisis. In terms of Granger causality and assuming one period of lagged returns, it was found that the null hypothesis that the returns of the large cap index did not Granger cause the returns of the small cap index was rejected with a test F-statistic of 6.1035, which was significant at the 1.49% level. On the other hand, the null hypothesis that the small cap index did not Granger cause the large cap index could not be rejected at any conventional levels of significance (see Table A2).

#### 3. Lead-Lag Effect

The integration of world financial markets has hastened due to the economic globalization and Internet communication spreading effortless and immediately the price movements from one to another market. Thus, financial markets are more dependent on each other than ever before; one market may lead another one under some circumstances, yet the relationship may be reversed under other circumstances. Consequently, knowing how the markets are interrelated is of great importance. In the same way, for an investor or a financial institution holding multiple assets, the dynamic relationships between asset returns play a vital role in decision making. Furthermore, stock trades do not occur in a synchronous manner, since the trading intensity varies from hour-to-hour and from day-to-day. This important phenomenon known as the lead-lag relationship was first documented by Lo and MacKinlay (1990). Assume that *LCR<sub>t</sub>* and *SCR<sub>t</sub>* are the returns of the large and the small cap index, and let  $r_t$  be a 2 × 1 vector of the index returns at time t. The dynamics of  $r_t$  are presumed to be governed by a first-order Gaussian vector autoregressive model:

$$r_t = c + \Phi r_{t-1} + \epsilon_t \tag{1}$$

where  $\epsilon_t \sim NIID(0, \Omega)$  is the error vector, *c* is a 2 × 1 vector of intercepts, and  $\Phi$  is a 2 × 2 matrix of slopes. The VAR specification assumes that the next period's index return is linearly dependent on today's with the linear dependency captured by the slope matrix. The analytic representation of the VAR(1) defined above suggests the following regression model:

$$\begin{pmatrix} LCR_t \\ SCR_t \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{pmatrix} \begin{pmatrix} LCR_{t-1} \\ SCR_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_t^{large} \\ \epsilon_t^{small} \end{pmatrix}$$
(2)

Following Hou (2007), who estimated the VAR equations assuming one lag and four lags using weekly data, we considered monthly returns of the large cap and the small cap indices, and we estimated a VAR(1) model. The results are as follows (*p*-values appear in brackets below estimates):

$$\widehat{LCR}_{t} = \underbrace{0.0038}_{(0.3953)} + \underbrace{0.7033LCR_{t-1}}_{(0.004)} - \underbrace{0.3277SCR_{t-1}}_{(0.245)} \quad \bar{R}^{2} = 20.40\%$$

$$\widehat{SCR}_{t} = \underbrace{0.0060}_{(0.1091)} + \underbrace{0.4922LCR_{t-1}}_{(0.0149)} - \underbrace{0.0969SCR_{t-1}}_{(0.6787)} \quad \bar{R}^{2} = 23.88\%.$$
(3)

The above-estimated coefficients derived a number of interesting conclusions. First, we confirmed the lead-lag reported by DeMiguel et al. (2014) and Lo and MacKinlay (1990), that the large cap index returns led the small cap index returns, since the large cap interaction coefficient  $\phi_{21}$  was positive and statistically significant. Second, the autoregressive coefficient of the large cap stocks was statistically significant and positive, and finally, in line with the Granger causality results obtained previously, large cap index returns did not depend on past small cap index returns ( $\phi_{12} = 0$ ).

We now present some robustness checks of our lead-lag effect exercise. A rolling analysis was used to evaluate the stability of the parameters identifying the periods where the interaction between the two different segments of the market was more intense. Rolling analysis is also useful to study if and how the direction of the interaction changes over time. Finally, with the rolling analysis, we could examine the evolution of the autoregressive coefficients through time. The VAR model was estimated using a 60 month window (close to the 2000 day estimation window of DeMiguel et al. (2014)) testing along side the significance of the coefficients. In Figure 1, we present the time path of the estimated autoregressive coefficients and interaction terms. The gaps indicate the periods where they were not statistically significant. The large cap autoregressive coefficient  $\phi_{11}$  was statistically significant for almost the entire sample period until August 2014. The estimates of  $\phi_{11}$  were quite variable, indicating that the market trend in the large cap index was not constant over time. The joint conditions  $\phi_{11}$ ,  $\phi_{22} > 0$  were needed to test for momentum, which in our case were eliminated to test that  $\phi_{11} > 0$ , since  $\phi_{22}$  was not significant in our benchmark model. It was apparent that the coefficient  $\phi_{11}$  was statistically positive for the entire sample period, highlighting the existence of momentum in the large cap segment of the market. The small cap interaction term  $\phi_{12}$  was statistically significant for the sample periods ending in November 2013 to April 2014, implying that the large cap index returns were affected by the lagged small cap index returns for a very short period. On the other hand, the interaction term of the lagged large cap return index on the small cap index return was statistically significant for almost the entire period ending in January 2010 to April 2014, with the exception of the period March 2012-May 2012.



**Figure 1.** Coefficient estimates of regression (1) plotted only when they are statistically significant. The grey-square marked line shows the estimates of the autoregressive coefficient of the lagged large cap index returns. The orange-cross marked line shows the estimates of the interaction term of the lagged large cap index returns on the small cap index returns. The blue solid line presents the interaction of the lagged small cap index returns on the large cap index returns.

#### 4. Systemic Risk and Network Measures

The number of systemic risk definitions is vast, and the underlying idea is either based on the market's efficiency, and therefore the information dispersion, or on the information coming from market data (e.g., accounting data). One prominent example of the market data based measure is the marginal expected shortfall (MES) of Acharya et al. (2017). In our analysis, we used MES and some variations of it.

#### 4.1. Marginal Expected Shortfall

Consider the bivariate vector  $r_t = (r_{i,t}, r_{m,t})'$  of the i<sup>th</sup> financial institution returns and of its reference market, *m*, at time *t*. Based on the expected shortfall, which is, in other words, the tail conditional expectation of Artzner et al. (1999), Acharya et al. (2017) introduced the marginal expected shortfall (*MES*) to capture the marginal contribution of the *i*<sup>th</sup> institution to the risk of the financial system, defined as:

$$MES_{i,t}(C) = \frac{\partial ES_{m,t-1}(C)}{\partial y_i} = -E[r_i | r_{m,t} \le C]$$
(4)

where  $y_i$  is the weight of the *i*<sup>th</sup> financial institution in the total portfolio  $r_{m,t} = \sum_i y_{i,t} r_{i,t}$  and *C* is a threshold that defines the distress event examined. Institutions with higher MES are the ones contributing the most to the market decline; hence, they are more likely to be systemically risky. Given our global dataset, we would be able to identify global systemically important financial institutions by estimating an institution's capital shortfall in the case of a worldwide shock. In the aspect of the "cause and effect", MES is on the "cause" side, in the sense that it is calculated assuming that the market index is already at the tail; therefore, MES captures the "effect" the later has, on the systemic risk of the stock. The aggregate MES is interpreted as the marginal expected shortfall of the returns of a portfolio consisting of individual banks' equities when the market returns fall below a certain threshold level. In our implementation of MES, we used the dynamic conditional correlation to take into account the increase in volatility during crisis times. To this aim, we followed Brownlees and Engle (2012) and Engle (2012), who employed a bivariate GARCH model for the demeaned returns process, based on a capital asset pricing model (CAPM). Let *H* be the variance-covariance matrix of  $r_t = (r_{i,t}, r_{m,t})'$ , Brownlees and Engle (2012). Engle (2012) proposed that:

$$r_t = H_t^{1/2} \epsilon_t, \tag{5}$$

where  $\epsilon_t = (\epsilon_{m,t}, \eta_{i,t})$  represents a vector of zero mean innovations, and:

$$H_t = \begin{pmatrix} \sigma_{m,t}^2 & \sigma_{m,t} \,\sigma_{i,t} \,\rho_{i,t} \\ \sigma_{m,t} \,\sigma_{i,t} \,\rho_{i,t} & \sigma_{i,t}^2 \end{pmatrix} \tag{6}$$

where  $\sigma_{m,t}$  is the standard deviation of the reference market returns,  $\sigma_{i,t}$  is the standard deviation of the financial institution's returns, and  $\rho_{i,t}$  is its correlation with the reference market returns. To estimate  $H_t$ , we used the dynamic conditional correlation model of Engle (2002) and Engle and Sheppard (2001). Under the model structure described by (5) and (6)<sup>6</sup> and the definition of MES, it is shown that:

$$MES_{i,t}(C) = E_{t-1}(r_{i,t}|r_{m,t} < C) = E_{t-1}(\sigma_{i,t}\rho_{i,t}\varepsilon_{m,t} + \sigma_{i,t}\sqrt{1 - \rho_{i,t}^2}\eta_{i,t}|\varepsilon_{m,t} < \frac{C}{\sigma_{m,t}})$$

$$MES_{i,t}(C) = \sigma_{m,t}\rho_{i,t}E_{t-1}(\varepsilon_{m,t}|\varepsilon_{m,t} < \frac{C}{\sigma_{m,t}}) + \sigma_{i,t}\sqrt{1 - \rho_{i,t}^2}E_{t-1}(\eta_{i,t}|\varepsilon_{m,t} < \frac{C}{\sigma_{m,t}})^7.$$
(7)

The last relationship states that MES is a weighted function of the tail expectation of the standardized market residual and the tail expectation of the standardized idiosyncratic financial institution's residual, measuring the vulnerability of the financial institution i to the systemic risk originated from the financial market m, given that the market returns are less than an assumed threshold C. The intuition behind higher values of MES is that the more vulnerable the institution is to systemic risk, the higher is its contribution to the risk of the financial system. Benoit et al. (2017) showed that MES and the systematic risk of the financial institution are proportional, that is:

$$MES_{i,t}(C) = \beta_{i,t}E_{t-1}(r_{m,t}|r_{m,t} < VaR_{m,t}(C)) = \beta_{i,t}ES_{m,t}(C),$$
(8)

where  $\beta_{i,t} = \rho_{i,t} \frac{\sigma_{i,t}}{\sigma_{m,t}}$  is the time-varying beta and  $ES_{m,t}(C)$  is the expected shortfall of the market.

The functional form of MES implies that it can be aggregated, resulting in an aggregate measure, which is interpretable as the marginal expected shortfall of the return of the portfolio of stocks conditional on the market returns being below a certain threshold level.

#### 4.2. Network Marginal Expected Shortfall

In highly correlated markets, such as financial systems, it could be very well the case that the correlation between the market and the institution returns contains other effects, for example, the correlation of the institution with other institutions or the correlation of the market with other institution returns. To remove "spurious" effects, which may bias the relationship between the institution and the market returns, we replaced marginal correlations with partial correlations: the correlations between the residuals from the regression of the institution returns on all other institution returns and the residuals from the regression of the market returns on all other institutions. In this way, we obtained a "netted" estimate of H, not biased by spurious effects, and consequently, a "netted" estimate of MES. We followed the definition of NetMES as introduced by Hashem and Giudici (2016) to take interconnectedness into account in the estimation of MES, and the partial correlations,  $\rho_{ij.V}$ , are calculated by:

$$\rho_{ij.V} = corr(\varepsilon_{X_i|X_{V\setminus\{j\}}}, \varepsilon_{X_j|X_{V\setminus\{i\}}})$$

<sup>&</sup>lt;sup>6</sup> Furthermore, considering that the Cholesky decomposition of the variance-covariance matrix  $H_t$  is  $H_t^{1/2} = \begin{pmatrix} \sigma_{m,t} & 0 \\ \sigma_{i,t}\rho_{i,t} & \sigma_{i,t}\sqrt{1-\rho_{i,t}^2} \end{pmatrix}$ . See, Benoit et al. (2013).

where  $\varepsilon_{X_i|X_{V\setminus\{j\}}}$  are residuals of the regression of  $X_i$  on all other variables excluding  $X_j$  and  $\varepsilon_{X_j|X_{V\setminus\{i\}}}$  are the residuals of the regression of  $X_j$  on all other variables excluding  $X_i$ . The partial correlation coefficient allows measuring the additional contribution of variable  $X_j$  to the variability of  $X_i$  that is not already explained by the other variables, and vice versa. In our setting, we regressed the market index and institution  $i_1$  to the rest of institutions returns to extract the residuals  $\epsilon_{i_1t}$  and  $\epsilon_{mt}$ , that is:

$$\begin{cases} r_{m,t} = a_1 + \beta_2 r_{i_2,t} + \dots + \beta_n r_{i_n,t} + \varepsilon_{i_1,t} \\ r_{i_1,t} = a_1 + \beta_2 r_{i_2,t} + ldots + \beta_n r_{i_n,t} + \varepsilon_{m,t} \end{cases}$$
(9)

and then, we obtained the partial correlation, that is  $\rho_{m,i_1} = corr(\varepsilon_{m,t}, \varepsilon_{i_1,t})$ . We repeated this extraction process for each pair of market and institution returns ( $r_{mt}$ ,  $r_{it}$ ), which are inserted in (8), to obtain the variance-covariance matrix, H, and consequently the NetMES.

#### 4.3. Bayesian Network Marginal Expected Shortfall

A network is comprised of a set of financial institutions, in which each institution represents a node. Assuming a multivariate Gaussian model for the time series observations of *N* financial agents, the linkages between the nodes can be described by an adjacency matrix *A* that has an  $N \times N$ dimension with elements  $a_{i,j}$ , in which  $a_{i,j} = 1$  when two nodes are correlated and  $a_{i,j} = 0$  when they are not correlated. Partial correlations can be estimated assuming that the same observations follow a graphical Gaussian model, in which the variance-covariance matrix  $\Sigma$  is constrained by the conditional independence described by a graph (see e.g., Lauritzen (1996)).

More formally, let  $x = (x_1, ldots, x_N) \in \mathbb{R}^N$  be an *N*-dimensional random vector distributed according to a multivariate normal distribution  $\mathcal{N}_N(\mu, \Sigma)$ . We assume throughout that the covariance matrix  $\Sigma$  is not singular. For an undirected graph, let G = (V, E), with vertex set  $V = \{1, ldots, N\}$ and edge set  $E = V \times V$ , a binary matrix, with elements  $e_{ij}$ , which describe whether pairs of vertices are (symmetrically) linked between each other ( $e_{ij} = 1$ ) or not ( $e_{ij} = 0$ ). If the vertices V of a graph are put in correspondence with the random variables  $X_1$ , *ldots*,  $X_N$ , the edge set E induces conditional independence on X via the so-called Markov properties (see, e.g., Lauritzen (1996)). More precisely, the pairwise Markov property determined by G states that for all  $1 \le i < j \le N$ :

$$e_{ij} = 0 \Longleftrightarrow X_i \perp X_j | X_{V \setminus \{i,j\}};$$

The absence of an edge between vertices *i* and *j* is equivalent to independence between the random variables  $X_i$  and  $X_j$ , conditionally on all other variables  $x_{V \setminus \{i,j\}}$ .

In our context, all random variables are continuous, and it is assumed that  $X \sim \mathcal{N}_N(0, \Sigma)$ . Let the elements of  $\Sigma^{-1}$ , the inverse of the variance-covariance matrix, whose elements are indicated by  $\{\sigma^{ij}\}$ . Whittaker (2009) proved that the following equivalence also holds:

$$X_i \perp X_j | X_{V \setminus \{i,j\}} \Longleftrightarrow \rho_{ij,V} = 0$$

where:

$$\rho_{ij.V} = \frac{-\sigma^{ij}}{\sqrt{\sigma^{ii}\sigma^{jj}}}$$

denotes the *ij*<sup>th</sup> partial correlation. It can also be shown that the partial correlation coefficient  $\rho_{ij,V}$  is equal to the correlation of the residuals from the regression of  $X_i$  on all other variables (excluding  $X_j$ ) with the residuals from the regression of  $X_i$  on all other variables (excluding  $X_i$ ), as in the following:

$$\rho_{ij,V} = (\varepsilon_{X_i|X_{V\setminus\{i\}}}, \varepsilon_{X_i|X_{V\setminus\{i\}}}).$$

In other words, the partial correlation coefficient measures the additional contribution of variable  $X_i$  to the variability of  $X_i$  not already explained by the others, and vice versa.

A graphical Gaussian model is a Gaussian distribution constrained by a set of partial correlations equal to zero, which corresponds to variables whose additional contribution is not statistically significant. Mathematically, by means of the pairwise Markov property, given an undirected graph G = (V, E), a graphical Gaussian model can be defined as the family of all *N*-variate normal distributions  $\mathcal{N}_N(0, \Sigma)$  that satisfy the constraints induced by the graph on the partial correlations for all  $1 \le i < j \le N$ , as follows:

$$e_{ij} = 0 \iff \rho_{ij,V} = 0$$

In practice, the available data are used to test which partial correlations are different from zero at the chosen significance level threshold  $\alpha$ . A drawback of this approach is that results are conditional on a fixed graphical structure. To overcome this problem, we employed a Bayesian model averaging approach, where the estimates were the averages of those coming from the different graphical structure, each with a weight that corresponded to the Bayesian posterior probability of the corresponding graph.

For the purpose of a Bayesian application, the first task was to derive the likelihood of a graphical network and specify an appropriate probability distribution over all graphical networks. For a given a graph *G*, we considered a sample *X* of size *n* from a Gaussian probability distribution  $P = \mathcal{N}_N(0, \Sigma)$ , and let *S* be the observed variance-covariance matrix that estimates  $\Sigma$ . The graph *G* has a defined subset of vertices  $A \subset N$ , in which  $\Sigma_A$  denotes the variance-covariance matrix of the variables in  $X_A$  and has  $S_A$  as the corresponding observed variance-covariance submatrix. When the graph *G* is decomposable, the likelihood of the data, under the graphical Gaussian model specified by *P*, nicely decomposes as follows (see, e.g., Giudici and Spelta (2016)):

$$p(x|\Sigma, G) = \frac{\prod_{c \in \mathcal{C}} p(x_C | \Sigma_C)}{\prod_{s \in \mathcal{S}} p(x_S | \Sigma_S)}$$

where C and S respectively denote the set of cliques and separators of the graph G, and:

$$P(x_{C}|\Sigma_{C}) = (2\pi)^{-\frac{n*|C|}{2}} |\Sigma_{C}|^{-n/2} exp[-1/2tr\left(S_{C}(\Sigma_{C})^{-1}\right)]$$

and similarly for  $P(x_S|\Sigma_S)$ . A convenient prior for the parameters of the above likelihood is the hyper inverse Wishart distribution. It can be obtained from a collection of clique specific marginal inverse Wishart distributions as follows:

$$l(\Sigma) = \frac{\prod_{c \in \mathcal{C}} l(\Sigma_C)}{\prod_{s \in \mathcal{S}} l(\Sigma_S)}$$

where  $l(\Sigma_C)$  is the density of an inverse Wishart distribution, with hyper-parameters  $T_C$ and  $\alpha$ , and similarly for  $l(\Sigma_S)$ . For the definition of the hyper-parameters, here we follow Giudici and Spelta (2016), and let  $T_C$  and  $T_S$  be the sub-matrices of a larger matrix  $T_0$  of dimension  $N \times N$ , obtained in correspondence with the two complete sets of vertices *C* and *S*, assuming that  $\alpha > N$ . To complete the prior specification, for P(G), we consider a uniform prior over all possible graphical structures. Dawid and Lauritzen (1993) showed that, under the previous assumptions, the posterior distribution of the variance-covariance matrix  $\Sigma$  is a hyper Wishart distribution with  $\alpha + N$ degrees of freedom and a scale matrix given by:

$$T_n = T_0 + S_n$$

where  $S_n$  is the sample variance-covariance matrix. This result can be used for quantitative learning on the unknown parameters, for a given graphical structure. In addition, Dawid and Lauritzen (1993) showed that the proposed prior distribution can be used to integrate the likelihood with respect to the unknown random parameters, obtaining the so-called marginal likelihood of a graph, which is the main metric for structural learning. Such a marginal likelihood is equal to:

$$P(x|G) = \frac{\prod_{c \in \mathcal{C}} p(x_C)}{\prod_{s \in \mathcal{S}} p(x_S)}$$

in which:

$$p(x_{\rm C}) = (2\pi)^{-\frac{n*|{\rm C}|}{2}} \frac{k(|{\rm C}|, \alpha+n)}{k(|{\rm C}|, \alpha)} \frac{\det(T_0)^{\alpha/2}}{\det(T_n)^{(\alpha+n)/2}}$$

where  $k(\cdot)$  is the multivariate gamma function, given by:

$$k_{p}\left(a\right) = \pi^{\frac{p\left(p-1\right)}{4}} \prod_{j=1}^{p} \Gamma\left(a + \frac{1-j}{2}\right)$$

Assume that we have several possible graphs, say n(G), and that they are equally likely a prior, so that the probability of P(G) is:

$$P(G) = \frac{1}{|G|}$$

By Bayes rule, the posterior probability of a graph is given by:

$$P(G|x) \propto P(x|G) P(G)$$

and therefore, since we assume a uniform prior over the graph structures, maximizing the posterior probability is equivalent to maximizing the marginal likelihood. For graphical model selection purposes, we searched in the space of all possible graphs for the structure such that:

$$G^* = \arg \max_{G} P(G|x) \propto \arg \max_{G} P(x|G).$$

A Bayesian model averaging approach does not force conditioning inferences on the (best) model chosen. If we assume that the network structure *G* is random and we assign a prior distribution on it, we derive inference on unknown parameters as model averages to all possible graphical structures, with weights that correspond to the posterior probabilities of each network. This derives from the application of Bayes' theorem, as follows:

$$P(\Sigma|X) = P(\Sigma|x, G)P(G|x).$$

Note that, in many real problems, the number of possible graphical structures could be very large, and we may need to restrict the number of models to be averaged. This can be done efficiently, for example, following a simulation based procedure for model search, such as Markov chain Monte Carlo (MCMC) sampling. In our context, given an initial graph, the algorithm samples a new graph using a proposal distribution. To guarantee irreducibility of the Markov chain, we followed Giudici and Spelta (2016) to test whether the proposed graph was decomposable. The newly sampled graph was then compared with the old graph, calculating the ratio between the two marginal likelihoods; if the ratio was greater than a predetermined threshold (acceptance probability), the proposal was accepted, otherwise, it was rejected. The algorithm continued until practical convergence was reached.

Following Hashem and Giudici (2016), we average NetMES as follows:

$$E(MES|x) = \sum_{g} E(MES|x,g)P(g|x),$$
(10)

where *x* represents the observed data evidence and *g* a specific network model. The estimated E(MES|X) is referred to as a Bayesian Network based marginal expected shortfall measure (Bayesian NetMES).

#### 4.4. Centrality Measures

Centrality measures address the question of who is the most important in the network. There are many answers to this question, depending on what we mean by importance. There are a vast number of different centrality measures. We used the most popular ones, like closeness, node degree, eigenvector, and betweenness. Closeness calculates the inverse of the fairness, or the inverse of the sum of shortest paths between a node and all other nodes, and thus, it allows detecting nodes that are best placed to influence the entire network quickly and that represent influence or information broadcasters. Node degree centrality assigns the node importance score based on the summation of the number of links a node has with others. Eigenvector centrality can identify nodes that possess influence over the whole network, not just those directly connected to it; in other words, eigenvector centrality is a measure of the overall influence extent of a specific node on others in a network, this measure assigns scores to nodes based on the concept that connections to high-score nodes contribute more to the score of the specified node than equal connections to low-score nodes. Betweenness centrality measures the number of times a node lies on the shortest path between other nodes, or the number of times a node acts as a bridge along the shortest path between others. It was introduced as a measure for quantifying the control of a human of the communication between other humans in a social network by Linton Freeman. Intuitively, betweenness measures a node's influence on the information flow circulating through the social network, under the assumption that the flow follows shortest paths.

#### 5. Findings and Discussion

We examined the lead-lag relationship of the survived financial institutions systemic risk measures by estimating the regression (1) using a two year rolling window. Figure 2 shows the evolution of the interaction terms  $\phi_{12}$  and  $\phi_{21}$  identifying the periods where the large cap survived financial institutions led the small cap<sup>8</sup> in terms of systemic risk, and vice versa. It is notable that the interaction terms did not show a pattern like that of the lead-lag behavior of the financial returns in Figure 1. The MES of the small cap led the MES of the large cap from 24 August 2007 until 12 September 2009. Moreover, the negative sign of the  $\phi_{21}$  implied a decrease of the MES of the large cap when an increase of the MES of small cap occurred. It is also worth noticing that the magnitude of  $\phi_{12}$  was 100 times larger than  $\phi_{21}$ . The MES behavior was interpreted with the crisis effect on the stock market returns behavior. Sandoval and Franca (2012) showed that an increase in market volatility led to an increase in the correlation between market assets, indicating the increase in the level of uniform behavior of market participants during crisis times. This being said, and knowing that MES estimation was not size dependent, nevertheless, it captured the increase in the small cap volatility during crisis times, which may be interpreted in terms of both capitalization and liquidity availability. Terraza (2015) showed that the capital adequacy degree declined during 2008, but there was an increase in capitalization and liquidity after that except for small banks in 2011 and 2012. In addition, Ding and Sickles (2018) pointed out a positive relation between capital and risk adjustments of large banks that held low capital buffers; however, they pointed out a negative relation between capital and risk adjustments for small banks with low capital buffers. The decrease of the large cap MES upon the increase in MES of the small cap along with the larger magnitude of the small cap MES could be foreseen as a positive improvement in large cap returns compared to small ones, which may be viewed as a change in the market expectations for large cap risks in relation to governmental bailout plans. Brewer and Klingenhagen (2010) showed that large banks' stock prices that were classified as too big to fail (TBTF) performed better in the short run than smaller banks in the USA as a reaction to the U.S. government bailout programs.

The evolution of NetMES showed that the small-large lead-lag relationship was present from 19 September 2008, until 11 November 2008. The coefficient  $\phi_{21}$  was mostly negative as in the case

<sup>&</sup>lt;sup>8</sup> For brevity, we use the terms "large cap" and "small cap" instead of the terms "large cap survived financial institutions" and "small cap survived financial institutions".

of MES. Again, the magnitude of the interaction term  $\phi_{12}$  was quite larger than the  $\phi_{21}$ . The results of NetMES were inline with MES, but were limited to a shorter time span that was located within the heart of the global financial crisis of 2008. Originally, MES was estimated using correlations that captured both direct and indirect relationships; mainly as it provided the degree of association between the financial institution and the specified index without controlling for the effects from other financial institutions, while NetMES was estimated using partial correlations that considered only the direct relationships; as the effect of the set of other financial institutions was removed. Therefore, NetMES excluded the impact from other institutions upon the computation of the co-movements between the selected institution and the market index. This estimation method of NetMES imposed sparsity on the financial network structure whenever the partial correlation coefficient was insignificant, indicating that the corresponding financial institution did not directly contaminate others. The lead-lag relationship was also confirmed by the Bayesian NetMES between the large and the small cap financial institutions from 10 October 2008, until 6 March 2009. From 3 December 2010-25 January 2013, the lead-lag relationship was supported again. The difference in Bayesian NetMES in terms of the longer periods of the lead-lag results referred to the model specification, which represented an averaging mechanism over the systemic risk measure. The Bayesian model allowed us to examine the network structure while tacking into account the model uncertainty.



**Figure 2.** Interaction terms  $\phi_{12}$  (orange-cross marked line) and  $\phi_{21}$  (blue solid line) (plotted only when they are statistically significant) estimates of regression (1) assuming as the dependent variable a systemic risk indicator. Beginning from the top-left and moving to the right, the figures present interaction terms between the marginal expected shortfall (MES), the network based MES (NetMES), and the Bayesian NetMES of the large and small cap survived financial institutions. In each graph, the left axis is  $\phi_{12}$  (orange-cross marked), and in the right is  $\phi_{21}$  (blue solid).

To reveal additional features of the evolution of the systemic risk level of financial institutions, we continued by examining the sub-industries. A careful examination of Figure 3 reveals that all the systemic risk indicators sharply increased their magnitude in 2009. In particular, for the large cap survived financial institutions, the MES showed that DB and TMF experienced the highest increase. The NetMES and Bayesian NetMES showed that except the aforementioned sub-industries, also DCM and IBB increased sharply. Furthermore, a notable feature was the negative signs of MES in the case of the AMC, DB, RB, and TMF. This suggested that the financial sub-industries responded negatively to the downfall of the market. Laopodis (2016) pointed out the presence of a significant explanatory power from industry to stock market returns, indicating the consistent informational leadership from

the financial industry to other industries. When NetMES and the Bayesian NetMES were considered, the negative values were present mainly for AMC and TMF. Additionally, MES for DB and TMF started to increase again in 2012 (Greek default) and in 2013 reached another peak. In the case of NetMES and Bayesian NetMES, there was a peak of the systemic risk measures for the IBB sub-industry.



**Figure 3.** Average MES, NetMES, and Bayesian NetMES per sub-industry of survived financial institutions. In the left (right) figures appear the evolution of the large (small) cap survived financial institutions, denoted with "L" ("S") before the name of the sub-industry. On the right axis (when it exists), MES of large cap Diversified Banks DB (LDB), NetMES, and Bayesian of large cap Thrifts & Mortgage Finance (LTMF). AMC, Asset Management & Custody Banks; IBB, Investment Banking & Brokerage; DCM, Diversified Capital Markets; RB, Regional Banks.

For the small cap, the systemic risk measures reached their highs in late 2008–early 2009. The sub-industries systemic risk change in magnitude could be interpreted in relation to the level of the financial leverage ratio<sup>9</sup>. It was shown that TMF was the one that had the highest leverage increase during the crisis period, followed by DB. It is noticeable that the magnitude change of NetMES and Bayesian NetMES was affected by the magnitude change of leverage. This indicated that the change magnitude within the netted financial risk network was leverage driven, which captured the specificity of the subprime mortgage crisis. This feature infused the debate on the MES rational concept, in which the MES was argued to be close to the too interconnected to fail (TITF) logic rather than the too big to

<sup>&</sup>lt;sup>9</sup> See Table A3. We estimated the financial leverage as the ratio of the sum of short and long term debt and market capitalization, divided by market capitalization.

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fail (TBTF) one. This logical relation could also be noticed from the sub-industries market capitalization (see Table A3) showing that large DB had the highest total market capitalization for the overall and the crisis periods, and the highest change in magnitude during the crisis period, while the change was a decrease for TMF, consistent with its higher leverage increase relative to its smaller capitalization. Several theories support the view that large and complex banks contribute to systemic risk. In the TBTF hypothesis, the regulators were reluctant to close or unwind large and complex banks, resulting in moral hazard behavior. As a result, the leading banks took on excessive risks in the expectation of government bailouts (Farhi and Tirole 2012).

Subsequent to our initial approach, we will tackle the issue in terms of the individual institution's system risk importance capturing their vulnerability to a market-wide systemic shock<sup>10</sup>. The rankings were based on the MES, the NetMES, and the Bayesian NetMES, respectively. We compared the three rankings by implementing a Kolmogorov–Smirnov test that compared their corresponding cumulative distributions. For the large cap, we rejected at 5% the null hypotheses in favor of the alternative that the MES of the large cap institutions was larger than the NetMES. The null hypothesis was not rejected when we compared the distributions of NetMES and the Bayesian NetMES. For the small cap, the MES and NetMES were found again significantly different. The null hypothesis was not rejected for NetMES and Bayesian NetMES, and MES and Bayesian NetMES. Additionally, we examined the autocorrelation structure of the series. Kendall's  $\tau$  between the spot and the lagged value of the systemic risk measures equaled 0.7488 (MES), 0.6005 (NetMES), and 0.5631 (Bayesian NetMES) for the large cap survived financial institutions and 0.8856 (MES), 0.6566 (NetMES), and 0.6611 (Bayesian NetMES), indicating strong autocorrelation of the MES values, and consequently, the more reluctant to changes rankings compared to NetMES and Bayesian NetMES values.

Next, we followed Benoit et al. (2013), who used the top ten financial institutions by systemic risk importance, which accounted for 10% of their sample, and we proceeded with our analysis using the top six the financial institutions, which accounted for 12.84% of the total number of the survived financial institutions<sup>11</sup>. For each sub-period, the institutions and the countries are provided in a dot joint ticker country column (Ticker.Country). Tables 1 and 2 summarize the financial institutions' systemic importance assumed by at least one of the systemic risk measures examined (Analytically, the top six ranked institutions per sub-industry are provided in the Tables A.2–A.7 of (Arakelian et al. 2019)). From the tables above, if we focus on the financial institutions retained systemically important by all the measures, we obtained a list of companies that was consistent with what happened to them:

In the United States, Legg Mason Inc. (LM.US) was one of the institutional investors that bore a huge loss when Bear Stearns collapsed, as the group held 11% of Bear Stearns, making the group the bank's biggest shareholder. Legg Mason was also ranked among the most important institutions by Acharya et al. (2017), as well as Goldman Sachs, TD Ameritrade, and New York Community Bancorp for the period June 2006–June 2007 that the authors examined.

In France, two prominent French financial institutions were among the most massively hit by the fear of contingent liabilities: Natixis, France's fourth largest bank, also assumed systemically important, had announced a  $\notin$ 1.2 billion write-down of exposure to bad U.S. mortgage debt. Natixis, a publicly-listed corporate and investment banking firm jointly controlled by Caisses d' Epargne (the French Savings Banks group) and Banques Populaires, and Dexia, a French-Belgian bank specializing in the financing of municipalities. In both cases, the problems were related to their investments in bond insurers in the United States: CDC IXIS Financial Guaranty (CIFG) in the case of Natixis and Financial Security Assurance (FSA) in the case of Dexia<sup>12</sup>.

<sup>&</sup>lt;sup>10</sup> We acknowledge the fact that the systemic risk measures did not identify simultaneously a financial institution as a top SIFI, as it was addressed by some papers in the literature, e.g., Danielsson et al. (2016), Benoit et al. (2013).

<sup>&</sup>lt;sup>11</sup> We selected the top six financial institutions from both the large and the small cap groups.

<sup>&</sup>lt;sup>12</sup> The state coordinated restructuring of Natixis precipitated the merger of its two parent groups to form the newly branded B.P.C.E. group in February 2009. In August 2009, the French investment bank Natixis said that its partially state-owned parent

In Germany, an investment-banking arm of Deutsche Bank deeply involved in toxic securities was found systemic by all measures. By some estimates, German banks at the outset of the crisis had an average ratio of debt to net worth of 52 to one compared with 12 to one in the U.S. Indeed, the U.S. Federal Reserve helped Deutsche Bank with \$290 billion in mortgage securities.

In South Africa, Investec Bank was systemically important by all the measures. Indeed, the British government was forced to act by injecting liquidity into financial markets through various schemes including a 50 billion Credit Guarantee Scheme in October 2008, in which Investec Bank was eligible to participate.

Subsequent to our initial objective was to investigate the network structure among the top six systemically important institutions per sub-industry. The network investigation aimed at modeling the interlinkages between the large and the small cap, revealing the channels through which shocks could propagate more widely in the financial system. Figures 4-6 represent the yearly correlation networks for MES, NetMES, and Bayesian NetMES vectors of the top six financial institutions per sub-industry based on eigenvector centrality, providing a ranking of the nodes from the most to the least systemically important (the details of the graphs, as well as, the ranking provided by using other centrality measures are given summarized into centrality measures in Tables A4–A6). The large cap financial institutions are represented by the dark blue nodes, and the small cap by the light blue nodes. The link between any two nodes of financial institutions represents the presence of a significant correlation coefficient between them. The main result was the strong clustering, both within the institution of the same market capitalization and between them. There were very few cases where an institution was not connected to the system, and digging more deeply could not identify any specific feature for them. For example, the country of domicile did not play any role, as the institutions that were not connected were based both in countries with many institutions in our sample, like the USA, or few, like Malaysia. Using the centrality measures in Tables A4–A6, notice that the MES and Bayesian NetMES had a higher node degree during the global financial crisis of 2008 and than in 2012 during the European sovereign debt crisis, but NetMES had a higher increase in 2007 and 2010. This fact implied that the measures were complementary to each other and were responsive in identifying the presence of a crisis period. However, MES and Bayesian NetMES showed higher density during the crisis and upon the crisis materialization, while NetMES showed higher density during the early crisis stage. From the MES correlation network, we note that closeness, node degree, and betweenness centrality were mostly dominated by large cap, while eigenvector centrality identified SDBbriefly during 2008. NetMES and Bayesian NetMES exhibited a similar behavior for closeness and node degree centrality of the LAMCand LDB, but showed an interplay between SRBand several large cap sub-industries for eigenvector and betweenness centrality. Bayesian NetMES exhibited similar behavior to NetMES within the different centrality measures. The networks' summary in terms of closeness indicated that large cap institutions could influence the entire network more quickly than small cap, and node degree indicated that large cap were very connected to the system, implying an informational advantage and most likely more cross-sectional positions with the other network participants than was the case for small cap institutions. Eigenvector centrality showed that the higher influence on the network in terms of risk during crisis times, and especially during 2008, cane from small cap rather than large cap. Betweenness centrality showed that small cap had the ability to influence the whole network during crisis times, and not just those connected to it, due to the behavior of the small cap as a connection bridge between the different network participants. It was obvious that both eigenvector centrality

company would guarantee about €35 billion in toxic assets on its books, in what amounted to a government-engineered reinforcement of its troubled finances. B.P.C.E., which held 70% of Natixis, guaranteed the loans, equivalent to \$50 billion, in exchange for fees of €48 million a year. The parent took on the risk for 85% of the assets, with Natixis holding the remaining 15%. Natixis reported a second-quarter loss of 883 million euros. While that was down from a loss of more than €1 billion for the same period last year, it marked the fifth straight losing quarter for Natixis, which continued to write down its monoline bond insurance portfolio, asset-backed securities, and collateralized debt obligations underpinned by subprime mortgages.

and betweenness reflected the difference in the network during turmoil times. Minoiu and Reyes (2013) showed that a change in the network interconnectedness of a country would signify a higher probability of a banking crisis that may lead to the instability of its financial system. In addition, Chowdhury et al. (2019) indicated the higher connectivity of the financial network during crisis periods. Furthermore, Heiberger (2014) showed that the stock network stability changed during crisis times as it changed its composition to become more tightened with a more centralized topology.

**Table 1.** Top six systemically important large cap survived financial institutions. In the fourth column, "3": systemically important by all three systemic risk measures (MES, NetMES, Bayesian NetMES); "2" systemically important by two of the three systemic risk measures; "1": systemically important by one of the three systemic risk measures.

legg Mason Inc.AMCUNITED STATES3Jatco Co Ltd.AMCJAPAN3Jatco Co Ltd.AMCCHILE3VP Bank AGAMCLIFCHTENSTEIN3Vontobel Holding AGAMCSWITZERLAND3Alpha Bank AEDBCKPRUS3Credicorp Ld.DBCKPRUS3Credicorp Ld.DBPERU3Anatixis SADCMHONG KONG3Credicorp Ld.DCMHONG KONG3Investec Ld.DCMSUTTAFILANA3Macquarie Group Ld.DCMAUSTRALIA3Macquarie Group Ld.DCMSUTTAFILANA3Joaka Sect Daewoo Co Ltd.DCMGERMANY3Colain Sachs Group Inc/IBBJAPAN3Colain Sachs Group Inc/IBBJAPAN3Colain Sachs Group Inc/IBBJAPAN3Caisse Regionale de Credit Agricole Mutuel de Paris et d'Ile-de-FranceRBFRANCE3MGIC Investment Corp, TrustCo Bank Corp NY, New York CommunityTMFUNITED STATES3MICH SEAMCGERMANY222Alled Irish Banks PLCDBRFANCE33China Banking Group TLCTMFGREAT BRITAIN33Colina Banking CorpBBUNITED STATES22China Banking CorpIBBINITED STATES23Caisse Regionale de Credit Agricole Mutuel Alpes ProvenceRBHAPAN2<	Financial Institution	Sub-Industry	Country	
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	Mediobanca Banca di Credito Finanziario SpA	DB	ITALY	1

Table 1. Cont.

Financial Institution	Sub-Industry	Country	
AFFIN Holdings Bhd	DB	MALAYSIA	1
BMCE Bank	DB	MOROCCO	1
Astoria Financial Corp	TMF	UNITED STATES	1
Aberdeen Asset Management PLC	AMC	GREAT BRITAIN	1
KBC Group NV	DB	BELGIUM	1
State Bank of India	DB	INDIA	1
BGC Partners Inc.	IBB	UNITED STATES	1
Marusan Securities Co Ltd.	IBB	JAPAN	1
BB&T Corp	RB	UNITED STATES	1
Piraeus Bank SA	DB	GREECE	1

**Table 2.** Top six systemically important small cap survived financial institutions. In the fourth column, "3": systemically important by all the three systemic risk measures (MES, NetMES, Bayesian NetMES); "2": systemically important by two of the three systemic risk measures; "1": systemically important by one of the three systemic risk measures.

Financial Institution	Sub-Industry	Country	
180 Degree Capital Corp	AMC	UNITED STATES	3
Effecten-Spiegel AG, Deutsche Beteiligungs AG	AMC	GERMANY	3
FDG Kinetic Ltd.	AMC	HONG KONG	3
GSD Holding AS	DB	TURKEY	3
Bank Ochrony Srodowiska SA	DB	POLAND	3
Alandsbanken Abp	DB	FINLAND	3
Barclays Bank of Botswana Ltd.	DB	BOTSWANA	3
Oppenheimer Holdings Inc.	IBB	UNITED STATES	3
Banca Profilo SpA	IBB	ITALY	3
Charles Stanley Group PLC	IBB	GREAT BRITAIN	3
Toyo Securities Co Ltd.	IBB	JAPAN	3
Banestes SA Banco do Estado do Espirito Santo	RB	BRAZIL	3
Seacoast Banking Corp of Florida, FNCB Bancorp Inc.	RB	UNITED STATES	3
Locindus SA	TMF	FRANCE	3
Federal Agricultural Mortgage Corp, NASB Financial Inc, OceanFirst Financial	TMF	UNITED STATES	3
Corp, Provident Financial Holdings Inc.			
Street Capital Group Inc.	TMF	CANADA	3
Bear State Financial Inc.	TMF	UNITED STATES	3
Peregrine Holdings Ltd.	AMC	SOUTH AFRICA	2
Sparebanken Vest	DB	NORWAY	2
Asia Plus Group Holdings PCL	IBB	THAILAND	2
First United Corp, CommunityOne Bancorp	RB	UNITED STATES	2
Atinum Investment Co Ltd.	AMC	SOUTH KOREA	2
National Bank of Kuwait-Egypt SAE	DB	EGYPT	2
Lan & Spar Bank	DB	DENMARK	2
Berliner Effektengesellschaft AG	IBB	GERMANY	2
GronlandsBANKEN A/S	RB	GREENLAND	2
Capital City Bank Group Inc, Baylake Corp	RB	UNITED STATES	2
SHK Hong Kong Industries Ltd.	AMC	HONG KONG	1
KAS Bank NV	AMC	NETHERLANDS	1
Airesis SA	AMC	SWITZERLAND	1
Norvestia Oyj	AMC	FINLAND	1
Sparebanken Ost	DB	NORWAY	1
Takagi Securities Co Ltd.	IBB	JAPAN	1
Cie Financiere Tradition SA	IBB	SWITZERLAND	1
South China Financial Holdings Ltd.	IBB	HONG KONG	1
Bryn Mawr Bank Corp, Cascade Bancorp, Commercial National Financial	RB	UNITED STATES	1
Corp/PA, Peoples Financial Corp/MS, C&F Financial Corp, Independent Bank			
Corp/MI, First Community Bancshares Inc/VA, First South Bancorp Inc/NC,			
Financial Institutions Inc, Heritage Commerce Corp, HopFed Bancorp Inc,			
MainSource Financial Group Inc, Pacific Continental Corp, Sun Bancorp Inc/NJ			
Tsukuba Bank Ltd.	RB	JAPAN	1
Sachsenmilch AG	AMC	GERMANY	1
Peapack Gladstone Financial Corp	RB	UNITED STATES	1
First US Bancshares Inc.		UNITED STATES	1
KAF-Seagroatt & Campbell Bhd	IBB	MALAYSIA	1



**Figure 4.** Yearly correlation networks for MES vectors of the top six MES financial institutions per sub-industry based on eigenvector centrality. The large cap financial institutions are in dark blue and the small cap financial institutions in light blue. The link between any two nodes of financial institutions represents the presence of a significant correlation coefficient between them. The graphs are summarized into the centrality measures provided in Table A4. The centrality measures rank the financial institutions on a yearly basis from the most to the least systemically important.



**Figure 5.** Yearly correlation networks for NetMES vectors of the top six NetMES financial institutions per sub-industry based on eigenvector centrality. The large cap financial institutions are in dark blue and the small cap financial institutions in light blue. The link between any two nodes of financial institutions represents the presence of a significant correlation coefficient between them. The graphs are summarized into the centrality measures provided in Table A5. The centrality measures rank the financial institutions on yearly basis from the most to the least systemically important.



**Figure 6.** Yearly correlation networks for Bayesian NetMES vectors of the top six Bayesian NetMES financial institutions per sub-industry based on eigenvector centrality. The large cap financial institutions are in dark blue and the small cap financial institutions in light blue. The link between any two nodes of financial institutions represents the presence of a significant correlation coefficient between them. The graphs are summarized into the centrality measures provided in Table A6. The centrality measures rank the financial institutions on yearly basis from the most to the least systemically important.

#### 6. Conclusions

In this work, we investigated the lead-lag relation between the large and the small cap indices that were rebalanced on a weekly basis, in terms of returns and in terms of systemic risk. Constructing a large and a small cap index of financial institutions, we found that the large cap index returns almost always led the small cap index returns. Kinnunen (2017) similarly showed that the returns of the large portfolio led the returns of the small one with a variation in the effect over time in relation to the change in the variance of the large-firm portfolio returns and indicated the overly restrictive traditional vector autoregressive analysis with constant cross-autoregressive coefficients upon analyzing the lead-lag relation in stock markets.

We also examined if the lead-lag relation was sustained when using systemic risk indicators for the large and the small cap financial institutions that remained constituents of the indices in every weekly rebalancing. To estimate the risk exposure of an individual institutions to the market, we used the standard bivariate based marginal expected shortfall (MES) systemic risk measure, as well as two alternatives: the network based MES (NetMES) that extends MES taking multivariate dependencies into account; and the Bayesian NetMES, which further accounts for network model uncertainty. Those market based risk measures allowed modifying expectations regarding the risk effect from holding a specific firm's returns within a portfolio on a real-time basis. Upon the estimation of the MES, NetMES, and Bayesian NetMES, we derived conclusions on which sub-industry and period led to the highest systemic risk. Our main findings implied that the risk measures reflected a change in the lead-lag relation during a financial downturn, in which the small cap led the large cap, which diverted from our findings in terms of returns. This implied that MES, NetMES, and Bayesian NetMES captured the change in the correlation between tranquil and turmoil market conditions, in addition to the lower capital buffers that small cap institutions possessed, making them exhibit higher volatility along with a herding behavior during a financial downturn relative to the behavior of larger cap institutions that were subject to receive governmental bailouts based on their size. Those results raised a question regarding the benefits of portfolio diversification during crisis times. Likewise, Chiang et al. (2007) showed a change in the correlation between two successive phases of the Asian crisis, with the first phase being characterized by an increase in the correlation as an implication of contagion, while the second implied the herding effect through the continuation of a high correlation that was accompanied by a change in variance during crisis times. Sandoval and Franca (2012) pointed out the presence of a link between the higher market volatility and stronger correlations, implying the herding behavior of market participants during a market crash, in addition to a common global comovements among the market indices that were characterized by non-normal correlation. Caporale et al. (2005) suggested the inefficiency of portfolio diversification during a financial crisis and the possible effect that resulted from bailouts.

We also identified the systemic importance of financial institutions by examining sub-industries. We found that for the large cap survived financial institutions, MES indicated higher importance of DB and TMF especially during the 2012-2013 European sovereign debt crisis, but NetMES and Bayesian NetMES indicated a higher importance of IBB. For the small cap, TMF and DB had higher importance during 2008 and early 2009. We also found that the magnitude change in the netted measures of NetMES and Bayesian NetMES was driven by leverage. On the other hand, large DB had the highest market capitalization and the highest change in market during the crisis period in market capitalization, which supported the point that large and complex banks' structure would contribute to systemic risk.

Next, we followed up by investigating the top six systemically important financial institutions per sub-industry. We found that the MES of large cap firms was significantly larger than NetMES and Bayesian NetMES, but we did not find a significant difference between the three measures for the small cap firms. Digging more into financial institutions' features, it appeared that large cap received financial aid due to their huge losses during the financial crisis of 2007. Additionally, we studied the evolution of the financial institutions network linkages as they changed during crisis times. The networks' summary indicated that large cap institutions were very connected to the system and could influence the entire network more quickly than small cap. In addition, we found that the higher influence on the network in terms of risk came from small cap that had the ability to influence the whole network during crisis times, and not just those connected to it, due to the behavior of the small cap as a connection bridge between the different network participants. Our findings suggested the existence of contagion not only from large cap institutions, but also from small cap institutions that acted in a herding manner during crisis periods. Xu et al. (2019) showed that the financial system interconnectedness level peaked during market downturns and could not be ignored in estimating the systemic risk of individual institutions.

There are numerous avenues for future work. First, we would like to study the behavior of the network, the interlinkages, and channels of risk transmission using different portfolio strategies. Second, we would like to examine the importance of institutions' corporate governance, as the market capitalization is not a factor that discriminates the institutions towards their behavior to major market events.

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Conflicts of Interest: The authors declare no conflict of interest.

## Appendix A

Sector: Fina	incials. Industry Group: Banks
Industry	Sub-industry
Banks	<b>Diversified Banks</b> (abbrev. DB) (e.g., Citigroup Inc. (U.S.), Bank of America Corp (U.S.), JPMorgan Chase & Co (U.S.), Wells Fargo & Co (U.S.), Banco Santander SA (Spain)) Large, geographically diverse banks with a national footprint whose revenues are derived primarily from conventional banking operations, have significant business activity in retail banking and small and medium corporate lending, and provide a diverse range of financial services. Excludes banks classified in the Regional Banks and Thrifts & Mortgage Finance sub-industries. Also excludes investment banks classified in the Investment Banking & Brokerage Sub-industry. <b>Regional Banks</b> (abbrev. RB) (e.g., SunTrust Banks Inc. (U.S.), BB&T Corp (U.S.), PNC Financial Services Group Inc/The (U.S.), Regions Financial Corp (U.S.), Fifth Third Bancorp (U.S.), M&T Bank Corp (U.S.)) Commercial banks whose businesses are derived primarily from conventional banking operations and have significant business activity in retail banking and small and medium corporate lending. Regional banks tend to operate in limited geographic regions. Excludes companies classified in the Diversified Banks and Thrifts & Mortgage Banks sub-industries. Also excludes investment banks classified in the Investment Banking & Brokerage sub-industry.
Thrifts & Mortgage Finance	Thrifts & Mortgage Finance (abbrev. TMF) (e.g., Federal National Mortgage Association (U.S.), Federal Home Loan Mortgage Corp (U.S.), Housing Development Finance Corp Ltd. (India), MGIC Investment Corp (U.S.), New York Community Bancorp Inc. (U.S.)) Financial institutions providing mortgage and mortgage related services. These include financial institutions whose assets are primarily mortgage related, savings & loans, mortgage lending institutions, building societies and companies providing insurance to mortgage banks.
Capital Markets	<ul> <li>Asset Management &amp; Custody Banks (abbrev. AMC) (e.g., Bank of New York Mellon Corp/The (U.S.) Franklin Resources Inc. (U.S.), State Street Corp (U.S.), Brookfield Asset Management Inc. (Canada), T Rowe Price Group Inc. (U.S.) Man Group PLC (U.K.))</li> <li>Financial institutions primarily engaged in investment management and/or related custody and securities fee based services. Includes companies operating mutual funds, closed-end funds and unit investment trusts. Excludes banks and other financial institutions primarily involved in commercial lending, investment banking, brokerage and other specialized financial activities.</li> <li>Investment Banking &amp; Brokerage (abbrev. IBB) (e.g., Goldman Sachs Group Inc/The (U.S.), Morgan Stanley (U.S.), Nomura Holdings Inc. (Japan) Charles Schwab Corp/The (U.S.), Daiwa Securities Group Inc. (Japan))</li> <li>Financial institutions primarily engaged in investment banking &amp; brokerage services, including equity and debt underwriting, mergers and acquisitions, securities lending and advisory services. Excludes banks and other financial activities.</li> <li>Diversified Capital Markets (abbrev. DCM) (e.g., UBS Group AG (Switzerland), Deutsche Bank AG (Germany), Credit Suisse Group AG (Switzerland), Natixis SA (France), Macquarie Group Ltd. (Australia))</li> <li>Financial institutions primarily engaged in diversified capital markets activities, including a significant presence in at least two of the following area: large/major corporate lending, investment banking, brokerage and asset management. Excludes less diversified companies classified in the Asset Management &amp; Custody Banks or Investment Banking &amp; Brokerage sub-industries. Also excludes companies classified in the Banks or Insurance industry groups or the Consumer Finance Sub-industry.</li> </ul>

	Mean Median Maximum Minir		Minimum	Std.Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.	
LCR	LCR 0.0046 0.0127 0.2243		-0.2128	0.0527	-0.3325	7.4896	102.9966	0.0000	
SCR	0.0076 0.0138 0.1793 -0.177		-0.1778	0.0449	-0.3497	6.8502	76.57078	0.0000	
Pairwise Granger Causality Tests									
Null HypothesisF-StatisticProb.									
SCR does not Granger cause LCR		1.3653	0.2450						
LCR does not Granger cause SCR		6.1030	0.0149						

**Table A2.** Descriptive statistics and Granger causality test for the weekly large and small capitalization index returns (LCR and SCR, respectively) from 1 January 2005 to 31 December 2014.

**Table A3.** Financial leverage and market capitalization of survived financial institutions per sub-industry (GICS). Panels A and C provide leverage of the large and small cap survived financial institutions per sub-industry calculated over two year sub periods from 2005–2014. Panels B and D provide the market capitalization of the large and small cap survived financial institutions calculated like the financial leverage.

Panel A: Financial Leverage of Large-Cap Survived Financial Institutions (Average Per Period)											
Sub-industry	1/1/2005-12/31/2006	1/1/2007-12/31/2008	1/1/2009-12/31/2010	1/1/2011-12/31/2012	1/1/2013-12/31/2014						
Asset Management & Custody Banks (AMC)	1.44	1.82	1.77	1.49	1.41						
Diversified Banks (DB)	2.80	3.75	5.67	6.23	4.68						
Diversified Capital Markets (DCM)	2.65	3.77	3.76	4.04	4.24						
Investment Banking & Brokerage (IBB)	3.34	4.13	4.97	7.13	5.51						
Regional Banks (RB)	1.81	2.28	2.92	2.58	2.36						
Thrifts & Mortgage Finance (TMF)	5.75	20.64	144.54	382.19	82.07						
Panel B: Market Capitalization of Large-Cap Survived Financial Institutions (Total Per Period. Numbers in Billion U.S. Dollars)											
Sub-industry	1/1/2005-12/31/2006	1/1/2007-12/31/2008	1/1/2009-12/31/2010	1/1/2011-12/31/2012	1/1/2013-12/31/2014						
Asset Management & Custody Banks (AMC)	212,536	271,262	197,192	219,003	289,875						
Diversified Banks (DB)	2,092,360	2,278,660	1,944,820	2,231,659	2,941,330						
Diversified Capital Markets (DCM)	88,566	109,625	77,923	77,553	95,089						
Investment Banking & Brokerage (IBB)	210,996	216,106 174,965		151,316	219,165						
Regional Banks (RB)	342,808	300,445	228,424	257,018	322,905						
Thrifts & Mortgage Finance (TMF)	125,271	90,002	36,084	37,321	67,174						
Panel C: Financial Leverage of Small-Cap Survived Financial Institutions Per Sub-Industry (Average Per Period)											
Sub-industry	1/1/2005-12/31/2006	1/1/2007-12/31/2008	1/1/2009-12/31/2010	1/1/2011-12/31/2012	1/1/2013-12/31/2014						
Asset Management & Custody Banks (AMC)	2.16	2.43	2.61	1.78	1.60						
Diversified Banks (DB)	5.09	8.14	11.71	7.82	6.89						
Investment Banking & Brokerage (IBB)	1.48	1.78	1.78	3.13	4.02						
Regional Banks (RB)	1.78	2.31	3.54	2.99	2.23						
Thrifts & Mortgage Finance (TMF)	5.36	27.92	56.08	23.04	10.45						
Panel D: Market Capitalization of Small-Cap	Survived Financial Instit	tutions (Total Per Period.	Numbers in Billion U.S.	Dollars)							
Sub-industry	1/1/2005-12/31/2006	1/1/2007-12/31/2008	1/1/2009-12/31/2010	1/1/2011-12/31/2012	1/1/2013-12/31/2014						
Asset Management & Custody Banks (AMC)	4634	5834	3727	3794	4039						
Diversified Banks (DB)	4034	6734	6180	5345	5331						
Diversified Capital Markets (DCM)	2077	2440	857	680	600						
Investment Banking & Brokerage (IBB)	5857	7802	6015	5250	5904						
Regional Banks (RB)	19,721	17,564	11,918	13,117	16,876						
Thrifts & Mortgage Finance (TMF)	3468	2506	1690	1988	2632						

**Table A4.** Yearly centrality measures for MES correlation network of top 6 survived financial institutions per sub-industry provided in Figure 4. The table lists the highest 6 ranking institutions based on their centrality measure.

		Industry	Closeness		Industry	Degree		Industry	Eigenvector Centrality		Industry	Betweenness %
2005	SANTGRU.CI	L.AM	0.005181	LM.US	L.AM	14	OCFC.US	S.TMF	0.178653	OCFC.US	S.TMF	0.048558
	LM.US	L.AM	0.004975	SANTGRU.CI	L.AM	12	PGR.SJ	S.AMC	0.177352	ALBAV.FH	S.DB	0.047278
	MLP.GR	L.AM	0.004608	MLP.GR	L.AM	6	SANTGRU.CI	L.AM	0.174771	IMH.US	S.TMF	0.037376
	CALEP	L.AM	0.003922	8616.JP BDI DM	L.IBB	4	FSBK.US SCB TB	5.KB	0.173471	8614.JP 8616 ID	5.IBB	0.035849
	CHFC.US	L.RB	0.003861	KN.FP	L.DB L.DCM	4	MQG.AU	L.DB L.DCM	0.171668	GKG.SP	S.RCS	0.032493
2006	8595.JP	L.AM	0.005102	LM.US	L.AM	13	TPEIR.GA	L.DB	0.181499	GKG.SP	S.RCS	0.052294
	LM.US	L.AM	0.005051	MLP.GR	L.AM	9	CRAP.FP	L.RB	0.180081	FSBK.US	S.RB	0.051185
	MLP.GR	L.AM	0.004762	VPBN.SW	L.AM	6	CAF.FP	L.RB	0.169709	KNK.MK	S.IBB	0.035955
	VONN.SW	L.AM	0.004065	8601.JP	L.IBB	6	PGR.SJ	S.AMC	0.168861	CAF.FP	L.RB	0.029135
	BAC.US SANTGRU.CI	L.DB L.AM	0.003906 0.003876	11G.US 8595.JP	L.IBB L.AM	5 4	SECH.KK 8616.JP	S.DCM L.IBB	0.167201 0.164756	IMH.US CHIB.PM	S.TMF L.DB	0.026233 0.025356
2007	MLP.GR	L.AM	0.005291	8595.JP	L.AM	14	MTG.US	L.TMF	0.172005	TMB.TB	L.DB	0.055944
	8595.JP	L.AM	0.005181	SANTGRU.CI	L.AM	9	FCBC.US	S.RB	0.171019	CNS.TB	S.IBB	0.042395
	SANTGRU.CI	L.AM	0.004831	VPBN.SW	L.AM	7	CFFN.US	L.TMF	0.165398	OPY.US	S.IBB	0.034206
	LM.US	L.AM	0.004082	MLP.GR	L.AM	6	CHIB.PM	L.DB	0.165047	DXIL.IT	S.DB	0.033959
	VPRN SW	L.DD L.AM	0.004082	LM.US TMR TR	L.AM L DR	5	SBCEUS	S PR	0.164251	AMID.US BPSO IM	L.IDD	0.030148
2008	SANTGRUCI	LAM	0.00578	SANTGRU.CI	L.DD	12	GSDHO.TI	S.DB	0.140767	626.HK	L.BB	0.078572
	MLP.GR	L.AM	0.004975	ALBK.ID	L.DB	10	GKG.SP	S.RCS	0.139739	MLP.GR	L.AM	0.043968
	ALBK.ID	L.DB	0.004739	VPBN.SW	L.AM	9	NYCB.US	L.TMF	0.138752	GKG.SP	S.RCS	0.043732
	HB.CY	L.DB	0.004484	ALPHA.GA	L.DB	6	MTG.US	L.TMF	0.138549	GSDHO.TI	S.DB	0.041172
	INL.SJ 8601 IP	L.DCM	0.004329	INL.SJ 8601 IP	L.DCM	5	PGR.SJ SANTGRU CI	S.AMC L.AM	0.138138	EFS.GR KN FP	S.AMC L DCM	0.036526
2009	VPBN.SW	LAM	0.005435	VPBN.SW	L.AM	16	626.HK	L.RB	0.142476	626.HK	L.RB	0.020224
	LM.US	L.AM	0.004505	8595.JP	L.AM	7	OPY.US	S.IBB	0.141236	OPY.US	S.IBB	0.017514
	BAC.US	L.DB	0.004464	SWEDA.SS	L.DB	7	TRST.US	L.TMF	0.141071	TRST.US	L.TMF	0.018687
	BAP.US	L.DB	0.004464	BAC.US	L.DB	5	NYCB.US	L.TMF	0.140346	NYCB.US	L.TMF	0.013479
	8595.JP	L.AM	0.004167	ITG.US	L.IBB	5	MQG.AU	L.DCM	0.140346	MQG.AU	L.DCM	0.013479
	INL.SJ	L.DCM	0.004032	AIRE.SW	S.AMC	5	KA.NA	S.AMC	0.14023	KA.NA	S.AMC	0.013905
2010	8595.JP	L.AM	0.005587	8595.JP	L.AM	10	AF.US	L.TMF	0.174098	AF.US	L.TMF	0.021152
	VPBN SW	L.AM	0.003128	SANTGRUCI	L.AM	0 7	INL SI	L.KB	0.170254	INL SI	L.KB	0.027633
	ALPHA.GA	LDB	0.004255	ALPHA.GA	L.DB	6	NYCBUS	L.TMF	0.169919	NYCBUS	LTMF	0.016441
	DBK.GR	L.DCM	0.004219	8616.JP	L.IBB	6	165.HK	L.DCM	0.158964	165.HK	L.DCM	0.025424
	LM.US	L.AM	0.004219	LM.US	L.AM	5	KN.FP	L.DCM	0.158697	KN.FP	L.DCM	0.010844
2011	LM.US	L.AM	0.005525	LM.US	L.AM	10	6800.KS	L.DCM	0.152724	CAF.FP	L.RB	0.094042
	SANTGRU.CI	L.AM	0.004651	MLP.GR	L.AM	8	CAF.FP	L.RB	0.152315	PAG.LN	L.TMF	0.051556
	VDPNI CM	L.AM	0.004566	VPBN.SW	L.AM	6	VONN.SW	L.AM	0.151866	OCFC.US	S.IMF	0.043034
	BAC US	L DB	0.004403	SANTGRUCI	L.AM	5	PAGIN	L TMF	0.151027	ALBAVEH	S DB	0.033062
	ALPHA.GA	L.DB	0.004115	8616.JP	L.IBB	5	BPOP.US	L.RB	0.150388	VPBN.SW	L.AM	0.030576
2012	LM.US	L.AM	0.005525	LM.US	L.AM	19	KN.FP	L.DCM	0.167036	NYCB.US	L.TMF	0.06052
	8595.JP	L.AM	0.004975	KN.FP	L.DCM	6	165.HK	L.DCM	0.167036	ALPHA.GA	L.DB	0.042107
	VDPNI GKU.CI	L.AM	0.004292	PAG.LN	L.IMP LAM	5	AF.U5	L.I.MF	0.165888	FDEF.US	S. I MF	0.041178
	VONN SW	L.AM	0.004219	SANTGRUCI	L.AM	5	INL SI	L DCM	0.164355	SANTGRU CI	L AM	0.035323
	MB.IM	L.DB	0.004115	MB.IM	L.DB	4	SNBC.US	S.RB	0.16297	8595.JP	L.AM	0.028406
2013	LM.US	L.AM	0.00578	SANTGRU.CI	L.AM	10	SPOG.NO	S.DB	0.176911	8601.JP	L.IBB	0.050827
	SANTGRU.CI	L.AM	0.005128	LM.US	L.AM	9	MTG.US	L.TMF	0.175996	TRST.US	L.TMF	0.047171
	MLP.GK	L.AM	0.005076	MLP.GK	L.AM	7	ADC.GK	5.AMC	0.170295	8014.JP	5.1BB	0.026822
	100.FIK	S AMC	0.004307	TPFIR GA	L DB	6	8625 IP	S IBB	0.170002	KN FP	L DCM	0.030655
	VPBN.SW	L.AM	0.004219	165.HK	L.DCM	5	666.HK	S.AMC	0.167537	6005.TT	L.IBB	0.030302
2014	8595.JP	L.AM	0.005618	8595.JP	L.AM	10	8616.JP	L.IBB	0.190897	MTG.US	L.TMF	0.050147
	SANTGRU.CI	L.AM	0.005102	LM.US	L.AM	9	8601.JP	L.IBB	0.187831	NASB.US	S.TMF	0.045331
	LM.US	L.AM	0.00495	SANTGRU.CI	L.AM	7	SGC.KK	S.DCM	0.184773	8625.JP	S.IBB	0.040566
	N F DIN.SW	L.AM L.DB	0.004202	V PDIN.5W	L.AM	7	GS US	L.DCM L.IBR	0.150595	SVEG NO	S DB	0.033206
	DBK.GR	L.DCM	0.004167	BAC.US	L.DB	6	ALMUTAHE.KK	L.DB	0.173706	OPY.US	S.IBB	0.031155

**Table A5.** Yearly centrality measures for NetMES correlation network of top 6 survived financial institutions per sub-industry provided in Figure 5. The table lists the highest 6 ranking institutions based on their centrality measure.

2005         LAMC         0.00565         8595,JP         LAMC         11         MQG,AU         LDCM         0.18481         PAG,LN         LTMF         0.0687           8595,JP         LAMC         0.00451         LM,US         LAMC         8         KN,FP         LDCM         0.18481         PAG,LN         LTMF         0.0687           VONN.SW         LAMC         0.00454         VONN.SW         LAMC         5         SANTGRU,CI         LAMC         0.17996         CFFN.US         LTMF         0.0571           RHBC.MK         LDB         0.00447         ALBK,ID         LDB         5         S601,P         LIBB         0.17986         ALPHA,GA         LDB         0.0489           ALBK,ID         LDB         0.00437         BCCPUS         LIBB         0.17833         6800.KS         LDCM         0.0354           2006         LM.US         LAMC         0.00502         PAG,LN         LTMF         5         FMBLUS         LRB         0.17833         6800.KS         LDCM         0.0354           2006         LM.US         LAMC         0.00500         ADN,LN         LAMC         9         8595,JP         LAMC         0.18794         8616,JP         LIBB         0.17874	ness %
8995.JP         LAMC         0.00541         LAMC         8         KN.FP         LDCM         0.18021         CAYLN         S.IBB         0.0057           VONN.SW         LAMC         0.00465         VONNSW         LAMC         5         SANTGRU.CI         LAMC         0.17996         CFFN.US         LTMF         0.0571           RHBC.MK         LDB         0.00444         ALBK.ID         LDB         5         8601.JP         LIBB         0.17986         ALPHA.GA         LDB         0.0515           FILUS         LAMC         0.00437         PAGLIN         LTMF         5         FNBLUS         LRB         0.17936         ALPHA.GA         LDM         0.0354           2006         LM.US         LAMC         0.00532         LM.US         LAMC         9         8595.JP         LAMC         0.21323         DBK.GR         LDCM         0.0567           ADN.LN         LAMC         0.00502         ADN.LN         LAMC         9         BS95.JP         LAMC         0.181794         8616.JP         LIBB         0.04378           SANTCRUCI         LAMC         0.00459         VON.SW         LAMC         8         FMBLUS         LRB         0.18017         CFFN.US         LTMF<	388
VONN.SW         LAMC         0.00465         VONN.SW         LAMC         5         SANTGRUCL         LAMC         0.17996         CFP.US         LIMF         0.0515           FILUS         LAMC         0.00444         ALBK.ID         LDB         5         860.1/P         LIBB         0.17996         ALPH.A.GA         LDB         0.0515           FILUS         LAMC         0.00437         BGCPUS         LIBB         5         OCFC.US         S.TMF         0.17986         ALPH.A.GA         LDM         0.0351           2006         LMUS         LAMC         0.00532         LMUS         LAMC         9         8595.JP         LAMC         0.21323         DBK.GR         LDCM         0.0357           ADN.LN         LAMC         0.00530         ADN.LN         LAMC         9         BCBB.BG         S.DB         0.18794         8616.JP         LIBB         0.0478           SANTGRUCI         LAMC         0.00420         HB.CY         LDB         7         6800.KS         LDCM         0.0396           BNILIJ         LDB         0.00413         8616.JP         LIBB         5         BSFUS         S.TMF         0.18017         CFPN.US         LTMF         0.0390	\$71
RHDC.MK         LDB         0.00447         RGCPUS         LDB         5         8601/P         LDB         0.17949         ALPHACA         LDB         0.00437           ALBK.ID         LDB         0.00437         RGCPUS         LIBB         5         OCFCUS         S.TMF         0.17949         SNVLUS         LRB         0.0489           2006         LMUS         LAMC         0.00532         LM.US         LAMC         9         8595.JP         LAMC         0.21323         DBK.GR         LDCM         0.0354           8595.JP         LAMC         0.00500         ADN.IN         LAMC         9         BCBB.BG         S.DB         0.18794         8616.JP         LIBB         0.0478           8595.JP         LAMC         0.00420         HB.CY         L.DB         7         6800.KS         LDCM         0.0380           BNILIJ         LDB         0.00413         8616.JP         LIBB         5         BSFUS         S.TMF         0.17666         BCBB.BG         S.DB         0.0380           BNILIJ         LDB         0.00407         BPOPUS         LRB         4         PRO.IM         S.IBB         0.17000         8614.JP         S.IBB         0.0380           <	12
ALBK.ID         LDB         0.00437         PAG.IN         LTMF         5         FMBLUS         LAR         0.17833         6800.KS         LDCM         0.0354           2006         LMUS         LAMC         0.00437         PAG.IN         LTMF         5         FMBLUS         LRB         0.17833         6800.KS         LDCM         0.0354           2006         LMUS         LAMC         0.00459         VON.SW         LAMC         9         8595.JP         LAMC         0.0354           8595.JP         LAMC         0.00459         VON.SW         LAMC         8         FMBLUS         LRB         0.18794         8616.JP         LIBB         0.0478           SANTGRUCI         LAMC         0.00459         VON.SW         LAMC         8         FMBLUS         LRB         0.18017         CFFN.US         LTMF         0.0390           BNILIJ         LDB         0.00478         POPUS         LRB         4         PRO.IM         S.IBB         0.17066         BCBB.BG         S.DB         0.0334           2007         LMUS         LAMC         0.00478         POPUS         LRB         4         PRO.IM         S.IBB         0.17000         8614.JP         S.IMF	.52 891
2006         LM.US         LAMC         0.00532         LM.US         LAMC         9         8595.JP         LAMC         0.21323         DBK.GR         L.DCM         0.0567           ADN.LN         LAMC         0.00532         ADN.LN         LAMC         9         8595.JP         LAMC         0.21323         DBK.GR         L.DCM         0.0567           8595.JP         LAMC         0.00459         VONNSW         LAMC         8         FMBLUS         LRB         0.18794         8616.JP         LIBB         0.0478           SANTGRUCI         LAMC         0.00459         VONNSW         LAMC         8         FMBLUS         LRB         0.18017         CFN.US         LTMF         0.0398           BNILIJ         LDB         0.00413         8616.JP         LIBB         5         BSF.US         S.TMF         0.17666         BCBB.BG         S.DB         0.0381           2007         LMUS         LAMC         0.00497         BPOPUS         LRB         4         PRO.IM         S.IBB         0.17000         8614.JP         S.IBB         0.0331           2007         LMUS         LAMC         0.00473         LMUS         LAMC         7         BSF.US         S.TMF	544
ADN.LN         LAMC         0.00500         ADN.LN         LAMC         9         BCBB.BG         S.DB         0.18794         8616,IP         LIBB         0.0478           \$\$595,JP         LAMC         0.00459         VON.SW         LAMC         8         FMBLUS         LRB         0.180794         \$\$616,IP         LIBB         0.0478           \$\$595,JP         LAMC         0.00420         HB.CY         LDB         7         6800.KS         LDCM         0.18017         CFFN.US         LTMF         0.0398           BNILIJ         LDB         0.00413         8616,JP         LIBB         5         BSFUS         S.TMF         0.17666         BCBB.BG         S.DB         0.0386           HBCY         LDB         0.00407         BPOPUS         LRB         4         PRO.IM         S.IBB         0.17000         8614,JP         S.IBB         0.0336           2007         LMUS         LAMC         0.00493         IMUS         LAMC         7         BSFUS         S.TMF         0.19450         OCFCUS         S.TMF         0.07300           SANTGRUCI         LAMC         0.00478         VPBN.SW         LAMC         6         BIM.IM         LIBB         0.18938         turm.US<	577
8595.JP         LAMC         0.00459         VONN.SW         LAMC         8         FMBLUS         LRB         0.18423         turn.US         S.AMC         0.0390           SANTGRUCI         LAMC         0.00420         HB.CY         L.DB         7         6800.KS         LDCM         0.18017         CFFNUS         LTMF         0.0390           BNILIJ         LDB         0.00413         8616.JP         LIBB         5         BSEUS         S.TMF         0.17666         BCBB.BG         S.DB         0.0386           2007         LMUS         LAMC         0.00552         BNILIJ         LDB         11         PAG.LN         LTMF         0.19938         turn.US         S.AMC         0.0730           SANTGRUCI         LAMC         0.00493         LMUS         LAMC         7         BSEUS         S.TMF         0.18938         turn.US         S.AMC         0.0430           VONN.SW         LAMC         0.00473         VPBN.SW         LAMC         6         BIM.IM         LIBB         0.18883         DBK.GR         LDCM         0.0382           BNILIJ         LDB         0.00474         SANTGRUCI         5         TRSTUS         LTMF         0.18745         PRO.IM         S.	'87
SANTGRUCI         LAMC         0.00420         HBCY         LDB         7         6800.KS         LDCM         0.18017         CFN.US         LIMP         00.390           BNILIJ         LDB         0.00413         8616JP         LIBB         5         BSEUS         S.TMF         0.17666         BCBB.G         S.DB         0.0386           HB.CY         LDB         0.00413         8616JP         LIBB         4         PRO.IM         S.IBB         0.17000         8614.JP         S.IBB         0.0336           2007         LM.US         LAMC         0.00552         BNILIJ         L.DB         11         PAG.LN         LTMF         0.19450         OCFC.US         S.TMF         0.0730.           SANTGRUCI         LAMC         0.00478         VPBNSW         LAMC         7         BSF.US         S.TMF         0.19450         OCFC.US         S.TMF         0.0730.           VONN.SW         LAMC         0.00478         VPBNSW         LAMC         6         BIM.IM         LIBB         0.18938         turn.US         S.AMCGRUCI         0.00478         VPBNSW         LAMC         0.0383           BNILIJ         LDB         0.00474         SANTGRUCI         LAMC         5         <	/86
DRMLIJ         LDB         0.00413         8016,17         L10B         5         DSECS         5.1MF         0.17000         BCDLBG         5.DB         0.0331           2007         LM.US         LAMC         0.00473         BYOPUS         LRB         4         PROLIM         S.IBB         0.17000         8614,19         S.IBB         0.0331           2007         LM.US         LAMC         0.00473         BYOPUS         LAB         11         PAG.LN         LTMF         0.19450         OCFC.US         S.TMF         0.0730           SANTGRUCI         LAMC         0.00478         VPSNSW         LAMC         7         BSF.US         S.TMF         0.19938         turn.US         S.AMC         0.0433           VONN.SW         LAMC         0.00478         VPSNSW         LAMC         6         BIM.IM         LIBB         0.18883         DBK.GR         L.DCM         0.0382           BNILIJ         LDB         0.00474         SANTGRUCI         LAMC         5         TRSTUS         LTMF         0.18745         PROLM         S.IBB         0.0349           JNLIN         LAMC         0.0474         SANTGRUCI         LAMC         5         MQG.AU         LDCM         0.18658<	262
2007         LM.US         LAMC         0.00552         BNILIJ         L.DB         11         PAG.LN         L.TMF         0.19450         OCFC.US         S.TMF         0.0730           SANTGRUCI         LAMC         0.00493         LM.US         LAMC         7         BSF.US         S.TMF         0.19450         OCFC.US         S.TMF         0.0430           VONN.SW         LAMC         0.00478         VPBN.SW         LAMC         6         BIM.IM         LIBB         0.18893         DBK.GR         L.DCM         0.0383           BNILIJ         LDB         0.00474         SANTGRU.CI         LAMC         5         TRSTUS         LTMF         0.18745         PROIM         S.IBB         0.0382           ADN.LN         LAMC         0.00422         ADN.LN         LAMC         5         MQG.AU         LDCM         0.18658         BGCPUS         LIBB         0.03349           INLSJ         LDCM         0.00412         BIM.IM         LIBB         5         165.HK         LDCM         0.18517         CIMB.KK         LDB         0.03349           2008         LMUS         LAMC         8         SANTGRUCI         LAMC         0.0577         VONN SW         LAMC         0.057	63 312
SANTGRUCI         LAMC         0.00493         LMUS         LAMC         7         BSF.US         S.TMF         0.18938         turn.US         S.AMC         0.0433           VONN.SW         LAMC         0.00478         VPBN.SW         LAMC         6         BIM.IM         LIBB         0.18893         DBK.GR         L.DCM         0.0383           BNILIJ         LDB         0.00474         SANTGRU.CI         LAMC         5         TRSTUS         LTMF         0.18745         PRO.IM         S.IBB         0.0382           ADN.LN         LAMC         0.00422         ADN.LN         LAMC         5         MQG.AU         LDCM         0.18658         BGCPUS         LIBB         0.0349           INLSJ         LDCM         0.00412         BIM.IM         LIBB         5         165.HK         LDCM         0.18517         CIMB.KK         LDB         0.0339           2008         LMUS         LAMC         8         SANTGRUCI         LAMC         0.0577         VONNSW         LAMC         0.0577	308
VONN.SW         LAMC         0.00474         SANTGRUCI         LAMC         6         BIM.IM         LIBB         0.18885         DBK.GR         LDCM         0.00385           BNILIJ         LDB         0.00474         SANTGRUCI         LAMC         5         TRSTUS         LTMF         0.18745         PROLM         SIBB         0.0382           ADN.LN         LAMC         0.00474         SANTGRUCI         LAMC         5         MQG.AU         LDCM         0.18658         BGCPUS         LIBB         0.0382           INLSJ         LDCM         0.00412         BIM.IM         LIBB         5         165.HK         LDCM         0.18517         CIMB.MK         LDB         0.0339           2008         LMUS         LAMC         8         SANTGRUCI         LAMC         0.0547	01
DNILIJ         LDB         0.004/4         SANGRUCI         LAMC         5         INSLUS         LIMF         0.18/49         FROIM         SIDD         0.0362           ADN.LN         LAMC         0.00422         ADN.LN         LAMC         5         MQG.AU         LDCM         0.18658         BGCPUS         LIBB         0.0349           INLSJ         LDCM         0.00412         BIM.IM         LIBB         5         165.HK         LDCM         0.18517         CIMB.MK         LDB         0.0338           2008         I.MUS         LAMC         8         SANTGRUCI         LAMC         0.18377         VONIN SW         LAMC         0.0547	38
INLSJ         LAMC         0.00412         BIM.IM         LIBB         5         165.HK         LDCM         0.18517         CIMB.KK         LDB         0.0338           2008         LMUS         LAMC         0.00488         LAMC         8         SANTGRUCT LAMC         0.18577         VONNISW         LAMC         0.0547	520 197
2008 LAMC 0.0148 LAMC 0.0547 VONDSW LAMC 0.0547	-97 384
$U_{1}U_{1}U_{2}U_{3}U_{3}U_{3}U_{3}U_{3}U_{3}U_{3}U_{3$	74
8595.JP LAMC 0.00474 KN.FP L.DCM 7 NYCB.US L.TMF 0.17727 CFFN.US L.TMF 0.0547	73
BC.SW L.DB 0.00429 BC.SW L.DB 6 MQG.AU L.DCM 0.17473 FMCC.US L.TMF 0.0519'	.93
VONN.SW L.AMC 0.00422 VONN.SW L.AMC 6 PRO.IM S.IBB 0.17240 KN.FP L.DCM 0.0365/	58
BNII.IJ L.DB 0.00386 BNII.IJ L.DB 6 INL.SJ L.DCM 0.17126 SVEG.NO S.DB 0.0356	65
RATLIN LAMC 0.00386 RHBC.MK LDB 6 BSFUS S.TMF 0.16836 ASP.TB S.IBB 0.0352	23
2009 SANTGRU.CI LAMC 0.00397 KBC.BB L.DB 7 6800.KS L.DCM 0.17504 BGCP.US L.IBB 0.05660	60
8595.JP LAMC 0.00394 BC:SW LDB 6 NYCB.US LTMF 0.17484 FMBLUS L.RB 0.00599	/99 799
DC.5W L.DB 0.00565 HD.CT L.DB 0 INST.05 L.IMF 0.12590 8010,JF L.IDB 0.004/2 IMTIC LAMC 0.00555 8214 U. U.BP 4 C. DMP.MC L.DP 0.17312 95431D L.DP 0.04/2	28
LINLOS L'AVIC 0.00355 0010.JF L.IDD 0 CIVID.VIK L.DD 0.17215 0590.JF L.KD 0.04900 CIVIR.MK L.DB 0.00355 SANTCRUCI LAMC 5 OPVIS SIBB 0.17158 SCRCN STMF 0.0362	07 521
VPBN.SW LAMC 0.00338 VONN.SW LAMC 5 8595.JP LAMC 0.17122 8614.JP S.IBB 0.0362'	520
2010 8595,JP L.AMC 0.00746 8595,JP L.AMC 21 SBCF.US S.RB 0.20901 UMBF.US L.RB 0.0444	46
HB.CY L.DB 0.00538 8601.JP L.IBB 5 BIM.IM L.IBB 0.20752 BPOP.US L.RB 0.04340	×40
SANTGRUCI LAMC 0.00538 HB.CY LDB 4 PROVUS S.TMF 0.20503 NYCB.US L.TMF 0.04130	.30
8001.JF LIDD 0.00532 LM.US LAMC 4 MIG.US LIMF 0.20123 0F1.US SIDD 0.0408 IMTIS LAMC 0.0522 AMTD IS LIBB 4 UBCV LDB 0.19200 21000 KS SAMC 0.0404	188 141
VPBNSW LAMC 0.00532 AWID-05 LAMC 3 COBJS S.RB 0.18107 HBCY LDB 0.0362	526
2011 8595.JP LAMC 0.00595 8595.JP LAMC 17 NYCB.US LTMF 0.19414 fusb.US S.RB 0.0591	17
VONN.SW LAMC 0.00556 VONN.SW LAMC 5 CIMB.MK LDB 0.18736 GRLA.DC S.RB 0.04217	12
BNII.IJ L.DB 0.00463 BNII.IJ L.DB 5 BPOP.US L.RB 0.18640 BIM.IM L.IBB 0.03264	:64
ADN.LN LAMC 0.00463 ADN.LN LAMC 4 GRLA.DC S.RB 0.18410 DBAN.GR S.AMC 0.0317	.70
LM.US LAMC 0.00442 LM.US LAMC 4 0PY.US S.IBB 0.18175 BPOPUS L.KB 0.0300 DBK CP 1 DCM 0.00442 INLIST LDCM 4 MTC US LTME 0.17002 KPC BB 1 DB 0.0300	/66 207
2012 VONSW I AMC 0.00559 VONSW I AMC 14 MCG0 LITH 0.0795 REDDIS I DR 0.059	08
8595.JP LAMC 0.00498 BUILIJ LDB 6 ASPTB S.IBB 0.19056 CAYLN S.IBB 0.0492	24
BNII.IJ L.DB 0.00452 8595.JP L.AMC 5 KN.FP L.DCM 0.19051 165.HK L.DCM 0.0454'	543
ALPHA.GA L.DB 0.00433 KBC.BB L.DB 5 SCB.CN S.TMF 0.18788 BGCP.US L.IBB 0.0425-	:54
SANTGRUCI LAMC 0.00422 CIMB.MK LDB 4 INLSJ LDCM 0.18722 HB.CY LDB 0.03699	,95
CIME.MK LDB 0.00422 165.HK LDCM 4 CIME.MK LDB 0.1864/ CIME.MK LDB 0.0310	.01
2013 LM.US LAMC 0.004978 LM.US LAMC 8 COB.US S.RB 0.21207 NBKE.EY S.DB 0.0462 HBCY L.DB 0.00457 HBCY L.DB 8 MTC.US L.TMF 0.20954 21080.KS S.AMC 0.0458	529 582
8595.IP LAMC 0.00441 8595.IP LAMC 6 BIM.IM LIBB 0.20328 BIM.IM LIBB 0.0443	138
ADN.LN LAMC 0.00405 BNILIJ LDB 6 21080.KS S.AMC 0.19951 COB.US S.RB 0.0428	286
DBK.GR L.DCM 0.00395 ADN.LN L.AMC 4 8625.JP S.IBB 0.19386 8543.JP L.RB 0.0394	41
VPBNSW         LAMC         0.00386         VPBN.SW         LAMC         4         SNV.US         LRB         0.19106         8616.JP         L.IBB         0.0310	516
2014 8595,JP LAMC 0.00658 8595,JP LAMC 15 ASP.TB S.IBB 0.21532 SAHA.GR S.AMC 0.0548 VONEW LAMC 0.00641 VONEW LAMC 11 BEOM SIPP 0.00648 PCCUV LTD 0.0548	81
SANTCRIFCE LAWE 0.00941 VOINGJW LAWE 11 FROUND SJDD 0.00946 DGCFUS LIBB 0.02524 SANTCRIFCE LAWE 0.00555 MTCHS ITME 5 INTER DOM 0.10070 ACDTR CHR 0.0427	.74 177
DBK GR LDCM 0.00450 FILIS LAMC 5 165.1K LDCM 0.19798 LD FP STMF 0.0387	
MTG.US LTMF 0.00481 DBK.GR LDCM 4 FMBLUS LRB 0.19687 PAG.IN LTMF 0.0375	18
<u>KN.FP</u> LDCM 0.00481 KN.FP LDCM 4 GRLA.DC S.RB 0.19351 BCBB.BG S.DB 0.0361/	318 '57

2005         8595.JP         LAMC         0.005319         LMUS         LAMC         11         MQG.AU         LDCM         0.184416         BCBB.BG         SDB           BAPUS         LDB         0.004512         8995.JP         LAMC         11         BIMIM         LIBB         0.18143         CAFPP         LRB           IMUS         LAMC         0.004425         DBK.GR         LDCM         6         OPCUS         SIBB         0.179497         PAGLIN         LTMF           SBININ         LDB         0.004425         DBK.GR         LDCM         6         OPCUS         SIBB         0.179404         21080.KS         SAMC           PBC         VONNSW         LAMC         0.006452         VONNSW         LAMC         14         BCBB.BG         SDB         0.195170         BCBB.BG         SDB           8595.JP         LAMC         0.00348         LMUS         LAMC         6         DBK.GR         LDCM         0.185441         8616.JP         LIBB           8543.JP         LRB         0.004739         SANTGRUCI         LAMC         6         MASUS         STMF         0.18341         861.JP         LIBB         SBBNIN         LDB         0.004595         STMF	0.081837 0.071296
VONNSW         LAMC         0.005102         \$\$\$95,P         LAMC         11         BMIM         LIBB         0.181143         CAFFP         LRB           BAPUS         LDB         0.00487         SBNIN         LDB         6         OCFCUS         S.TMF         0.179697         PAGLIN         LTMF           SBIN.IN         LDB         0.004425         DBK.GR         LDCM         6         KN:P         LDCM         0.179697         CAVLN         S.IBB           2006         VONN.SW         LAMC         0.006452         VON.SW         LAMC         14         BCBB.BG         S.DB         0.195170         BCBB.BG         S.DB           2006         VONN.SW         LAMC         0.006452         VON.SW         LAMC         14         BCBB.BG         S.DB         0.195170         BCBB.BG         S.DB           8595,P         LAMC         0.005780         RATLN         LAMC         6         NASBUS         S.TMF         0.18326         BCBLB         LDCM         0.18226         DBC.GR         LDCM           8543,P         LRB         5         8595,P         LAMC         0.180163         PAGLIN         LTMF           2007         ADNLN         LAMC <t< td=""><td>0.071296</td></t<>	0.071296
BAPUS         LDB         0.004587         SBIN.IN         LDB         6         OCPCUS         S.TMF         0.179697         PAG.LN         LTMF           SBIN.IN         LDB         0.004132         6800.KS         LDCM         6         OPYUS         SIBB         0.179640         21080.KS         S.AMC           PBC         LDB         0.00498         HB.CY         LDB         4         SANTGRUCI         LAMC         0.179640         21080.KS         S.AMC           PBC         NNSW         LAMC         LAMC         14         BCBB.EG         S.DB         0.195170         BCBB.EG         S.DB           RATLN         LAMC         0.004758         RATLN         LAMC         14         BCBB.EG         S.DB         D195170         BCBB.EG         S.DB           8595.JP         LAMC         0.004758         S95.JP         LAMC         6         DBK.GR         LDCM         0.183326         B543.JP         LRB         DCM           SBIN.IN         LDB         0.004759         SANTGRUCI         LAMC         5         6800.KS         LDCM         0.18259         8614.JP         S.IBB           2007         ADN.LN         LAMC         0.004768         RATLN	0.0(1202
LMUS         LAMC         0.004425         DBK.CR         LDCM         6         OPYUS         S.IBB         0.179587         C.AYLN         S.IBB           BININ         LDB         0.00498         HB.CY         LDB         4         SANTGRUCI         LAMC         0.179505         CFN.US         LTMF           2006         VONNSW         LAMC         0.00498         HB.CY         LDB         4         SANTGRUCI         LAMC         0.178505         CFFN.US         LTMF           2006         VONNSW         LAMC         0.00538         RATLN         LAMC         11         165.HK         LDCM         0.195170         BCBB.BG         S.DB           8595.JP         LAMC         0.00538         LM.US         LAMC         6         DBK.GR         LDCM         0.185441         8616.JP         LIBB           8543.JP         LAR         0.004739         SANTGRUCI         LAMC         6         MASG.US         STMF         0.18326         8843.JP         LRB         5         895.JP         LAMC         0.18163         PAGLN         LTMF           2007         ADN.LN         LAMC         0.004608         S43.JP         LRB         9         BSEUS         STMF	0.061393
SBIN.IN         LDB         0.004132         6800.KS         LDCM         6         KN.FP         LDCM         0.179040         21080.KS         S.AMC           2006         VONN.SW         LAMC         0.006492         VONN.SW         LAMC         14         BCBB.BG         S.DB         0.178505         CFFN.US         LTMF           2006         VONN.SW         LAMC         0.006472         VONN.SW         LAMC         11         BCBB.BG         S.DB         0.195170         BCBB.BG         S.DB           8595.JP         LAMC         0.005780         RATLN         LAMC         6         DBK.GR         LDCM         0.18541         8616.JP         LIBB           BAPUS         LDB         0.004785         8595.JP         LAMC         6         NASB.US         S.TMF         0.18326         8543.JP         LRB           2007         ADN.IN         LAMC         0.004785         RHB.CMK         LDB         9         BSFUS         S.TMF         0.189265         OCFC.US         S.TMF           2007         ADN.IN         LAMC         0.004762         RHB.CMK         LDB         8         TRST.US         LTMF         0.189265         OCFC.US         S.TMF         1.1806	0.038407
HBCY         LDB         0.004098         HBCY         LDB         4         SANTGRUCI         LAMC         0.178505         CFFN.US         LTMF           2006         VONNSW         LAMC         0.006452         VONNSW         LAMC         14         BCBB.BG         S.DB         0.195170         BCBB.BG         S.DB           8595.JP         LAMC         0.005780         RATLN         LAMC         6         DBK.GR         LDCM         0.185244         B616.JP         LIBB           8543.JP         LRB         0.004785         S59.JP         LAMC         6         NASB.US         S.TMF         0.18326         S631.JP         LRB           BAPUS         LDB         0.004785         S59.JP         LAMC         6         NASB.US         S.TMF         0.1820559         8614.JP         SIBB           2007         ADNLIN         LAMC         0.004608         CHIB.PM         LDB         9         BSFUS         S.TMF         0.189265         OCFC.US         STMF           LM.US         LAMC         0.004762         RHBCMK         LDB         8         TRST.US         LTMF         0.189265         OCFC.US         STMF           LM.US         LAMC         0.004750 </td <td>0.036663</td>	0.036663
2006         VONNSW         LAMC         0.006452         VONNSW         LAMC         14         BCBB.BG         S.DB         0.195170         BCBB.BG         S.DB           8595.JP         LAMC         0.005780         RATLN         LAMC         6         DBK.GR         LDCM         0.192246         DBK.GR         LDCM           8595.JP         LAMC         0.005780         RATLN         LAMC         6         DBK.GR         LDCM         0.182549         BBK.LB         DBK.GR         LDCM         0.182559         8614.JP         LIBB           SBIN.IN         LDB         0.004739         SANTGRUCL         LAMC         5         6800.KS         LDCM         0.182559         8614.JP         SIBB           2007         ADN.LN         LAMC         0.004608         CHIB.PM         LDB         9         BSFUS         STMF         0.189265         OCFCUS         STMF           LMUS         LAMC         0.004750         RATLN         LAMC         7         BIM.IM         LIBB         0.184042         DBK.GR         LDCM         1844806         turn.US         S.AMC           165.HK         LDCM         0.003780         RATLN         LAMC         4         PAG.LN         L	0.035094
RATLIN         LAMC         0.005780         RATLN         LAMC         11         165.HK         LDCM         0.192246         DBK,GR         LDCM           8595,JP         LAMC         0.004785         8595,JP         LAMC         6         DBK,GR         LDCM         0.18541         8616,JP         LIBB           BAPUS         LDB         0.004735         SSNTGRUCL         LAMC         6         NASB,US         STMF         0.18326         8543,JP         LRB           2007         ADN.IN         LDB         0.00468         S43,JP         LRB         5         8595,JP         LAMC         0.189265         OCFCUS         S.TMF           2007         ADN.IN         LAMC         0.004605         RATLN         LAMC         1.0180163         PAG,LN         LTMF           2007         ADN.IN         LAMC         0.004752         RHEC.MK         LDB         8         TST.US         LTMF         0.189265         OCFCUS         S.TMF           LMUS         LAMC         0.004750         RATLN         LAMC         4         165.HK         LDCM         0.184042         DBK,GR         LDCM           165.HK         LDC         0.003788         LMUS         LAMC	0.073190
8595.JP         LAMC         0.005348         LMUS         LAMC         6         DBK.GR         LDCM         0.185441         8616.JP         LIBB           8543.JP         LRB         0.004785         \$55.JP         LAMC         5         6800.KS         LDCM         0.18326         8543.JP         LRB         5           2007         ADN.LN         LDB         0.004608         \$543.JP         LRB         5         8595.JP         LAMC         0.180163         PAG.LN         LTMF           2007         ADN.LN         LAMC         0.004608         CHIB.PM         LDB         9         BSFUS         STMF         0.189265         OCFC.US         STMF           LMUS         LAMC         0.004762         RHBC.MK         LDB         8         TRSTUS         LTMF         0.189265         OCFC.US         STMF           LMUS         LAMC         0.004757         RATLN         LAMC         7         BIM.IM         LDB         0.189265         OCFC.US         STMF           VONNSW         LAMC         0.004757         NLN         LAMC         4         IDCLN         LDCM         0.18942         DBK.GR         LDCM           VONNSW         LAMC         0.003	0.050477
8543.JP         LRB         0.004785         8595.JP         LAMC         6         NASB.US         S.TMF         0.183326         8543.JP         LRB           BAPUS         LDB         0.004789         SANTCRUCL         LAMC         5         6800.KS         LDCM         0.182559         8614.JP         S.IBB           2007         ADN.I.N         LAMC         0.004608         8543.JP         LRB         5         8595.JP         LAMC         0.182559         OCFC.US         S.TMF           2007         ADN.I.N         LAMC         0.004608         CHIB.PM         LDB         9         BSFUS         S.TMF         0.189265         OCFC.US         S.TMF           CHIB.PM         LDB         0.004505         RATLN         LAMC         4         TASTUS         LTMF         0.187098         BGCPUS         LIBB           CHIB.PM         LDM         0.004378         K.ULS         LAMC         4         MGAU         LDCM         0.184806         turn.US         S.AMC           VONN.SW         LAMC         0.003789         MLUS         LAMC         4         PAGLN         LTMF         0.18406         turn.US         S.AMC           2008         SANTGRUCI         L	0.046745
BAPUS         LDB         0.004/39         SANTGRUCI         LAMC         5         890LKS         LDCM         0.182539         8614,P         SIBB           2007         ADN.LN         LDB         0.004608         8543,P         LRB         5         895,JP         LAMC         0.180163         PAGLN         LTMF           2007         ADN.LN         LAMC         0.004608         8543,P         LRB         5         895,JP         LAMC         0.189265         OCFCUS         S.TMF           LMUS         LAMC         0.004762         RHBC.MK         LDB         8         TRST.US         LTMF         0.189265         OCFCUS         S.TMF           RATLN         LAMC         0.004755         RATLN         LAMC         4         165,HK         LDCM         0.18406         tum.VS         S.AMC           165,HK         LDCM         0.003788         LMUS         LAMC         4         PAGLN         LTMF         0.18406         PGR.S         S.AMC           2008         SANTGRU.CI         LAMC         0.005780         BAPUS         LDB         9         NYCB.US         LTMF         0.17649         VONN.SW         LAMC         0.004785         RATLN         LAMC	0.039037
SBININ         LDB         0.004608         8543,17         LRB         5         8595,17         LAMC         0.180163         PAGLN         LIMF           2007         ADNLN         LAMC         0.004608         CHIBPM         LDB         9         BSEUS         STMF         0.189265         OCFCUS         STMF           LM.US         LAMC         0.004762         RHBCMK         LDB         8         TRST.US         LTMF         0.187098         BGCPUS         LIBB           CHIB.PM         LDB         0.004505         RATLN         LAMC         7         BIMIM         LIBB         0.184042         DBK.GR         LDCM           165.HK         LDCM         0.003789         LMUS         LAMC         4         PAGLN         LTMF         0.184042         DBK.GR         LDCM           2008         SANTGRUCI         LAMC         0.005780         BAPUS         LDB         9         NYCB US         LTMF         0.184042         DDK.DS         LAMC           LMUS         LAMC         0.005780         BAPUS         LDB         9         NYCB US         LTMF         0.18404         DNLN         LAMC         1.00243         LTMF         D.17406         LASC	0.038075
2007         ADN.LN         LAMC         0.004808         CHIB.PM         LDB         9         058:US         S.IMF         0.189265         OCFC.US         S.IMF           LMUS         LAMC         0.004762         RHB.CMK         LDB         8         TRST.US         LTMF         0.187098         BGCP.US         LIBB           RATLN         LAMC         0.004505         RATLN         LAMC         7         BIM.IM         LIBB         0.184042         DBK.GR         LDCM           165.HK         LDCM         0.003789         LMUS         LAMC         4         MQG.AU         LDCM         0.184042         DBK.GR         LDCM           2008         SANTCRUCI         LAMC         0.003789         ADN.IN         LAMC         4         MQG.AU         LDCM         0.184042         DBK.GR         LDCM           RATLN         LAMC         0.003789         ADN.IN         LAMC         4         MQG.AU         LDCM         0.18749         PRO.IM         SIBB           2008         SANTCRUCI         LAMC         0.005780         RAPUS         LDB         9         MYCR.US         LTMF         0.175540         PRO.IM         SIBB         0.175540         PMC.US         LTMF </td <td>0.037034</td>	0.037034
LMUS         LANC         0.004762         KHZLM         LDD         6         HSLUS         L1MP         0.16/1936         BOCHUS         LBD           CHIBPM         LDB         0.004765         RATLN         LAMC         7         BIM.IM         LIBB         0.184806         tum.US         S.AMC           RATLN         LAMC         0.00455         VONNSW         LAMC         4         I65.HK         LDCM         0.184706         tum.US         S.AMC           165.HK         LDCM         0.003759         ADN.LN         LAMC         4         PAG.LN         LTMF         0.18370         PRO.IM         SIBB           2008         SANTGRUCI         LAMC         0.003759         ADN.LN         LAMC         4         PAG.LN         LTMF         0.174743         CFFN.US         LTMF           1MUS         LAMC         0.003788         KLILN         LAMC         8         INLSJ         LDCM         0.176199         VONNSW         LAMC           1MUS         LAMC         0.004785         RATLN         LAMC         8         INLSJ         LDCM         0.17540         FMCCUS         LTMF           8616.JP         LIBB         0.004785         RATLN	0.069634
CHID1 M         LDD         0.00425         NONSW         LAMC         1         LDCM         0.184042         DBK.GR         LDCM           165.HK         LDCM         0.00425         VONSW         LAMC         4         165.HK         LDCM         0.184042         DBK.GR         LDCM           165.HK         LDCM         0.003788         LMUS         LAMC         4         MQG.AU         LDCM         0.184042         DBK.GR         LDCM           2008         SANTGRUCI         LAMC         0.005780         BAPUS         LDB         9         NYCB.US         LTMF         0.184049         VONNSW         LAMC         0.005780         BAPUS         LDB         9         NYCB.US         LTMF         0.177473         CFFN.US         LTMF           LMUS         LAMC         0.005780         BAPUS         LDB         9         NYCB.US         LTMF         0.176499         VONNSW         LAMC         0.004785         RATLN         LAMC         7         LASEDC         S.DB         0.174415         KN.FP         LDCM         NFP         LDCM         0.17549         VONNSW         LAMC         1.004405         SATGRUCI         LAMC         7         LASEDC         S.DB         0.174415 <td>0.062759</td>	0.062759
IANLEN         LAMC         0.01NLS         LAMC         4         MOLIN         LDCM         0.018972         DDR.M         LDCM         LDCM           165.HK         LDCM         0.003789         LLUS         LAMC         4         MQG.AU         LDCM         0.183710         PRO.IM         SIBB           2008         SANTGRUCI         LAMC         0.003789         ADN.IN         LAMC         4         PAG.IN         LTMF         0.183710         PRO.IM         SIBB           2008         SANTGRUCI         LAMC         0.005780         BAP.US         LDB         9         MYCB.US         LTMF         0.183710         VONNSW         LAMC           RATLIN         LAMC         0.005780         BAP.US         LDB         9         MYCB.US         LTMF         0.174973         CFN.US         LTMF           RATLN         LAMC         0.004739         RATLN         LAMC         8         INLS         LDCM         0.175840         FMCC.US         LTMF           8616.JP         LIBB         0.004405         SANTGRUCI         LAMC         7         OCFC.US         S.TMF         0.174915         KN.FP         LDCM           VPBN.SW         LAMC         0.004405	0.040719
VONNSW         LAMC         0.003759         ADN.I.N         LAMC         4         PAG.I.N         LTMF         0.181808         PGR.SJ         S.AMC           2008         SANTGRU.CI         LAMC         0.003759         ADN.I.N         LAMC         4         PAG.I.N         LTMF         0.181808         PGR.SJ         S.AMC           2008         SANTGRU.CI         LAMC         0.003780         BAPUS         LDB         9         NYCB.US         LTMF         0.177473         CFFN.US         LTMF           LMUS         LAMC         0.004785         RATLN         LAMC         8         INLSJ         LDCM         0.175540         FMCC.US         LTMF           8616.JP         LIBB         0.004735         RATLN         LAMC         7         LASPDC         S.DB         0.174415         KN.FP         LDCM           BAPUS         LDB         0.00475         RATLN         LAMC         7         OCCUS         S.TMF         0.174960         LASPDC         S.DB           VPBNSW         LAMC         0.004367         ALPHA.GA         LDB         4         PRO.IM         S.IBB         0.176723         UMBEUS         LRB           895.JP         LAMC         0.00566<	0.032516
2008         SANTGRU.CI         LAMC         0.005780         BAP.US         LDB         9         NYCB.US         LTMF         0.177473         CFFN.US         LTMF           RAT.LN         LAMC         0.005780         BAP.US         LDB         9         NYCB.US         LTMF         0.176499         VONN.SW         LAMC           LM.US         LAMC         0.004785         RAT.LN         LAMC         8         INLS]         LDCM         0.176499         VONN.SW         LAMC           8616.JP         LIBB         0.004785         RAT.LN         LAMC         7         LASEDC         S.DB         0.174415         KN.FP         LDCM           BAP.US         LDB         0.004367         ALPHA.CA         LDB         4         PRO.IM         S.IBB         0.176400         LASEDC         S.DB           2009         LM.US         LAMC         0.004367         ALPHA.CA         LDB         4         PRO.IM         S.IBB         0.176723         UMBEUS         LRB           8595.JP         LAMC         0.004364         8595.JP         LAMC         8         SNG.RE         SANTGRU.CI         LAMC           VONN.SW         LAMC         0.00576         VONN.SW	0.031952
RATLN         LAMC         0.005348         8616.JP         LIBB         9         MQG.AU         LDCM         0.176199         VONN.SW         LAMC           LM.US         LAMC         0.004785         RATLN         LAMC         8         INLSJ         LDCM         0.175199         VONN.SW         LAMC           B616.JP         LIBB         0.004785         RATLN         LAMC         8         INLSJ         LDCM         0.17540         FMCC.US         LTMF           BAPUS         LDB         0.004795         LAUS         LAMC         7         LASPDC         S.DB         0.174415         K.N.FP         LDCM           BAPUS         LDB         0.004367         ALPHAGA         LDB         4         PROLM         SIBB         0.173592         SIBB         SIBB         SIG17523         UMBEUS         LRB           2009         LMUS         LAMC         0.006369         LMUS         LAMC         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           VONN.SW         LAMC         0.0063676         VONNSW         LAMC         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           NVLS         LDCM         0.006451 <td>0.070379</td>	0.070379
LM.US         LAMC         0.004785         RATLN         LAMC         8         INLSJ         LDCM         0.175540         FMCC.US         LTMF           8616.JP         LIBB         0.004739         LMUS         LAMC         7         LASP.DC         S.DB         0.17540         FMCC.US         LTMF           BAPUS         LDB         0.004405         SANTGRUCI         LAMC         7         OCFC.US         S.TMF         0.174010         LASP.DC         S.DB           VPBN.SW         LAMC         0.004367         ALPHA.GA         LDB         4         PRO.IM         S.IBB         0.173592         8614.JP         S.IBB           2009         LMUS         LAMC         0.005464         8595.JP         LAMC         0.0175862         SANTGRUCI         LAMC           8595.JP         LAMC         0.005464         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           NNLS         LAMC         0.005464         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           INLS         LDCM         0.004651         VPBNSW         LAMC         7         NYCB.US         LTMF         0.174494         KN.FP         LDCM	0.050911
8616.JP         LIBB         0.004739         LMUS         LAMC         7         LASEDC         S.DB         0.174415         K.N.FP         LDCM           BAPUS         LDB         0.004405         SANTGRUCI         LAMC         5         OCFCUS         S.TMF         0.174060         LASPDC         S.DB           2009         LAMC         0.004367         ALPHA.GA         LDB         4         PRO.IM         S.IBB         0.173592         8614.JP         S.IBB           2009         LMUS         LAMC         0.006369         LMUS         LAMC         13         OPYUS         S.IBB         0.176723         UMBEUS         LRR           8595.JP         LAMC         0.005646         8595.JP         LAMC         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           VONN.SW         LAMC         0.005676         VONN.SW         LAMC         7         NYCB.US         LTMF         0.176494         KN.FP         LDCM           INLS         LDCM         0.004651         VPB.SW         LAMC         4         TRSUS         LTMF         0.171275         GRLA.DC         S.RB           6800.KS         LDCM         0.004651         RATLN         L	0.049563
BAPUS         LDB         0.004405         SANTGRUCI         LAMC         5         OCFC.US         S.TMF         0.174060         LASP.DC         S.DB           2009         LAMC         0.004367         ALPHA.GA         LDB         4         PRO.IM         S.IBB         0.173592         8614.JP         S.IBB           2009         LM.US         LAMC         0.004367         ALPHA.GA         LDB         4         PRO.IM         S.IBB         0.173592         8614.JP         S.IBB           2009         LM.US         LAMC         0.005464         895.JP         LAMC         13         OPY.US         S.IBB         0.176723         UMBEUS         LAMC           VONN.SW         LAMC         0.005676         VONN.SW         LAMC         7         NYCB.US         L.TMF         0.174494         KN.FP         LDCM         0.004651         VPBN.SW         LAMC         7         NYCB.US         LTMF         0.17175         GRLA.DC         S.RB           KN.FP         LDCM         0.004651         VPBN.SW         LAMC         3         MQG.AU         LDCM         0.171251         FMBI.US         LRB           6800.KS         LDCM         0.004651         RATLN         LAMC	0.037231
VPBN.SW         LAMC         0.004367         ALPHA.GA         LDB         4         PR0.IM         S.IBB         0.173592         8614.JP         S.IBB           2009         LM.US         LAMC         0.006369         LM.US         LAMC         13         OPY.US         S.IBB         0.173592         8614.JP         S.IBB           8595.JP         LAMC         0.006369         LM.US         LAMC         13         OPY.US         S.IBB         0.176723         UMBEUS         LRB           8595.JP         LAMC         0.005464         8595.JP         LAMC         0.175862         SANTGRUCI         LAMC           INLS         LDCM         0.005076         VONN.SW         LAMC         7         NYCB.US         LTMF         0.174494         KN.FP         LDCM           INLS         LDCM         0.004651         VPBNSW         LAMC         4         TRSTUS         LTMF         0.172134         BCBB.BG         S.DR           6800.KS         LDCM         0.004651         RAT.LN         LAMC         3         MQG.AU         LDCM         0.171251         FMBI.US         LRB           600.KS         LDCM         0.004651         RAT.LN         LAMC         3 <td< td=""><td>0.033454</td></td<>	0.033454
2009         LM.US         LAMC         0.006369         LM.US         LAMC         13         OPY.US         S.IBB         0.176723         UMBEUS         L.RB           \$\$95,JP         LAMC         0.005464         \$\$95,JP         LAMC         8         \$\$95,JP         LAMC         0.175862         SANTCRUCI         LAMC           VONN.SW         LAMC         0.00576         VONN.SW         LAMC         7         NYCB.US         LTMF         0.174494         KN.FP         LDCM           INLS         LDCM         0.004651         VBNSW         LAMC         6         \$800,KS         LDCM         0.172144         BCBB.BG         S.DB           6800,KS         LDCM         0.004651         VBNSW         LAMC         4         TRSTUS         LTMF         0.171275         GRLa.DC         S.RB           6800,KS         LDCM         0.004651         RATLN         LAMC         3         MQG.AU         LDCM         0.171251         FMBI.US         LRB           2010         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         SLBB           1MUS         LAMC         0.005000         RNIIII         LDB         8	0.031573
8595.JP         LAMC         0.005464         8595.JP         LAMC         8 8595.JP         LAMC         0.175862         SANTGRU.CI         LAMC           VONN.SW         LAMC         0.00576         VONN.SW         LAMC         7         NYCB.US         LTMF         0.175862         SANTGRU.CI         LAMC           INLSJ         LDCM         0.004831         INLSJ         LDCM         6         6800.KS         LDCM         0.172134         BCBB.BG         S.DB           KN.FP         LDCM         0.004651         VPBN.SW         LAMC         4         TRST.US         LTMF         0.171775         GRLA.DC         S.RB           6800.KS         LDCM         0.004651         RATLN         LAMC         3         MQG.AU         LDCM         0.171251         FMBLUS         LRB           2010         VONN.SW         LAMC         0.005263         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         S.IBB           IMUS         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         S.IBB	0.047378
VONNSW         LAMC         0.005076         VONNSW         LAMC         7         NYCB.US         L.TMF         0.174194         KN.FP         LDCM           INLSJ         LDCM         0.004651         VPBN.SW         LAMC         7         NYCB.US         L.TMF         0.172134         BCBB.BG         SDB           KN.FP         LDCM         0.004651         VPBN.SW         LAMC         4         TRST.US         L.TMF         0.171775         GRLA.DC         S.RB           6800.KS         LDCM         0.004651         RATLN         LAMC         3         MQG.AU         LDCM         0.171251         FMBLUS         L.RB           2010         VONN.SW         LAMC         0.005263         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         SIBB           IMUS         LAMC         10.08         SBCFUS         S.B         0.200952         OPY.US         SIBB	0.044767
INLS         LDCM         0.004831         INLS         LDCM         6         6800.KS         LDCM         0.122134         BCBB.BG         S.DB           KN.FP         LDCM         0.004651         VPBNSW         LAMC         4         TRST.US         LTMF         0.17175         GRLA.DC         S.RB           6800.KS         LDCM         0.004651         VPBNSW         LAMC         3         MQG.AU         LDCM         0.171251         FMBI.US         LRB           2010         VONN.SW         LAMC         0.005263         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         SIBB           IMUS         LAMC         0.005000         BNIH         LDB         8         SRCFUS         SRB         0.200952         OPY.US         SIBB	0.043701
KN.FP         LDCM         0.004651         VPBNSW         LAMC         4         INST.US         L.IMF         0.1/17/5         GRLA.DC         S.KB           6800.KS         LDCM         0.004651         RAT.LN         LAMC         3         MQG.AU         LDCM         0.171251         FMBLUS         L.RB           2010         VONN.SW         LAMC         0.005263         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         S.IBB           1MUS         L         L         D         8         SRCFUS         S.R         0.200977         SANTCRUCU         1 AMC	0.042210
0000.KS         LDAM         0.004601         KALLIN         LAMC         5         MQGAU         LDCM         0.171291         FMBLUS         LRN           2010         VONN.SW         LAMC         0.005263         VONN.SW         LAMC         10         BIM.IM         LIBB         0.200952         OPY.US         S.IBB           1MUS         LAMC         10         B         SRCFUS         SRB         0.200952         OPY.US         S.IBB	0.040354
2010 VONN.SW LANC 0.005265 VONN.SW LANC 10 DIM.IM LIDD 0.20092 OFT.05 S.DD IMIIS LANC 0.005000 RNIIII I. D.B. & SBCFUS S.B. 0.200907 SANTCPUCT LANC	0.033732
	0.087552
SEG ID LAME 0.0057 IMILS LAME 6 DOULD STAD 0.2020/ JUVICRUE LAME	0.032690
HBCY LDB 0004505 HBCY LDB 6 MTGUS LTME 0195417 LMUS LAMC	0.04/20/
RATLN LAMC 0.004032 85951P LAMC 5 BAPUS LDB 0.193931 OCFCUS STME	0.039587
8543.JP L.RB 0.004032 BIM.IM L.IBB 5 HB.CY L.DB 0.183587 BAP.US L.DB	0.037286
2011 VONN.SW L.AMC 0.006024 VONN.SW L.AMC 13 NYCB.US L.TMF 0.188460 DBAN.GR S.AMC	0.046681
C.US L.AMC 0.005319 C.US L.AMC 9 CIMB.MK L.DB 0.182926 BIM.IM L.IBB	0.043714
LM.US L.AMC 0.005155 CHIB.PM L.DB 6 KN.FP L.DCM 0.180730 PGR.SJ S.AMC	0.039625
FILUS L.AMC 0.004545 LM.US L.AMC 5 MTG.US L.TMF 0.176983 CACB.US S.RB	0.037534
CIMB.MK LDB 0.004505 RATLN LAMC 5 BSFUS 5.1MF 0.176903 FMBLUS LRB	0.032418
boller in the second se	0.030919
2012 8595.JF LAMC 0.006173 8595.JF LAMC 13 KN.FP LDCM 0.198168 BAPUS LDB	0.052362
VUNNASYV LANG UUUDDO VUNNASY LAMC 6 INLSJ LDCM UL951UI CAYLN SJBB DRV CP LDCM 0.005555 PATINI LAMC 6 MOCALI LDCM 0.189007 DVICT LDCM	0.048/78
RATIN LAMC 0004050 CHIRPM I DR 6 TRETIS LTME 018700/ INLS) LDCM RATIN LAMC 0004050 CHIRPM I DR 6 TRETIS LTME 0187001 RDODIS I DR	0.047075
BNULL LDR 0.004587 DBK GR LDCM 6 165 HK LDCM 0.180399 BCCPUS LIB	0.043087
LMUS LAMC 0.004464 KN.FP LDCM 6 ALPHA.GA LDB 0.174612 HB.CY LDB	0.039755
2013 LM.US L.AMC 0.005587 LM.US L.AMC 10 MTG.US L.TMF 0.211206 BCBB.BG S.DB	0.050632
VONN.SW L.AMC 0.005291 ALPHA.GA L.DB 8 SNV.US L.RB 0.199877 SCB.TB L.DB	0.047976
ALPHA.GA L.DB 0.004831 SANTGRU.CI L.AMC 6 BIM.IM L.IBB 0.199045 NBKE.EY S.DB	0.039395
SANTGRU.CI L.AMC 0.004525 165.HK L.DCM 5 BYLK.US S.RB 0.193692 21080.KS S.AMC	0.038239
165.HK L.DCM 0.004405 MTG.US L.TMF 5 21080.KS S.AMC 0.190409 BIM.IM L.IBB	0.037467
DBK.GR L.DCM 0.004255 VONN.SW L.AMC 4 8614.JP S.IBB 0.187220 BSEUS S.TMF	0.034415
2014 VONN.SW LAMC 0.004808 VONN.SW LAMC 7 PRO.IM S.IBB 0.208298 BGCP.US LIBB	0.048682
8595,JP LAMC 0.004505 RATLN LAMC 6 CFFLUS S.RB 0.205214 NYCB.US LTMF	0.040771
SANTGRUCI LAMC 0.004274 SANTGRUCI LAMC 5 INLSJ LDCM 0.203851 LD.FP S.TMF	0.040653
CHIBJYM LDB 0.004098 BAPUS LDB 5 PGKSJ SAMC 0.198631 PGKSJ SAMC	0.038840
8616 IP LIBB 0003817 8595 IP LAMC 4 165 HK LDCM 0.192385 ALPHA.GA LDB	111122010

**Table A6.** Yearly centrality measures for Bayesian NetMES correlation network of top 6 survived financial institutions per sub-industry provided in Figure 6. The table lists the highest 6 ranking institutions based on their centrality measure.

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