CEO Social Network and Systemic Risk

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Current Draft: 16th September, 2019

Abstract

We examine the relationship between chief executive officer (CEO) connections and banks' contribution to systemic risk. Using biographical information about CEOs of publicly traded banks, we provide evidence suggesting that a bank's contribution to systemic risk increases with CEO's employment connections with other banks' CEOs. To identify the causal effect, we employ instrumental variable two-stage least square regression, and a difference-in-differences estimation using the death of a CEO as an exogenous shock to the social network within the banking sector. The result indicates that banks affected by the death of a connected CEO contribute less to systemic risk. The results further show that banks with CEOs who have more connections in the banking network are net lenders in the interbank market, which serves as a source of liquidity for banks and could also be a potential source of systemic risk.

JEL codes: G21, G32, D85

Keywords: systemic risk, social connections, network centrality

1 Introduction

Recent research in finance examines systemic risk, defined as the risk that the capacity of the entire financial system is impaired, with potentially adverse consequences for the real economy, and develops measures of systemic risk contribution of financial institutions (Chan-Lau 2010; Huang *et al.* 2012; Adrian & Brunnermeier 2016; Acharya *et al.* 2017; Brownlees & Engle 2017).[1] These studies emphasize on certain characteristics of banks such as leverage, size, complexity, maturity mismatch, asset valuation and interconnectedness as determinants of banks' contribution to systemic risk. Adrian and Brunnermeier (2016) and Laeven *et al.* (2016) show that bank size is positively associated with systemic risk. Other studies emphasize on networks and systemic interconnectedness within the financial system. For instance, banks are mostly linked to each other through common asset holdings or balance sheet connections (Dasgupta 2004; Billio *et al.* 2012; Braverman & Minca 2014). In the presence of interbank network, a substantive negative shock to a large bank can initiate cascading bank failures which spreads through the whole financial system leading to systemic risk (Acemoglu *et al.* 2015). In their early works, Allen and Gale (2000) and Freixas *et al.* (2000) reveal that the financial system is interconnected in the sense that small shocks or distress, which affect a few institutions, spread by contagion to the rest of the larger economy. Financial network and interconnectedness therefore generates systemic risk by enhancing the spread of relatively larger shocks, or by interacting with propagation mechanisms which includes bankruptcy cost and uncertainty about bank's balance sheet (Gai & Kapadia 2010; Caballero & Simsek 2013; Elliott *et al.* 2014).

In order to contribute to and comprehend the relative value of networks, we identify a new determinant of systemic risk known as the social network among banks' executives. This paper studies this unexplored determinant by considering how CEO social network will affect systemic risk through the interbank transaction network. Banks are linked to each other when top management as well as board members are socially connected. These connections, established through work experience, common education as well as social clubs and activities, among executives can enhance information sharing, business transactions and in other settings destroy value-creating financial transactions (El-Khatib *et al.* 2015). In their study, Fracassi (2017)

[1] Similarly, the European Central Bank defines systemic risk as the risk of simultaneous failure of a number of institutions, or entire financial system, as a result of the interlinkages that exist in the system (ECB 2010).

shows that managers who share social connections tend to have more similar investment. Banks' executives with social connection through common background and experience are more likely to engage in business transaction especially in the interbank market which serves as a platform for lending and borrowing. Hence, personal connection may play a key role in the interbank market.

We posit that CEO connections affect systemic risk from two channels. First, the social network among bank executives enables them to engage in a wide range of inter-bank transactions such as interbank lending. By engaging in interbank lending, banks may have financial exposure to each other, and this may allow shocks to spread across the financial system in the event of market failure leading to systemic risk. We hypothesis that higher social connections increase banks' contribution to systemic risk. Secondly, the interconnections among banks may occur as a result of common asset holdings (Dasgupta 2004; Brunetti *et al.* 2019). These linkages among banks can transmit shocks in the event of crisis. If two banks are linked to each other, during financial crisis the failure of one bank can have negative impact on the other bank in which it is linked to. We emphasize that social connections among banks' executives which result in bank interconnections can influence banks portfolio choices. We however argue from the interbank transaction view point, that through CEO personal connections, a bank will be able to lend more to other connected banks not taking into consideration the counterparty risk. This further suggest that, in the event of market failure the effect of most banks not able to fulfill the payment of their debt will be contagion on connected banks leading to financial sector's systemic risk. The investigation of social connections within the banking system is relevant since the banking sector is a vital part of the financial system. A distressed banking system will not have the capacity to make enough credit available for ongoing business activities and this can affect the economy at large (Brownlees & Engle 2017).

We test our hypothesis on a sample of 991 unique CEOs at 563 unique U.S. publicly traded banks over the period 2000 to 2018. We first document the increasing CEO connections overtime from 2000 to 2018. (Fig. 1). The figure 1 shows how CEO employment connection with other bank's CEOs increased overtime within the sample banks. We use the BoardEx database for measuring CEO connections and network centralities. Using the biographical information of CEOs, we measure CEO employment connections as the total number of other banks CEOs with whom the

CEO shares common employment history in BoardEx. Following recent studies, we employ the SRISK and $\Delta CoVaR$ proposed by Brownlees and Engle (2017) and Adrian and Brunnermeier (2016) respectively as proxies for systemic risk. The results show that banks' contribution to systemic risk increases with banks' CEO employment connections and network centralities. Our results reveal that an additional increase in CEO employment connection will lead to $8.98billion increase in SRISK. The coefficient of CEO employment connections with other banks' CEOs suggests that a one-percent increase in employment connection may increase SRISK and $\Delta CoVaR$ by 0.68 and 0.01 percentage points respectively. The result is robust using the CEO total connections through employment history, common education or social history in BoardEx. We further test for the robustness of our result using CEO network centrality measures which includes degree, closeness, betweenness, eigenvector and first principal component score. We provide evidence that CEO centrality is associated with systemic risk. The coefficient of the first principal component of centralities suggests that a one-percent increase in CEO centrality may increase SRISK and $\Delta CoVaR$ by 0.58 and 0.004 percentage points respectively.

A major concern is whether the regression result is attributable to reverse causality and omitted variable. For instance, it is more likely for a bank with higher systemic risk contribution to hire more connected CEO, since more connected CEO can help the bank to reduce their risk of capital shortfall. Meanwhile there are other factors that are not considered. For example, a bank with certain characteristics such as large banks for some specific reason happens to have higher systemic risk and also happens to hire more connected CEOs who can help the bank reduce bankruptcy risk. We use few methods to mitigate these endogeneity concerns. First we add bank fixed effects. Second we use instrumental variable two-stage least square regression. Last we employ a difference-in-differences estimation using the death of a CEO as an exogenous shock to the social network within the banking sector. The results reveal that banks which were affected by the death of a connected CEO contribute less to systemic risk after the death of the connected CEO. The instrumental variable two-stage least squares (2SLS) regression results remain robust.

Next, we evaluate the potential channel through which CEO connections leads to banks' contribution to systemic risk focusing on interbank lending. Banks embark on several business transactions with other banks on the interbank market. The interbank market serves as a platform where liquidity flows from banks with excess liquidity to liquidity needy banks (Acharya *et al.*

2012b). One of the concerns in the interbank market is that, efficient flow of liquidity among banks can be hindered due to certain frictions such as information asymmetry (Flannery 1996; Freixas & Jorge 2008). Since interbank deposits and loans are not insured and often uncollateralized in the interbank market, banks have great incentive to monitor each other (Furfine 2001). We believe personal connections can mitigate the information asymmetry and hence improve lending relationship. In our analysis we anticipate that the CEOs with more personal connections will be willing to lend as a result of the informational advantages coming from the social networks. We define interbank loan as the ratio of net interbank loan and deposit to total asset. This measure captures the interbank lending activities of banks.

We conduct the empirical analysis and our results show that the relationship between CEO employment connections and interbank loan is positive and significant. The findings reveal that an additional CEO employment connection will increase interbank loan by 0.004. The coefficient of CEO employment connections indicates that a one-percent increase in employment connection may increase interbank loan by 0.16 percentage points. This suggests that banks with CEOs who have more connections with other banks CEOs tend to lend more to other banks relative to banks with CEOs who have fewer connections. We employ a difference-in-differences estimation using the death of a CEO as an exogenous shock to the social network within the banking sector. The results reveal that banks who were affected by the death of a connected CEO reduce interbank loan after the death of the connected CEO. We further estimate the instrumental variable two-stage least squares (2SLS) regression and the results remains robust. As we discussed earlier, the interbank market can serve as a source of liquidity for banks. However, this market could be a potential source of systemic risk in the event of counterparties default. In view of this, we examine the effect of interbank loan on systemic risk. We anticipate that in the event of counterparties default, interbank loan may lead to systemic risk. Our results show that interbank loan is positively related to both measures of systemic risk.

This study contributes to two distinct literature. First, this study contribute to the literature on the determinants of systemic risk. Recent studies in this area (e.g. Adrian and Brunnermeier (2016) and Laeven *et al.* (2016)) indicate that size, leverage, maturity mismatch are important determinants of systemic risk. Elliott *et al.* (2014) reveal that financial network generates systemic risk by interacting with propagation mechanism such as bankruptcy. In their recent study, Anginer *et al.* (2018) find that shareholder-friendly corporate governance is associated with systemic risk in the banking sector. We add to this literature by showing that CEO social network also plays significant role in explaining banks' contribution to systemic risk. Houston *et al.* (2018) reveal that banks with shared social connections partner more often in the global syndicated loan market and that social connections facilitate business connections. Our study differs with their study in the following ways. We focus on CEO personal connections to other banks' CEOs within the U.S. banking sector and how these social connections facilitate business transaction. We focus on CEO employment connections with other banks' CEOs in the U.S. banking sector taking into consideration the influence of CEOs on the dynamics of the firm and the fact that the CEO, as a principal architect of corporate strategy can influence firm's strategic decision and directions relative to other top management executives (Child 1972; Bigley & Wiersema 2002).

Second, this paper adds to the literature on the effect of social networks in finance. For instance, Engelberg et al. (2012) find that the social networks between banks and firms reduces interest rate. Ferris et al. (2017) reveal positive association between CEO social capital and corporate risk taking. Again, our study differs with their study. We focus on CEO personal connections to other banks' CEOs within the U.S. banking sector. Ferris *et al.* (2017) use volatility of stock return, volatility of return on assets and volatility of return on equity as proxies for individual firm risk taking. Since our goal is on how CEO social network in the banking sector affects systemic risk, we employ SRISK (Acharya *et al.* 2012a; Brownlees & Engle 2017) and $\Delta CoVaR$ (Adrian & Brunnermeier 2016) as proxies for systemic risk.

The rest of the paper proceeds as follows. Section 2 presents the related literature and hypothesis development, section 3 presents the sample and data used, sections 4 presents the methodology and main results, section 5 presents potential channels through which CEO connections leads to systemic risk, section 6 presents results of additional robustness tests. Section 7 concludes

2 Related Literature and Hypothesis Development

2.1 Interconnection of Financial Institutions

Our paper draws on the growing literature that focuses on financial networks. Dasgupta (2004) indicates that financial institutions are mostly linked to each other through direct portfolio or balance sheet connections. For example, banks are linked to other banks through interbank lending and deposits. Recent finance research highlights how common asset holdings among banks can propel interconnectedness within correlation network. The networks formed through common asset holding of banks may not be specifically indicated in bank's balance sheet, but they can be inferred by the linkages in stock market returns (Billio *et al.* 2012; Brunetti *et al.* 2019). Banks are therefore interconnected through the correlation network of stock returns (Billio *et al.* 2012).

A growing literature also focuses on how financial network structure affects systemic risk. The early works emphasize that the financial system is interconnected in the sense that small shocks or distress which affect few institutions spread by contagion to the rest of the financial sector (Kiyotaki & Moore 1998; Allen & Gale 2000; Freixas *et al.* 2000; Lagunoff & Schreft 2001; Allen *et al.* 2012; Elliott *et al.* 2014). Gai and Kapadia (2010) describe how network can generate systemic risk by enhancing the spread of relatively larger shocks, or by interacting with propagation mechanisms which includes bankruptcy cost, and uncertainty about bank's balance sheet (Caballero & Simsek 2013; Elliott *et al.* 2014). Elsinger *et al.* (2006) demonstrate that correlation network through common asset holdings is a main source of systemic risk.

In addition to these strand of studies, other researchers emphasize on measures and other determinants of systemic risk. The systemic risk of the financial system has resulted in several prominent systemic risk measurements.[2] In this study, we adopt SRISK proposed by Acharya *et al.* (2012a) and Brownlees and Engle (2017) and $\Delta CoVaR$ proposed by Adrian and Brunnermeier (2016) as proxies for systemic risk. These measures have been widely used in recent studies (Diebold & Yılmaz 2014; Laeven *et al.* 2016; Anginer *et al.* 2018; Cai *et al.* 2018; Houston *et al.* 2018). Acharya *et al.* (2010) and Acharya *et al.* (2017) propose systemic risk

[2] Example of systemic risk measurement Systemic Expected Shortfall (Acharya *et al.* 2010, 2017), Risk Codependence (Chan-Lau 2010), Distress Insurance Premium (Huang *et al.* 2012), Component Expected shortfall (Banulescu & Dumitrescu 2015), Conditional Value-at-Risk (CoVaR) (Adrian & Brunnermeier 2016), SRISK (Brownlees & Engle 2017).

measure known as systemic expected shortfall, which is the financial institution's propensity to be undercapitalized when the system as a whole is undercapitalized. They find that systemic expected shortfall increases with leverage of financial institution and the marginal expected shortfall (that is the losses in the tail of the financial system's loss distribution). Adrian and Brunnermeier (2016) propose $\Delta CoVaR$ which is the difference between the value at risk of the financial system conditional on an institution being under distress and the value at risk of the financial system conditional on an institution operating in its median state. Their study reveals that higher leverage, more maturity mismatch, larger size and higher asset valuation predict higher $\Delta CoVaR$. Brownlees and Engle (2017) introduce a systemic risk measure of a financial firm known as SRISK. SRISK estimate the capital shortfall of a financial institution conditional on an extreme market decline. The SRISK relies on information on balance sheet and market prices and can only capture systemic risk so far as it is reflected in market prices. This measure is a function of the financial institution's size, its degree of leverage and its expected equity loss conditional on the market decline.

2.2 CEO Social Connections

The literature on social connection has recently expanded. Earlier studies in contemporary social science focused on social capital (Portes 1998; Woolcock 1998). Woolcock (1998, p. 153) defined social capital as 'the information, trust, and norms of reciprocity inhering in one's social networks. CEO social connection is important and constitute social capital because such social networks benefit the firms and its executives through access to improved resources obtained through their networks. Executives social networks established over time is vital for his or her employment and can be important in the labour market (Faleye *et al.* 2014; Liu 2014).

CEO personal connections have economic consequences. Engelberg *et al.* (2013) shows that CEOs with large connections earn more than those with small connections. Engelberg *et al.* (2012) document that when firms and banks are socially connected through interpersonal linkages (such as having worked together in the past and having attended same college), interest rates are markedly reduced. Cohen *et al.* (2008) show that mutual fund managers undertake larger investment in firms in which they share some form of social connections and perform relatively better on these holdings relative to their non-connected holdings.

Other strand of literature focus on risk taking behavior emanating from social connections. Ferris et al. (2017) examined the social capital of CEOs and reveal that CEO social capital is positively associated with corporate risk taking. In another study, Houston *et al.* (2018) examine the effect social connections among global banks on global syndicate loan market. In this study, we consider the connections among CEOs in the U.S. banking sector and analyze how these connections affect banks' contribution to the financial sector systemic risk through interbank transactions.

2.3 Hypothesis development

Our study seeks to empirically examine the models on how network of banks generates systemic risk when large shocks affect these banks. We do this by introducing CEO social connections as a new driving force of systemic risk. We argue that the interbank market serves as a platform where banks are linked to each other. This interconnection among banks even becomes stronger and effective when the top executives, including CEOs, are also socially connected to each other. Therefore, social network among banks' executives will enable them to engage in a wide range of inter-bank transactions such as interbank lending. By engaging in interbank lending, banks may have financial exposure to each other, and this network can generate systemic risk in the event of market failure. We therefore hypothesis that higher CEOs social network will increase banks' contribution to systemic risk.

The interbank deposits and loans are not insured and often uncollateralized in the interbank market, and for this reason banks have a great incentive to monitor each other (Furfine 2001). We further argue that personal connections can alleviate the information asymmetry and hence enhance lending relationship. In our empirical analysis we expect that the CEOs with more personal connections will be willing to lend to other banks as a result of the informational advantages coming from the social networks. The increase in interbank lending will lead to higher systemic risk in the event of market failure.

3 Sample and Data

Our sample begins with publicly traded banks and bank holding companies in the U.S. The Federal Reserve provides a link for banks and bank holding companies using the CRSP PERMCO identifier.[3] The data link includes 1,412 PERMCOs and the names of the banks.[4] We focus on commercial banks and bank holding companies, and this procedure reduces our sample banks to 882. About 92% of the commercial banks in the U.S. are under a holding company name. [5] We obtain data on these banks and other state variables from several sources. We use the BoardEx database to construct the various measures of CEO connections with other banks CEOs. The database provides extensive biographical and relationship information of board members and top management in notable private and public global companies including banks. We obtain accounting information from Bankfocus, Compustat, CRSP-Compustat merged and market information from CRSP. We supplement the above-mentioned data with other data from Bloomberg, Federal Reserve Bank, and World Development Indicators (WDI).

The BoardEx database has a unique company ID, ticker, ISIN, CIK for all listed firms. We use the bank PERMCOs to obtain their ticker from CRSP and merged these data using ticker. We also confirm the merging with the CIK and some manual matching using the bank names. Our final sample consists of 9,548 firm-year observations for 991 unique CEOs at 563 unique banks over the period 2000 to 2018.

[3] The New York Fed data set documents historical linkages between regulatory entity codes and Center for Research in Security Prices (CRSP) PERMCOs for publicly traded banks and bank holding companies. Useful for researchers conducting academic research involving commercial banks.

[4] For more details on the CRSP-FRB link "Federal Reserve Bank of New York. 2017. *CRSP-FRB Link*."

[5] List of larger commercial banks, their Holding company name and consolidated asset can be found on the Federal reserve website https://www.federalreserve.gov/releases/lbr/current/default.htm

3.1 Variable Definition

3.1.1 CEO Network Connections

Using the biographical information of CEOs of publicly traded banks in U.S, we measure the connections among CEOs of the various banks as the total number of other banks CEOs with whom a CEO shares common employment, educational or social history in BoardEx. We define three (3) forms of social network that represent the connections among CEOs as follows; (1) Employment Connection: Two CEOs are socially connected through employment networks if they both worked in the same company (private or public) or sit together either in the top management team or on board of directors before or during that year. (2) Education Connection: Two CEOs are socially connected through education if both CEOs attended the same school and graduated within two years of each other. (3) Social connection: Two CEOs are socially connected through their social activities if they share same membership in clubs, charities and non-for-profit organizations.

In our main results, we focus on CEO employment connections and use the CEO total connections (thus employment, education and social connections) as robustness check in our additional analysis. For all types of connections, once a CEO establishes connection with another CEO, this connection continues into the future. This implies that the number of connections does not decrease over time but rather the network is monotonically larger over time.

3.1.2 CEO Network Centrality

We also construct series network centrality measures which includes betweenness, closeness, degree and eigenvector centrality. The centrality measures are such that, they can capture how each CEO is positioned in the whole network and how much information even flows through each CEO. We use the CEO employment connections to construct the centrality measure. Considering the CEO employment connections, each year we construct *nXn* unweighted adjacency matrix (where n is the total number of CEOs in the network of CEOs) which takes a dummy value 1 if CEO_i and CEO_j are connected and 0 otherwise. Following Hochberg *et al.* (2007), Larcker *et al.* (2013) and Houston *et al.* (2018), we construct the following four measures of CEO network centrality.

Degree: The degree centrality computes the number of other CEOs in which a CEO_i shares a first-degree connection. Let $D_{i,j}$ denotes that CEO_i and CEO_j are connected. We normalize the degree centrality by dividing by $n-1$, where n is the total number of CEOs in the network. Formally, degree centrality of CEO_i is defined as

$$Degree_i = \frac{1}{n-1} \sum_{i \neq j} D_{i,j}$$

Closeness: The closeness centrality computes the inverse of the average length of shortest path that two CEOs lies on. Let $L_{i,j}$ indicates the number of steps in the shortest path between CEO_i and CEO_j. Formally, closeness centrality of CEO_i is defined as

$$Closeness_i = \frac{n-1}{\sum_{j \neq i} L_{i,j}}$$

Betweenness: Betweenness centrality captures the frequency in which a given CEO lies on the shortest path between all sets of possible CEO pairs within the sample of networks. This centrality measure determines the extent of the importance of a given node in a whole network. Let $T_{i,j}$ indicates the total number of shortest paths from CEO_i to CEO_j and $T_{i,j}(k)$ is the number of those paths that pass through CEO_k. We use normalized values of the betweenness centrality. Formally, betweenness centrality of CEO_k is defined as

$$Betweenness_k = \sum_{i,j:i \neq j, k \notin i,j} \frac{T_{i,j}(k)/T_{i,j}}{((n-1) * (n-2)/2)}$$

Eigenvector: Eigenvector centrality assigns high values to those CEOs that have many links to other important CEOs that are central within the network system. The eigenvector centrality of a given CEO depends on the centrality of other important CEOs in the network. The computation of eigenvector centrality involves more mathematical and require computation of eigen values. For more details on the computation refer to Bonacich (1987).

3.1.3 Measures of Systemic risk

We adopt SRISK proposed by Acharya *et al.* (2012a) and Brownlees and Engle (2017) and $\Delta CoVaR$ proposed by Adrian and Brunnermeier (2016) as proxies for systemic risk. These measures are used in the literature and are recognized measures of systemic risk (Laeven *et al.* 2016; Cai *et al.* 2018; Houston *et al.* 2018). Adrian and Brunnermeier (2016)'s $\Delta CoVaR$ is the difference between the value at risk of the financial system conditional on an institution being under distress and the value at risk of the financial system conditional on an institution operating in its median state. According to Acharya *et al.* (2012a) and Brownlees and Engle (2017), SRISK estimates the capital shortfall of a financial institution conditional on a systemic event.

More specifically, SRISK is defined as

$$SRISK_{it} = kD_{it} - (1-k)W_{it}(1 - LRMES_{it})$$
$$= W_{it}[kLVG_{it} + (1-k)LRMES_{it} - 1] \quad (1)$$

Where $SRISK_{it}$ is the systemic risk of bank *i* at time *t*, *k* is the prudential capital fraction, D_{it} is the book value of debt, W_{it} is the market value of equity, LVG_{it} denotes the quasi-leverage ratio $(D_{it} + W_{it})/W_{it}$ and $LRMES_{it}$ is Long Run Marginal Expected Shortfall of the firm equity multi-period arithmetic return conditional on the systemic event, that is

$$LRMES_{it} = -E_t(R_{i\,t+1:\,t+h} | R_{m\,t+1:t+h} < C) \quad (2)$$

where $R_{i\,t+1:t+h}$ is the multi period arithmetic bank return between period t+1 and t+h, $R_{m\,t+1:t+h}$ is the multi period arithmetic market return between period t+1 and t+h, C is the threshold of the decline in market index, We denote systemic event as $\{R_{m\,t+1:t+h} < C\}$. Following Acharya *et al.* (2012a), we set prudential capital fraction k to 8%, threshold C to -40% and horizon *h* to six months (that is 180 days).

The second measure of systemic risk is $\Delta CoVaR$. The measure of $\Delta CoVaR$ follows Adrian and Brunnermeier (2016). $\Delta CoVaR$ as defined earlier is the difference between the Value at Risk (VaR) of the banking sector conditional on an individual bank being in distress and the Value at Risk of the banking sector conditional on this bank operating in its median state. Formally, the Value at Risk of the banking system conditional upon bank-*i* performing at its worst q% quantile ($CoVaR_q^{system|i}$) is defined as

$$Pr\left(X^{system}\right| \leq CoVaR_q^{system|i} \left|X^i = VaR_q^i \right) = q$$

Where X^{system} is the asset-level return of the banking system, X^i is the asset-level return of bank-*i* and VaR_q^i is the Value at Risk of bank-*i* at the q% quantile. Similarly, the Value at Risk of the banking system conditional upon bank-*i* performing at its median state ($CoVaR_q^{system|i,median}$) is defined as

$$Pr\left(X^{system}\right| \leq CoVaR_q^{system|i,median} \left|X^i = VaR_{median}^i \right) = q$$

Therefore, bank-*i*'s contribution to systemic risk is defined as

$$\Delta CoVaR_q^i = CoVaR_q^{system|i} - CoVaR_q^{system|i,median}$$

In order to compute $\Delta CoVaR$ over time and capture the variations in the $\Delta CoVaR$, we follow Adrian and Brunnermeier (2016) and control for a number of state variables. The state variables include interest rate risk (proxy for change in the three-month Treasury bill rate), term spread change (measured as yield spread between ten-year Treasury rate and three-month Treasury bill rate), liquidity risk (measured as the difference between the three-month LIBOR rate and the three-month bill rate, default risk (measured as change in the credit spread between Baa-rated corporate bonds and the ten-year Treasury rate), weekly market return computed from the S&P 500 and equity volatility (computed as the 60-day rolling standard deviation of the daily CRSP market value-weighted index return.[6] In our empirical analysis, we take the negative value of $\Delta CoVaR$ to translate it into increasing measure of systemic risk. We provide details of the implementation of SRISK and $\Delta CoVaR$ in appendix B and C.

[6] Three-month Treasury bill rate, ten-year Treasury rate is from Federal Reserve Board's H.15 release, three-month LIBOR rate is obtained from Bloomberg, Baa-rated corporate bonds is from Moody's, Moody's Seasoned Baa Corporate Bond Yield [DBAA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DBAA.

3.2 Variables and Descriptive Statistics

3.2.1 CEO Connections and CEO-level control variables

Table 1 presents the summary statistics of the variables employed in the study. Specifically, Panel A provides summary statistics of the CEOs, banks and macroeconomic level variables.

Table 1

On average, a CEO has 6 total connections. Of these, 4 are CEOs he or she knows from employment and at least one connection through shared educational histories and social clubs or non-for-profit organizations. Panel A of Table A1 in appendix A provides list of top 10 most connected CEOs in sample banks based on employment history (Panel B and C of same table provide list of the top 10 connected CEOs in sample banks as at 2006 and 2010 respectively). In addition to the CEO connection measures, we employ the measures of CEO network centrality which include degree, closeness, betweenness and eigenvector centralities. The degree, closeness, betweenness and eigenvector centralities has mean values of 0.003, 0.002, 0.002 and 0.014 respectively. We provide a graphical representation of CEO betweenness centrality within the sample banks in 2000 and 2018 in Fig. 2 and 3 respectively. In this graph, the node size is increasing in CEO's betweenness centrality. Fig. 4 shows how CEO network centralities varies overtime from 2000 to 2018.

To control for CEO characteristics, our regressions include CEO age, CEO tenure, Chair-CEO and Founder-CEO. We measure CEO age as the chief executive officer age measured in years, CEO tenure is the number of years for which the CEO has been in office, Chair-CEO is a dummy variable which is equal to 1 if the CEO serves as board chair during his position as CEO of the bank or zero otherwise, Founder-CEO is a dummy variable which is equal to 1 if the CEO was a founder or co-founder of the bank or 0 otherwise, and the average CEO age is 60 years and a CEO can serve his or her tenure for an average of 8years. Engelberg *et al.* (2013) examine 2700 CEOs of large public companies and find that on average a CEO's tenure and age are 7 years and 56 years respectively. On average 28% of the CEOs also served as the board's chair and only 2% were CEOs and at the same time founders (or co-founder). Faleye *et al.* (2014) analyze 2366 CEOs of firms in S&P 1500 indexes and show that on average 66% of the CEO also serve as board chair while 10% of the CEOs were also founders (or co-founder) of the company.

3.2.2 Systemic risk, Bank-level, Macroeconomic and State variables

The Table 1 again report summary statistics of the two measures of systemic risk. The average value of SRISK is US$ 13.03 billion and a 25th percentile of US$ -0.39 billion. The average SRISK is higher than the value reported in Laeven *et al.* (2016) who find average US$ 5.08 billion for 412 banks in 56 countries over the period July 1, 2007 to December 31, 2008. The average $\Delta CoVaR$ for our sample banks is 0.76% which is a little lower than the value 1.17% as reported by Adrian and Brunnermeier (2016). The differences may be due to different sample size and study period (1986Q1 – 2010Q4) and the fact that Adrian and Brunnermeier (2016) report weekly percent. Higher values of systemic risk indicate higher systemic risk contribution. Value at Risk (VaR) is obtained by running 5 percent quantile regression of asset level returns on the one-week lag of the state variables and by computing the predicted value of the regression. The VaR is the individual bank risk measure with an average value of -7.03% and standard deviation of 2.23%.

Laeven *et al.* (2016) argue that larger financial institutions contribute more to systemic risk because they are likely to enjoy Too-big-to-fail subsidies in the event of failure. Adrian and Brunnermeier (2016) reveal that higher leverage, larger size and higher asset valuation predict higher $\Delta CoVaR$. Therefore, we control for bank characteristics such as bank size, growth opportunities, deposit-asset ratio and leverage. The average bank size which we proxy by total asset for the sample is US$ 29.29 billion. Market-to-book ratio, which represents growth opportunities, is ratio of market value to book value of equity and has a mean value of 1.41 and standard deviation of 0.87. The deposit-to-asset ratio is the ratio of deposit to total asset and has a mean value of 75%. Leverage, which is the ratio of the book value of total asset to the book value of total equity, has a mean value of 10.48. This findings is close to Houston *et al.* (2018) who find average market to book ratio and leverage of 1.99 and 21.15 respectively for a sample of 99 largest banks in BoardEx. In addition, we control for stock return and volatility. Volatility, which is the annualized daily standard deviation of bank equity returns over trading days in the year window has an average value of 2.46% and standard deviation of 1.95%. Return is the annual equity returns with an average value of -0.52%. Interbank loan, which is the ratio of net interbank loan and deposit to total asset has an average value of 0.03 and standard deviation of

0.05. We also provide summary statistics of the macroeconomic variables employed. GDP growth rate has an average value of 2.07%.

In panel B, we present the summary statistics of state variables as described in Adrian and Brunnermeier (2016). Market return is the return computed from S&P 500 index. The average market return is -0.006%. The equity volatility is the 60-day rolling standard deviation of the daily CRSP market value-weighted index return. We find that on average equity volatility is 1.05% with standard deviation of 0.44%. As a proxy for interest rate risk, we employ the change in the three-month Treasury bill rate. The average interest rate risk 3.28%. The term spread change is proxied by the change in the slope of the yield curve and is measured as the spread between ten-year Treasury rate and three-month Treasury bill rate. The average term spread change is 1.90%. Liquidity risk is captured using the difference between the three-month LIBOR rate and the three-month bill rate and has an average of 0.44%. Default risk is proxied by the change in the credit spread between Baa-rated corporate bonds and the ten-year Treasury rate. The average default risk is 0.06% with a standard deviation of 0.75%.

3.2.3 Pairwise correlation across different CEO Centrality and Employment Connections

Table 2 presents the pairwise correlation across different CEO network centralities and CEO Employment connections. The table shows that our measures CEO network centrality and CEO Employment connections are positively correlated and significant at 1% level. The correlation between degree centrality and betweenness centrality is 73%. There is also a strong and positive correlation between degree centrality and CEO Employment connections.

Table 2

4 Methodology and Main Results

In this section, we present our methodology followed by a discussion of our main empirical results

4.1 Baseline model

There exist linkages among banks through the interbank market and common asset holdings. The interconnection of banks within the financial system makes it possible for small shocks to transmit form one bank to the others. Gai and Kapadia (2010) demonstrate that network can generate systemic risk by facilitating the spread of larger shocks. Recent studies also reveal that bank size, leverage, maturity mismatch are determining factors of systemic risk. We consider that a new determining factor, social connections that exist among the CEOs in the banking sector, which can affect banks' contribution to systemic risk. To test this hypothesis, we estimate the following baseline model, controlling for lagged value of CEO- and bank- specific characteristics, macroeconomic and state variables.

$$SR_{i,t} = \alpha + \beta_0 CEO\ Employment\ connections_{j,t-1} + \beta_1 X_{i,t-1} + \beta_2 Y_{j,t-1} + \beta_3 Z_{t-1} + \lambda_i + \delta_t + \varepsilon_{j,t} \quad (1)$$

Where $SR_{i,t}$ is the proxy for systemic risk measure of bank i at year t. We employ SRISK and $\Delta CoVaR$ as measures of banks' contribution to the systemic risk. CEO Employment connections is the natural logarithm of 1 plus the number of other CEOs with whom a CEO shares common employment history. $X_{i,t-1}$ is a set of bank level controls. $Y_{i,t}$ is a set of CEO level controls. Z_t is the set of macroeconomic and state variables. We include bank fixed effects λ_i and year fixed effects δ_t to control for time-invariant bank level heterogeneity and macroeconomic shocks that affect all banks in a given year. In all regressions, we cluster the standard errors at the CEO level.

4.2 Endogeneity Issues

A primary concern is whether the regression result is attributable to reverse causality and omitted variable. For example, a bank with higher contribution to systemic risk may hire a CEO with large network in order to help the bank reduce the risk of bankruptcy. In this case, the main regression may show a positive relation between systemic risk and connections, even though this would be because banks with higher contribution to systemic risk hire CEOs with more connection. The type of reverse causality problem has been addressed in prior studies by regressing the dependent variable on lagged values of the explanatory variables (Faleye 2007; Cheng 2008). In all our regression estimation, we use one-year lagged of the explanatory variable. In other robustness we employed two-year lagged explanatory variables. We further include bank fixed effect to the main model to control for unobservable time-invariant characteristics that may affect systemic risk.

4.2.1 **Instrumental Variable Regression**

Our baseline model could just indicate that a correlation may exist between systemic risk and CEO employment connections. In order to further address such issues, we estimate instrumental variable two-stage least squares (2SLS) regressions to address other potential endogeneity arising from unobservable heterogeneity. For instance, other factors such as executive MBA education pursued by the CEO could influence his or her board positions and other related jobs since such programs serves as a platform for social networking. Basically, we suspect that our main independent variable may be endogenous. We employ three instrumental variables in our regression. Following previous studies, our first instrument is two-year lagged of the main independent variable, CEO employment connections. We use this instrument because our results maybe be influenced by the current position of the CEO rather than the CEO personal connections. Using the death of a CEO as a shock to the CEO network connections, we are able to obtain another instrument. We believe that a CEO connected to another CEO who passed on can have his or her network connections affected. In this case, our second instrument is death dummy which is a dummy variable indicating whether a CEO is connected to another CEO who passed on over the sample period. We exclude all CEOs who passed on from the observation. The number of CEOs affected by the death of other CEOs (Treatment group) were 53 (with 299 bank-year observations). Also, the control group has 921 CEOs (with 8719 bank-year observations). The death dummy takes a value equal 1 if CEO is affected by the death of other CEOs and 0 otherwise. Our last instrumental variable is binary variable indicating whether the CEO earned the MBA degree in addition to a degree obtained. In order for our instrument to be valid, it should satisfy both the relevance and exclusion condition. This implies the partial correlation between the instrument and the endogenous variable not be zero and the instruments are exogenous. The basic rule concerning the validity of the instrument chosen here is that the instrument can influence the dependent variables through its effect on the variable we believe may be endogenous. We test the relevance condition with a test of the joint null hypothesis that the coefficients are equal to zero (0). Our joint test is significant in the first-stage regression predicting the CEO employment connections.

4.2.2 **Difference-in-Differences Analysis**

We use a difference-in-differences estimation to further explore the causal relationship between CEO employment connections and systemic risk. The death of a CEO which serves as exogenous shock to the network connections within the banking sector allows us to conduct a difference-in-differences analysis. The analysis compares CEOs whose network were affected by the death of a connected CEO with those unaffected CEOs. There were 50 CEO death recorded over our sample period. We define our treated group as the number of CEOs affected by the death of a connected CEO (in other words CEOs who were connected to other CEOs who passed on) and the control group as the CEOs who were not connected to other CEOs who passed on. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. We exclude all CEOs who passed on from the observation. The number of CEOs affected by the death of other CEOs (Treated group) were 53 (with 299 bank-year observations) and a control group of 921 CEOs (with 8719 bank-year observations).

Next, we use one-to-one propensity score-matching algorithm without replacement based on the banks' total asset and leverage to define the control group of CEOs. This procedure reduces our observation to 598. Using the matching algorithm, we employ in the regression 53 treated CEOs (with 299 bank-year observations) and 172 control CEOs (with 299 bank-year observations).

4.2.3 **Propensity Score Matching - Average treatment effect**

We estimate the Average treatment effect on the treated using stratification matching and report the Average Treatment Effect on the Treated (ATET) for the outcome of interest, interaction of Treated and Post (Treated x Post). We use the death of a CEO as an exogenous shock. Our treated is therefore a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on over the sample period and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. We exclude all CEOs who passed on from the observation. The number of CEOs affected by the death of other CEOs (Treated group) were 53 (with 299 bank-year observations). Also, the control group has 921 CEOs (with 8719 bank-year observations).

4.3 Main Results - CEO Employment Connections and Systemic Risk

Table 3 reports the regression results of the effect of CEO Employment connections on banks' contribution to systemic risk. Panel A of Table 3 reports the results on the effect of CEO Employment connections on SRISK. In all columns of Panel A, we examine the effect of CEO Employment connections on SRISK, controlling for the control variables. All explanatory variables are one-year lagged. CEO Employment connections is the natural logarithm of 1 plus the number of other bank CEOs with whom a CEO shares common employment history. We also include year fixed effects to control for common fluctuations in banks' contribution to systemic risk over time, bank fixed effects to control for bank differences in the level of systemic risk contribution. Finally, we correct standard errors for CEO-level clustering. We provide evidence that CEO Employment connections increases with banks' contribution to systemic risk. The coefficient of CEO employment connections is 8.98, which is significant at the 5% level. The coefficient of CEO employment connections with other banks suggests that a one-percent increase in employment connections may increase SRISK by 0.69 (8.978/13.028) percentage points. Columns (3) and (4) of Panel A show similar significant results after controlling for macroeconomic variables. The coefficient of CEO-chair is negative and statistically significant at 5% level. This shows that CEOs who were also board chair reduces SRISK. The coefficient of Founder-CEO is positive but insignificant.

In all columns of Panel A in Table 3, we examine other determinants of SRISK as indicated in the literature. We find that bank size is strongly associated with SRISK and statistically significant at 1% level. In column (4), the coefficient of Bank size is 15.6, which is statistically significant. The coefficient of Bank size suggests that a one-percent increase in total asset may increase SRISK by 1.18 (15.60/13.028) percentage points. This result is consistent with Laeven *et al.* (2016) who find that bank size is associated with SRISK with similar economic magnitude. The coefficient for market-book ratio is negative and insignificant. We also find that GDP growth reduces SRISK and is statistically significant at the 1% level

Table 3

In Panel B of Table 3 we employ the second measure of systemic risk, $\Delta CoVaR$. Both SRISK and $\Delta CoVaR$ captures systemic risk in different ways. According to Brownlees and Engle (2017), Adrian and Brunnermeier (2016)'s $CoVaR$ links systemic risk contribution of a bank with the increase in VaR of the entire financial system associated with that financial entity being under distressed. SRISK combines both market and balance sheet information in order to construct market based measure of financial distress, which is the expected capital shortfall of a bank conditional on a systemic event (Brownlees & Engle 2017) . Panel B of Table 3 reports the results on the effect of CEO Employment connections on $\Delta CoVaR$. In all columns of Panel B, we examine the effect of CEO Employment connections on $\Delta CoVaR$, controlling for the control variables. All explanatory variables are one-year lagged. The coefficient of CEO employment connections is 0.008, which is significant at the 1% level. The coefficient of CEO employment connections with other banks suggests that a one-percent increase in employment connection may increase $\Delta CoVaR$ by 0.01 percentage points. The coefficient of CEO tenure is positive and statistically significant at 1% level. This suggests that CEOs who have longer years of tenure contribute more to systemic risk. The coefficient of CEO-chair is negative and statistically significant at 1% level. The result shows that CEOs who were board chair reduce $\Delta CoVaR$. As expected and consistent with previous studies, the coefficient of the VaR is positive and statistically significant at 1% level. VaR measures individual bank risk. This result suggest that higher individual bank risk is associated with higher systemic risk. The result is consistent with Adrian and Brunnermeier (2016), who find that VaR is positively associated with $\Delta CoVaR$. The coefficient of the state variables are all statistically significant at 1% level. Specifically, higher equity volatility is associated with higher $\Delta CoVaR$. We also find that leverage is negatively associated with $\Delta CoVaR$ and significant at 1% level. Our findings for leverage is similar with Houston *et al.* (2018), however our result is relatively statistically significant.

In columns (3) of Panel B in Table 3, we examine other determinants of $\Delta CoVaR$. We find that bank size is strongly associated with $\Delta CoVaR$. The coefficient of Bank size is 0.044, which is significant at the 1% level. The coefficient of Bank size suggests that a one-percent increase in total asset may increase $\Delta CoVaR$ by 0.06 percentage points. This result is consistent with Adrian and Brunnermeier (2016) who find that size is associated with $\Delta CoVaR$.

4.4 2SLS Regression, Difference-in-Differences Estimation and Propensity Score Matching

Panel A of Table 4 reports the 2SLS regression results on the effect of predicted CEO Employment connections (from the first stage regression) on SRISK. In all columns of Panel A, we examine the effect of predicted CEO Employment connections on SRISK. All explanatory variables are one-year lagged. The coefficient of predicted CEO employment connections is 10.49, which is significant at the 5% level. The coefficient of predicted CEO employment connections suggests that a one-percent increase in employment connection may increase SRISK by 0.81 (10.49/13.028) percentage points. The result is consistent with the results in the main regression in Table 3 after controlling for the set of control variables.

Table 4

Panel B of Table 4 reports the 2SLS regression results on the effect of predicted CEO Employment connections (from the first stage regression) on $\Delta CoVaR$. In all columns of Panel B, we examined the effect of predicted CEO Employment connections on $\Delta CoVaR$. All explanatory variables are one-year lagged. The coefficient of predicted CEO employment connections is 0.008, which is significant at the 1% level. The coefficient of predicted CEO employment connections with other banks suggests that a one-percent increase in employment connection may increase $\Delta CoVaR$ by 0.01 percentage points. The result is consistent with the result in the main regression in Table 3 after controlling for the set of control variables.

Table 5

Table 5 presents the regression results for difference-in-differences estimation, propensity score matching and set of placebo test. In Panel A of Table 5, we conduct the difference-in-difference analysis. We examine the effect of the interaction of Treated and Post on systemic risk using the matched sample. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on over the sample period and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. All explanatory variables are one-year lagged except treated and post. The coefficient of the interaction of Treated and Post is negative and significant at 5% level. The results show that, systemic risk may be reduce for banks affected by the death of a connected CEO after the death of the connected CEO. The coefficient of Treated is positive and statistically significant. The results suggest that, banks affected by the death of connected CEOs contributes to systemic risk. However, banks affected by the death of a connected CEO contribute less to systemic risk after the death of the connected CEO. We include the set of all controls and the results remains robust.

In Panel B of Table 5, we estimate the average treated effect on the treated. Before estimating the ATET, we first estimate the propensity score (pscore) of the Treated x Post on a set of variables; bank size, leverage, and returns over each year. Panel B of Table 5 presents the results of the effect of the interaction of Treated and Post on systemic risk using the matched sample. The coefficient of the 'Treated x Post' is negative and significant at 1% level. The result indicate that banks with CEOs affected by the death of a connected CEO contribute less to systemic risk after the death of the connected CEO. The result is similar and statistically significant using radius matching and controlling for the set of controls.

In Panel C and D of Table 5, we further conduct placebo test. In Panel C of Table 5, we assume that the CEO passed on a year before the actual date of death. The result is insignificant. In Panel B of Table 5, we conduct another placebo test by randomly assigning the treatment and control groups from the sample CEOs. The result still remains insignificant.

5 Potential Channels for facilitating Systemic Risk

In other to evaluate the potential channels through which CEO connections leads to banks' contribution to systemic risk, we focus on interbank lending. As already discussed, the interbank market serves as a platform where liquidity flows from banks with excess liquidity to liquidity needy banks (Acharya *et al.* 2012b). We expect that personal connections can mitigate the information asymmetry and hence improve lending relationship. To test this hypothesis, we estimate the following baseline model, controlling for lagged value of CEO- and bank- specific characteristics.

$$Interbank\ loan_{i,t} = \alpha + \beta_0 CEO\ Employment\ connecttion_{j,t-1} + \beta_1 X_{i,t-1} + \beta_2 Y_{j,t-1} + \lambda_i + \varepsilon_{j,t} \quad (2)$$

Where $CEO\ Employment\ connecttion_{j,t-1}$ is the natural logarithm of 1 plus the number of other bank CEOs with whom a CEO shares common employment history. $Interbank\ loan_{i,t}$ is the ratio of net interbank loan and deposit to total asset. $X_{i,t-1}$ is a set of bank level control variables. $Y_{i,t}$ is a set of CEO level control variables. We include bank fixed effects λ_i to control for bank level heterogeneity.

5.1 Interbank Market and CEO Employment Connections

Panel A of Table 6 reports the regression results on the effect of CEO Employment connections on Interbank loan. In all columns of Panel A of Table 6, we examine the effect of CEO Employment connections on Interbank loan. All explanatory variables are one-year lagged. We provide evidence that CEO Employment connections increases with Interbank loan. The coefficient of CEO employment connections is 0.0045, which is significant at the 1% level. The coefficient of CEO employment connections with other banks suggests that a one-percent increase in employment connection may increase Interbank loan by 0.16 (0.0045/0.028) percentage points. This result implies that banks with CEOs who have more employment connections with other banks' CEOs lend more to their peer banks relative to banks with CEOs who have few employment connections. We control for set of control variables but do not report coefficients in the table. The coefficient of CEO age and CEO tenure is positive and statistically significant at 1% level. The coefficient for market-book ratio is negative and significant. We find that volatility is positively associated with Interbank Loan. The coefficient of deposit-asset ratio is positive, which is significant at the 1% level. This result suggests that banks with higher deposit are net lenders in the interbank market.

Table 6

Our results from the regression in Panel A of Table 6 show a correlation exist between Interbank loan, and CEO employment connections and centrality. However, these results could be biased due to omitted variables. In addition to this regression, we estimate the instrumental variable two-stage least squares (2SLS) regression in order to address and mitigate possible endogeneity arising from unobservable heterogeneity.

Using the same instruments as discussed above we report the 2SLS regression results in Panel B of Table 6. In all columns of Panel B of Table 6, we examine the effect of predicted CEO Employment connections (from the first stage regression) on interbank loan. All explanatory variables are one-year lagged. The coefficient of CEO employment connections is positive and significant at the 1% level. This result is consistent with the results in Panel A of Table 6. The result suggests that banks with CEOs who have more employment connections with other banks' CEOs lend more to their peer banks relative to banks with CEOs who have few employment connections.

5.2 Difference-in-Difference Estimator – Interbank Loan

In this section, we use a difference-in-differences estimation to further explore the causal relationship between CEO employment connections and interbank loan. We use the same approach of difference-in-difference estimation in the main regression. The number of CEOs affected by the death of other CEOs (Treated group) were 37 (with 328 bank-year observations) and a control group of 525 CEOs (with 5171 bank-year observations).

Next, we use one-to-one propensity score-matching algorithm without replacement based on the banks' total asset to define the control group of CEOs. This procedure reduces our observation to 598. Using the matching algorithm, we employ in the regression 35 treated CEOs (with 198 bank-year observations) and 123 control CEOs (with 198 bank-year observations).

Table7

Table 7 presents the regression results for difference-in-differences estimation. We examine the effect of the interaction of Treated and Post on interbank loan using the matched sample. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on over the sample period and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. All explanatory variables are one-year lagged except treated and post. The coefficient of the interaction of Treated and Post is negative and significant at 1% level. The results show that, interbank loan may be reduce for banks affected by the death of a connected CEO after the death of the connected CEO. The coefficient of Treated is positive and statistically significant. The results suggest that, banks affected by the death of connected CEOs increase interbank loan. However, banks affected by the death of a connected CEO reduces interbank loan after the death of the connected CEO.

5.3 Interbank Market and Systemic risk

Interbank market can serve as a source of liquidity for banks. However, this market could be a potential source of systemic risk in the event of counterparties default. In this section, we examine the effect of interbank loan on systemic risk. We anticipate that in the event of counterparties default, interbank loan may be associated with systemic risk. Panel A of Table A1 (reported in appendix) presents the regression results for the effect of interbank loan on SRISK. All control variables are one-year lagged. The coefficient of interbank loan is positive and statistically significant at 5% level. The coefficient of interbank loan suggests that a one-percent increase in interbank loan may increase SRISK by 0.11 (1.462/13.028) percentage points.

Panel B of Table A1 (reported in appendix) presents the regression results for the effect of interbank loan on $\Delta CoVaR$. All control variables are one-year lagged. The coefficient of interbank loan is positive and statistically significant at 1% level. The coefficient of interbank loan suggests that a one-percent increase in interbank loan may increase $\Delta CoVaR$ by 0.35 (0.265/0.759) percentage points. Most of the control variables remains statistically significant.

6 Additional Robustness Check

6.1 CEO Total Connections and SRISK

We conduct additional robustness check using CEO total connections. CEO total connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common education, employment history and social activity in BoardEx.

Table 8

Table 8 reports the regression results on the effect of CEO total connections on banks' contribution to systemic risk. In all columns of Panel A of Table 8, we examine the effect of CEO total connections on SRISK, controlling for control variables. All control variables are two-year lagged. We also include year fixed effects to control for common fluctuations in banks' contribution to systemic risk over time, bank fixed effects to control for bank differences in the level of systemic risk contribution. Finally, we correct standard errors for CEO-level clustering. Our results reveal that CEO total connections increase with SRISK. The coefficient of CEO total connections is 8.97, which is significant at the 5% level. The coefficient of CEO total connections with other banks suggests that a one-percent increase in total connection may increase SRISK by 0.69 (8.97/13.028) percentage points. The coefficient of CEO-chair remains negative and statistically significant. This shows that CEOs who were board chair reduces SRISK. The coefficient of Founder-CEO is positive but not significant.

We also examine other determinants of systemic risk. The results show that bank size is strongly associated with SRISK. In column (2) - (4) of Panel A of Table 8, the coefficient of Bank size is positive, which is significant at the 1% level. The coefficient of Bank size suggests that a one-percent increase in total asset may increase SRISK by 1.14 (14.91/ 13.028) percentage points. This result is consistent with Laeven *et al.* (2016) who find that bank size is associated with SRISK. The coefficient for market-book ratio is negative and significant.

In Panel B of Table 8, we examine the effect of CEO total connections on $\Delta CoVaR$, controlling for control variables. The coefficient of CEO total connections is positive and significant at the 5% level. The control variable remains statistically significant.

6.2 CEO Network Centrality and Systemic Risk

In this section, we introduce the series of CEO network centrality measures which include closeness, degree, betweenness, eigenvector and principal component score. The centrality measures are able to capture how each CEO is positioned in the banking network, and how much information flows through each CEO. Each of these centrality measures is captured using the employment connections.

Panels C and D of Table 8 reports the regression results on the effect of CEO network centrality on banks' contribution to systemic risk. In Panel C of Table 8, we examine the effect of CEO network centrality on SRISK. CEO network centrality is measured by closeness in column (1), degree in column (2), betweenness in column (3), eigenvector in column (4) and first principal component score in column (5). All explanatory variables are one-year lagged. We also include year fixed effects to control for common fluctuations in banks' contribution to systemic risk over time, bank fixed effects to control for bank differences in the level of systemic risk contribution. Finally, we correct standard errors for CEO-level clustering. Our results show that CEO centrality is positive and statistically significant in all columns except betweenness in column (3). Our results reveal that CEO centrality is positively associated with SRISK. The point estimate of the first principal component of centralities is 0.0076, which is significant at the 5% level. The coefficient of the first principal component of centralities suggests that a one-percent increase in CEO centrality may increase SRISK by 0.58 (0.0076/0.013) percentage points. The positive and statistically significant coefficient of the first principal component of centralities in column (5) suggest that the four centrality dimensions plays a substantial joint common effect on banks' contribution to systemic risk. Most of the control variables are statistically significant.

In Panel D of Table 8, we examine the effect of CEO network centrality on $\Delta CoVaR$. Similarly, CEO network centrality is measured by closeness in column (1), degree in column (2), betweenness in column (3), eigenvector in column (4) and first principal component score in column (5). Our results show that CEO centrality is positive and statistically significant at either 1% or 5% in all columns except betweenness in column (3) where the coefficient is insignificant. Our results confirms that CEO centrality is positively associated with banks' contribution systemic risk. The point estimate of the first principal component of centralities is 0.0036, which is significant at the 1% level. Again, the positive and statistically significant coefficient of the first principal component of centralities in column (5) suggest that the four centrality dimensions plays a substantial joint common effect on banks' contribution to systemic risk. Most of the control variables remain statistically significant but not reported.

6.3 2SLS Regression - CEO Network Centrality and Systemic Risk

Using the same instruments as discussed above we report the 2SLS regression results on the effect of predicted CEO network centrality (from first stage regression) on systemic risk. Panel E of Table 8 reports the 2SLS regression results on the effect of predicted CEO network centrality on SRISK. All explanatory variables are one-year lagged. Our results show that predicted CEO centralities are positive and statistically significant except for the coefficient of predicted betweenness and eigenvector.

Panel F of Table 8 reports the 2SLS regression results on the effect of predicted CEO network centrality on $\Delta CoVaR$. All the explanatory variables are one-year lagged. Our results show that CEO centrality is positive and statistically significant except for the coefficient of predicted betweenness and eigenvector. The coefficient of the first principal component of centralities is 0.002, but insignificant.

6.4 CEO Employment connections and Systemic risk: Excluding SIFI Banks

Our main results is likely to be influenced by large banks within the sample. These banks because of their size and complexity are systemically important in the financial system. According to the Financial Stability Board (FSB), systemically important financial institutions (SIFI) are financial institutions whose distress, because of their size, complexity and systemic interconnectedness, would cause disruption to the financial system as a whole. Due to the complexity and size of these banks, we exclude them from our sample and re-estimate the regression. These banks include JP Morgan Chase, Citigroup, Bank of America, Goldman Sachs, Wells Fargo, Bank of New York Mellon, Morgan Stanley and State Street. We report the results in Table 9

Table 9

In Panel A and B of Table 9, we examine the effect of CEO employment connections on SRISK and $\Delta CoVaR$ respectively. Our finding remains similar and statistically significant. We thus provide evidence that bank's CEO employment connections is positively associated with banks' contribution to systemic risk.

7 Conclusion

A link exists among banks usually through common asset holding and interbank lending relationships. The network within the financial system can generate systemic risk by transmitting the spread of larger shocks. Moreover, the interconnections among these banks can be enhanced through the network connections of their executives. As a principal architect of corporate strategy, the CEO can influence bank's strategic decisions and directions. As a result, we examine the CEO network connections in the U.S. banking sector and how this can affect banks' contribution to systemic risk. We conduct our analysis on a sample of sample of 991 unique CEOs at 563 unique U.S. publicly traded banks over the period 2000 to 2018. Our results suggest that CEO employment connections in the banking sector is an important determining factor of banks' contribution to systemic risk. Our study provide evidence that CEO social network contribute indeed to systemic risk in the banking sector. We further show that CEO centrality is positively associated with systemic risk.

Additionally, we examine how social network among executives in the banking sector serve as important tool in the interbank market. We expect that if there is a large shock to the banking sector that can generate systemic risk, the interbank market would play a role. The interbank market is an informal market that enables banks to borrow funds from and/or lend funds to other banks and so serve as a platform for financial intermediation. We document that banks with CEOs who have more connections to other banks' CEOs lend more to their peer banks relative to other CEOs with few connections. The result further indicates that banks affected by the death of a connected CEO contribute less to systemic risk. This implies that, CEO social network plays key role in the interbank market.

In some instance, CEO social network is a valuable in the interbank market by alleviating the information asymmetry and hence enhance lending relationship. In other ways, these network connections can cause a significant shock to the banking system in the event of market failure. This is evident in our result that CEO connections increases with interbank lending and in effect interbank lending is positively related to systemic risk in the banking sector.

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Table 1: Summary Statistics of CEOs, Banks and Macroeconomic level variables

The sample consists of 9548 bank-year observations for 991 unique CEOs at 563 unique banks. CEO Employment connections is the number CEOs with whom a CEO shares common employment history in BoardEx. Education connections is the number of CEOs with whom a CEO attended the same school and graduated within two years of each other in BoardEx. Social connections is the number of CEOs with who a CEO shares membership in clubs, charities and other non-for-profit organizations. CEO connections is the sum of the Employment connections, Education connections and social connections. Degree, Closeness, betweenness and eigenvector are the measures of CEO network centrality and are defined in section 3. Panel A provide the summary statistics and panel B provides the pairwise correlation across different network centralities. CEO age is the chief executive officer age measured in years. CEO tenure is the number of years for which the CEO has been in office. Chair-CEO is a dummy variable which is equal to 1 if a CEO also serves as board chairman during his position as CEO of the bank or zero otherwise. Founder-CEO is a dummy variable which is equal to 1 if the CEO was a founder or co-founder of the bank or 0 otherwise. SRISK and $\Delta CoVaR$ are proxies for systemic risk contribution of a bank expressed in billions of U.S. dollars and percentage respectively. VaR is the individual bank risk measure expressed in percentage. Bank size is the total asset of the bank in billions of U.S. dollars. Market-book ratio is the ratio of market value to book value of equity. Deposit-Asset ratio is the ratio of deposit to total asset of the bank. Leverage is the ratio of the book value of total asset to the book value of total equity. Volatility is the annualized daily standard deviation of bank equity returns over trading days in the year window expressed in percent. Return is the annual equity returns expressed in percent. Interbank loan is the ratio of net interbank loan and deposit to total asset. GDP growth is the annual percentage growth rate of GDP. Market return is the market return computed from the S&P 500, equity volatility is the 60-day rolling standard deviation of the daily CRSP market value-weighted index return, interest rate risk is the change in the three-month Treasury bill rate, term spread change is measured as spread between ten-year Treasury rate and three-month Treasury bill rate, liquidity risk is measured as the difference between the three-month LIBOR rate and the three-month bill rate, and default risk is measured as the change in the credit spread between Baa-rated corporate bonds and the ten-year Treasury rate. All state variables are the annualized weekly data expressed in percent.

Panel A: Summary Statistics of CEOs, Banks and Macroeconomic level variables

Variables	N	Mean	STD	25th Pctl.	50th Pctl.	75th Pctl.
CEO Connections						
CEO Employment connections	9548	3.205	3.780	1	2	4
CEO Education connections	9548	0.466	0.999	0	0	1
CEO Social connections	9548	1.554	5.175	0	0	0
CEO Total Connections	9548	5.224	7.305	1	3	6
CEO Network Centrality						
Degree	9548	0.003	0.003	0.001	0.002	0.003
Closeness	9548	0.002	0.001	0.001	0.002	0.003
Betweenness	9548	0.002	0.004	0	0	0.002
Eigenvector	9548	0.014	0.078	0	0	0.002
CEO Charateristics						
CEO age	9515	59.653	8.838	54	59	65
CEO tenure	9548	8.200	6.117	4	7	11
Chair-CEO	9548	0.282	0.450	0	0	1
Founder-CEO	9548	0.023	0.151	0	0	0
Bank						
SRISK	9548	13.028	121.989	-0.394	0.063	1.226

ΔCoVaR	9525	0.759	0.227	0.625	0.676	0.828
VaR	9525	-7.033	2.229	-7.569	-6.244	-5.662
Bank size	9546	29.287	166.957	0.808	1.808	6.058
Market-book ratio	9545	1.417	0.867	0.968	1.301	1.748
Deposit-asset ratio	9546	0.751	0.139	0.717	0.782	0.829
Leverage	9546	10.485	41.913	8.688	10.344	12.148
Volatility	9548	2.465	1.954	1.466	1.831	2.717
Returns	9524	-0.524	40.745	-14.015	3.174	20.211
Interbank Loan	5744	0.028	0.047	0.001	0.009	0.034
Macroeconomic						
GDP growth	19	2.067	1.495	1.567	2.250	2.861

Panel B: Summary Statistics of State variables

Variables	N	Mean	STD	25th Pctl.	50th Pctl.	75th Pctl.
Market return	19	-0.006	0.195	-0.067	0.033	0.129
Equity volatility	19	1.048	0.443	0.710	0.872	1.416
Interest rate risk	19	3.276	5.439	0.221	1.692	3.571
Term spread change	19	1.895	1.010	1.141	2.091	2.896
Liquidity risk	19	0.437	0.322	0.209	0.343	0.476
Default risk	19	0.061	0.754	-0.422	-0.022	0.511

Table 2: Pairwise correlation across different CEO Centrality and Employment Connections

Degree, Closeness, betweenness and eigenvector are the measures of CEO network centrality and are defined in section 3.1.2. Table 2 provides the pairwise correlation across different network centralities. * indicates significance at the 1% level.

Variables	Degree	Closeness	Betweenness	Eigenvector	CEO Employment connections
Degree	1.0000				
Closeness	0.4894*	1.0000			
	0.0000				
Betweenness	0.7288*	0.2675*	1.0000		
	0.0000	0.0000			
Eigenvector	0.5654*	0.1219*	0.2850*	1.0000	
	0.0000	0.0000	0.0000		
CEO Employment connections	0.8855*	0.6201*	0.6137*	0.3555*	1.0000
	0.0000	0.0000	0.0000	0.0000	

Table 3: CEO Employment Connections and Systemic Risk

The dependent variables are SRISK and $\Delta CoVaR$. The main explanatory variable is CEO Employment connections. CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Panel A: CEO Employment Connections and SRISK

Dependent Variable	SRISK			
	(1)	(2)	(3)	(4)
CEO Employment Connections	12.04**	9.466**	8.978**	8.978**
	(5.179)	(4.418)	(4.209)	(4.209)
CEO age	1.277	-0.00231	0.0253	-1.631
	(1.079)	(1.284)	(1.315)	(1.344)
CEO tenure	-7.513	-8.061	-8.099	-8.099
	(5.615)	(5.016)	(5.051)	(5.051)
Chair-CEO	-16.01**	-16.40**	-16.38**	-16.38**
	(7.729)	(7.536)	(7.487)	(7.487)
Founder-CEO	17.01	21.96	22.12	22.12
	(15.31)	(14.18)	(14.25)	(14.25)
Market-book ratio		-7.566	-8.043	-8.043
		(4.951)	(5.362)	(5.362)
Bank size		14.69*	15.60**	15.60**
		(7.786)	(7.585)	(7.585)
Deposit-asset ratio		52.54	52.54	52.54
		(48.00)	(48.12)	(48.12)
Leverage		-0.00158	-0.0882	-0.0882
		(0.311)	(0.370)	(0.370)
Volatility			1.456	1.456
			(1.169)	(1.169)
Returns			0.0485	0.0485
			(0.0400)	(0.0400)
GDP growth				-14.74***
				(2.995)
Number of CEOs	912	912	912	912
Bank FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Adj. R^2	0.0238	0.0306	0.0319	0.0319
N	8,510	8,510	8,487	8,487

Panel B: CEO Employment Connections and $\Delta CoVaR$

Dependent Variable	$\Delta CoVaR$		
	(1)	(2)	(3)
CEO Employment Connections	0.00642***	0.00781***	0.00823***
	(0.00203)	(0.00216)	(0.00218)
CEO age	-7.54e-05	5.72e-05	8.20e-05
	(0.000106)	(0.000106)	(0.000108)
CEO tenure	0.00952***	0.00903***	0.00899***
	(0.00154)	(0.00162)	(0.00162)
Chair-CEO	-0.00743**	-0.0101***	-0.0106***
	(0.00340)	(0.00359)	(0.00362)
Founder-CEO	-0.00975	-0.0151	-0.0150
	(0.0155)	(0.0154)	(0.0155)
VaR	1.437***	1.279***	1.328***
	(0.0450)	(0.0441)	(0.0448)
Market return	0.507***	0.507***	0.506***
	(0.00456)	(0.00461)	(0.00454)
Equity volatility	3.829***	3.462***	3.591***
	(0.116)	(0.115)	(0.117)
Interest rate risk	-0.0246***	-0.0254***	-0.0252***
	(0.000211)	(0.000251)	(0.000253)
Term spread change	1.168***	1.045***	1.083***
	(0.0351)	(0.0342)	(0.0347)
Liquidity risk	5.937***	5.333***	5.504***
	(0.168)	(0.165)	(0.167)
Default risk	0.170***	0.184***	0.182***
	(0.00306)	(0.00300)	(0.00302)
Leverage	0.000322	-0.00141***	-0.00161***
	(0.000446)	(0.000432)	(0.000383)
Bank size		0.0435***	0.0417***
		(0.00388)	(0.00385)
Deposit-asset ratio		0.0386	0.0391
		(0.0291)	(0.0291)
Market-book ratio	-0.0599***		
	(0.00424)		
Returns			-0.000226***
			(2.83e-05)
Number of CEOs	911	911	911
Bank FE	YES	YES	YES
R^2	0.819	0.806	0.808
N	8,488	8,488	8,465

Table 4: 2SLS Regression - CEO Employment Connections and Systemic Risk

The dependent variables are SRISK and $\Delta CoVaR$. The main explanatory variable is predicted CEO Employment connections from the first stage regression. CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Panel A: Predicted CEO Employment Connections and SRISK

Dependent Variable	SRISK		
	(1)	(2)	(3)
Predicted CEO Employment Connections	14.29**	10.97**	10.49**
	(6.324)	(5.333)	(5.180)
Controls	YES	YES	YES
Number of CEOs	764	764	764
Bank FE	YES	YES	YES
Year FE	YES	YES	YES
Adj. R^2	0.0263	0.0297	0.0318
N	6,328	6,328	6,328

Panel B: Predicted CEO Employment Connections and $\Delta CoVaR$

Dependent Variable	$\Delta CoVaR$		
	(1)	(2)	(3)
Predicted CEO Employment Connections	0.00794***	0.00624**	0.00631**
	(0.00274)	(0.00312)	(0.00313)
Controls	YES	YES	YES
Number of CEOs	764	764	764
Bank FE	YES	YES	YES
R^2	0.872	0.866	0.866
N	6,298	6,298	6,298

Table 5: Difference-in-Differences Estimation, Propensity Score Matching, Placebo Test

Panel A: Difference-in-Differences Estimation

The dependent variable is SRISK. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged except Treated and Post. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable		SRISK	
	(1)	(2)	(3)
Treated x Post	-4.835*	-5.022*	-6.381**
	(2.749)	(2.793)	(2.755)
Treated	4.589*	4.993*	6.020**
	(2.751)	(2.801)	(2.825)
Controls	YES	YES	YES
Number of CEOs	82	82	82
Year FE	YES	YES	YES
R^2	0.221	0.227	0.196
N	334	334	334

Panel B: Propensity Score Matching (Average Treatment effect on the Treated)

The dependent variable is SRISK. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. *** indicates significance at the 1% level

Variable	SRISK
Treated x Post	-11.24***
	(1.352)
Controls	YES
N	9,018

Panel C: Placebo test: Changing death date

The dependent variable is SRISK. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on and 0 otherwise. Here, we conduct placebo test by changing the death date of a connected CEO to the previous year. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	SRISK		
	(1)	(2)	(3)
Treated x Post	-0.346	-0.380	-0.378
	(0.469)	(0.466)	(0.463)
Controls	YES	YES	YES
Number of CEOs	89	89	89
Bank FE	YES	YES	YES
Year FE	YES	YES	YES
Adj. R^2	0.242	0.244	0.244
N	370	370	370

Panel D: Placebo test: Random assigning of treatment group

The dependent variable is SRISK. We assign the treatment group by generating random variables for the CEOs and grouping them based on their ranking. Treated is equal to 1 if the rank of the CEO is below 400th position and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	SRISK		
	(1)	(2)	(3)
Treated x Post	-9.809	-9.908	-7.716
	(7.321)	(7.143)	(5.270)
Treated	-0.455	-0.532	—
	(4.587)	(4.471)	
Controls	YES	YES	YES
Number of CEOs	865	865	865
Bank FE	NO	NO	YES
Year FE	YES	YES	YES
Adj. R^2/R^2	0.0291	0.0283	0.0341
N	8,007	8,007	8,007

Table 6: Interbank Market and CEO Employment Connections

Panel A: Interbank Loan and CEO Employment Connections

The dependent variable is Interbank loan. The main explanatory variable is CEO Employment connections. CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	Interbank Loan			
	(1)	(2)	(3)	(4)
CEO Employment Connections	0.00448***	0.00299**	0.00202**	0.00208**
	(0.00109)	(0.00118)	(0.000999)	(0.00103)
Controls	YES	YES	YES	YES
Number of CEOs	552	552	552	552
Bank FE	YES	YES	YES	YES
R^2	0.058	0.115	0.106	0.159
N	5,117	5,117	5,106	5,106

Panel B: 2SLS Regression – Interbank Loan and CEO Employment Connections

The dependent variable is Interbank loan. The main explanatory variable is predicted CEO Employment connections from the first stage regression. CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	Interbank Loan			
	(1)	(2)	(3)	(4)
Predicted CEO Employment Connections	0.00743***	0.00339**	0.00352**	0.000431
	(0.00150)	(0.00150)	(0.00145)	(0.00147)
Controls	NO	YES	YES	YES
Number of CEOs	459	459	459	459
Bank FE	YES	YES	YES	YES
R^2	0.0149	0.0489	0.0894	0.162
N	3,985	3,985	3,985	3,985

Table 7: Difference-in-Differences Estimator – Interbank Lending

The dependent variable is Interbank loan. Treated is a dummy variable which is equal to 1 if a CEO is connected to another CEO who passed on and 0 otherwise. Post is a dummy variable which is equal to 1 after the death of a CEO and 0 otherwise. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged except Treated and Post. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	Interbank Loan				
	(1)	(2)	(3)	(4)	(5)
Treated x Post	-0.0572***	-0.0586***	-0.0565***	-0.0602***	-0.0508***
	(0.00479)	(0.00478)	(0.00519)	(0.00462)	(0.00634)
Treated	0.0500***	0.0509***	0.0475***	0.0481***	—
	(0.0103)	(0.0101)	(0.0104)	(0.0108)	
CEO age	0.000723*	0.000719*	0.000660	0.000207	-0.00331
	(0.000424)	(0.000406)	(0.000436)	(0.000432)	(0.00259)
CEO tenure	0.00212	0.00237	0.00267	0.000495	0.00230
	(0.00379)	(0.00386)	(0.00399)	(0.00318)	(0.00553)
Chair-CEO	0.000802	0.000412	-0.000622	-0.00417	-0.00815
	(0.00660)	(0.00634)	(0.00664)	(0.00596)	(0.00833)
Leverage	0.00113	0.000588	0.000734	0.00102	0.00214**
	(0.000907)	(0.000997)	(0.000967)	(0.000914)	(0.00104)
Bank size	-0.000778	0.00107	0.00175	-0.000852	-0.0205
	(0.00271)	(0.00319)	(0.00339)	(0.00293)	(0.0168)
Deposit-asset ratio		0.0630	0.0748*	0.0673*	0.0152
		(0.0385)	(0.0413)	(0.0401)	(0.0549)
Market-book ratio			-0.0142	-0.0181***	-0.0454***
			(0.00949)	(0.00590)	(0.0129)
Volatility	0.00246	0.00268	0.00152	-0.00156	-0.00282
	(0.00369)	(0.00371)	(0.00360)	(0.00204)	(0.00493)
Returns	-0.000155***	-0.000160***	-0.000111**	-7.36e-05*	-2.36e-05
	(4.69e-05)	(4.45e-05)	(4.48e-05)	(4.16e-05)	(5.13e-05)
GDP growth			0.0208	-0.00159	-0.00755
			(0.0133)	(0.00170)	(0.00469)
Number of CEOs	59	59	59	59	59
Bank FE	NO	NO	NO	NO	YES
Year FE	YES	YES	YES	NO	YES
Adj. R^2/R^2	0.282	0.284	0.314	0.257	0.355
N	218	218	218	218	218

Table 8: Robustness Checks

Panel A: CEO Total Connections and SRISK

The dependent variable is SRISK. The main explanatory variable is CEO total connections. CEO total connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common education, employment and social activity in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are two-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	SRISK			
	(1)	(2)	(3)	(4)
CEO Total Connections	8.967**	5.061*	4.832*	7.016*
	(4.556)	(2.650)	(2.554)	(3.975)
CEO age	1.040	0.638	0.636	1.278
	(1.038)	(0.753)	(0.752)	(1.255)
CEO tenure	-7.856	-5.834	-5.756	-8.372
	(5.771)	(3.922)	(3.854)	(5.283)
Chair-CEO	-17.43*	-17.41*	-17.16*	-17.33*
	(10.04)	(9.352)	(9.198)	(9.525)
Founder-CEO	14.56	18.17	18.18	20.19
	(18.28)	(12.74)	(12.60)	(16.83)
Market-book ratio		-8.879*	-10.18*	-8.226
		(5.255)	(6.145)	(6.282)
Bank size		23.48***	24.03***	14.91**
		(6.342)	(6.568)	(6.008)
Deposit-asset ratio		-28.75	-28.24	40.65
		(28.26)	(27.98)	(44.03)
Leverage		0.378	0.320	0.0720
		(0.301)	(0.363)	(0.307)
Volatility			0.977	0.966
			(1.357)	(1.328)
Returns			0.109	0.0988
			(0.0688)	(0.0655)
GDP growth				9.946***
				(2.492)
Number of CEOs	863	863	862	862
Bank FE	YES	NO	NO	YES
Year FE	YES	YES	YES	YES
Adj. R^2/R^2	0.0239	0.0281	0.0306	0.0307
N	7,592	7,592	7,569	7,569

Panel B: CEO Total Connections and $\Delta CoVaR$

The dependent variable is $\Delta CoVaR$. The main explanatory variable is CEO total connections. CEO total connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common education, employment and social activity in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are two-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable		$\Delta CoVaR$	
	(1)	(2)	(3)
CEO Total Connections	0.00343*	0.00388**	0.00430**
	(0.00177)	(0.00185)	(0.00187)
CEO age	-6.51e-05	7.43e-05	9.95e-05
	(0.000107)	(0.000109)	(0.000110)
CEO tenure	0.00925***	0.00864***	0.00860***
	(0.00152)	(0.00161)	(0.00161)
Chair-CEO	-0.00747**	-0.0101***	-0.0106***
	(0.00340)	(0.00357)	(0.00360)
Founder-CEO	-0.00994	-0.0155	-0.0153
	(0.0156)	(0.0153)	(0.0154)
VaR	1.438***	1.279***	1.328***
	(0.0450)	(0.0441)	(0.0448)
Market return	0.507***	0.508***	0.507***
	(0.00461)	(0.00470)	(0.00464)
Equity volatility	3.832***	3.462***	3.590***
	(0.116)	(0.115)	(0.117)
Interest rate risk	-0.0246***	-0.0253***	-0.0251***
	(0.000213)	(0.000255)	(0.000256)
Term spread change	1.169***	1.045***	1.083***
	(0.0351)	(0.0343)	(0.0348)
Liquidity risk	5.942***	5.334***	5.505***
	(0.169)	(0.165)	(0.167)
Default risk	0.170***	0.184***	0.181***
	(0.00306)	(0.00300)	(0.00302)
Leverage	0.000324	-0.00141***	-0.00161***
	(0.000445)	(0.000433)	(0.000385)
Bank size		0.0439***	0.0420***
		(0.00398)	(0.00394)
Deposit-asset ratio		0.0417	0.0419
		(0.0292)	(0.0292)
Market-book ratio	-0.0603***		
	(0.00429)		
Returns			-0.000225***
			(2.83e-05)

Number of CEOs	911	911	911
Bank FE	YES	YES	YES
R^2	0.819	0.806	0.807
N	8,488	8,488	8,465

Panel C: CEO Network Centrality and SRISK

The dependent variable is SRISK.[7] The main independent variables are Closeness in column (1), Degree in column (2), Betweenness in column (3), Eigenvector in column (4), Principal component which is the first principal component score in column (5). CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	SRISK				
	(1)	(2)	(3)	(4)	(5)
Closeness	3.147**				
	(1.598)				
Degree		5.574*			
		(3.368)			
Betweenness			0.502		
			(1.388)		
Eigenvector				0.306*	
				(0.176)	
Principal Component					0.00765**
					(0.00378)
Controls	YES	YES	YES	YES	YES
Number of CEOs	912	912	912	912	912
Bank FE	YES	YES	NO	NO	YES
Year FE	YES	YES	YES	YES	YES
Adj. R^2/R^2	0.0279	0.0379	0.0239	0.0413	0.0335
N	8,487	8,487	8,487	8,487	8,487

[7] SRISK is measured in trillion of U.S. dollars

Panel D: CEO Network Centrality and $\Delta CoVaR$

The dependent variable is $\Delta CoVaR$. The main independent variables are Closeness in column (1), Degree in column (2), Betweenness in column (3), Eigenvector in column (4), Principal component which is the first principal component score in column (5). CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable			$\Delta CoVaR$		
	(1)	(2)	(3)	(4)	(5)
Closeness	6.223***				
	(1.196)				
Degree		1.461***			
		(0.384)			
Betweenness			0.518*		
			(0.286)		
Eigenvector				-0.0130	
				(0.0121)	
Principal Component					0.00357***
					(0.000905)
Controls	YES	YES	YES	YES	YES
Number of CEOs	911	911	911	911	911
Bank FE	YES	YES	YES	YES	YES
R^2	0.803	0.803	0.807	0.807	0.805
N	8,488	8,488	8,465	8,465	8,465

Panel E: 2SLS Regression - CEO Network Centrality and SRISK

The dependent variables is SRSIK.[8] The main independent variables are Predicted Closeness in column (1), Predicted Degree in column (2), Predicted Betweenness in column (3), Predicted Eigenvector in column (4), Predicted Principal component in column (5). CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	SRISK				
	(1)	(2)	(3)	(4)	(5)
Predicted Closeness	5.764**				
	(2.538)				
Predicted Degree		4.641*			
		(2.724)			
Predicted Betweenness			-0.251		
			(1.810)		
Predicted Eigenvector				0.322	
				(0.202)	
Pred. Principal Component					0.0119*
					(0.00619)
Controls	YES	YES	YES	YES	YES
Number of CEOs	764	764	764	764	764
Bank FE	YES	NO	YES	NO	YES
Year FE	YES	YES	YES	YES	YES
Adj. R^2/R^2	0.0287	0.0377	0.0319	0.0376	0.0346
N	6,328	6,328	6,328	6,328	6,328

[8] SRISK is in trillion of U.S. dollar

Panel F: 2SLS Regression - CEO Network Centrality and $\Delta CoVaR$

The dependent variable is $\Delta CoVaR$. The main independent variables are Predicted Closeness in column (1), Predicted Degree in column (2), Predicted Betweenness in column (3), Predicted Eigenvector in column (4), Predicted Principal component in column (5). CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Dependent Variable	$\Delta CoVaR$				
	(1)	(2)	(3)	(4)	(5)
Predicted Closeness	5.642***				
	(1.598)				
Predicted Degree		1.009**			
		(0.479)			
Predicted Betweenness			-0.0428		
			(0.585)		
Predicted Eigenvector				-0.0249	
				(0.0225)	
Pred. Principal Component					0.00197
					(0.00140)
Controls	YES	YES	YES	YES	YES
Number of CEOs	764	764	764	764	764
Bank FE	YES	YES	YES	YES	YES
R^2	0.864	0.864	0.864	0.864	0.864
N	6,298	6,298	6,298	6,298	6,298

Table 9: CEO Employment Connection and Systemic risk: Excluding SIFI Banks

The dependent variables are SRISK and $\Delta CoVaR$. The main explanatory variable is CEO Employment connections. CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are one-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Panel A: CEO Employment Connection and SRISK

Dependent Variable	SRISK			
	(1)	(2)	(3)	(4)
CEO Employment Connections	3.064***	3.117***	2.980*	2.980*
	(1.019)	(0.996)	(1.778)	(1.778)
CEO age	0.0988*	0.0989*	-0.188	-1.104***
	(0.0547)	(0.0538)	(0.190)	(0.233)
CEO tenure	-1.214*	-1.079*	-2.501**	-2.501**
	(0.652)	(0.620)	(1.131)	(1.131)
Chair-CEO	0.839	0.654	0.531	0.531
	(0.849)	(0.843)	(0.996)	(0.996)
Founder-CEO	-2.038	-1.280	-4.892	-4.892
	(4.271)	(4.001)	(7.062)	(7.062)
Market-book ratio		-2.696**	-2.446**	-2.446**
		(1.124)	(1.166)	(1.166)
Bank size			6.591***	6.591***
			(1.900)	(1.900)
Deposit-asset ratio		-12.00**	-4.719	-4.719
		(5.644)	(11.80)	(11.80)
Leverage			0.0443	0.0443
			(0.0549)	(0.0549)
Volatility			0.388***	0.388***
			(0.147)	(0.147)
Returns			-0.00524	-0.00524
			(0.00648)	(0.00648)
GDP growth				-8.151***
				(0.783)
Number of CEOs	898	898	898	898
Bank FE	NO	NO	YES	YES
Year FE	YES	YES	YES	YES
Adj. R^2/R^2	0.0541	0.0669	0.0805	0.0805
N	8,319	8,319	8,296	8,296

Panel B: CEO Employment Connection and $\Delta CoVaR$

Dependent Variable	$\Delta CoVaR$		
	(1)	(2)	(3)
CEO Employment Connections	0.00586***	0.00789***	0.00831***
	(0.00205)	(0.00217)	(0.00219)
CEO age	-6.90e-05	9.00e-05	0.000112
	(0.000107)	(0.000109)	(0.000110)
CEO tenure	0.00943***	0.00880***	0.00879***
	(0.00154)	(0.00163)	(0.00163)
Chair-CEO	-0.00738**	-0.00926**	-0.00967***
	(0.00345)	(0.00368)	(0.00372)
Founder-CEO	-0.00868	-0.0161	-0.0161
	(0.0155)	(0.0154)	(0.0155)
VaR	1.443***	1.275***	1.328***
	(0.0463)	(0.0450)	(0.0458)
Market return	0.507***	0.508***	0.507***
	(0.00464)	(0.00475)	(0.00468)
Equity volatility	3.842***	3.452***	3.589***
	(0.119)	(0.117)	(0.119)
Interest rate risk	-0.0245***	-0.0253***	-0.0251***
	(0.000213)	(0.000259)	(0.000261)
Term spread change	1.173***	1.042***	1.082***
	(0.0361)	(0.0349)	(0.0355)
Liquidity risk	5.960***	5.319***	5.502***
	(0.173)	(0.168)	(0.171)
Default risk	0.170***	0.184***	0.181***
	(0.00314)	(0.00306)	(0.00308)
Leverage	0.000112	-0.00143***	-0.00165***
	(0.000435)	(0.000457)	(0.000401)
Bank size		0.0419***	0.0400***
		(0.00397)	(0.00392)
Deposit-asset ratio		0.0450	0.0454
		(0.0299)	(0.0299)
Market-book ratio	-0.0615***		
	(0.00456)		
Returns			-0.000231***
			(2.89e-05)
Number of CEOs	897	897	897
Bank FE	YES	YES	YES
R^2	0.820	0.807	0.808
N	8,297	8,297	8,274

Fig. 1: CEO Employment connections in Sample Banks and Bank Holding Companies overtime

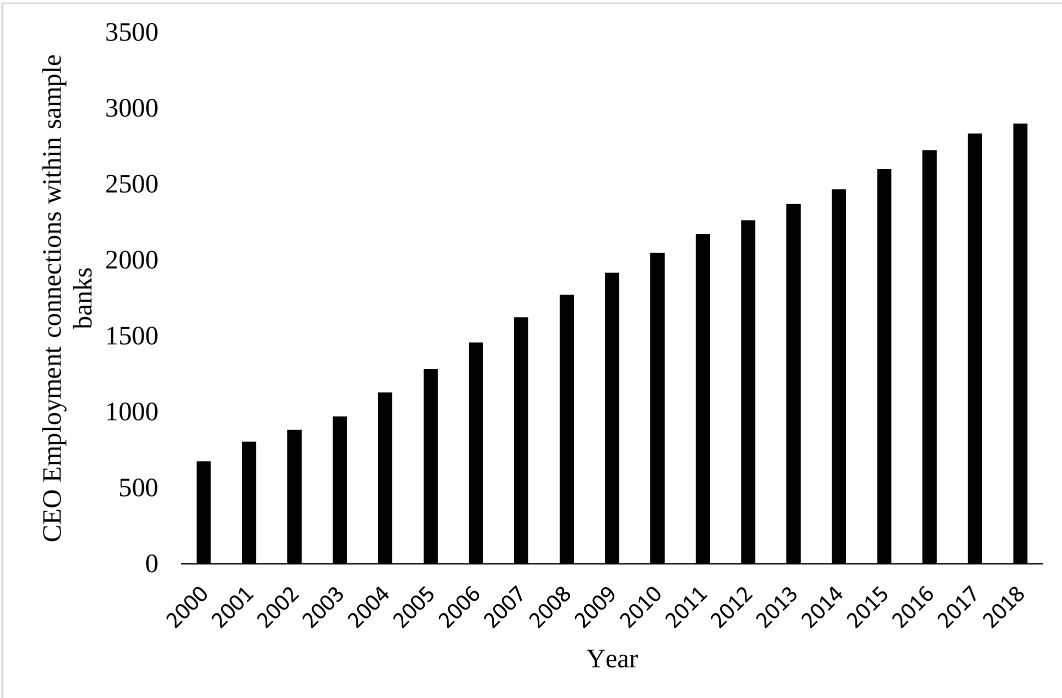


Fig. 2: Betweenness centrality based on CEO employment network within the sample banks as at 2000

The node size is increasing in the CEO's betweenness centrality. CEO betweenness centrality is based CEO employment connections as at 2000.

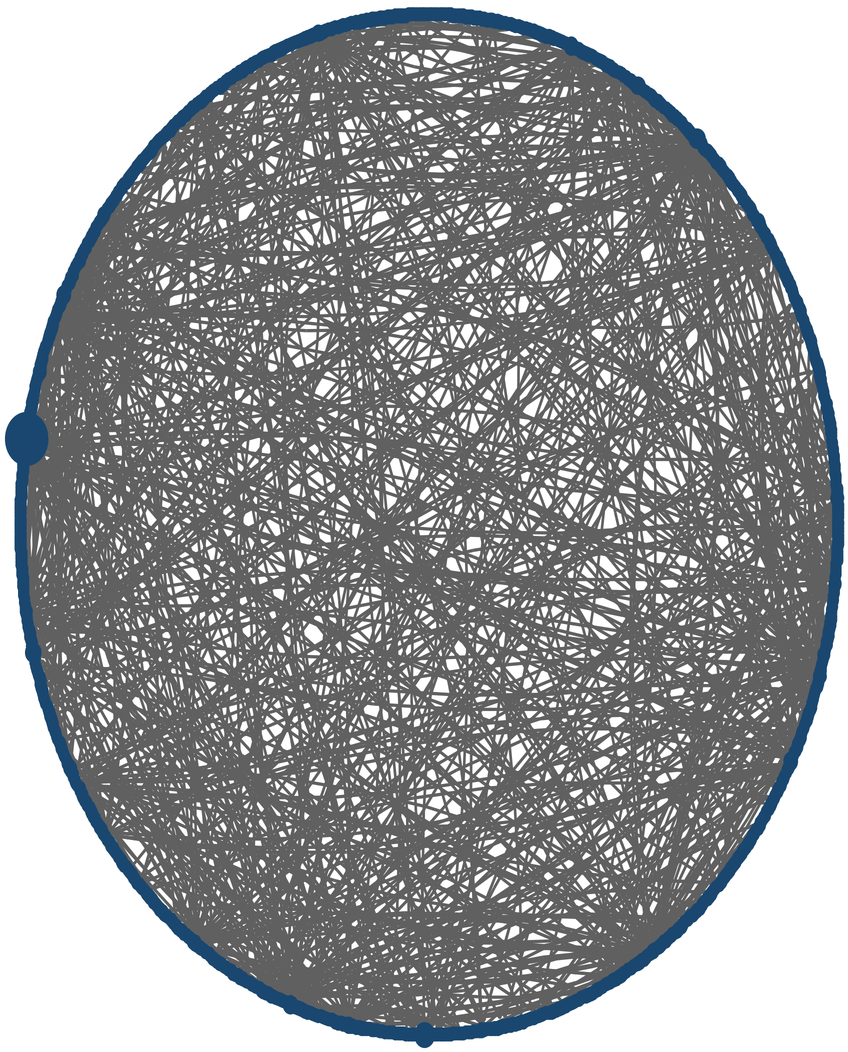


Fig. 3: Betweenness centrality based on CEO employment network within the sample banks as at 2018

The node size is increasing in the CEO's betweenness centrality. CEO betweenness centrality is based CEO employment connections as at 2018.

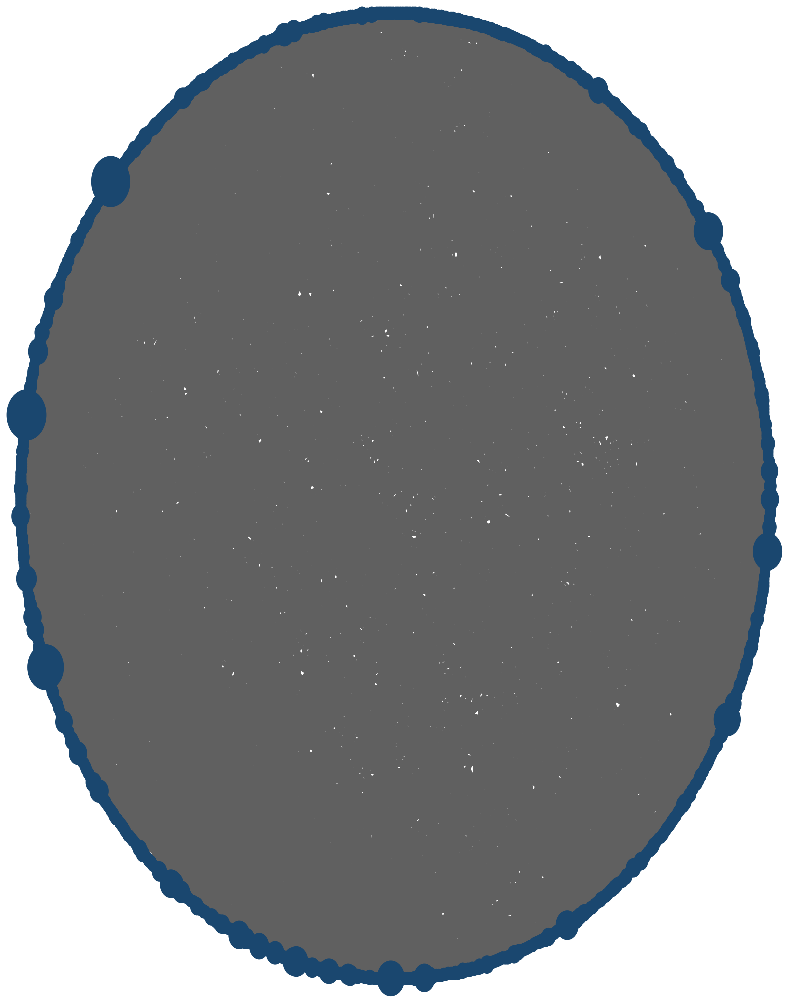
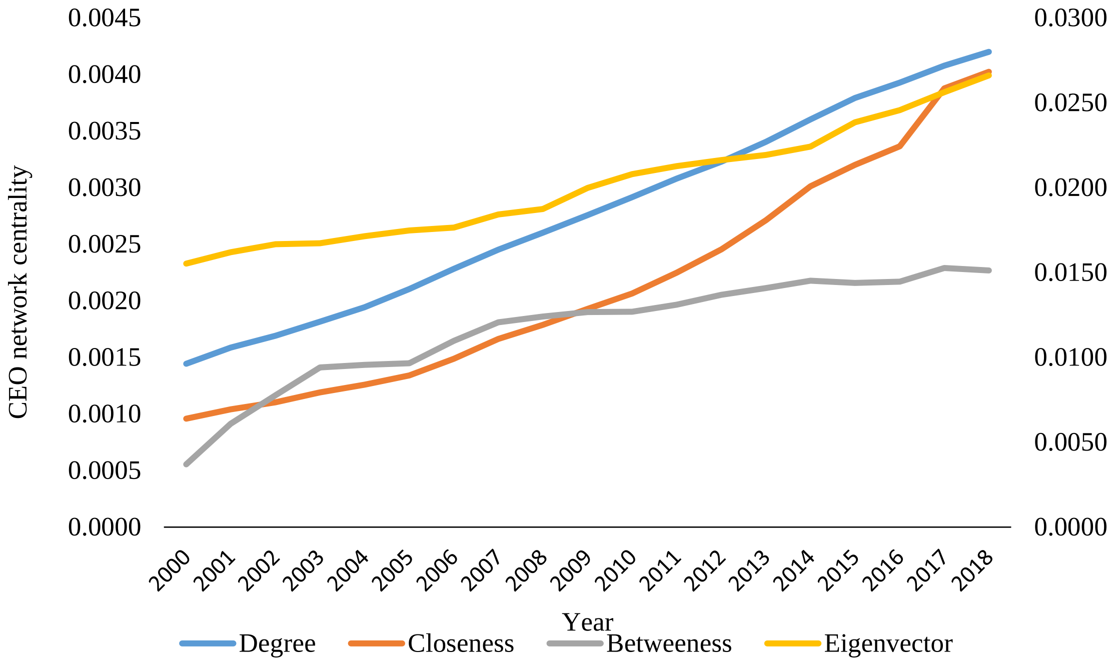


Fig. 4: CEO network centrality overtime (2000 to 2018)



Appendix

Appendix A

Table A1: Interbank Loan and Systemic Risk

The dependent variables are SRISK and $\Delta CoVaR$. The main explanatory variable is interbank loan. Interbank loan is the ratio of net interbank loan and deposit to total asset expressed in percent. CEO employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history in BoardEx. CEO tenure is the natural log of the number of years for which the CEO has been in office. Bank size is the natural logarithm of total asset in millions of U.S. dollars. All other explanatory variables definitions are same as indicated in Table 1. All explanatory variables are two-year lagged. Robust standard errors clustered at CEO level and are shown in brackets. ***, **, * indicate significance at the 1%, 5% and 10% levels respectively.

Panel A: Interbank Loan and SRISK

Dependent Variable	SRISK			
	(1)	(2)	(3)	(4)
Interbank Loan	1.552*	1.462**	0.924*	0.884*
	(0.858)	(0.723)	(0.553)	(0.533)
CEO Employment Connections	17.99**	16.26*	14.56*	14.96*
	(8.942)	(8.324)	(7.724)	(7.938)
CEO age	1.159	-0.186	-0.740	0.176
	(1.382)	(1.948)	(1.684)	(2.129)
CEO tenure	-6.582	-7.327	-7.515	-8.016
	(8.460)	(7.673)	(7.686)	(7.874)
Chair-CEO	-25.25*	-25.06**	-23.61**	-23.96**
	(13.00)	(12.66)	(12.01)	(12.19)
Founder-CEO	27.14	27.06	27.85	31.50
	(23.13)	(20.10)	(19.13)	(21.41)
Bank size		16.34	16.78	12.75
		(13.67)	(13.35)	(14.69)
Market-book ratio			-15.61*	-13.75
			(9.282)	(9.080)
Leverage			-0.960	-1.200
			(0.939)	(0.987)
Deposit-asset ratio		69.90	83.96	
		(57.34)	(64.37)	
Volatility				4.238
				(2.633)
Returns				0.0475
				(0.0553)
GDP growth				0.300
				(1.242)
Number of CEOs	552	552	552	552

Bank FE	YES	YES	YES	YES
R2	0.0225	0.0247	0.0373	0.0399
N	5,117	5,117	5,117	5,106

Panel B: Interbank Loan and $\Delta CoVaR$

Dependent Variable	COVaR			
	(1)	(2)	(3)	(4)
Interbank Loan	0.305***	0.306***	0.265***	0.277***
	(0.0533)	(0.0560)	(0.0568)	(0.0586)
CEO Employment Connections	0.0108***	0.0108***	0.00699***	0.00698***
	(0.00274)	(0.00276)	(0.00266)	(0.00270)
CEO age	-0.000107	-0.000105	-0.000241**	-0.000231*
	(0.000133)	(0.000132)	(0.000117)	(0.000119)
CEO tenure	0.0106***	0.0106***	0.00898***	0.00923***
	(0.00210)	(0.00210)	(0.00200)	(0.00200)
Chair-CEO	-0.00940**	-0.00942**	-0.00714	-0.00755
	(0.00464)	(0.00467)	(0.00456)	(0.00461)
Founder-CEO	-0.0356**	-0.0355**	-0.0305*	-0.0306*
	(0.0179)	(0.0180)	(0.0170)	(0.0171)
VaR	0.977***	0.977***	0.961***	1.009***
	(0.0606)	(0.0606)	(0.0609)	(0.0625)
Market return	0.513***	0.513***	0.501***	0.495***
	(0.00514)	(0.00515)	(0.00533)	(0.00544)
Equity volatility	2.650***	2.650***	2.618***	2.740***
	(0.158)	(0.158)	(0.159)	(0.162)
Interest rate risk	-0.0243***	-0.0243***	-0.0253***	-0.0251***
	(0.000318)	(0.000324)	(0.000332)	(0.000339)
Term spread change	0.815***	0.815***	0.803***	0.840***
	(0.0471)	(0.0471)	(0.0474)	(0.0485)
Liquidity risk	4.218***	4.218***	4.155***	4.321***
	(0.226)	(0.226)	(0.227)	(0.232)
Default risk	0.198***	0.198***	0.202***	0.198***
	(0.00384)	(0.00383)	(0.00381)	(0.00390)
Leverage	-0.00196***	-0.00196***	-0.00159**	-0.00196***
	(0.000751)	(0.000753)	(0.000725)	(0.000742)
Bank size			0.0255***	0.0237***
			(0.00434)	(0.00436)
Deposit-asset ratio		-0.00362	0.00682	0.00847
		(0.0414)	(0.0408)	(0.0409)
Returns				-0.000259***
				(4.02e-05)

Number of CEOs	551	551	551	551
Bank FE	YES	YES	YES	YES
R2	0.798	0.798	0.798	0.800
N	5,103	5,103	5,103	5,092

Table A2: List of top 10 connected CEOs Sample Banks

Panel A: Top 10 connected CEOs in sample banks

No.	Name of Bank CEO	CEO Employment Connections	Name of Bank/ Bank Holding Company
1	Tim Laney	29	NATIONAL BANK HOLDINGS CORP
2	John Asbury	28	ATLANTIC UNION BANKSHARES CORP
3	Al de Molina	25	ALLY FINANCIAL INC
4	Jerry Grundhofer	24	US BANCORP
5	Martin Birmingham	24	FINANCIAL INSTITUTIONS INC
6	Gene Taylor	22	CAPITAL BANK FINANCIAL CORP (De-listed 11/2017)
7	Ken Lewis	20	BANK OF AMERICA CORP
8	Ron DeBerry	20	RELIANT BANCORP INC
9	Walt Standish III	20	BEACH FIRST NAT. BANCSHARES INC (De-listed 04/2010)
10	Carol Nelson	19	CASCADE FINANCIAL CORP (De-listed 06/2011)

Panel B: Top 10 connected CEOs in sample banks as at 2006 (Before Crisis)

No.	Name of Bank CEO	CEO Employment Connections	Name of Bank/ Bank Holding Company
1	Tim Laney	24	NATIONAL BANK HOLDINGS CORP
2	Martin Birmingham	22	FINANCIAL INSTITUTIONS INC
3	Al de Molina	21	ALLY FINANCIAL INC
4	John Asbury	20	ATLANTIC UNION BANKSHARES CORP
5	Carol Nelson	19	CASCADE FINANCIAL CORP (De-listed 06/2011)
6	Ron DeBerry	19	RELIANT BANCORP INC
7	Walt Standish III	19	BEACH FIRST NAT. BANCSHARES INC (De-listed 04/2010)
8	Jerry Grundhofer	18	US BANCORP
9	Mike McMullan	17	BANK OF FLORIDA CORP (De-listed 06/2010)
10	Pat Frawley	16	INTEGRITY BANCSHARES INC (De-listed 03/2008)

Panel C: Top 10 connected CEOs in sample banks as at 2010(After Crisis)

No.	Name of Bank CEO	CEO Employment Connections	Name of Bank/ Bank Holding Company
1	Tim Laney	29	NATIONAL BANK HOLDINGS CORP
2	John Asbury	26	ATLANTIC UNION BANKSHARES CORP
3	Al de Molina	25	ALLY FINANCIAL INC
4	Jerry Grundhofer	23	US BANCORP
5	Martin Birmingham	22	FINANCIAL INSTITUTIONS INC
6	Ken Lewis	20	BANK OF AMERICA CORP
7	Walt Standish III	20	BEACH FIRST NAT. BANCSHARES INC (De-listed 04/2010)
8	Carol Nelson	19	CASCADE FINANCIAL CORP (De-listed 06/2011)
9	Gene Taylor	19	CAPITAL BANK FINANCIAL CORP (De-listed 11/2017)
10	Ron DeBerry	19	RELIANT BANCORP INC

Table A3: Banks and the Number of CEO employment connections in 2006

No.	Bank	Number of CEO Connections in 2006
1	BANK OF AMERICA CORP	347
2	KEYCORP	80
3	US BANCORP	58
4	CITIGROUP INC	46
5	REGIONS FINANCIAL CORP	34
6	MORGAN STANLEY (Morgan Stanley Dean Witter & Co prior to 07/2002)	25
7	BANK OF NEW YORK CO INC (De-listed 07/2007)	20
8	NATIONAL CITY CORP (De-listed 12/2008)	20
9	HUDSON UNITED BANCORP (De-listed 02/2006)	16
10	ZIONS BANCORPORATION	16
11	PAB BANKSHARES INC (De-listed 05/2011)	16
12	BB&T CORP	15
13	HOPE BANCORP INC (BBCN Bancorp Inc prior to 07/2016)	14
14	JPMORGAN CHASE & CO	13
15	AMERICAN EXPRESS CO	12
16	NATIONAL COMMERCE FINANCIAL CORP (De-listed 10/2004)	12
17	SYNOVUS FINANCIAL CORP	12
18	AMERIS BANCORP (ABC Bancorp prior to 12/2005)	12
19	HARLEYSVILLE NATIONAL CORP (De-listed 04/2010)	11
20	HANCOCK WHITNEY CORP (Hancock Holding Co prior to 05/2018)	11

Table A4: Banks and the Number of CEO employment connections in 2010

No.	Bank	Number of CEO Connections in 2010
1	BANK OF AMERICA CORP	392
2	KEYCORP	81
3	CITIGROUP INC	73
4	US BANCORP	60
5	REGIONS FINANCIAL CORP	51
6	MORGAN STANLEY (Morgan Stanley Dean Witter & Co prior to 07/2002)	26
7	BANK OF NEW YORK CO INC (De-listed 07/2007)	20
8	NATIONAL CITY CORP (De-listed 12/2008)	20
9	PAB BANKSHARES INC (De-listed 05/2011)	20
10	AMERIS BANCORP (ABC Bancorp prior to 12/2005)	18
11	HARLEYSVILLE NATIONAL CORP (De-listed 04/2010)	18
12	CIT GROUP INC	17
13	FIFTH THIRD BANCORP	17
14	HUDSON UNITED BANCORP (De-listed 02/2006)	16
15	ZIONS BANCORPORATION NA (Zions Bancorporation prior to 10/2018)	16
16	BB&T CORP	16
17	COMMUNITY BANKERS TRUST CORP (Community Bankers Acquisition Corp prior to 06/2008)	16
18	SYNOVUS FINANCIAL CORP	15
19	AMERICAN EXPRESS CO	15
20	HOPE BANCORP INC (BBCN Bancorp Inc prior to 07/2016)	14

Figure A1: Number of Sample Banks and Bank Holding Companies overtime (2000 to 2018)

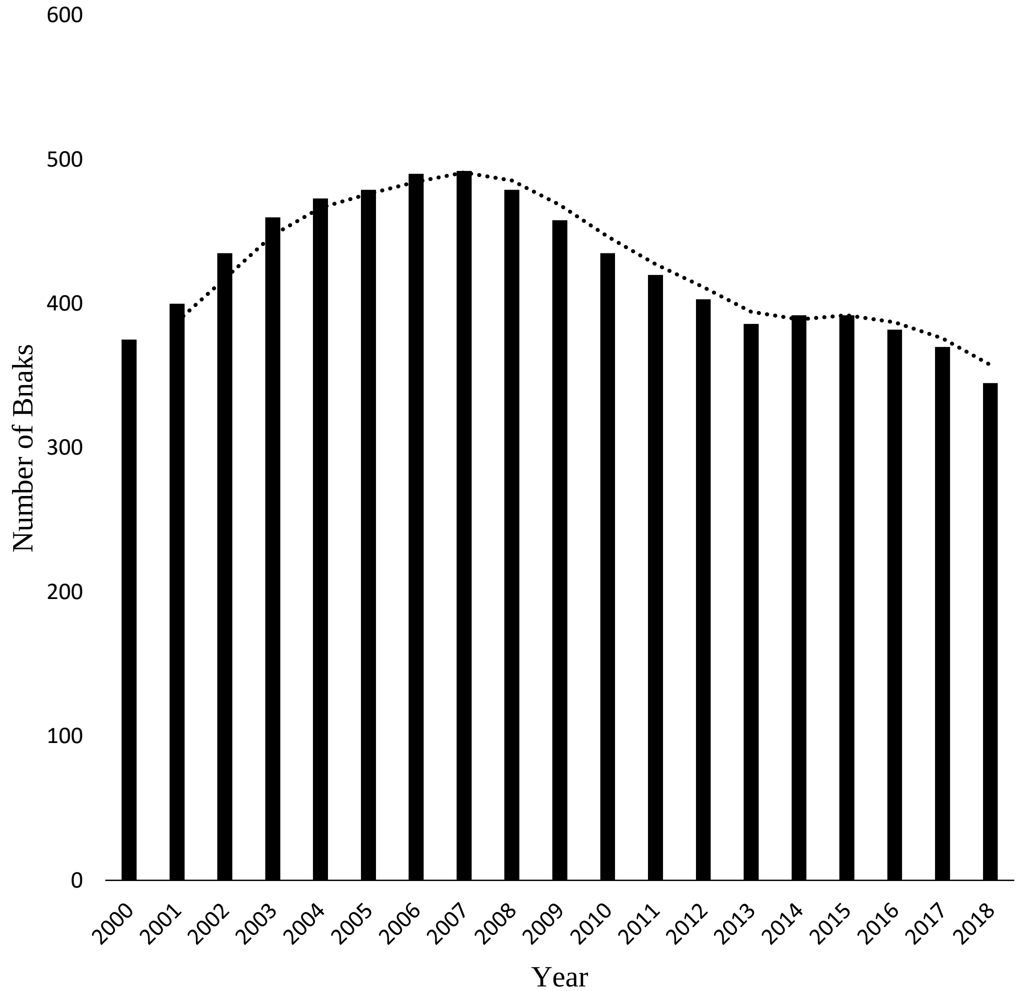


Table A5: Variable Definitions

Variable	Definition
CEO Employment Connections	CEO Employment connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common employment history.
CEO Total Connections	CEO total connections is the natural logarithm of 1 plus the number of other banks' CEOs with whom the CEO shares common education, employment and social activity.
CEO network centrality	Degree, Closeness, betweenness and eigenvector are the measures of CEO network centrality and are defined in section 3.1.2
CEO age	CEO age is the chief executive officer age measured in years.
CEO tenure	CEO tenure is the natural log of the number of years for which the CEO has been in office.
Chair-CEO	Chair-CEO is a dummy variable which is equal to 1 if a CEO also serves as board chairman during his position as CEO of the bank or zero otherwise.
Founder-CEO	Founder-CEO is a dummy variable which is equal to 1 if the CEO was a founder or co-founder of the bank or 0 otherwise.
SRISK	SRISK estimates the capital shortfall of a financial institution conditional on a systemic event. SRISK is the proxy for systemic risk. Refer to 3.1.3 for details.
ΔCoVaR	ΔCoVaR is the difference between the value at risk of the financial system conditional on an institution being under distress and the value at risk of the financial system conditional on an institution operating in its median state. ΔCoVaR is the second proxy for systemic risk. Refer to 3.1.3 for details.
VaR	Value at Risk (VaR) is obtained by running 5-% quantile regression of asset level returns on the one-week lag of the state variables and by computing the predicted value of the regression.
Bank size	Bank size is the natural logarithm of total asset in millions of U.S. dollars.
Market-book ratio	Market-book ratio is the ratio of market value to book value of equity
Deposit-asset ratio	Deposit-Asset ratio is the ratio of deposit to total asset of the bank.
Leverage	Leverage is the ratio of the book value of total asset to the book value of total equity.

Volatility	Volatility is the annualized daily standard deviation of bank equity returns over trading days in the year window expressed in percent.
Returns	Return is the annual equity returns expressed in percent.
Interbank loan	Interbank loan is the ratio of net interbank loan and deposit to total asset.
GDP growth	GDP growth is the annual percentage growth rate of GDP
Market return	Market return is the market return computed from the S&P 500
Equity volatility	Equity volatility is the 60-day rolling standard deviation of the daily CRSP market value-weighted index return
Interest rate risk	Interest rate risk is the change in the three-month Treasury bill rate
Term spread change	Term spread change is measured as spread between ten-year Treasury rate and three-month Treasury bill rate
Liquidity risk	Liquidity risk is measured as the difference between the three-month LIBOR rate and the three-month bill rate
Default risk	Default risk is measured as the change in the credit spread between Baa-rated corporate bonds and the ten-year Treasury rate.

Appendix B: Implementation of SRISK

The Capital shortfall is considered as the capital reserves that the institution needs to hold due to regulation less the institution's equity. Thus, capital shortfall of an institution at time t is defined as

$$CS_{i\,t} = kA_{i\,t} - W_{i\,t} = k(D_{i\,t} + W_{i\,t}) - W_{i\,t}$$

where $CS_{i\,t}$ is Capital Shortfall of bank *i* in time *t*, *k* is the prudential capital fraction, $A_{i\,t}$ is the value of quasi assets, W_{it} is the market value of equity and D_{it} is the book value of debt.
More specifically, SRISK is defined as

$$\begin{aligned} SRISK_{it} &= E_t(CS_{i\,t+h} | R_{m\,t+1:t+h} < C), \\ &= kE_t(D_{i\,t+h} | R_{m\,t+1:t+h} < C) - (1-k)E_t(W_{i\,t+h} | R_{m\,t+1:t+h} < C) \end{aligned}$$

where $SRISK_{it}$ is the systemic risk of bank *i* at time *t*, $CS_{i\,t+h}$ is Capital Shortfall of bank *i* over time horizon t+h, $R_{m\,t+1:t+h}$ is the multi period arithmetic market return between period t+1 and t+h, C is the threshold of the decline in market index, *k* is the prudential capital fraction, $D_{i\,t+h}$ is the book value of debt, $W_{i\,t+h}$ is the market value of equity. We denote systemic event as $\{R_{m\,t+1:t+h} < C\}$. Following Acharya *et al.* (2012a), we set prudential capital fraction k to 8%, threshold C to -40% and horizon *h* to six months (that is 180 days).
We further assume that in the case of a systemic event debt cannot be negotiated, implying $E_t(D_{i\,t+h} | R_{m\,t+1:t+h} < C) = D_{it}$. Based on this assumption, it follows that

$$\begin{aligned} SRISK_{it} &= kD_{it} - (1-k)W_{it}(1 - LRMES_{it}) \\ &= W_{it}[kLVG_{it} + (1-k)LRMES_{it} - 1] \end{aligned}$$

Where $SRISK_{it}$ is the systemic risk of bank *i* at time *t*, *k* is the prudential capital fraction, D_{it} is the book value of debt, W_{it} is the market value of equity, LVG_{it} denotes the quasi-leverage ratio $(D_{it} + W_{it})/W_{it}$ and $LRMES_{it}$ is Long Run Marginal Expected Shortfall of the firm equity multi-period arithmetic return conditional on the systemic event, that is

$$LRMES_{it} = -E_t(R_{i\,t+1:\,t+h} | R_{m\,t+1:t+h} < C)$$

Appendix C: Implementation of is $\Delta CoVaR$

We follow Adrian and Brunnermeier (2016) and define banking system to be our sample of banks. We transform book value of total assets into market value using its market-to-book equity ratio following Adrian and Brunnermeier (2016). We construct the weekly asset-level returns using estimates of the market-valued total assets. We estimate $\Delta CoVaR$ at the 5% level by running quantile regressions on weekly data for each bank. We predict each bank's VaR at 5% level and at the 50% (median) level using a vector of one-week lagged state variables. We then calculate time varying $VaR_{5\%}^{i}$ and $VaR_{50\%}^{i}$ as fitted values from the quantile regressions. We then estimate the Value at Risk of the banking system conditional on the same lagged state variables and asset-level return of each individual bank. We use varying $VaR_{5\%}^{i}$ and $VaR_{50\%}^{i}$ to calculate $CoVaR_{5\%}^{system|i}$ and $CoVaR_{5\%}^{system|i,median}$. The $\Delta CoVaR_{5\%}^{i}$ of the individual bank-i is the difference between the two $CoVaR$ values.

Formally, we estimate the following quantile regression on weekly data:

$$X_t^i = \alpha_q^i + \gamma_q^i M_{t-1} + \varepsilon_{q,t}^i$$

$$X_t^{system|i} = \alpha_q^{system|i} + \gamma_q^{system|i} M_{t-1} + \beta_q^{system|i} X_t^i + \varepsilon_{q,t}^{system|i}$$

We then use the predicted values from these regressions to obtain

$$VaR_t^i = \hat{\alpha}_q^i + \hat{\gamma}_q^i M_{t-1}$$

$$CoVaR_t^i = \hat{\alpha}_q^{system|i} + \hat{\gamma}_q^{system|i} M_{t-1} + \hat{\beta}_q^{system|i} VaR_{q,t}^i$$

We compute $\Delta CoVaR_{q,t}^{i}$ for each bank:

$$\Delta CoVaR_{q,t}^i = CoVaR_{q,t}^i - CoVaR_{50\%,t}^i$$

$$= \hat{\beta}_q^{system|i} (VaR_{q,t}^i - VaR_{50\%,t}^i)$$

Where X^i is the asset-level return of bank-i, $M_{t-1}$is the lagged state variables, VaR_q^i is the Value at Risk of bank-i at the q% quantile, X^{system} is the asset-level return of the banking system.