Stronger Risk Controls, Lower Risk: Evidence from U.S. Bank Holding Companies

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Abstract

We construct a Risk Management Index (RMI) to measure the strength and independence of the risk management function at bank holding companies (BHCs). U.S. BHCs with higher RMI before the onset of the financial crisis have lower tail risk, lower non-performing loans, and better operating and stock return performance during the financial crisis years. Over the period 1995 to 2010, BHCs with a higher lagged RMI have lower tail risk and higher return on assets, all else equal. Overall, these results suggest that a strong and independent risk management function can curtail tail risk exposures at banks.

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> "The failure to appreciate risk exposures at a firmwide level can be costly. For example, during the recent episode, the senior managers of some firms did not fully appreciate the extent of their firm's exposure to U.S. subprime mortgages. They did not realize that, in addition to the subprime mortgages on their books, they had exposures through the mortgage holdings of off-balance-sheet vehicles, through claims on counterparties exposed to subprime, and through certain complex securities..."
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> - Chairman of the Federal Reserve, Ben Bernanke[1]

There is wide-spread agreement on the proximate causes of the current financial crisis: banks had substantial exposure to subprime risk on their balance sheets, and these risky assets were funded mostly by short-term market borrowing (Kashyap, Rajan, and Stein (2008), Acharya et al. (2009a)). Among the explanations for why banks exposed themselves to such risks, a prominent explanation that has been advanced by policymakers, bank supervisors and academics is that there was a failure of risk management at banks:[2] either bank executives and traders with high-powered compensation schemes were knowingly taking excessive tail risks and could not be restrained by risk managers (Senior Supervisors Group (2008), Kashyap, Rajan, and Stein (2008)),[3] or bank managements were unaware of their risk exposures because they were assessing risks historically and were neglecting what appeared to be low probability, non-salient events that turned out to be significant (Shleifer (2011)). At the same time, as the Senior Supervisors Group (2008) notes, there were important cross-sectional differences, even among the largest financial institutions, in terms of their risk exposures leading up to the financial crisis and how they fared during the financial crisis. It is, thus, important to investigate the sources of such cross-sectional differences.

In this paper, we examine if cross-sectional differences in risk taking among bank holding companies (BHCs) in the United States can be explained by differences in the organizational structure of their risk management functions. To this end, we construct an innovative risk management index (RMI) that measures the importance attached to the risk management function within each BHC, and the quality of risk oversight provided by the BHC's board of directors.

Our main hypothesis is that BHCs with strong and independent risk management functions should have lower tail risk, all else equal. This is because executives and traders in financial institutions have incentives to exploit deficiencies in internal controls to take on excessive amounts of tail risk that will enhance performance in the short run, but when it materializes, can cause significant damage to the institution (Kashyap, Rajan, and Stein (2008), Hoenig (2008)). A strong risk management function is *necessary* to correctly identify risks and prevent such excessive risk taking (Kashyap, Rajan, and Stein (2008), Stulz (2008)), which cannot be controlled entirely by regulatory supervision or external market discipline.

In our empirical analysis, we recognize that a bank's risk management function is itself endogenous. It may be that the BHC's underlying business model (or risk culture) determines both the choice of the risk and the strength of the risk management system, such that conservative (aggressive) BHCs take lower (higher) risks and also put in place stronger (weaker) risk management systems. We refer to this as the "business model channel". Alternatively, given that banks are in the business of taking risks, it is possible that some BHCs optimally choose to undertake high risks coupled with a strong risk management function, whereas others optimally choose low risks coupled with a weak risk management function. We refer to this as the "hedging channel" because it is consistent with the core predictions of the theories of hedging (Smith and Stulz (1985), Froot, Scharfstein, and Stein (1993)).

Our main alternative hypothesis is that the risk management function does not have any real impact on tail risk. This may be because banks appoint risk managers, without giving them any real powers, merely to satisfy bank supervisors, whereas the real power rests with trading desks and bank executives who control the bank's risk exposure.[4]

In order to construct the *RMI*, we hand-collect information on the organizational structure of the risk management function for each BHC from its 10-K statements, proxy statements, and annual reports. Given the effort involved in hand-collection and validation of information, we restrict ourselves to the 72 publicly-listed BHCs among the 100 largest BHCs in terms of the book value of total assets at the end of 2007. These 72 BHCs accounted for 78% of the total book value of assets of the U.S. banking system at the end of 2007. For this sample, we are able to construct the *RMI* for the period 1994 to 2009.

As banks are in the business of taking risks, the main purpose of the risk management function would be to mitigate the risk of large losses, i.e., to mitigate tail risk. Accordingly, our main risk measure of interest is *Tail Risk*, which is based on the expected shortfall (ES) measure that is widely used within financial firms to measure expected loss conditional on returns being less than some α-quintile (see Acharya et al. (2010)). Specifically, in a given year, the *Tail risk* is defined as the negative of the average return on the BHC's stock over the 5% worst return days for the BHC's stock.

We begin our analysis by examining the BHC characteristics that determine the choice of *RMI*. Not surprisingly, size is an important determinant of *RMI*, with larger BHCs likely to have higher values of *RMI*, although the relationship is concave. Consistent with the idea that BHCs exposed to greater risk put in place stronger risk management functions, we find that *RMI* is higher for BHCs with lower Tier-1 capital ratio, larger derivatives trading operations, and a larger fraction of income from non-banking activities. Moreover, BHCs with CEO compensation contracts that induce greater risk taking have higher *RMI*; specifically, higher sensitivity of CEO compensation to volatility in stock returns (higher *CEO's vega*) is associated with higher *RMI*. The BHC's corporate governance affects its *RMI* as we find that BHCs with better corporate governance (lower G-index), more independent boards, and less entrenched CEOs have higher *RMI*. Board experience and *RMI* seem to be substitutes as we find that BHCs that have a larger fraction of independent directors with prior financial industry experience have lower *RMI*.

One way to distinguish between the hedging channel and the business model channel is to examine how BHCs change their *RMI* in response to unexpected large losses, such as those they would have experienced during the 1998 Russian crisis. The BHCs' response can tell us whether they have a fairly rigid business model, or whether they readjust their risk levels and risk management systems by learning from the bad experience, as predicted by the hedging channel. The evidence we find is more consistent with the business model channel. Specifically, we find that BHCs with high tail risk in 1998 had lower *RMI* in the subsequent years, 1999 to 2009, compared with other BHCs. Moreover, even though there was an across-the-board increase in *RMI* after 1999, BHCs with high tail risk in 1998 did not have higher increases in their *RMI* compared to the other BHCs. This result may explain the finding in Fahlenbrach, Prilmeier, and Stulz (2011) that financial institutions with the worst performance in the 1998 crisis were also among the worst performers in the financial crisis of 2007 and 2008.

In keeping with the motivation of our paper, we next examine whether BHCs that had strong internal risk controls in place before the onset of the financial crisis fared better during the crisis years, 2007 and 2008. We find that BHCs with higher *pre-crisis RMI* (defined as the average *RMI* of the BHC over 2005 and 2006) had lower tail risk, smaller fraction of non-performing loans, and experienced better operating performance (higher return on assets) and stock return performance (higher annual returns) during the financial crisis years.

Next, we examine the association between *RMI* and tail risk using a panel spanning the time period 1995 to 2010, so that we are better able to control for unobserved (time-invariant) heterogeneities across BHCs by including either size-decile fixed effects or BHC fixed effects. After controlling for various BHC characteristics, we find that BHCs with stronger organizational risk controls (i.e., higher values of *RMI*) in the previous year have lower tail risk in the current year. We must emphasize that our results cannot be explained by differences in management quality across BHCs because we do include BHC fixed effects, and also control for stock return performance which should reflect the BHC's management quality. They also cannot be explained by a non-linear relationship between BHC size and tail risk.

A natural question that arises is whether the reduction in risk from having a higher *RMI* is value-enhancing for the BHC. In this regard, we find a robust positive association between BHCs' return on assets and their lagged *RMI*, which is especially stronger during the financial crisis years. As we describe in detail below in Section IV.D, the predictions for the association between *RMI* and stock returns are more complicated because they depend on the nature of risk (idiosyncratic vs. systematic) that the risk management function is aimed at controlling, and also on the pricing of risk factors by investors. We find that BHCs with higher *RMI* have higher annual stock returns during the financial crisis years (2007 and 2008), but that there is no association between *RMI* and annual stock returns during non-crisis years. This evidence suggests that investors undertake a flight to quality during crisis periods (consistent with the prediction in Gennaioli, Shleifer, and Vishny (2012) by investing in BHCs with higher *RMI*, but may not otherwise attach value to *RMI* in non-crisis periods. Overall, these results suggest that strong risk controls are value-enhancing during the financial crisis.

There are two possible interpretations for the robust negative association between tail risk and *RMI* that we have documented so far. First is the causal interpretation that a strong risk management function lowers tail risk by effectively restraining excessive risk-taking behavior of executives and traders within the BHC. Alternatively, it could be that both risk and the risk management function are jointly determined by some unobserved *time-varying* risk preferences of the BHC; e.g., the BHC may be responding to a recent bad experience by simultaneously lowering risk exposures and strengthening its risk controls (i.e., increasing its *RMI*). We believe that both these channels are important in practice, and that it is very difficult to empirically distinguish between them. Nonetheless, we carry out additional tests, using an instrumental-variables (IV) regression approach and a dynamic panel GMM estimator, to distinguish between these two channels. The results suggest that our findings cannot entirely be driven by changes in risk preferences of BHC, that cause them to simultaneously lower (increase) risk exposures and strengthen (weaken) risk controls.

Our paper makes the following important contributions: First, our paper is the first to offer a systematic examination of the organization of the risk management function at banking institutions. We propose a new measure, the *RMI*, that measures the strength and independence of the risk management function at U.S. BHCs. The *RMI* is largely constructed using only the publicly available information provided by BHCs in their regulatory filings. Despite some data limitations, the *RMI* seems to adequately capture the quality of internal risk controls at BHCs as evidenced by the strong robust negative association between *RMI* and tail risk that we document.

Second, our paper highlights that weakening risk management at financial institutions may have contributed to the excessive risk-taking behavior that brought about the financial crisis.[5] To the best of our knowledge, we are the first to show that banks with strong internal risk controls in place before the onset of the financial crisis were more judicious in their tail risk exposures and fared better, both in terms of their operating performance and stock return performance, during the crisis years. At the least, these results cast doubt on the narrative that the financial crisis was a "hundred year flood"that hit all banks in the same way, because if so, then we should not observe these cross-sectional differences (Shleifer (2011)). These results are related to the finding in Keys et al. (2009) that lenders with relatively powerful risk managers, as measured by the risk manager's share of the total compensation given to the five highest-paid executives in the institution, had lower default rates on the mortgages they originated.

Third, our paper contributes to the large literature that examines risk taking by banks (e.g., see Keeley (1990), Demsetz and Strahan (1997), Demsetz, Saidenberg, and Strahan (1997), Hellmann, Murdock, and Stiglitz (2000), Demirgüç-Kunt and Detragiache (2002), Laeven and Levine (2009)) by examining how the strength and independence of the risk management function affects risk taking. Finally, our paper is also related to the small but growing literature on the corporate governance of financial institutions, which examines the impact of board characteristics and ownership structure on bank performance and risk taking (e.g., see Beltratti and Stulz (2009), Erkens, Hung, and Matos (2012), and Minton, Taillard, and Williamson (2010)).

The rest of the paper is organized as follows. We outline our key hypotheses in Section I. We describe our data sources and construction of variables in Section II, and provide descriptive statistics and preliminary results in Section III. We present our main empirical results in Section IV, and the results of additional robustness tests in Section V. Section VI concludes the paper.

I. Theoretical Background

Our main hypothesis, which is motivated by Rajan (2005), Kashyap, Rajan, and Stein (2008), and Hoenig (2008), is that banking institutions with strong and independent risk management functions should have lower enterprise-wide tail risk, all else equal. The argument is twofold: First, high-powered compensation packages combined with high leverage incentivize top executives and traders in financial institutions to take on tail risks that may enhance performance in the short run, but when such risks materialize, can cause significant damage to the institution. Second, the tendency of executives and traders to take such tail risks cannot entirely be contained either through regulatory supervision or through traditional external market discipline from bondholders or stockholders. As Acharya et al. (2009b) note, deposit insurance protection and implicit too-big-to-fail guarantees weaken the incentives of debtholders to impose market discipline, and the size of financial institutions shields them from the disciplinary forces of the market for takeovers and shareholder activism. Moreover, given the ever-increasing complexity of financial institutions, it is difficult for outsiders to distinguish between management actions that generate true positive alphas (i.e. after adjusting for this risk) from those that generate high returns but are just compensation for taking tail risk, that has not yet shown itself. Therefore, the presence of a strong and independent risk management team may be *necessary* to control tail risk exposures of financial institutions (Kashyap, Rajan, and Stein (2008), Stulz (2008)).

For risks to be successfully managed, they must first be identified and measured. As highlighted by past research (Stein (2002)), the organizational structure of the risk management function is likely to be important in determining how effectively qualitative and quantitative information on risk is shared between the top management and the individual business segments. Accordingly, we collect information on how the risk management function is organized at each bank holding company in our sample. However, measuring risk by itself may not be enough to restrain bank executives and traders, whose bonuses depend on the risks that they take. As Kashyap, Rajan, and Stein (2008) note,

> "...high powered pay-for-performance schemes create an incentive to exploit deficiencies

in internal measurement systems... this is not to say that risk managers in a bank are unaware of such incentives. However, they may be unable to fully control them. "

Therefore, it is important that the risk management function be strong and independent (Kashyap, Rajan, and Stein (2008), Stulz (2008)). Accordingly, we collect information on not just whether a BHC has a designated officer tasked with managing enterprise-wide risk, but also how important such an official is within the organization.

In our empirical analysis, we recognize that a BHC's risk management function is itself endogenous. The endogeneity of the risk management function could arise through two different channels. First, it is possible that a BHC's underlying business model (risk culture) determines both the risk and the strength of the risk management system. That is, some BHCs may have a conservative risk culture and choose to take lower risks and put in place stronger risk management systems, whereas others may have an aggressive risk culture and may choose to take higher risks and also have weaker risk management functions. We refer to this as the "business model channel". Support for the business model channel can be found in recent work by Fahlenbrach, Prilmeier, and Stulz (2011) who show that financial institutions with the worst performance in the 1998 Russian crisis were also the worst performers during the recent financial crisis.

An alternative channel, which we refer to as the "hedging channel", follows from the theoretical literature on risk management which proposes that firms that are more likely to experience financial distress should also be more aggressive in managing their risks (Smith and Stulz (1985), Froot, Scharfstein, and Stein (1993)). Therefore, given that banks are in the business of taking risks, it is possible that some BHCs optimally choose to take high risks coupled with a strong risk management function, whereas others optimally choose low risk coupled with a weak risk management function. In other words, banks with high risk exposures or those that intend to increase their risk exposures may also adopt a more aggressive stance on risk management, which involves both increased hedging as well as putting in place a strong risk management function.[6]

Note that, as the risk measure may be endogenous to the quality of the risk management activities, it is difficult to distinguish between the business model channel and the hedging channel based on the nature of association between risk and *RMI*. However, the business model channel and the hedging channel have contrasting predictions for how BHCs learn from and respond to unexpected bad experiences, such as those in a crisis. As a BHC's risk culture or business model is likely to be fairly rigid, the business model channel suggests that BHCs will not learn from their experiences, and will either fail to adapt or be slow in adapting their risk management functions in response to their experiences in a crisis. On the other hand, if BHCs are optimally choosing their risk and risk management functions as per the hedging channel, then they will learn from and respond to bad experiences during a crisis by either tightening risk controls or lowering risk exposures, or both. In Sections IV.A and V.A below, we attempt to distinguish between these two channels based on how BHCs changed the organization of their risk management function in response to their experience in the 1998 Russian crisis.

Our main alternative hypothesis is that the risk management function does not have any real impact on the bank's tail risk. This may be because banks appoint risk managers, without giving them any real powers, merely to satisfy bank supervisors, while the real power rests with trading desks and bank executives who control the bank's risk exposure. Alternatively, it may be that even the most sophisticated risk management team is unable to grasp the swiftness with which traders and security desks can alter the bank's tail risk profile. The compensation packages of traders may be so convex that they cannot be restrained by the risk officers (Landier, Sraer, and Thesmar (2009)).

II. Sample Collection and Construction of Variables

A. Data Sources

Our data comes from several sources. From the Edgar system, we hand-collect data on the organization structure of the risk management function at BHCs using the annual 10-K statements and proxy statements filed by the BHCs with the Securities and Exchange Commission (SEC). Whenever the data is not available from these documents we use the

BHCs' annual reports or contact the BHCs directly. We use this information to create a unique Risk Management Index (*RMI*) that measures the organizational strength and independence of the risk management function at the given BHC in each year. We do this over the time period 1994–2009. Given the effort involved in hand-collecting and validating the information for each BHC, we restrict ourselves to the 100 largest BHCs, in terms of the book value of their total assets at the end of 2007. Although there were over 5,000 BHCs at the end of 2007, the top 100 BHCs account for close to 92% of the total assets of the banking system. Because only publicly listed BHCs file 10-K statements with the SEC, our sample reduces to 72 BHCs, that accounted for 78% of the total assets of the banking system in 2007. Overall, we are able to construct the *RMI* for 72 BHCs over the time period 1994–2009, although the panel is unbalanced because not every BHC exists for the entire sample period. We list the names of these BHCs in Appendix A.

We obtain consolidated financial information of BHCs from the FR Y-9C reports that they file with the Federal Reserve System. Apart from information on the consolidated balance sheet and income statement, the FR Y-9C reports also provide us a detailed break-up of the BHC's loan portfolio, security holdings, regulatory risk capital, and off-balance sheet activities such as usage of derivatives. The financial information is presented on a calendar year basis.

We obtain data on stock returns from CRSP, and use these to compute our measure of *Tail risk*, which is based on the expected shortfall (ES) measure that is widely used within financial firms to measure expected loss conditional on returns being less than some α-quintile (see Acharya et al. (2010)).[7] Specifically, in a given year, the *Tail risk* is defined as the negative of the average return on the BHC's stock over the 5% worst return days for the BHC's stock.

We obtain data on CEO compensation from the Execucomp database, and use these to compute the sensitivity of the CEO's compensation to stock price (*CEO's delta*) and stock return volatility (*CEO's vega*). We obtain data on institutional ownership from the 13-F forms filed by each institutional investor with the SEC, and the Gompers, Ishii, and Metrick (2003) G-Index from the IRRC database.

B. The Risk Management Index

We hand-collect information on various aspects of the organization structure of the risk management function at each BHC for each year, and use this information to create a Risk Management Index to measure the strength and independence of the risk management function.

Our first set of variables are intended to measure how important the Chief Risk Officer (i.e., the official exclusively charged with managing enterprise risk across all business segments of the BHC) is within the organization.[8] Specifically, we create the following variables: *CRO present*, a dummy variable that identifies if a CRO (or an equivalent function) responsible for enterprise-wide risk management is present within the BHC or not; *CRO executive*, a dummy variable that identifies if the CRO is an executive officer of the BHC or not; *CRO top5*, a dummy variable that identifies if the CRO is among the five highest paid executives at the BHC or not; and *CRO centrality*, defined as the ratio of the CRO's total compensation, excluding stock and option awards, to the CEO's total compensation.[9] The idea behind *CRO centrality* is to use the CRO's relative compensation to infer his/ her relative power or importance within the organization. For example, Keys et al. (2009) use a similar measure to capture the relative power of the CFO within the bank.

We must note that reporting issues complicate the definition of the *CRO centrality* variable, because publicly-listed firms are only required to disclose the compensation packages of their five highest paid executives. Thus, we have information on the CRO's compensation only when he/ she is among the five highest paid executives. We overcome this difficulty as follows: When the BHC has a CRO (or an equivalent designation) who does not figure among the five highest paid executives, we calculate *CRO centrality* based on the compensation of the fifth highest-paid executive, and subtract a percentage point from the resultant ratio; i.e., we implicitly set the CRO's compensation just below that of the fifth-highest paid executive. In case of BHCs that do not report having a CRO, we define *CRO centrality* based on the total compensation of the Chief Financial Officer if that is available (which happens only if the CFO is among the five highest paid executives);[10] if CFO compensation is not available, then we compute *CRO centrality* based on the compensation of the fifth highest-paid executive, and subtract a percentage point from the resultant ratio. To the extent that the CRO's true compensation is much lower, these methods only bias against us, and should make it more difficult for us to find a negative relationship between *RMI* and risk. Another alternative is to code *CRO centrality*=0 when the BHC does not have a designated CRO. Not surprisingly, in unreported tests, we find that our results become stronger when we use this more stringent definition of *CRO centrality*.

Our next set of variables are intended to capture the quality of risk oversight provided by the BHC's board of directors. In this regard, we examine the characteristics of the board committee designated with overseeing and managing risk, which is usually either the Risk Management Committee or the Audit and Risk Management Committee. *Risk committee experience* is a dummy variable that identifies whether at least one of the independent directors serving on the board's risk committee has banking and finance experience. The dummy variable *Active risk committee* then identifies if the BHC's board risk committee met more frequently during the year compared to the average board risk committee across all BHCs.

We obtain the *RMI* by taking the first principal component of the following six risk management variables: *CRO present*, *CRO executive*, *CRO top5*, *CRO centrality*, *Risk committee experience*, and *Active risk committee*. Principal component analysis effectively performs a singular value decomposition of the correlation matrix of risk management categories. The single factor selected in this study is the eigenvector in the decomposition with the highest eigenvalue. The main advantage of using principal component analysis is that we do not have to subjectively eliminate any categories, or make subjective judgements regarding the relative importance of these categories (Tetlock (2007)). As suggested by Tetlock (2007), we construct the principal component analysis on a year-by-year basis using only the information from the current year, so as to avoid possible look-ahead bias that may arise if we use information from the future.[11]

III. Descriptive Statistics and Preliminary Results

A. Descriptive Statistics

We present summary statistics of the key risk and risk management variables, financial characteristics and governance characteristics for the BHCs in our panel in Table I. The panel has one observation for each BHC-year combination, spans the time period 1995 to 2010, and includes the 72 publicly listed BHCs listed in Appendix A. Panel A of Table I contains the summary statistics for the entire panel.

[Insert Table I here]

The mean of 0.047 on *Tail risk* indicates that the mean return on the average BHC stock on the 5% worst return days for the BHC's stock during the year is -4.7%. As can be seen, the average annual return on a BHC stock during our sample period is 10.4%. However, annual stock returns are highly variable: the BHC at the 25^{th} percentile cutoff had an annual return of -7.0%, whereas the BHC at the 75^{th} percentile cutoff had an annual return of 27.3%.

The summary statistics on *RMI* indicate that our index is not highly skewed, and does not suffer from the presence of outliers. Examining the components of *RMI*, we find that a designated Chief Risk Officer (or an equivalent designation) was present in 80.6% of the BHC-year observations in our sample. The CRO had an executive rank in 40.2% of BHC-year observations, and was among the top five highly-paid executives in only 20.5% of BHC-year observations. On average, the CRO's base compensation (i.e., excluding stock- and option-based compensation) is 31.3% that of the CEO's total compensation.

The mean value of 0.307 on *Risk committee experience* indicates that, in around 69.3% of BHC-year observations, not even one independent director on the board's risk committee had any prior financial industry experience. The board risk committee meets 5.369 times each year on average, although a number of BHCs have risk committees that meet much more frequently, some even twice or more every quarter (the 75^{th} percentile cutoff for this variable is 8). We classify a BHC as having an *Active risk committee* during a given year if the frequency with which its board risk committee met during the year was higher than the average frequency across all BHCs during the year. By this classification, 43.9% of BHCs in our sample had active board risk committees.

The size distribution of BHCs, in terms of the book value of their assets, is highly skewed with total assets varying from $156 million at the lower end to over $2 trillion at the higher end. Given the skewness of the size distribution we use the logarithm of the book value of assets, denoted *Size*, as a proxy for BHC size in all our empirical specifications. Moreover, in our empirical analysis, we also check for possible non-linear relation between size and risk characteristics.

In Panel B of Table I, we seek to better understand the differences in characteristics between BHCs with strong risk controls (high values of *RMI*) and BHCs with weaker risk controls (low values of *RMI*). To do this, we define the dummy variable *High RMI* to identify, in each year, BHCs whose *RMI* is greater than the median value of *RMI* across all BHCs during the year. We then do a univariate comparison of the mean values of various BHC characteristics between the two subsamples identified by *High RMI*= 0 and *High RMI*= 1.

As can be seen, BHCs with high *RMI* are larger in size. This is not surprising because larger BHCs are more likely to be involved in riskier non-banking activities, and hence, are more likely to benefit from a strong risk management function. They are also more likely to be able to afford the costs of implementing a strong risk management function. In terms of risk, we find that BHCs with high *RMI* have significantly lower tail risk, which is consistent with our main hypothesis as well as with the business model channel.

BHCs with high *RMI* are more likely to be funded by riskier short-term debt, and have lower tier-1 capital ratio, which is consistent with the hedging channel view that BHCs exposed to greater risk should adopt stronger risk management functions. Along these lines, we also find that BHCs with high *RMI* have larger fraction of non-performing loans ($(Bad\ loans/Assets)_{t-1}$), greater reliance on off-balance sheet activities (as proxied by *(Non-*

int. income/Income)$_{t-1}$), larger derivative trading operations, and are more likely to use derivatives for hedging purposes.

In terms of governance and ownership characteristics, we find that BHCs with high *RMI* have higher institutional ownership, which may be driven by the fact that larger BHCs have both higher institutional ownership and higher *RMI.* Although we do not find significant differences in overall quality of corporate governance (*G-Index*$_{t-1}$), we find that BHCs with high *RMI* have a larger fraction of independent directors on their boards, are more likely to have experienced CEO turnover in the previous year, have CEOs with shorter tenure, and are less likely to have undertaken a large merger and acquisition (M&A) in the previous year.

We must caution that the differences listed in Panel B are simple univariate differences that do not control for differences in other BHC characteristics, most notably BHC size. We do a formal multivariate analysis below in Section IV.A where we control for these other important differences.

In Panel C of Table I, we present the mean values of *RMI* and its components separately for each year in our sample, to provide a sense of how these variables changed over time. As can be seen, there has been a gradual improvement in all of the *RMI* components over the years. For instance, only 40% of BHCs had a CRO in 1994, whereas all of them have a CRO by 2008. Similarly, the proportion of BHCs in which the CRO was among the five highest paid executives increased from 11.1% in 1994 to 43.5% in 2009. Similar trends can be observed in other *RMI* components as well. Consistent with these trends, the *RMI* increases significantly over our sample period from an average of 0.479 in 1994 to 0.729 in 2009. Interestingly, the most significant year-on-year increase in *RMI* occurs in 2000. This may partly be due to the passage of the Gramm-Leach-Bliley Act in 1999 which repealed some of the restrictions placed on banks by the Glass-Stegall Act of 1933. Another important factor behind this increase in *RMI* could have been the Russian financial crisis of 1998 which at that time was described as the worst crisis in the past 50 years.

B. Correlations Among Key Variables

In Table II, we list the pair-wise correlations between BHCs' tail risk, *RMI*, and financial and governance characteristics. We use the superscript 'a' to denote statistical significance at the 10% level. Although the univariate correlation between *Tail risk* and RMI_{t-1} is negative, it is not statistically significant at the 10% level. Tail risk is negatively correlated with the profitability measure ROA_{t-1} and positively correlated with *Bad loans/Assets*$_{t-1}$, which is consistent with the idea that profitable BHCs and BHCs with healthier loan portfolios are less risky.

[Insert Table II here]

Consistent with the idea that, in the presence of deposit insurance, institutional investors have incentives to take on higher risks (Saunders, Strock, and Travlos (1990)), we find a strong positive correlation between tail risk and *Inst. ownership*. The positive correlation between tail risk and *CEO's vega* indicates that tail risk is higher for BHCs whose CEO compensation is more sensitive to risk. The positive correlation between tail risk and *CEO's tenure* indicates that BHCs with more entrenched CEOs have higher tail risk.

Not surprisingly, *RMI* is positively correlated with *Size*. The negative correlation between *RMI* and *Tier-1 capital/Assets* suggests that Tier-1 capital and strong risk controls are substitutes. Recall that *ST borrowing/Assets* is the proportion of assets financed by commercial paper and other short-term non-deposit borrowing. Therefore, the positive correlation between *RMI* and *ST borrowing/Assets* suggest that BHCs which rely more on risky short-term sources of funding have higher *RMI*. The positive correlation between *RMI* and *Bad loans/Assets* indicates that BHCs with a higher proportion of non-performing loans have higher *RMI*. Consistent with the idea that BHCs with a larger presence in non-banking activities have higher *RMI*, we find that *RMI* is positively correlated with *Non-int. income/Income*, *Deriv. trading/Assets* and *Deriv. hedging/Assets*.

In terms of governance characteristics, we find that *RMI* is positively correlated with institutional ownership and the fraction of independent directors on the board, and is negatively correlated with the CEO's tenure. We fail to detect any correlation between *RMI* and *G-Index*. Examining CEO compensation characteristics, we find that *RMI* is negatively correlated with *CEO's delta* and positively correlated with *CEO' vega*. Because high delta (vega) is thought to weaken (strengthen) the CEO's risk-taking incentives, these correlations suggest that CEO compensation and risk controls are substitutes.

We must, however, caution against over-interpreting the results from Panel A because these are simple pair-wise correlations that do not control for the impact of BHC characteristics, most notably, size. We now proceed to the multivariate analysis where we examine the determinants of a BHC's *RMI*, and the relationship between tail risk and *RMI* after controlling for key BHC characteristics.

IV. Empirical Results

A. Determinants of RMI

We begin our multivariate analysis by examining the determinants of *RMI*. To do this, we estimate panel regressions of the following form:

$$RMI_{j,t} = \alpha + \boldsymbol{\beta} * X_{j,t-1} + \text{Year FE} + \text{BHC or Size decile FE} \qquad (1)$$

In the above equation, subscript 'j' denotes the BHC and 't' denotes the year. In these regressions, we control for important BHC financial characteristics and governance characteristics ($X_{j,t-1}$) that may affect the BHC's *RMI*. The definitions of all the variables we use in our analysis are listed in Appendix B. One important BHC characteristic that may affect its *RMI* is size, which we control for using the natural logarithm of the book value of total assets (*Size*). As we showed in Table I, the size distribution of BHCs is highly skewed. Therefore, it is also important to check for possible non-linear relationship between *RMI* and size. One way to do this is to include size decile fixed effects to control for unobserved heterogeneities across BHCs in different size categories. Alternatively, we include both *Size* and $Size^2$ as control variables in the regressions; as these variables are highly correlated with each other, we orthogonalize them before including them in the regression.

Apart from size, we control for the BHC's profitability using the ratio of income before extraordinary items to assets (*ROA*), and for past performance using its *Annual return*. We control for balance sheet composition using the ratios *Deposits/Assets*, *ST borrowing/Assets*, *Tier-1 capital/Assets* and *Loans/Assets*, and for the quality of loan portfolio using the ratio *Bad loans/Assets*, where *Bad loans* include non-accrual loans and loans past due 90 days or more. We proxy for the BHC's reliance on off-balance sheet activity using the ratio *Non-int. income/Income* (see Boyd and Gertler (1994)). We control for the BHC's derivatives usage for hedging purposes and trading purposes using the ratios *Deriv. hedging/Assets* and *Deriv. trading/Assets*, respectively. The ownership and governance characteristics that we control for are as follows: institutional ownership (*Inst. ownership*); quality of governance using *G-Index*, *Board independence* and *Board expertise*; CEO compensation characteristics, *CEO's delta* and *CEO's vega*; CEO entrenchment using *CEO's tenure*; and the dummy variable *Change in CEO* which identifies whether the BHC's CEO changed during the year. We also define the dummy variable *Post 1999* to identify the years 2000–09.

The results of our estimation are presented in Panel A of Table III. The positive coefficient on the dummy variable *Post 1999* confirms our earlier observation that there was an across-the-board increase in *RMI* after the year 1999. As the positive coefficients on $Size_{t-1}$ and ROA_{t-1} in column (1) indicate, larger and more profitable BHCs have higher *RMI*; the negative coefficient on $Size^2$ suggests that a concave relationship between *RMI* and size. Moreover, the positive coefficients on $(Deposits/Assets)_{t-1}$ and $(Loans/Assets)_{t-1}$ indicate that BHCs with a larger fraction of their balance sheet devoted to banking have higher *RMI*. The positive coefficient on *Non-int.* $income/Income_{t-1}$ indicates that BHCs with a higher proportion of their income from trading, investment banking and insurance have higher *RMI*. Similarly, the positive coefficient on *Deriv.* $trading/Assets_{t-1}$ indicates that BHCs with a larger derivatives trading operation have higher *RMI*. Consistent with our findings in Table II, the negative coefficient on *Tier-1* $capital/Assets_{t-1}$ indicates that well-capitalized BHCs have lower *RMI*, which seems to suggest that Tier-1 capital and risk controls are substitutes.

The BHC's governance structure seems to matter for its choice of *RMI*. Specifically, we find that BHCs with poor quality of corporate governance (higher $G\text{-}Index_{t-1}$) have lower *RMI*, whereas BHCs with a higher fraction of independent directors on the board (higher value of $Board\ independence_{t-1}$) have higher *RMI*. On the other hand, we do not find any significant association between institutional ownership and *RMI*. Interestingly, BHC's with a higher fraction of directors with prior banking and financial industry experience (higher value of $Board\ expertise_{t-1}$) have lower *RMI*, which suggests that BHCs build strong internal risk controls when they lack directors with financial industry expertise; i.e., internal risk controls and board expertise are substitutes.

In column (2), we repeat the regression in column (1) after including CEO compensation characteristics, $CEO's\ delta_{t-1}$ and $CEO's\ vega_{t-1}$, as additional controls. We also control for CEO entrenchment using $CEO's\ tenure_{t-1}$. The sample size for this regression is significantly smaller than in column (1) because only the larger BHCs in our sample are covered by the Execucomp database, which we use to obtain estimates for delta and vega, and to measure CEO's tenure. The positive coefficient on $CEO's\ vega_{t-1}$ indicates that BHCs in which the CEO's compensation is highly sensitive to volatility in returns have higher *RMI*. On the other hand, although the coefficient on $CEO's\ delta_{t-1}$ is negative, it is not statistically significant. Because high vega is thought to strengthen the CEO's risk-taking incentives, this result suggests that CEO compensation and risk controls are substitutes. The negative coefficient on $CEO's\ tenure_{t-1}$ indicates that BHCs with more entrenched CEOs have weaker risk management functions.

In column (3), we repeat the regression in column (1) after including size-decile fixed effects to control for unobserved heterogeneities across BHCs in different size deciles. Although the signs of the coefficients on the control variables are the same as in column (1), many of the coefficients lose statistical significance in this specification. However, we still continue to find that profitable BHCs and BHCs with a higher proportion of independent directors have higher *RMI*, and that the increase in *RMI* post-1999 isn't confined to any particular size category.

In column (4), we repeat the regression in column (1) after including BHC fixed effects to control for unobserved heterogeneities across BHCs. Therefore, the coefficients now capture the effect of a within-BHC change in the underlying variable on the change in *RMI*. After inclusion of BHC fixed effects, the coefficients on *G-Index* and *Board independence* lose significance possibly due to lack of sufficient within-BHC variation in these variables. However, consistent with column (1), we continue to find that BHCs with lower Tier-1 capital and lower proportion of directors with prior financial industry experience have higher *RMI*.

As we noted earlier, there was a significant across-the-board increase in *RMI* after the year 1999, which may have been driven both by the passage of the Gramm-Leach-Bliley Act in 1999 and by the heavy losses suffered by banks during the Russian financial crisis of 1998. One way to distinguish between the hedging channel and the business model channel is to examine how the experience of BHCs during the 1998 crisis affected their *RMI* in subsequent years. If we find that BHCs with the worst performance during the 1998 crisis responded by strengthening their risk controls more than other BHCs in subsequent years, that would be consistent with the hedging channel because it would suggest that these BHCs fixed the shortcomings in their risk controls that were revealed by their experience in the 1998 crisis. On the other hand, if we find that the BHCs with the worst performance during the 1998 crisis either did not alter their risk controls or did not strengthen their risk controls more than other BHCs in subsequent years, that would be more consistent with the business model channel.

To test these hypotheses, we define the dummy variable *High tail risk, 1998* to identify BHCs whose *Tail risk* in 1998 exceeded the median value across all BHCs during that year. Recall that *Tail risk* measures the size of losses in the extreme left-tail of the BHC's return distribution. Therefore, the dummy variable *High tail risk, 1998* identifies the BHCs that had high left-tail losses during 1998. We then estimate the regression in column (3) of Panel A after confining the sample to the period 1999-2009, and include *High tail risk, 1998* as an additional regressor.[12] The results of our estimation are presented in Panel B of Table III. Although we employ the full set of control variables that we used in column (3) of Panel

A (except *Post 1999*), to conserve space, we do not report the coefficients on any of the control variables. Please see Table IA.I in the internet appendix for the unabridged version of the table.

As the negative coefficient on *High tail risk, 1998* in column (1) indicates, BHCs with the worst performance during the 1998 crisis had lower *RMI* in subsequent years compared with other BHCs. We find this result even after including size-decile fixed effects to control for unobserved heterogeneities across BHCs in the different size deciles. Therefore, this result cannot be explained by differences in size between BHCs with high and low tail risk in 1998.

Note that the finding in column (1) does not say anything about how BHCs responded to their experience in the 1998 crisis, and could be driven by the fact that BHCs with the worst experience during the 1998 crisis had low *RMI* prior to 1998, and continued to have low *RMI* after 1998. To examine how BHCs responded to their experience in the 1998 crisis, in column (2), we examine the association between *High tail risk, 1998* and increase in *RMI* in subsequent years using a *first-differences* specification. The dependent variable in this regression is the first-difference in *RMI* ($\Delta RMI_t = RMI_t - RMI_{t-1}$), and the regressors are the first-differences of the control variables from column (1), alongwith year fixed effects and size-decile fixed effects. Recall that the hedging channel predicts a positive coefficient on *High tail risk, 1998*, whereas the business model channel does not. As can be seen, the coefficient on *High tail risk, 1998* in column (2) is negative but not statistically significant, which is more consistent with the business model channel.

It is possible that the reaction of BHCs to their experience in the 1998 crisis varied between the immediate aftermath of the crisis and in subsequent years. For instance, BHCs with large losses in 1998 may have responded by increasing their *RMI* in 1999 and 2000, but may have reverted to their preferred business model after 2000, when sufficient time elapsed from the effects of the 1998 crisis. To test this, we estimate three separate cross-sectional regressions: In column (3), we examine the relationship between *High tail risk, 1998* and the increase in *RMI* over 1998 to 2000, after controlling for all the BHC characteristics in column (1) for the year 1998, including size decile fixed effects. Similarly, in column (4) (column (5)), we examine the relationship between *High tail risk, 1998* and the increase in *RMI* over 2000 to 2003 (increase in *RMI* over 2003 to 2006), after controlling for all the BHC characteristics in column (1) for the year 2000 (year 2003), including size decile fixed effects. As can be seen, the coefficient on *High tail risk, 1998* is negative but insignificant in all three columns, which is more consistent with the business model channel.

B. RMI and Performance during Crisis Years

In motivating our paper, we cited the Senior Supervisors Group (2008) report which suggested that institutions with stronger risk management functions fared better in the early months of the crisis. So it is natural to ask whether BHCs that had stronger internal risk controls in place before the onset of the financial crisis were more judicious in their risk exposures and fared better during the crisis years, 2007 and 2008. To investigate this, we define a BHC's *Pre-crisis RMI* as the average of its RMI_{2005} and RMI_{2006}. We are interested in this variable because institutions with strong risk controls would have identified risks and started taking corrective actions as early as in 2006, when it was easier to offload holdings of mortgage-backed securities and CDOs, and was relatively cheaper to hedge risks.

We begin by investigating the univariate relationship between BHCs' *Pre-crisis RMI* and their average tail risk over the crisis years, 2007 and 2008. In Figure 1, we plot the relationship between the actual and fitted values of the BHCs' average tail risk during the crisis years versus their *Pre-crisis RMI.* The fitted values are the predicted values obtained from an OLS regression of BHCs' average tail risk during the crisis years on a constant and the *Pre-crisis RMI.* The $t-$statistic of the coefficient estimate is -2.38.

[Insert Figure 1 here]

This univariate test reveals a clear and statistically significant negative relationship between *Pre-crisis RMI* and average tail risk during the financial crisis years, providing the first preliminary indication that BHCs with stronger risk controls in place before the onset of the financial crisis had lower tail risk during the crisis years.

Following the univariate tests, we proceed to estimate cross-sectional regressions only for the crisis years, 2007 and 2008, that are of the following form:

$$Y_{j,t} = \alpha + \beta * \text{Pre-crisis RMI}_j + \boldsymbol{\gamma} * X_{j,2006} + \text{Year FE} \tag{2}$$

In the above equation, subscript 'j' denotes the BHC and 't' denotes the year. Our main independent variable of interest is the BHC's *Pre-crisis RMI*, which we defined above. We also control for BHC characteristics at the end of calendar year 2006.[13] The results of our estimation are presented in Table III. We include 2007 and 2008 year dummies in all specifications. The standard errors are robust to heteroskedasticity and are clustered at the BHC level.

[Insert Table IV here]

The dependent variable in column (1) is *Private MBS*, which denotes the total value of private-label mortgage-backed securities (in $ million) held in both trading and investment portfolios; i.e., we exclude mortgage-backed securities that are either issued or guaranteed by government sponsored enterprises (GSEs), because these are less risky. We are interested in exposure to mortgage-backed securities because the financial crisis was itself triggered by a housing crisis in the U.S., and there was considerable uncertainty regarding the true values of these securities during 2007 and 2008. The negative coefficient on *Pre-crisis RMI* indicates that BHCs with stronger risk controls in place before the crisis had lower exposure to private-label mortgage-backed securities during the crisis years.

Observe that we did not control for a possible non-linear relation between MBS holdings and BHC size in column (1). To check the robustness of the result in column (1), we estimate the regression after including $Size^2$ in 2006 as an additional control. Once we do so, the magnitude of the coefficient on *Pre-crisis RMI* decreases significantly, and the coefficient is not statistically significant. Instead, we find a large positive coefficient on $Size^2$, which points to a convex relationship between size and MBS holdings. Therefore, in all remaining specifications, we control for both *Size* and $Size^2$ to account for possible non-linear relationship between the dependent variable and size.

The dependent variable in column (3) is *Deriv. trading*, which is the gross notional amount (in $ billion) of derivative contracts held for trading. As can be seen, the coefficient on *Pre-crisis RMI* is not significant in this column. Once again, the strong positive coefficient on $Size^2$ points to a convex relationship between size and off-balance sheet derivative trading activities of BHCs during the crisis years.

In columns (4) through (6), we examine whether the operating and stock performance of BHCs during the crisis years varies based on their *Pre-crisis RMI.* The performance measures that we examine are: *Bad loans/Assets* in column (4) to measure the health of the BHC's loan portfolio, *ROA* in column (5) to measure the BHC's overall operating profitability, and *Annual return* in column (6) which denotes the buy-and-hold return on the BHC's stock over the calendar year. As can be seen, BHCs with strong risk controls before the onset of the financial crisis had a lower proportion of bad loans during the crisis years (negative coefficient on *Pre-crisis RMI* in column (4)), and experienced better operating and stock return performance (positive coefficient on *Pre-crisis RMI* in columns (5) and (6)).

In column (7), we turn our focus to the BHCs' tail risk during the crisis years. Recall that *Tail risk* is the negative of the average return on the BHC's stock over the 5% worst return days for the BHC's stock during the year. As can be seen, the coefficient on *Pre-crisis RMI* is negative and significant in column (7), indicating that BHCs with strong risk controls before the onset of the financial crisis had lower tail risk during the crisis years.

Overall, the results in Table IV are broadly supportive of the argument in the Senior Supervisors Group (2008) report that BHCs with strong and independent risk management functions in place before the onset of the financial crisis were more judicious in their tail risk exposures, and fared better during the crisis years. These results are also economically significant: For instance, a one standard deviation increase in *Pre-crisis RMI* is associated with an 89.24% increase in *ROA* (relative to sample mean *ROA* over 2007–08). Similarly, a one standard deviation increase in *Pre-crisis RMI* is associated with 41.58% higher annual return, and a 10.64% lower tail risk. However, we must be very cautious with these economic magnitudes for two reasons. First, these are simple cross-sectional regressions which do not control for unobserved heterogeneities across BHCs. Second, as we show below, our results tend to be stronger during the crisis years. Hence, these magnitudes cannot be generalized to non-crisis years.

It is natural to ask whether the results hold more generally even during non-crisis years, and whether they are robust to controlling for unobserved heterogeneity across BHCs. To address these questions, we next proceed to panel regressions where we examine a longer time span, and are also able to control for unobserved heterogeneity using either size decile fixed effects or BHC fixed effects.

C. RMI and Tail Risk

In this section, we examine whether BHCs that had strong and independent risk management functions in place had lower tail risk, after controlling for the underlying risk of the BHC's business activities. Accordingly, we estimate panel regressions that are variants of the following form:

$$\text{Tail risk}_{j,t} = \alpha + \beta * \text{RMI}_{j,t-1} + \gamma * X_{j,t-1} + \text{BHC or Size Decile FE} + \text{Year FE} \qquad (3)$$

We estimate this regression on a panel that has one observation for each BHC-year combination, includes the BHCs listed in Appendix A, and spans the time period 1995–2010. In the above equation, subscript 'j' denotes the BHC and 't' denotes the year. The dependent variable is *Tail risk*, and the main independent variable is the BHC's lagged *RMI*. We include year fixed effects in all our specifications, and control for unobserved heterogeneities across BHCs using either size-decile fixed effects or BHC fixed effects. Size decile fixed effects control for the fact that larger BHCs have different risk profiles than smaller BHCs, whereas BHC fixed effects control for any time-invariant unobserved BHC characteristics that might affect tail risk; e.g., the BHC's risk culture.

In these regressions, we control for important lagged BHC characteristics ($X_{j,t-1}$) that may affect risk. The definitions of all the variables we use in our analysis are listed in Appendix B. As described in Section IV.A, we control for financial characteristics such as size, profitability, balance-sheet composition, quality of loan portfolio, and reliance on off-balance sheet activity. To account for possible non-linear relationship between risk and size, we either explicitly control for both $Size_{t-1}$ and $Size^2_{t-1}$ or include size-decile fixed effects. As far as possible, we attempt to mitigate any omitted variable bias by directly controlling for other time-varying BHC characteristics that are likely to be related to BHC Risk. These include the BHC's reliance on derivatives for hedging (*Deriv. hedging/Assets*) and trading purposes (*Deriv. trading/Assets*), institutional characteristics such as *Inst. ownership* and quality of governance (*G-Index*), CEO compensation characteristics (*CEO's delta* and *CEO's vega*), management turnover (using *Change in CEO*), CEO entrenchment (using *CEO's tenure*), and large-scale M&A activity (using *Large M&A*).

The results of our estimation are presented in Table V. In all specifications, the standard errors are robust to heterogeneity and are clustered at the individual BHC level.

[Insert Table V here]

In column (1), we estimate a cross-sectional panel regression without any size-decile fixed effects or BHC fixed effects. In this specification, we control for both $Size_{t-1}$ and $Size^2_{t-1}$. As can be seen, the coefficient on RMI_{t-1} in column (1) is negative and statistically significant, which indicates that BHCs that had strong internal risk controls in place in the previous year have lower tail risk in the current year.

In terms of the coefficients on the control variables, note that the coefficient on $Size^2_{t-1}$ is positive and significant, indicating that the largest BHCs had significantly higher tail risk. This is consistent with the idea that the "too-big-to-fail" banks take on excessive tail risks in anticipation of being bailed out in the event of a systemic financial risk. The negative coefficients on ROA_{t-1} and $Annual\ return_{t-1}$ indicate that BHCs with better past operating and stock return performance have lower tail risk. The positive coefficient on $(Tier\text{-}1\ Capital/Assets)_{t-1}$ probably reflects the fact that riskier BHCs have higher tier-1 capital. One variable that has a strong positive relationship with tail risk is *(Bad loans/Assets)*$_{t-1}$, which indicates that the risk of large negative returns is higher for BHCs that have a larger fraction of non-performing loans.

In column (2), to mitigate any omitted variable bias, we also control for additional BHC characteristics that the existing literature has shown to be related to risk. Past research has highlighted that, in the presence of deposit insurance, diversified stockholders such as institutional investors may have incentives to take on higher risk (Saunders, Strick, and Travlos (1990), Demsetz, Saidenberg, and Strahan (1997), Laeven and Levine (2009)). Therefore, we include *Inst. ownership*$_{t-1}$, the fraction of stock owned by institutional investors, as an additional control. We control for the BHC's overall corporate governance using the lagged value of its G-Index. We also attempt to proxy for the time-varying risk preferences by including two new ratios, (*Deriv. hedging/Assets*)$_{t-1}$ and (*Deriv. trading/Assets*)$_{t-1}$, which measure the BHC's reliance on derivatives for hedging purposes and trading, respectively. The idea here is that if a BHC changes its risk exposure or the way it manages risk, it should be captured by these two additional ratios. Finally, we control for CEO turnover and large-scale M&A activity using the dummy variables, *Change in CEO*$_{t-1}$ and *Large M&A*$_{t-1}$, respectively.

Consistent with the predictions of past literature that institutional investors encourage risk-taking at banks, the coefficient on *Inst. ownership*$_{t-1}$ is positive and significant. However, we fail to detect any relationship between the G-index and tail risk, or between the derivative usage for hedging purposes and tail risk. Somewhat surprisingly, the coefficient on (*Deriv. trading/Assets*)$_{t-1}$ is negative and statistically significant, although it is not economically significant. The insignificant coefficients on *Change in CEO*$_{t-1}$ and *Large M&A*$_{t-1}$ indicate that neither CEO turnover nor large-scale M&A activity is related to BHCs' tail risk. Importantly, the coefficient on RMI_{t-1} remains negative and significant after the inclusion of these additional controls, and has similar magnitude as in column (1).

It is commonly argued in the popular press that bank CEO compensation packages have contributed to higher risk taking.[14] In column (3), we repeat the regression in column (2) after controlling for *CEO's tenure*, and for the following characteristics of CEO compensation: *CEO's delta*, which is the sensitivity of the CEO's compensation to stock price; and *CEO's vega*, which is the sensitivity of compensation to stock return volatility (see Core and Guay (1999)). This lowers our sample size significantly, because the ExecuComp database, from which we obtain information on CEO compensation and tenure, does not cover all the BHCs in our sample. As can be seen, we fail to detect any relationship between tail risk and either CEO compensation characteristics or CEO tenure. More importantly, the coefficient on RMI_{t-1} continues to be negative and significant even after controlling for CEO compensation characteristics and tenure.

In column (4), we repeat the regression in column (2) after including size-decile fixed effects to control for unobserved heterogeneities in tail risk across BHCs in different size deciles. As can be seen, the coefficient on RMI_{t-1} continues to be negative and significant, and is slightly larger in size when compared with the corresponding coefficient in column (2).

In column (5), we repeat the regression in column (2) after including BHC fixed effects to control for unobserved heterogeneities in tail risk across BHCs. The idea is to control for unobserved time-invariant BHC factors that may have a bearing on tail risk; e.g., the BHC's risk culture. Note that the interpretation of coefficient estimates changes after inclusion of BHC fixed effects, because the coefficients now represent the effect of a within-BHC change in the underlying variable on changes in risk. As can be seen, the coefficient on RMI_{t-1} continues to be negative and significant even after the inclusion of BHC fixed effects.

Overall, the results in Table V indicate that BHCs with strong internal risk controls in place in the previous year have lower tail risk in the current year. These findings are also economically significant: a one standard deviation increase in *RMI* is associated with a 5.4% decrease in tail risk (relative to the sample average tail risk of 0.047) based on the coefficient in column (1), and a 13.2% decrease in tail risk based on the coefficient in column (5).

We estimate several additional specifications which we do not report here to conserve space. We briefly describe these tests, and provide references to the corresponding tables in the internet appendix in parentheses. First, for robustness, we estimate two alternative specifications: a GLS random-effects model with an AR(1) disturbance to account for possible serial correlation in the error term,[15] and a first-difference (FD) regression as an alternative to the specification with BHC fixed effects.[16] We find that our results are robust to these alternative specifications (Table IA.II). Second, we replicate both the crisis-period results in Table IV and the panel regression results in Table V using two alternative measures of *RMI*, namely *RMI-FW* and *Alt. RMI*, and obtain qualitatively similar results (Table IA.III). Third, we obtain qualitatively similar results when we use *Downside risk* and *Aggregate Risk* as our risk measures (Table IA.IV).

D. Relationship between RMI and BHC Performance

So far, we have shown that BHCs with strong internal risk controls in the previous year have lower tail risk in the current year, all else equal. In this section, we examine if the reduction in risk is value-enhancing for the BHC. We do this by estimating regressions to understand the association between *RMI* and BHC performance, both operating performance and stock return performance. If strong risk controls allow BHCs to manage their risks more effectively, then we expect BHCs with higher *RMI* to be more profitable as measured by their *ROA*. Moreover, we expect the positive association between ROA_t and RMI_{t-1} to be stronger during the crisis years as compared to non-crisis years.

The predictions for stock returns are more ambiguous and depend on whether strong risk controls lower the BHC's systematic risk or idiosyncratic risk, or both. Moreover, as we explain below, the predictions for the association between *RMI* and stock returns could vary between the crisis periods and non-crisis periods depending on how investors price risks.

Theory predicts that in a world where investors hold well-diversified portfolios, expected returns should depend only on systematic risk and not on idiosyncratic risk. Therefore, if the reduction in risk due to high *RMI* is mainly on account of idiosyncratic risk (systematic risk), then there should be no relationship (a negative relationship) between *RMI* and *expected returns*. An additional complication is that BHCs' *realized returns* may differ from their *expected returns*, either because of alphas generated by their managements or because of the mispricing of risk factors. Unfortunately, our sample is too small and the sample period too short to provide clear-cut answers regarding the nature of risk (idiosyncratic versus systematic), and to be able to precisely measure alphas.[17]

More importantly, the predictions for the association between *RMI* and stock returns could vary between the crisis periods and non-crisis periods depending on how investors price risks. Recent work by Gennaioli, Shleifer, and Vishny (2012) highlights that if investors neglect certain unlikely risks (e.g., tail risks), then the pricing of risk by investors could vary between crisis periods, when these unlikely risks suddenly materialize, and non-crisis periods. This is because of a flight to quality during crisis periods when the risks that were thought to be unlikely materialize in an unexpected manner. Applying this logic to our setting, it is possible that there is a positive relationship between *RMI* and realized returns only during the financial crisis years, and not otherwise. It can even be argued that the stock market should penalize BHCs with high *RMI* during non-crisis years if they are lowering their exposure to risky but profitable activities like derivatives trading.

To test these hypotheses, we estimate the panel regression (3) with *ROA*, *Annual return*, and *Abnormal return* as dependent variables. Recall that *Annual return* is the buy-and-hold return on the BHC's stock over the calendar year, whereas *Abnormal return* is the difference between the *Annual return* and a "predicted" return from a market model. We include either size-decile fixed effects or BHC fixed effects in all specifications. Standard errors are robust to heteroskedasticity, and clustered at the BHC level. The results of our estimation are presented in Table VI. To conserve space, we do not report the coefficients on the control variables, which are reported in the unabridged version of the table in Table IA.V of the internet appendix.

[Insert Table VI here]

The positive and significant coefficient on RMI_{t-1} in column (1) indicates that BHCs with stronger risk controls have higher *ROA* in the subsequent year. As we have included size decile fixed effects in our specification, the positive association between RMI_{t-1} and ROA_t cannot be due to BHCs in a particular size category.

In column (2), we examine how the association between RMI_{t-1} and ROA_t varies between crisis years and non-crisis years. We define the dummy variable *Crisis years* to identify the financial crisis years, 2007 and 2008. We then estimate the regression in column (1) after replacing RMI_{t-1} with two interaction terms, RMI_{t-1}**Crisis years* and RMI_{t-1}*(1-*Crisis years*). As can be seen, the coefficient on RMI_{t-1}**Crisis years* is larger in magnitude than the coefficient on RMI_{t-1}*(1-*Crisis years*), suggesting that the positive association is more pronounced during crisis years.

In column (3), we repeat the regression in column (1) after including BHC fixed effects instead of size decile fixed effects, and find that the coefficient on RMI_{t-1} continues to be positive and significant. These results are economically significant: the coefficient of 0.006 on RMI_{t-1} in column (1) indicates that a one standard deviation increase in *RMI* is associated with a 15.82% increase in *ROA* (relative to the sample mean *ROA* of 1.07%).

In columns (4) through (6), we repeat the same set of tests with *Annual return* as the dependent variable. We find in column (4) that BHCs with higher RMI_{t-1} have higher annual returns even after controlling for unobserved heterogeneities across BHCs in different size categories. However, the results in column (5) indicate that the positive effect of RMI_{t-1} on annual returns is confined only to financial crisis years, and is not present in other years, which is consistent with the flight-to-quality argument in Gennaioli, Shleifer, and Vishny (2012). Moreover, we do not find any significant association between RMI_{t-1} and annual returns if we include BHC fixed effects. We obtain qualitatively similar results in columns (7) through (9) when we use *Abnormal return* instead of *Annual return* as the dependent variable.

Overall, the results in Table VI indicate that BHCs with stronger risk controls have better operating performance, and are rewarded with better returns during the financial crisis years.

V. Additional Robustness Tests

Our results so far lend themselves to two possible interpretations. First, a strong risk management function lowers tail risk by restraining risk-taking behavior within the BHC. Second, given that the choice of the risk management function may itself be endogenous, it could be that both the risk and the risk management function are jointly determined by some unobserved *time-varying omitted variable* (note that we have already controlled for time-invariant omitted variables through inclusion of BHC fixed effects); e.g., a change in the risk preferences of the BHC that causes it to simultaneously lower (increase) risk and strengthen (weaken) internal risk controls. We believe that both these channels are important in practice, and that it is difficult to empirically distinguish between them. Nonetheless, in this section, we carry out some additional tests to show that our results are not being driven entirely by time-varying risk preferences of BHCs.

A. Instrumental-Variables Regressions

In this section, we replicate both our crisis-period cross-sectional regressions (equation (2)) and the panel regressions (equation (3)) using an instrumental-variables (IV) regression approach. We identify instruments for *RMI* by examining how BHCs *changed their RMI* in response to their experiences in the 1998 crisis. As we note in the paper, there was a significant across-the-board increase in *RMI* during the period 1998–2000, which may be partly due to the experience of BHCs during the 1998 Russian crisis and partly due to the passage of the Gramm-Leach-Bliley Act in 1999.

A key property of the instrument is that it should not have any direct effect on the dependent variable in the regression (i.e., crisis-period performance measures, and tail risk in the years after the Russian crisis). It could be argued that a BHC's own increase in *RMI* over the period 1998–2000 (denoted $\Delta \text{RMI}_{1998-00}$) does not satisfy this key property required of an instrument, because the underlying business model or risk culture of the BHC, which may be persistent (see Fahlenbrach, Prilmeier, and Stulz (2011)), can affect both the BHC's response to the Russian crisis and its performance and risk in subsequent years. Therefore, for each BHC, we instead focus on the average $\Delta\text{RMI}_{1998-00}$ for *all other* BHCs (i.e., excluding the BHC itself) in the size decile to which the BHC belonged to in the year 1998. We refer to this variable as the *Comparable BHCs'* $\Delta RMI_{1998-00}$, and use it as an instrument for the BHC's *RMI* in subsequent years, 2001 and beyond. We focus on commonalities in size while defining *Comparable BHCs'* $\Delta RMI_{1998-00}$ because, as we showed in Section IV.A, size is a very important determinant of *RMI*.

We feel confident about the identifying assumption that *Comparable BHCs'* $\Delta RMI_{1998-00}$ does not have any direct impact on the BHC's tail risk during the subsequent years or its performance during the financial crisis years, and that any impact is only through its effect on *RMI* in subsequent years. Our confidence stems from two reasons: First, *Comparable BHCs'* $\Delta RMI_{1998-00}$ is not specific to a particular BHC; it is only an average measure over all other BHCs in the size decile to which the BHC belonged in 1998. Second, as Fahlenbrach, Prilmeier, and Stulz (2011) note, the proximate causes of the 1998 crisis were very different from those of the financial crisis in 2007–2008; the former was triggered by events in Russia whereas the latter was triggered by problems in the housing sector in the United States. Therefore, it is unlikely that *Comparable BHCs'* $\Delta RMI_{1998-00}$ is picking up any commonalities in investment decisions during 1998 and the years leading up to the financial crisis. Even in the panel regressions, we confine the sample to the period 2001-2010, so that there is a gap of at least three years between the 1998 crisis and our sample period.

In Panel A of Table VII, we present the results of the crisis-period regressions using the IV regression approach implemented using the two-stage least squares (2SLS) estimator. The empirical specification is very similar to the regressions in Table IV, except that we use the instrumented value of *Pre-crisis RMI* estimated from a first-stage regression with *Comparable BHCs'* $\Delta RMI_{1998-00}$ as an exogenous instrument. Note that the sample size in Panel A of Table VII is lower in comparison with Table IV because we can only estimate the IV regression for those BHCs which existed in 1998. To conserve space, we do not report the coefficients on the control variables in the either the first-stage or second-stage regressions. The unabridged results are presented in Table IA.VI in the internet appendix.

We present the results of the first-stage regression in Column (1).[18] The positive and significant coefficient on *Comparable BHCs'* $\Delta RMI_{1998-00}$ indicates that it is a good predictor of *Pre-crisis RMI*. Following Staiger and Stock (1997), it is common to examine first stage power using $F-$statistics. The $F-$statistic for the excluded instrument in the first-stage regression is 12.83 with a $p-$value of 0.0005. Based on cut-off values of Stock, Wright, and Yogo (2002), we can reject the hypothesis of insufficient first stage power in all the regressions reported in Panel A.[19]

As can be seen from columns (2) through (6), the results of the IV regression are qualitatively similar to the corresponding results in Table IV. Overall, the results in Panel A of Table VII support the argument that BHCs with strong and independent risk management functions in place before the onset of the financial crisis were more judicious in their risk exposures, and fared better during the crisis years.

[Insert Table VII here]

In Panel B of Table VII, we apply the IV regression approach to the panel regressions investigating the relationship between *Tail risk*$_t$ and RMI_{t-1}. The empirical specification is very similar to Column (1) in Table V, except for the following differences: first, the main regressor is the instrumented value of RMI_{t-1} estimated from a first-stage regression with *Comparable BHCs'* $\Delta RMI_{1998-00}$ as an exogenous instrument; second, to confirm to the identifying assumption that our instruments must not have any direct impact on $Risk_t$, we restrict the panel regression to the period 2001–2010. We continue to cluster standard errors at the BHC level.

We present the results of the first- and second-stage regressions of the IV regression with *Tail risk* as dependent variable in columns (1) and (2). The positive and significant coefficient on *Comparable BHCs'* $\Delta RMI_{1998-00}$ in column (1) indicates that it is a good predictor of RMI_{t-1} during the period 2001–2009. The $F-$statistic for the excluded instrument is 9.24 with a $p-$value of 0.0035 (adjusted for 60 clusters in BHCs) in column (1).[20] The negative and significant coefficient on RMI_{t-1} in column (2) supports our earlier finding of a negative association between *Tail risk*$_t$ and RMI_{t-1}.

Overall, the results of the instrumental-variables regressions indicate that our crisis-period results are not being driven by a change in the risk-preferences of BHCs just before the onset of the financial crisis. Similarly, the negative association between $\textit{Tail risk}_t$ and RMI_{t-1} that we documented in our panel regressions cannot entirely be explained by time-varying risk preferences that cause BHCs to simultaneously lower (increase) risk exposures and strengthen (weaken) risk controls.

B. Dynamic Panel GMM Estimator

Another potential concern with our analysis could be that the relationship between *RMI* and tail risk is *dynamically endogenous*; i.e., causation runs both ways, such that a BHC's past tail risk determines both current *RMI* and current risk (see Wintoki, Linck, and Netter (2010) for a discussion of dynamic endogeneity in a corporate finance setting). To address this concern, we use a dynamic panel GMM estimator developed by Arellano and Bond (1991) that enables us to explicitly control for lagged values of tail risk, and to use the information from the BHC's history, in the form of distant lags of risk and other BHC characteristics to provide instruments for identifying the relationship between *RMI* and risk. Specifically, we estimate the following dynamic model:

$$\text{Tail risk}_{j,t} = \alpha + \beta * \text{RMI}_{j,t-1} + \kappa_1 \text{Tail risk}_{j,t-1} + \kappa_2 \text{Tail risk}_{j,t-2} + \gamma * X_{j,t-1} + \eta_i + \epsilon_{it} \quad (4)$$

Observe that model (4) employs two lags of the tail risk measure as regressor variables. This means that historical risk measures and BHC characteristics that are lagged three periods or more are available for use as exogenous instruments. The estimation of the model itself involves two steps: (i) first-differencing equation (4) to eliminate the unobserved η_i; and (ii) estimating the first-differenced equation via GMM using lagged values of risk and other BHC characteristics as possible instruments.

[Insert Table VIII here]

The results of our estimation are presented in Table VIII, where the dependent variable is *Tail risk*. We employ the full set of control variables including CEO compensation characteristics, that we used in column (3) of Table V. As can be seen, the coefficient on RMI_{t-1} continues to be negative and significant. We also present the results of the Sargan test for the validity of instruments employed in the model. The Sargan test yields a statistic which is distributed χ^2 under the null hypothesis of the validity of our instruments. The p-value equals 1 in both columns, indicating that we cannot reject the null hypothesis that our instruments are valid.

To conserve space, we do not report the coefficients on the control variables in Table VIII. The unabridged results are presented in Table IA.VII in the internet appendix. Overall, the results in Table VIII indicate that BHCs with a high *RMI* in the previous year have lower tail risk, even after controlling for any dynamic endogeneity between tail risk and *RMI*.

C. Other Miscellaneous Tests

We have undertaken other tests which we do not report in the paper, in order to conserve space. These tests are available in the internet appendix to this paper. In this section, we briefly summarize these tests.

C.1. Do Our Results Hold With Investment Banks?

As prominent investment banks such as Bear Stearns and Lehman Brothers were at the heart of the financial crisis, a natural question that arises is whether our results hold with investment banks as well. Given the effort involved in hand-collecting and validating the information required to construct our *RMI*, replicating our study on a large sample of investment banks is beyond the scope of this paper. Nonetheless, to briefly address this question, we construct our *RMI* for the ten most high-profile investment banks over our sample period. These are (in alphabetical order): Ameriprise Financial Inc., Bear Stearns Companies Inc., Credit Suisse Group, Goldman Sachs Group Inc., Legg Mason Inc., Lehman Brothers Holdings Inc., Merrill Lynch & Co Inc., MF Global Holdings Ltd., Morgan Stanley, and Nomura Holdings Inc.

We create a combined panel that includes both investment banks and BHCs. As investment banks do not file FR Y-9C reports, we obtain financial characteristics for both investment banks and BHCs by matching this panel with the Compustat database. We then examine whether our main crisis-period results (from Table IV) and the negative association between tail risk and lagged *RMI* that we document continue to hold after the inclusion of investment banks in the sample. These results are presented in Table IA.IX of the internet appendix. To summarize, we continue to find that firms with higher *Pre-crisis RMI* had higher stock returns and lower tail risk during the financial crisis years, 2007 and 2008. Moreover, in panel regressions spanning the period 1995–2010, we continue to find a negative association between $Tail\ risk_t$ and RMI_{t-1}.

C.2. Impact of CRO Power and the Quality of Risk Oversight on Enterprise Risk

Recall that we obtain the *RMI* by taking the first principal component of four CRO-related variables, and two board-level variables that capture the quality of the risk oversight by the BHC's board of directors. As we mentioned in Section II.B, the main advantage of using principal component analysis is that we do not have to make any subjective judgements regarding the relative importance of these different components. An obvious drawback of this approach is that we cannot say whether it is CRO power or the quality of risk oversight by the board that has a larger impact on enterprise risk.

To address this question, we replicate our crisis period regressions (Table IV) and the panel regressions (Table V) after replacing *RMI* with the following two variables: *CRO centrality* to proxy for the CRO's power within the BHC; and *Quality of oversight* to proxy for the quality of risk oversight by the BHC's board of directors, and which is defined as the simple average of the two dummy variables, *Risk committee experience* and *Active risk committee*.[21]

The results of this analysis are presented in Table IA.X of the internet appendix. A brief summary of the results is as follows: First, all our crisis period results from Table IV cannot be fully explained by either the BHCs' *CRO centrality* or *Quality of oversight* before the onset of the crisis. Specifically, the higher *ROA* during the crisis years seems to be associated primarily with higher CRO centrality before the onset of the crisis. On the other hand, our findings of lower non-performing loans, lower tail risk and higher annual stock returns during the crisis years seem to be driven mainly by better quality of risk oversight before the onset of the crisis.

Second, in terms of the panel regression results in Table V, we find that only $CRO\ centrality_{t-1}$ is significant in the cross-sectional regression specifications. However, when we include BHC fixed effects, neither $CRO\ centrality_{t-1}$ nor $Quality\ of\ oversight_{t-1}$ has a statistically significant association with $Tail\ risk_t$.

These results suggest that, although *CRO centrality* and *Quality of oversight* are important proxies for some dimensions of the strength of the risk management function, neither of them can fully replicate the results we find with the *RMI* measure. Put differently, the *RMI* captures some aspects of the strength of the risk management function that are not captured by *CRO centrality*.

VI. Conclusion

In this paper, we examine the organizational structure of the risk management function at bank holding companies (BHCs) in the United States, and investigate whether differences in tail risk exposures across BHCs can be explained by differences in the strength of their risk management functions. We propose a new measure, the Risk Management Index (*RMI*), to measure the strength and independence of risk management functions at BHCs. We construct the *RMI* by hand-collecting information on the risk management functions at BHCs which we obtain from the public filings (10-Ks, proxy statements, and annual reports).

We find that BHCs with stronger risk management functions (i.e., higher *RMI*) in place before the onset of the financial crisis had lower tail risk, a smaller fraction of non-performing loans, better operating performance, and higher annual returns during the crisis years, 2007–08. In a panel spanning the time period 1995–2010, we find that BHCs with a high lagged *RMI* had, all else equal, lower tail risk, and higher return on assets. Moreover, BHCs with high *RMI* had higher stock returns during crisis years, but there is no association between *RMI* and stock returns during normal non-crisis years. Overall, these results suggest that a strong and independent risk management function can curtail tail risk exposures at banks, and possibly enhance value, particularly during crisis years.

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Appendix A: List of BHCs in our Sample

Name of BHC	2007 Assets ($ bn)	Pre-crisis RMI	Time span in panel
Citigroup Inc.	2188	0.482	1999–2010
Bank of America Corporation	1721	0.788	1995–2010
JPMorgan Chase & Co.	1562	1.178	1995–2010
Wachovia Corporation	783	0.830	1995–2008
Wells Fargo & Company	575	1.272	1995–2010
Metlife, Inc.	559	0.426	2002–2010
U.S. Bancorp	238	1.183	1995–2010
Bank of New York Mellon Corporation, The	198	0.693[a]	2008–2010
Suntrust Banks, Inc.	180	1.070	1995–2010
Capital One Financial Corporation	151	0.741	2005–2010
National City Corporation	150	0.470	1995–2008
State Street Corporation	143	0.601	1995–2010
Regions Financial Corporation	141	0.638	2005–2010
PNC Financial Services Group, Inc., The	139	1.142	1995–2010
BB&T Corporation	133	1.004	1996–2010
Fifth Third Bancorp	111	0.952	1995–2010
Keycorp	100	0.587	1995–2010
Northern Trust Corporation	68	0.982	1995–2010
M&T Bank Corporation	65	1.200	1995–2010
Comerica Incorporated	63	1.111	1995–2010
Marshall & Ilsley Corporation	60	0.410[a]	2008–2010
Unionbancal Corp	56	1.019	1997–2009
Huntington Bancshares Inc.	55	0.953	1995–2010
Zions Bancorporation	53	0.540	1995–2010
Commerce Bancorp, Inc.	49	0.645	1995–2008
Popular, Inc.	44	0.896	1995–2010
First Horizon National Corporation	37	0.970	1995–2010
Synovus Financial Corp.	33	0.497	1995–2010
New York Community Bancorp, Inc.	31	0.995	1995–2010
Colonial Bancgroup, Inc., The	26	0.531	1995–2009
Associated Banc-Corp	22	1.187	1996–2010
BOK Financial Corp	21	0.489	1997–2010
W Holding Company, Inc.	18	0.478	2000–2010
Webster Financial Corporation	17	0.383	2005–2010
First Bancorp	17	0.674	1999–2009
First Citizens Bancshares, Inc.	16	0.878	1995–2010
Commerce Bancshares, Inc.	16	0.473	1995–2010
TCF Financial Corporation	16	0.225	1998–2010
Fulton Financial Corporation	16	0.601	1995–2010
City National Corporation	16	0.719	1995–2010
South Financial Group, The	14	0.639	1995–2010
Cullen/Frost Bankers, Inc.	14	0.940	1995–2010
Citizens Republic Bancorp, Inc.	14	0.559	1995–2010
Bancorpsouth, Inc.	13	0.687	1997–2010

[a] denotes *RMI* in 2007

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Name of BHC	2007 Assets ($ bn)	Pre-crisis RMI	Time span in panel
Susquehanna Bancshares, Inc.	13	0.760	1995–2010
Valley National Bancorp	13	0.587	1995–2010
Sterling Financial Corporation	12	0.358	2006–2010
East West Bancorp, Inc.	12	0.514	1999–2010
UCBH Holdings, Inc.	12	0.329	1999–2009
Wilmington Trust Corporation	12	0.875	1995–2010
International Bancshares Corporation	11	0.505	1999–2010
Whitney Holding Corporation	11	0.351	1995–2010
Bank Of Hawaii Corporation	10	1.087	1995–2010
Firstmerit Corporation	10	0.603	1995–2010
Cathay General Bancorp	10	0.330	1995–2010
Franklin Resources, Inc.	10	0.513	2002–2010
Wintrust Financial Corporation	9	0.599	1997–2010
UMB Financial Corporation	9	0.570	1995–2010
Santander Bancorp	9	0.737	2001–2010
Trustmark Corporation	9	0.898	1995–2010
Corus Bankshares, Inc.	9	0.144	1995–2009
Umpqua Holdings Corporation	8	0.499	2000–2010
Newalliance Bancshares, Inc.	8	0.581	2005–2010
First Midwest Bancorp, Inc.	8	0.572	1995–2010
Alabama National Bancorporation	8	0.177	1996–2008
United Bankshares, Inc.	8	0.540	1995–2010
Old National Bancorp	8	1.022	1995–2010
MB Financial, Inc	8	0.551	1996–2010
Chittenden Corporation	7	0.314	1995–2008
Pacific Capital Bancorp	7	0.619	1995–2010
Boston Private Financial Holdings, Inc.	7	0.457	1996–2010
Park National Corporation	7	0.314	1995–2010

[a] denotes *RMI* in 2007

Appendix B: Definitions of Key Variables

BHC Risk and Return Measures:

- *Tail risk*: The negative of the average return on the BHC's stock during the 5% worst returns days for the BHC's stock over the year.
- *Downside risk*: Mean implied volatility over the year estimated from put options written on the BHC's stock.
- *Aggregate risk*: Standard deviation of the BHC's weekly return over the year.
- *Annual return*: The buy-and-hold return on the BHC's stock over the calendar year.
- *Abnormal return*: Difference between *Annual Return* and the expected return from a market model, where the market model is estimated by regressing daily returns on the BHC's stock versus a constant and daily returns on the S&P500 over the previous three calendar years.

BHC Risk Management Measures:

- *CRO present*: A dummy variable that identifies if the BHC has a designated Chief Risk Officer (or an equivalent designation, such as Chief Credit Officer, Chief Lending Officer, or Chief Compliance Officer) with an enterprise-wide remit.
- *CRO executive*: A dummy variable that identifies if the Chief Risk Officer (or the official with an equivalent designation) is an executive officer.
- *CRO top5*: A dummy variable that identifies if the Chief Risk Officer (or the official with an equivalent designation) is among the five highest paid executives.
- *CRO centrality*: Ratio of the CRO's total compensation, excluding stock and option awards, to the CEO's total compensation. When the BHC has a CRO who does not figure among the five highest paid executives, we calculate *CRO centrality* based on the compensation of the fifth highest-paid executive, and subtract a percentage point from the resultant ratio. In case of BHCs that do not report having a CRO, we define *CRO centrality* based on the total compensation of the Chief Financial Officer if that is available; if CFO compensation is not available, then we compute *CRO centrality* based on the compensation of the fifth highest-paid executive, and subtract a percentage point from the resulting ratio.
- *Risk committee experience*: A dummy variable that takes the value of 1 if at least one of the independent directors serving on the board's risk committee has prior banking and financial industry experience, and 0 otherwise.

- *Freq. meetings of risk committee*: The number of times the BHC's board risk committee met during the year.

- *Active risk committee*: A dummy variable that takes the value of 1 if the frequency with which the BHC's board risk committee met during the year is higher than the average frequency across all BHCs during the year, and 0 otherwise.

- *Quality of oversight*: Equals the simple average of the dummy variables, *Risk committee experience* and *Active risk committee*.

- *Reports to board*: A dummy variable that identifies whether the key management-level risk committee (usually called the "Asset and Liability Committee") reports directly to the BHC's board of directors, instead of to the CEO.

- *RMI*: Computed as the first principal component of the following six risk management variables: *CRO present*, *CRO executive*, *CRO top5*, *CRO centrality*, *Risk committee experience*, and *Active risk committee*.

- *Alt. RMI*: Computed as the first principal component of the following seven risk management variables: *CRO present, CRO executive*, *CRO-top5*, *CRO centrality*, *Risk committee experience*, *Reports to board* and *Active risk committee*.

BHC financial characteristics:

The expressions within the parentheses denote the corresponding variable names in the FR Y-9C reports.

- *Size*: Natural logarithm of the book value of total assets (BHCK2170).

- *ROA*: Ratio of the income before extraordinary items (BHCK4300) to assets.

- *Deposits/Assets*: Ratio of total deposits (BHDM6631+BHDM6636+BHFN6631+BHFN6636) to assets.

- *Core deposits/Assets*: Ratio of "core" deposits to assets, where core deposits include deposits held in domestic offices of the subsidiaries of the BHC, excluding all time deposits of over $100,000 and any brokered deposits (BHCB2210+ BHCB3187+ BHCB2389+ BHCB6648+ BHOD3189+ BHOD3187+ BHOD2389+ BHOD6648- BHDMA243- BHDMA164).

- *Non-core deposits/Assets*: Ratio of (total deposits-core deposits) to assets.

- *Tier-1 capital/Assets*: Ratio of Tier1 capital (BHCK8274) to assets.

- *Loans/Assets*: Ratio of total loans (BHCK2122) to assets.

- *Real estate loans/Assets*: Ratio of loans secured by real estate (BHCK1410) to assets.
- *C&I loans/Assets*: Ratio of commercial and industrial loans (BHDM1766) to assets.
- *Consumer loans/Assets*: Ratio of consumer loans (BHDM1975) to assets.
- *Agri. loans/Assets*: Ratio of agricultural loans (BHCK1590) to assets.
- *Other loans/Assets*: Ratio of all other loans to assets.
- *Loan concentration*: Measures the concentration of the BHC's loan portfolio among the five loan segments defined above. It is computed as the sum of squares of each segment's share in the total loan portfolio.
- *Bad loans/Assets*: Ratio of the sum of loans past due 90 days or more (BHCK5525) and non-accrual loans (BHCK5526) to assets.
- *Non-int. income/Income*: Ratio of non-interest income (BHCK4079) to the sum of interest income (BHCK4107) and non-interest income (BHCK4079).
- *Private MBS*: The total value of private-label mortgage backed securities held in both trading and investment portfolios; i.e., this excludes mortgage-backed securities that are either issued or guaranteed by government sponsored enterprises. This measure is computed as summing the following variables: BHCK1709, BHCK1733, BHCK1713, BHCK1736 and BHCK3536.
- *Deriv. trading*: Total gross notional amount of derivative contracts held for trading, obtained by adding amounts on interest rate contracts (BHCKA126), foreign exchange contracts (BHCKA127), equity derivative contracts (BHCK8723), and commodity and other contracts (BHCK8724).
- *Deriv. hedging*: Value of derivatives used for hedging purposes. Obtained by adding the following variables: BHCK8725, BHCK8726, BHCK8727 and BHCK8728.

Other BHC Variables:

- *Inst. ownership*: Percentage of shares owned by 13-F institutional investors.
- *G-Index*: Gompers, Ishii and Metrick (2003) governance index.
- *Board independence*: The fraction of independent directors on the BHC's board of directors.
- *Board experience*: The fraction of independent directors on the BHC's board of directors that have prior banking or financial industry experience.
- *Experienced board*: A dummy variable that takes the value of 1 if *Board experience* for the BHC is higher than the average value across all BHCs during the year, and 0 otherwise.

- *CEO's delta*: Sensitivity of CEO compensation to share price, expressed in $ '000.
- *CEO's vega*: Sensitivity of CEO compensation to stock return volatility, expressed in $ '000.
- *Change in CEO*: A dummy variable that identifies BHCs which experienced a change in CEO during the year.
- *CEO's tenure*: The number of years that the CEO has spent in his/her current position at the BHC.
- *Large M&A*: A dummy variable that identifies BHCs that experienced a year-on-year growth in book value of assets exceeding 20%.

Figure 1. Avg. Tail Risk during Crisis Years vs. Pre-Crisis RMI

This figure plots the average *Tail risk* of each BHC over the crisis years (2007 and 2008) versus its corresponding *Pre-crisis RMI*, which is defined as the average RMI of the BHC over the period 2005–2006. The solid straight line in the figure is a plot of predicted values obtained from a regression of *Tail risk* versus a constant and the *Pre-crisis RMI*.

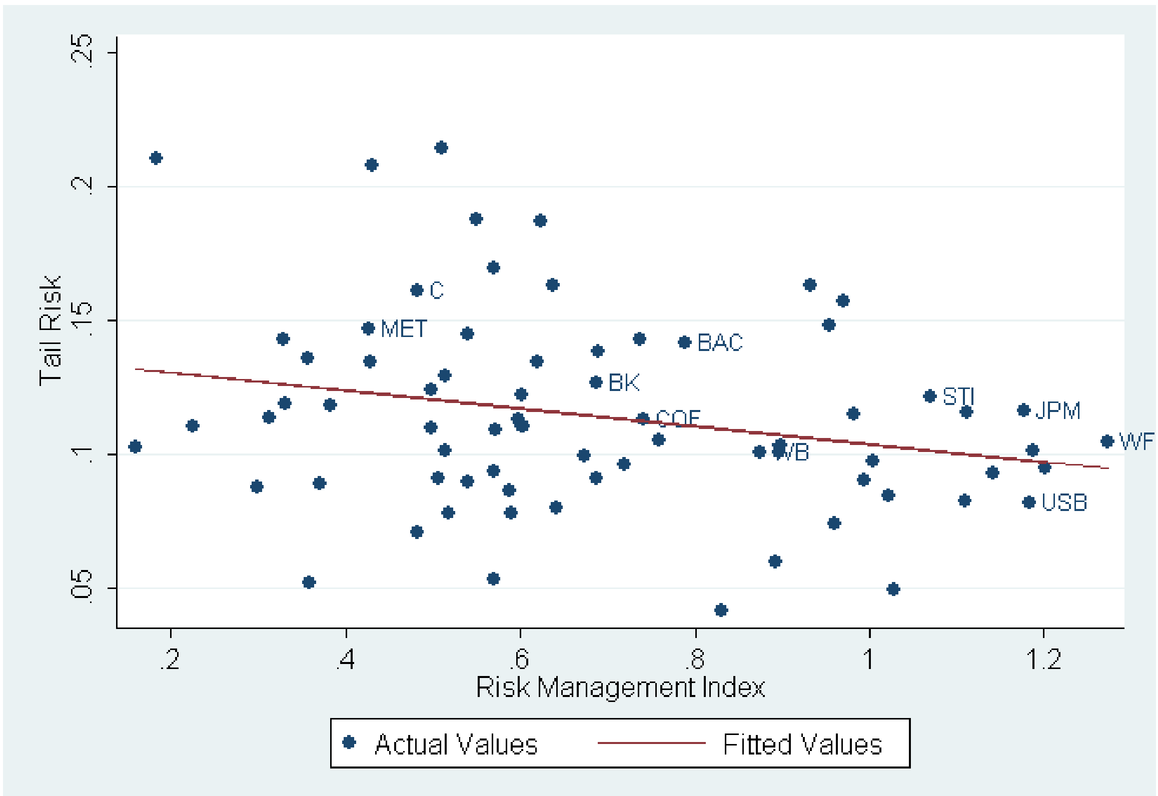

Table I: Summary Statistics

Panel A presents the descriptive statistics for the key variables used in our analysis. All variables are defined in Appendix B.

Panel B presents a univariate comparison of BHC characteristics between BHCs with high values of RMI versus those with low values of RMI. We define the dummy variable *High RMI* to identify, in each year, BHCs whose RMI is greater than the median value of RMI across all BHCs during the year. *High RMI*$= 1$ identifies BHCs with a high value of RMI, whereas *High RMI*$= 0$ identifies BHCs with a low value of RMI. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel C presents a year-wise distribution of the mean value of the Risk Management Index (RMI) and its components across all BHCs.

Panel A: Summary Statistics (Entire Panel)

	Mean	Median	Std. Dev.	p25	p75	N
Risk and Return Characteristics:						
Tail risk	0.047	0.038	0.033	0.027	0.052	989
Annual return	0.104	0.086	0.302	-0.070	0.273	989
Characteristics of the Risk Management Function:						
CRO present	0.806	1.000	0.395	1.000	1.000	1007
CRO executive	0.402	0.000	0.491	0.000	1.000	1007
CRO top5	0.205	0.000	0.404	0.000	0.000	1007
CRO centrality	0.313	0.303	0.124	0.216	0.403	1007
Experienced risk committee	0.307	0.000	0.461	0.000	1.000	1007
Freq. meetings risk committee	5.369	5.000	3.443	3.000	8.000	1007
Active risk committee	0.439	0.000	0.497	0.000	1.000	1007
RMI	0.595	0.555	0.282	0.398	0.808	1007
Financial Characteristics:						
Assets	84.615	11.588	258.522	6.167	42.032	1007
Size	16.631	16.266	1.586	15.635	17.554	1007
ROA	0.011	0.011	0.014	0.009	0.014	1007
Deposits/Assets	0.687	0.699	0.138	0.634	0.776	962
Tier-1 capital/ Assets	0.081	0.076	0.041	0.066	0.086	911
Loans/Assets	0.626	0.672	0.151	0.578	0.720	1007
Bad loans/Assets	0.008	0.005	0.011	0.003	0.008	1007
Non-int. income/Income	0.237	0.211	0.135	0.142	0.304	1007
Deriv. hedging/Assets	0.086	0.019	0.184	0.000	0.090	962
Deriv. trading/Assets	1.108	0.000	4.958	0.000	0.101	962
Governance, Ownership, and Compensation Characteristics:						
G-Index	9.252	9.000	2.963	7.000	11.000	934
Board independence	0.606	0.625	0.120	0.522	0.697	942
Board experience	0.179	0.152	0.114	0.088	0.235	946
Inst. ownership	0.393	0.373	0.247	0.178	0.596	898
CEO's delta (in $ '000)	0.012	0.004	0.022	0.002	0.012	525
CEO's vega (in $ '000)	0.123	0.041	0.243	0.014	0.116	496
CEO's tenure (in years)	8.049	6.000	6.792	2.000	12.000	636
Change in CEO	0.049	0	0.215	0	0	1007
Large M&A	0.215	0	0.411	0	1	989

Panel B: Univariate comparison of High vs. Low RMI BHCs

	High RMI = 0	*High RMI* = 1	Difference
Size_{t-1}	15.920	17.110	-1.198***
$\text{Annual return}_{t-1}$	0.122	0.120	0.002
Tail risk_{t-1}	0.044	0.040	0.004*
$(\text{ST borrowing/Assets})_{t-1}$	0.032	0.052	-0.020***
$(\text{Tier-1 capital/Assets})_{t-1}$	0.086	0.074	0.012***
$(\text{Bad loans/Assets})_{t-1}$	0.005	0.006	-0.001*
$(\text{Non-int. income/Income})_{t-1}$	0.214	0.248	-0.034***
$(\text{Deriv. trading/Assets})_{t-1}$	0.283	1.837	-1.555***
$(\text{Deriv. hedging/Assets})_{t-1}$	0.047	0.121	-0.074***
$\text{Inst. ownership}_{t-1}$	0.338	0.411	-0.074***
G-Index_{t-1}	9.359	9.093	0.266
$\text{Board independence}_{t-1}$	0.579	0.626	-0.047***
$\text{Board experience}_{t-1}$	0.183	0.173	0.009
$\text{Change in CEO}_{t-1}$	0.027	0.056	-0.030*
$\text{CEO's tenure}_{t-1}$	9.133	6.874	2.260***
$\text{Large M\&A}_{t-1}$	0.263	0.195	0.068*

Panel C: Year-Wise Distribution of RMI and its Components

Year	RMI	CRO present	CRO executive	CRO top5	CRO centrality	Risk comm. experience
1994	0.479	0.400	0.289	0.111	0.199	0.311
1995	0.472	0.420	0.280	0.120	0.206	0.420
1996	0.466	0.455	0.291	0.218	0.206	0.418
1997	0.466	0.518	0.304	0.214	0.206	0.411
1998	0.473	0.590	0.311	0.230	0.203	0.508
1999	0.478	0.609	0.406	0.266	0.256	0.453
2000	0.566	0.738	0.538	0.323	0.299	0.446
2001	0.617	0.818	0.515	0.303	0.332	0.500
2002	0.656	0.894	0.530	0.288	0.329	0.500
2003	0.683	0.909	0.545	0.318	0.348	0.394
2004	0.678	0.900	0.614	0.314	0.286	0.486
2005	0.681	0.915	0.634	0.296	0.282	0.493
2006	0.663	0.957	0.571	0.300	0.274	0.514
2007	0.644	0.972	0.486	0.278	0.258	0.542
2008	0.643	1.000	0.522	0.343	0.277	0.552
2009	0.729	1.000	0.645	0.435	0.305	0.565

Table II: Correlations among Key Variables

This table presents pair-wise correlations between *Tail risk*, *RMI*, *Size*, and other important BHC characteristics. Variable definitions are in Appendix B. We use the symbol * to denote statistical significance at the 10% level.

	Tail $risk_t$	RMI_{t-1}	$Size_{t-1}$
Tail $risk_t$	1.000		
RMI_{t-1}	-0.031	1.000	
$Size_{t-1}$	0.127*	0.498*	1.000
ROA_{t-1}	-0.253*	-0.008	-0.058*
(Tier-1 capital/Assets)$_{t-1}$	0.000	-0.084*	-0.180*
(Deposits/Assets)$_{t-1}$	-0.144*	-0.193*	-0.573*
(ST borrowing/Assets)$_{t-1}$	0.118*	0.176*	0.267*
(Bad loans/Assets)$_{t-1}$	0.453*	0.066*	0.095*
(Non-int. income/Income)$_{t-1}$	-0.072*	0.258*	0.481*
(Deriv. trading/Assets)$_{t-1}$	0.046	0.196*	0.501*
(Deriv. hedging/Assets)$_{t-1}$	0.030	0.296*	0.427*
Inst. $ownership_{t-1}$	0.263*	0.355*	0.509*
G-$Index_{t-1}$	0.036	-0.036	-0.049
Board $experience_{t-1}$	0.022	-0.046	0.064*
Board $independence_{t-1}$	0.087*	0.281*	0.204*
CEO's $tenure_{t-1}$	0.077*	-0.149*	-0.164*
CEO's $delta_{t-1}$	0.053	-0.151*	-0.272*
CEO's $vega_{t-1}$	0.153*	0.302*	0.501*

Table III: Determinants of RMI

This table reports the results of panel regressions that examine how a BHC's choice of RMI is affected by its financial, ownership, and governance characteristics. Definitions of variables are listed in Appendix B. In Panel A, we estimate the regression

$$\text{RMI}_{j,t} = \alpha + \boldsymbol{\beta} * X_{j,t-1} + \text{Year FE} + \text{BHC or Size decile FE}$$

We estimate the regression on a panel that has one observation for each BHC-year combination, and spans the time period 1995 to 2009. Column (2) repeats the regression in column (1) for the post-1998 period only. We include year fixed effects in all specifications, size decile fixed effects in column (3), and BHC fixed effects in column (4). Standard errors (reported in parentheses) are robust to heteroskedasticity. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel B reports the results of panel regressions examining how BHCs changed their RMI in response to their experiences in the 1998 Russian crisis. We estimate the regression on a panel that has one observation for each BHC-year combination, and spans the time period 1999 to 2009. Apart from *High tail risk 1998*, we control the regression in column (1) for the following BHC characteristics, but do not report the coefficients in order to conserve space: $Size_{t-1}$, $Size^2_{t-1}$, ROA_{t-1}, $Annual\ return_{t-1}$, $Tail\ risk_{t-1}$, $(Deposits/Assets)_{t-1}$, $(ST\ borrowing/Assets)_{t-1}$, $(Tier\text{-}1\ capital/Assets)_{t-1}$, $(Loans/Assets)_{t-1}$, $(Bad\ loans/Assets)_{t-1}$, $(Non\text{-}int.\ income/Income)_{t-1}$, $(Deriv.\ trading/Assets)_{t-1}$, $(Deriv.\ hedging/Assets)_{t-1}$, $Inst.\ ownership_{t-1}$, $G\text{-}Index_{t-1}$, $Board\ independence_{t-1}$, $Board\ experience_{t-1}$, $Change\ in\ CEO_{t-1}$, and $Large\ M\&A_{t-1}$.

In column (2), we estimate a first-difference specification which is similar to the specification in column (1), except that we first-difference the dependent variable and all the independent variables, with the exception of *Change in CEO* and *Large M&A*.

The empirical specification in columns (3) through (5) is similar to that in column (1) with the following differences: the dependent variable in column (3) is the increase in RMI over 1998 to 2000, and we control for all the BHC characteristics in column (1) for the year 1998 including size decile fixed effects; the dependent variable in column (4) is the increase in RMI over 2000 to 2003, and we control for all the BHC characteristics in column (1) for the year 2000 including size decile fixed effects; the dependent variable in column (5) is the increase in RMI over 2003–2006, and we control for all the BHC characteristics in column (1) for the year 2003 including size decile fixed effects.

Panel A: RMI and BHC Characteristics, 1995–2009

	RMI_t			
	(1)	(2)	(3)	(4)
Post 1999	0.236***	0.537***	0.441***	0.234***
	(0.085)	(0.183)	(0.130)	(0.060)
$Size_{t-1}$	0.150***	0.120***		-0.037
	(0.019)	(0.026)		(0.052)
$Size^2_{t-1}$	-0.074***	-0.098***		0.023
	(0.014)	(0.021)		(0.016)
ROA_{t-1}	4.290***	4.069	4.826*	1.594***
	(1.563)	(3.831)	(2.286)	(0.570)
Annual $return_{t-1}$	-0.022	-0.140**	-0.030	-0.027*
	(0.039)	(0.068)	(0.028)	(0.014)
Tail $risk_{t-1}$	-1.234	-4.206**	-1.205	0.538
	(0.751)	(1.850)	(0.910)	(0.384)
$(Deposits/Assets)_{t-1}$	0.345***	-0.000	0.420	-0.062
	(0.088)	(0.235)	(0.261)	(0.132)
$(ST\ borrowing/Assets)_{t-1}$	0.446	-0.613	0.464	-0.055
	(0.280)	(0.564)	(0.433)	(0.174)
$(Tier\text{-}1\ capital/Assets)_{t-1}$	-1.015**	-3.409**	-1.036	-0.891**
	(0.508)	(1.535)	(0.853)	(0.342)
$(Loans/Assets)_{t-1}$	0.150*	0.234*	0.133	0.030
	(0.080)	(0.140)	(0.141)	(0.115)
$(Bad\ loans/Assets)_{t-1}$	3.369	8.545**	2.639	0.111
	(2.117)	(4.053)	(1.886)	(0.798)
$(Non\text{-}int.\ income/Income)_{t-1}$	0.176*	0.236	0.084	-0.019
	(0.091)	(0.157)	(0.222)	(0.127)
$(Deriv.\ trading/Assets)_{t-1}$	0.007***	0.007***	0.003	-0.003
	(0.002)	(0.002)	(0.003)	(0.002)
$(Deriv.\ hedging/Assets)_{t-1}$	0.072	-0.090	0.037	0.032
	(0.113)	(0.132)	(0.239)	(0.053)
Inst. $ownership_{t-1}$	0.014	-0.014	-0.024	-0.006
	(0.049)	(0.087)	(0.095)	(0.048)
$G\text{-}Index_{t-1}$	-0.008***	-0.009	-0.006	-0.007
	(0.003)	(0.006)	(0.003)	(0.008)
Board $independence_{t-1}$	0.268***	0.097	0.242*	0.028
	(0.075)	(0.132)	(0.123)	(0.064)
Board $experience_{t-1}$	-0.239***	-0.406***	-0.239	-1.116**
	(0.072)	(0.121)	(0.229)	(0.432)
Change in CEO_{t-1}	0.048	-0.019	0.033	0.022
	(0.044)	(0.059)	(0.032)	(0.014)
Large $M\&A_{t-1}$	-0.037*	-0.063*	-0.029	-0.010

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Table continued...

	RMI_t			
	(1)	(2)	(3)	(4)
	(0.022)	(0.036)	(0.021)	(0.008)
CEO's $delta_{t-1}$		-0.873		
		(0.562)		
CEO's $vega_{t-1}$		0.193***		
		(0.054)		
CEO's $tenure_{t-1}$		-0.010***		
		(0.003)		
Constant	0.110	0.815***	-0.241	0.796***
	(0.103)	(0.276)	(0.222)	(0.182)
Observations	695	366	695	695
R^2	0.404	0.438	0.470	0.953
Year FE	Yes	Yes	Yes	Yes
Size decile FE	No	No	Yes	No
BHC FE	No	No	No	Yes

Panel B: Performance during 1998 Crisis and RMI in 1999-2009

	(1)	(2)	(3)	(4)	(5)
	RMI	ΔRMI	$\Delta RMI_{1998-00}$	$\Delta RMI_{2000-03}$	$\Delta RMI_{2003-06}$
High tail risk 1998	-0.075***	-0.009	-0.015	-0.063	-0.001
	(0.022)	(0.006)	(0.057)	(0.072)	(0.046)
Constant	0.283	0.001	0.122	0.330	-0.077
	(0.221)	(0.014)	(0.579)	(0.602)	(0.317)
Observations	570	549	37	48	55
R^2	0.480	0.270	0.834	0.301	0.357
Year FE	Yes	Yes	No	No	No
Size decile FE	Yes	Yes	Yes	Yes	Yes
BHC controls	Yes	Yes	Yes	Yes	Yes

Table IV: Pre-crisis RMI and Performance during the Crisis Years

This table reports the results of cross-sectional regressions that examine whether BHCs with high *Pre-crisis RMI* (defined as the BHC's average *RMI* over the years 2005 and 2006) fared better during the crisis years. We estimate the regression

$$Y_{j,t} = \alpha + \beta * \text{Pre-crisis RMI}_j + \boldsymbol{\gamma} * X_{j,2006} + \text{Year FE}$$

We confine this regression to the financial crisis years, 2007 and 2008. In columns (1) and (2), Y is *Private MBS* which denotes the total value of private-label mortgage-backed securities (in $ million) held in both trading and investment portfolios. In column (3), Y is *Deriv. trading* which is the gross notional amount (in $ billion) of derivative contracts held for trading purposes. In column (4), Y is *Bad loans/assets* where *Bad loans* include loans past due 90 days or more and non-accrual loans. In column (5), Y is *ROA* which is the ratio of income before extraordinary items to assets. In column (6), Y is *Annual return* which is buy-and-hold return on the BHC's stock over the calendar year. In column (7), Y is *Tail risk* which is the negative of the average return on the BHC's stock during the 5% worst return days for the BHC's stock over the year. Definitions of all other variables are listed in Appendix B. We control the regression for BHC characteristics in the year 2006, and include year fixed effects in all specifications. Standard errors (reported in parentheses) are robust to heteroskedasticity and are clustered at the BHC level. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Private MBS		Deriv. trading	Bad loans/Assets	ROA	Annual return	Tail risk
Pre-crisis RMI	-8.492*	-3.355	5.246	-0.019**	0.017***	0.330***	-0.029***
	(4.340)	(2.591)	(3.259)	(0.008)	(0.005)	(0.083)	(0.010)
$Size_{2006}$	8.171***	2.330***	-0.569	0.002	-0.003	-0.140***	0.004
	(2.120)	(0.633)	(0.661)	(0.001)	(0.002)	(0.045)	(0.004)
$Size^2_{2006}$		7.799***	10.340***	-0.001	0.001	0.048	-0.003
		(2.156)	(2.304)	(0.001)	(0.001)	(0.034)	(0.003)
ROA_{2006}	239.126*	176.456	-228.264	0.029		1.301	-0.201
	(141.879)	(108.001)	(142.778)	(0.217)		(4.548)	(0.517)
$(\text{Tier1 capital/Assets})_{2006}$	-85.291*	-58.127	75.824*	-0.004	0.313***	-0.602	0.002
	(50.721)	(36.732)	(41.437)	(0.055)	(0.037)	(1.336)	(0.149)
$(\text{Bad loans/Assets})_{2006}$	67.151	115.540	-92.799	2.934***	-0.562	-11.789	1.949*
	(171.065)	(114.816)	(174.255)	(0.962)	(0.379)	(8.559)	(1.040)
$(\text{Deposits/Assets})_{2006}$	-2.655	1.358	12.452**	0.021	-0.007	0.160	-0.033
	(8.054)	(6.339)	(5.726)	(0.025)	(0.010)	(0.229)	(0.022)
$(\text{Loans/Assets})_{2006}$	-11.342***	-7.756**	-5.035	-0.016	-0.014	-0.322	0.004
	(4.280)	(3.336)	(3.503)	(0.023)	(0.010)	(0.201)	(0.019)
Constant	18.854*	12.521*	-6.641	0.016**	-0.021***	-0.230	0.148***
	(9.748)	(6.805)	(5.825)	(0.008)	(0.005)	(0.173)	(0.016)
Observations	138	138	138	138	138	138	138
R^2	0.556	0.720	0.646	0.415	0.769	0.174	0.666
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table V: Relationship between Tail Risk and RMI

This table reports the results of panel regressions that examine the relationship between a BHCs' *Tail risk* and *RMI*. We estimate the regression

$$\text{Tail risk}_{j,t} = \alpha + \beta * \text{RMI}_{j,t-1} + \gamma * X_{j,t-1} + \text{BHC or Size Decile FE} + \text{Year FE}$$

We estimate the regression on a panel that has one observation for each BHC-year combination, and spans the time period 1995 to 2010. *Tail risk* is defined as the negative of the average return on the BHC's stock over the 5% worst return days for the BHC's stock during the year. All other variables are defined in Appendix B. We include year fixed effects in all specifications, size decile fixed effects in column (4), and BHC fixed effects in column (5). Standard errors (reported in parentheses) are robust to heteroskedasticity and are clustered at the level of the BHC. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Tail risk$_t$				
	(1)	(2)	(3)	(4)	(5)
RMI$_{t-1}$	-0.009**	-0.008**	-0.009**	-0.010**	-0.022**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.010)
Size$_{t-1}$	0.001	0.000	0.003		0.004
	(0.001)	(0.002)	(0.002)		(0.006)
Size$^2_{t-1}$	0.002*	0.003***	0.004**		0.007***
	(0.001)	(0.001)	(0.002)		(0.002)
ROA$_{t-1}$	-0.688***	-0.760***	-1.266***	-0.695***	-0.747**
	(0.187)	(0.203)	(0.177)	(0.208)	(0.283)
Annual return$_{t-1}$	-0.010***	-0.009***	-0.011**	-0.009***	-0.007***
	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)
(Deposits/Assets)$_{t-1}$	-0.006	-0.009	0.023	-0.014	0.040**
	(0.010)	(0.011)	(0.015)	(0.012)	(0.020)
(ST borrowing/Assets)$_{t-1}$	0.017	0.016	0.007	0.008	0.037
	(0.019)	(0.019)	(0.032)	(0.019)	(0.027)
(Tier-1 capital/Assets)$_{t-1}$	0.164***	0.192***	0.058	0.164***	0.226***
	(0.047)	(0.052)	(0.103)	(0.054)	(0.079)
(Loans/Assets)$_{t-1}$	-0.012	-0.021***	-0.022**	-0.024***	-0.031
	(0.007)	(0.006)	(0.011)	(0.006)	(0.021)
(Bad loans/Assets)$_{t-1}$	1.061***	1.156***	1.587***	1.125***	0.906**
	(0.250)	(0.267)	(0.505)	(0.261)	(0.423)
(Non-int. income/Income)$_{t-1}$	-0.005	-0.020*	-0.010	-0.023**	-0.048**
	(0.010)	(0.011)	(0.010)	(0.011)	(0.020)
(Deriv. trading/Assets)$_{t-1}$		-0.000***	-0.000***	0.000	0.000

Continued on next page...

Table continued...

	Tail risk$_t$				
	(1)	(2)	(3)	(4)	(5)
		(0.000)	(0.000)	(0.000)	(0.001)
(Deriv. hedging/Assets)$_{t-1}$		-0.001	-0.005	0.003	-0.001
		(0.005)	(0.004)	(0.005)	(0.006)
Inst. ownership$_{t-1}$		0.015***	0.015***	0.013***	0.018**
		(0.004)	(0.005)	(0.004)	(0.007)
G-Index$_{t-1}$		0.000	0.001	0.000	0.001*
		(0.000)	(0.000)	(0.000)	(0.001)
Change in CEO$_{t-1}$		0.003	-0.000	0.003	0.002
		(0.003)	(0.003)	(0.003)	(0.003)
Large M&A$_{t-1}$		0.002	-0.000	0.002	-0.002
		(0.001)	(0.002)	(0.002)	(0.002)
CEO's delta$_{t-1}$			0.025		
			(0.059)		
CEO's vega$_{t-1}$			-0.004		
			(0.003)		
CEO's tenure$_{t-1}$			0.000		
			(0.000)		
Constant	0.098***	0.096***	0.055***	0.110***	0.034*
	(0.012)	(0.014)	(0.015)	(0.015)	(0.018)
Observations	803	701	368	701	701
R^2	0.809	0.837	0.883	0.839	0.877
Year FE	Yes	Yes	Yes	Yes	Yes
Size decile FE	No	No	No	Yes	No
BHC FE	No	No	No	No	Yes

Table VI: Relationship between RMI and Performance

This table reports the results of panel regressions investigating the relationship between a BHC's performance and its *RMI*. We estimate the following regression:

$$\mathrm{Y}_{j,t} = \alpha + \beta * \mathrm{RMI}_{j,t-1} + \gamma * X_{j,t-1} + \mathrm{BHC\ or\ Size\ Decile\ FE} + \mathrm{Year\ FE}$$

In this regression, Y is a measure of the BHC's operating performance (in columns (1) through (3)) or stock return performance (in columns (4) through (9)). We measure operating performance using *ROA* which is the ratio of income before extraordinary items to assets. We measure stock return performance using the following variables: *Annual return*, which is the buy-and-hold return on the BHC's stock over the calendar year; and *Abnormal return* which is the difference between the actual *Annual return* and the expected return from a market model, where the market model is estimated by regressing daily returns on the BHC's stock versus a constant and daily returns on the S&P500 over the past three calendar years. *Crisis year* is a dummy variable that identifies the financial crisis years, 2007 and 2008. We also control the regressions for the following BHC characteristics, but do not report the coefficients in order to conserve space: $\textit{Annual return}_{t-1}$ (in columns (1) through (3) only), ROA_{t-1} (in columns (4) through (9) only), $\textit{(Deposits/Assets)}_{t-1}$, $\textit{(Tier-1 capital/Assets)}_{t-1}$, $\textit{(Loans/Assets)}_{t-1}$, $\textit{(Bad loans/Assets)}_{t-1}$, and $\textit{Non-int. income/Income}_{t-1}$. All variables are defined in Appendix B. We include year fixed effects and either size decile fixed effects or BHC fixed effects in all specifications. Standard errors (reported in parentheses) are robust to heteroskedasticity and are clustered at the BHC level. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	ROA_t			Annual $return_t$			Abnormal $return_t$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RMI_{t-1}	0.006**		0.007*	0.072**		0.037	0.075**		0.074
	(0.002)		(0.004)	(0.032)		(0.121)	(0.032)		(0.115)
Crisis year		0.008***			-0.295***			-0.731***	
		(0.002)			(0.036)			(0.041)	
RMI_{t-1}*Crisis year		0.010***			0.157**			0.147**	
		(0.004)			(0.073)			(0.072)	
RMI_{t-1}*(1-Crisis year)		0.005*			0.048			0.054	
		(0.002)			(0.035)			(0.035)	
Constant	-0.017***	-0.014**	-0.002	0.224***	0.263***	3.367***	0.645***	0.687***	2.963***
	(0.006)	(0.006)	(0.027)	(0.063)	(0.067)	(0.671)	(0.069)	(0.071)	(0.707)
Observations	805	805	805	804	804	804	803	803	803
R^2	0.726	0.728	0.802	0.523	0.525	0.565	0.572	0.573	0.605
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size decile FE	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
BHC FE	No	No	Yes	No	No	Yes	No	No	Yes
BHC controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table VII: Instrumental-Variables Regressions

Panel A reports the results of instrumental-variables regressions that examine whether BHCs with high *Pre-crisis RMI* fared better during the crisis years. We instrument for each BHC's *Pre-crisis RMI* using its *Comparable* $\Delta RMI_{1998-00}$, which is defined as the average increase in RMI over the period 1998 to 2000 for *all other BHCs* (i.e., excluding the BHC itself) in the size decile to which the BHC belonged in 1998. The regressions are estimated using the two-staged least squares (2SLS) estimator, and are confined to the crisis years, 2007 and 2008. The results of the first-stage regression are presented in column (1), whereas the results of the second-stage regressions are presented in columns (2) through (4). We control both the first- and second- stage regressions for the following BHC characteristics, but do not report these coefficients in order to conserve space: $Size_{2006}$, $Size^2_{2006}$, ROA_{2006}, $(Deposits/Assets)_{2006}$, $(Tier\text{-}1\ capital/Assets)_{2006}$, $(Loans/Assets)_{2006}$, and $(Bad\ loans/Assets)_{2006}$. Definitions of variables are listed in Appendix B. We include year fixed effects in all specifications. Standard errors (reported in parentheses) are robust to heteroskedasticity and are clustered at the BHC level. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel B reports the results of an instrumental-variables panel regression that examines the relationship between BHCs' $Tail\ risk_t$ and RMI_{t-1}. We instrument for each BHC's RMI_{t-1} using its *Comparable BHCs'* $\Delta RMI_{1998-00}$, which is defined as the average increase in RMI over the period 1998-2000 for *all other BHCs* (i.e., excluding the BHC itself) in the size decile to which the BHC belonged in 1998. The regressions are estimated using the two-staged least squares (2SLS) estimator. The results of the first- and second-stage regressions are presented in columns (1) and (2), respectively. We control both the first- and second-stage regressions for the following BHC characteristics, but do not report these coefficients in order to conserve space: $Size_{t-1}$, $Size^2_{t-1}$, $Annual\ return_{t-1}$, ROA_{t-1}, $(Deposits/Assets)_{t-1}$, $(Tier\text{-}1\ capital/Assets)_{t-1}$, $(Loans/Assets)_{t-1}$, $(Bad\ loans/Assets)_{t-1}$, and $Non\text{-}int.\ income/Income_{t-1}$. We estimate the regressions on a panel that has one observation for each BHC-year combination, and spans the time period 2001 to 2010. We include year fixed effects in the regression. Standard errors (reported in parentheses) are robust to heteroskedasticity, and are clustered at the BHC level. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Pre-crisis RMI and Performance During Crisis Years

	(1)	(2)	(3)	(4)
	RMI Pre-Crisis	ROA	Annual Return	Tail Risk
Pre-crisis RMI		0.018*	0.582**	-0.049*
		(0.010)	(0.271)	(0.027)
Comparable BHCs' $\Delta RMI_{1998-00}$	1.603***			
	(0.474)			
Constant	0.578**	-0.008	-0.583*	0.158***
	(0.259)	(0.010)	(0.326)	(0.027)
Observations	116	116	116	116
R^2	0.428	0.348	0.146	0.699
F-stat (p-value) of excluded instrument	12.83 (0.0005)			
Year FE	Yes	Yes	Yes	Yes
BHC controls	Yes	Yes	Yes	Yes

Panel B: Relationship between *Tail risk*$_t$ and *RMI*$_{t-1}$, 2001–2010

	(1)	(2)
	RMI_{t-1}	Tail Risk_t
RMI_{t-1}		-0.021*
		(0.012)
Comparable BHCs' $\Delta\text{RMI}_{1998-00}$	1.736***	
	(0.571)	
Constant	0.518*	0.097***
	(0.291)	(0.013)
Observations	524	524
R^2	0.420	0.840
F-stat (p-value) of excluded instrument	9.24 (0.0035)	
Year FE	Yes	Yes
BHC controls	Yes	Yes

Table VIII: Dynamic Panel GMM Estimation for the Relationship between Tail Risk and RMI

In this table, we report the results of the Arellano and Bond (1991) dynamic panel GMM estimator to investigate the relationship between *Tail risk*$_t$ and *RMI*$_{t-1}$. The model we estimate is

$$\text{Tail risk}_{j,t} = \alpha + \beta * \text{RMI}_{j,t-1} + \kappa_1 \text{Tail risk}_{j,t-1} + \kappa_2 \text{Tail risk}_{j,t-2} + \gamma * X_{j,t-1} + \eta_i + \epsilon_{it}$$

The model employs two lags of *Tail risk* as regressor variables; i.e., BHC characteristics that are lagged three periods or more are available for use as exogenous instruments. Apart from the variables reported below, we control the model for the following BHC characteristics, but do not report the coefficients in order to conserve space: *Size*$_{t-1}$, *Size*$^2_{t-1}$, *Annual return*$_{t-1}$, *ROA*$_{t-1}$, *(Deposits/Assets)*$_{t-1}$, *(Tier-1 capital/Assets)*$_{t-1}$, *(Loans/Assets)*$_{t-1}$, *(Bad loans/Assets)*$_{t-1}$, *Non-int. income/Income*$_{t-1}$, *Inst. ownership*$_{t-1}$, *G-Index*$_{t-1}$, *(Deriv. trading/Assets)*$_{t-1}$, *(Deriv. hedging/Assets)*$_{t-1}$, *CEO's delta*$_{t-1}$, *CEO's vega*$_{t-1}$, *Change in CEO*$_{t-1}$, and *Large M&A*$_{t-1}$. Variable definitions are in Appendix B. Standard errors are reported in parentheses. We use the symbols ***, **, and * to denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	Tail risk$_t$
RMI$_{t-1}$	-0.097***
	(0.014)
Tail risk$_{t-1}$	0.196**
	(0.092)
Tail risk$_{t-2}$	-0.335***
	(0.067)
Constant	0.189***
	(0.027)
Observations	338
Sargan χ^2	37.184
Sargan p-value	1.000
BHC Controls	Yes

Notes

[1]Comments from his special address delivered at the 44^{th} annual Conference on Bank Structure and Competition, held at the Federal Reserve of Chicago in May 2008.

[2]Stulz (2008) characterizes a failure of risk management as one of the following: failure to identify or correctly measure risks, failure to communicate risk exposures to the top management, and failure to monitor or manage risks adequately.

[3]The Senior Supervisors Group (SSG) is a group of supervisory agencies from France, Germany, Switzerland, the United Kingdom, and the United States.

[4]The inability of risk managers to restrain bank executives is highlighted by the experience of David Andrukonis, a risk manager at Freddie Mac, who tried to alert his senior management to the risks in subprime and Alt-A loans, but was unable to restrain them (see Calomiris (2008)).

[5]In this regard, our paper is related to the literature that examines whether executive compensation may have contributed to the risk-taking behavior of financial institutions in the lead up to the financial crisis. Fahlenbrach and Stulz (2011) find that CEOs with higher option/ cash bonus compensation did not perform worse during the crisis. On the other hand, Cheng, Hong, and Scheinkman (2011) find a correlation between total executive compensation, controlling for firm size, and risk measures.

[6]Consistent with hedging theories, Purnanandam (2007) shows that banks that face a higher probability of financial distress manage their interest rate risk more aggressively, both by using derivatives and by adopting conservative asset-liability management policies.

[7]We also create two additional risk measures, *Downside risk* and *Aggregate risk*; the results using these risk measures are shown in the internet appendix. The *Downside risk* measure is defined as the mean implied volatility estimated using put options written on the BHC's stock (Bali and Hovakimian (2009), Cremers and Weinbaum (2010) and Xing, Zhang, and Zhao (2010)). We obtain implied volatilities estimated from option prices from the OptionMetrics database. *Aggregate risk* is defined as the standard deviation of the BHC's weekly return over the calendar year (see Demsetz, Saidenberg, and Strahan (1997) and Laeven and Levine (2009)).

[8]In some of the smaller BHCs that are mainly oriented towards retail banking, the Chief Lending Officer or the Chief Credit Officer may be the official in charge of risk management. To ensure that we are not missing out on these alternative designations, we treat them on par with Chief Risk Officer while coding these variables.

[9]We exclude the CRO's stock and option awards while computing the *CRO centrality* measure because

it could be argued that a CRO with a high proportion of variable compensation will not have the incentives to restrain the risk-taking tendencies of executives and traders. We thank an anonymous referee for this suggestion.

[10]The reasoning behind using the CFO's compensation is that, in BHCs that do not have a designated CRO, the CFO is most likely in charge of risk management.

[11]We recognize that this procedure may potentially generate inconsistent factor loadings across the years in our sample. To investigate this potential problem, and to check the stability and robustness of our factors, we also use a principal component analysis where the loadings are determined over the entire sample period. The correlation between the loadings of the two principal components (one where the analysis is done annually and the other done over the entire sample period) is very high for all 6 factors (it ranges from 81% to 90%), giving us comfort about the stability of our analysis independent of how loadings are determined. Moreover, we obtain very similar results when we employ an alternative *RMI* where the factor loadings are measured over the entire sample period (see Table IA.III in the internet appendix).

[12]We obtain qualitatively similar results when we use the buy-and-hold return from August-December 1998 to identify the BHCs with the worst performance during the 1998 crisis. As Fahlenbrach, Prilmeier, and Stulz (2011) note, the 1998 crisis began in August 1998 but was fairly short-lived. Many bank stocks plummeted initially but then also recovered somewhat subsequently. Therefore, the August-December return is a reasonable metric to measure how BHCs fared during the 1998 crisis.

[13]We obtain qualitatively similar results when we use lagged BHC characteristics, instead of 2006 characteristics, as control variables.

[14]However, the findings in the empirical literature in this regard are somewhat mixed. Examining bank behavior during the period 1992–2002, Mehran and Rosenberg (2007) find that equity volatility and asset volatility of banks increase as their CEO stock option holdings increase. However, examining the behavior of banks during the crisis period, Fahlenbrach and Stulz (2011) find that option compensation did not have an adverse impact on bank performance.

[15]Specifically, the model that we estimate is $\text{Tail risk}_{j,t} = \alpha + \beta * RMI_{j,t-1} + \gamma * X_{j,t-1} + \mu_j + \mu_t + e_{j,t}$, where the error term $e_{j,t}$ is modeled as $e_{j,t} = \rho * e_{j,t-1} + z_{j,t}$.

[16]The fixed effects estimation is based on deviations of variables from their mean values for the BHC, which may introduce look-ahead bias because the mean value is computed over the entire sample period. The advantage of the first-difference specification is that it examines deviations of variables from their values in the previous period, and hence, is not subject to look-ahead bias.

[17]In the context of large financial institutions, it is particularly difficult to distinguish between idiosyncratic and systematic risk.

[18]The first-stage regressions are the same for all IV regressions in Panel A. Therefore, to conserve space, we only report the first-stage regression once.

[19]With one exogenous instrument, the first-stage $F-$statistic must exceed 8.96 for the 2-SLS inference to be reliable (see Table 1 in Stock, Wright, and Yogo (2002)).

[20]Again, the $F-$statistic of 9.24 is higher than the threshold of 8.96 specified in Stock et al. (2002), despite the fact that we have a small sample, and that we cluster standard errors at the BHC level (as we should).

[21]We use a simple average to define *Quality of oversight* because it is objectively difficult to figure out the relative importance of the *Risk committee experience* and *Active risk committee.* We obtain qualitatively similar results when we estimate the regression with all the six *RMI* components as separate regressor variables, instead of combining them into two categories. However, the interpretation of results is more meaningful with *CRO centrality* and *Quality of oversight* as the independent variables.