Modeling the Relation of Bank Governance and Risk Management

by

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Abstract

The Great Recession (2008-2010) highlighted the complexity of risk management and the global impact of accumulated risk. The complexity of risk management in bank holding companies (BHC, or banks) often results in a lack of transparency for stakeholders, thus affecting their decisions. This research aims to simplify this complexity to help consumers, investors, regulators, management, policymakers, and taxpayers understand how well a firm structures its risk function and manages it. The research methodology uses Principal Components Analysis (PCA) and regression analysis to study the impact of various factors on bank risk management and performance. The analysis process starts with a replication of work done by other researchers, and moves to using a large, aggregated set of variables to determine a variable subset that creates a more effective risk management index (RMI), then to regression analysis, and concluding with sensitivity analysis. Three alternative RMI models were created and analyzed. However, none of them proved to be effective replacements for the existing RMI model. The correlation between these RMIs and tail risk was inconsistent, in terms of both strength and direction. Regression analysis was performed on the entire forty-six element factor set against tail risk, default risk, and return on assets (ROA). The former model resulted in fourteen statistically significant variables and explained just over 22% of the variation in tail risk. The second model resulted in seventeen statistically significant factors and explained just under 60% of the variation in default risk. The third model resulted in seven statistically significant variables and explained over 74% of the variation in ROA. Finally, a sensitivity analysis of the selected models was conducted. The removal of certain variables significantly reduced the strength of the models, indicating the importance of these factors in explaining the variation in the respective models. In particular, the removal of Tobin's Q in the ROA model reduced the adjusted R^2 from 73.72% to 26.07%. Similarly, the removal of the real estate loans variable significantly reduced the strength of the default risk model, with a nearly 50% reduction in adjusted R^2.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Bank holding companies are parent organizations that own a bank or banks, but also other subsidiaries. BHC's can own commercial, retail, investment, and other bank types within their portfolio. The complexity of risk management and the inability of stakeholders to understand whether it is done well or is structured effectively results in a lack of transparency for BHC stakeholders, which can have negative impacts on their decisions related to firms. This complexity must be explained in a way that allows consumers, investors, regulators, management, policymakers, and taxpayers to understand how a firm structures its risk function as well as how carefully it manages it. We only have to look at a firm's annual report to see the complexity of the risk topic. Goldman Sachs 2020 Form 10-k (Annual Report) has 25 pages dedicated to risk factors (GS 2020 10-k, pp 26-51), and JP Morgan Chase, long considered a leader in risk management, dedicates a full 66 pages to discuss the various risks the firm faces (JPM 2020 10-k, pp85-151) and also discusses it in its 2021 Proxy statement.

The events leading up to the Great Recession (2008-2010) made it obvious that risk management is a complex topic, and that the impact of the accumulation of risk, and how ineffective understanding and monitoring risk leading up to this accumulation, triggered systemic issues that spanned the globe (Anna Katherine Barnett-Hart; "The Story of the CDO Market Meltdown: An Empirical Analysis;" March, 2009). Consumers, investors (creditors/shareholders) (Mohammed,

Knapkova, Procedia - Social and Behavioral Sciences 220 (2016), 271–277), regulators, policymakers, and taxpayers (Kaufman, Journal of Financial Stability 13 (2014) 214–223) all pay the price when risk management is not done well. There have been questions whether bank holding company boards have been unable to effectively monitor and control bank risk and whether bank holding company risk management systems have been adequate (Bebchuk and Spamann, 2009; Kashyap, Rajanand Stein, 2008; Kirkpatrick, 2009).

Failures in the banking system have highly negative economic impacts. In the US, unemployment reached a high of 10.8% in October of 2009 (Hurd, Bureau of Labor Statistics, 2018), the national Gross Domestic Product (GDP) contracted by 8.4% (Bureau of Economic Analysis, 2019), and the stock market lost $8 trillion in value (Merle, 2018). During the financial crisis US shareholders lost $10.2B (Kalwarski, 2009), 45% of worldwide wealth was destroyed (Davies, Siew, 2009). Three of the largest bankruptcies in history happened during this period (Pirson, Turnbull, 2011). In addition, well before the Great Recession and well after it, examples exist where the activity of individual employees resulted in significant firm losses. JP Morgan Chase absorbed a $5.8 billion dollar loss on the trades of one person. (Callahan, Soileau, 2017). Société Générale lost $4.44 billion (£3.7 billion) in January 2008 due to a single trader who had taken unauthorized stock futures positions. Barings Bank lost $992 million (£827M) in 1992 which led to the firm's failure and subsequent sale to ING in 1995. Diawa Bank (Japan) lost $1.1 billion from the unauthorized bond trading of one executive. UBS lost $2.3B (£1.48B) due to trading of one person based in the London investment banking unit in 2011. Failures of this magnitude as well as the inherent importance of banks in the overall financial system and the global interconnectedness of the banking system have resulted in a search for answers as to why corporate governance and risk

management performed poorly. Banking is a highly complex system and risk can be added to the bank holding company very quickly given the complicated nature of financial instruments, products and transactions that have been developed over the years. Risk impact is exacerbated by the high leverage levels that can be accrued in a short period of time. The speed at which a bank's risk profile can change makes it so that the view of risk is not immediately apparent to directors and other stakeholders (Becht, 2011). This complexity impacts stakeholder ability to understand the strength and quality of risk management and board governance which can have negative impacts on stakeholder decision making. Mehran, et al. (2011) and John, deMasi, Paci, (2016) point out that bank holding company governance is unique in that there exists an inherent conflict of interest between shareholders and the public, the highly regulated nature of the system, opacity, and complexity of bank holding company activities. Complexity, even if transparent, impacts ability to understand and manage (Ferrarini, 2015)

Bank holding companies are different as it relates to complexity because they can enhance their valuation by boosting performance through the increased use of leverage and taking on greater risk in the process. Leverage can amplify their returns, but this can significantly increase the level of risk being taken. This can be a good outcome for shareholders but can negatively impact the larger economy (Laeven, 2013). The types of financial instruments (products) that banks "produce" all add to the complexity of their environment. Add to this the heightened nature of regulatory oversight. Multiple agencies with overlapping jurisdictions add to the complexity of managing this industry.

The word "opaque" appears often when describing the complexity of banking. The quality of loans and other bank assets are not easily observed. This "opaque" situation makes it very

difficult for stakeholders outside the bank holding company to accurately assess the risk that banks carry. Consumers, investors (both individual and institutional), policymakers and regulators do not have direct line of sight on the risks the bank holding company carries. Another factor that contributes to the complexity of seeing and understanding risk levels for external stakeholders is the speed at which banks can change their risk composition. The impact of macroeconomic factors can substantially alter the value of assets. Likewise, these factors can significantly and quickly impact counterparties in transactions and their ability to function, rapidly increasing the risk profile potentially unbeknownst to directors, consumers, and other stakeholders (Fernandes, et al 2018); (Philippon, Reshef, 2012).

There needs to be a way to see how, and how well, bank holding companies are managing risk in order to make better consumer choices (should I bank with this firm?), better investment decisions (should I buy this bond [make this loan], stock, or funds that invest in it?), better regulations (how do we protect our financial system?), more effective operational decisions (how do we structure our management team, who should be invited to sit on our board, on our risk committee?) and more effective policy (how do we address firms in trouble, how best protect taxpayer interests?).

1.2 Research Goal and Objectives

A current problem in the banking industry is that stakeholders, including consumers, investors (creditors, shareholders), regulators, management, policymakers, and taxpayers do not have a clear view of how bank holding companies identify, structure, and manage the multitude of risks

they face in the course of doing business. In an effort to address this inability to see into the opaque world of risk management in bank holding companies (BHC), this research seeks to understand how the industry currently measures risk and to determine if there is a way to make these measures simpler and more effective for use by people outside the banks. There is a significant amount of literature about different factors that contribute to effective measurement (and reporting) of the quality and strength of risk management. There is much less literature examining the most effective combination of these factors to give a useful picture to those outside the bank. One approach to this problem has been to create an index made up of key factors that might give insight into the quality and strength of risk management structures in bank holding companies. The idea is to create a model, or index, which incorporates the most insightful factors together. The first objective of this research is searching for works in the literature of risk management index creation. Two relevant papers are Ellul and Yerramilli (2013) whose authors developed an index for US BHC's, and Magee and Wright, et al. (2015) where the index extended that work in looking at Australian BHC's.

The second objective of this research is to measure BHC risk management by creating an index that represents or captures the impact of elements from several facets of risk management. The research assembles factors into the following "buckets": Board of Directors (BoD) factors, Director specific factors, Risk Committee (RC) factors, Chief Risk Officer (CRO) specific factors, 'activity factors and quality/value factors. The study will determine which factors are most influential and associated with better risk management in US bank holding companies. With this understanding, the third objective is to determine the impact of improved risk management on bank holding company risk outcomes as well as bank holding company performance.

1.3 Research Methodology

The research methodology involves testing the original Ellul and Yerramilli work using a post crisis data set to evaluate if their suppositions about their Risk Management Index (RMI) holds in a different time period. Next, it identifies a larger set of additional factors from the multiple papers in the field and uses this pool of factors to create a new index and tests if this new index might be a more effective tool. Following this, an alternate approach to important factor identification using regression analysis is completed to create a new model. Finally, sensitivity analysis on the regression model is conducted to see the individual impact of each factor on Tail Risk.

The following questions are answered in this research:

Q1: Does the RMI proposed by ELLUL AND YERRAMILLI correlate to tail risk in a different time period?

Q2: Does including other factors improve the RMI correlation to tail risk?

Q3: If Q2 is negative, does other methodology identify factors that influence tail risk?

Q4: If Q3 is negative, can another risk measure be identified that is highly influenced by additional factors?

Q5: Do governance and risk variables influence bank holding company performance (ROA)

1.4 Contributions

This work contributes to the literature in three ways. First, it recreates earlier work to comment on the effectiveness of Ellul and Yerramilli's 2013 RMI model in a different time period. Second,

the study tests the impact of additional variables on the RMI model, and subsequently on risk metrics and also bank holding company performance. Third, the research creates a model that can be used by consumers, investors, regulators, management, policymakers, and taxpayers to understand effectiveness of risk management structures and to gauge BHC risk management strength (quality), thus helping all to make better decisions. There appears to be no other study that has used as comprehensive a variable set to examine which factors have the most impact on risk management (via RMI), risk taking (via TR, DR), or performance (via ROA).

This research helps consumers both directly and indirectly. It directly impacts their decision making relative to investment choices both in banks but also other investments that might be affected by the performance of bank holding company's and the impact of that performance on the global financial system. Consumers are impacted indirectly by the actions of another set of stakeholders, namely policymakers. As policy is created in response to the performance of banks, this impacts the consumer because it impacts the global financial system. This research helps investors of all sizes but especially institutional investors whose decisions impact governments domestically and globally via sovereign wealth funds, pension funds and corporate entities that invest and manage cash balances for example. This research helps shareholders in the same ways. While shareholder interests are not always in alignment with those of consumers (Main Street) and investors, in this case their desire to measure the strength and quality of board governance and risk management aligns with other stakeholders. Bank holding company leadership can be seen as an internal shareholder and as such would benefit from a potential better means of measuring the strength and quality of their own board governance and risk management function. Lastly, policymakers will benefit from this research on which factors are

important to risk management and by extension what the potential optimal settings are for these factors so it can help them to write useful and impactful policy. Policy that focuses on the right factors can help provide stability in the financial system and potentially prevent or at least mitigate the impact of crises. Bottom line, good policy is important at all times for the stability of the global financial markets. This work is useful to future academic researchers as it contributes to the field of study of board governance and risk management specific to financial institutions and in doing so highlights the gaps that exist in this field of research. It also may help to clarify some of the contradictions that exist in the literature as to what factors are important and which are not.

1.5 Organization of the research

The rest of the dissertation is organized as follows. Chapter 2 includes a review of the literature on the topic of risk management quality/effectiveness and strength, as well as the work done around risk management index creation. It describes the RMI work that has been done by Ellul and Yerramilli, Magee, Wright, et al. and others. It details the research the comprehensive factor list came from and is used to address the research questions. Chapter 3 describes the research methodology used to understand the impact of the various variables in the process through which the most impactful factors are determined. Chapter 4 is the actual analysis of the data using the methodology from chapter 3. Chapter 5 discusses conclusions and suggests further lines of research from the findings of both chapter 4 and chapter 2.

CHAPTER 2

LITERATURE REVIEW

2.1 History/Background of Risk Management

Banks in the United States have been struggling with risk management since the first chartered bank proposed by Alexander Hamilton in 1782 (Murdock, 2012). In the mid-1800's, risk management pertained to the use of insurance used to protect an asset, an individual, or to give a company protection. In 1864, the market sees the first futures contract written at the Chicago Board of Trade, to hedge risk to agricultural products. In the early 20th century, risk management is still largely reactive in focus, and seeks to mitigate the outcome of events. In 1932, the Journal of Risk and Insurance begins publication. In the early 1970's, futures contracts on currencies are written at the Chicago Mercantile Exchange to hedge the risk associated with differences and volatility in currency valuation globally. In the early 1980's, the market introduces complex products like exotic options, swaps, and derivatives. These products are meant as risk management tools. In the 1980's, the US markets endured high volatility, which spurred large US investment banks to put in place risk management departments. Merrill Lynch created the first risk management department in 1987. Companies began incorporating risk management into strategic planning and broadened their view of risk in the early 1990's to now consider financial/portfolio, operational, reputational, and strategic risks. This resulted in the early stages of an integrated approach to risk management. Financial institutions, including bank holding

company's and insurance companies, intensified their market risk and credit risk management activities. In the late 1990's operational risk and liquidity risk emerge and are added to the portfolio of risks to be managed.

The first significant company level impacts of poor risk management are experienced (e.g., Orange County, California, 1994, Baring Bank, 1995). International regulation of risk begins. Financial institutions developed internal risk management models and capital calculation formulas (e.g., RiskMetrics, CreditMetrics) to protect themselves from unanticipated risks and reduce regulatory capital. Governance of risk management became essential, integrated risk management was introduced, and in 1993 the chief risk officer (CRO) position was created in the marketplace at GE Capital. In the early 2000's, the approach to risk management becomes more comprehensive and begins to include emerging risks like cyber risk and emphasized organizational culture in risk management. (Dionne, 2019)

2.1.1 How risk management fits into the organization

The role of the risk management function is to identify, evaluate, monitor, advise, and communicate about the risks of all types that face the organization. Corporate governance is typically operationalized within companies through a set of internal structures including the board of directors, board committees (like the risk management committee), and the management team. Internal functional units related to risk, including internal audit and risk management, which contribute to internal control systems and reporting functions. External

elements that contribute to corporate governance include regulators, governmental agencies, external auditors, and shareholders.

2.1.2 What makes banks different and why RM is therefore different

Risk management at the corporate level is a complex activity because of the variety of factors that influence it. Risk management in banking is further complicated by a number of factors. Banking as an industry is highly complex. Banks offer the market a complex set of products while also maintaining an inventory of complex assets. Products that are used to hedge the variety of risks are by their nature very complex. Additionally, bank holding companies operate in a complex regulatory environment. There are multiple agencies at the national and state level with unclear boundaries as to who regulates or supervises what function resulting in overlaps. Legislative bodies also contribute to this as they seek to impose regulatory parameters to keep both the financial system and the consumer safe from harm. The industry faces complexity because of the inherent conflict amongst the goals of the different stakeholders (Adams, Mehran, 2012). Regulators, shareholders, and depositors have different outcome goals. Regulators and depositors focus on the safety of the bank, whereas shareholders and management will aim to maximize the bank holding company's performance and therefore its value. These conflicting goals can influence the structure of the board, the risk committee, and those selected for those roles. The desired outcomes cascade down into day-to-day operations and influence the amount of risk that the bank holding company will take and the decisions that are made. Complexity exists as well due to the structure of the domestic banking system, further complicated by the high interconnectedness with the international banking systems. Market activities change at

lightning speed making it exceptionally difficult for bank holding company management, specifically risk management, to have a clear and up-to-date view of the risk profile of the bank. Micro and macro-economic factors impact bank operations, changing the risk profile of the bank holding company without the bank having to make any transactional changes. Asset values respond to conditions in the market, regardless of whether the bank has made any change to the asset. While regulatory requirements for reporting have been imposed, and shareholders demand for information has required reporting, there is an opacity in banking that obscures timely and full disclosure of activities and risk-taking activity.

2.1.3 The risks managed by banks

At its most basic level, risk is defined as the possibility that an event outcome will not match its expected outcome which could lead to the loss of something valued. There are a very large set of potential risks faced by banks. There is not one definitive list of risks that all banks need to oversee. Nor is there a standard definition of each of these risks. The Office of the Comptroller of the Currency (OCC), a significant regulator in this industry, defines eight categories of risk for bank supervision purposes: credit, interest rate, liquidity, price, operational, compliance, strategic, and reputation. (OCC, 2019 Comptrollers Handbook). In Goldman Sachs 2022 annual report there are thirty-seven risk factors discussed within ten broad categories, taking up twenty-six pages of the report (GS, 2022, pp. 28-54). Some of the more common risk types include:

Systematic or market risk is the risk of asset value change that is associated with systemic factors, also called market risk as it is associated with market factors. This risk is driven by broad market

or economic factors. This type of risk potentially impacts all investors that are in the market. Within the market risk is interest rate risk, the risk of a decline in net interest income due to a change in interest rates. *Foreign exchange risk* is the risk of a change in the value of foreign currencies relative to the home currency and its potential impact on asset valuation and income. *Commodity price risk* is the risk of pricing changes and the impact of these changes on asset values, expenses, and income. *Industry concentration risk* is the risk that comes from an overweighting of assets related to a specific industry; for instance if a firm invests heavily in electric vehicle battery companies. This risk can be related to the number of holdings but also can be related to the size of holdings. The size of holdings can change without any action on the part of the bank and as reaction to market activity. *Country risk* is similar and relates to the concentration of activity with or in a specific country. (Santomero, 1997). *Credit risk* is related to failure on the part of a borrower. This risk affects the lender who holds the loan contract and may also impact those who lend to or transact business with the creditor who holds the loan. Where this becomes problematic is when it creates deviation from the expected value of assets within the portfolio. *Counterparty risk* pertains to non-performance by a trading partner. This differs from credit risk in that the counterparty failure may come from factors other than credit issues and can be from a transient situation. Another way this can be a risk is when an organization has a large concentration of transactions with one or a very small number of other parties. *Liquidity risk* pertains to a disruption in funding. It is usually associated with some type of unexpected event. Liquidity, which is the ability to transform assets into cash, itself can be viewed as an asset to the bank, so the risk is to operations as well as assets. *Operational risk* is associated with failure in some aspects of the operations of the bank. It could take the form of operational problems

with processing, settling, taking/making delivery on trades, record keeping problems, compliance failures or the acts of individuals (cyber-attack, phishing, etc.). *Compliance/Legal risk* can be defined or experienced in two ways. The 1st is related to contracts and contractual language. Changes to law, legislation, tax rules can impact agreed upon contracts and potentially impact agreed upon transactions. The 2nd is related to the actions of the organization's management and/or employees. Fraud, breaking the law or disregarding regulatory guidance can put the firm in legal jeopardy. *Idiosyncratic risk* is a risk associated with a particular investment within the organization's portfolio of investments or assets and is a subset of total risk. *Reputational risk* relates to the intangible asset associated with the reputation of the firm. Brands have value, and trust in the reputation of an organization to be who they say they will be and do what they say they will do is critically important in the financial industry where trust and confidence are important. Any activity that damages the reputation of the firm puts the firm at risk because it can impact current transaction flow and asset valuation as well as future activity and relationships. *Default risk* is associated with the probability that an entity will be unable to meet its obligations. At the bank or counterparty level this risk measures the probability that liabilities will exceed assets and that the organization will default. *Model risk* is associated with the impact of incorrect or faulty models used to model risk. Assumptions made in the building of risk (or operational or economic) models can oversimplify highly complex and interrelated economic factors resulting in a model that does not truly represent the environment.

Risk is an evolving field, as we see with the introduction of contagion risk (Harle, et al, 2016), which is a risk related to association. One firm's connection to another firm can create risk if one of the firms is in financial distress, likewise among firms in a sector or country. *Contagion risk* is

the risk that what is impacting one firm may "infect" other firms. To monitor these various risks, banks have determined several metrics of interest. For this dissertation, there is a narrow set of risk related metrics that data was collected for. *Tail risk* (TR) is the probability that an asset performs well below or well above its average past performance, defined as 3 standard deviations below (above) the average expected return. Risk managers are most concerned with tail risks that fall to the left side of the curve indicating a negative 3 standard deviation observation below expected return. TR is calculated as the negative of the average return on the BHC stock during the 5% worst return days for that stock over the year. *Downside risk* relates to the probability that an asset will fall in value, specifically measured by the mean implied volatility over the year estimated from put options written on the BHC stock. *Aggregate risk* is the risk across the portfolio and is calculated as the standard deviation of BHC return over the year. Total risk measures the aggregation of systemic (e.g., risk carried by an entire class of assets) and unsystematic risks (e.g., risks unique to a specific investment in the asset class, also known as idiosyncratic risk) in a company portfolio and is measured by the standard deviation of daily stock returns. *Market risk* is a measure of the probability of a risk to asset (liability) value due to factors impacting the overall market. It is a measure of a firm's contribution to overall systematic risk, also known as beta in the capital asset pricing (CAPM) model. *Idiosyncratic risk* is the risk associated with the specifics of an asset or asset class, also known as unsystematic risk. This risk is important to firms because it can contribute to volatility and alter asset values. *Default risk* (DR) is the probability of insolvency of the bank. It is measured by z-score (Laeven, Levine 2009), with a high z-score indicating that the bank is more stable, or further away from insolvency. The z-score uses accounting measures (in this dissertation bank activity measures) in its calculation. It

is important because firms with a higher probability of failure tend to have higher costs of borrowing (get charged higher interest) to compensate lenders for the higher failure risk and influence valuation and performance. The basic principle of the z-score measure is to relate a bank's capital level to variability in its returns so that one can identify how much volatility in returns can be absorbed by the bank's capital without the bank becoming insolvent (Hafeez, et al., 2022). Works including Beltratti and Stulz (2012), Houston, et al. (2010), and Laeven and Levin (2009), include default risk as a dependent variable in their analysis of governance characteristics. It is common in literature to use the z-score to measure bank risk, examples include Maudos (2017), Uhde and Heimeshoff (2009), Ravi and Ravi (2007). The higher the z-score ratio is, the greater the distance to default and, consequently, the lower the risk profile of the bank; conversely, the closer the z-score is to zero, the higher the risk and the greater the probability of default. The z-score is calculated as follows:

$$z\text{-}score_{i,t} = (ROA_{i,t} + CAR_{i,t}) / \sigma(ROA)_{i,t}$$

where $ROA_{i,t}$ represents the return on assets of bank *i* in year *t*, $CAR_{i,t}$ denotes the ratio of capital/equity to total assets and $\sigma(ROA)_{i,t}$ is the standard deviation of the return on total average assets (Afaneh, 2023). Additional research using z-score includes Drakos et al. (2016), Khan et al. (2017), Skala and Weil (2017) and Afaneh (2023). Switzer and Wang (2013) relate governance variables to the probability of default over time, for a broad spectrum of US banks, including commercial and savings banks. They extend their research (2018) and study default risk and governance factors using an international panel of banking firms.

2.2 Factors that influence risk management

This dissertation expands the set of factors being analyzed by aggregating these to see which combinations of factors, across clusters, have greatest influence on the strength and quality of risk management in bank holding companies. While the idea of creating a large set of factors may not be statistically useful on the surface, it is a starting point from which we can then reduce the number of factors across multiple segments to find that set of factors that might be combined to create an index that allows multiple stakeholders to better insight into the quality and strength of risk management at a bank, with the ultimate goal to help all stakeholders make better potential decisions about the BHC related to risk management. This dissertation is the first to aggregate factors into clusters in this way and analyze the impact across these facets.

Factors that pertain to that structure of the board indicate at a high level how the firm seeks to provide its monitoring and advising functions. Board independence relates to measuring either the number of, or percentage of, the entire board who are considered independent directors. An independent board member or director is someone not employed by the company and who has no financial interest in it. This factor is seen as important because the general thinking is that individuals who are not tied to the bank will bring outside perspective and are free and clear of any bias, can exercise their judgment freely and may reduce the possibility of conflicts of interest. There is conflicting evidence related to the impact of the board's independence and risk measures. For instance, there is research that shows that the total number of independent directors is negatively correlated to bank risk measures (Pathan, 2009). In this work, they show that the more independents there are, the worse the risk measures perform. Erkens (2012) shows no significant relationship with risk measures, in their study they looked specifically at default risk

or equity risk and yet Vallascas, et al. (2017) show that board independence is positively correlated with bank risk taking, meaning the more independent the board, the better the risk profile of the bank. The studies focused on US banks that incorporate board independence as a factor look at different time periods (pre, during, and post financial crisis) and the research does not focus on a single risk measure. Due to these differences in time frame and metrics it is easy to see why the research outcomes are inconsistent. Regardless of this inconsistency it is a factor that bears study as it is a contributor to the makeup of boards in banking. It is a factor that can be "set" by the organization and so it can be controlled. Several regulators in this industry, including the OCC, FDIC, and SEC, have developed requirements and/or guidance related to bank board independence because it is seen as an important factor. International bank policymakers emphasize the importance of bank board governance characteristics like board independence ("Enhancing Corporate Governance in the Banking Industry," BCBS, 2006, 2010) as an important part of risk management.

The busyness of the board of directors is measured by the number of or percentage of directors who have more than one board of director appointment outside of the bank. This factor is considered important for a couple of reasons. On one hand, it is seen that a board member who has appointments on other corporate boards will bring a diverse thought process and a different perspective to the bank board. On the other hand, this is an important factor because there is a line of thinking that says that busy board members can be distracted by their commitments to these other boards and may not perform their monitoring function as well as someone with fewer to no outside board appointments. The research that includes this board busyness shows inconsistent results. Some show that busy directors reduce bank risk, (Cooper, Uzun, 2012) while

others like (Elyasiani, Zhang, 2015) show that a busy board results in poorer risk management (but better performance). Regardless of the inconsistency in the literature, this is another board of director factor that can be set and is controlled by the organization. Since it can be set and is under their control, its impact needs to be studied. Some of the reported inconsistencies can be attributed to the definition of the measure and by how that busyness and its impact is measured. There is significant research related to the impact on performance of busy independent board members related to Fortune 500 firms. The results are inconclusive in this space, with some work showing that firms with board members who have multiple external directorships can be seen as being distracted from their board work, thus "rending them ineffective monitors of corporate governance" (Fich, 2006) This work speaks to the growing trends that while investors may give positive weight to and applaud the value outside directors with multiple board appointments bring, some of the research shows that firms with such busy outside directors suffer poorer performance. Fich's work studied the effect of a board being busy, in different industries, not just banks. Elyasiani and Zhang (2015) show a positive impact to bank performance of busy board members, as does the work of Aebi et al. (2012).

Board experience is related to the number of people or the percentage of the total who have experience in finance or banking. Seen as important because understanding of the industry can bring perspective that can assist with the complexity of the environment, the products, and the economy. The question here becomes is the board skilled enough technically to understand the nature of the different types of risks as well as understanding the analysis that illustrates the banks' exposure to risk. Minton's work (2014) shows a positive correlation between this experience and risk taking. Fernandes and Fich (2009) show that an increase in finance

experience, specifically banks with more financial experts serving as outside directors, have lower risk exposure (and better performance). The thing about this expertise question is that it is seen as potentially positive due to the insight that the expertise brings and the help that that brings in the monitoring role of the board. Expertise potentially allows the directors to better assess and monitor what is going on risk related in the organization. At the same time though there is discussion in the research that this expertise might not be as useful in the advising role. For example, expertise may lead to over confidence and result in a board that advises higher risk taking or capital allocation decisions that have higher risk.

There is a significant amount of literature on bank board size and performance but few studies that explicitly investigate how a firm's risk-taking is related to board size. Size of the board of directors is important because it is another factor that can be set by the organization and is worth study because the number of voices that are monitoring the organization and advising the operational management team would be expected to impact the performance of the leadership team. The work by DeHaan and Vlahu, (2016) shows that board size is negatively related to risk taking (but board size is positively related to performance) and discusses the impact on both the advisory role of board as well as the monitoring role of board. Likewise, Wang (2012) finds that board size has negative impact on firm's risk taking which is in line with Pathan and Faff's (2013) work. What is found in this work is that when boards are smaller, they tend to put more of the risk of decisions on the executive leadership team and CEO, which can lead to higher risk taking (due to potentially misaligned incentives). Research on board size produces a different line of thinking in that larger boards are inefficient and therefore not able to adequately monitor and advise on risk taking.

Board member characteristics are collected and studied. At the individual level, the work by Adams (2012) indicates that that an individual who is independent of the company does a better job in the monitoring function but is less effective in the advising role. Pathan's work (2009) has novel findings in that individuals who are independent on the board may be more effective on boards because of the personal reputational risk associated with poor performance of the bank. Individuals seek to maximize their directorships from a personal reputation perspective and so may be more effective as monitors. Individual director busyness comes up in the work by Nguyen et al. (2015) A factor that has not been found to be studied in the literature and is original to this work is the risk experience of individual directors. In contrast, there is work found on individual director financial experience. This line of research produces ambiguous results. On the one hand research shows that lower levels of financial industry expertise weakly influenced good performance (pre-crisis), it definitively resulted in poor bank performance (Minton, et al., 2014) during the 2008-2010 crisis; Minton posits that the difference in findings may be due to the difference in how they measure this expertise. Minton uses the percent (fraction) of independent board members classified as financial experts, but other research (Kirkpatrick, 2009) and (Fernandes, Fitch, 2009) shows it has a positive impact

Fernandes and Fich (2023) suggest that outside directors who have gained financial expertise due to long tenure on bank boards (at their own bank, vs those whose expertise came from service on another financial institution) limited risk exposure and had better performance in the timeframe studied. Industry expertise on the positive side could be that they understand the industry and the trends and the products, especially complex products within banking. On the downside expertise might make these directors overly confident in their knowledge and may

create blind spots around industry direction. Also, there might be inefficient communication because there are assumptions about others' knowledge of the industry. Another characteristic not found in other literature is the impact on risk management or performance when an individual comes to the board of directors with regulatory experience. Including this factor is another contribution of this dissertation.

Research exists on the previous level of education of the individual board member. Gray and Nowland (2013) completed work that connects director effectiveness as measured by prior experience as a director to stock performance. While their findings relative to their main objective does not add to this work, it is compelling to see the results of their well-developed analysis of the education level of directors and its impact (it's important to note this work was focused on firms in Australia). Positive correlation is shown to stock performance for undergraduate and masters (to include MBA) level, but the opposite is shown for law degrees and PhD. Berger, et al (2014) develops director education and its impact on bank performance with work focused on German banks and is related to education at the PhD level, showing that increasing the number or proportion of executives with this terminal degree reduces portfolio risk. While not focused on the US market, the identification of education as a factor and its impact on risk management is validated. This dissertation includes this educational factor but instead of looking at the board, it looks at the education of the Chief Risk Officer (CRO).

Section 165 of the Dodd-Frank Act (2010) requires the establishment of a separate risk committee. It also requires at least one member of this committee to have risk management experience. Another requirement is that the risk committee meet regularly. The regulation was introduced in 2010 but was not required to be fully implemented until 2015. This dissertation

studies the existence of a stand-alone risk committee as well as the makeup of the risk committee of the board. Factors studied in this cluster add value due to the specific risk focus of the committee and its regulatory requirements. The characteristics of the members impact the strength and quality of the overall risk management function of the bank holding company. The stand-alone risk committee requirement is for the purpose of aggregating an understanding of risks across the enterprise. This committee has the goal of holding line units accountable for their risk management as well as monitoring the performance of the organization pertaining to the optimal risk profile of the firm. Balasubramanyan (2019) and Stulz, et al. (2021) show that the existence of a stand-alone risk committee does not reduce bank risk. In contrast, Jiang (2023) found that the establishment of a risk committee reduced bank risk, as measured by total risk, tail risk, residual risk, and asset risk. The formation of the standalone risk committee results in a reduction in non-performing loans as well as an improvement in firm profitability. The difference in these research outcomes is partly explained by differences in research methodology and samples (e.g., size of bank in the study).

Independence of risk committee members was studied by Mongiardino and Plath (2010) and their work looked specifically at the impact of three factors (dedicated risk comm, majority independent, CRO as executive). Jiang (2023) looks at the number of independent directors on the risk committee with results indicating that more who are independent reduces risk for the firm. Activity level of the risk committee, measured by the number of meetings held, is found to positively impact risk metrics – the more risk meetings, the lower the risk (Jiang, 2023) . Ellul and Yerramilli define Active Risk Committee in their 2013 work as a categorical value indicating if the number of RC meetings is above the average for the firms in the year and gives another view of

the impact of committee activity on management of bank risk taking. The experience of RC members relates to their expertise in their field. Factors focused on risk committee member expertise in both finance and risk management (% risk committee with prior risk management experience, Risk committee experience related to Finance, Risk committee experience related to risk management) are studied. The impact on risk taking related to the size of the risk committee is reported on in Jiang (2023) showing that larger risk committees result in a reduction of risk. An analysis of the literature around the characteristics of the chief risk officer adds value because the person in the role sets the tone for the risk culture in the firm. The existence of a CRO shows conflicting results, with some research showings negative correlation to firm performance (insurance) Grace, et al. (2015) while research conducted by Balasubramanyan (2019) indicates no impact to bank risk.

Work done by Aebi, et al (2012) shows the existence of a CRO has a positive correlation to bank performance. The CRO having a position as an executive officer was studied by Aebi et al (2012) and like Ellul and Yerramilli's 2013 research shows this factor has a positive correlation to performance. The reporting line for the CRO is studied to see if reporting to the board or reporting to the CEO impacts performance. CRO reports to the board, (Aebi, et al., 2012) shows stronger bank performance than when the CRO reports to the CEO, with Grace, et al. (2015) showing similar impact, albeit in the insurance field. Ellul and Yerramilli's original work addresses several CRO specific factors, including CRO Top Five paid, and CRO Centrality. While there is research on director education, the impact of education of the chief risk officer and the performance of banks lacks research. This dissertation contributes to this literature by examining two variables related to CRO education. We include CRO education level which is a categorical factor measuring

whether the CRO holds an undergraduate, master's or terminal degree. An original contribution to this area of research is the inclusion of a variable indicating the focus of that education (finance/business or other). King's (2016) work on education and implications on bank performance focuses on CEO education level and the "sensitivity of bank performance to the level and quality of CEO educational attainment" and creates an education index and relates that index to bank performance. King's findings are that educational level and educational quality have an impact on bank performance. Banks led by CEOs with master's in business administration (MBA) outperform others. Nguyen's work (Nguyen et al, 2015) focuses on executive directors and the performance of U.S. banks and finds that age, education, and work experience of executives is positively correlated or "performance relevant". Afaneh's work (2023) does extensive analysis on the impact of several CRO characteristics (Presence, power, qualifications, tenure, and gender) and the impact of these characteristics on both risk and performance. The work also studies risk committee factors (existence, size, independence, activity, and qualifications) and their impact on risk and performance, showing no significant association between these qualifications and risk or performance. Education is a relevant factor because studies in psychology show that education level is connected to cognitive ability and decision-making skill (Jensen, 1998). "Education is often seen as a proxy for cognitive ability" (King, et al., 2016). Research has also shown a link between the educational background of executives and the performance of their firms (Finklestein, Hambrick 1996). The research shows that the firm results depend to some level on the type and level of education of the firm's executives.

The type of activities the bank participates in is related to both bank performance and risk taking. According to work done by Kashyap, short term borrowing (Kashyap, 2010) contributed to the

financial distress of firms during the Great Recession. Berger's 2016 work studied the impact of ownership structure, CEO compensation and management structure on bank failure probability during the crisis period. In (Berger, et al. 2016), the authors introduce "accounting measures of bank risk" and while the paper is focused on drivers of bank failures, it is a wide-ranging look at how accounting measures (which this paper clusters into bank activity factors) are important measures for study. The work includes bank activity factors equity capital/assets, loan concentrations, non-performing loans/assets among others as well as deposit types. This work also includes five distinct indicators of bank risk, which they describe as risk channel variables. Work by DeYoung, R., and Torna, G. (2013) shows non-interest income, another bank activity factor, as a contributing factor in bank failure, as well as correlation between percentage of non-performing loans and bank failures.

The final cluster of factors in this dissertation are considered quality/value factors. Quality of oversight measures include the G-index, a proposed measure of board governance quality. This index was created in Gompers (Gompers, et al., 2003) 2003 work through an analysis of 1500+ firms across industry types using 24 governance measures, rating firms' corporate performance using the index. The G-index is used as a measure of the quality of governance. The work in Landier, et al. (2013) brings into their research a small number of more common factors discussed earlier (e.g., size of board, percentage of independent board members), but also include the G index. Landier et al study the effect of these factors against several performance factors like firm size (book value of assets) and ROA, among others. The work studies internal governance versus performance and shows that firms perform better when internal governance measures are positive (e.g., more independent directors, etc.) as well as firm decision making as measured by

acquisitions. Tobin's Q is a measure of a firm's value. It is a framework for comparing market valuation as a firm adds products and is widely used as a measure of firm performance. It is not a financial performance measure, per se, like an ROA, so it is used in this dissertation to measure the quality of management. It is included due to the complex nature of bank products and their impact on valuation. Singh, et al (2017) show positive relationship between Tobin's Q (also known as the Q ratio) and board size among other variables. Singh's team studies banks in the then emerging Pakistani market. Minton et al (2017) study the relation between Tobin's Q and three different risk measures.

2.3 Risk management index

There is much research on segments of bank risk (e.g., credit risk, operations risk, etc.) but very little on creating a risk index that measures overall risk management quality. Groundbreaking work in bank risk indexing research was done by Andrew Ellul and Vijay Yerramilli and motivates my research on this topic. In their work, Ellul and Yerramilli created an innovative Risk Management Index comprised of six factors and associated this index with tail risk. They select tail risk because of their stated belief that the risk management function exists to mitigate the risk of large losses, otherwise measured by tail risk (Ellul and Yerramilli, 2013). Their dataset consists of seventy-two publicly traded bank holding companies in the US (BHC's) representing 78% of all banking assets (by book value) in the US system for the 1994 to 2009 time period. (Ellul and Yerramilli, pg.1759) They collect two sets of variables, characteristics about the Chief Risk Officer (CRO) and characteristics about the Risk Committee. They complete a Principal Component Analysis and using six variables (CRO Present, CRO Executive, CRO Top %

compensation, CRO Centrality, Experienced Risk Committee, Active Risk Committee) calculate their Risk Management Index. They find a robust negative correlation between RMI and Tail Risk. They find a contradictory correlation between RMI and ROA between the crisis years and noncrisis years.

Additional risk management index research is completed by Magee, et al. (2015) who take a similar approach to Ellul and Yerramilli's work, only they use 159 banks across thirty-three countries, not including the US. They use four factors to create their Risk Governance Index (RGI). CRO Executive, Risk Committee manpower (risk comm size to bod size) risk comm independence, Risk Comm experience. They conduct a Principal Component Analysis to calculate RGI, then use regression analysis to understand influential factors. Their work confirms Ellul and Yerramilli's findings, but only during the years of the financial crisis. Their work indicates there is no correlation between RGI and tail risk during the post crisis years (Magee, et al. 2015). Lingel and Sheedy construct a Risk Governance Index (RGI) in order to test the Ellul and Yerramilli model in an international setting, with 60 organizations across 17 countries in the 2004-2010 time frame. Their research includes collecting data on multiple variables (the general to specific strategy), but through PCA and regression analysis they narrow their list down to only four factors to include in their RGI. Their results mirror Ellul and Yerramilli's findings, but only for the years of the financial crisis (Lingel, Sheedy, 2012).

2.4 Problem statement

This dissertation analyzes risk management in banking by taking pre- and during crisis RMI analysis into the non-crisis period to analyze ongoing effectiveness. Also, where previous work primarily focuses just on the correlation between factors and bank performance, this work contributes analysis to risk taking and performance. This dissertation contributes to the research by clustering factors and understanding the relative importance of each cluster to risk taking by banks. Additionally, previous works are very narrowly focused research efforts using small sets of factors. This work expands the factor base to give a wider view of factors that impact risk management and bank performance. It is in line with the findings of Srivastav and Hagendorff (2016) in their extensive literature review where they point out that "extant research has largely looked at the impact of governance on bank risk by looking at a select few governance mechanisms in isolation". Their review identifies "blind spots" in the research by this narrow approach and follows in line with DeHaan and Vlahu's (2016) work that finds most studies ignore multiple variables across multiple clusters and that the extant research instead focuses on specific elements in isolation and not the potential impact and interdependence of multiple elements together (DeHaan, Vlahu, 2016).

CHAPTER 3

RESEARCH METHODOLOGY

The research methodology includes the use of the statistical technique called Principal Components Analysis (PCA). This methodology is frequently used because of its ability to identify possible trends and patterns in large complex data sets, where it is often hard to see anything due to the number of variables, for example correlations between the substantial number of data elements for a large set of BHCs. This technique was used by Ellul and Yerramilli, Magee, et al. and Afaneh in their related analyses.

3.1 Principal Components Analysis

PCA is a data analysis tool used to extract relevant information for a diverse multi-dimensional data set. This analysis technique shows how to "reduce a complex data set to a lower dimension" (Schlens, 2014). It is a technique which uses sophisticated underlying mathematical principles to transform several possibly correlated variables into a smaller number of variables called principal components (Richardson, 2009). PCA is also a way to identify patterns in a data set and express the data in a way to highlight its similarities and differences. It also allows for compression of the data by reducing the number of dimensions, all without losing much information about the data (Smith, 2002).

3.1.1 Benefits of Principal Component Analysis

According to (Bharadiya, 2023), the benefits of PCA are:

- Dimensionality Reduction: PCA helps in reducing the dimensionality of high-dimensional datasets by identifying a smaller set of principal components that capture the most important information in the data. This reduces computational complexity, memory requirements, and improves algorithm efficiency.
- Feature Extraction: PCA can extract meaningful features from complex datasets, allowing for better understanding and interpretation of the underlying data structure. It helps in identifying the most influential variables or features contributing to the variation in the data.
- Noise Reduction: PCA can effectively filter out noise and irrelevant variations in the data by focusing on the components with the highest eigenvalues. It helps in improving the signal-to-noise ratio and enhances the performance of subsequent analysis or modeling tasks.
- Visualization: PCA enables the visualization of high-dimensional data in a lower-dimensional space. By projecting the data onto a reduced set of principal components, it allows for the visualization of clusters, patterns, and relationships in the data, aiding in exploratory data analysis.
- Multicollinearity Detection: PCA can identify and address multicollinearity issues in datasets, where variables are highly correlated. It helps in identifying linear dependencies among variables and provides a more independent set of components.

3.1.2 Limitations of Principal Component Analysis

The work of (Bharadiya, 2023) also identifies some limitations of PCA:

- Linearity Assumption: PCA assumes that the data is linearly related to the principal components. If the underlying data has complex nonlinear relationships, PCA may not capture all the relevant information, and other nonlinear dimensionality reduction methods may be more appropriate.
- Loss of Interpretability: While PCA reduces the dimensionality of the data, the resulting principal components are usually combinations of the original variables, making their interpretation less straightforward. The interpretability of the transformed features may be challenging, especially when dealing with a large number of components.
- Sensitivity to Outliers: PCA is sensitive to outliers in the data, as outliers can disproportionately influence the estimation of principal components. Outliers can distort the resulting variance-covariance structure and affect the quality of dimensionality reduction.
- Information Loss: PCA aims to capture the most important information in the data, but there is inevitably some loss of information during the dimensionality reduction process. The lower-dimensional representation may not fully retain all the details and nuances present in the original data.
- Selecting the Number of Components: Determining the optimal number of principal components to retain is a subjective decision. Choosing too few components may result in significant information loss, while retaining too many components may lead to overfitting or unnecessary complexity in the data representation.

3.2 Regression Analysis

An alternate methodology used in this work is linear regression, which is a widely used statistical technique for finding relationships between explanatory variables and a main dependent variable of interest. This technique is used in this work to estimate the effects each of the variables in the large factor set has on tail risk, default risk and ROA. Stiroh (2006) uses this method in their work on determinants of bank risk in US BHC's for the 1997-2004 time period. Bakar and Tahir (2009) use linear regression in their research on bank performance in Malaysian banks. Similarly, Martinez-Malvar, Baselga-Pascual (2020) use regression to confirm variable selection in their study identifying factors influencing risk for commercial banks in Latin America. Tran, et al (2020) use multiple regressions to analyze bank characteristics in commercial banks in Vietnam. Erkins, Hung, Matos (2012) use regression analysis to tie bank performance to corporate governance factors during the financial crisis. King, Srivastav, Williams (2016) use regression analysis to study bank governance factors and bank performance. Aebi, Sabato, Schmid use regression analysis in their work studying risk management, corporate governance, and bank performance in the financial crisis (2012). Florio and Leoni (2017) use regression analysis for the identification of governance factors that impact bank performance.

3.3 Risk Management Index (RMI)

RMI conceptually is an important concept as it seeks to simplify the highly complex risk management environment. Work in this area seeks to bring multiple factors together into one single number that simplifies the highly complex and tightly interconnected factors that influence

bank risk management. The goal in creating an index is to give stakeholders a single data point with which to make decisions about banks and the strength and quality of the bank's risk management function. Ellul and Yerramilli (2013) focused on creating a simple index from a handful of risk management factors. They analyzed seventy-two publicly listed bank holding companies (BHCs). Their RMI work used data for the 1994-2009 timeframe. Their main risk measure was Tail Risk. They gathered data on seven characteristics of the Risk Management function, 10 Financial Characteristics, and 9 Governance, Ownership and Compensation characteristics. They conducted a PCA to find the principal component of their top 6 Risk Management function characteristics, which they then use to calculate the index. To check if their RMI remains effective in a different time period, the model is tested in Chapter 4 using a post crisis data set.

3.4 Factor Set

With the purpose of analyzing factors for a more effective index, a larger factor set from multiple papers in the field is considered. Forty-six distinct data elements have been identified from various research papers. Three bank performance metrics and eight risk metrics are also collected. These factors are grouped in 6 clusters, including Board Factors (variables related to characteristics of the whole Board of Directors), Director Factors (variables that describe characteristics of the individual board member), Risk Committee Factors (variables that describes characteristics of the Risk Committee), CRO Factors (variables that describe attributes of the Chief Risk Officer), Bank Activity Factors (variables that describe financial characteristics of each

BHC), and Quality/Value Factors (variables that describe the quality of governance or bank valuation).

Table 1. Board/Director Factors.

Board Factors	
Board independence	Proportion of independent directors on the board of directors (%). Independence = no employment or other financial ties to the organization
Busy board	A categorical factor (0, 1) that takes the value of 1 if 50% or more of the board's outside directors are considered busy. Busy = holding three or more external board appointments
Board experience	Percentage of independent directors on the board of directors that have prior banking or financial industry experience (%)
Experienced board	A categorical variable (0, 1) that takes the value of 1 if board experience for the bank is higher than the average value across all banks in that year
Percent of independent board members with prior risk experience	Percentage of independent directors on the board that have prior risk management experience at a different company (%)
Board size	Natural log of the number of directors on the board

Board age	Average age of the directors on the board (Years)
<u>Director Factors</u>	
Number of independent directors	Number of members of the board who have no employment or other financial ties to the organization.
Fraction of busy independent directors	Percent of independent directors considered busy (%)
Number of busy independent directors	Number of independent directors who are considered busy
Number of independent directors with prior finance experience	Count of independent directors with prior finance experience
Number of independent directors with prior risk experience	Count of independent directors with prior risk experience (#)
Regulator experience	Percent of individuals that have experience on a regulatory body prior to joining the board (e.g., SEC, OCC, etc.). (%)
Director quality	Percentage of all directors (independent or otherwise) on more than one external S&P 500 firm board appointment (%).

Table 2. Risk Committee/Risk Officer Factors

Risk Committee Factors	
Risk committee independence	Number of directors on the risk committee that are independent.
Risk committee meetings	Number of times the bank risk committee met during the year.
Active risk committee	A categorical variable (0, 1) that takes the value of 1 if the frequency with which the banks risk committee met during the year is higher than the average meeting frequency across all banks during that year.
Risk committee experience	A categorical variable (0, 1) that takes the value of 1 if at least one independent director on the risk committee has prior banking or financial industry experience.
Risk committee risk experience	A categorical variable (0, 1) that takes the value of 1 if any risk committee member has prior external risk experience.
Percent of risk committee with risk experience	Percent of risk committee members that have prior risk management experience (%).
Number of risk committee with prior risk experience	Number of risk committee members with prior risk experience.
Risk committee size	Number of members on the risk committee
Dedicated risk committee	A categorical variable (0, 1) that takes a value of 1 if the bank has a dedicated committee

	solely charged with monitoring and managing the risk management efforts within the bank.
Quality of oversight	Simple average of risk committee experience and active risk committee as defined by Ellul and Yerramilli's 2013 research.
<u>CRO Factors</u>	
CRO Present	A categorical variable (0, 1) that takes a value of 1 if the bank has designated a chief risk officer.
CRO Executive	A categorical variable (0, 1) that takes a value of 1 if the CRO is an executive officer of the bank.
CRO Report To	A categorical variable (0, 1) indicating if the CRO reports to the board (1), otherwise reports to the CEO.
CRO Top 5	A categorical variable (0, 1) with a value of 1 if the CRO is among the five highest paid executives of the bank.
CRO Centrality	Ratio of the CRO's total compensation (excluding stock options) relative to the CEOs total compensation (%).
CRO Change	A categorical variable (0, 1) with a value of 1 if the CRO had changed in that year.

CRO Tenure	Length of time the CRO has served the firm in the CRO role (years).
CRO Education Level	A categorical variable (1, 2, 3) indicating level of education of the CRO; 1: bachelors, 2: masters, 3: terminal degree.
CRO Education Focus	A categorical variable (0, 1) indicating if the CRO education is in finance or business (1) or a non-business major.

Table 3. Activity/Quality Factors.

Bank Activity Factors	
Deposits to assets	Ratio of total deposits to assets (%)
Core deposits to assets	Ratio of core deposits to assets where core deposits include deposits held in domestic offices of the subsidiaries of the bank, excluding all time deposits over $100,000 and any brokered deposits (%)
Non-core deposits to assets	Ratio of (total deposits-core deposits) to assets (%)
Loans to assets	Ratio of total loans to total assets (%)
Real estate loans to assets	Ratio of loans secured by real estate to assets (%)
Commercial & industrial loans to assets	Ratio of commercial and industrial loans to assets (%)
Consumer loans to assets	Ratio of consumer loans to assets (%)

Agricultural loans to assets	Ratio of loans to agricultural entities to assets (%)
Other loans to assets	Ratio of all other loan types to assets (%)
Percent of non-performing loans	Ratio of the sum of loans past due 90 days or more to assets (%)
Short term borrowing to assets	Ratio of short-term borrowing to assets of the bank (%)
Non-interest income	Ratio of noninterest income to total income (%)
<u>Quality/Value Factors</u>	
Tobin’s Q	Ratio of the firm's market value to its book value of assets (%)
G index	An index with twenty-four equally weighted elements used to measure firm performance
Tier 1 capital to assets	Ratio of a bank's tier 1 capital (the primary funding source of the bank and consists of shareholders' equity and retained earnings) to assets (%)
Size	Natural logarithm of book value of total assets for the bank

3.5 Methodology

For this research, data was collected on bank holding companies (BHC) in the United States in line with the work of Ellul and Yerramilli. It was intended that this research would use the same seventy-two banks from the Ellul and Yerramilli study, but due to mergers, bankruptcies, etc., not all the same banks exist in their original form. Twenty of the banks in the original analysis, accounting for twenty-seven percent of the original list, merged with other banks through purchase or Federal Reserve action. Four percent of the banks in the original study failed or were closed by regulators. This research uses data collected for sixty two banks, resulting in 620 bank-year observations. The sixty two banks in this research represent sixty-seven percent of total US banking assets in 2010 dollars. Data was collected from a variety of data sources, using the Wharton WRDS database, and including the SEC's EDGAR database, ISS database (formerly known as RiskMetrics), BoardEx, Execucomp, the Chicago Fed database, CRSP, OptionMetrics database, and Compustat.

Bank holding companies are parent organizations that own a bank or banks, but also other subsidiaries. BHCs can own commercial, retail, investment, and other bank types within their portfolio. The BHC structure allows the parent organization to spread risk between its subsidiaries, but it also allows for risk to be added to the portfolio based on the assets, liabilities and products offered by the subsidiaries and adds to the complexity of the organization. Focusing on bank holding companies allows for a broader view of the banking sector. The focus is on U.S. banks because of the advanced nature of the American banking system and regulatory structure and the prominence of the United States in the global marketplace. This analysis focuses on the post crisis time period 2010- 2019. This period has not been studied as deeply as the pre and

during crisis time period. This time period also is pre-COVID19 which was highly disruptive to bank operations and performance.

The dissertation methodology consists of a four-step analysis. In the first step, EY's work is replicated by running a PCA analysis using EY's original factors (CRO present, CRO executive, CRO Top 5, CRO Centrality, Risk comm exp, and active RC) but this time using data from 2010- 2019 in an effort to verify if this original work holds in a new post crisis time frame. The PCA is conducted to get load factors for each of these six variables. The load factors are then used to calculate the RMI for the post crisis data set. The RMI is analyzed against tail risk (TR) using scatter plots as well as correlation/matrix plots. This analysis is conducted for the entire data set (all 10 years) as well as for each year and compared to the results that Ellul and Yerramilli published to determine time frame to time frame continuity. This step answers research question Q1.

Research question (Q1): **Does RMI correlate to tail risk for the time period 2010-2019?**

The second step consists of using the large, aggregated set of variables to determine a variable subset that creates a more effective RMI. Three PCA analyses are conducted for the 2010 - 2019 time period using all forty-six variables in the data set to identify potentially influential factors which might be combined to create a more effective RMI, but with different selection criteria. In the first PCA, load factors from PC1 and PC2 are analyzed. Six variables are identified and selected and included in the new model. The selection criterion is any load factor above 0.250 (the largest six load factors, regardless of cluster). Six factors are selected in order to align with Ellul and

Yerramilli work as well as to result in an RMI that is similar in scale and size to the work by Ellul and Yerramilli.

The second PCA uses a different variable selection process, but the same initial PCA load factors. One variable per cluster is selected to include in the calculation of the RMI. The variable with the largest load factor in each *cluster* is selected. The load factor indicates the weight or amount of influence of that variable. One factor per cluster is stipulated to ensure each facet of the research is included in the analysis. PCA is re-run using just these six variables and the output used to calculate the RMI. A correlation analysis of RMI versus tail risk is conducted. The third PCA analysis consists of selecting six variables using information from a review of the literature and not related to each cluster but the same initial PCA load factors. The PCA uses just these six factors and the output to calculate the RMI. This set of steps answers research question Q2.

Research question (Q2): Does including other factors improve RMI correlation to tail risk?

In the third step of the methodology, regression analysis is used in a manner like McGee et al. Regression analysis for variable impact is the more widely used and accepted methodology than the Risk Management Index approach proposed by Ellul and Yerramilli. After completing the RMI analysis approach, the research shifts analysis approach to regression utilization to identify factors that impact risk and performance of banks. Regression analysis is a statistically useful econometric technique that models the relationship between a set of independent explanatory variables and a dependent variable of interest. This phase of the analysis furthers the work of identifying variables that influence tail risk, default risk, and ROA. PCA is considered an

unsupervised analysis, meaning the process analyzes only the variables themselves, whereas regression is considered a supervised analysis, meaning that it considers variables relative to a dependent variable (StackExchange). Using the original large data set, regression analysis is conducted against the independent variable tail risk. All forty-six factors are included in the initial regression as independent variables to identify a set of variables of statistical significance. A second regression analysis is conducted using just the subset of statistically significant factors as dependent variables against independent variable tail risk to further reduce the variable set to those with the most statistical significance.

Research question (Q3): If Q2 is negative, does another methodology identify factors that influence tail risk?

E/ Y original work selected tail risk as the most impactful risk to shareholders. Reviewing the literature and considering the wider stakeholder set, I propose that stakeholders are more concerned with default risk, which is the risk that the entity is unable to meet its obligations. Tail risk is known as Black Swan risk, the risk of a massive, unexpected loss, the once in a 100-year major loss. While this is a significant risk to measure and monitor, risk that is related to the possible failure of the bank on an ongoing basis is very important to stakeholders. The risk that the organization fails or is unable to continue operations due to default is significant to all stakeholders. Given that reputation and trust are critical to the confidence stakeholders have in an individual bank or the banking sector as a whole, anything bank activity that might result in a default would have a negative impact on bank performance. This thought process introduces a new analysis approach that is not seen in the literature - regression analysis using the large

variable set as independent variables against the dependent variable default risk (DR). Default risk is an estimate of the number of standard deviations below the mean that bank's profits would have to fall to make the bank's equity negative (Fiordelisi, et al., 2013). Higher values of z-score indicate low probability of insolvency and signals greater bank stability (Afeneh, 2023). The wide use of the default risk measure comes from its relative conceptual simplicity as well as the ease of its calculation due to its use of accounting information (bank activity factors). Research indicates it can predict bank failure seventy six percent of the time (Chiaramonte, 2016). While drivers of bank failure are not the point of this research, this research finding validates its use as a risk measure of importance. "Assessment of bank default risk is important not only from an investor's viewpoint but also for risk managers analyzing counterparty risks and for regulators gauging the risk of bank failure. " (Nagel, 2020).

Research question (Q4): If Q3 is negative, can another risk measure be identified that is highly influenced by additional factors?

Several researchers who study the impact of governance variables on risk management also study how these factors impact BHC performance, from the approach that bank risk taking contributes to bank performance. Ellul and Yerramilli (2013), Lingel and Sheedy (2012), Magee (2015), Gontarek and Belghitar, 2018), and Afaneh (2023) all include analysis of risk taking on the performance of banks. Return on Assets (ROA) is the main performance metric used for those analyses. Given this other work and its potential connection to risk governance, regression analysis is conducted using the entire set of 46 factors against the dependent variable return on assets (ROA) to understand factor impact on bank performance. A second regression is

completed, including in the model those factors that are statistically significant. The refined model, using the reduced variable set from this initial regression process indicates the impact of these variables on ROA.

Research question (Q5) Do governance and risk variables influence bank performance (ROA)

The fourth analysis entailed conducting sensitivity analysis on the model from step three. Sensitivity analysis is used to identify individual factors that impact model effectiveness. The sensitivity of the dependent variable to factors in the model gives stakeholders an understanding of factors that strengthen or improve the model or those that reduce its effectiveness. This information should inform the monitoring and advising actions of the risk and governance functions of the bank. The information gained from sensitivity analysis impacts the risk profile of the bank and can give stakeholders insights to make better investment or operational decisions.

CHAPTER 4

ANALYSIS AND RESULTS

This section delves into the collected data to uncover insights related to the research questions. Through this examination, we provide interpretation of the analysis that explains the underlying dynamics of the research findings.

4.1 Overall Descriptive Statistics of the Data

Descriptive statistics for the forty-six variables in the data set are computed and shown in Table 4. For variables in the Board cluster, Board Independence is up eight percent, indicating organizations continue to value external experience but not at a much greater rate. Eighty-three percent of banks in the study have board membership that is considered independent. Busy Board decreased forty two percent for the ten-year period, but in year by year analysis there is no trend, with the percentage up one year and down the next year. The decrease indicates that overall firms put less value on board members having external board appointments. Board experience variable showed no significant change, indicating that organizations value financial expertise on the board but not at an increased rate. Seventy-five percent of boards have members reporting financial experience, again suggesting that this expertise is valued on boards. The percentage of independent board members with prior board risk experience surged over 220% for the ten year period. Fifty-four percent of board members now bring risk experience to

their board member role. Board Age has not increased or decreased significantly with an average age of 63 years. Likewise, the board size has not changed significantly.

Factors related to the characteristics of the people who sit on BHC boards indicate one development of note. The variable Regulator Experience is up forty eight percent over the period with approximately eight percent of boards having some type of regulator experience in their membership. This is a new variable not studied in detail in other literature and indicates that firms value adding members who understand the regulatory environment and what the regulators that they will work with are testing for.

Factors related to the Risk Committee characteristics show many changes. The size of the risk committee has increased almost fifty percent, which signals that organizations realize that more people focused on this critical topic is beneficial. This increase is in line with the significant increases in the percentage of individuals on the risk committee with risk experience, which advanced two hundred sixty percent by the end of the period. While the increase is significant, the percentage of risk committee members with risk experience is reported at only just over ten percent, which indicates that this expertise had not become deeply embedded in organizations in the researched time period. The risk committee member financial background increased just under two hundred fifty percent in the period. Risk committee meetings are down fifteen percent, indicating that while there are more members focused on risk they are meeting less regularly. The decrease in meetings is seen steadily over the ten-year period. Risk committee independence is up fifty five percent, suggesting that organizations value external perspective on the risk committee. Organizations that have a standalone dedicated risk committee is up thirty

eight percent, with ninety four percent of organizations having a standing committee focused on risk management.

Analysis of the factors in the CRO cluster show a thirty seven percent increase in organizations naming a chief risk officer or having a position whose sole focus is on the risk management of the firm, with over eighty six percent of firms have a dedicated risk officer. The measures that indicate the importance of the CRO role to the organization have experienced declines in this time period. The CRO as an executive officer is down just under three percent, and while this number is lower, seventy five percent of organizations have the CRO as an executive. CRO Centrality is down just over seven percent, as is CRO Top 5 paid (down four percent), with only twenty-five percent of organizations placing the CRO in the top five of pay. CRO Reports to Board increased seventeen percent for the period with eighty seven percent of organizations having that reporting arrangement and less than twenty percent of CRO's reporting to the CEO. CRO Tenure is up forty eight percent with average length of service at just over 5 years in duration. Sixty six percent of organizations changed chief risk officer in the time period, which may skew the tenure number, as some organizations made more than one change. CRO Education Level and Education Focus have increased but only slightly, indicating that additional formal education may not be as valued as experience in the field, as indicated earlier.

Bank activity factors related to deposits, non-interest income, consumer loans, agricultural loans and commercial and industrial loans all show increases, as is short term borrowing. Short-term borrowing activity, as noted previously was a contributing factor to the financial crisis, so its increase in the time period is well noted. Monitoring these factors is important as they signal potential red flags for stakeholders. Real Estate Loans are down five percent for the period and

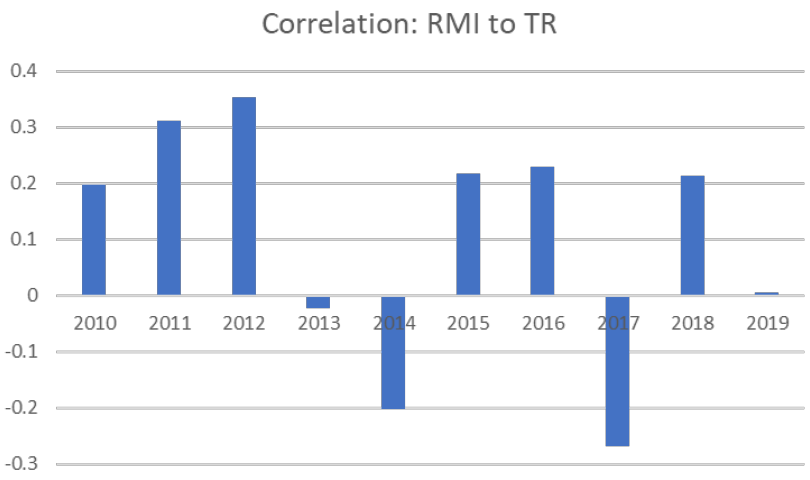
is an important factor to monitor as it was another contributing factor to the financial crisis. The percentage of non-performing loans is up significantly for the time period, with an increase overall of seven hundred eighty percent. Year to year analysis of this data shows that the trend in the 2010-2017 period is steadily lower, yet 2018 shows a dramatic increase, followed by a doubling of this factor in 2019. This analysis confirms the speed at which asset values and risk profile can change in a bank.

Table 4. Descriptive statistics for the 2010-2019 post crisis period.

Variable	Mean	StDev		Variable	Mean	StDev
Num of Ind Dir	10.0460	2.0110		Risk Com Mtgs	8.0280	4.1550
Fraction of Busy Ind Dir	0.1327	0.1535		Quality of Oversight	0.3268	0.3529
Board Independence	0.8193	0.0976		Size of Risk Committee	5.0079	2.5033
Num of Ind Dirs w/ FIN	7.5449	2.1931		Risk Com Independence	4.4803	2.3071
Board Experience	0.7517	0.1630		G-Index	5.4992	1.1350
Director Quality - Total	0.1550	0.1996		Busy Board	0.0315	0.1748
Board Age	63.3190	3.3790		Experienced Board	0.5480	0.4981
Board Size	2.4934	0.1662		Dedicated Risk Comm	0.8772	0.3285
Any Reg Exp	0.0700	0.0863		CRO present	0.8205	0.3841
Num Risk com mbr	5.0047	2.5071		Change CRO	0.1654	0.3718
Num Risk Com mbr w/ risk exp	0.3386	0.6052		CRO Exec Officer	0.7685	0.4221
Num Ind Dirs with prior risk ex	0.3701	0.5864		CRO Top 5	0.2835	0.4510
% ind bd mbr w prior bd ris	0.0356	0.0564		CRO Education Level	1.3748	0.8562
% Risk comm w risk exp	0.0637	0.1214		CRO Education Focus	0.1213	0.3267
CRO Centrality	0.3530	0.1625		CRO Reports to Bd	0.8283	0.3774
CRO Tenure	4.5600	3.9640		Risk Com Exp	0.2567	0.4372
Size	17.5870	1.6300		Risk Com Risk Exp	0.2819	0.4503
Deposits / assets	0.7107	0.1636		Active Risk Com	0.3969	0.4896
Loans / total assets	0.6008	0.1915		BAH Annual return	0.1428	0.2669
RE loans / assets	0.3461	0.1807		ROA	0.0067	0.0080
Comm & Ind Loans/assets	0.1299	0.0835		Profitability	0.0223	0.0165
Consumer Loans / assets	0.0655	0.1170		Tail Risk	0.0381	0.0135
Ag Loans / assets	0.0021	0.0035		Downside risk	0.3252	0.1885
Other Loans / assets	0.0572	0.0570		Aggregate risk	0.0360	0.0128
Short-term borrowing / assets	0.0295	0.0277		Total risk	0.0173	0.0062
% Non Performing loans	0.0361	0.0718		BHC risk	0.0719	0.0305
Non interest income / income	0.3130	0.1887		Market risk	1.3768	0.3050
Tobins Q	1.0479	0.1328		Idiosyncratic risk	0.0554	0.0170
				Default risk	0.2944	0.1043

4.2 Using the Ellul and Yerramilli RMI Model on the 2010-2019 Period

The analysis comparing Ellul and Yerramilli's work in the new 2010-2019 time frame shows inconsistent correlation between RMI and tail risk (TR) year to year in both size of correlation and direction (sign) for the entire data set. For the time period, the correlation is positive (unlike Ellul and Yerramilli's findings) and close to zero (R=0.036) in seven of the ten years, and three years have negative correlation. The original Ellul and Yerramilli work claimed robust correlation between RMI and tail risk. That is not the case in the 10-year period studied as shown in Figure 1. The correlation ranges between -1 and +1, but in this research, there is no year in which the correlation between RMI and TR would be considered robust. The strongest positive year is a correlation of 0.354, and the strongest negative correlation is -0.268. This suggests that the Ellul and Yerramilli RMI model does not hold in the post crisis period. This outcome drives the search for a new variable set that results in a more effective RMI.



	TR to RMI
Year	R
ALL	0.036
2010	0.198
2011	0.312
2012	0.354
2013	-0.022
2014	-0.202
2015	0.217
2016	0.23
2017	-0.268
2018	0.214
2019	0.006

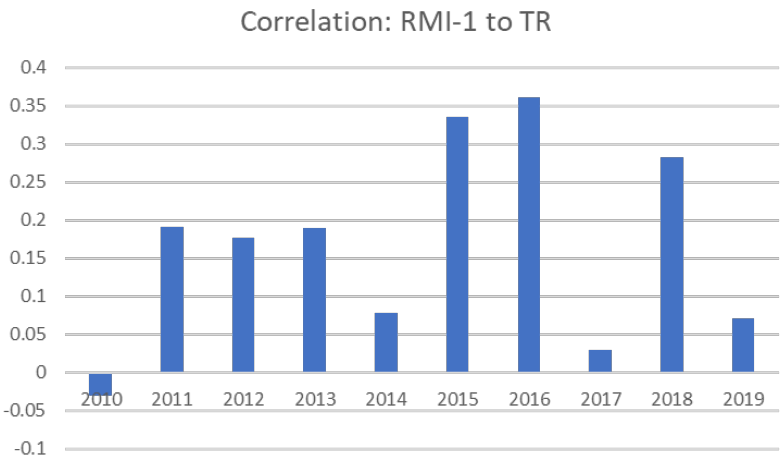
Figure 1. Correlation between RMI for the 2010-2019 time period and tail risk.

4.3 Alternative RMI Models

Three PCA analyses using different factor combinations are conducted to obtain three alternative RMI models, called RMI-1, RMI-2, and RMI-3.

4.3.1 RMI-1 Model

RMI-1 includes director quality, bank size, the percent of independent directors with prior risk management experience, the percent of the risk committee members with prior risk management experience, the number of risk committee members with previous financial experience and the number of risk committee members with prior risk committee experience. These factors were selected based on the load factors from the PCA output. These factors represent four of the six factor clusters. Factors with a loading score of 0.250 or higher were selected for this model. The correlation between RMI-1 and TR was computed by each year and is represented in Figure 2. The correlation is consistent in direction (sign) in nine of the 10 years studied. This positive correlation is unexpected, as we anticipate that when factors that drive stronger risk management improve and would in turn drive tail risk down, there would be a negative correlation. The strength of correlation is not robust across the time period, with the largest correlation factor at 0.361. The one negative correlation is very close to zero at -0.031. In four of the ten years, the correlation is close to zero. This analysis indicates that this combination of factors is not an effective replacement for the Ellul and Yerramilli RMI.

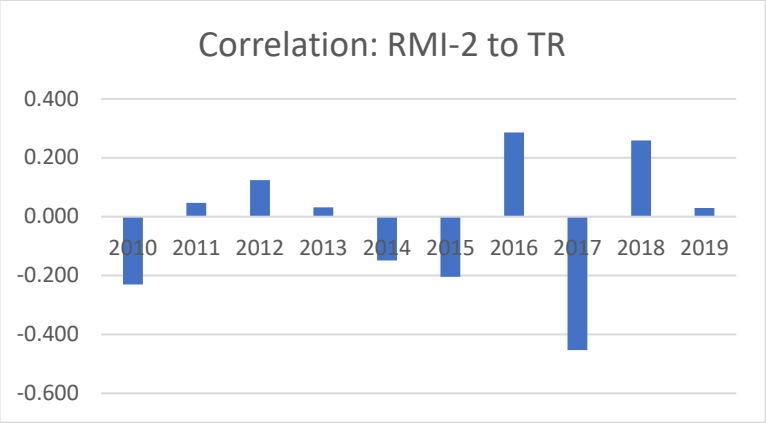


	TR to RMI-1
Year	R
2010	-0.031
2011	0.191
2012	0.177
2013	0.189
2014	0.078
2015	0.335
2016	0.361
2017	0.029
2018	0.282
2019	0.071

Figure 2. Correlation between RMI-1 and tail risk.

4.3.2 RMI-2 Model

The next variable selection process took a variable from each of the six variable clusters. Using the initial PCA output, the variable with the largest load factor in each of the six variable clusters was selected and used to create RMI-2. Overall, RMI-2 is negatively correlated with tail risk. However, a year by year analysis of that correlation shows inconsistency in both strength of correlation and sign (direction) of correlation (Figure 3). Four of the ten years studied have negative correlation, with only one year showing any level of strength at -0.453. Of the six that are positively correlated three of the correlations very close to zero and none of the remaining three have strong correlation factors. The analysis indicates that the RMI-2 factor set is not an effective combination and does not create a more useful RMI.

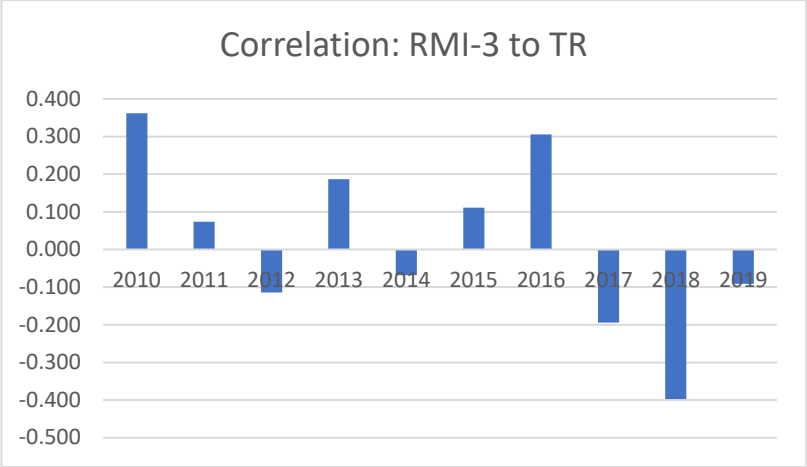


	TR to RMI-2
Year	R
2010	-0.230
2011	0.047
2012	0.124
2013	0.032
2014	-0.149
2015	-0.204
2016	0.286
2017	-0.453
2018	0.259
2019	0.030

Figure 3. Year by year correlation of RMI-2 to tail risk.

4.3.3 RMI-3 Model

The third RMI model is based on a meta-analysis of the literature. Four of the six factors selected are indicated in the literature as having an impact on tail risk (board experience, risk committee member with risk experience, two bank activity factors including real estate loans as a percent of assets and the percentage of non-performing loans). Two of the factors selected are not addressed in the literature and because of their novelty are included in this proposed RMI factor set (CRO Education Focus and Regulator Experience). Four of the six factors selected do not appear in any of the three previously analyzed models. RMI-3 is shown to be negatively correlated to tail risk for the 10-year period studied, however year by year analysis of the correlation to tail risk is inconsistent in both strength of correlation and sign (direction) of correlation (Figure 4).



	TR to RMI-3
Year	R
2010	0.362
2011	0.074
2012	-0.114
2013	0.187
2014	-0.068
2015	0.111
2016	0.306
2017	-0.194
2018	-0.397
2019	-0.091

Figure 4. Correlation between RMI-3 and tail risk.

An analysis of the four RMI factor sets on a year-to-year basis shows no patterns related to correlation in any of the years of the time frame studied (Figure 5). This result and the analysis of these four RMI factor sets indicates that creating an index that aggregates risk management factors is not effective post crisis as it relates to tail risk. The lack of consistent size or sign of the correlation to tail risk further indicates the complexity of risk management as well as the speed with which factor impact can change.

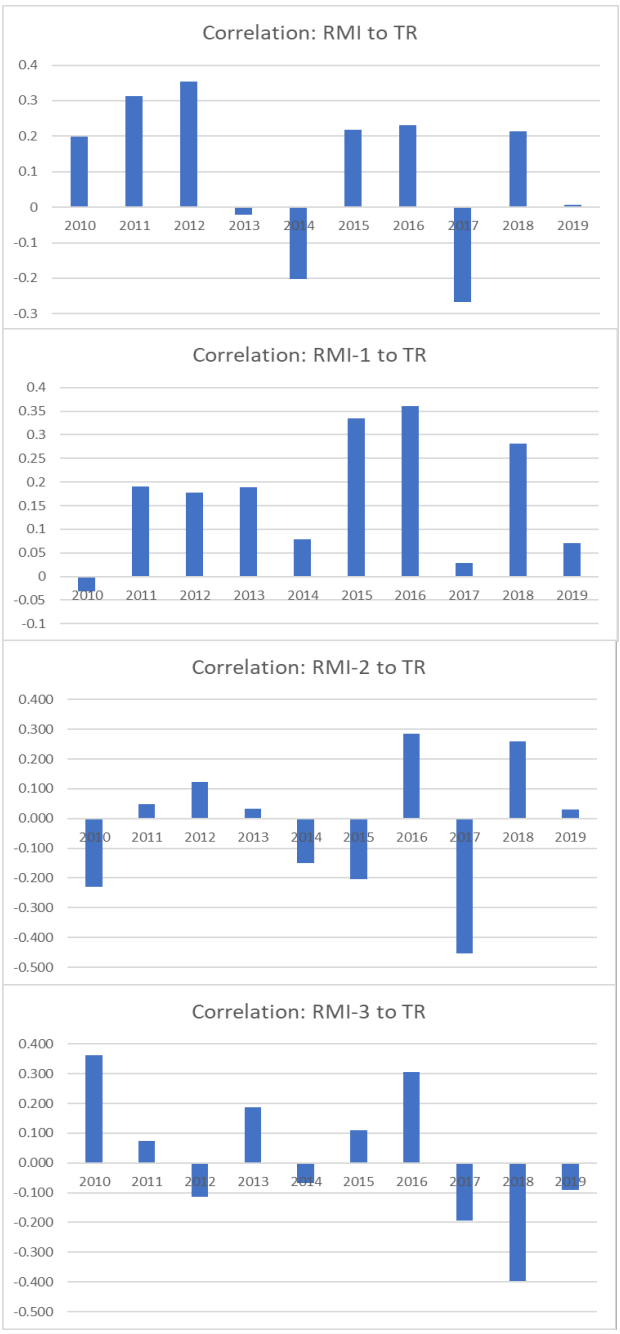


Figure 5. Comparison of four RMI models.

4.4 Regression Analysis

The next analysis path is to find meaningful variables that effect risk management uses regression similar to McGee, Afaneh, and others. Completed regression analysis of the entire forty-six element factor set against tail risk seeking statistically significant factors. This model results in fourteen statistically significant variables (Table 5) and an R^2(adj.) of just 22.04%, meaning that just over 22% of the variation in tail risk is explained by this model.

Table 5. Regression output for all variables and tail risk.

	Coeff	SE Coef	T-Value	P-Value	VIF		Coeff	SE Coef	T-Value	P-Value	VIF
Constant	0.2465	0.0573	4.31	0.000		CRO Centrality	0.0089	0.0038	2.34	0.020	1.70
Size	-0.0029	0.0007	-4.05	0.000	6.21	CRO Tenure	-0.0003	0.0001	-2.35	0.019	1.13
Deposits / assets	-0.0290	0.0057	-5.11	0.000	3.86	Loans / total assets	0.0189	0.0112	1.68	0.093	20.71
RE loans / assets	-0.0196	0.0113	-1.74	0.083	18.60	Comm & Ind Loans/assets	-0.0277	0.0149	-1.86	0.064	6.93
Consumer Loans / assets	-0.0316	0.0117	-2.70	0.007	8.41	Ag Loans / assets	-0.4090	0.1630	-2.51	0.012	1.43
Short-term borrowing / assets	-0.0851	0.0218	-3.89	0.000	1.64	Non interest income / income	-0.0172	0.0054	-3.20	0.001	4.62
% Non Performing loans	0.0012	0.0071	0.17	0.862	1.16	Risk Com Mtgs	0.0003	0.0002	1.51	0.132	3.26
G-Index	0.0018	0.0005	3.30	0.001	1.68	Quality of Oversight	-0.0009	0.0034	-0.27	0.789	6.43
Tobins Q	-0.0249	0.0050	-4.96	0.000	1.98	Size of Risk Committee	0.0016	0.0063	0.26	0.798	1093.65
Num of Ind Dir	0.0001	0.0024	0.04	0.967	100.62	Risk Com Independence	-0.0017	0.0007	-2.31	0.021	12.55
Fraction of Busy Ind Dir	0.0079	0.0066	1.20	0.230	4.55	Busy Board	-0.0006	0.0035	-0.17	0.865	1.70
Board Independence	-0.0196	0.0260	-0.75	0.452	28.82	Experienced Board	0.0014	0.0018	0.80	0.425	3.39
Num of Ind Dirs w/ FIN	0.0024	0.0016	1.47	0.143	57.89	Dedicated Risk Comm	-0.0036	0.0028	-1.27	0.205	3.78
Board Experience	-0.0239	0.0170	-1.40	0.161	34.28	CRO present	-0.0012	0.0016	-0.74	0.462	1.78
Director Quality - Total	0.0146	0.0052	2.81	0.005	4.82	Change CRO	-0.0008	0.0014	-0.53	0.596	1.22
Board Age	-0.0007	0.0002	-3.68	0.000	1.67	CRO Top 5	0.0021	0.0013	1.65	0.099	1.42
Board Size	-0.0199	0.0201	-0.99	0.322	49.84	CRO Education Level	-0.0042	0.0018	-2.30	0.022	3.48
Any Reg Exp	-0.0030	0.0080	-0.38	0.704	2.13	CRO Education Focus	0.0026	0.0016	1.66	0.096	1.20
Num Risk com mbr	-0.0006	0.0062	-0.10	0.918	1082.06	CRO Exec Officer	-0.0026	0.0015	-1.75	0.081	1.77
Num Risk Com mbr w/ risk exp	0.0018	0.0038	0.46	0.648	23.87	CRO Reports to Bd	-0.0010	0.0015	-0.68	0.498	1.44
Num Ind Dirs with prior risk ex	0.0021	0.0047	0.44	0.658	33.25	Risk Com Exp	0.0019	0.0043	0.44	0.657	15.64
% ind bd mbr w prior bd ris	-0.0247	0.0480	-0.51	0.607	32.72	Risk Com Risk Exp	0.0019	0.0042	0.46	0.643	15.78
% Risk comm w risk exp	-0.0108	0.0172	-0.63	0.532	19.46						

The regression was rerun using just the fourteen statistically significant factors against tail risk and resulted in all fourteen remaining statistically significant. These fourteen variables represent five of the six clusters (Board, Risk Committee, CRO, Bank Activity, Quality/Value) and going forward are considered tail risk significant factors (Table 6).

Table 6. Regression analysis output of tail risk significant factors.

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.1601	0.0162	9.85	0.000	
Size	-0.0023	0.0006	-4.06	0.000	3.90
Deposits / assets	-0.0296	0.0047	-6.36	0.000	2.55
Consumer Loans / assets	-0.0115	0.0046	-2.50	0.013	1.29
Short-term borrowing /assets	-0.0861	0.0201	-4.29	0.000	1.37
G-Index	0.0019	0.0005	3.92	0.000	1.37
Tobins Q	-0.0217	0.0047	-4.61	0.000	1.72
Director Quality	0.0181	0.0042	4.32	0.000	3.06
Board Age	-0.0006	0.0002	-3.71	0.000	1.18
CRO Centrality	0.0112	0.0035	3.16	0.002	1.46
CRO Tenure	-0.0002	0.0001	-1.97	0.049	1.05
Ag Loans / assets	-0.4090	0.1510	-2.71	0.007	1.21
Non interest income /income	-0.0179	0.0042	-4.30	0.000	2.73
Risk Committee Indep	-0.0007	0.0002	-3.22	0.001	1.14
CRO Ed Level	-0.0052	0.0016	-3.33	0.001	2.43

Model Summary

S = 0.0119934 R^2 = 23.02% R^2 (adj.) = 21.02%

The model for tail risk important factors:

TR = 0.1601 – 0.002346*Size -0.02957*dep/asst - 0.01154*Cons loan/asst -0.0861*ST borrow + 0.001928*G Ind - 0.02169*Tobin's Q - 0.01805*Dir Quality - 0.000569*Bd Age + 0.01118*CRO Centrality - 0.000243*CRO Tenure - 0.4090*Ag Loans - 0.01794*Non Int Inc - 0.000710*RC Indep) - 0.00516*CRO Ed Level 2

The next analysis in this alternate methodolgy track focuses on default risk, a potentially more powerful risk measure for stakeholders than Ellul and Yerramilli's original tail risk metric. Regression analysis of the original forty six variables against default risk results in a model with seventeen statistically significant factors and an R^2 (adj.) 59.84% as shown in Table 7. This model explains just under 60% of the variation in default risk, and is 2.84 times stronger than the model created with the same methodology with tail risk as the dependant variable.

Table 7. Regression output, all variables and default risk.

Term	Coef	SE Coef	T-Value	P-Value	VIF		Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.2090	0.3180	0.66	0.511			CRO Centrality	-0.1080	0.0211	-5.13	0.000	1.70
Size	-0.0036	0.0040	-0.89	0.372	6.21		CRO Tenure	0.0031	0.0008	4.08	0.000	1.31
Deposits / assets	0.0462	0.0315	1.47	0.143	3.86		Loans / total assets	0.4810	0.0624	7.71	0.000	20.71
RE loans / assets	-0.5091	0.0627	-8.13	0.000	18.60		Comm & Ind Loans/assets	-0.3490	0.0827	-4.22	0.000	6.93
Consumer Loans / assets	0.1081	0.0651	1.66	0.097	8.41		Ag Loans / assets	1.3330	0.9030	1.47	0.141	1.43
Short-term borrowing / assests	0.5230	0.1210	4.32	0.000	1.64		Non interest income / income	0.2040	0.0299	6.83	0.000	4.62
% non performing loans	0.1633	0.0394	4.15	0.000	1.16		Risk Comm Mtgs	-0.0038	0.0011	-3.35	0.001	3.26
G-Index	0.0030	0.0030	0.98	0.326	1.68		Quality of Oversight	0.0137	0.0189	0.73	0.468	6.43
Tobins Q	0.0856	0.0278	3.08	0.002	1.98		Size of Risk Committee	0.0504	0.0347	1.45	0.147	1093.65
Num of Ind Dir	0.0166	0.0131	1.27	0.205	100.62		Risk Committee Indep	-0.0056	0.0040	-1.39	0.166	12.55
Fraction of Busy Ind Dir	-0.0663	0.0365	-1.82	0.070	4.55							
Board Independence	-0.3130	0.1440	-2.17	0.031	28.82		CRO Exec officer	0.0196	0.0083	2.38	0.018	1.77
Num of Ind Dirs w/ FIN	-0.0078	0.0091	-0.85	0.395	57.89		Busy Board	0.0079	0.0196	0.40	0.688	1.70
Board Experience	0.0451	0.0943	0.48	0.632	34.28		Experienced Board	-0.0292	0.0097	-3.01	0.003	3.39
Director Quality	-0.0451	0.0289	-1.56	0.119	4.82		Dedicated Risk Comm	-0.0003	0.0155	-0.02	0.983	3.78
Board Age	0.0062	0.0010	6.18	0.000	1.67		CRO Present	-0.0055	0.0091	-0.60	0.550	1.78
Board Size	-0.1440	0.1120	-1.29	0.198	49.84		Change CRO	0.0038	0.0078	0.49	0.625	1.22
Any Reg Exp	0.1809	0.0444	4.08	0.000	2.13		CRO Top 5	-0.0002	0.0069	-0.02	0.982	1.42
Num Risk com mbr	-0.0411	0.0344	-1.19	0.233	1082.06		CRO Ed Level	-0.0157	0.0100	-1.57	0.117	3.46
Num Risk Com mbr w/ risk exp	-0.0308	0.0212	-1.46	0.146	23.87		CRO Ed Focus	-0.0122	0.0088	-1.39	0.165	1.20
Num Ind Dirs with prior risk ex	0.0504	0.0258	1.95	0.051	33.25		CRO Reports to Bd	-0.0193	0.0084	-2.31	0.021	1.44
% ind bd mbr w prior bd ris	-0.5630	0.2660	-2.11	0.035	32.72		Risk Com Exp	-0.0101	0.0237	-0.43	0.669	15.64
% Risk comm w risk exp	0.1480	0.0954	1.55	0.121	19.46		Risk Com Risk Exp	-0.0124	0.0232	-0.54	0.591	15.78

Model Summary

S = 0.0661053 R^2 = 62.75% R^2 (adj.) = 59.84%

The regression was rerun using the statistically signifcant variables from the larger model output and resulted in sixteen statistically significant variables in the final model, with an R^2 (adj) of 57.02% (Table 8).

Table 8. Default risk statistically significant variables.

Term	Coef	SE Coef	T-Value	P-Value	VIF		Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.0286	0.0751	0.38	0.704			Loans / total assets	0.5471	0.0283	19.31	0.000	3.99
Tobins Q	0.1022	0.0243	4.20	0.000	1.41		RE loans / assets	-0.5358	0.0272	-19.69	0.000	3.28
Board Age	0.0043	0.0009	4.76	0.000	1.25		Comm & Ind Loans/assets	-0.4373	0.0429	-10.19	0.000	1.74
CRO Centrality	-0.1256	0.0196	-6.40	0.000	1.38		Short-term borrowing / assets	0.3430	0.1070	3.20	0.001	1.20
% Non performing loans	0.1577	0.0392	4.03	0.000	1.07		Non interest income /income	0.1268	0.0250	5.08	0.000	3.02
Board Independence	-0.1963	0.0330	-5.95	0.000	1.40		Risk Committee Mtgs	-0.0033	0.0007	-4.55	0.000	1.23
Any Reg Exp	0.1048	0.0405	2.58	0.010	1.66		Experienced Board	-0.0351	0.0059	-5.98	0.000	1.16
% Ind Bd mbr w prior risk exp	-0.1854	0.0520	-3.56	0.000	1.17		CRO Exec officer	0.0019	0.0070	0.27	0.787	1.18
CRO Tenure	0.0027	0.0007	3.80	0.000	1.05		CRO Reports to Bd	-0.0216	0.0077	-2.81	0.005	1.14

Model Summary

S = 0.0683891 R^2 = 58.17% R^2 (adj.) = 57.02%

With R^2 (adj.) of 57.02%, this model remains significantly stronger than the tail risk model.

The final model for default risk important factors:

DR = 0.0286 - 0.5358*RE loan/asst + 0.3430*ST Borrow + 0.5471* Loans/assets - 0.4373*C&I Loans + 0.1268*Non Int Inc + 0.1577*% non-perf loans + 0.1022*Tobin's Q - 0.1963*Bd Ind + 0.004294*Bd Age - 0.1854* % Ind Dir w Bd Risk - 0.1256* CRO Centrality + 0.0027*CRO Tenure - 0.0033*RC Mtg - 0.0216*CRO Reports to Bd - 0.0351*Experienced Bd + 0.1048*Reg Exp

On the research question exploring factors that impact bank performance, regression analysis was completed (Table 9) using all forty-six variables against return on assets (ROA), a common performance metric. This model resulted in seven statistically significant factors, with a 74.31 R^2 (adj.), meaning that this model accounts for 74.31% of the variation around return on assets.

Table 9. Regression Output for all variables and ROA

Term	Coef	SE Coef	T-Value	P-Value	VIF		Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-0.0590	0.0194	-3.04	0.003			CRO Centrality	-0.0043	0.0013	-3.31	0.001	1.70
Size	0.0002	0.0002	0.90	0.368	6.21		CRO Tenure	0.0000	0.0000	-0.54	0.592	1.31
Deposits / assets	-0.0052	0.0019	-2.69	0.007	3.86		Loans / total assets	-0.0064	0.0038	-1.69	0.092	20.71
RE loans / assets	0.0012	0.0038	0.31	0.756	18.60		Comm & Ind Loans/assets	0.0076	0.0051	1.51	0.132	6.93
Consumer Loans / assets	0.0120	0.0040	3.00	0.003	8.41		Ag Loans / assets	0.0130	0.0553	0.24	0.814	1.43
Short-term borrowing / assets	-0.0017	0.0074	-0.23	0.822	1.64		Non interest income/income	-0.0015	0.0018	-0.79	0.428	4.62
% Non performing loans	0.0081	0.0024	3.35	0.001	1.16		Risk Com Mtgs	-0.0001	0.0001	-1.25	0.214	3.26
G-Index	-0.0001	0.0002	-0.74	0.461	1.68		Quality of Oversight	0.0012	0.0012	1.05	0.295	6.43
Tobins Q	0.0472	0.0017	27.74	0.000	1.98		Size of Risk Come	-0.0010	0.0021	-0.45	0.652	1093.65
Num of Ind Dir	0.0000	0.0008	0.05	0.961	100.62		Risk Com Ind	0.0001	0.0002	0.29	0.773	12.55
Fraction of Busy Ind Dir	0.0012	0.0022	0.54	0.592	4.55							
Board Independence	0.0026	0.0088	0.29	0.771	28.82		Busy Board	0.0013	0.0012	1.12	0.264	1.70
Num of Ind Dirs w/ FIN	-0.0004	0.0006	-0.75	0.456	57.89		Experienced Board	-0.0007	0.0006	-1.19	0.236	3.39
Board Experience	0.0057	0.0058	0.99	0.323	34.28		Dedicated Risk Comm	0.0022	0.0010	2.27	0.024	3.78
Director Quality	-0.0030	0.0018	-1.67	0.095	4.82		CRO Present	-0.0007	0.0006	-1.17	0.244	1.78
Board Age	0.0001	0.0001	1.99	0.047	1.67		Change CRO	0.0003	0.0005	0.63	0.529	1.22
Board Size	0.0036	0.0068	0.52	0.600	49.84		CRO Top 5	0.0003	0.0004	0.70	0.481	1.42
Any Reg Exp	0.0003	0.0027	0.10	0.921	2.13		CRO Ed Level	0.0001	0.0006	0.10	0.923	3.46
Num Risk com mbr	0.0007	0.0021	0.35	0.728	1082.06		CRO Ed Focus	-0.0003	0.0005	-0.64	0.521	1.20
Num Risk Com mbr w/ risk exp	0.0016	0.0013	1.24	0.215	23.87		CRO Reports to Bd	0.0007	0.0005	1.32	0.186	1.44
Num Ind Dirs with prior risk ex	0.0001	0.0016	0.08	0.939	33.25		Risk Com Exp	-0.0018	0.0015	-1.25	0.211	15.64
% ind bd mbr w prior bd ris	0.0111	0.0163	0.68	0.495	32.72		Risk Com Risk Exp	0.0000	0.0014	0.02	0.980	15.78
% Risk comm w risk exp	-0.0101	0.0058	-1.74	0.083	19.46		CRO Exec officer	-0.0003	0.0005	-0.51	0.612	1.77

Model Summary

S = 0.0040467 R^2 = 76.17% R^2 (adj.) = 74.31%

The regression was rerun using just these seven statistically significant variables and resulted in a model with six remaining statistically significant factors that impact ROA. The R^2 (adj.) for this subset regression is 74.23%, indicating this model remains very strong even with the loss of the Dedicated Risk Committee variable. Going forward, these remaining six variables are considered performance important factors (Table 10).

Table 10: ROA regression statistically significant factors.

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	-0.0458	0.0039	-11.86	0.000	
Deposits / assets	-0.0062	0.0012	-5.17	0.000	1.49
Consumer Loans/assets	0.0065	0.0014	4.51	0.000	1.09
Tobins Q	0.0475	0.0014	34.28	0.000	1.31
Board Age	0.0001	0.0000	2.28	0.023	1.04
CRO Centrality	-0.0039	0.0011	-3.41	0.001	1.33
% non performing loans	0.0081	0.0023	3.59	0.000	1.01
Dedicated Risk Comm	0.0010	0.0005	1.93	0.054	1.08

Model Summary

S = 0.0040528 R^2 = 74.52% R^2 (adj.) = 74.23%

The model for performance important factors:

ROA = -0.04582 - 0.00622*dep/asst + 0.00646*Cons loan/asst + (0.04746*Tobin's Q) + 0.000111*Bd Age - 0.00389*CRO Centrality + 0.00808*% non perf

4.5 Sensitivity Analysis

The 4th analysis path is sensitivity analysis of the selected models from the previous steps. Regression is run repeatedly for DR, with one factor removed for each run to understand the impact of single factors on the strength or quality of the model.

4.5.1 Sensitivity Analysis – Default Risk Model

As can be seen in Table 11, the removal of Real Estate Loans variable significantly reduces the strength of the model, with a nearly 50% reduction in R^2 (adj.). The removal of the Loans/Assets

factor has a similar effect on the model quality. This indicates the strength of this factor in explaining the variation in the default risk model.

Table 11: Sensitivity Analysis, default risk model.

Removed Factor	S	R^2	R^2 (adj)	R^2 (pred)
Tobin's Q	0.0692980	56.98	55.87	54.22
Board Age	0.0695725	56.64	55.52	52.92
CRO Centrality	0.0705599	55.40	54.24	51.41
% Non performing Loans	0.0692223	57.07	55.96	53.39
Board Independence	0.0702624	55.77	54.63	51.92
Regualtor Experience	0.0686975	57.72	56.63	54.05
% Ind Bd w/ risk exp	0.0690321	57.31	56.20	53.50
CRO Tenure	0.0691203	57.20	56.09	53.38
Loans/assets	0.0865476	32.90	31.16	25.71
RE Loans/assets	0.0871863	31.90	30.14	24.94
C&I Loans/assets	0.0738504	51.14	49.88	46.65
ST Borrowing	0.0688913	57.48	56.38	53.78
Non interest income	0.0697463	56.42	55.29	52.51
Risk Comm meetings	0.0694628	56.78	55.66	53.07
Experienced Board	0.0702846	55.75	54.60	51.91
CRO Exec Officer	0.0683324	58.17	57.09	54.55
CRO Reports to Board	0.0687640	57.64	56.54	54.01

4.5.2 Sensitivity Analysis – ROA Model

The removal of Tobin's Q in the ROA model reduces the R^2 (adj.) from 73.72% to 26.07%. This indicates the strength of that one factor in explaining the variation in the ROA model. The removal of Tobin's Q from this model reduces the model's quality by nearly two-thirds (Table 12).

Table 12. Sensitivity Analysis, ROA model.

Removed Factor	**S**	**R^2**	**R^2 (adj)**	**R^2 (pred)**
Dedicated Risk Committee	0.0040616	74.37%	74.12%	72.51%
% Non performing Loans	0.0040911	73.99%	73.74%	71.93%
CRO Centrality	0.0040869	74.05%	73.80%	72.05%
Board Age	0.0040663	74.31%	74.06%	72.22%
Tobin's Q	0.0068650	26.77%	26.07%	21.24%
Consumer Loans/assets	0.0041147	73.69%	73.44%	71.71%
Deposits	0.0041351	73.43%	73.18%	71.43%

CHAPTER 5

CONCLUSIONS AND FUTURE RESEARCH

The culmination of the research work is condensed into key insights, organized by research question. The chapter synthesizes the research results and provides potential next steps for the direction of future research.

5.1 Conclusions

Research question (Q1): **Does RMI correlate to tail risk for the time period 2010-2019?**

In the analysis of Ellul and Yerramilli's RMI findings, the correlation between post crisis time period RMI and tail risk was positive in seven out of the ten years and overall, for the entire 10 year period. In three out of the ten years, the correlation is negative. The correlation between RMI and tail risk is inconsistent year to year in both sides of the correlation as well as the direction (sign) of the correlation. The highest positive correlation is 0.354, which indicates a relatively weak positive correlation. The largest negative correlation is -0.268, which is also a relatively weak correlation strength. This analysis indicates that the Ellul and Yerramilli RMI does not hold in a different period. This failure to reproduce results aligned with Ellul and Yerramilli's original outcomes motivated the search for more impactful variables and also a reconsideration of the concept of creating a single index to aggregate all the potential factors that can singly represent the strength and quality of the risk management functions of a BHC.

Research question (Q2): Does including other factors improve RMI correlation to tail risk?

RMI-1 was created using the six highest load factors in the original, large factor data set PCA analysis (director quality, size, percent independent directors with prior risk management experience, percent of risk committee members with prior risk management experience, risk committee experience, and risk committee risk experience). No other variables from the forty-six variable set were considered as they fell outside of the selection criteria for this iteration. RMI-1 was calculated for the entire data set and for each year for each bank. Analysis of scatter plots as well as correlation/matrix plots were conducted for entire data set (all 10 years) as well as for each year, correlating RMI-1 to TR. These results show a positive correlation between the new index and tail risk. Positive correlation was found in nine out of the ten years. The largest correlation factor was 0.361, which indicates a relatively weak positive correlation. The positive correlation is an unexpected result as previous work indicates that an increase in RMI should result in tail risk decreasing. While this result does not fit with findings from the limited literature on risk management indexing, the finding of a positive relationship can still be useful in a practical sense. Certain stakeholders can still use the outcome of the RM-1 analysis. These specific stakeholders would no longer look at the RMI number, or its trend over time, but instead would look at the underlying variables like director quality, percentage of independent directors with prior risk management experience, percentage of risk committee members with risk management experience and use the information they provide to determine the most useful "settings" for those variables in an organization they are working with. For example, the board of directors might look at each factor and how it impacts tail risk, then could organize the different facets (board characteristics, director characteristics, risk committee characteristics, CRO

characteristics, and activity characteristics) of their risk management and governance structures in ways that the factors suggest would optimize the tail risk outcome the organization seeks. In a situation where there is an increasing RMI (which means the factors have positive load factors) the board would take operational actions that would mitigate those factors. If a higher percentage of directors with prior risk management experience (variable #9) increases RMI (which in turn would drive a higher tail risk value) then the board's actions would be to reduce that percentage. What this dissertation does not provide is the optimal level of that percentage, or down to what level the board needs to lower it in order to drive the tail risk outcome they desire. Likewise, if the percent of directors with more than one outside directorship (variable #5) increases RMI (because of its positive load factor) then the board of directors' action would be to reduce that percentage as well. With factors that are categorical, the same decision making by the board of directors would be appropriate, the board of directors would take actions that would move that "setting" from its high state to its low state. In summary, any factor that raises RMI would drive the opposite operational activity. Others that could use this finding would include regulators and policymakers. While they operationally do not control the "settings", they could assess (regulators) or mandate (policymakers, legislators) the settings that would result in the reduction of tail risk in an organization. Another way to look at this would be for further study of load factors. Internal risk management operations might look at the load factors, as opposed to external stakeholders, who would not likely have access to the information and highly unlikely to do the calculation of such information since load factor information is not readily available and are the outcome of PCA analysis. This might be a valuable activity for internal risk operations because while they could look at the individual factors and their values that kind of individual

value analysis does not take into consideration the weight of that individual factor. The load factor gives us an idea of the size (and direction) of the impact that that factor has. Even more, the load factor gives us this weighting relative to the other factors which could also be useful for internal operations. A load factor of .623 being larger than .323 signals that the former has more impact than the latter. Extending this thinking, internal risk operations could provide load factor information to regulators and the board of directors, so that the information could be useful to those stakeholders as well.

An alternate RMI, RMI-2, was calculated using the largest load factor variable in each of the six variable clusters. An ancillary benefit of this dissertation is an understanding of the influence of variable clusters. A first step in that direction is to ensure each cluster is represented in a potential risk management index. Another benefit of this variable subset selection process is the inclusion of categorical variables, whose analysis outcomes might be easier to use operationally as organizational leadership can change these settings from a high state to a low state. The findings in this analysis shows the correlation factor to be inconsistent year to year in both strength and direction (sign) of correlation. In four of the ten years, the correlation is negative. Half of the remaining six years have a correlation near zero, with the remaining three being weak positive correlations. The largest positive correlation is 0.286 and the largest negative correlation -0.453. This set of factors does not more effectively model a risk management index.

For the third RMI, RMI-3, factor selection was based on a meta-analysis of the literature. Four of the six factors selected are indicated in the literature as having an impact on tail risk (board experience, risk committee member with risk experience, two bank activity factors including real estate loans as a percent of assets and the percentage of non-performing loans). Two of the

factors selected are not addressed in the literature and because of their novelty are included in the RMI-3 factor set (CRO Education Focus and Regulator Experience). Four of the six factors selected do not appear in any of the three previously analyzed models. The finding in this analysis shows the correlation factor to be inconsistent in both strength and direction (sign) of correlation. The overall RMI to tail risk correlation is negative, as expected, but the correlation is only -0.201, which is not very strong. Further analysis by year shows that five of the ten years have negative correlation, with one of the years (2018) being 2.08 times stronger than the next largest negative correlation, possibly skewing the overall correlation to be negative. The remaining five years showed positive correlation, with two years (2010, 2016) having the strongest correlation but with two others being very close to zero.

While the RMI creation process and its correlation to tail risk does not show the expected outcomes and casts doubt on the usefulness of creating such a single index, an analysis of the yearly average RMI for each of RMI-1, RMI-2 and RMI-3 indicates that the measure shows almost steady improvement year to year. The average annual RMI for the factor sets used in RMI-1, RMI-2 and RMI-3 are larger and more positive at the end of the ten year period, indicating stronger risk management as time progressed, which is in line with Ellul and Yerramilli's finding.

In conclusion, the results from these three different RMI analyses produced correlation results that were unexpected. This indicates that a single metric that adequately encapsulates multiple factors of risk management/governance and correlates effectively with risk measures is elusive and needs further analysis. The idea that there is one number that all stakeholders (consumers, investors, regulators, boards, policymakers, etc.) can use to gauge the strength and quality of the risk management and governance function of an organization is valuable given the realities of the

deep complexity of banking organizations and dynamic/fast speed of risk profile change that are challenging risk management in organizations in the banking industry. The hard part about creating an index, a combination of multiple factors, is that each factor setting can drive the index in a different direction and is often at cross purposes with other measures in the index. When analyzing the risk management index number against the individual elements it is found that an individual factor drives the index in the direction opposite to the direction of other factors, making the overall usefulness of the index ineffective.

Research question (Q3): If Q2 is negative, does another methodology identify factors that influence tail risk?

Analyzing the entire forty-six element data set using regression analysis indicated that there are fifteen factors that are statistically significant relative to tail risk. These fifteen variables represent all six factor clusters. The model including all the variables has an R^2 (adj.) of just 22.04% indicating that the model that includes all forty-six initial variables only accounts for 22% of the variation around tail risk. One third of the variables found to be statistically significant fall into the bank activity cluster, indicating that this variable cluster might have the most impact out of the six analyzed in this dissertation. Only one of the factors from EY's original work is statistically significant in this tail risk model (CRO Centrality). Size, G index and Tobin's Q, all from the Quality/Value cluster were indicated as statistically significant. Size is not as unexpected given the results of other research indicating it is an important factor related to risk because the larger a BHC is, the more resources it may have to better monitor and advise related to risk. A second regression analysis conducted using just the subset of fifteen statistically significant factors as

dependent variables against independent variable tail risk results in all fifteen factors remaining statistically significant.

Research question (Q4): If Q3 is negative, can another risk measure be identified that is highly influenced by additional factors?

A regression analysis was completed relative to default risk in an effort to understand which factors have an impact on this stakeholder important risk measure. Using all forty-six original variables, the analysis produces a model with an R^2 (adj.) of 59.84% indicating a good model related to default risk. The default risk regression has seventeen factors that are statistically significant. These seventeen factors represent all six of the variable clusters, with over one third from the bank activity cluster.

Research question (Q5) Do governance and risk variables influence bank performance (ROA)

All forty-six variables were used in analyzing how the large factor set impacts performance, as measured by ROA. This analysis results in seven statistically (ROA) significant variables. The model has an R^2 (adj) of over 74%. These seven factors are found to represent five of the six clusters, with just under one half of the factors from the bank activity cluster. These seven factors are then used in a second regression to further understand their impact on ROA. The analysis shows six statistically significant variables, with Dedicated Risk Committee factor falling out. The refined model has an R^2 (adj.) of 74.23, indicating it loses very little strength with the loss of the one variable.

In summary, the regression analysis approach using the large factor set results in two models that are useful. The strongest model relates the collected variables with bank performance, with a

good model produced relative to default risk. The valuable takeaway from this analysis process is that a small set of measures are found that effectively model both bank risk, albeit default risk and not tail risk, as well as bank performance. Stakeholders would be better served to take a dashboard approach to metric use for decision making relative to a BHC's risk management strength (and performance). Seeing a small number of variables vs one single number gives the stakeholder the ability to see the impact of both size and direction of the variables impact on their view of risk management for a particular bank. Likewise, this approach allows stakeholders to find the individual variables, unlike an RMI which would need to be calculated and which currently is not.

A sensitivity analysis of the default risk model indicated the model is robust to changes in factors except for Loans. When the Loans variable is removed from the model, there is fifty four percent decrease in model strength. Further analysis shows that removing Real Estate loans from the model reduces the model effectiveness from just under sixty percent down to thirty percent, a full fifty five percent reduction in effectiveness. We see a sharp decrease in model effectiveness as well when Commercial & Industrial Loans are removed from nearly sixty percent R^2 (adj.) down to just under fifty percent effective. Loans, and specifically real estate loans, are very important to the explanation of the variation in the default risk model.

Similarly, the sensitivity analysis of the ROA model indicated that the model remains robust to changes in the factor set until Tobin's Q is removed, which drops the R^2 (adj.) of the model by nearly two thirds. This finding suggests that Tobin's Q, which is a widely regarded management quality measure, signals that management quality has significant influence on the performance of BHC's. This factor is statistically significant in all three models and is one of the very few

overlapping factors across all three. Operationally this is important as internal stakeholders can use this measure, and more so the sub-elements that make it up, to make decisions on how to build their governance structures.

The conclusion of this research work is that an index approach is ineffective and that a better approach for stakeholders to measure variables impacting risk management strength and bank performance is through a multi-factor dashboard method. As stated earlier, lost in an index are the strength and direction of the individual variables. This research did not find a set of factors that result in an effective risk management index but did find a small set of impactful variables that might best be used together for the stakeholder to make decisions about the risk management strength of a bank. Value can be found using this small variable set, making it feasible that stakeholders to use them. Tracking an index over time in the complex system that is domestic banking may be less effective than monitoring a small dashboard of variables. This work indicates that a dashboard of this type would focus on variables related to two variable clusters, bank activity factors and quality/ value factors.

5.2 Future Research

This research illuminates that there is scant research in the field related to the creation of an index that adequately synthesizes the various factors that measure the complex and highly interconnected elements of bank risk structures into one metric. Further research on risk management and governance structures is critical to the future resilience and stability of the global banking system. Research specific to the effectiveness of risk management governance

structures and the people who hold those seats is warranted. There is not a repeatable risk management index that is useful in all economic scenarios, and there is no index for risk management strength that is widely accepted in the industry. There are simply too many potential variables to study, both inside organizations as well as in the broader macroeconomic environment. Adding to these complexities is the global nature of banking and the differences in stakeholder goals, domestically and internationally. There would be value for stakeholders for there to be further research identifying a small set of impactful metrics, using widely available public information, for the creation of risk management focused dashboards. Future research would be well spent on the impact of regulatory actions and legislation on bank risk management. This dissertation has shown that there are variables that are known to impact risk management and further research is needed to identify and validate the optimal operational settings for those specified risk related factors. Future research could focus on risk committee activity, as well as deepening the research on the characteristics of the members of risk committees. Likewise, further research into the characteristics of the critical roles in a risk management function, e.g., CRO or internal risk management teams, would deepen understanding of the roles and their interconnected relationship to successful risk management. Future research would be valuable on the connection between characteristics of risk management and bank performance measures, beyond the look at ROA done in this research. Additional work could be done in using the impactful identified risk (and performance) variables in a machine learning setting for the development of tools used to predict risk metrics as well as performance metrics. Analysis of risk management factors segmented by bank size might give greater insight into how factor settings might be set, allowing for better risk performance and lower burden instead of a one size fits all

approach. Likewise, more research on the effectiveness of regulatory requirements and their impact on risk profiles could be completed. An additional study related to the impact on performance of multiple risk metrics to understand which risk measures are important to bank performance, in line with Jiang and Ji's recent work (2023) might provide insights useful for operational risk managers.

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Appendix 1: List of banks

ISS Company ID	BoardEx Company ID	TICKER	Company Name
5191	1815	AXP	AMERICAN EXPRESS COMPANY
9130	2817	ASBC	ASSOCIATED BANC-CORP
12048	3477	BXS	BANCORPSOUTH, INC.
515366	4504	BAC	BANK OF AMERICA CORPORATION
533744	253576	BOH	BANK OF HAWAII CORPORATION
12517	945834	BK	BANK OF NEW YORK MELLON CORPORATION, THE
10880	3718	BBT	BB&T CORPORATION
18099	4862	BPFH	BOSTON PRIVATE FINANCIAL HOLDINGS, INC.
24476	5734	COF	CAPITAL ONE FINANCIAL CORPORATION
25973	6053	CATY	CATHAY GENERAL BANCORP
513010	6930	C	CITIGROUP INC.
33509	7401	CMA	COMERICA INCORPORATED
33572	7431	CBSH	COMMERCE BANCSHARES, INC.
34052	7483	CBU	COMMUNITY BANK SYSTEM, INC.
38775	8414	CFR	CULLEN/FROST BANKERS, INC.
576129	78171	DFS	DISCOVER FINANCIAL SERVICES
513808	9926	EWBC	EAST WEST BANCORP, INC.
53359	324	FITB	FIFTH THIRD BANCORP

513195	30	FBP	FIRST BANCORP
54323	71	FCF	FIRST COMMONWEALTH FINANCIAL CORPORATION
54612	112	FFBC	FIRST FINANCIAL BANCORP
34010	233	FHN	FIRST HORIZON NATIONAL CORPORATION
54930	151	FMBI	FIRST MIDWEST BANCORP, INC.
59129	12463	BEN	FRANKLIN RESOURCES, INC.
59984	12645	FULT	FULTON FINANCIAL CORPORATION
62788	13309	GBCI	GLACIER BANCORP, INC.
515391	13564	GS	GOLDMAN SACHS GROUP, INC., THE
68361	14261	HWC	HANCOCK WHITNEY CORPORATION
33566	15235	HBAN	HUNTINGTON BANCSHARES INCORPORATED
77198	16495	IBOC	INTERNATIONAL BANCSHARES CORPORATION
525302	17528	JPM	JPMORGAN CHASE & CO.
82972	17862	KEY	KEYCORP
513015	19327	MTB	M&T BANK CORPORATION
523434	20426	MET	METLIFE, INC.
517989	21105	MS	MORGAN STANLEY
105035	21699	NBTB	NBT BANCORP INC.
525488	22029	NYB	NEW YORK COMMUNITY BANCORP, INC.
111229	22509	NTRS	NORTHERN TRUST CORPORATION
114096	23049	ONB	OLD NATIONAL BANCORP
526290	73	PACW	PACWEST BANCORP
526646	24487	PNFP	PINNACLE FINANCIAL PARTNERS, INC.
116690	24669	PNC	PNC FINANCIAL SERVICES GROUP, INC., THE

513517	25277	PRSP	PROSPERITY BANCSHARES, INC.
538010	440376	PFS	PROVIDENT FINANCIAL SERVICES, INC.
53772	550049	RF	REGIONS FINANCIAL CORPORATION
146377	29131	STT	STATE STREET CORPORATION
148574	29586	STI	SUNTRUST BANKS, INC.
141184	27981	SIVB	SVB FINANCIAL GROUP
105027	29817	SNV	SYNOVUS FINANCIAL CORP.
149466	30053	TCF	TCF FINANCIAL CORPORATION
536869	66710	TCBI	TEXAS CAPITAL BANCSHARES, INC.
155208	31417	TRMK	TRUSTMARK CORPORATION
156067	31946	USB	U.S. BANCORP
157521	31671	UMBF	UMB FINANCIAL CORPORATION
513965	31677	UMPQ	UMPQUA HOLDINGS CORPORATION
157276	32080	UBSI	UNITED BANKSHARES, INC.
519642	480535	UCBI	UNITED COMMUNITY BANKS, INC.
159382	32254	VLY	VALLEY NATIONAL BANCORP
164028	33221	WBS	WEBSTER FINANCIAL CORPORATION
164268	33264	WFC	WELLS FARGO and COMPANY
168034	33592	WTFC	WINTRUST FINANCIAL CORPORATION
170181	34139	ZION	ZIONS BANCORPORATION

Appendix 2: arrangement of factor sets

The comprehensive list of factors is a combination of factors from the Ellul and Yerramilli paper (bold), FO3 "original idea" factors (in boxes) and factors discussed in other papers (plain letters). [No one other paper brought all the non-boxed, non bolded, plain letter factors together.]