商業銀行の役員報酬制度が金融システムの安定に及ぼす影響の実証分析[1]

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【要旨】

本研究では、銀行の役員報酬制度が、金融システムの安定性に及ぼす影響を、実証的に分析した上で、動的コーポーレート・ファイナンス・モデルを構築し、各種報酬規制（ドッド・フランク法、ユーロ・ボーナス・キャップ、英国報酬規制等）が銀行のリスクテイクに与える影響を考察する。

2007 年の金融危機以降、銀行の役員報酬制度が、リスクテイクを助長させたという認識が深まり、新たな金融規制の導入が欧州を中心に進められてきた。もっとも、業績連動型の報酬（現金支給の賞与等）に紐付けられた短期的な利益追及が、銀行の過剰なリスクテイクに繋がったのか否かは未だコンセンサスが得られていない。本研究では、米国商業銀行の役員報酬に関する新たなデータベースを、ディスクロージャー誌等から構築し、役員報酬の違い（保有株式、ボーナス、株式報酬型ストックオプション等）が、銀行のリスクテイクに与える影響を定量的に評価する。

本研究の貢献は、以下の２点である。

１つ目の貢献は、役員報酬制度に関して、中小商業銀行を含めた包括的な実証分析を行った点である。筆者の知る限り、米国・欧州（一部地域を除く）において、中小商業銀行の役員報酬制度に着目した実証分析は行われていない。本稿の実証分析では、ボーナスと株式報酬型ストックオプションが、銀行のリスクテイクを助長することを示す。

２つ目の貢献は、銀行の①リスクテイク、②資金調達における資本構成、③役員報酬を取り込んだ動的コーポーレート・ファイナンス・モデルを構築した点である。モデル分析を行う利点は、大きく２つある。１つ目は、役員の報酬体系がリスクテイクに対するインセンティブに与える影響を理論的に明らかにする点である。２つ目は、“現実に導入された実績がない報酬規制に対する政策効果”を定量的に評価することが可能となる点である。本稿のモデル分析によると、ユーロ・ボーナス・キャップと英国報酬規制と比較して、ドッド・フランク法に基づく報酬規制は、（イ）銀行破綻を抑制し、（ロ）貸出を増加させる効果が高い。一方、ユーロ・ボーナス・キャップと英国報酬規制は、金融システムの安定に資するものの、その効果は個別銀行でばらつきが大きく、全体としての改善効果も限定的である。

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[1] 紙幅の都合上、本文中で引用されるインターネット付録（Appendix）は、次を参照されたい。
https://drive.google.com/file/d/12C4yvNrkMgeYe7RlnWm0kphXir9N8ysd/view?usp=sharing

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Bank CEO Compensation to Enhance Stability*

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Abstract

To understand bank risk-taking incentives, I construct a novel dataset of small and medium-sized U.S. bank Chief Executive Officer (CEO) compensation contracts and bank financials. First, I find empirical evidence of bonus and stock option compensations that explain the bank's poor performance and failure during the financial crisis of 2007-2009. Second, I quantitatively evaluate regulatory policies for bank CEO compensation to promote long-run financial stability. I develop a dynamic model of banking with agency conflicts to characterize the effect of shares owned, bonuses, and stock options on risk-taking. The bank CEO faces trade-offs between short-termism for immediate payment of cash and long-termism for stability subject to costs of external equity issuance under capital regulation and deposit insurance. The model is calibrated to U.S. data using the novel dataset. Counterfactual analysis shows that the Euro bonus cap and U.K. remuneration code —limitations to the ability of the bonus payment —improve financial stability and welfare. Finally, I argue that the Dodd-Frank proposal of 2016, which included a combination of deferred dividends and bonuses, has a further improvement according to the model prediction. Heterogeneity in compensation among bank CEOs has aggregate consequences of designing a proper compensation system.

Keywords: Compensation Regulation; Deferred Compensation; Risk-taking; Short-termism; Commercial Banks
JEL Classification: G21, G32, J33, M12

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1 Introduction

"Most importantly, we need to recognize that an effective regulatory regime and comprehensive supervision are not sufficient. We also need to focus on the incentives facing banks and their employees."

William C Dudley, President and CEO of the Federal Reserve Bank of New York, at the U.S. Chamber of Commerce, Washington DC, March 26, 2018[1]

1.1 Motivation

Strong criticism arises after the financial crisis of 2007-2009 that U.S. bank Chief Executive Officer (CEO) compensation spurred excess risk-taking. This disapproval is specially reserved for large financial institutions which are considered "too big to fail" and thus must be supported by the government when they do face failure.[2] For instance, the American International Group (AIG) is scheduled to pay $450 million bonuses to employees after receiving a $170 billion bailout from the U.S. government. Policymakers in the U.S. react to these incidents by proposing rules, Dodd-Frank Wall Street Reform in July 2010, mandating clawbacks of executive compensation.[3] After revisions of this proposal, the new compensation regulations are aimed to reduce excessive compensation and to prevent material financial loss.[4] A few anecdotes like the AIG bonus payments controversy support the views of incentive misalignment to the bank failure. However, this limited evidence for the entrenchment perspective creates doubt on the effectiveness of compensation regulation planned after the financial crisis.

While the vast majority of literature tries to understand the policy implication for big banks, this paper focuses on Small and Medium-sized Banks (SMB). I pick SMB for two reasons. First of all, SMB, as well as big banks, struggle through the financial crisis. One piece of evidence shows that 113 SMB owe Troubled Asset Relief Program (TARP) money five years later the financial crisis while most of the big banks repaid TARP money (Coles et al. (2006)). Other evidence shows that after the wake of the crisis, SMB who have high exposure to commercial real estate loans experience high failure rates (Friend et al. (2013)). Those banks had been increasing commercial real estate loans for several decades until the financial crisis (DiSalvo et al. (2016)). Second, studies of SMB help scholars and policymakers to understand the quantitative impact of executive compensation structure on risk-taking. I argue that large financial institutions hinder researchers from testing hypotheses and from

[1]Another related quote from the testimony to Congress on June 6, 2009, by Timothy Geitner, United States Secretary of the Treasury, *"I think that although many things caused this crisis, what happened to compensation and the incentives in creative risk taking did contribute in some institutions to the vulnerability that we saw in this financial crisis."*

[2]This view is consistent with the findings of size anomalies in bank stock prices (Gandhi and Lustig (2012)). Their evidence suggests that big banks are supported by implicit government guarantees.

[3]Dodd-Frank Act is a comprehensive package of financial regulation to prevent the repetition of the financial crisis. Two proposals are published in 2010 and 2016. However, the latest proposal is postponed in 2016.

[4]The United Kingdom implements the Remuneration Code, which requires executives and other employees to defer a large portion of their bonus compensation. Kleymenova and Tuna (2018) find a modest effect of reduction in risk-taking.

building a tractable model for the quantitative evaluation of policy reforms. Namely, large financial institutions run complex businesses, have unrestricted market access, have inherent government protection, and interact among loan markets strategically. These features create obstacles but interesting interactions for future studies to understand the channel to describe the effects of unimplemented policy. Nevertheless, this paper's policy implication for SMB applies to big banks to some extent since managerial conflicts faced by the bank manager and shareholders are a common characteristic of banks of all sizes.

This paper applies insights and techniques developed in corporate finance to banking literature. Research on non-financial firms supports that short-termism and managerial entrenchment as potential factors in corporate decisions (Coles et al. (2006)).[5] I ask a similar question for financial firms. Is it true bank CEO compensation can explain bank performance during the financial crisis? The answer to this question is not obvious because of the huge difference in market structure: the financial sector is more levered and regulated than the non-financial sector.

I take two steps to investigate the link between bank compensation and risk-taking. In the first part of the analysis, I apply simple regression models to test the hypothesis of this connection. As Cheng et al. (2015) pointed out, there is very little direct evidence for the entrenchment perspective among financial firms, even though many policymakers share the idea that managerial entrenchment caused risk-taking. In fact, Fahlenbrach and Stulz (2011) (hereafter FS (2011)) find no evidence that the bank's poor performance during the credit crisis is related to lack of alignment of bank CEO incentives with shareholder interests for a small sample of *big* financial institutions. I construct a novel dataset that includes a roughly ten times larger sample of SMB with financial statements, CEO compensations, and market prices. I also restricted my sample to commercial banks.[6] I find evidence in the regression analysis which supports short-term cash compensation and stock option stimulate risk-taking. Since bonus has an economically significant impact on risk-taking given evidence from this paper, restricting short-term cash compensation is a reasonable way to improve the economy. However, I argue by building a dynamic model of banking that a combination of restricting dividends and bonuses has further improvement.

The second part of the analysis asks which compensation regulation reduces risk-taking of the banking sector. I run a counterfactual experiment using a structural banking model with agency conflicts. In the model, the bank CEO faces trade-offs between short-termism for immediate profit and long-termism for stability. Policymakers suggest a wide variety of regulation tools which includes debt compensation, a combination of deferred dividends and deferred bonuses, and bonus caps. For example, William C. Dudley, the former president and CEO of the Federal Reserve Bank of New York, presents his idea (Dudley (2014)) that bank CEO compensation *"needs to be a shift in the mix of deferred compensation away from equity and towards debt"* in order to improve financial stability and rebuild the public trust. There is an important distinction between compensation regulation and standard bank regulation, such as capital requirement ratio or liquidity coverage ratio. Policymakers

[5]There is also disagreement about this statement. Hayes et al. (2012) find a causal relationship between option-based compensation and risk-taking using the exogenous change of the revised accounting standard change as an instrument.

[6]Compared to the study of FS (2011), my paper's sample contains only commercial banks that prevent the potential bias caused by difference of industry groups such as investment banking and brokerage.

claim that complex rules of capital requirement ratio and others can create an incentive where banks feel free to do anything, which increases risk and bad behavior.[7] Compensation regulations are believed to be simple, and therefore to avoid regulatory arbitrage, which lowers the effectiveness of the banking regulation. The key contribution of this paper is to conduct a series of counterfactuals that quantifies the effects of compensation regulations.

The important question becomes which tool is best suited to fixing misaligned incentives of CEOs in the U.S. banking sector. Counterfactual policy scenarios are (i) Dodd-Frank, (ii) pure debt-based compensation (Bebchuk and Spamann (2009)), (iii) the Euro bonus cap, and (iv) U.K. remuneration code to a standard compensation plan, and see how the bank manager responds optimally to change in these regulations.[8] On top of that, I investigate the effects of (v) hypothetical option ban, which is an extreme case of FAS 123R and (vi) capital requirement ratio from Basel II to III. In conclusion, the model suggests that the Dodd-Frank proposal of 2016 leads to the largest improvement in financial stability and welfare measured by consumption. This stems from the fact that the bank CEO's compensation structure is heterogeneous. Therefore, the Dodd-Frank proposal of 2016, which is two combinations of deferred dividends and deferred bonuses, reduces heterogeneous reactions.

1.2 Literature Overview

I will not provide a comprehensive review of CEO compensation and risk-taking on non-financial firms. But here I provide a list of literature about financial firms.

FS (2011) find that banks in which the CEO's incentives were better aligned with those of shareholders did not perform better during the crisis. At the same time, authors alert to the problem that their data source Execucomp is biased toward larger firms. In this paper, I collect both SMB and large banks to understand industry-wide implications to the entrenchment perspective. Berger et al. (2016) also do not find any evidence of direct impact from shareholdings of bank CEO to bank failure. For a study of European countries, Efing et al. (2015) use payroll data from German, Austrian, and Swiss treasury/capital market management and investment banks employees. Authors find incentive pay correlates positively with risk-taking.

Extensive literature shows a positive relationship between risk-taking by banks and CEO compensation structure. DeYoung et al. (2013) and Bai and Elyasiani (2013) find that higher compensation sensitivity to changes in volatility which is Vega leads to greater bank instability. On the contrary, my study focuses on a dynamic trade-off of risk-taking rather than a static trade-off. Bennett et al. (2015) argue that CEO inside debt reduces default risk. Iqbal and Vähämaa (2019) document managerial risk-taking incentives increase the level of systemic risk during the financial crisis.

Cheng et al. (2015) claim that the riskier firms may offer higher total pay as compensation for the extra risk in equity. In other words, they claim that the causality can be reversed as many believe that misalignment from shareholders' value caused financial firms to take risks

[7] Banks control their Risk-Weighted Assets in capital requirements via regulatory arbitrage (e.g., Blundell-Wignall and Atkinson (2010)).

[8] There are other types of debt-based compensations proposed in the literature. Subordinated debt compensation (Tung (2011)) and convertible equity compensation (Gordon (2010)) are two common types. I leave them to explore for future research.

before the crisis. This paper does not deal with this issue of reverse causality. This paper's argument fixes compensation structure and discusses regulating bank CEO compensation package by restricting the flow of income.

Nikolov and Whited (2014) develop a dynamic model with agency conflicts to explain corporate cash policy. Glover and Levine (2017) study a structural model of manager's conflict. My model alters their model to accommodate features of the banking industry: decreasing returns to scale; endogenous risk-taking and capital structure; short-term cash compensation; capital regulation; and deposit insurance.

Roadmap. The remainder of the paper is organized as follows. In Section 2, I provide reduced-form evidence. Section 3 introduces the model and provides counterfactual experiments. Section 4 concludes.

2 Regression Analysis

2.1 Sample Construction

The primary data source is S&P Capital IQ collecting data from U.S. Securities and Exchange Commission (SEC) company filings, the Center for Research in Security Prices (CRSP), Call Reports from Federal Deposit Insurance Corporation (FDIC), Intercontinental Exchange (ICE). For publicly listed banks, the balance sheet and income statement are coming from annual reports (10-K). The CEO compensation is collected from proxy statement pursuant (DEF 14A) for publicly listed banks. The price data is collected both from CRSP and ICE. CRSP contains equity price with banks' primary listings on major stock market s.t. NYSE, NYSE MKT, NASDAQ, Arca, and Bats exchanges. ICE covers stock traded in other markets such as Pink Sheets and OTC Bulletin Board.

I collect the data of all companies with Standard Industry Classification (SIC) codes 6020 commercial banks at the end of the fiscal year of 2006 in S&P Capital IQ. This sample includes community banks, regional banks, banks traded on major U.S. stock exchange markets, and those traded in the Over-The-Counter stock markets (i.e., the OTC Bulletin Board and the Pink Sheets).[9] I restrict my sample to a geographic location in the U.S.. I also drop banks that do not report total assets, bank CEO's salary, and market capitalization at the end of the fiscal year of 2006. My final sample contains 721 commercial banks at the end of the fiscal year of 2006. This sample size is roughly twice as many as Berger et al. (2016) collected from the Mergent database. Most previous research about bank CEO compensation relies on Execucomp to construct the sample. Execucomp sample is limited because the data covers only banks listed on S&P 1500, and banks are removed from the index that is still trading. The commercial bank sample size of S&P 1500 in my full sample is 69 by the end of 2006. My novel dataset consists additional 652 commercial banks, excluding commercial banks listed on S&P 1500, which allows me to increase the sample size substantially.[10,11]

[9]The OTC Bulletin Board and the Pink Sheets restrict non-SEC-registered securities of U.S. banks to follow the disclosure guidelines outlined in the OTCQX Rules for U.S. banks.

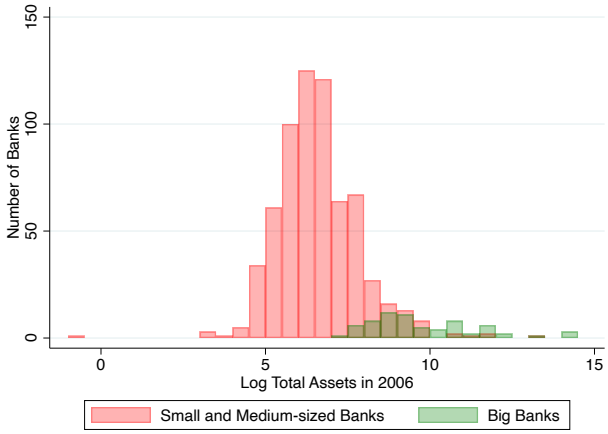
[10]A full sample of FS (2011) is 95 financial institutions which include both bank holding companies, and investment banks, which correspond to SIC codes between 6000 and 6300 for the fiscal year of 2006. Their subsample is 83 banks which remove nondepository banks from the full sample.

[11]Berger et al. (2016) has a total sample of 341 commercial banks from 2006Q1 to 2010Q3. They admit

Technical details to construct variables from S&P Capital IQ are described in Appendix A.1.

I create a subsample of S&P 1500 from the list of sample firms in the appendix of FS (2011). I hand-corrected the bank name if the name is not exactly the same. 69 banks are matched with my final sample. I call this group big banks or S&P 1500 bank. The remaining group of banks is named SMB (size distribution measured by total assets in Figure 1).[12]

Figure 1: Size Distribution of SMB and Big Banks



2.2 Timeline of Returns and Failure in the Financial Crisis

In the regression analysis, I construct crisis period returns of banks from July 1, 2007, to December 31, 2008, as in FS (2011). Figure 2 shows the evolution of Return Of Asset (ROA) and Return Of Equity (ROE). The crisis does not end on December 31, 2008, but I leave subsequent periods out from the calculation of return to separate the threat of nationalization, which would affect the value of bank stocks and the incentives of CEOs.

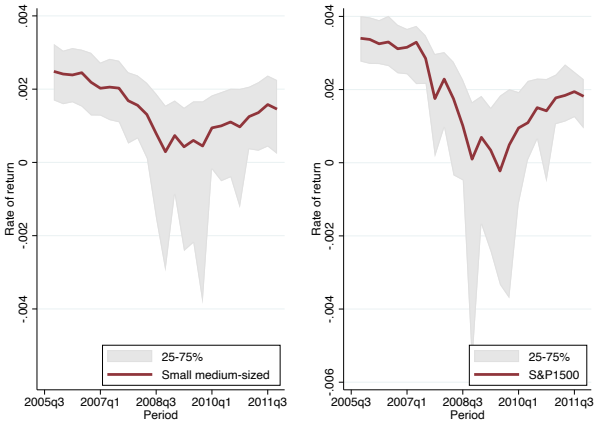
that they put more effort into hand-collect data from failed banks than non-failed banks. Therefore, they have a potential issue of sample selection bias toward failed banks. My data collect almost twice as many non-failed banks to fix this data collection issue.

[12] Gandhi and Lustig (2012) use a definition of big banks as the first decile of total assets of commercial banks in CRSP. The number of banks for the years 2000 to 2008 is approximately 630 banks.

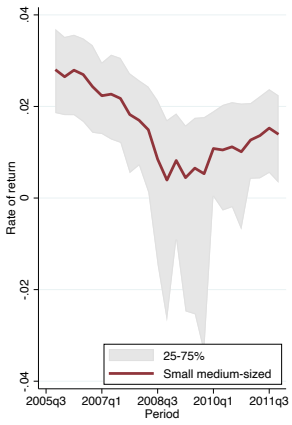
Figure 2: Evolution of the Rate of Returns from 2005q3 to 2011q3

The figures show the time series of return of asset (ROA) and return of equity (ROE). The full sample is split into a group of S&P1500 banks and a group of SMB. S&P1500 consists of shares traded in NYSE, NYSE Arca, NYSE MKT, NASDAQ Global Select Market, NASDAQ Select Market, and NASDAQ Capital Market. The solid lines are the median of the rate of return, and the shaded region is 25-75% interval of the rate of return. ROA is defined as net income divided by total assets. ROE is defined as net income divided by equity. A sample of commercial banks for 24 quarters.

Panel A: Return of Asset (ROA)



Panel B: Return of Equity (ROE)



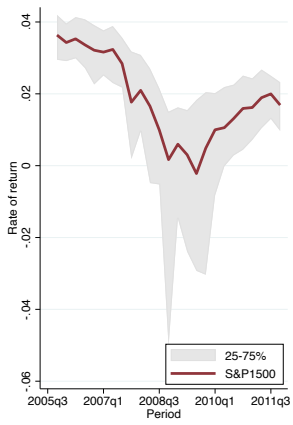
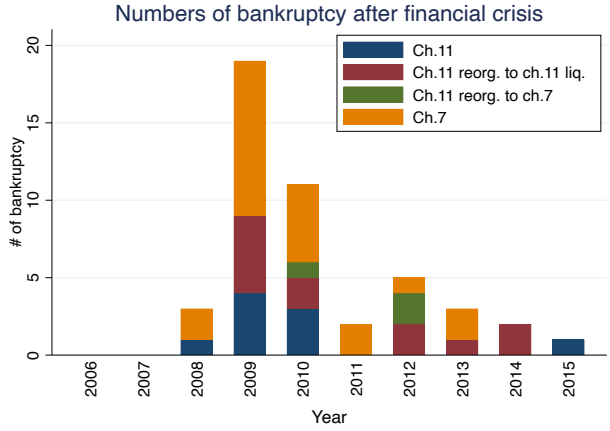


Figure 3 shows the evolution of the numbers of bankruptcy in our final sample. 2009 and 2010 record the first and second peaks of the number of bankruptcy in the financial crisis. The evolution of bankruptcy has a lag period for bank returns because the bankruptcy process takes time. I classify all the bankrupted banks between July 2007 to December 2010 as bankruptcy in the cross-sectional regression analysis to take into account the length of time for filing chapter 11 and chapter 7 bankruptcy. Total 42 banks file bankruptcy between July 2007 to December 2010.

Figure 3: Evolution of Failed Banks from 2006 to 2015

The figure shows the evolution of the number of failed banks from 2006 to 2015. No bankruptcy is reported for 2006 and 2007. The number is a sum of banks filed chapter 11 or chapter 7 bankruptcy to the court at the period of a voluntary petition filing date. The sample includes both S&P 1500 banks and SMB.



2.3 Summary Statistics

Tables 1-2 report key summary statistics of banks' financial statements and CEO compensation for the fiscal year of 2006. The average size of SMB is 3.2 billion dollars. Buy-and-hold returns of SMB during the crisis is -39% on average. Bonus/revenue is a proxy of the elasticity of annual incentive on the performance measure.[13] The average of unexercisable options/total shares is 0.3% in SMB sample.[14] There is notable heterogeneity in compensation structure in the SMB sample. The SMB sample has 4 (5) times larger standard deviation of bonus/revenue ("Percentage ownership from shares") than FS (2011) sample. Scatter diagrams in Appendix A1 show negative correlations between buy-and-hold returns during crisis and compensations (bonus/revenues and unexercisable options/total shares) in 2006.

Table 1: Sample Summary Statistics of Banks Financial Statements for Fiscal Year 2006

Panel A: Comparison of 2006 financial characteristics of small and medium-sized banks and S&P1500

	Small and medium-sized banks				S&P1500: Fahlenbrach and Stulz (2011)			
	Number	Mean	Median	Std. Dev	Number	Mean	Median	Std. Dev
Total assets (million dollars)	650	3,190.5	648.59	28,981.07	69	105,436.5	10,571.8	324,929.7
Total liabilities	650	2,848.4	588.34	25,841.19	69	96,257.1	9,804.3	299,782.3
Market capitalization	650	605.8	104.03	4,703.07	69	17,812.8	2,055.1	48,807.0
Buy-and-hold returns during crisis	599	-38.7	-41.52	34.92	62	-36.1	-38.4	34.6
Net income/total assets (%)	650	0.84	0.90	1.03	69	1.29	1.26	0.42
Net income/book equity (%)	650	9.36	9.96	6.19	69	13.32	12.92	4.87
Cash/total assets (%)	650	0.05	0.04	0.06	69	0.04	0.03	0.03
Dividend per share	650	1.02	0.34	5.98	69	1.67	1.00	3.13
Book-to-market ratio	650	0.62	0.60	0.22	69	0.52	0.50	0.16
Tier1 capital ratio (%)	650	13.44	11.84	13.50	69	10.14	9.80	2.69
Tangible common equity ratio	650	5.15	6.14	5.82	69	5.31	6.21	2.53

Panel B: Comparison of 2006 financial characteristics of group in total asset size

	Full sample (group in total asset size)							
	1st quartile		2nd quartile		3rd quartile		4th quartile	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Total assets (million dollars)	216.5	226.7	535.0	524.8	1,223.7	1,108.3	50,233.7	5,763.5
Total liabilities	192.5	204.0	486.5	476.0	1,112.4	1,000.0	45,638.6	5,006.8
Market capitalization	36.4	32.2	83.2	78.4	218.2	177.2	8,725.2	1,103.3
Buy-and-hold returns during crisis	-46.1	-45.9	-45.8	-47.6	-37.1	-38.6	-24.7	-20.6
Net income/total assets (%)	0.49	0.71	0.91	0.90	0.95	0.95	1.20	1.13
Net income/book equity (%)	6.33	7.19	10.20	10.66	10.72	11.37	11.72	11.97
Cash/total assets (%)	0.08	0.05	0.04	0.04	0.04	0.03	0.04	0.03
Dividend per share	0.25	0.00	1.04	0.36	1.06	0.46	2.00	0.76
Book-to-market ratio	0.70	0.67	0.62	0.62	0.56	0.55	0.56	0.50
Tier1 capital ratio (%)	16.86	13.28	12.64	11.95	12.00	11.11	11.01	10.51
Tangible common equity ratio	2.37	0.00	4.79	6.44	7.11	7.26	6.41	6.38

[13] Annual Incentive Plan Design Survey conducted in 1996–1997 by Towers Perrin shows that 19 U.S. finance and insurance corporations out of 21 are using earnings as one of the performance measures in annual incentive plans. Earnings include net income, pre-tax net income, and returns on assets, equity, and capital. However, these measures are not non-negative. Revenue is a good measure of earnings because it is non-negative. Therefore, the elasticity of annual incentive is non-negative.

[14] This is less than the average of exercisable options/total shares because unexercisable options are issued recently and exercisable options are issued in the past.

Table 2: Sample Summary Statistics of Bank CEO Compensation for Fiscal Year 2006

Panel A: Comparison of 2006 CEO compensation characteristics of small and medium-sized banks and S&P1500

	Small and medium-sized banks				S&P1500: Fahlenbrach and Stulz (2011)			
	Number	Mean	Median	Std. Dev	Number	Mean	Median	Std. Dev.
Annual compensation								
Total compensation (thousand dollars)	650	807.7	422.9	2,206.0	69	5,858.3	2,602.2	8,288.3
Cash compensation	650	543.5	348.0	994.9	69	2,417.7	1,495.7	2,897.8
Salary and others	650	473.2	307.5	933.1	69	1,885.7	1,187.7	1,990.9
Salary	650	287.5	240.0	155.2	69	730.6	737.5	260.8
Bonus	650	70.2	4.1	266.0	69	532.0	0.0	2,214.1
Annual stock grant	650	86.1	0.0	645.2	69	1,283.4	306.2	2,569.7
Annual option grant	650	81.6	0.0	519.9	69	1,554.7	389.9	3,602.8
All other compensation	650	82.4	27.7	639.8	69	207.5	119.5	276.1
Salary and others/total assets (%)	650	0.12	0.05	1.49	69	0.01	0.01	0.01
Salary/total assets (%)	650	0.10	0.04	1.26	69	0.01	0.01	0.01
Bonus/revenue (%)	647	0.18	0.01	0.32	69	0.03	0.00	0.08
Cash compensation/total compensation (%)	647	84.57	90.34	17.49	69	56.84	50.64	21.82
Equity portfolio value								
Value equity	650	545.3	0.0	2,255.1	69	14,761.1	3,574.0	31,440.4
Value shares	650	235.1	0.0	1,272.8	69	6,087.8	1,142.8	13,493.9
Exercisable options/total shares (%)	650	1.03	0.44	2.43	69	0.67	0.41	0.86
Unexercisable options/total shares (%)	650	0.23	0.00	0.51	69	0.24	0.12	0.59
Value unvested stock	650	130.0	0.0	729.8	69	3,869.8	451.6	11,540.2
Equity portfolio incentives								
Percentage ownership from shares (%)	527	2.66	0.86	5.92	60	0.66	0.28	1.15

Panel B: Comparison of 2006 CEO compensation characteristics of group in total asset size

	Full sample (group in total asset size)							
	1st quartile		2nd quartile		3rd quartile		4th quartile	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Annual compensation								
Total compensation (thousand dollars)	268.4	238.5	417.3	362.5	678.5	544.3	3,817.4	1,346.5
Cash compensation	234.0	215.4	345.0	319.9	533.2	451.0	1,785.2	942.0
Salary and others	212.3	199.8	301.6	280.5	450.6	385.5	1,473.3	822.2
Salary	172.0	166.5	230.9	225.2	319.3	300.0	599.1	536.5
Bonus	21.7	5.0	43.4	10.0	82.6	0.0	311.8	0.0
Annual stock grant	4.8	0.0	8.1	0.0	21.6	0.0	772.7	74.2
Annual option grant	18.0	0.0	14.3	0.0	41.3	4.0	821.8	91.6
All other compensation	28.4	18.6	36.5	26.1	58.7	31.6	254.5	62.8
Salary and others/total assets (%)	0.33	0.10	0.06	0.06	0.04	0.03	0.02	0.01
Salary/total assets (%)	0.27	0.08	0.04	0.04	0.03	0.03	0.01	0.01
Bonus/revenue (%)	0.24	0.06	0.20	0.05	0.16	0.00	0.05	0.00
Cash compensation/total compensation (%)	91.51	99.18	87.03	91.86	82.45	86.29	66.65	68.28
Equity portfolio value								
Value equity	42.7	0.0	108.6	0.0	353.2	42.4	7,163.5	1,290.0
Value shares	10.4	0.0	31.7	0.0	77.3	0.0	3,080.5	386.2
Exercisable options/total shares (%)	1.21	0.50	1.00	0.50	0.84	0.41	0.95	0.36
Unexercisable options/total shares (%)	0.30	0.00	0.19	0.00	0.22	0.05	0.22	0.08
Value unvested stock	9.1	0.0	25.0	0.0	45.6	0.0	1,883.8	0.0
Equity portfolio incentives								
Percentage ownership from shares (%)	2.81	1.20	2.30	0.96	2.65	0.84	2.14	0.45

2.4 Empirical Results

In this section, I find that bonus/revenue and unexercisable options/total shares explain the bank performance and bankruptcy in the crisis for SMB. Bonus/revenue is a quantitatively more important factor than unexercisable options/total shares. A large number of a specification does not allow ownership from shares to find statistically significant relationship to

risk-taking.

The specification of cross-sectional regression:

$$\begin{aligned}\text{Risk-Taking}_i &= \beta_0 + \beta_1 \text{Salary and others/total assets}_i + \beta_2 \text{Bonus/revenue}_i \\ &+ \beta_3 \text{Ownership from shares}_i + \beta_4 \text{Unexercisable options/total shares}_i \\ &+ \text{Controls}_i + \varepsilon_i\end{aligned}$$

where risk-taking is measured in between crisis and right-hand variables are measured in pre-crisis. β_j are coefficients ($j \in \{0, 1, 2, 3, 4\}$) and ε_i is error term where i is an index for bank CEO. The measure of risk-taking captures poor bank performance during the crisis period.

I run regression models for four different bank performance measures: buy-and-hold returns, ROA, ROE, and bank failure.

Market Returns. My benchmark specification is model (6) in Table 3. The dependent variable is buy-and-hold-returns. One standard deviation increase in bonus/revenue 0.32(%) explains $-8.03\%(= -25.09 \times 0.32(\%))$ (or -0.21% in annual returns) drop of buy-and-hold returns. One standard deviation increase in unexercisable options/total shares 0.2(%) decreases $-2.29\%(= -11.47 \times 0.2(\%))$ (or -1.53% in annual rate). Since the median drop of buy-and-hold returns in the crisis is 41.52%, bonus/revenue has quantitative significance as well. The quantitative impact is less pronounced for unexercisable options/total shares.

Table 3: Buy-and-hold Returns during the Financial Crisis and Bonus, Ownership, and Options of 2006 for SMB

The table shows results from cross-sectional regressions of buy-and-hold returns for commercial banks from July 1, 2007 to December 31, 2008. "Salary and others/total assets" is annual salary plus other cash compensation excluding bonus for the fiscal year of 2006 divided by total assets at the end of the fiscal year of 2006. "Bonus/revenue" is an annual bonus for the fiscal year of 2006 divided by annual revenue of the fiscal year of 2006. "Exercisable options/total shares" and "Unexercisable options/total shares" are ratios of the number of options and the total number of shares of common stock outstanding. "ln(market capitalization" is a natural log of market capitalization. Market capitalization is a product of share price and shares outstanding at the end of the fiscal year of 2006. TCE ratio stands for tangible common equity ratio. Numbers in parentheses are t-statistics, and ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample is for SMB.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Salary and others/total assets	-0.640					-12.50	12.48
	(-0.70)					(-0.26)	(0.26)
Bonus/revenue (θ_B)		-23.12***				-25.09***	-26.31***
		(-5.43)				(-3.95)	(-4.12)
Ownership from shares (%, θ_S)			0.000513			0.00177	0.000861
			(0.19)			(0.65)	(0.31)
Exercisable options/				-0.0277		0.0301	0.0351
total shares				(-0.34)		(0.38)	(0.44)
Unexercisable options/					-9.939***	-11.47***	-10.66***
total shares (θ_O)					(-3.70)	(-3.63)	(-3.36)
Stock return 2006						-0.000126	0.00732
						(-0.00)	(0.11)
Book to market ratio						-0.101	-0.0673
						(-1.14)	(-0.75)
ln(market capitalization)						0.0561***	0.0570***
						(3.14)	(3.06)
Tier 1 capital ratio (%)						0.00876**	
						(2.58)	
TCE ratio (%)							0.00119
							(0.26)
Number of observations	598	595	485	598	598	476	476
R^2	0.000813	0.0473	0.0000773	0.000193	0.0224	0.129	0.117

I run several robustness tests. First, I run a regression close to FS (2011) which uses cash bonus/salary as a measure of short-term cash compensation in Appendix A.2. Again, I reach the same conclusion that the big bank sample has no explanatory power, but the SMB sample brings back the statistical power of this link (Appendix Table A1). Second, I use salary/total assets instead of salary and others/total assets (results are reported in Appendix Table A2). The results are unchanged qualitatively and quantitatively. Third, I use cash bonus/salary in the regression analysis as a measure of reliance on bonuses. Appendix Table A2 shows that the main results still hold. Forth, I compared my main regression to a full sample excluding the top 10 banks for checking my result for a broader definition of SMB (Appendix Table A4). The largest banks in the U.S. are known to be different from other fringe banks. However, this also does not change my results in Table 3 qualitatively and quantitatively.

ROA. For my benchmark specification model (6) for ROA as the dependent variable (Table 4), one standard deviation increase in bonus/revenue 0.32(%) reduces ROA by $-0.22\%(= -0.684 \times 0.32(\%))$ (or -0.15% in annual returns). One standard deviation increase in unexercisable options/total shares 0.2(%) reduces ROA by $-0.07\%(= -0.357 \times 0.2(\%))$ (or -0.05% in annual returns). The quantitative implication is similar to buy-and-hold returns. Book to market ratio has negative sign and statistically significant. This is aligned with the finding in FS (2011). To compare these result with previous research, I report regression results for

big banks sample in Appendix Table A5. bonus/revenue is not statistically significant for big banks.

Table 4: Return of Asset during the Financial Crisis and Bonus, Ownership, and Options of 2006 for SMB

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Salary and others/total assets	-4.744***					-1.447	-0.856
	(-3.39)					(-0.56)	(-0.33)
Bonus/revenue (θ_B)		-0.357				-0.684**	-0.712**
		(-1.57)				(-2.10)	(-2.19)
Ownership from shares (%, θ_S)			-0.0000294			0.0000365	0.0000129
			(-0.19)			(0.25)	(0.09)
Exercisable options/				0.000599		0.00100	0.00117
total shares				(0.13)		(0.25)	(0.29)
Unexercisable options/					-0.374**	-0.357**	-0.349**
total shares (θ_O)					(-2.44)	(-2.05)	(-2.01)
Lagged ROA						0.189**	0.205**
						(2.34)	(2.58)
Book to market ratio						-0.0160***	-0.0151***
						(-3.50)	(-3.34)
ln(market capitalization)						-0.00202**	-0.00208**
						(-2.30)	(-2.29)
Tier 1 capital ratio (%)						0.000189	
						(1.05)	
TCE ratio (%)							0.0000755
							(0.33)
Number of observations	624	622	518	624	624	507	507
R^2	0.0181	0.00394	0.0000678	0.0000261	0.00945	0.0635	0.0616

ROE. The model (6) is my benchmark specification for ROE (Table 5). One standard deviation increase in bonus/revenue 0.32(%) explains $-2.83\%(= -8.864 \times 0.32(\%))$ (or -1.90% in annual returns) drop of ROE. One standard deviation increase in options/total shares 0.2(%) decreases $-0.94\%(= -4.704 \times 0.2(\%))$ (or -0.62% in annual returns). The implication of quantitative impact looks similar to other returns.

Table 5: Return of Equity during the Financial Crisis and Bonus, Ownership, and Options of 2006 for SMB

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Salary and others/total assets	-22.14*					-16.90	-10.06
	(-1.88)					(-0.74)	(-0.44)
Bonus/revenue		-4.337**				-8.864***	-8.987***
		(-2.08)				(-2.98)	(-3.02)
Ownership from shares (%)			-0.000419			-0.000871	-0.00112
			(-0.34)			(-0.69)	(-0.89)
Exercisable options/				0.00884		0.0168	0.0194
total shares				(0.23)		(0.45)	(0.52)
Unexercisable options/					-3.924***	-4.704***	-4.682***
total shares					(-3.08)	(-3.03)	(-3.01)
Lagged ROE						0.391***	0.389***
						(3.97)	(3.94)
Book to market ratio						-0.117***	-0.107**
						(-2.60)	(-2.40)
ln(market capitalization)						-0.0172**	-0.0190**
						(-2.10)	(-2.23)
Tier 1 capital ratio (%)						0.00213	
						(1.32)	
TCE ratio (%)							0.00177
							(0.86)
Number of observations	621	619	514	621	621	503	503
R^2	0.00570	0.00695	0.000220	0.0000826	0.0151	0.102	0.100

Bank Failure. The number of failed banks counts the number of bankruptcy and taken over by FDIC from July 2007 to December 2010 (Table 6). I measure the number of failed banks in two ways. "Only child" is a bank that is taken over by FDIC. "Child & parent" is a bank that is its parent is taken over by FDIC. It is hard to say which is better or worse. "Child & parent" might be overweighting the managerial influence to the child subsidiaries who are taken over by FDIC. Moreover, some bank holding companies experience multiple times of taken over by FDIC. These bank holding companies might have been more distressed than the bank holding company experiences only one time of taken over by FDIC. I check results computed from both measures for concreteness. I do not count banks that were merged within a bank holding company as a failure because it is unclear whether these mergers happen because these banks are troubled or not.

Larger banks are more likely to bankrupt or taken over by FDIC (Table 6). 12% of banks fail in the SMB sample, while 32% of banks fail in the S&P1500 sample.

Table 6: Summary Statistics of Bank Failure from July 2007 to December 2010

The table shows the summary statistics of bank failure from July 2007 to December 2010. "Bankruptcy" is a sum of the number of banks filed Chapter 11, Chapter 11 reorganization to Chapter 7 liquidation, Chapter 11 reorganization to Chapter 7, and Chapter 7. "Taken over by FDIC" is the number of banks that are on the failed bank list by the FDIC. I match the commercial bank on the list of failed banks and the parent BHC.

	Small and medium-sized		S&P1500		Total	
	Number	Percentage	Number	Percentage	Number	Percentage
Failed bank	79	12	22	32	101	14
Bankruptcy	37	6	5	7	42	6
Taken over by FDIC (child & parent)	48	7	17	25	65	9
Taken over by FDIC (only child)	16	2	3	4	19	3
Total	652	100	69	100	721	100

I run Probit models for three different dependent variables: the probability of failure, bankruptcy, and taken over by FDIC. Table 7 shows that bonus/revenue and unexercisable options/total shares have statistical power to explain the bankruptcy rate in the crisis. Bonus/revenue does not explain the probability of taken over by FDIC. I run similar regression models for the full sample in Appendix Table A7. The qualitative result is unchanged.

Table 7: Bank Failure during the Financial Crisis and Bonus, Ownership, and Options of 2006 for SMB

The table reports the regression coefficients from running Probit model of the number of bankruptcies, the number of banks taken over by FDIC, and failed banks from July 2007 to December 2010. "Bankruptcy" is an indicator of banks declared bankruptcy under Chapter 11 or Chapter 7. "Taken over by FDIC" is an indicator of banks listed on FDIC. "Failed Bank" is an indicator of banks either declared bankruptcy or listed on the FDIC list. Numbers in parentheses are t-statistics, and ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. The sample is for SMB.

	Failure		Bankruptcy	Taken over by FDIC	
	Child & parent	Only child		Child & parent	Only child
Dependent variables	(1)	(2)	(3)	(4)	(5)
Salary and others/total assets	247.8	113.4	48.04	350.2	268.3
	(1.21)	(0.49)	(0.20)	(1.53)	(0.85)
Bonus/revenue (θ_B)	48.74*	74.95**	87.05***	24.46	65.25
	(1.77)	(2.50)	(2.76)	(0.76)	(1.58)
Ownership from shares (%, θ_S)	0.0256**	0.0276**	0.0296**	0.00888	-0.00449
	(2.26)	(2.24)	(2.33)	(0.63)	(-0.17)
Exercisable options/	-0.471	-0.178	-2.617	-0.0449	0.0562
total shares	(-0.22)	(-0.19)	(-0.83)	(-0.07)	(0.10)
Unexercisable options/	50.27***	65.53***	66.64***	17.51	43.98**
total shares (θ_O)	(3.47)	(4.73)	(3.90)	(1.11)	(2.44)
Stock return 2006	-0.140	-0.700	-1.147*	0.267	0.176
	(-0.44)	(-1.35)	(-1.94)	(0.86)	(0.38)
Book to market ratio	0.00327	0.131	0.256	-0.444	-0.667
	(0.01)	(0.26)	(0.49)	(-0.81)	(-0.72)
ln(market capitalization)	0.319***	0.155*	0.187**	0.298***	-0.0458
	(4.43)	(1.74)	(2.03)	(3.72)	(-0.27)
Tier 1 capital ratio (%)	-0.0244	-0.0381*	-0.0405*	-0.0102	-0.0399
	(-1.28)	(-1.71)	(-1.68)	(-0.47)	(-1.18)
Number of observations	516	516	516	516	516

3 Counterfactual Analysis

This section builds a model cast in discrete time with an infinite horizon ($t = 1, 2, \ldots$). The model frequency is annual. The variable x is the current period (t) and x' is the next period ($t+1$) for simplified notation. There are two agents in the economy: the bank manager and a representative household. A representative household is the majority of the shareholder.

3.1 The Model

Bank Manager. Endogenous risk-taking follows Allen and Gale (2000). Assume $p(S) = 1 - S^{\eta}$ is the probability of success and $S \in [0, 1]$ is the level of risk-taking where the elasticity of success among the level of risk-taking is a parameter $\eta \in [0, 1]$. Probability p satisfies:

$p(0) = 0$, $p(1) = 1$, $p' < 0$, and $p'' \leq 0$ for all $S \in [0, 1]$.[15] When the bank is subject to failure with the probability of $1 - p$, the bank manager and a representative household lose all benefits.[16] Failed banks lose their franchise value (Martinez-Miera and Repullo (2010)).

The bank manager lives two periods: the young bank manager decides (i) risk-taking, (ii) deposits, and (iii) next period equity; the old bank manager is replaced by a new bank manager. The old bank manager discounts his utility by the rate of β. The bank manager receives utility from three different types of compensation: shareholdings, bonuses, and stock options.[17]

The bank manager has access to decreasing returns to scale technology $e^z S l^{\alpha_l}$ with fixed costs f. l is the outstanding of loans and returns to scale is $\alpha_l \in (0, 1)$. Productivity z is the idiosyncratic following AR(1) process ($z' = \rho_z z + \sigma_z \varepsilon_z$) which ε_z is i.i.d. shocks from a normal distribution. Loans depreciate by the rate of $\delta \in [0, 1]$ after production. The bank incurs external equity financing costs proportional to λ (Gomes (2001); Hennessy and Whited (2007)). The net deposit return is $r + \alpha$ which r is the risk-free rate and α is the deposit insurance costs. The share price is endogenous determined in the partial equilibrium model.

Representative Household. The representative household has limited power to enforce the bank manager not to deviate from the shareholder's interest. The risk-neutral household maximizes its own utility by choosing the portfolio of safe and risky assets with a discount rate of β.

Optimization Problem and Equilibrium. The risk-neutral (young) bank manager solves dynamic programming problem:

$$\begin{aligned} W(e, z) &= \max_{S, d \geq 0, e'} \theta_S \left(D(e, z, S, d, e') + p(S) \beta E_{z'|z}[V(e', z'|\Phi)] \right) \\ &+ \theta_B e^z S l^{\alpha_l} \\ &+ \theta_O p(S) \beta E_{z'|z}[\max\{V(e', z'|\Phi) - \kappa(e, z|\Phi), 0\}] \end{aligned}$$

.

subject to

$$\begin{aligned} \tilde{D} &= e^z S l^{\alpha_l} - \delta l - (r_f + \alpha) d - (e' - e) - f \\ D &= (1 + \lambda \mathbb{1}_{\tilde{D} < 0}) \tilde{D} \\ \kappa(e, z|\Phi) &= \text{ATM} + \frac{\lambda_\kappa}{2} \text{ATM}^2 \\ \text{ATM} &= V(e, z|\Phi) - D \end{aligned} \tag{1}$$

[15] S increases returns in loans but decreases the probability of success ($p'(S) = -\eta S^{\eta - 1} < 0$).

[16] For technical reasons, I assume that the bank's internal fund is reduced to minimum value $\underline{e}$ when the bank defaults. The bank distributes new bank's shares to households. Since I focus on the long-run effect, this assumption allows fixing the mass of banks across time.

[17] Since my regression exercises show that fixed compensation (salary and others/total assets) is statistically insignificant to explain bank performance and failure during the crisis, I do not include fixed compensation in my model for simplicity. Therefore, the bank CEO is feared to take a risk by losing his value of shareholding and stock options but not from fixed compensation in the model.

$$\begin{aligned} l &= d + e \\ \frac{e}{l} &\geq \chi \end{aligned}$$

$\tilde{D}$ is equity payout before external financing costs. D is equity payout after external financing costs. Equity financing costs have a linear relationship as in Gomes (2001). If D is negative, the bank manager and shareholders pay additional costs for equity issuance. Φ is a set of policy functions with respect to control variables S, d, and e'. The bank is not allowed to issue negative deposits ($d < 0$). The bank manager earns income from stock holdings, short-term cash compensation, and stock options. $\kappa(e, z|\Phi)$ is the "effective" strike price of stock option compensation. In practice, the strike price is set to at the money (ATM). At the same time, stock options are less frequently exercised in data even though the stock price is deeply in the money (ITM). I capture the hidden costs of the bank's manager by assuming that the "effective" strike price is a quadratic decreasing function of the fair value of the current stock price. This functional form helps me to match data and to solve value function iteration by restoring local concavity.[18] Lastly, the stock option is not dividend protected, and therefore stock price (ATM) is an ex-dividend price which is a cum-dividend price V minus equity payout D.

The model reflects empirical findings of compensation in reduced-form analysis in this paper. θ_S term represents the value of shareholdings. I assume that cash-bonus is a performance-based payment based on bank's operating profit which is proportional to the parameter θ_B. θ_O term is the expected value of stock option over productivity z' evaluated at the current period. The bank manager loses all the option value when the bank defaults. The stock option is discounted by β which I assume that the stock option expires in the next period. As a special case of no agency conflict, $\theta_S > 0$, $\theta_B = 0$, $\theta_O = 0$, the bank manager maximizes the shareholder's value.

V is determined in the stock market by the mass of shareholders.

$$V(e, z|\Phi) = D(e, z, S, d, e'|\Phi) + p(S)\beta E_{z'|z}[V(e', z'|\Phi)]$$

Formal derivation of this Euler equation is in Appendix A.6.3. The representative household optimizes her portfolio by taken policy function Φ as given. Therefore, the bank manager's decision has direct effects from the performance of compensation and indirect equilibrium effects from the stock price.

3.2 Theoretical Prediction and Equilibrium Policy Function

This section explores policy function dependence to compensation parameters (θ_S, θ_B, θ_O) and state variable e. I am interested in risk-taking S since it has implication to findings in the empirical analysis section. I apply Topkis's theorem to run comparative static. First, the marginal value of risk taking:

[18] The bank manager is not willing to save too much since the share price has a negative marginal value of ATM when ATM $< \lambda_\kappa^{-1}$. I calibrate λ_κ that matches the observed probability of option exercise in the data.

$$
\begin{aligned}
\text{MVRT} &= \theta_S \left(\frac{\partial D}{\partial S} + \frac{\partial p}{\partial S} \beta E_{z'|z}[V(e', z'|\Phi)] \right) \\
&+ \theta_B e^z l^{\alpha_l} \\
&+ \theta_O \beta \Bigg(p \frac{\partial \kappa}{\partial S} E_{z'|z} \left[\mathbb{1}_{V(e',z'|\Phi) - \kappa(e,z|\Phi) \geq 0} \right] \\
&+ \frac{\partial p}{\partial S} E_{z'|z}[\max\{V(e', z'|\Phi) - \kappa(e, z|\Phi), 0\}] \Bigg)
\end{aligned}
$$

by assuming (i) equity payout is positive and (ii) capital constraints are not binding for simplicity. Second, concavity of value function w.r.t. risk-taking S:

$$
\begin{aligned}
\frac{\partial \text{MVRT}}{\partial S} &= \theta_S \left(\frac{\partial^2 p}{\partial S^2} \right) \beta E_{z'|z}[V(e', z'|\Phi)] \\
&+ \theta_O \beta \left(\frac{\partial^2 p}{\partial S^2} \right) E_{z'|z}[\max\{V(e', z'|\Phi) - \kappa(e, z|\Phi), 0\}] < 0
\end{aligned}
$$

where $\frac{\partial^2 p}{\partial S^2} = -\eta(\eta - 1) S^{\eta - 1} < 0$ if $\eta > 1$. Topkis's theorem gives $\frac{\partial S}{\partial \theta_i} = -\left(\frac{\partial \text{MVRT}}{\partial \theta_i} \right) / \left(\frac{\partial \text{MVRT}}{\partial S} \right)$ where $i \in \{S, B, O\}$ and $\frac{\partial S}{\partial e} = -\left(\frac{\partial \text{MVRT}}{\partial e} \right) / \left(\frac{\partial \text{MVRT}}{\partial S} \right)$. Given the concavity of value function, risk-taking depends on the sign of marginal value of risk-taking s.t. $\text{sign}\left(\frac{\partial S}{\partial \theta_i} \right) = \text{sign}\left(\frac{\partial \text{MVRT}}{\partial \theta_i} \right)$ and $\text{sign}\left(\frac{\partial S}{\partial e} \right) = \text{sign}\left(\frac{\partial \text{MVRT}}{\partial e} \right)$. The simplest application is

Proposition 1 (Cash) $\frac{\partial S}{\partial \theta_B} \geq 0$

This proposition means that the manager takes more risk when the marginal value of risk-taking increases by compensations (Prop. 1). Short-term cash compensation (θ_B) increases the marginal value of risk-taking, $\frac{\partial \text{MVRT}}{\partial \theta_B} \geq 0$, since $\frac{\partial p}{\partial S} = -\eta S^{\eta - 1} \leq 0$.

Another simple application is

Proposition 2 (Size) $\frac{\partial S}{\partial e} \geq 0$

In turn, equity increases the probability of default (Prop. 2). I find this relationship from the sign of $\frac{\partial \text{MVRT}}{\partial e}$ is positive s.t.

$$
\begin{aligned}
\frac{\partial \text{MVRT}}{\partial e} &= \theta_S \frac{\partial}{\partial e} \left(\frac{\partial D}{\partial S} \right) \\
&+ \theta_B e^z \alpha_l l^{\alpha_l - 1} \\
&- 2\theta_O \beta \left(\frac{\partial p}{\partial S} \right) \left(\frac{\partial \kappa}{\partial e} \right) E_{z'|z} \left[\mathbb{1}_{V(e',z'|\Phi) - \kappa(e,z|\Phi) \geq 0} \right] \\
&\geq 0
\end{aligned}
$$

If higher equity increases the strike price s.t. $\frac{\partial \kappa}{\partial e} \geq 0$ to get the last inequality. The rise in strike price lowers the bank manager's utility. In order to keep the strike price κ low, the bank manager takes more risk.

However, the signs of $\frac{\partial \text{MVRT}}{\partial \theta_S}$ and $\frac{\partial \text{MVRT}}{\partial \theta_O}$ are ambiguous. The stock has a decreasing marginal value of risk-taking ($\frac{\partial \text{MVRT}}{\partial \theta_S} \leq 0$) when the marginal costs of bankruptcy exceed the marginal benefit of equity payout. On the other hand, stock option has a positive marginal value of risk-taking ($\frac{\partial \text{MVRT}}{\partial \theta_O} \geq 0$) when the marginal benefit of equity payout exceeds the marginal value of bankruptcy. This might be the case if the strike price is sufficiently high (the model assumes the exercise price is close or below of at the money).

Finally, I document

Proposition 3 (Scale Invariance) *Allocation is invariant to the scale of compensations:* θ_S, θ_B, *and* θ_O

The absolute scale of compensation does not change any allocation in the economy. This proposition relies on the assumption that the bank manager is atomistic. Suppose compensations are scaled up by α. Then, the bank manager's value is W times the scaling factor α. Policy functions are invariant under the change of scale.[19]

3.3 Calibration and Validation

Calibrated parameters and targeted moments are reported in Table 8. Panel A contains parameters calibrate outside the model. The depreciation rate is set to charge-off rate, which is a loan deemed unlikely to be repaid by the creditor. Deposit insurance costs are premiums paid by banks at the rate of historically 30bps of insured deposits. Parameters of productivity process (ρ_z and σ_z) are estimated outside the model (Appendix A.5). The parameter λ of external financing costs is consistent with underwriting fees of equity 10% observed in the data for non-financial firms.

Panel C contains parameters calibrate inside the model. I target 4 parameters in the model to 4 moments in the data. The default probability is informative to determine the elasticity of risky investment (η). I compute the probability of failure from the post-crisis period.[20] The regulatory capital requirement ratio η is matched to the equity to loans ratio. Since regulatory capital requirement ratio uses granular information about the numerator ("capital") and denominator ("risk-weighted assets"). In turn, the model has the book value of loans and equity, and no further details. To fill in the gap, I calibrate capital requirement ratio χ inside the model to observed equity to loans ratio in data. The data implies the model's capital requirement ratio $\chi = 4.4\%$ is above the regulatory ratio 4% in the Basel II rule since my model overpredicts the regulatory capital, which is equal to the book value of equity inside the model. Finally, convex costs of the stock option are set to a value consistent with the frequency of option exercise between 2002 and 2006 for bank CEO reported by Ma (2015).

[19] This proposition might not true when the bank manager has sufficiently large compensations. A sizable compensation affects the distribution of cash to shareholders, and therefore the value of shareholding might appreciate or depreciate.

[20] I use the number of SMB who bankrupt from July 2007 to December 2010, and calculate the annual rate of failure. The model does not distinguish between non-crisis and crisis periods.

The model is solved numerically by an iterative procedure (details are in Appendix A.7.1). Appendix A.7.2 shows equilibrium policy functions for baseline calibration.

Table 8: Calibrated Parameters

	Value	Description	Target	Data	Model
Panel A: Technology and Financial Frictions Selected Outside Model					
β	0.950	Discount Factor	Standard Parameter		
α_l	0.333	Decreasing Returns to Scale	Standard Parameter		
δ	0.0041	Depreciation Rate	Charge-off Rate		
α	0.003	Deposit Insurance	Historical Average		
ρ_z	0.903	Persistency of Productivity	Interest Income on Loans		
σ_z	0.282	Standard Deviation of Productivity Shock	Interest Income on Loans		
λ	0.100	External Financing Costs	Hennessy and Whited (2007)		
Panel B: Compensation Structure Selected Outside Model (Small and Medium-sized Bank)					
θ_S	0.0272	Total Stock Holding to Total Shares	Capital IQ		
θ_B	0.0018	Bonus Payment to Operating Profit	Capital IQ		
θ_O	0.0020	Total Unexercised Stock Option to Total Shares	Capital IQ		
Panel C: Selected Inside Model					
η	8.183	Elasticity of Risky Investment	Default Probability (bps)	162	164
χ	0.044	Capital Requirement Ratio	Equity to Loans Ratio (%)	8.73	8.48
f	0.287	Fixed Costs	Frequency of Equity Issuance (%)	9.59	14.98
λ_κ	0.010	Convex Costs of Stock Option	Frequency of Option Exercise	0.29	0.35

Average Bank. The first part of validation explores comparative statics for different compensation structures and costs of financial friction. Table 9 shows key moments in the model for benchmark, three sets of compensation parameters, and an environment where convex costs of the stock option are set to zero ($\lambda_\kappa = 0$). Stock $+1\sigma$ uses a compensation parameter of an *average* SMB (see Table 2 and 8), adding one standard deviation of shareholdings. Bonus $+1\sigma$ and option $+1\sigma$ are calculated in similar ways. The average SMB is riskier if bonuses and options increase. The first observation about the bonus is consistent with the theoretical findings in Prop. 2. The second observation about the option fits the empirical results in Section 2. The magnitude of risk-taking is more significant for the bonus than the option. Lastly, an alternative model with parametrization of $\lambda_\kappa = 0$ finds that quadratic costs of the stock option are necessary to match data. Linear exercise gives 82% of the probability of exercise, which is nearly 50%pts higher than data. Finally, I want to motivate my study to investigate heterogeneity effects on compensation regulation change for two reasons. First, data observes a considerable variation in the compensation package of bank CEO. Second, the model suggests a nonlinear response to compensation parameters Θ.[21]

[21] Appendix Figure A2 plots the probability of default of the average SMB to the change in compensation parameters. I find a significant response for a slight shift in bonus (θ_B). Also, the response declines for a high fraction of the bonus.

Table 9: Simulated Moments

	Benchmark	Stock (θ_S) $+1_\sigma$	Bonus (θ_B) $+1_\sigma$	Option (θ_O) $+1_\sigma$	Linear exercise λ_κ=0
Loans	8.26	8.12	9.08	8.28	8.47
Equity to loans ratio (%)	8.48	8.87	8.33	8.29	8.98
Default probability (bps)	164	161	190	173	169
Dividends/loans	0.06	0.07	0.06	0.06	0.06
Frequency of equity issuance (%)	14.98	14.94	14.67	15.08	15.00
Loan returns (%)	11.11	11.23	10.72	11.12	11.01
Exercise Probability	0.35	0.30	0.30	0.30	0.82

Heterogeneous Banks. The analysis extends to *heterogeneous* banks and studies size effects between SMB and big banks. I run regressions of the probability of default on compensation parameters and report the sample for SMB (big banks) in Panel A (B). The specification (4) in Table 10 is

$$p_i = \beta_0 + \beta_1 \theta_{S,i} + \beta_2 \theta_{B,i} + \beta_3 \theta_{O,i} + \varepsilon_i$$

for bank i. The left-hand variable is the probability of default which is not perfectly observable in data. Proxies of the probability of default in data — buy-and-hold returns, ROA, ROE, and the actual default event during the financial crisis — are noisy measures of p inside the model. Although these regressions from simulated data have no measurement error compared to my empirical section, it is interesting to see the implication from standard OLS in this hypothetical setting. The simulated cross-sectional data is the long-run average of moments generated from the benchmark model, solving it for compensation parameter Θ of each bank.

First, I find shareholdings, short-term cash compensation, and stock options have statistical power for SMB (Panel A) to explain the default probability in specifications (1-4). Second, the statistical power of these compensations to explain the probability of default becomes less important for big banks (Panel B) in the specification (4) and insignificant in specifications (1-2). This difference in big bank sample comes from two channels: (i) the size of the sample; (ii) the variation in compensation Θ. In order to understand the difference (i), I run a bootstrap method to construct a sub-sample of 60 banks from SMB (the specification (6)). This approximately corresponds to the size of the sample of big banks. I find statistical power also decreases in sample size. Therefore, I conclude that empirical section results are partially driven by small sample size in big banks, and it could be fixed by using SMB sample while assuming that agency conflicts exist in throughout the banking industry. In specifications (5) and (7), I include control variables used in the empirical section. These controls contaminate the estimates of coefficient in the model since book to market ratio, log of market capitalization, and equity to loans ratio are endogenous variables, and therefore highly correlated with compensation Θ. In the data, these financial variables might also depend on other bank characteristics, which is not fully captured by the model. Therefore, it is reasonable to include these variables in the empirical analysis to control unobservable bank characteristics which is orthogonal to the compensation structure.

Table 10: Heterogeneous Response to Probability of Default

Dependent variables	(1)	(2)	(3)	(4)	(5)	Bootstrap (6)	Bootstrap (7)
Panel A: Small and Medium-sized Banks							
Shareholdings (θ_S)	-0.0383***			-0.0452***	-0.00283	-0.0452	-0.00283
	(-3.43)			(-4.39)	(-1.03)	(-0.80)	(-0.45)
Bonus (θ_B)		1.994***		1.885***	0.0281	1.885*	0.0281
		(7.00)		(6.82)	(0.32)	(1.74)	(0.09)
Stock options (θ_O)			1.040***	0.856***	-0.0892**	0.856	-0.0892
			(5.92)	(5.11)	(-2.03)	(1.19)	(-0.28)
Book to market ratio					2.889***		2.889***
					(55.23)		(5.64)
ln(e)					-0.123***		-0.123***
					(-32.66)		(-7.32)
Equity to loans ratio					-0.371***		-0.371
					(-8.78)		(-1.56)
N	445	445	445	445	445	445	445
R-squared	0.0258	0.0996	0.0733	0.185	0.949	0.185	0.949
Panel B: Big Banks							
Shareholdings (θ_S)	-0.146			-0.162*	-0.000838		
	(-1.54)			(-1.84)	(-0.02)		
Bonus (θ_B)		2.378		2.945**	-1.536**		
		(1.54)		(2.06)	(-2.18)		
Stock options (θ_O)			0.600**	0.617**	0.156		
			(2.42)	(2.60)	(1.65)		
Book to market ratio					2.237***		
					(13.49)		
ln(e)					-0.0918***		
					(-6.23)		
Equity to loans ratio					-0.514**		
					(-2.40)		
N	49	49	49	49	49		
R-squared	0.0481	0.0483	0.110	0.227	0.915		

3.4 Counterfactual Simulation Results

In this section, I study the effect of policy counterfactuals to the *average* SMB to understand the key trade-offs. Then, I extend my analysis to the *heterogeneous* SMB to investigate the overall impact of compensation regulations on the banking industry. Each experiment fixes compensation structure $\Theta = \{\theta_S, \theta_B, \theta_O\}$ and change the pay-offs to bank CEO and shareholders. One exception is FAS 123R. I assume a hypothetical ban on option ($\theta_O = 0$). Counterfactual policy scenarios are (i) Dodd-Frank, (ii) pure debt-based compensation, (iii) the Euro bonus cap, (iv) U.K. remuneration code to a standard compensation plan, (v) hypothetical option ban, which is an extreme case of FAS 123R, and (vi) capital requirement ratio from Basel II to III. More details about policy designs are in Appendix A.8.

3.4.1 Regulation to Compensation for SMB - Average Effect

Dodd-Frank Wall Street Reform.

$$
\begin{aligned}
W(e,z) &= \max_{S,d\geq 0,e'} \theta_S \left\{ (p(S)\mathbb{1}_{D>0} + \mathbb{1}_{D<0}) D(e,z,S,d,e') + p(S)\beta E_{z'|z}[V(e',z'|\Phi)] \right\} \\
&+ \theta_B p(S) e^z S l^{\alpha_l} \\
&+ \theta_O p(S) \beta E_{z'|z}[\max\{V(e',z'|\Phi) - \kappa(e,z|\Phi), 0\}]
\end{aligned}
$$

This reform takes a form of deferred dividend and deferred bonus. Deferred dividend (bonus) repays a fraction of $1-p$ of dividend (bonus). This alternative model induces to undertake corporate policies that lower the bank's default risk. I abstract the role as an inventory to offset financial losses from deferred cash because CEO's compensation is too small to cover the private costs associated with the bank's failure.[22]

Debt-based compensation.

$$
\begin{aligned}
W(e,z) &= \max_{S,d\geq 0,e'} \theta_S \left(D(e,z,S,d,e') + p(S)\beta E_{z'|z}[V(e',z'|\Phi)] \right) \\
&+ \theta_B e^z S l^{\alpha_l} \\
&+ \theta_O p(S) \beta E_{z'|z}[\max\{V(e',z'|\Phi) - \kappa(e,z|\Phi), 0\}] \\
&+ \theta_D p(S) l
\end{aligned}
$$

This adds debt contract which is contingent on default. I set θ_D to 10bps of loans in the counterfactual study. This value is an upper bound, which is larger than bank CEO compensation in the current regime. The median of SMB has 346.5 thousand dollars of cash compensation and 648.59 million dollars of total assets in 2006, which corresponds to 5.3bps of total assets.

Euro Bonus Cap.

$$
\begin{aligned}
W(e,z) &= \max_{S,d\geq 0,e'} \theta_S \left(D(e,z,S,d,e') + p(S)\beta E_{z'|z}[V(e',z'|\Phi)] \right) \\
&+ \theta_B \min\{e^z S l^{\alpha_l}, \underbrace{\tau f(l)}_{\text{bonus cap}} \} \\
&+ \theta_O p(S) \beta E_{z'|z}[\max\{V(e',z'|\Phi) - \kappa(e,z|\Phi), 0\}]
\end{aligned}
$$

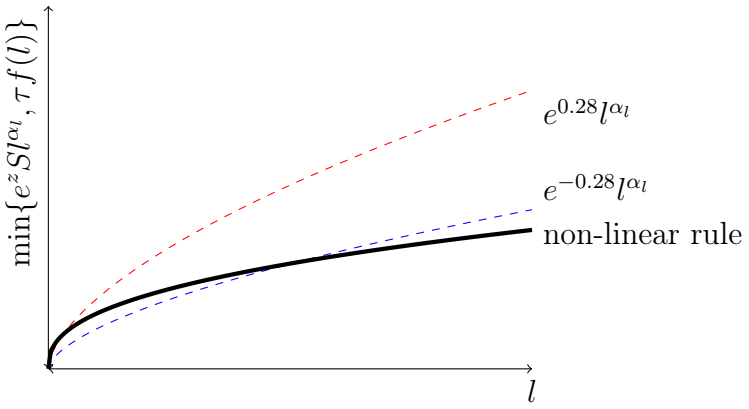
where $\tau f(l)$ is the bonus cap where τ is a parameter of the ratio of variable-to-fixed compensation. I set τ at 100%. The non-linear function of fixed compensation takes $f(l) = l^{\theta_C}$ where the elasticity parameter is estimated from data ($\theta_C = 0.397$).[23] Figure 4 illustrates the case that the Euro bonus cap is binding (see also Appendix Figure A3 for distribution of banks before and after the reform).[24] Given this parametrization, the Euro bonus cap becomes a constraint for low productivity banks (dotted blue lines) and high productivity (dotted red lines) banks with smaller loan sizes.

[22] This role is pointed out by Mehran and Tracy (2016).

[23] I estimate the power law by regressing the logarithm of salary and others on the logarithm of total assets.

[24] The parameters of productivity 0.28 of up-state and -0.28 of down-state correspond to 2-state Markov process estimated in Appendix A.5for illustrative purposes. In turn, the quantitative model uses 5-state Markov process.

Figure 4: Euro Bonus Fixed Cap without Risk-taking



U.K. Remuneration Code.

$$
\begin{aligned}
W(e,z) &= \max_{S,d\geq 0,e'} \theta_S \left(D(e,z,S,d,e') + p(S)\beta E_{z'|z}[V(e',z'|\Phi)] \right) \\
&+ \theta_B \{(1-\tau)e^z S l^{\alpha_l} + \underbrace{\tau p(S) e^z S l^{\alpha_l}}_{\text{deferred bonus}}\} \\
&+ \theta_O p(S)\beta E_{z'|z}[\max\{V(e',z'|\Phi) - \kappa(e,z|\Phi), 0\}]
\end{aligned}
$$

where $\tau = 60\%$ which follows the implementation in U.K.. This is a weighted deferred bonus. Increasing in bonus has less effect if the bank is restricted to defer short-term cash compensation since deferred bonus has less bonus payment and the default probability of survival marginally decreases in risk-taking.[25]

The average effects of the counterfactual experiment are reported in Table 11. Dodd-Frank Wall Street Reform has an overall positive impact. It increases loans and equity to loans ratio while it decreases the default probability. Dodd-Frank Wall Street Reform vastly improves welfare measured by consumption. Introducing debt-based compensation creates a safer economy while bank leverage is lower than the benchmark economy. 10bps of loans decrease the default probability by 6bps. However, debt-based compensation hurts welfare measured by household consumption. The Euro bonus cap and U.K. remuneration code have a similar impact on the average SMB. Another counterfactual experiment demonstrates that raising the capital requirement ratio from 4% to 6.5% significantly reduces bank's leverage and aggregate loans. The default probability decreases to promote financial stability. This view is shared by Admati et al. (2012), who argue a key benefit of increasing banks' capital requirements, but the effect is quantitatively small in my model.

[25]Suppose $\tau = 100\%$ which corresponds to a perfect deferred bonus. Then, the increase in the marginal value of risk-taking to short-term cash compensation is $\frac{\partial MVRT}{\partial \theta_B} = \left(p + \frac{\partial p}{\partial S} S\right) S e^z l^{\alpha_l} \leq S e^z l^{\alpha_l}$. This relationship shows that the deferred bonus reduces $\frac{\partial MVRT}{\partial \theta_B}$ since $p \leq 1$ and $\frac{\partial p}{\partial S} \leq 0$.

Table 11: Counterfactual Simulations for Dodd-Frank, Debt-based Compensation, Euro Bonus Cap, U.K. Remuneration Code, and FAS123 R (Average SMB)

	Benchmark	Dodd-Frank Wall Street Reform	Debt-based comp. (+0.10% of loans)	Euro Bonus Cap non-linear rule 100%	UK	FAS 123r	Capital Req. 4% to 6.5%
Loans	8.26	8.47	7.64	8.36	8.26	8.36	7.99
Equity to loans ratio (%)	8.48	12.00	4.39	8.60	8.48	8.60	12.41
Default probability (bps)	164	150	158	161	164	161	161
Dividends/loans	0.06	0.07	0.07	0.06	0.06	0.06	0.07
Frequency of equity issuance (%)	14.98	14.53	18.77	14.94	14.98	14.94	13.87
Loan returns (%)	11.11	10.97	12.13	11.06	11.11	11.06	11.36
Consumption	0.91	0.93	0.87	0.92	0.91	0.92	0.90
Change in % compared to benchmark	n.a.	1.65	-4.87	0.81	0.00	0.84	-2.07

Finally, I compared the benchmark model to a model without agency conflict (i.e. $\theta_S > 0$, $\theta_B = 0$, and $\theta_O = 0$). When agency conflict is absent, then the optimization problem collapses to a standard discounted future equity payout maximization problem s.t.

$$V(e,z) \quad = \quad \max_{S,d\geq 0,e'} D(e,z,S,d,e') + p(S)\beta E_{z'|z}[V(e',z')]$$

subject to same constraints. Shareholders' first-best benchmark has a higher loan, higher capital ratio, and lower default. Shareholder's first-best does not necessarily coincide with the social planner's first best. In my simulation study, Dodd-Frank outperforms shareholder's first-best under the presence of financial frictions.

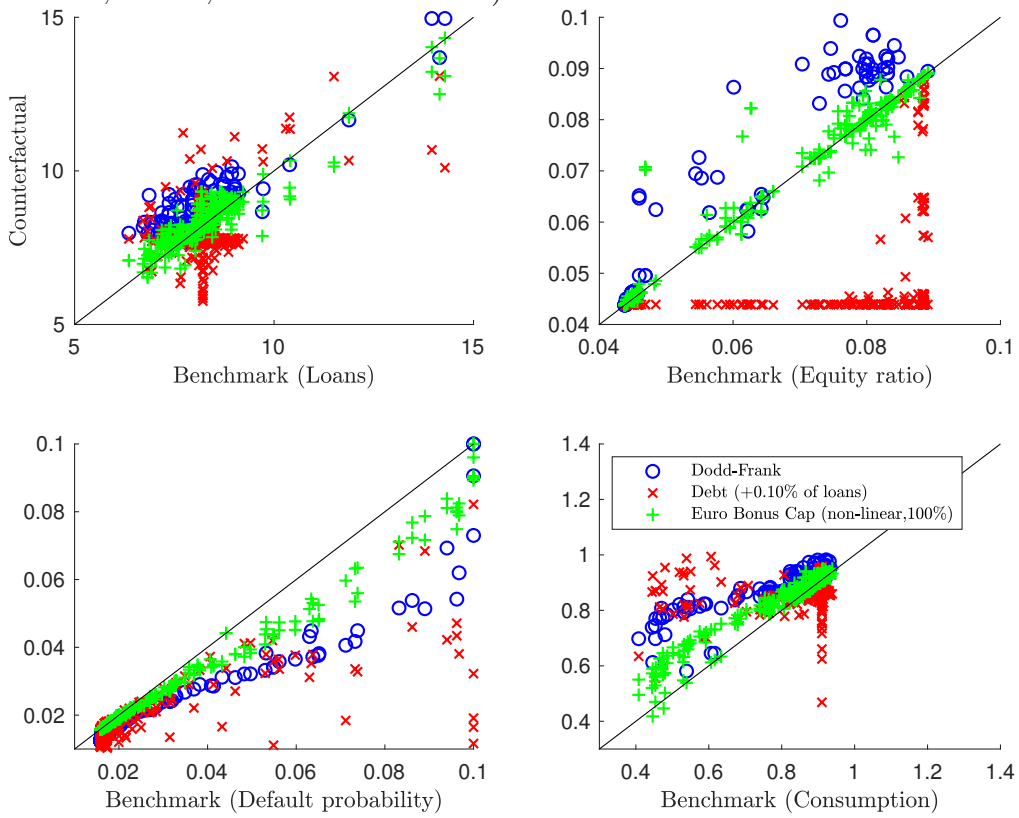
Table 12: Counterfactual Simulations for Agency Conflict (Average SMB)

	Benchmark	Frictionless (a)	Frictionless (b)
Panel A: Compensation			
w/o agency conflict		✓	✓
w/o external equity financing costs			✓
Panel B: Compensation			
Stock (θ_S)	0.0272	0.0272	0.0272
Bonus (θ_B)	0.0018	0.0000	0.0000
Option (θ_O)	0.0023	0.0000	0.0000
Panel C: Moments			
Loans	8.26	8.29	8.23
Equity to loans ratio (%)	8.48	8.89	16.70
Default probability (bps)	164	157	152
Dividends/loans	0.06	0.07	0.08
Frequency of equity issuance (%)	14.98	14.88	11.68
Loan returns (%)	11.11	11.13	10.79
Consumption	0.91	0.92	0.93
Change in % compared to benchmark	n.a.	0.85	1.70

3.4.2 Regulation to Compensation for SMB - Heterogeneous Effect

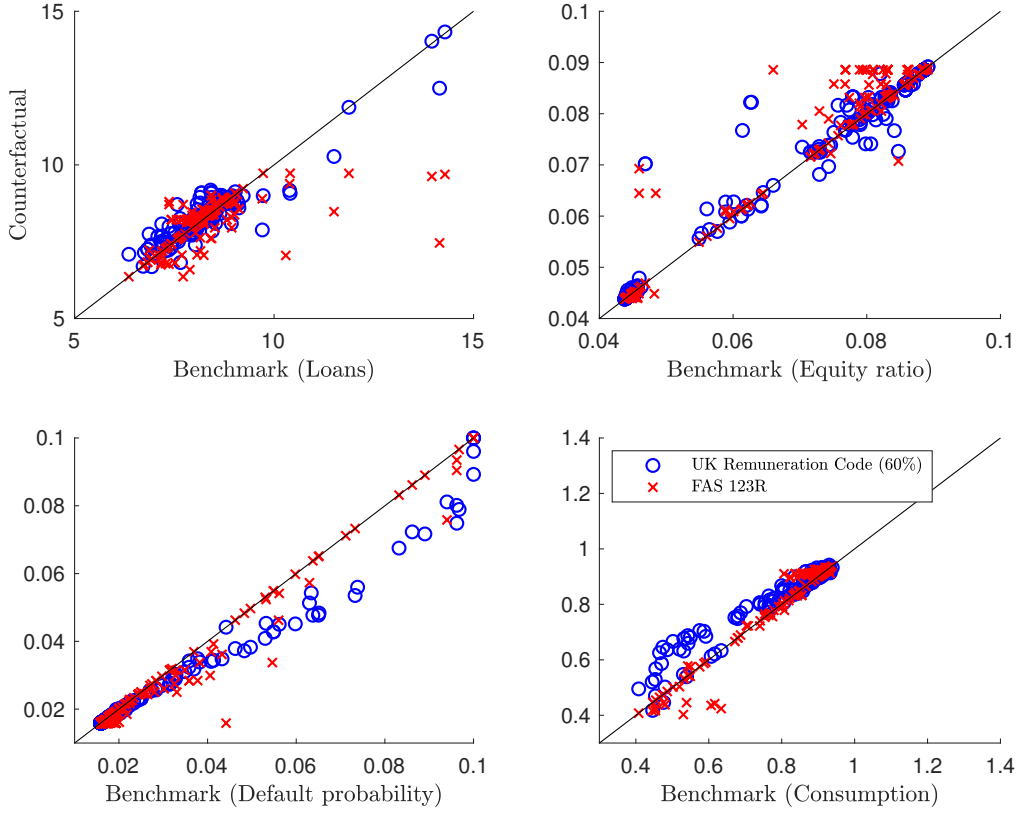
Figure 5 shows the individual bank loans, equity ratio, the default probability, and consumptions by the change of compensation for Dodd-Frank, debt compensation, and the Euro bonus cap in the long-run. The horizontal axis shows moments for the benchmark model. And the vertical axis shows moments for the counterfactual model. Dodd-Frank works well in the sense that it has sizable improvement across banks. On the other hand, debt compensation and the Euro bonus cap have heterogeneous effects across banks. Debt-based compensation creates less incentive to preserve the charter value. Therefore, a large mass of banks saves less for the future, which leads to a binding constraint of capital requirement ratio (Appendix Figure A3).

Figure 5: Individual Effects of SMB in Response to Counterfactual Policy (Dodd-Frank, Debt, Euro Bonus Cap)



U.K. remuneration code has similar homogeneous improvement to banks as I find in the Euro bonus cap (Figure 6). FAS 123R reduces the default probability and increases equity ratio. However, the default probability drops less than U.K. remuneration code for risky banks.

Figure 6: Individual Effects of SMB in Response to Counterfactual Policy (U.K. Remuneration Code and FAS 123R)



Finally, I derive aggregate implications in SMB and big banks (Table 13). The aggregate moments are the sum of banks. The mass of banks is normalized to one. The most important finding is that Dodd-Frank has the most considerable improvement in SMB. The size of effects differs among SMB and big banks, but Dodd-Frank increases consumption by more than 2%. Option banning (FAS 123R) has more increase in big banks. This prohibition has a significant effect on big banks because they utilize more stock options than SMB.[26] The Euro bonus cap and U.K. remuneration code have a similar effect.

[26]The ratio of stock option to shareholdings on an average bank is 0.0846 (=0.0023/0.0272) for SMB and 0.3636 (=0.0024/0.0066).

Table 13: Aggregate Size Effects between SMB and Big Banks

	Loans		Default Probability (bps)		Consumption	
		% Change		Change		% Change
Panel A: Small and Medium-sized Banks						
Benchmark	8.24	n.a.	221	n.a.	0.87	n.a.
Dodd-Frank	8.34	1.17	180	-41	0.89	2.16
Debt (+0.10% of loans)	7.93	-3.74	174	-47	0.86	-0.39
Euro Bonus Cap (non-linear,100%)	8.27	0.35	211	-10	0.88	1.75
UK Remuneration Code (60%)	8.25	0.06	210	-11	0.88	1.08
FAS 123R	8.20	-0.53	209	-12	0.87	0.74
Panel B: Big Banks						
Benchmark	8.05	n.a.	207	n.a.	0.87	n.a.
Dodd-Frank	8.25	2.52	172	-35	0.89	2.88
Debt (+0.10% of loans)	7.73	-4.04	143	-64	0.86	-0.52
Euro Bonus Cap (non-linear,100%)	8.12	0.81	201	-6	0.88	1.30
UK Remuneration Code (60%)	8.12	0.89	200	-6	0.88	1.12
FAS 123R	8.22	2.16	167	-40	0.91	4.43

4 Conclusion

This paper's contribution to the literature is twofold. First, this paper provides new evidence to link between bank performance and failure to CEO compensation structure. I construct a novel dataset for both big banks and SMB. I find an economically significant positive relationship between risk-taking and cash-bonus. This result is robust under different bank performance measures (buy-and-hold returns, ROE, ROA). When I restrict my sample size to big banks, the result is almost identical to FS (2011), which cannot support a statistically significant relationship. Therefore, I conclude that this missing link of incentive misalignment is due to the small sample size. A similar exercise is repeated using the model and reached the same conclusion, but it also suggests measurement errors of risk-taking create some difficulty to empirical analysis.

Second, I develop a quantitative banking model with dynamic financing choice to characterize the effect of shares owned, bonus, and stock option on risk-taking under financial frictions and regulations: external equity financing costs, capital requirement, and deposit insurance. I calibrate the model to U.S. data, and I show that my model is consistent with findings in the empirical section. Since I find a considerable variation in compensation structure from the novel dataset, it is vital to consider the cross-sectional effects of compensation regulation. The model is helpful for this dimension but also helps to understand the quantitative impact. Then, I perform counterfactual analysis and find Dodd-Frank proposal of 2016 improves the welfare measured by consumption and reduces the probability of bankruptcy. I arrive at this conclusion by solving the model with compensation parameters across bank CEOs in 2006. This policy, which is a combination of deferred dividends and bonuses, has less heterogeneity in improving the welfare of households and banks' stability. On the contrary, the Euro bonus cap and U.K. remuneration code lead to more extensive heterogeneity in change of consumption and default. Therefore, the overall improvement in welfare is less pronounced.

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