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Three Essays in Corporate Finance and Financial Intermediation

A Dissertation submitted in partial satisfaction
of the requirements for the degree of

Doctor of Philosophy

in

Management

by

Raymond Nam Kim

June 2020

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To my wife and my parents for all of their support. Apparently, my parents will take me seriously now. Thinking of Daniel, my Texan son, and my newborn son from Riverside, Joshua.

ABSTRACT OF THE DISSERTATION

Three Essays in Corporate Finance and Financial Intermediation

by

Raymond Nam Kim

Doctor of Philosophy, Graduate Program in Management
University of California, Riverside, June 2020
Dr. Jean Helwege, Chairperson

I find a persistently positive relationship between debt and acquired cash, contradicting the pecking order preference [131] of *internal financing* over *external debt*. Using a broad cross-section of firms from 2003-2019, this positive relationship increases for larger firms with lower information asymmetry, higher debt capacity, greater multinational operations, and greater financial constraints identified by Altman Z-Score and textual analysis of SEC filings. The convexity of this relationship supports the increasing benefits of debt due to taxes while textual analysis supports the role of cash in relieving financial constraints on debt. This evidence supports a "cash collateral" channel where distressed firms can acquire cash to mitigate the adverse effects of financial constraints of leverage.

When the Federal Reserve first started to pay interest on excess reserves (IOER) in October 2008, it presented a choice that banks had not previously faced. That is, they could invest bank capital in precautionary excess reserves and earn the "better than" risk-free rate or they could lend and earn a higher, but riskier interest rate. This paper provides empirical evidence of banks using a risk-adjusted framework to maximize returns when deploying capital between loan assets and excess reserve assets. Two-stage panel estimations show that "reserve premiums" are associated with a 6%

or $408.5 billion reduction in total US bank lending. This IOER channel highlights the tradeoff between credit access by economic participants and the precautionary buildup of excess reserves in the US banking system.

Uncertainty in banking regulation may impose widespread economic costs by increasing financial constraints on credit availability. Four years of Dodd Frank uncertainty over undecided risk weightings increased regulatory uncertainty for smaller banks, restricting "vanilla" interest rate hedging activities. This paper uses newly reported mortgage banking data as an identification strategy and finds that when costs of uncertainty are removed, small banks hedge 97-120% more interest rate risk while mortgage securitization income increases by 65.2% compared to large banks. These findings support the need for tailored regulations that considers the higher costs of regulatory uncertainty for smaller banks.

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Chapter 1

Introduction

The first two chapters of my dissertation deal with the relationship between cash and credit. The first chapter deals with credit from the borrower perspective, while the second chapter deals with credit from the lender perspective. The relationship between cash and credit depends on the roles that cash plays for the borrower and lender. For a firm with overseas operations, overseas cash can represent a repatriation tax strategy that increases the value of debt. For a distressed borrower, cash can represent a high quality collateral that lowers the costs of debt. For a lender, cash represents a lendable assets, so the risk based return from sitting cash can determine the lower boundary of loans that offer a higher risk adjusted return.

The third chapter of my dissertation deals with the costs of uncertainty that smaller community banks faced during Dodd-Frank. Banks reach a scale of operations around $500M-$1B in total assets, when they find that using interest rate derivatives help offset interest risk exposure and strengthen a balance sheet for another round of loans. Regulatory uncertainty hinders this process when information asymmetry costs are high, as it is for smaller community banks.

Chapter 2

Does Acquired Cash Increase Leverage?

As corporate cash holdings and debt reach record levels, its contemporaneous nature poses unique questions for modern corporate times: Are firms that acquire cash associated with increased leverage? And if so, why? This paper finds that as firms acquire cash, firms increase debt levels. Evidence suggests this is due to the repatriation tax benefits of debt after the Homeland Investment Act of 2004 and the use of acquired cash to relieve financial constraints and increase debt capacity. This positive relationship between acquired cash and debt runs may be surprising as it is not supported by some established understandings of capital structure theory. The pecking order theory [131] posits that information asymmetry increases the cost of external financing, suggesting that once firms acquire cash, firms may reduce debt levels. This suggests a non-positive relationship between acquired cash and debt. The capital structure literature has mostly internalized the assumption that external financing is utilized after the exhaustion of internal financing [131, 132]. Use of internal cash allows a business to conduct its operations fundamentally independent of capital markets, with management freedom from external monitoring with independent jurisdiction [64]. In the "pecking order theory", [131] and [64] stress that firms will prefer internal cash for investment outlays. This suggests a negative relationship between cash and debt as firms will prefer to use excess retained earnings to pay down debt to reduce adverse selection costs for future financing needs. However, recent strategies suggest that the relationship between acquired cash and debt may be positive. US corporations like Apple, hold record amounts of overseas cash while issuing record amounts of debt [80] and Apple CEO Tim Cook clarified this strategy by noting:

> *"If you earn money globally, you can't bring it back into the United States unless you pay 35% plus your state tax. And you look at this and you go, 'This is kind of bizarre.' You want people to use this money in the United States to invest more. We are in a good position, but an unusual one. Our good position is we can borrow. And so to invest in the United States, we have to borrow."*
>
> **-Apple CEO Tim Cook on CNBC: May 11, 2017**

US corporations holding nearly $4 trillion in internal cash [76] while holding $9.1 trillion in debt[1] has significant implications not only for research on capital structure, but also research on financial constraints. Figure 2.1 and Tim Cook's quote suggests that an increase in cash leads to an increase in liabilities. This implies a positive relationship driven by: 1) tax liabilities and 2) the role of cash in increasing future debt capacity. Research suggests that repatriation tax liabilities play a significant role in the accumulation of overseas cash [79, 55, 93, 76, 97][2]. Research also suggests that overseas tax liabilities also play a significant role in increasing leverage ratios [75] and domestic liabilities [54]. [75] also adds to the importance of tax rates on capital structure by finding that firms have higher debt ratios when operating in countries with higher tax rates. [54] finds that higher taxes

[1] According to Securities Industry and Financial Markets Association data total corporate debt reached $9.1 trillion as of 2018.

[2] [79] explores why firms hold record amounts of cash by using Compustat data from 1982-2004, showing when multi-national firms face higher repatriation tax burdens, they hold higher levels of cash abroad to avoid those taxes. Overseas cash has reached record levels, as [79] found that 10.5 of all aggregate assets of Compustat firms was in cash, while [43] found that S&P rated corporations held $1.9 trillion in cash and short term investments. In this paper I also find that all non financial Compustat firms held $3.2 trillion in cash at the end of 2016.

on overseas cash may increase leverage, but does not find a positive relationship between cash and leverage. As far as I am aware, this is the first paper to find a positive relationship between acquired cash and debt.

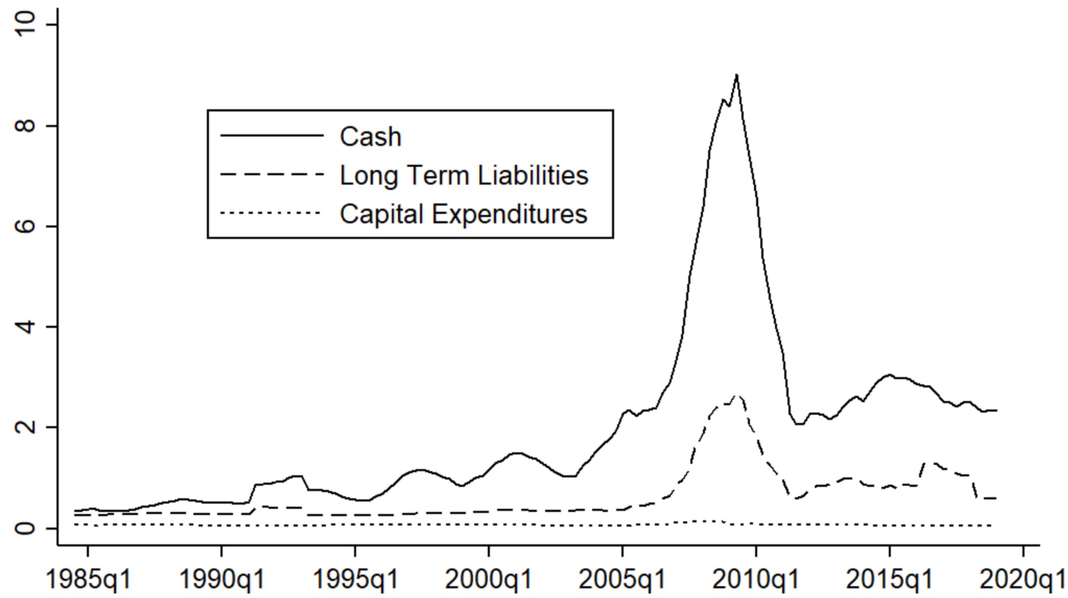


Figure 2.1: This figure represents all firms in COMPUSTAT except for financials and utilities. The data is quarterly from 1984Q1 to 2019Q1 and is scaled by net assets defined as book assets minus cash and cash equivalents.

This positive relationship between acquired cash and debt is at odds with not only the pecking order [131, 132, 141, 122], but also some of the research findings on precautionary cash [134] and debt conservatism [92]. Precautionary cash supports a negative coefficient on cash when it comes to leverage, while debt conservativism associates excess cash with low levels of debt. One can also argue that free cash flow theory [106] and managerial entrechment leads to excess cash and low debt levels, supporting a non-positive relationship. [37] also finds that M&A bidders decrease cash and increase debt during an acquisition, also implying a non-positive relationship. However, [100] investigates IPOs from 1984-1992 and finds that IPO cash shortfalls are unrelated to external financing, which lends support to a non-negative relationship between cash and debt.

This paper finds that acquired corporate cash holdings have an economically and statistically significant positive relationship to corporate leverage across a broad cross section of firms. This relationship persists after accounting for financial deficits, other traditional leverage controls, and omitted variable bias due to missing firm characteristics or macro variables. This relationship is also stronger for large, multinational corporations and firms with financial constraints as indicated by bankruptcy risk and textual analysis of 10K SEC filings. These findings also suggest that acquired cash can increase leverage through a collateral channel [19, 42]. However, unlike [19] and [42] where firms use plant property and equipment and real estate for collateral, respectively, this paper's results suggest that firms are using acquired cash as collateral for leverage. The literature demonstrates that firms address financial constraints by acquiring cash [8, 61]. Since cash is the highest quality collateral that exists, this type of collateral can lower borrowing interest rates [14]. When short term interest rates fall, lenders lower their lending standards [125]. This paper argues that by using a cash collateral channel, distressed firms can lower costs of debt and increase leverage. Together, the cash collateral channel supports the findings of [8] and [60] showing that firms can mitigate the adverse effects that financial constraints have on debt by acquiring cash.

Results from panel data regressions suggest that acquired cash predicts corporate liabilities with three times the stand-alone explanatory power of the pecking order's financing deficit. Additional tests suggests the existence of convexity between cash and liabilities, providing support that repatriation taxes and progressive taxable investment income on overseas cash may result in an increasing need for tax deductions.

However, this paper's findings also has important implications for capital structure literature that focuses on the role of intertemporal choices on optimal capital allocation. By showing that acquired cash positively predicts corporate liabilities even after accounting for financing deficit needs, "transitory cash" may provide intertemporal debt capacity for future financing needs. This revelation is complementary to dynamic capital structure models such as [56] that suggest transitory debt and adjustment speeds reflect intertemporal sequencing of funding needs. "Transitory cash" may play a role similar to cash flows in adjusting leverage in [74]. This paper also has implications in the capital structure literature in regards to the role that constraints play in the pecking order vs. tradeoff literature. [141] find that pecking order preference of debt over equity explains a firm's deficit financing while [122] finds holds this to be true when firms are not constrained by debt capacity. On the other hand, [81], [73], [100], [120] and [38] suggest that adverse selection costs are just one of many factors that firms consider when choosing between debt or equity external funding. [24] shows that firms with more information asymmetry finance their deficits with more debt than firms with less information asymmetry. [11] suggests that the timing of equity market conditions plays a factor in capital structure decisions, as does equity investor sentiment [101]. [121] suggest that one reason for this contention is because of the low statistical power of capital structure studies. This paper addresses this concern by using all observations (except for financial firms and utilities) from the COMPUSTAT database from 1969-2019, comprising 770,972 firm quarter observations. This provides some support to the argument of [122] that debt capacity matters for pecking order preference of debt over equity, if one of the tradeoffs of cash is that it expands debt capacity to maintain this preference of debt over equity. This paper contributes to the literature by examining recent trends of firms holding records amount of cash and debt simultaneously, which challenges our understanding of capital structure theory.

The empirical models initially tests the tradeoff and pecking order theory in a horse race using firm fixed effects, time fixed effects, firm clustering, and time clustering of standard errors. These results hold after the introduction of the Homeland Investment Act of 2004 as shown in Table 2.2, after controlling for capital expenditure in Table 2.3, disaggregating the financing deficit in Table 2.4, using traditional leverage controls and financing constraints using textual analysis in Table 2.5, and confirmed using placebo tests in Table 2.6. This relationship between acquired cash and leverage grows stronger in larger firms with less information asymmetry (Table 2.9), more overseas operations (Table 2.7), more debt capacity (Table 2.11), and displays convexity (Table 2.8). The relationship between acquired cash and leverage also increases when large multinationals as shown in Table 2.12. Firms can mitigate the adverse effects of financial constraints on debt issuance by acquiring cash as shown in Table 2.13 and 2.14. The rest of the paper is organized as follows: Section 2.1 is Capital Structure Motivations, Section 4.4 is Data and Empirical Methodologies, and Section 3.4 is the Conclusion.

2.1 Capital Structure Motivations

This period from 2003-2019[3] examines firms exposed to the first ever repatriation tax holiday from the American Jobs Creation Act (AJCA) of 2004, otherwise known as the Homeland Investment Act (HIA). The HIA updated the Internal Revenue Code number 965 so that American companies can repatriate foreign sourced income at a reduced tax rate of 5.25 during 2005 and 2006. In total, according to the Internal Revenue Service, companies brought back $312 billion during this

[3] [55] finds that the introduction of the Homeland Investment Act of 2003 influenced expectations of a tax holiday in 2003 Q1. I use this starting period for the cutoff date.

time period. After the expiration of the HIA, US firms updated their priors[4]. in expecting reduced repatriation tax rates in the future [55] and saw an optimal capital structure following the heuristics of [129] where the marginal benefits of debt increase in the corporate tax rate, and additionally the costs of repatriating overseas cash. This unique novel setting of the HIA allows for the study of increasing benefits of debt separately from the adverse selection costs of externally financed debt.

The pecking order from [132] and [131] looks at three sources of funding available to corporations: internal cash financing, external debt financing, and external equity financing. Internal cash financing has no adverse selection problem, while external debt has a minor adverse selection problem, and external debt as a serious adverse selection problem. From the perspective of an outsider, debt is strictly riskier than internal cash and has some adverse selection risk premium. From the same perspective, equity is strictly riskier than debt and has a larger adverse selection risk premium.

The notation follows [141] and [81] and is defined as follows:

- $Cash_t$ = Cash and cash equivalents;
- DIV_t = Cash dividends;
- I_t = Net investment (Capital Expenditures + Increase in Investments + Acquisitions – Sale of PPE – Sale of Investments)
- ΔW_t = Changes in working capital (Changes in Working Capital + Changes in Cash and Cash Equivalent + Changes in Current Debt);

[4]These expectations of a repatriation tax holiday were fulfilled in 2017 with the Tax Cut and Jobs Act. There are two tax-preferred rates for the foreign earnings deemed repatriated: foreign earnings held in cash and cash equivalents were taxed at 15.5 percent and those not held in cash or cash equivalents at only 8 percent. The TCJA permits a US corporation to pay any tax on the deemed repatriations in installments over eight years. The tax revenue raised by this transition tax on earnings accumulated abroad was estimated at $340 billion over the 10 years from 2018 to 2027.
https://www.taxpolicycenter.org/briefing-book/what-tcja-repatriation-tax-and-how-does-it-work

- C_t = Cash flow after interest (Income before Extraordinary Items + Depreciation and Amortization + Extraordinary Items and Discontinued Operations + Deferred Taxes + Equity in Net Loss/Earnings + Other Funds from Operations + Gain/Loss from Sale of PPE and Investments;

- R_t = Current Portion of Long Term Debt;

- ΔD_t = Long Term Liabilities; Long Term Debt; Issued Net Debt (Long Term Debt Issuance – Long Term Debt Reduction)

- ΔE_t = Issued Net Equity (Sale of Common Stock – Stock Repurchases)

Computation of the financing deficit follows [81]:

$$DEF_t = DIV_t + I_t + \Delta W_t - C_t = \Delta D_t + \Delta E_t$$

Which defines it as the sum of net debt (long term debt issuance – long term debt reduction) and equity issues (sale of common stock – stock repurchases). The financing deficit is also equal to the sum of cash dividends, net investment, change in working capital, and internal cash flow. [141] include the current portion of long term debt as part of the financing deficit, and [81] empirically show empirically that this should not be included. [122] also do not include the current portion of long term debt as part of the financing deficit, and I follow their example.

In a strict pecking order model, all components of the financing deficit are exogenous as long as safe debt can be issued [141]. In the traditional pecking order model, the firm prefers internal financing to external financing [131]. This preference is based upon the costs derived from asymmetric information between the managers of the firm and the financial markets. According to the pecking order theory, these costs should be paramount over the benefits and costs of internal financing and external financing.

[141] argues that in their pecking order model:

$$\Delta D_{it} = \alpha + \beta_{PO} DEF_{it} + u_{it}$$

the hypothesis of $\alpha = 0$ and $\beta_{PO} = 1$ is statistically rejected, but provides a good first order approximation of their data. [81] finds that this "first order descriptor of corporate financing behavior" (using the financial deficit variable of [141]) is not broadly applicable, and they show that the pecking order is strongest in firms with the least adverse selection (large firms), and not the most adverse selection (smaller firms) as expected by [141]. [122] reconciles the finding of [81] that large firms have the most pecking order, by showing that smaller firms with the most adverse selection are most constrained by debt capacity and therefore issue equity over debt. [122] argues that their evidence is in support of the pecking order, taking into account a firm's debt constraints.

If firms that are exposed to higher tax rates overseas issue more debt [75] and hold more cash overseas because of repatriation taxes [75, 55], then Apple's strategy of issuing debt domestically to avoid repatriation taxes on cash holdings overseas reveals a situation where companies prefer debt over cash. Therefore, I formulate the following three hypothesis for testing:

After accounting for financing deficits, firms increase debt after acquiring cash. This relationship is in line with the Homeland Investment Act of 2004. I construct the following empirical model using the financing deficit based on [81]:

$$\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_T Post\ Tax\ Holiday \times Cash_{i,t-1} + \beta_D DEF_{it} + u_{it}$$

Adding firm fixed effects account for omitted variables for invariant firm characteristics and adding time fixed effects account for omitted macro variables. Standard errors are clustered at the firm level as well as the time level. If the Hypothesis 2.1 holds, then β_C should be positive and significant as acquired cash will explain debt levels. This relationship should persist after controlling for debt due to capital expenditure, financing deficits, and traditional leverage controls. On the other hand, if β_C is negative and significant after controlling for financing deficit, then acquired cash would be associated with debt reduction, supporting the pecking order. The following indicates are outlined:

$$\beta_C \begin{cases} (+) \text{ and significant} & \implies \textbf{\textit{tax benefits}} \\ \text{insignificant} & \implies \textbf{\textit{neither}} \\ (-) \text{ and significant} & \implies \textbf{\textit{pecking order}} \end{cases}$$

If β_T is positive and significant, this is in line with Hypothesis 2.1. I also run several robustness checks following the specifications in [81]. I first run the following empirical model using the disaggregated financing deficit to see if there is further information contained in DEF_{it} that can help account for ΔD_{it} or subsume the effects of β_C.

$$\Delta D_{it} = \alpha_i + \lambda_t + \beta_{PO} Cash_{t-1} + \beta_{DIV} DIV_{it} + \beta_I I_t + \beta_W \Delta W_t - \beta_C C_t + \varepsilon_{it}$$

I also use traditional and non-traditional leverage controls such as financing constraints using textual analysis. I textually analyze 10-K SEC filings using a keyword list from [26] which is shown to predict corporate finance liquidity events such as dividend omissions, equity recycling, and underfunded pensions. The following empirical model is used:

$$\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_{PO} Deficit_{it} + \beta_1 Constrained_{it} + \beta_2 Liabilities_{i,t-1}$$
$$+ \beta_3 log(NetAssets)_{it} + \beta_4 Profitability_{it} + \beta_5 Tangibility_{it} + \beta_5 TobinsQ_{it} + \varepsilon_{it}$$

Using fixed effects will provide for time invariant characteristics at the firm level, while a lagged dependent variable $Liabilities_{i,t-1}$ may subsume the effect of the lagged cash variable.

In the next hypothesis, I test whether the predictions of tradeoff theory will materialize among different firm characteristics.

If the tax motive is supported, this relationship should be stronger in firms with overseas operations. Convexity between cash and debt reflects a progressive corporate tax rate.

In testing for Hypothesis 2.1, I group firms into quartiles based on overseas revenues. The coefficient on acquired cash should increase as quartiles increase.

[129] models the increasing benefits of debt in the corporate tax rate, which in modern times would include the cost of repatriation taxes on overseas cash holdings and progressive corporate tax rate on Subpart F income generated on overseas cash. [129] models the gains from leverage, $G + L$ for the stockholders in a firm holding real assets as:

$$G_L = [1 - \frac{(1-\tau_c)(1-\tau_{PS})}{1-\tau_{PB}}]B_L$$

where τ_c is the corporate tax rate, τ_{PS} is the personal income tax rate applicable to income from common stock, τ_{PB} is the personal income tax rate applicable to income from bonds and B_L is the market value of the levered firm's debt. As the corporate tax rate, τ_c, increases, the gains in leverage increase as [129] points to the increasing benefits of debt on tax rates on non-debt income. Subpart F income [5] is taxable non-debt income on overseas cash holdings subject to the progressive corporate tax rate in the US, and an increase in Subpart F income would increase the benefits of debt for a corporation. The corporate tax rate on overseas cash, τ_c^{OC} can be modeled as:

$$\tau_c^{OC} = C^F[X(I,\omega)](\tau_{t+\epsilon}^R + r\tau^I)$$

Where the overseas cash C^F is dependent on a firm's cash flows X which is a function of a firm's investment I and state of the world ω. This overseas cash is subject to the repatration tax of τ^R at time $t+\epsilon$, and the investment income rate r generated on overseas cash will be immediately subject to the progressive corporate tax rate of τ^I. This additional tax burden from Subpart F income suggests that there may be convexity in the gains from leverage and the amount of overseas cash held by a corporation. A modification of the baseline regression of this paper can capture this convexity:

$$\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \gamma Cash_{i,t-1}^2 + u_{it}$$

Figure 2.2 shows that firms with increasing gains in leverage will have a $\gamma > 0$, displaying convexity in the relationship between cash and debt.

If the heuristics of [129] hold for firms with overseas cash and taxable non-debt income, then bankruptcy costs of debt may be dominated by the benefits of debt and this relationship may display convexity which would contribute to new understandings about capital structure theory.

Constraints such as information asymmetry and debt capacity, will reduce this relationship.

[5] US corporations are taxed on income generated from overseas cash, even if those overseas cash holdings are not repatriated.
https://www.irs.gov/pub/int_practice_units/DPLCUV_2_01.PDF

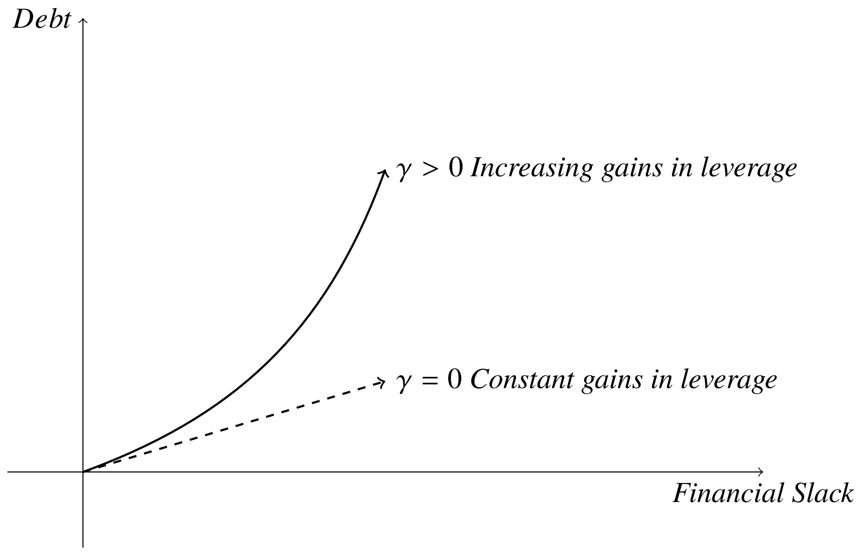


Figure 2.2: This outlines the relationship between financial slack and debt for firms with high information asymmetry and low information asymmetry.

In testing for Hypothesis 2.1, I group firms into quartiles based on firm size and leverage ratios, and overseas revenues. Pecking order theory often proxies firm size for information asymmetry as smaller firms are theorized to have greater information asymmetry and therefore higher adverse selection costs. However, [100] and [81] found that smaller firms with higher adverse selection costs do not display the capital structure behaviors of higher information asymmetry. Leverage ratios may also indicate that the general range of debt capacity of a firm, as firms with higher leverage ratios may be characterized with greater debt capacity than firms with lower leverage ratios. Firms that show greater overseas revenues are also proxy for greater overseas operations. These characteristics of quartiles should follow the relationship between cash and debt as outlined in Figure 3.4. Firms with less information asymmetry have fewer frictions to take advantage of the tradeoff benefits of debt over cash, firms with greater debt capacity also have smaller bankruptcy costs in the tradeoff costs of debt, and firms with more overseas operations have greater overseas tax liabilities and higher

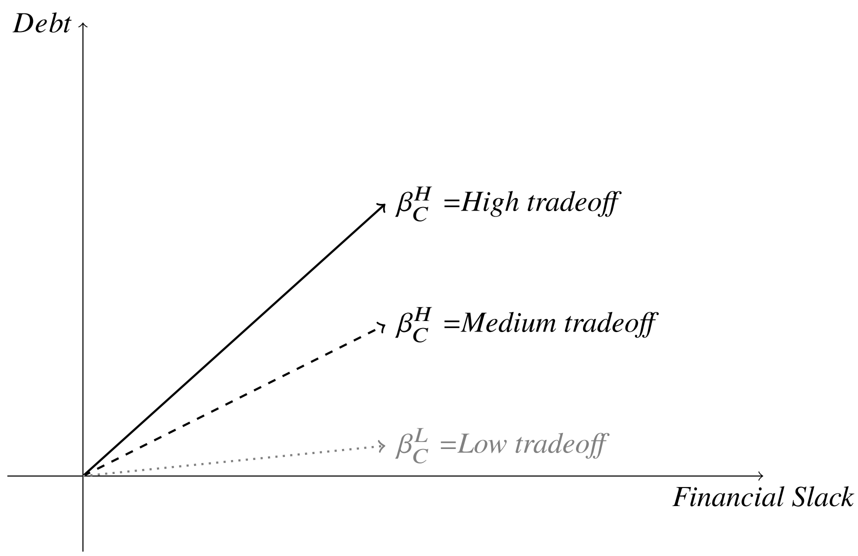


Figure 2.3: This outlines the relationship between financial slack and debt for firms according to tradeoff indicators. High tradeoff indicators are large firms indicating low information asymmetry, firms with significant overseas operations, and firms with unconstrained debt capacity.

5

demand for the tax deductions of debt.

Acquired cash reduces financial constraints in debt.

2.2 Data and Empirical Methodologies

The data needed to test the four hypotheses consists of all firms in the Compustat-Capital IQ database from Standard & Poor's. Following [141] and [81], the dataset starts at 1971, which marks the beginning of the flow of funds data. Financial firms (SIC codes 6000-6999) and Utilities (SIC Codes 4900-4999) are excluded as well as quarterly or yearly observations with missing values for market capitalization, cash holdings, or financing deficit. Previous literature uses annual data observations, while this paper uses mostly quarterly observations across all empirical tests.

Chart 3.4 shows balance sheet and flow of funds data for the main sample period in question

2003-2019	Obs	Mean	S.D.	P25	P50	P75	Max
Cash Holdings	349,676	1.43	8.18	0.04	0.14	0.50	276.43
Financing Deficit	349,817	0.26	1.94	-0.03	0.02	0.11	43.86
Capital Expenditure	343,423	0.05	0.10	0.01	0.02	0.06	1.10
Gross Debt (Long Term Liabilities)	343,787	0.42	1.26	0.05	0.21	0.45	54.00
Gross Debt (Long Term Debt)	347,048	0.24	0.49	0.00	0.09	0.31	7.16
Net Debt	349,817	0.14	0.41	0.00	0.01	0.09	7.00
Dividends (Millions)	341,905	0.01	0.03	0.00	0.00	0.00	0.69
Investment	349,817	0.07	0.19	0.01	0.03	0.08	3.29
Δ Working Capital	349,817	0.05	1.40	-0.04	0.00	0.04	27.79
Internal Cash Flow	349,817	-0.12	1.02	0.00	0.02	0.06	4.64
Book Assets (Millions)	363,795	3,396	13,548	32	198	1,233	260,000
Leverage	363,745	1.69	9.95	0.13	0.38	0.96	469

1990-1998	Obs	Mean	S.D.	P25	P50	P75	Max
Cash Holdings	181,978	0.52	1.81	0.02	0.07	0.30	27.47
Financing Deficit	182,235	0.11	0.67	-0.03	0.03	0.12	12.63
Capital Expenditure	177,387	0.06	0.09	0.01	0.03	0.07	0.98
Gross Debt (Long Term Liabilities)	176,292	0.27	0.31	0.04	0.19	0.39	3.68
Gross Debt (Long Term Debt)	180,681	0.21	0.26	0.01	0.13	0.31	2.94
Net Debt	182,235	0.14	0.34	0.00	0.02	0.11	4.09
Dividends (Millions)	179,820	0.01	0.02	0.00	0.00	0.00	0.36
Investment	182,235	0.08	0.16	0.01	0.04	0.10	1.80
Δ Working Capital	182,235	0.02	0.51	-0.04	0.00	0.04	9.79
Internal Cash Flow	182,235	0.01	0.30	0.00	0.02	0.05	2.33
Book Assets (Millions)	197,083	829	3,171	18	69	310	37,427
Leverage	197,054	1.45	4.61	0.16	0.45	1.15	124

1971-1989	Obs	Mean	S.D.	P25	P50	P75	Max
Cash Holdings	180,760	0.25	0.78	0.02	0.06	0.18	15.04
Financing Deficit	188,411	0.05	0.45	-0.01	0.01	0.06	10.20
Capital Expenditure	100,022	0.06	0.10	0.01	0.03	0.07	0.90
Gross Debt (Long Term Liabilities)	153,748	0.27	0.25	0.09	0.23	0.38	2.67
Gross Debt (Long Term Debt)	186,090	0.22	0.22	0.05	0.18	0.31	2.28
Net Debt	188,411	0.05	0.17	0.00	0.00	0.03	2.52
Dividends (Millions)	101,563	0.01	0.02	0.00	0.00	0.01	0.39
Investment	188,411	0.05	0.13	0.00	0.00	0.05	2.27
Δ Working Capital	188,411	0.00	0.39	-0.01	0.00	0.00	8.38
Internal Cash Flow	188,411	0.02	0.11	-0.01	0.00	0.02	1.83
Book Assets (Millions)	204,065	536	1,932	16	60	237	30,050
Leverage	203,880	1.64	3.26	0.30	0.76	1.70	69

Table 2.1: **Balance Sheet and Corporate Cash Flows for US firms**
This table presents summary statistics for US firms for selected time periods. Financial firms and utilities are excluded and so are firms with missing market to book ratios. All variables are scaled by book assets except for Dividends, Book Assets, and Leverage. Gross Debt(L) is Long Term Liabilities and Gross Debt(D) is Long Term Debt. Leverage is calculated as the total liabilities of a firm divided by the market capitalization of a firm.

2003-2019 compared to two other sample periods used in [81], 1990-1998, and [141], 1971-1989. The latter two periods are also used in placebo tests. All items except for dividends are scaled by total book assets in the same period. Similar to [81], the data shows relative stability in liabilities and a rapid increase in book assets and cash holdings over time. Median cash assets rise from 6% in the first period to 14% in the latest sample period.

One notable departure from [141] and [81] is this paper's use of both total long term liabilities (COMPUSTAT Item LLTQ) and long term debt (COMPUSTAT Item DLTTQ) as dependent variables for the quarterly data and the use of total liabiltiies (COMPUSTAT Item LT) for the yearly data. In [141] and [81], the empirical tests specify "Gross Debt" on the left hand side. However, it is not entirely clear which accounting items are used in making up "Gross Debt". Although liabilities and debt are commonly used interchangeably, the differences between the two have grown in recent years. In Table 3.4, the differences between Gross Debt (Liabilities) and Gross Debt (Debt) are smaller in the first two periods (1971-1989, 1990-1998) and larger in the main sample period (2003-2019). This growing difference between the two is evident not only in the panel data, but also in the aggregate where in Figure 2.1 Gross Debt (L) grows at a faster rate than Gross Debt (D) in starting around 2003. Long term liabilities that do not show up in long term debt can be tax deductible, such as capital leases or intra-company loans between holding companies and their foreign subsidiaries [54]. Also, other long term liabilities may be financed with tax deductible debt or lower repatriation taxes at a later date. Another notable difference with [141] and [81] lies in the econometric method of this paper. This paper incorporates time fixed effects and clustered standard errors at the firm level and time level across all specifications and robustness checks. These specifications are missing in [141] or [81]. This paper also winsorizes all variables at the 0.5% and 99.5%.

2.2.1 Baseline Empirical Tests of Hypothesis 2.1

The first empirical model tests Hypothesis 2.1 using the baseline panel regression that tests whether acquired cash increase debt after the Homeland Investment Act of 2014. This directly tests the whether acquired cash is associated with debt after controlling for the financing deficit.

In Table 2.2 I test the assumption that the tax holiday of the 2004 Homeland Investment Act marked a shift in capital structure preferences from internal cash to external debt. I use the entire COMPUSTAT flow of funds data from 1971-2019 and include a dummy variable for the period from 2003 to 2019, interacted with the $Cash_{t-1}$ variable. Table 2.2 scales all variables by net assets, defined as book assets minus cash. (1) shows that a β_C coefficient of 0.0541 with a t-stat of 5.60 in a univariate panel regression. (2) then tests the financing deficit and shows that $Financing\ Deficit_t$ has a coefficient of 0.048 with a t-stat of 8.54. In the horse race regression (3), the coefficient on $Cash_{t-1}$ maintains nearly all of it's economic and statistical significance from the univariate regression while the $Financing\ Deficit_t$ coefficient reduces to 0.0175. However, specification (4) shows that the significance of $Cash_{t-1}$ is coming entirely from the post tax holiday period. The coefficient of $Post\ Tax\ Holiday \times Cash_{t-1}$ is 0.057 with a t-statistic of 6.41, while the $Cash_{t-1}$ has a coefficient of -0.001 with a t-statistic of -0.2. The negative coefficient on $Cash_{t-1}$ applies to the pre-tax holiday period from 1971-2002, emphasizing the findings of this paper that firms started to prefer debt over cash after the repatriation tax holiday. The significance of $Post\ Tax\ Holiday \times Cash_{t-1}$ is roughly 3 times larger than $Financing\ Deficit_t$. These results are stable with firm and time fixed effects, time clustering, and firm clustering of standard errors.

Table 2.3 and 2.4 use quarterly data to test the robustness of the relationship between acquired cash and debt. In Table 2.3, (3), (4), and (5) shows that the coefficient on $Cash_{t-1}$ is

	Gross Debt (L) 1971-2019			
	(1)	(2)	(3)	(4)
$Cash_{t-1}$	0.0541***		0.053***	-0.001
	(5.60)		(5.28)	(-0.2)
$Post\ 2003 \times Cash_{t-1}$				0.057***
				(6.41)
$Financing\ Deficit_t$		0.0481***	0.0175***	0.0198***
		(8.54)	(2.58)	(2.998)
Observations	770,972	770,972	770,972	770,972
Firm FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓
R^2	0.56	0.51	0.56	0.56
Within R^2	0.12	0.02	0.12	0.13

Table 2.2: **Panel Regression 1971-2019 with Post Tax Holiday Dummy**
The sample period is from 1971Q1 to 2019Q1. Financial firms, utilities, and firms with missing market to book ratios are excluded. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_T Post\ Tax\ Holiday \times Cash_{i,t-1} + \beta_{PO} DEF_{it} + u_{it}$ where ΔD_{it} is long term liabilities or Gross Debt (L). The financing deficit as defined in [81], $DEF_t = DIV_t + I_t + \Delta W_t - C_t$ is the sum of dividends, investment, change in working capital minus the cash flow after interest and taxes. All variables are scaled by net assets, which is defined as total book assets minus cash. T-statistics are reported in parentheses.

	Gross Debt (L) 2003-2019				
	(1)	(2)	(3)	(4)	(5)
$Cash_{t-1}$	0.059***		0.058***	0.059***	0.058***
	(5.43)		(5.2)	(5.48)	(5.25)
Financing Deficit$_t$		0.047***	0.013		0.014*
		(6.55)	(1.59)		(1.69)
Capital Expenditure$_t$				0.006	0.006
				(1.44)	(1.44)
Observations	343,502	343,502	343,502	337,453	337,453
Firm FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓
R^2	0.60	0.54	0.60	0.61	0.61
Within R^2	0.14	0.01	0.14	0.14	0.14

Table 2.3: **Long Term Liabilities Scaled by Net Assets 2003-2019**
The sample period is from 2003Q1 to 2019Q1. Financial firms, utilities, and firms with missing market to book ratios are excluded. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_{PO} DEF_{it} + u_{it}$ where ΔD_{it} is long term liabilities or Gross Debt (L). The financing deficit as defined in [81], $DEF_t = DIV_t + I_t + \Delta W_t - C_t$ is the sum of dividends, investment, change in working capital minus the cash flow after interest and taxes. All variables are scaled by net assets, which is defined as total book assets minus cash. T-statistics are reported in parentheses.

persistent after controlling for debt due to a financing deficit and capital expenditure. The positive significance of $Cash_{t-1}$ suggests that external financing decisions are driven by more by previous cash balances and not as much by deficit in financing needs.

The empirical testing so far supports Hypothesis 2.1, however the pecking order's *Financing Deficit*$_t$ variable may be aggregating individual components that have stronger associations with debt than the $Cash_{t-1}$ variable. In Table 2.4 the *Financing Deficit*$_t$ variable is disaggregated into it's individual components. All disaggregated variables are economically and statistically significant in specification (1), and the addition of the $Cash_{t-1}$ variable in (2) either entire or partially subsumes each of the disaggregated variables. $Dividends_t$ reduces its coefficient from 0.367 to -0.006, suggesting that lagged cash and dividends have the strongest relationship among the disaggregated variables. The $Cash_{t-1}$ coefficient is 0.058 with a t-statistic of 5.26, which is nearly identical to its coefficient in Table 2.2 and Table 2.3.

For another robustness check on Hypothesis 2.1, I use traditional and non-traditional leverage controls in Table 2.5. Traditional leverage controls include the lagged dependent variable of *Gross Debt (L)*$_{t-1}$, $Size_t$, $Profitability_t$, $Tangibility_t$, and *Tobins* Q_t. Non-traditional leverage controls include *Textually Constrained*$_t$, which textually analyzes 10-K SEC filings using a keyword list from [26] which is shown to predict corporate finance liquidity events such as dividend omissions, equity recycling, and underfunded pensions. *Textually Constrained*$_t$ is a variable of the count of constraining words divided by total words in a 10-K. The use of 10-Ks necessitate the use of annual data, and results support the findings of previous regressions. Specification (1) and (2) using yearly data shows larger coefficients on $Cash_{t-1}$ compared to the quarterly data. For instance, in specification (2), the $Cash_{t-1}$ coefficient of 0.165 while in Table 2.3, specification (3) shows a coefficient of 0.058 for $Cash_{t-1}$. This indicates that the firm decision to use acquired cash to increase debt may be happening on a yearly basis than a quarterly basis. In Table 2.5 (3) I add the *Textually Constrained*$_t$ variable and $Cash_{t-1}$ has a coefficient of 0.180 with a t-statistic of 9.27, which is stronger both economically and statistically than the pecking order's *Financing Deficit*$_t$ coefficient of 0.122 with a t-statistic of 5.50. The coefficient on *Textually Constrained*$_t$ is positive with a coefficient of 3.393 and a t-statistic of 2.26. This suggests that firms increase the use of debt when financially constrained. Observations also drop from 87,112 to 51,106 while matching the SEC's CIK to Compustat's GVKEY. The addition of the lagged dependent variable *Gross Debt (L)*$_{t-1}$ in (4)

Table 2.4: **Disaggregation of Financing Deficit 2003-2019**
The sample period is from 2003Q1-2019Q1. Financial firms, utilities, and firms with missing market to book ratios are excluded. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_{PO} Cash_{t-1} + \beta_{DIV} DIV_{it} + \beta_I I_t + \beta_W \Delta W_t - \beta_C C_t + \varepsilon_{it}$. Gross Debt(L) is long term liabilities and Gross Debt(D) is long term debt. (1) and (4) replicates the specifications and results found in [81]. (3) and (6) uses the raw variables while the other specifications are scaled by net assets (book assets minus cash). and uses time fixed effects and firm clustering of standard errors. All specifications use firm fixed effects, time fixed effects at the quarter level, firm clustering of standard errors, and time clustering of standard errors. T-statistics are reported in parentheses.

	2003-2019			
	Gross Debt (L)		Gross Debt (D)	
	(1)	(2)	(4)	(5)
$Cash_{t-1}$		0.058***		0.001**
		(5.26)		(1.97)
$Dividends_t$	0.367**	-0.006	0.026	0.018
	(2.02)	(-0.04)	(0.31)	(0.22)
$Investments_t$	0.33***	0.219***	0.19***	0.188***
	(11.73)	(7.25)	(15.39)	(15.34)
$\Delta Working\ Capital_t$	0.035***	0.017**	0.006***	0.005***
	(4.96)	(2.16)	(3.23)	(2.95)
$Internal\ Cash\ Flow_t$	-0.056***	0.018	-0.017***	-0.015***
	(-3.84)	(0.91)	(-3.86)	(-3.51)
Observations	338,342	338,342	341,463	341,463
Firm FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓
R^2	0.55	0.61	0.52	0.52
Within R^2	0.01	0.14	0.02	0.02

does not significantly affect the $Cash_{t-1}$ and *Financing Deficit*$_t$ coefficient but raises the Within R^2 from 0.24 to 0.25. The addition of leverage controls in specification (5) does reduce the coefficient of $Cash_{t-1}$ to 0.099 with a t-statistic of 8.94 while the coefficient on the *Financing Deficit*$_t$ changes to 0.124 with a t-statistic of 4.65. $Profitability_t$ and $Tangibility_t$ may be partially subsuming the $Cash_{t-1}$, which makes sense as overseas profits would the source of retained earnings which would add to overseas cash balances and the subsequent tax liabilities associated with overseas cash. However, even with the stringent controls in specification (5), which takes the unusual approach of using fixed effects as well as using the lagged dependent variable *Gross Debt (L)*$_{t-1}$ as a control variable, the t-statistic of $Cash_{t-1}$ is the highest of all independent variables.

So far, the period of 2003-2019 presents a compelling case for internal financing positively predicts external financing in the future, after controlling for financing deficits. However, this relationship should be verified that it only exists in the most recent period and not in prior periods not covered by the HIA. In Table 2.6 Panel A, the time period from 1990Q1 to 1998Q4 used in [81] is the first placebo, while in Panel B, the time period from 1971Q1-1989Q4 used in [141] is used as the second placebo. Placebo tests use Gross Debt(L) and Gross Debt(D) as dependent variables. Raw variables are used because of the favorable specification found for raw variables in previous regressions. In 3 of 4 placebo tests, Panel A (2)and (4) and Panel B (2) and (4), the $Cash_{t-1}$ variable is insignificant as expected, while Panel B (4) shows significance. However, this may be due to the use of raw variables and may not exist when scaling the variables by net assets.

Overall, the empirical tests for Hypothesis 2.1 show a persistent and significantly positive relationship between acquired cash and debt. This implies that firms increase debt after acquiring cash, especially after the Homeland Investment Act of 2004. This supports the tradeoff theory

Table 2.5: **Debt Regressions with Conventional Leverage Controls 2003-2019**

The sample period is from 2003-2019 using annual data. Financial firms, utilities, and firms with missing market to book ratios are excluded. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_{PO} Deficit_{it} + \beta_1 Constrained_{it} + \beta_2 Liabilities_{i,t-1} + \beta_3 log(NetAssets)_{it} + \beta_4 Profitability_{it} + \beta_5 Tangibility_{it} + \beta_5 TobinsQ_{it} + \varepsilon_{it}$. Gross Debt(L) is total liabilities, $Cash_{t-1}$ is one period lagged cash and cash equivalents, Financing Deficit is taken from [81], Size is the log of net assets (book assets minus cash), profitability is operating income before depreciation, tangibility is net property plant and equipment, Tobins Q is market capitalization divided by total assets. (1)-(5) uses variables that are scaled by net assets. All specifications use firm fixed effects, year fixed effects, firm clustering, and year clustering of standard errors. T-statistics are reported in parentheses.

	Gross Debt (L)				
	(1)	(2)	(3)	(4)	(5)
$Cash_{t-1}$	0.158***	0.165***	0.180***	0.176***	0.099***
	(8.60)	(8.04)	(9.27)	(7.78)	(8.94)
Financing Deficit$_t$		0.117***	0.122***	0.139***	0.124***
		(5.59)	(5.50)	(5.27)	(4.65)
Constrained$_t$			3.393**	2.721**	2.741**
			(2.26)	(2.18)	(2.23)
Gross Debt (L)$_{t-1}$				0.173***	0.162***
				(6.00)	(6.01)
$log(Assets)_t$					0.007
					(0.24)
$Profitability_t$					-0.237***
					(-9.39)
$Tangibility_t$					1.043***
					(10.44)
Tobins Q$_t$					0.008
					(0.64)
Observations	87,112	87,112	51,106	44,712	44,632
Firm FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓
R^2	0.58	0.60	0.65	0.65	0.69
Within R^2	0.19	0.22	0.24	0.25	0.34

Table 2.6: **Placebo Tests in Prior Periods**
The sample period in Panel A is from 1990Q1 to 1998Q4 and Panel B is from 1971Q1-1989Q4 as in [81] and [141]. Financial firms, utilities, and firms with missing market to book ratios are excluded. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \beta_{PO} DEF_{it} + u_{it}$. The financing deficit is defined as in [81] $DEF_t = DIV_t + I_t + \Delta W_t - C_t$ is the sum of dividends, investment, change in working capital minus the cash flow after interest and taxes. Gross Debt(L) is long term liabilities and Gross Debt(D) is long term debt. All variables are not scaled. T-statistics are reported in parentheses.

Panel A: 1990-1998

	Gross Debt (L)		Gross Debt (D)	
	(1)	(2) Placebo	(3)	(4) Placebo
$Cash_{t-1}$		0.94		0.417
		(1.6)		(0.76)
Financing Deficit$_t$	0.39***	0.454	-0.027***	-0.071
	(73.53)	(1.3)	(-6.75)	(-0.47)
Observations	190,219	176,020	195,075	180,424
Firm FE	✓	✓	✓	✓
Time FE		✓		✓
Firm Cluster		✓		✓
Time Cluster		✓		✓
Adjusted R^2	0.88	0.88	0.88	0.88

Panel B: 1971-1989

	Gross Debt (L)		Gross Debt (D)	
	(1)	(2) Placebo	(3)	(4) Placebo
$Cash_{t-1}$		0.62		1.134**
		(1.29)		(2.31)
Financing Deficit$_t$	0.649***	0.63***	0.807***	0.651***
	(141.01)	(3.15)	(146.91)	(3.57)
Observations	163,916	153,528	226,373	185,899
Firm FE	✓	✓	✓	✓
Time FE		✓		✓
Firm Cluster		✓		✓
Time Cluster		✓		✓
Adjusted R^2	0.81	0.82	0.52	0.48

explanation of the tax benefits of debt for the period of 2003-2019. Using the initial results of this baseline regression, I test Hypothesis 2.1 in the next section.

2.2.2 Empirical Tests of Hypothesis 2.1

In Hypothesis 2.1, empirical tests are needed to explore whether the tax motive is supported with stronger results in firms with more overseas operations and the existence of convexity between cash and debt, reflecting a progressive corporate tax rate.

Tradeoff theory would predict that firms with more overseas operations would be more likely to take advantage of the tradeoff benefits of debt over cash. The more revenues and cash flows a firm generates overseas, the greater their tax liabilities and marginal benefit of debt. [54], [75], and [97] show that overseas operations and taxes play a significant factor in capital structure decisions regarding cash and debt. The increasing marginal benefits of debt mean that firms will prefer external debt over cash when financing deficits. This means that cash will be a better predictor of debt than the financing deficit. In order to further test Hypothesis 2.1, I look at firms in the COMPUSTAT Annual Segments database. Firms are sorted into four quartiles based on the size of their overseas operations. For this measure, I average the annual overseas revenues using annual data from 2011-2018 and sort into four quartiles based on this measure, with the lowest quartile is comprised of firms that report zero overseas revenue. The results are shown in Table 2.7.

In Table 2.7, from the lowest to highest quartiles of overseas revenue, the coefficients on $Cash_{t-1}$ are monotonically increasing with values of 0.031, 0.092, 0.157, and 0.177. All variables are significant, but the highest quartile shows that the $\mathit{Financing\ Deficit}_t$ has a higher coefficient of 0.305. The results in Panel B are unscaled, but it's values of 0.992, 1.023, 0.683, and 0.9063 are not

Table 2.7: **Panel Testing by Overseas Revenue Quartiles**
The sample period is from 2003Q1-2019Q1 and excludes financial firms, utilities, and firms with missing market to book ratios. Firms are sorted into quartiles based on reported COMPUSTAT Historical Segments Annual data based on average annual overseas revenue. Zero consists of firms with no overseas revenue while 2nd, 3rd, and Highest are quartiles ranked by overseas revenue in increasing order. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{it} + \beta_{PO} DEF_{it} + u_{it}$ where the dependent variable is long term liabilities. In Panel A, all variables are scaled by net assets (book assets minus cash) while in Panel B, variables are unscaled. Firm fixed effects, quarter fixed effects, firm clustering, and time clustering of standard errors are used across all specifications. T-statistics are reported in parentheses.

	Quartiles by Multinational Revenues			
	Zero	2nd	3rd	Highest
$Cash_{t-1}$	0.031***	0.092***	0.157***	0.177***
	(2.61)	(3.3)	(6.1)	(2.73)
Financing Deficit$_t$	0.039**	0.01	0.026	0.305***
	(2.09)	(0.38)	(0.49)	(8.16)
Observations	41,386	35,037	42,595	42,960
Firm FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓
R^2	0.40	0.53	0.69	0.58

monotonically increasing but do show to be greater in economic and statistical significance than the respective coefficient on the *Financing Deficit*$_t$. Results suggest that tradeoff theory generally holds across all firms with reported overseas revenue in the COMPUSTAT Annual Segments database.

Figure 2.2 outlines the relationship between cash and debt if the benefits of debt were accelerating as cash increases. This is because the gains in leverage increase as the corporate tax rate increases, and the corporate tax rate on overseas cash is modeled as $\tau_c^{OC} = C^F(X(I, \omega))(\tau_{t+\epsilon}^R + r\tau^I)$. As Subpart F Income on overseas cash is taxed at a progressive corporate tax rate, the benefits of debt should be accelerating as the tax rate progressively increases at higher levels of Subpart F Income.

In Table 2.8, I explore the potential for convexity by examining whether $\gamma > 0$ in the panel regression $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \gamma Cash_{i,t-1}^2 + u_{it}$. In the first column which uses the entire sample, the results do suggest convexity as $\gamma > 0$ with a value of 0.0002 which is significant with a t-stat of 2.19. Looking at the four quartiles based on size, the bulk of this significance originates from the 2nd largest and the largest quartiles which has γ coefficient values of 0.0003 and 0.0015 respectively with t-statistics of 2.28 and 2.33. Convexity in the positive relationship between cash and debt provides a new understanding of capital structure as our previous understanding of this relationship was that if anything, cash is preferred to debt and may display instead a negative relationship.

2.2.3 Empirical Tests of Hypothesis 2.1

For Hypothesis 2.1, I test whether constraints reduce the positive relationship between acquired cash and debt. Constraints such as information asymmetry and debt capacity are used in Table 2.9 and 2.11.

Table 2.8: **Testing for Convexity in Firms with Overseas Operations**
The sample period is from 2003Q1-2019Q1 and excludes financial firms, utilities, and firms with missing market to book ratios. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{i,t-1} + \gamma Cash^2_{i,t-1} + u_{it}$ where ΔD_{it} is long term liabilities and all observations are at the quarterly level. Gross Debt(L) is long term liabilities. Firm fixed effects, quarter fixed effects, firm clustering, and time clustering of standard errors are used across all specifications. T-statistics are reported in parentheses.

	Sorted by Size				
	Gross Debt (L) 2003-2019				
	All	Lowest	2nd	3rd	Highest
$Cash_{t-1}$	0.023**	0.022***	0.034**	0.118***	0.276***
	(2.45)	(4.93)	(2.38)	(3.24)	(3.61)
$Cash^2_{t-1}$	0.0002**	-0.0001	0.0003**	0.0001	0.0015**
	(2.19)	(-1.49)	(2.28)	(0.49)	(2.33)
Observations	343,502	84,943	86,804	87,184	83,935
Firm FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓
R^2	0.61	0.49	0.77	0.81	0.69
Within R^2	0.16	0.02	0.28	0.55	0.47

In Table 2.9, quartiles are sorted by book assets. In (4), the largest quartile based on book assets, the coefficient on $Cash_{t-1}$ is 0.401 with a t-stat of 11.93 using the conservative specifications of firm fixed effects, time fixed effects, firm clustering, and time clustering of standard errors used throughout every regression in this paper. This coefficient is economically and statistically more significant than the *Financing Deficit*$_t$ coefficient of 0.323 with a t-statistic of 5.33. The predictions that lower tradeoff firms with higher information asymmetry will have lower $Cash_{t-1}$ is perfectly shown in Table 2.9. The smallest to largest quartiles have respective coefficients of 0.01, 0.086, 0.135, and 0.401, with respective t-statistics of 3.27, 5.22, 7.02, and 11.93. The significance of $Cash_{t-1} \times log(Assets)_t$ in specification (6) shows that clearly size seems to matter, and if we assume that size is a proxy for information asymmetry, then less information asymmetry means higher tradeoffs for corporations.

This tradeoff may be also be limited by debt capacity, similar to the limitations of pecking order in firms with limited debt financing [122]. In order to test these characteristics across debt capacity, each firm is sorted into four quartiles by based on leverage ratios, or Total Liabilities divided by Market Capitalization. The coefficient for $Cash_{t-1}$ should be stronger as for firms with more debt capacity as the tradeoff benefits of minimizing repatriation taxes will be greater for firms with more capacity to take on debt. Figure 3.4 shows that the relationship between cash and debt will be stronger for firms with more tradeoff benefits. Results in Table 2.11 show results that are in line with this explanation.

Going from (1) to (4), the coefficient of $Cash_{t-1}$ increases monotonically with values of 0.047, 0.086, 0.114, and 0.154 respectively. All are greater in magnitude than the coefficient on the *Financing Deficit*$_t$. This supports the tradeoff theory because firms with more debt capacity

Table 2.9: **Testing Across Size Quartiles**
The sample period is from 2003Q1-2019Q1 and excludes financial firms, utilities, and firms with missing market to book ratios. Firms are sorted into quartiles based on total assets in line with Table 6 in [81]. Smallest to largest quartiles are sorted from left to right. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{it} + \beta_{PO} DEF_{it} + u_{it}$. Gross Debt(L) is long term liabilities. Firm fixed effects, quarter fixed effects, firm clustering, and time clustering of standard errors are used across all specifications. T-statistics are reported in parentheses.

	Sorted by Book Assets					
	Gross Debt (L) 2003-2019					
	(1) Smallest	(2) 2nd	(3) 3rd	(4) Largest	(5) All	(6) All
$Cash_{t-1}$	0.01***	0.086***	0.135***	0.401***	0.059***	0.071***
	(3.27)	(5.22)	(7.02)	(11.93)	(5.1)	(5.88)
Financing Deficit$_t$	0.024***	0.001	0.028	0.323***	0.014	0.008
	(2.97)	(0.05)	(1.1)	(5.33)	(1.66)	(0.92)
log(Assets)$_t$					0.02	-0.002
					(1.12)	(-0.15)
$Cash_{t-1} \times log(Assets)_t$						0.009***
						(5.02)
Observations	84,943	86,804	87,184	83,935	343,419	343,419
Firm FE	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓	✓
R^2	0.48	0.75	0.81	0.71	0.60	0.62
Within R^2	0.02	0.23	0.55	0.50	0.14	0.17

Table 2.10

	Multinational		Domestic		Mean Comparison	
2003-2019	Obs	Mean	Obs	Mean	Difference	T-Stat
Cash Holdings ($M)	184,661	453.1	165,274	77.6	375.4	131.87
Total Assets ($M)	191,353	5,714.1	172,442	823.1	4,890.9	115.78
Net Assets ($M)	191,220	5,056.9	172,336	740.2	4,316.7	114.56
Financing Deficit ($M)	191,392	97.0	172,452	25.5	71.5	60.87
LT Liabilities	180,731	0.405	163,056	0.441	-0.036	-8.18
LT Debt	182,901	0.253	164,147	0.220	0.033	20.07
Cash	184,546	0.876	165,130	2.049	-1.173	-40.94
Financing Deficit	184,634	0.153	165,183	0.369	-0.216	-32.03
Dividends	179,529	0.010	162,376	0.006	0.004	38.50
Tangibility	184,203	0.325	164,926	0.425	-0.100	-88.44
Tobins Q	191,353	1.777	172,442	2.175	-0.398	-36.21

Table 2.11: **Testing Across Leverage Quartiles**
The sample period is from 2003Q1-2019Q1 and excludes financial firms, utilities, and firms with missing market to book ratios. Firms are sorted into quartiles based on leverage ratios (Total Liabilities/Market Capitalization) in line with Table 6 in [81]. Lowest to highest quartiles are sorted from left to right. The following regression is estimated: $\Delta D_{it} = \alpha_i + \lambda_t + \beta_C Cash_{it} + \beta_{PO} DEF_{it} + u_{it}$. Gross Debt(L) is long term liabilities. Firm fixed effects, quarter fixed effects, firm clustering, and time clustering of standard errors are used across all specifications. T-statistics are reported in parentheses.

	Sorted by Leverage Ratio				
	Gross Debt (L) 2003-2019				
	Lowest	2nd	3rd	Largest	All
$Cash_{t-1}$	0.047***	0.086***	0.114***	0.154***	0.058***
	(4.64)	(6.57)	(4.95)	(3.12)	(5.2)
$Financing\ Deficit_t$	-0.004	0.077***	0.095***	0.109***	0.013
	(-0.57)	(5.27)	(4.72)	(3.39)	(1.59)
Observations	83,954	87,530	85,840	82,953	343,502
Firm FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓
R^2	0.76	0.72	0.75	0.68	0.60
Within R^2	0.19	0.17	0.19	0.14	0.14

should take more advantage of tradeoff benefits of debt over cash. This also suggests that in spite of bankruptcy costs, the tradeoff benefits of tax deductability of interest increases for firms with more debt capacity. This also demonstrates that debt capacity constraints can weaken the relationship between acquired cash and leverage.

This phenomenon is stronger in firms with less information asymmetry, greater debt capacity, and more overseas operations. The driving force behind the pecking order is information asymmetry and the subsequent adverse selection cost. A firm with high information asymmetry may prefer cash over external debt because of adverse selection costs of external finance, exposure to volatile market conditions, and more monitoring. Within this framework, the results of Hypothesis 2.1 may be subdued in firms with higher adverse selection costs, such as small firms. As shown in Figure 3.4, firms with high information asymmetry will have lower tradeoffs of debt resulting in a lower coefficient than firms with low information asymmetry. In Table 2.9, this is exactly what the results show.

Next in Table 2.12, using annual data, I look at how acquired cash interacts with size and multinational status. In (1) through (4), the MNC dummy is 1 if the firm is listed in the COMPUSTAT Annual Historical Database. In (5), the MNC dummy is one if the firm is listed in the COMPUSTAT Annual Historical database and averaged at least $1B in overseas revenue during the specified time period. In (2), the interaction coefficient on $Cash_{t-1} \times log(Assets)$ is positive and significant with a value of 0.015 and a coefficient of 3.10. This indicates that the relationship between acquired cash and leverage changes based on firm size. Larger firms have a stronger relationship compared to weaker firms, similar to the results using quarterly data found in Table 2.9. (3) indicates that the coefficient on $Cash_{t-1} \times MNC$ is positive and significant with a value of 0.032 and a t-statistic of 2.28. This indicates that the relationship between acquired cash and leverage changes based on multinational status. Multinationals have a stronger relationship compared to non-multinationals, similar to the results using quarterly data found in Table 2.9. The coefficient on $Cash_{t-1}$ is still positive and significant with a value of 0.153 and a t-statistic of 6.75. This indicates that something other than repatriation tax benefits is also driving the relationship between acquired cash and leverage.

In (4), I use both interactions as well as the triple interaction term $Cash_{t-1} \times log(Assets)_t \times MNC$. The coefficient for $Cash_{t-1} \times log(Assets)$ is positive and significant while the coefficient for

Table 2.12: **Interaction of Cash with Size and Multinational Corporations**
The sample period is from 2003-2019 using annual data. Financial firms, utilities, and firms with missing market to book ratios are excluded. Gross Debt(L) is total liabilties, $Cash_{t-1}$ is one period lagged cash and cash equivalents, Size is the log of net assets (book assets minus cash), and in (4) MNC is a dummy variable where 1 indicates a firm that is listed as a multinational firm in the Compustat Annual Historical Database. In (5) MNC is a dummy variable where 1 indicates a firm with an average annual revenue of over $1 billion. Control variables include the financing Deficit which is taken from [81]. Variables are scaled by net assets. All specifications use firm fixed effects, year fixed effects, firm clustering, and year clustering of standard errors. T-statistics are reported in parentheses.

	Gross Debt (L)				
	(1)	(2)	(3)	(4)	(5)
$Cash_{t-1}$	0.165***	0.147***	0.153***	0.143***	0.147***
	(7.92)	(6.61)	(6.75)	(5.94)	(6.64)
log(Assets)	0.016	-0.039*	0.019	-0.036*	-0.032
	(0.57)	(-1.79)	(0.68)	(-1.75)	(-1.41)
$Cash_{t-1} \times log(Assets)$		0.015***		0.015***	0.014***
		(3.1)		(3.59)	(3.15)
$Cash_{t-1} \times MNC$			0.032**	0.015	-0.249
			(2.28)	(0.84)	(-0.72)
$Cash_{t-1} \times log(Assets) \times MNC$				-0.003	0.125*
				(-0.47)	(1.86)
Observations	87,098	87,098	87,098	87,098	87,098
Controls	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓	✓
R^2	0.60	0.60	0.60	0.60	0.60
Within R^2	0.21	0.23	0.22	0.23	0.23

$Cash_{t-1} \times MNC$ is not. This indicates that larger firms are driving the change in relationship between acquired cash and leverage, and many larger firms happen to be multinational. When I define a multinational to have an average of at least $1B in overseas revenue, then the triple interaction term $Cash_{t-1} \times log(Assets) \times MNC$ has a positive and significant coefficient of 0.125 and a t-statistic of 0.125. This indicates that large multinationals are driving the change in the relationship between acquired cash and leverage. The base relationship between acquired cash and leverage still exists in smaller domestic firms.

The results from Table 2.12 provides support for the conclusions of [54], [75], and [97] that overseas operations and taxes has a significant factor in capital structure decisions regarding cash and debt.

2.2.4 Empirical Testing of Hypothesis 2.1

So far, empirical results indicate that the large multinationals acquire cash and increase leverage due to repatriation tax benefits. This relationship may be negatively affected due to frictions such as greater information asymmetry lower and debt capacity. However, in this section, I explore whether acquiring cash may also affect frictions such as financial constraints, uncertainty, and negative sentiments.

Table 2.13 looks at the interaction of acquired cash with sentiment analysis. I first interact acquired cash with $Constrained_t$i, which is a textual sentiment score given to 10K SEC filings using a financial constraints word list from [26]. I also incorporate textual analysis using $Uncertainty\ _t$ and $Negative_t$ which are textual sentiment scores given to 10K SEC filings using word lists from [124]. (1) and (2) both have the coefficient on $Cash_{t-1} \times Constrained_t$ positive and significant. The addition

Table 2.13: **Interaction of Cash with Financial Constraints, Uncertainty, and Negative Sentiments**

The sample period is from 2003-2019 using annual data. Financial firms, utilities, and firms with missing market to book ratios are excluded. Gross Debt(L) is total liabilties, $Cash_{t-1}$ is one period lagged cash and cash equivalents, $Constrained_t$ is a textual sentiment score given to 10K SEC filings using a financial constraints word list from [26], $Uncertainty_t$ and $Negative_t$ is a textual sentiment score given to 10K SEC filings using word lists from [124] , and MNC is a dummy variable with a value of 1 for firms with an average annual revenue of over $1 billion as listed in the COMPUSTAT Annual Historical Database. Control variables include size, which is the log of net assets, and the financing deficit, which is taken from [81]. Variables are scaled by net assets. All specifications use firm fixed effects, year fixed effects, firm clustering, and year clustering of standard errors. T-statistics are reported in parentheses.

	Gross Debt (L)			
	(1)	(2)	(3)	(4)
$Cash_{t-1}$	0.139***	0.153***	0.162***	0.171***
	(13.5)	(14.43)	(2.59)	(2.55)
$Constrained_t$	1.464	2.191		
	(0.59)	(0.9)		
$Cash_{t-1} \times Constrained_t$	1.643***	1.287**		
	(2.815)	(2.01)		
$Uncertainty_t$			-10.54*	
			(-1.96)	
$Cash_{t-1} \times Uncertainty_t$			0.779	
			(0.41)	
$Negative_t$				-6.854**
				(-2.19)
$Cash_{t-1} \times Negative_t$				0.297
				(0.16)
Observations	51,106	51,102	51,103	51,103
Controls		✓	✓	✓
Firm FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Industry Cluster	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓
R^2	0.64	0.65	0.65	0.65
Within R^2	0.22	0.24	0.24	0.24

of controls reduces the coefficient from 1.643 to 1.287 and the t-statistic from 2.82 to 2.01. This shows that for constrained firms, acquiring cash will allow them to increase their ability to raise debt. These results support Hypothesis 2.1 that acquiring cash will reduce leverage constraints.

(3) and (4) show that textual analysis measuring uncertainty and negative sentiments are associated with less lending. However, the interaction coefficients on $Cash_{t-1} \times Uncertainty_t$ and $Cash_{t-1} \times Negative_t$ are positive but not significant.

Using the [9] Z Score to measure financial distress risk, Table 2.14 looks at the interaction of $Cash_{t-1} \times AltmanZ$. In (1), the interaction of $Cash_{t-1} \times AltmanZ$ has a coefficient of -0.015 with a t-statistic of -3.00. Lower Altman Z Scores that have more distress risk and higher financial constraints. The indicates that a distressed firm that acquires cash will increase debt more than a firm that is not distressed. This supports Hypothesis 2.1 that acquired cash will reduce financial constraints on debt. If this was not the case, the interaction term of $Cash_{t-1} \times AltmanZ$ would be either insignificant or positive.

Column (2) adds control variables of size and the financing deficit which does not impact the coefficient on $Cash_{t-1} \times AltmanZ$. The multinational dummy variable in (3) does not affect the coefficient on $Cash_{t-1} \times AltmanZ$. The multinational dummy variable is 1 for firms with an average of at least $1B in overseas revenue, and zero if not. In (4), the addition of a triple interaction term $Cash_{t-1} \times AltmanZ \times MNC$ does not have a significant coefficient. This shows that domestic and multinational firms do not vary in terms of how acquired cash reduces financial constraints on debt for either types of firm. Overall, Table 2.13 and 2.14 implies that acquiring cash reduces financial constraints in debt by showing a positive and significant coefficent for the interaction term $Cash_{t-1} \times Constrained_t$ and a negative and significant coefficient for $Cash_{t-1} \times AltmanZ$.

Table 2.14: **Interaction of Cash with Altman Z Score**

The sample period is from 2003-2019 using annual data. Financial firms, utilities, and firms with missing market to book ratios are excluded. Gross Debt(L) is total liabilties, Altman Z Score is a measure of bankruptcy risk where a lower number indicates higher bankruptcy risk, $Cash_{t-1}$ is one period lagged cash and cash equivalents, and in (4) MNC is a dummy variable where 1 indicates a firm that is listed as a multinational firm in the Compustat Annual Historical Database. In (5) MNC is a dummy variable where 1 indicates a firm with an average annual revenue of over $1 billion. Control variables include size, which is the log of net assets, and the Financing Deficit, which is taken from [81]. Variables are scaled by net assets. All specifications use firm fixed effects, year fixed effects, firm clustering, and year clustering of standard errors. T-statistics are reported in parentheses.

	Gross Debt (L)			
	(1)	(2)	(3)	(4)
$Cash_{t-1}$	0.161***	0.169***	0.168***	0.168***
	(8.19)	(7.55)	(7.61)	(7.6)
$AltmanZ_t$	-0.183	-0.205	-0.207	-0.207
	(-1.096)	(-1.09)	(-1.09)	(-1.09)
$Cash_{t-1} \times AltmanZ$	-0.015***	-0.016***	-0.016***	-0.016***
	(-2.998)	(-3.04)	(-2.98)	(-2.99)
$Cash_{t-1} \times MNC$			0.421***	0.481***
			(6.94)	(3.24)
$Cash_{t-1} \times AltmanZ \times MNC$				-0.442
				(-0.88)
Observations	84,193	84,182	84,182	84,182
Controls		✓	✓	✓
Firm FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Firm Cluster	✓	✓	✓	✓
Time Cluster	✓	✓	✓	✓
R^2	0.59	0.60	0.60	0.60
Within R^2	0.20	0.22	0.22	0.22

2.3 Conclusion

Using the pecking order [131, 132] and precautionary cash theory [134] as a rule of thumb, when firms increase cash, a significantly positive relationship with debt should not exist. On the other hand, if cash increases the tax benefits of debt [79, 55, 93, 76, 97] and acts as a collateral channel, cash can relieve financial constraints [2, 61] and significantly increase an already positive relationship between acquired cash and leverage. This paper finds this persistent relationship is consistent with a new understanding of the roles of cash and leverage. In most specifications, acquired cash has an economically and statistically greater relationship with leverage than the pecking order's financing deficit used in [141, 81, 122]. This trend is stronger for firms with lower information asymmetry, higher debt capacity, and more overseas operations. Results also show a significant interaction between acquired cash and bankruptcy risk, suggesting that distressed firms can acquire cash to mitigate the adverse effects of financial constraints when increasing leverage. [26]. Results also display positive convexity between cash and debt, which is suggested by progressive tax rates on income generated from overseas cash. Empirical tests are conducted across a broad cross section of public US companies from 2003-2019, after the introduction of the Homeland Investment Act of 2004. addressing the statistical power concerns of [121]. Placebo tests show that this effect is largely absent in earlier periods of 1971-1989 and 1990-1998 used in [141, 81] and concerns about omitted variable bias in time invariant firm characteristics and macro variables are addressed in throughout the paper.

The literature on capital structure has significantly improved our understanding of firm financing decisions since [131] and there are many more salient factors to consider [60]. A more perfect story of capital structure should consider incorporating an updated understanding of the tax benefits of debt and the role of cash in relieving financial constraints on leverage. The findings outlined in this paper can increase our understanding of how and why capital structure is moving towards a world of simultaneously high cash and debt levels by incorporating the heuristics of [129]. This paper demonstrates that not only do firms display preferences of debt over cash, but this preference is suggested to be three times more relevant than financing deficits. As [129] asserted, the benefits of debt may be overwhelmingly larger than expected, and this paper shows that the may just have made this true in modern times.

Appendix

Specifications of a Two Stage Least Squares Instrumental Variable estimation.

Table 2.15: **Two-Stage Lending Sensitivity Estimation**

The sample period is from 2003-2019 using annual data. Financial firms, utilities, and firms with missing market to book ratios are excluded. The empirical model of the two-stage ordinary least squares regression is as follows:

$$\begin{aligned} Cash_{i,t-1} &= \alpha_i + \beta 10Y\,Treasury_t + X'\Gamma + \varepsilon_{i,t} && \text{1st Stage} \\ Liabilities_{i,t} &= \lambda_i + \gamma \widehat{Cash}_{i,t-1} + X'\Gamma + \mu_{i,t} && \text{2nd Stage} \end{aligned}$$

Control variables include size, which is the log of net assets, and the Financing Deficit, which is taken from [81]. Variables are scaled by net assets. All specifications use firm fixed effects, firm clustering, and year clustering of standard errors. T-statistics are reported in parentheses.

$\widehat{Cash_{t-1}}$	0.221***
	(3.18)
Log(Assets)$_t$	0.092
	(1.5)
Financing Deficit$_t$	0.137***
	(5.04)
Observations	87,098
Bank FE	✓
Bank Clusters	✓
Time Clusters	✓
Kleinbergen-Paap (p-value)	0.00
Cragg-Donald Wald F Statistic	173.8

Chapter 3

Better than Risk Free: Do Reserve Premiums Crowd Out Bank Lending?

When former Fed chair Ben Bernanke was turned down for a mortgage refinancing in 2014, he lamented the lack of credit access by musing “I think the tightness of mortgage credit, lending is still probably excessive.”[1]. One explanation for this credit market tightness [2] is that banks found other investments to have higher risk-adjusted returns. This may explain why banks at the time held an unprecendented $2.8 trillion[3] of excess reserve assets, which yielded a *risk-free* interest rate of 24 basis points above the 3 month treasury yield (Figure 3.1). Some viewed excess reserves to be irrational as [112] posited banks would “forego [profits]... in the purchase of bills and investments”

[1]On October 2, 2014 at a Chicago conference, Ben Bernanke was quoted as saying “Just between the two of us, I recently tried to refinance my mortgage and I was unsuccessful in doing so. . . I think the tightness of mortgage credit, lending is still probably excessive.”

[2] Banks restricted credit supply [3] to large firms [105], small firms [44], and households [128] because of bank illiquidity [48] and insolvency concerns [33], which exacerbated employment losses [89, 68] and firms forgoing investment projects [39] during the Great Recession.

[3]As of 2014 Q3 according to the Federal Bank of St. Louis.

by holding excess reserves[4]. This changed on October 2008 as the Federal Reserve started to pay interest on excess reserves for the first time in history, in a move ironically championed by Federal Reserve Chair Ben Bernanke. Under this new IOER framework, this paper primarily addresses two questions. Were banks incentivized to accumulate excess reserves? If so, did banks reduce credit access and lending to clients? This paper presents a “reserve premium" (IOER minus the risk-free rate) that measures an incentive for banks to hold “better than risk-free” excess reserves and extend fewer loans to borrowers. In two-stage panel estimations, the reserves premium (which averaged 18 basis points) led to a decrease in total lending volume by 6.0% or $761M ($13.6M) in loans for the average transactional (relationship) bank. This suggests a total reduction of $408.5 billion in bank lending is associated with reserve premiums. These findings contribute to [130, 69, 126] by using a risk adjusted framework to verify their theoretical banking models regarding the negative relationship between excess reserve and lending and estimate its impact on bank lending behavior.

In assessing the role of reserve premiums on credit access, I look at banking models from the Great Depression era [130, 84, 135] when banks held up to 30% of deposits in excess reserves which earned zero interest. Starting in October 2008 banks had a *risk-free* incentive to hold excess reserves instead of investing in loan assets [5] [6]. The reserves premium measures the superior risk adjusted returns of IOER over the risk-free 3-month treasury bill. This premium highlights the

[4]In the *Treatise of Money*, J.M. Keynes' view regarding a bank's reserve ratio was “ To let the [reserve] ratio fall below the figure which has been fixed... would be a sign of weakness or, at least, of weak mindedness; whilst to let it rise above would be to forego quite unnecessarily a source of profit, since surplus reserves can always be employed in the purchase of bills or investments.
Accordingly, the statistics show that, save in exceptional circumstances, all banks use their reserves up to the hilt; that is to say, they seldom or never maintain idle reserves in excess of what is their conventional or legal proportional for the time being.” ([112], Volume II p.53)

[5]After the passage of the Financial Services Regulatory Relief Act of 2006 which authorized the Federal Reserve to start paying interest on reserves and excess reserves starting in October 2008 to compensate depository institutions a rate of interest on excess reserves (IOER) “not to exceed the general level of short-term interest rates"

[6]FSRR Section 201 states: (A) In general balances maintained at a Federal Reserve bank by or on behalf of a depository institution may receive earnings to be paid by the Federal Reserve bank at least once each calendar quarter, at a rate or rates **not to exceed** the general level of short-term interest rates.

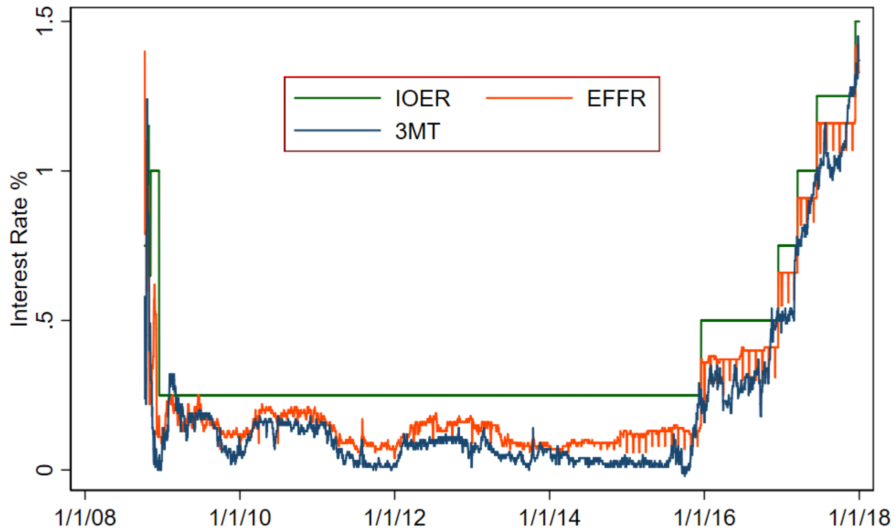


Figure 3.1: **Interest Rates** Interest rate data is from the Federal Reserve and U.S. Treasury. IOER is interest on excess reserves, 3MT is the 3 Month Treasury rate, and EFFR is the effective federal funds rate.

similar risk profile of excess reserves and treasuries, which are both risk-free and explicitly backed by the US government. They both carry lower risk than the federal funds market where a fed funds lender is exposed to the counter-party risk of a fed funds debtor. Excess reserves also tend to offer not only higher interest rates than treasuries, but also offer zero volatility and zero transaction costs compared to treasury bills, the latter being higher on both counts.[7]. When examining excess reserves on an aggregated basis, Figure 3.2 suggests that excess reserves in the US banking system closely track the "reserve premium" introduced in this paper. This suggests that banks may be incentivized to hold excess reserves which may in turn be associated with less bank lending.

Initially, [111] attributed ballooning reserve balances to Federal Reserve asset purchase programs and not the lack of lending while [10] attributed the subsequent lack of inter-bank lending to

[7]From 1934-1940, US banks held significant amounts of excess reserves and [130] surmises that in periods of low-interest rates, banks become indifferent between holding cash and treasury bills because the return from treasuries net of transaction costs were zero.

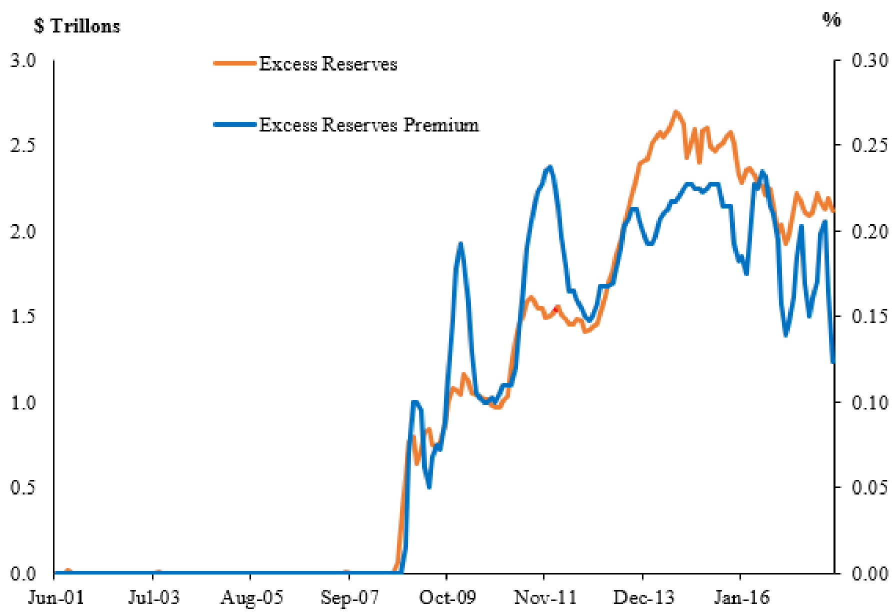


Figure 3.2: Aggregate Excess Reserves Held at the Federal Reserve and the Reserves Premium [Interest on Excess Reserves-3M Treasury Rate]. Excess reserves ($trillions) are on the left y-axis representing values excess reserves in red, while basis points are on the right y-axis representing values for excess reserves premium in blue.

volatile federal funds rates. On the other hand, [67, 147, 52][8] supported incentives to reduce excess reserves while [69] and [126] presented the first formal theories proposing the conditions where excess reserves and lending would have a negative relationship. [69] proposes a model scenario when IOR exceeds i^*, a benchmark interest rate, there exists a negative relationship between the level of excess reserves and bank loans. [126] also proposes a model where loans are negatively related to excess reserves and positively related to deposits. My results mostly verify [69] and [126] by estimating a negative relationship between excess reserves and lending, where a 1 SD increase in reserve premiums is associated with a 2% or $136 billion decrease in total bank lending. The use of the reserves premium is unique to this paper and is derived from a risk-adjusted framework using

[8] [147] proposed a reserve tax while [52] proposed a maximum reserve ratio in order to incentivize banks to hold fewer excess reserves and to lend more.

the insightful assumptions of [130][9].

Related literature suggests bank lending increases when total bank reserves increase due to quantitative easing (QE)[10] or when lending profitability increases[11]. I incorporate this literature by using QE and lending profitability as control variables and find that results are still robust in the aggregated weekly data and the Call Report panel data. I show that an increase in reserves premium is associated with an increase in excess reserves and subsequently, a decrease in bank lending. I also show an increase in excess reserves may be partly due to bank selling of securities such as mortgaged backed securities (MBS), or capital that was not initially used for lending. In the panel data I use the most conservative specifications of bank fixed effects and clustering of standard errors by firm and quarter. I also address potential measurement error due to omitted variable bias by using two-stage panel estimations and find similar results to one-stage panel estimations. Lending sensitivities to the reserve premium are similar for both transactional and relationship banks. However, transactional banks hold significantly larger excess reserves, holding a disproportionate influence on the restriction of credit access.

The framework of this paper builds upon the excess reserve banking models of [130] and [69] by utilizing a Sharpe ratio framework to compare the risk-adjusted returns of excess reserves and

[9][130], [135], and [84] recognize that bank demand for excess reserves is a function of short term interest rates, central to this paper's first structural relationship in using the reserve premium. [130] also states that bank demand for excess reserves is a function of not only the nominal interest rate treasuries and loans, but also their respective risk of default as well. [130] states in page 13 " The only adjustment of this estimate of the yield on earning assets will be to allow for changes in the risk of loss from the default of principal or interest on earning assets. Variations in the default risk of an entire spectrum of earning assets including secondary reserves is a different matter, however, and must be controlled statistically. This will be done by introducing the market yield spread between corporate bonds of different grade symbolized by P, as a variable in the statistical demand equation. "

[10] [109, 41, 138] find that QE increased lending for banks holding mortgage backed securities.

[11][85] documents evidence that during positive QE1 announcement dates, there are large reductions in rates, finding 113 bps reductions in MBS yields. [117] finds evidence of a reduction in long term risk premium from the unique demand for long term assets. [148] also presents statistically significant evidence resulting from the Fed's large scale purchases of long term treasuries. [146] also show that MBS purchases by the Fed reduced spreads via risk reduction channels. These findings are extended to loan interest rates and net interest margins for banks.

loans. This framework predicts the positive impact of increasing reserve premiums on excess reserves and the negative impact of increasing reserve premiums on bank lending. This paper contributes to the literature on credit access issues that exacerbated the financial crisis and the literature on bank decision making regarding lending, non-lending activities, and charter values [30]. An example of risk adjusted frameworks restricting credit access is the Bank United earnings call on January 21, 2016, where the CEO John Kanas exited the consumer lending business by announcing "Our job is to allocate resources and put all of our efforts into the areas where we can make money and where we think the least amount of risk is."

The rest of this paper consists of a literature review in Section 3.1, the presentation of the risk-adjusted framework and the four main predictions in Section 3.2, the empirical model in Section 4.4, tests of the aggregate data in Section 3.3.2, one stage panel estimations in Section 3.3.3, two stage panel estimations in Section 3.3.3 and the conclusions in Section 3.4. A graphical summary of the formal empirical testing mechanism is shown in Figure 3.4.

3.1 Literature Review

This paper's contribution is primarily related to the literature on credit markets during the Great Recession and bank risk taking. While much of this literature focuses on the short run impact of credit shocks and how these shocks exacerbated the Great Recession, this paper conducts a formal analysis of the long-run dynamics of bank lending, excess reserves, and the reserves premium. In focusing on this paper's unique contributions, this literature review covers the role of excess reserves during a financial crisis, bank risk taking, and bank lending during a crisis. This literature review is segmented into three sections in order to provide a comprehensive understanding of the motivations of this paper.

Excess Reserves in Financial Crisis

The role of excess reserves during a financial crisis is closely linked to the fixed-rate deposit insurance system and the role of bank charter values. Fixed rate deposit insurance systems, such as the Federal Deposit Insurance Corporation (FDIC), insures a bank's liabilities, which allows banks to borrow at below-market rates from depositors and invest in riskier loans at higher interest rates. Deposit insurance poses a moral hazard risk for excessive risk-taking [110]. As [127] noted, insured deposits act as a "put option" on bank assets with a strike price equal to the maturity value of its debt. The savings and loan crisis was due in part to the moral hazard of deposit insurance [110], which can have the same negative impact on bank stability in other countries as well [58].

While FDIC deposit insurance may encourage risk-taking, then bank charter values encourage the opposite. The banking literature typically defines charter value as benefits from access to deposit insurance, access to the Federal Reserve discount window, low cost of funding, bank reputation, monopoly rents, economies of scale, and superior information[1]. The possession of this charter value makes it difficult for a bank to shift losses to the FDIC, as the FDIC may sell an insolvent bank charter in a purchase and assumption [110]. Maximizing bank charter values also leads to more prudent investment [99] in investments such as excess reserves.

Financial crises in the United States typically opens with financial panic, followed by discussions of draconian "narrow banking" regulations, and concludes with a compromise where banks still delegate credit to market participants, albeit under stricter regulations and increased regulatory capital requirements. These compromises often included reserves, such as in the aftermath of the Banking Panic of 1907[12] when the U.S. implemented the Federal Reserve Act of 1913, which introduced the first fractional reserve banking system in the US. Banks also held large balances of excess reserves before and after the banking panic of 1933, which [130] attributes to precautionary excess reserves in anticipation of bank runs [13] in line with the recent arguments of [104]. In July 1936, excess reserve balances reached $2.9 billion even though the Federal Reserve paid no interest on reserve balances [130]. Holding more excess reserves was frequently an alternative to the "Chicago Plan", a narrow banking proposal which calls for a 100% reserve system. Since then, variations of the "Chicago Plan" surface among academics after a crisis such as the S&L crisis and the recent financial crisis of 2008. However, it was not until this latest crisis that banks held excess reserves in significant amounts as they did in the 1930s.

In recent years under the Financial Services Regulatory Relief Act of 2006 and the Emergency Economic Stabilization Act of 2008, the Board of Governors directed the Federal Reserve to start paying interest on required reserve and excess reserves starting on October 2008 in order to set a hypothetical floor for the effective federal funds rate [14]. By providing interest on excess reserves, this would allow the Federal Reserve to change the supply of reserves held by banks so that the effective fed funds rate equals the target policy rate [70]. By raising interest on excess reserves, this would allow the Federal Reserve to increase the supply of reserves held by the Federal Reserve, and vice versa. Interest on reserves and excess reserves gave the Federal Reserve a fourth policy tool to manage the short term interest rates on top of open market operations, the discount rate,

[12] During the Banking Panic of 1907, banks suspended cash withdrawals and only allowed depositors to transfer funds by check [82]. This was characteristic of banking panics during the 19th century.

[13] [135] argues that the other reason to hold excess reserves is to prepare for uncertainty during the normal course of operations of daily transactions.

[14] Refer to the Federal Reserve Bank of New York, https://www.newyorkfed.org/aboutthefed/fedpoint/fed15.html which states: "While IOER has been effective at influencing the FFER, it has not served as a hard minimum rate at which all institutions are willing to lend funds. This is because some institutions are eligible to lend funds in the federal funds market, but are not eligible to earn IOER, such as the government-sponsored enterprises (GSEs)."

and reserve requirements. It was a policy tool was introduced by [135], advanced by many others [65, 94, 47, 15, 16], which became very effective at influencing the effective fed funds rate. From this literature, it can be deduced that interest on reserves was designed to control the level of total reserves in the system.

Bank Risk-Taking

Starting on November 25, 2008, the Federal Reserve started a large scale asset purchase program (LSAP) to purchase $4.5 trillion in US Treasuries and agency MBS [133] in accordance with their stated goal to "ease credit conditions". As the Federal Reserve purchased assets from financial intermediaries, this led to a dramatic increase in the aggregate reserves in the banking system. However, the main purpose of QE was to ease credit conditions for businesses and households. On January 13, 2009 in a speech to the London School of Economics, the former Fed Chair Ben Bernanke said " The Federal Reserve's [asset purchases] focuses on the mix of loans and securities that it holds and on how this composition of assets affects credit conditions for households and businesses." One main accomplishment of these three rounds of QE was lowering the long term interest rate. [85] finds that MBS yields fell 113 bps as a result of the announcement of QE1, and this announcement effect was verified by [96] while [146] also finds that MBS purchases by the Federal Reserve reduced MBS spreads by risk reduction channels. [66, 85, 117, 148] also finds evidence of a reduction in MBS and long term treasury risk premiums from the Federal Reserve's open market purchases. This reduction in long term risk premiums relates to the transmission of monetary policy by the Federal Reserve. Another way this transmission may be occurring is through the creation of reserves through QE [109] which will induce more lending and bank risk taking.

The transmission channel of monetary policy encompassed the two types of channels, the “lending-channel” [115] and the “risk-taking channel” [32, 4]. The risk taking channel outlines a monetary policy strategy where lowering policy rates incentivize financial institutions to take on larger risks, resulting in lower risk premia. Risk management and the pricing of risk is central to financial research, as bank risk management during the financial crisis revolved around banking decisions that contribute to balance sheet solvency [33], balance sheet weakness[15] and systematic risk [16]. In this context, the injection of liquidity through the LSAP and QE was a measure to ease credit conditions for households and businesses by allowing banks to reprice and shift the risk of their balance sheets in order to lend again. [138] find that QE 1 and QE3, where the Federal Reserve targeted MBS purchases, had a positive effect on lending for commercial banks that held MBS on their balance sheets. [41] also finds that banks that hold MBS increased mortgage originations during QE. From this literature, it can be deduced that bank risk taking considers risk levels across different types of assets and maturities.

Relationship and Transactional Lending During Crisis

During a financial crisis, lending has been documented to be heterogeneous by bank type, as relationship banks lend more than transactional banks. For example,[28] finds that during a crisis, relationship banks in Italy lend more than transactional banks. [17] supports these findings using European banking data while [21] finds similar results for US banks. During a financial downturn, relationship banking benefits from information gained from it’s client from monitoring. Monitoring costs are considered to be a fixed cost of debt [63, 107], and lender gains from processing

[15] The literature shows that non-lending services such as non-interest income and trading were riskier than lending activities during the financial crisis, contributing to balance sheet weaknesses [53, 59, 72].

[16] [57] notes that pre-Lehman, 2001-2008, low interest rates triggered substantial risk taking by banks, in line with standard banking models that strictly maximize returns when rates fall. This very behavior led to systemic risks, as modeled by [140], as new regulations like Dodd-Frank changed the behavior of large transaction banks.

private information are higher for borrowers with soft information [22, 20, 21] who engage in relationship lending. Small relationship banks have comparative advantages in lending to firms with soft information, while large transaction banks specialize in lending to larger firms using hard quantitative information. Such characteristics suggest that market based liquidity injections by the Federal Reserve may have more effect on transactional than relationship banking. When it comes to risk management of loan portfolios, the literature on relationship lending agrees that relationship banks have lower loan default rates than transactional banks, but disagree on what happens to loan interest rates during a crisis. Literature that uses European banking data shows that relationship banks have lower lending rates than transactional banks during a crisis [28, 17] as banks learn about borrowers creditworthiness and adapt lending terms to evolving economic conditions. On the other hand, literature that uses US banking data finds that relationship banks charge higher interest rates than transaction banks [5, 22, 20, 21]. This latter assumption is verified and used in this paper's model when comparing lending in relationship and transactional banks.

Relationship banks will lend more because of greater lending margins from soft information. [98] notes that relationship banking by small community banks involves the use of "soft information" leading to larger net interest margins compared to non-relationship lending by large banks. Hein notes that this difference is difficult to quantify, but tests show that the difference in net interest margins between small banks and large banks is significant.[17] [28] models higher funding costs for Italian relationship banks because of higher monitoring costs, and shows that relationship banks lend at lower rates than transactional banks during crises. However, in the US, net interest margins are larger for small relationship banks vs large transactional banks (Figure **??**, and this difference grew wider during the financial crisis. As such, funding costs of monitoring are used as

[17] During 1Q 2009- 2Q 2015, this difference was on average approximately 57 basis points.

a model parameter.

The difference between relationship and transactional banking also underlies a fundamental difference in how these types of banks perceive and allocate resources according to risk. [30] touches on these differences in risk by comparing relationship banking and market based trading. [41] also touches on the links between market based and relationship banking in the context of QE by documenting a crowding out effect of MBS purchases on C&I loans of exposed banks. This paper introduces a risk adjusted framework similar to a Sharpe ratio in order to tease out the effects of interest on reserves on bank lending. These details are further discussed in Section 3.2.6.

3.2 Risk-Adjusted Framework

Using the framework of comparing risk adjusted returns between bank assets, [130] considers a banking agent model with a portfolio choice consisting of excess reserves and interest bearing assets[18]. This paper extends [130]'s framework to two types of banks found in [28] while incorporating the lending framework of [69]. There is a transaction lending bank ("T-Bank") and a relationship lending bank ("R-Bank") choosing which loans to fund and not fund. If banks choose not to fund, they invest in reserves at the central bank. Central banks conduct unconventional monetary policies of raising interest on reserves and quantitative easing. For simplicity, standard monetary policy is not explicitly modeled, but consists of open market operations (central bank issues bonds) that affect short term interest rates.

Section 3.2.1 sets up the banks. Section 3.2.2 shows the characteristics of loans. Section 3.2.3 introduces the central bank. Section 3.2.4 describes the bank objective function in choosing

[18][130] refers to excess reserves as "primary reserves" in his model.

between loans and reserves by comparing risk-adjusted returns. Section 3.2.5 describes the new equilibrium after central bank actions that lower transactional lending rates and increase reserve interest rates.

3.2.1 Banks

There is an R-bank and a T-bank where both banks have fixed monitoring cost F to process hard quantitative information. The R-bank has a variable monitoring cost function $f : \xi \Rightarrow C_R$ for processing privately acquired soft information ξ. As in [28], R-banks also have lower loan delinquency rates than T-banks, $\lambda_R < \lambda_T$.

- Each bank is endowed with n units of loanable funds from bank equity. $n < \infty$ will be scaled across a unitary based normalization to bring values into the range $n \in [0, 1]$.
- Both banks are funded only by bank equity and owned 100% by the managers. Both banks will retain 100% of the gains in processing privately acquired soft information.
- Both T-banks and R-banks process hard quantitative information in underwriting loans, but only small banks use soft information ξ in the underwriting process.
- Banks will seek to maximize risk-adjusted returns.
- Soft information ξ can only be acquired privately and allows a bank to lower the risk of default, increasing the risk-adjusted return of a loan.

R-banks have a total monitoring cost $F + C_R$ while the T-bank has a monitoring cost of F. Banks will maximize their objective function, risk-adjusted return $R_i = \frac{1}{n} \sum_{j=1}^{n} \max[\rho_{ij}, \gamma]$ where ρ is the risk-adjusted return of a loan and γ is the risk-adjusted return of reserves.

conditionF+C$_R \geq F + C_T$

Monitoring costs of an R-Bank are greater than or equal to that of a T-Bank.

3.2.2 Loans

There are j participants each with capital needs and a loan application with a bank. For simplicity, this model assumes that the number of participants j and the units of loanable funds n are equal.

- Two firm specific variables determine each loan's risk-adjusted return $\rho_j \in [0, 1]$:
  - Credit risk $\theta_j \in (0, \hat{\theta}]$ where $\theta < \infty$ and represents the default and bankruptcy risk of a firm. Credit risk increases as bankruptcy and default risk increases.
  - Soft information ratio $\xi_j \in [0, 1]$. where $\xi_L \in [0, \xi^*]$ represents a loan with low soft information and high hard information $\xi_H \in (\xi^*, 1]$ represents a loan with high levels of soft information compared to hard information. A loan with only hard information and no soft information will have a ratio of 0, while a loan equally comprised of soft and hard information will have a ratio of 1.
  - $f : \xi \Rightarrow C_R$ is a monitoring cost function based on the soft information ratio ξ. The function will be monotonically increasing in ξ.
  - Both credit risk and soft information ratio comprises the overall loan risk $\lambda(\theta, \xi)$
- Two systemic factors determine loan risk-adjusted returns ρ_j
  - Central bank purchases of long term assets, QE
  - risk-free rate is assumed to be short term market interest rate

– Nominal interest rate of loan $r_j(QE, \theta_j, \xi_j)$

As in [27] the expected net excess return per loan is calculated. However, this paper calculates the risk-adjusted return ρ . Also instead of excess returns over government bonds found in [27], this model uses opportunity costs $\gamma = \max\,[r^f, \delta]$ where r^f is the market risk-free rate and δ is the interest on reserves. The opportunity cost is what the bank gives up to invest in a loan. These variables are used to calculate the risk-adjusted net excess return of the loan ρ_j.

$$
\begin{gathered}
\rho_j = \frac{r_j(\theta_j, \xi_j, QE) - \gamma}{\lambda_{ij}(\theta_j, \xi_j)} \\
\theta, r, \gamma \in \mathbb{R}^+ \\
\rho, \xi, QE \in [0, 1]
\end{gathered}
\tag{3.1}
$$

Conceptually, the risk-adjusted return ρ_j is similar to a Sharpe ratio that looks at excess returns divided by risk.

$$
\rho_j = \frac{\text{interest rate - opportunity cost}}{\text{overall loan risk}}
$$

For simplicity, the risk-adjusted return of a loan is transformed into a uniform distribution $\rho_j \sim U[0, 1]$. R-banks exploit soft information to increase return and lower default risk. T-banks have an advantage in using hard quantitative information. For example, T-banks may have transactional agreements to sell or transfer a securitized loan in default to special servicers. These transactional agreements specify securitized loans with quantifiable hard information such as LTV and credit rating. In modeling the features of risk-adjusted returns of loans, a key dynamic in modern banking is linked between the pricing of loans and the ability of banks to manage loan risk. Next is how this interacts with the second activity in this model, the central bank.

3.2.3 Central Bank

In this economy, two aggregate shocks of unconventional monetary policies are modeled after the Federal Reserve's actions during the US financial crisis.

- The first monetary policy consists of a large-scale asset purchase program defined by the variable $QE_i \in [0, 1]$. This variable represents the proportion of the central bank's asset holdings as a percentage of total financial assets in the financial markets. A value of zero indicates that the central bank holds no financial assets, while a value of 1 means that the central bank holds all assets outstanding in the market. The central bank's aim in QE is to lower long term interest rates associated with the financial asset in order to ease credit conditions.

- There are two-stages of QE in our model. The first stage $QE_L \in [0, \tau_m)$ represents a level of asset purchases where the central bank has a limited influence on prices. τ_m represents the lower bound threshold of a dominant market maker.

- The second stage $QE_D \in [\tau_m, 1]$ represents a level of asset purchases where the central bank has tenable influence on prices and is a dominant market maker.

- The second monetary policy action considers an increase in the reserve interest rate δ^*. This is the interest rate that the central bank compensates banks for holding required and excess reserves at the central bank. The central bank normally holds the reserve interest rate at zero, but in our model this rate will be increased to a level above r^f or the risk-free rate. This interest rate on reserves $\delta^* > r^f$ also applies to the interest on excess reserves, or IOER.

Central bank asset purchases have a monotonically decreasing effect on loan nominal interest rates r_j in accordance with the stated policy of the Federal Reserve in their quantitative easing programs.

3.2.4 Objective Function

The bank objective function maximizes the *risk-adjusted returns* of a bank's loanable funds by modeling bank i with a decision to make for each n unit of capital. This decision is to lend to a set of loan applicants j or not. By not investing, the bank will invest its loanable funds in treasuries, earning the risk-free rate, or at the central bank, earning the interest on excess reserves. By not lending, the bank is forgoing the risk-adjusted return of the loan applicant and earning the risk-adjusted returns of the opportunity cost γ. The opportunity cost $\gamma = \max{[r_f, \delta]}$ is greater when reserve interest rates are increased by the central bank. At the margin, using this model's framework, a greater opportunity cost will increase the risk-adjusted returns of a reserve account relative to transactional loans.

$$\begin{gathered} \gamma = \max{[\frac{r_f}{\theta_{rf}}, \frac{\delta}{\theta_\delta}]} \\ \theta_{rf} > \theta_\delta \end{gathered} \tag{3.2}$$

The risk-adjusted returns R_i of bank i, net of non-financial expenses is a function of the risk-adjusted returns of its balance sheet. For n units of loanable funds, the bank i will be faced with the decision to either lend to borrower j and earn a risk-adjusted return ρ_{ij}, or not lend and earn the loan opportunity cost $\gamma = max(r_f, \delta)$, which is the higher of the risk-free rate r_f or interest on excess reserves δ. The objective function is:

$$R_i = \frac{1}{n} \sum_{j=1}^{n} \max{[\rho_{ij}, \gamma]} \tag{3.3}$$

For ease of exposition the objective function is rewritten as:

$$R_i = \frac{1}{n}\sum_{j=1}^{n} \max\left[\text{Net Interest Margin}_{\textit{risk-adjusted}}, \text{Reserve Interest}_{\textit{risk-adjusted}}\right]$$

Banks look at maximizing the risk-adjusted return of *n* units of loanable funds. In defining the objective function in more detail:

$$\begin{gathered} R_i = \frac{1}{n}\sum_{j=1}^{n} \max\left[\frac{\rho_{ij}(\theta_j, \xi_j, QE) - \gamma}{\lambda_{ij}(\theta_j, \xi_j)}, \frac{\delta}{\theta_\delta}\right] \\ \frac{\partial r}{\partial QE} < 0 \quad \frac{\partial \rho}{\partial r} < 0 \quad \frac{\partial r}{\partial \theta} < 0 \\ \frac{\partial r}{\partial \xi} < 0 \quad \frac{\partial \lambda}{\partial \theta} < 0 \quad \frac{\partial \lambda}{\partial \xi} < 0 \end{gathered} \tag{3.4}$$

Key first order conditions are listed as follows:

- $\frac{\partial r}{\partial QE} < 0$ Central bank's large scale asset purchases (QE) lower the long term interest rate and the nominal interest rate of loans in the market.
- $\frac{\partial \rho}{\partial r} \times \frac{\partial r}{\partial \theta} = \frac{\partial \rho}{\partial \theta} < 0$ Greater credit risk $\theta_j \in (0, \infty]$ of a firm translates into higher interest rates and higher overall risk
- $\frac{\partial r}{\partial \xi} < 0$ High soft information ratio $\xi_H \in (\xi^*, 1]$ loans have higher nominal interest rates r_j, higher monitoring costs, and lower default rates than low soft information ratio loans $\xi_H \in [0, \xi^*]$.

The next section outlines these new equilibrium conditions taking central bank policies as an exogenous factor.

3.2.5 Equilibrium Conditions

In conjunction with the activities of banks and properties of loans set forth in Section 3.2.1 and 3.2.2, the following proposition specifies the theoretical parameters of the banking agent model.

propositionank loanable funds are fixed at n, and bank $i = [Large, Small]$ cannot borrow to fund loans $j = [1...n] \in \mathbb{R}^{+}$. Only bank i can fund loan projects and the credit risk of each loan is considered. The distribution of the risk-adjusted returns of loans $\rho_j \in [0, 1]$. is uniform.

B . 1. For the set of loans with a risk-adjusted return $\rho_j \in [0, 1]$ and an opportunity cost $\gamma \in [0, 1]$, the equilibrium will have the following properties

   (a) Funded loans $F = [1...n]$ will have risk-adjusted returns greater than the opportunity cost $\rho_{ij} \leq \gamma$

   (b) Unfunded loans $U = [1...n]$ will have risk-adjusted returns lower or equal to the opportunity cost $\rho_{ij} \leq \gamma$.

2. $\forall\ j : [U \mid \rho_{ij} < \gamma] = \varnothing$

   (a) Bank will not invest in a loan with lower risk-adjusted returns than the opportunity cost.

   (b) There is no reserve account limit at the Federal Reserve

The equilibrium is determined by the following lemma characterizing the exogenous actions of a central bank on the economy.

lemmaentral bank's large scale asset purchases lower long term interest rates, modeled after quantitative easing (QE). QE is characterized by a strong preference for higher duration assets which were underwritten using hard information. QE affects duration risk premiums, but not relationship lending risk premiums. There is a level of asset purchases QE_D where the central bank is characterized as a dominant market maker. At this level, there exist loans where duration risk premiums will be smaller than relationship lending risk premiums.

These central bank actions initiate the new equilibrium in this paper's model. Condition **??** defines the threshold of the second stage of the economy.

conditioncondom The progression from the first stage to the second stage is defined by two actions: 1) Large scale asset purchases will increase to the level where the central bank is the dominant market maker $QE_L \rightarrow QE_D$ and 2) the normal reserve interest rate $\delta = 0$ is increased from $\delta \longrightarrow \delta^*$ where $\delta^* > r_f$.

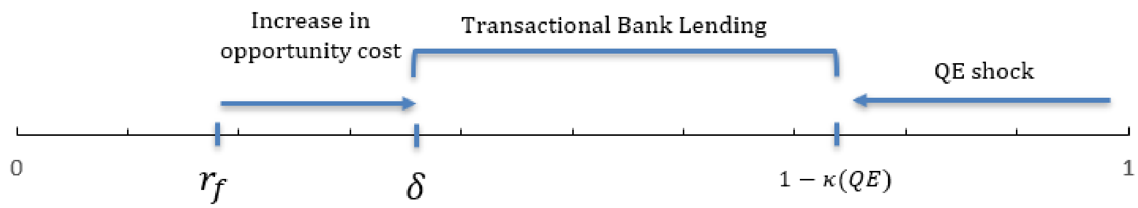
Changes in reserve interest rate will increase the opportunity cost for both types of banks equally. Condition 4.11 outlines why a transactional bank will be affected by Condition **??**'s QE differently from a relationship bank. This can also be observed in Figure 3.3.

conditionprofit A T-bank B_L in this economy faces an exogenous shock of central bank asset purchases. QE lowers duration risk premiums $\kappa(QE_D)$ by a factor κ, which reduces the number of profitable loans to $1 - \kappa(QE_D)$. The increase in IOER (Condition **??**) also increases the opportunity cost of lending. B_L engages only in transactional lending and is unable to exploit soft information. B_L only makes a loan when the risk-adjusted return is greater than the reserve interest rate $\delta^* < \rho'_{lj}$.

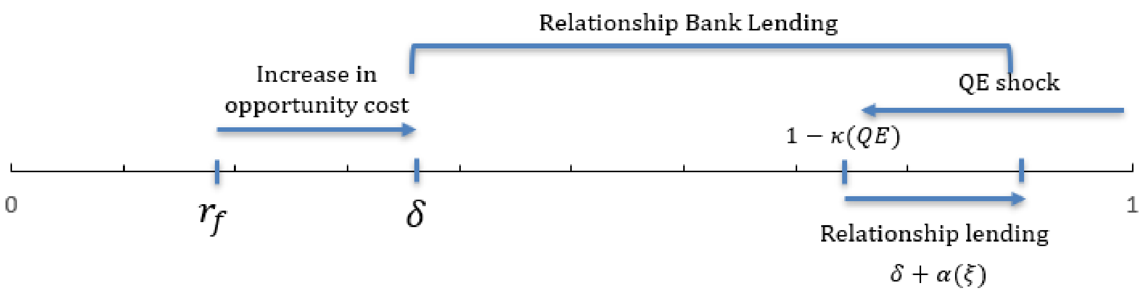
$$F_L^* \sim U[0, 1 - \kappa(QE_D)] < 1 \quad where \quad 0 < \kappa(QE_D) < 1$$

$$1 - \delta^* > 1 - \kappa(QE_D) \tag{3.5}$$

$$\gamma = \frac{\delta^*}{\sigma_\delta} \in [0, 1]$$



((a)) Transactional Bank B_L Distribution of risk-adjusted Returns



((b)) Relationship Bank B_S Distribution of risk-adjusted Returns

Figure 3.3: Before Condition **??**, risk-adjusted returns of lending opportunities are distributed uniformly $\rho_{ij} \sim U[0, 1]$ for both banks. As the central bank increases interest on reserves above the risk-free rate, higher reserve interest rates δ represent a new opportunity cost hurdle, where banks will only lend if loans return greater than δ. The central bank also engages in QE, which lowers long term interest rates , net interest margins and duration risk premiums so that the new distribution of risk-adjusted returns on loans is $\rho_{ij} \sim U[0, 1 - \kappa(QE)]$. Transactional banks lend to loans between δ and $1 - \kappa(QE)$. Relationship banks have "soft information" premiums that are independent from duration premiums. So relationship banks lend to a greater breadth of risk-adjusted loans between δ and $\delta + \alpha(\xi)$. Given equal amounts of loanable funds n, this result shows that transactional banks have greater relative risk aversion compared to relationship banks and as a result, make fewer loans.

We also observe a small relationship bank, B_S outlined in Condition **??**. This can also be observed in Figure 3.3.

conditioncond4 A small relationship bank, B_S experiences an exogenous shock of $\kappa(QE_2)$ and an increase in interest on reserves (Condition **??**). The small bank engages in both relationship lending and transactional lending. Ability to exploit soft information, represented by $\alpha\xi$, allows a smaller bank to increase the risk-adjusted returns of loan. B_S will only engage in lending if the loan has a greater risk-adjusted return than the reserve interest rate $\delta^* < \rho'_{Sj}$.

$$F_L^* \sim U(0, \alpha_S(\xi) + \delta^*) \quad where \quad 0 < \alpha_S(\xi) \leq 1$$
$$1 - \delta^* > \alpha_S(\xi) + \delta^* > 1 - \kappa(QE_M) \tag{3.6}$$
$$\gamma = \frac{\delta^*}{\sigma_\delta} \in [0, 1]$$

A new equilibrium shows that after central bank actions, relationship banks exploit more loans with higher risk-adjusted returns than transactional banks. While the opportunity cost of a loan increases for both large and small banks, the set of profitable loans shrinks more for transactional banks than relationship banks. The range of funded loans for relationship banks is greater than that for transactional banks because $1 - \kappa(QE_D) < \alpha(\xi) + \delta^*$. A more detailed proof of this model is in Appendix 3.5 and comparative statics of the model is discussed in Appendix 3.6.

3.2.6 Discussion

Empirical predictions of this paper's risk-adjusted framework can be summarized as the following:

1. Reserve premiums will positively affect excess reserve holdings.
2. Excess reserves will have a negative relationship with bank lending.
3. Reserve premiums will negatively affect bank lending.
4. This negative relationship between reserve premiums and bank lending will be stronger in transactional banks compared to relationship banks.

From my understanding of the literature, the four predictions of this framework have never been tested before. The first prediction is that an increase in reserve premiums γ will lead to an increase in excess reserve holdings, both in the aggregate data as well as the bank level data. This is similar to the findings in [130] where his variable ρ_t, or excess reserves as a percentage of deposits[19], was negatively related to the cost of holding cash, r_t[20]. As defined in this paper's framework, as interest on excess reserves increases above the risk-free rate, the reserves premium γ will also increase. The first prediction of this framework is shown in Figure 3.3, as the opportunity cost increases from $r_f \rightarrow \delta$, the amount of excess reserves held by a bank also increases. This rate of increase is estimated to be positive and significant in the empirical results of Table 3.5 which is further discussed in Section 4.4.

In the second prediction of this framework, banks accumulate more excess reserves which is associated with banks making fewer loans. This prediction is similar to banking models where agents hold two types of assets, non-interest bearing cash and interest bearing loans. However, in this paper's model banks hold interest bearing excess reserves instead of non-interest bearing cash, and returns are measured in a risk-adjusted framework similar to a Sharpe ratio. This negative relationship between excess reserves and lending is estimated in the empirical results of Table 3.6 and is further discussed in Section 4.4.

The third prediction of this framework is that reserve premiums will have a negative relationship with bank lending. As excess reserves increase from $r_f \rightarrow \delta$, lending will decrease from $[1-r_f] \rightarrow [1-\delta]$ as shown in Figure 3.3. This negative relationship between reserve premiums and bank lending is estimated in the aggregate in Table 3.2 and Table 3.3, while this is also estimated

[19]page 92 in [130]

[20][130] calls the cost of holding cash to be the short term money market interest rate measured by the call money rate from 1874-1929, and the average yield on U.S. Treasury short term obligations, represented by various yields on the three to six month Treasury bills, notes and certificates from 1930-1955.

at the firm level in Table 3.7 and Table 3.8. This negative relationship is further discussed in Section 4.4.

The fourth prediction is that reserve premiums and bank lending will have a significantly more negative relationship for transactional banks than relationship banks. This is due to persistent monitoring gains from relationship lending, as QE reduces transactional lending rates downwards by a factor of $\kappa(QE)$. As transactional lending rates compress, transactional bank lending contracts from $[1 - \delta] \rightarrow [1 - \kappa(QE) - \delta]$. Loans based on soft information are not targeted by QE, so relationship bank lending only contracts from $[1 - \delta] \rightarrow [\alpha\xi]$ as shown in Figure 3.3. The difference in lending sensitivity between the two types of banks is estimated Table 3.7 and Table 3.8. This difference is further discussed in Section 4.4.

Next in Section 4.4 is the empirical model to test and estimate the predictions of this paper's framework.

3.3 Empirical Analysis

This section outlines the empirical tests of the four empirical predictions in Section 3.2.6. For reference, Figure 3.4 outlines the empirical strategy and the respective regressions used to support the hypothesis of this paper.

The empirical strategy proceeds in three steps. First are the empirical tests using aggregated weekly banking data to test the prediction that reserves premiums and lending are negatively related. Second, are the panel data regressions in estimating the four predictions of this paper. Third, are further tests of bank liquidity preferences and excess reserve sensitivities to treasuries and securities. This empirical model **??** will test the third and fourth predictions listed in Section 3.2.6. In testing

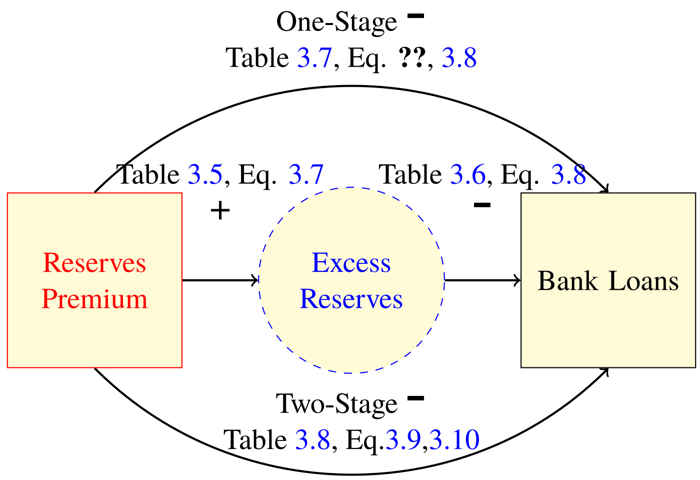


Figure 3.4: This outlines the main panel data empirical tests of the first three predictions of this paper's framework and the predicted signs of the variables in question.

for the negative effect of reserves premiums on lending, it is important to control for quantitative easing, lending premiums, regulation, and market volatility. Quantitative easing is an important control variable because of it's effect on lending. The literature shows that banks that benefit from QE's MBS purchases were more likely to increase mortgage lending[41]. [109] also found that an increase in bank reserves from QE purchases also helped increase lending. This paper controls for loan premiums to address concerns that a reduction in lending is driven by market variables and excess tier 1 ratio[21] to control for reduction in lending due to regulations. This paper further controls for reduction in lending due to market volatility by using the VIX as a control variable. This paper conducts time series regressions on both groups of banks to test for the fourth prediction. Although the two groups of banks are not perfect classifications of transactional and relationship banks, it is shown in the literature that transactional banks are significantly larger than relationship banks.

[21] As yearly stress tests of banks are not announced ahead of time by the Federal Reserve, banks have to build up Tier 1 risk weighted ratios in anticipation of its requirements.

Second, using quarterly Call Report data of all US domestic banks, this paper runs panel data regressions testing the four empirical predictions in Section 3.2.6. The basic panel data empirical model is as follows:

$$\begin{aligned} \frac{[\textit{Total Loans, Excess Reserves}]_{it}}{[\textit{Total Assets}]_{it}} &= \alpha_i + \textit{Transactional Dummy } \times \beta_1 \Big[\textit{IOER - Risk-Free Rate}_t \Big] \\ &+ \beta_2 \frac{\textit{[Lending Rate - Risk-Free Rate]}_t}{\textit{Loan Risk}_t} \\ &+ \beta_3 \frac{\textit{Fed Holdings}_t}{\textit{Market Outstanding}_t} + \varepsilon_{it} \end{aligned} \tag{3.7}$$

When using excess reserves as the dependent variable, β_1 should positive and significant in accordance with the prediction of the first empirical prediction. Next, using loans as the dependent variable, β_1^{loans} should be negative and robust across all specifications if the third and main empirical prediction of this paper were to be verified. The interaction between transactional and β_1 should also be negative in order to verify the fourth empirical prediction of this paper. Transactional banks should be more sensitive to market variables and incentives to lend less than their counterpart community banks. Next this paper tests the second prediction, the negative effect of excess reserves on lending. The following empirical model is used:

$$\begin{aligned} \frac{[\textit{Total Loans}]_{it}}{[\textit{Total Assets}]_{it}} &= \alpha_i + \textit{Transactional Dummy } \times \beta_1 \frac{\textit{Excess Reserves}_{it}}{\textit{Total Assets}_{it}} \\ &+ \beta_2 \frac{\textit{Deposits}_{it}}{\textit{Total Assets}_{it}} + \varepsilon_{it} \end{aligned} \tag{3.8}$$

This specification 3.8 also tests whether this negative relationship varies across banks with different levels of excess reserve holdings. If β_1 is significantly negative after controlling for deposits, this supports the second prediction of this model and demonstrates that the assumptions of [67] and [69] are supported. In further testing the third prediction of this paper, this paper runs a two-stage least squares regression where the first stage is estimates the level of excess reserves as a function of reserve premiums:

$$\begin{aligned} \textit{Excess Reserves}_{i,t} &= \alpha_i + \beta_1 \textit{Reserve Premiums}_t \\ &\quad + \beta_2 \textit{Loan Premiums}_t^{RiskAdj} + \beta_3 QE_t + \epsilon_{i,t} \end{aligned} \tag{3.9}$$

Next, this regression takes the predicted value $\widehat{\textit{Excess Reserves}}_{i,t}$ from the first stage 3.9 and use those estimations for the second stage 3.10 as follows:

$$\begin{aligned} \textit{Total Loans}_{i,t} &= \alpha_i + \lambda_t + \gamma_1 \widehat{\textit{Excess Reserves}}_{i,t} \\ &\quad + \gamma_2 \textit{Loan Premiums}_t^{RiskAdj} + \gamma_3 QE_t + \varepsilon_{i,t} \end{aligned} \tag{3.10}$$

This second stage 3.10 estimates the effects of the reserve premiums on bank lending using a two-stage least squares model.

Lastly, this paper looks at the different levels of excess reserve holdings in banks and examine whether their lending behavior and liquidity preference vary. Banks with higher levels of nominal reserves should demonstrate higher sensitivities of excess reserves to the reserve premium. Domestic bank i is classified according to their level of excess reserves as large, medium, or none according to the following specifications.

$$\textit{Bank with Reserves}_i \begin{cases} Large & i > \$1B \\ Medium & \$1M \leq i \leq \$1B \\ None & i < \$1M \end{cases}$$

Dummy variables are assigned if a bank has high levels of reserves. Then this paper examines whether their preference for liquidity is different from banks that hold no reserves. 3.11 uses the interaction between *Bank with Reserves* and the Reserves Premium to test whether banks with more reserves have higher preferences for liquidity.

$$\frac{\textit{Excess Reserves}_{it}}{\textit{[Total Assets, Cash Assets, Deposits]}_{it}} = \alpha_i + \beta_1 \textit{Bank with Reserves} \times \left[\textit{Reserves Premium}_t\right] + \beta_2 \textit{Loan Premiums}_t + QE_t + \varepsilon_{it} \tag{3.11}$$

Next this paper examines whether there is substitution between excess reserves and treasuries. 3.12 looks at whether the selling of securities and treasures are associated with the increase in excess reserves.

$$\frac{\textit{Excess Reserves}_{it}}{\textit{Total Assets}_{it}} = \alpha_i + \lambda_t + \beta \frac{\textit{[Securities, Treasuries]}_{it}}{\textit{Total Assets}_{it}} + \varepsilon_{it} \tag{3.12}$$

The next Section 3.3.1 outlines the sources of data used in the empirical tests in this paper.

3.3.1 Data

This paper uses two datasets to test the empirical predictions of the framework. The first data set is the H8 aggregated weekly data from the Federal Reserve consisting of top 25 domestic banks[22] ranked by size and all other domestic banks. These top 25 rankings are based on total domestic assets in the last available Call Report. If a large bank is acquired by a commercial bank or if a large bank leaves the commercial bank universe, then it is replaced with the bank next in line, typically the bank ranked number 26. The weekly data set also includes time series data consisting of domestically chartered commercial banks that are not in the top 25 ranking by size. This balance sheet data is collected on a weekly basis by the FR 2644 Report by the Federal Reserve. The main advantage in using this data is the high frequency of data. The main disadvantage in using this data is that the cash assets variable is not just comprised on excess reserves, but also includes vault cash, cash items in process of collection and balances due from depository institutions.

The second data set is the Call Reports from the Federal Financial Institutions Examination Council (FFIEC). This data set reports quarterly financial data by all depository banking institutions in the US. The advantage of this data set is the greater level of detail of financial items including excess reserves which is represented by RCON 0090 from the Schedule RC-A, or balances due from the Federal Reserve Banks. This greater detail allows for a more thorough panel data level analysis of the four empirical predictions of this paper's framework.

Each bank is also identified by a unique FDIC identifier from the Federal Deposit Insurance Corporation, which classifies each bank by its lending technology, relationship lending (R-Bank) or transactional lending (T-Bank). This classification is based on the Community Banking identifier

[22]Banking literature consistently regards small banks as characterized by relationship lending and using soft information to a greater degree than larger banks. ([98, 23, 144, 22, 123, 40, 118])

[78] where banks classified as community banks were marked as R-banks while non-community banks were classified as T-banks. This identifier classifies community banks not only based on size, but also on geographical and business model restrictions which identifies unique aspects of the relationship banking model of community banks [78, 7] [23]. One such unique criteria is the use of traditional lending and deposit gathering activities which is limited in geographic scope. This definition of R-bank captures 330 banks that exceed $1 billion in assets [78]. Similar to the weekly data, quarterly observations such as the 3M T-bill rate, effective fed funds rate, 10Y US Treasury rate, Federal Reserve holdings, VIX index, and total agency MBS outstanding were obtained from the Chicago Board of Options Exchange, Federal Reserve, and the Securities Industry and Financial Markets Association. Data on agency mortgage backed securities is from the Securities Industry and Financial Markets Association and Federal Reserve, and stress test data was collected from the SCAP, CCAR and Dodd-Frank Act.

The panel data uses Call Report data from 2008 Q4-2017 Q3 using the RC, RC-A, RCCI, RCCII, and RC-B files. Initially the panel data keeps all bank observations and then merges the Call Report data with the respective FDIC Community Bank Identifier using FDIC codes. Then we match all active banks with their community banking identifier as of 2017Q3. Then with the non-matched banks we use the FDIC community banking identifiers as of 2008Q4. After this step, all non-matched bank observations are dropped from the sample. FDIC reports about 390 active non-community banks which is confirmed by my data. Next, in the construction of the quantitative easing variable, we use Federal Reserve data that tracks the balance sheet amount of agency mortgage backed securities held on its balance sheet after accounting for purchases, sales, and maturities. This number is scaled by the total number of agency mortgage backed securities

[23] The FDIC (2012) study on community banks describes the process to identify a community bank in detail.

outstanding, which is obtained from the SIFMA. Loan premiums consists of the appropriate market loan interest rate subtracted by the 10 year US Treasury rate divided by the loan delinquency rate. Loan rates are obtained from Freddie Mac and the Prime Mortgage Market Survey and the Federal Financial Institutions Examination Council, 10Y US treasury rates are obtained the US Treasury, and loan delinquency rates are obtained from the Federal Reserve. VIX data is obtained from the Chicago Board of Options Exchange while Tier 1 Ratios are extracted from the Call Reports.

3.3.2 Aggregated Data

Table 3.1 shows summary statistics for aggregated weekly time series data from October 2008 to August 2015. Non top 25 banks display higher ratios of loans to total assets, total cash assets, and total deposits than the top 25 banks. For instance, top 25 banks have a mean aggregated loan to asset ratio of 56% while non top 25 banks have a mean ratio of 65%. On a nominal basis total loans and total C&I loans are higher for top 25 banks with a median of $4.2 trillion compared to a median of $2.3 trillion for non-top 25 banks. Total cash assets, which includes excess reserves, are also consistently higher at top 25 banks with a median value of $600 billion compared to $290 billion for non top 25 banks. In Panel C, one figure to note is that Federal Reserve holdings of agency MBS at one point reached 29% of total agency MBS outstanding in the market. Also, the effective fed funds rate is consistently above the 3M treasury bill rate, and this is to be expected because of the higher frictions associated with lending to member FDIC banks compared to lending to the US government. The downward trend over time in net interest margins and loan delinquency rates for large and small banks is also reflected in the summary data.

Using this weekly data, multivariate regressions are run to test the banking sector's lending sensitivities across total loans and total C&I loan using seasonally adjusted data in Table 3.2 and

Table 3.3 respectively. The dependent variable of total aggregated loans is shown as a log value, a percentage of cash assets, and a percentage of total assets. Bank cash assets consist of bank cash held at the Federal Reserve, which includes reserves and excess reserves. Across all specifications, an increase in the reserves premium is associated with a decrease in lending, supporting the third hypothesis in Section 3.2.6. In Table 3.2, when Loans are the dependent variable, a 1% increase in the reserves premium is associated with a 6.1% decrease in lending for large banks and a 8% decrease in lending for smaller banks, with an R^2 of 78.5% and 90.5% respectively. When looking at total loans scaled by total assets, results are similar as a 1% increase in the reserves premium is associated with a 3.1% decrease in lending for large banks and a 3% decreased in lending for smaller banks, with an R^2 of 86.2% and 89.9% respectively. In Table 3.3, the decrease for C&I loans is 13.7% for large banks and 16.9% for smaller banks and for C&I loans as a percentage of total assets, the decrease in lending is 1.3% for both large banks and smaller banks. Results are similar when looking at loans as a percentage of deposits in both Table 3.2 and Table 3.3. The control variables for both tables and across all specifications are mostly as predicted, as an increase in lending premiums is associated with an increase in lending across all specifications and an increase in market volality (VIX) is associated with a decrease in lending. An increase in regulatory expectations is associated with a decrease in lending across all specifications except for total loans as scaled by assets for top 25 banks in Table 3.2. Quantitative easing is associated with an increase in overall lending is shown when looking at nominal loans in both tables, which supports previous research by [41] and [109]. However, the coefficient on QE in Table 3.2 in the scaled lending regressions show a negative coefficient of -0.146 for large banks and -0.062 for small banks. Overall, while QE may support more lending on a nominal basis, it may do so at a lower rate of lending when scaled by total assets, which would be a new finding in the literature on QE and lending. Overall, the weekly aggregated regressions lend support for the third prediction that reserve premiums have a negative association with lending. This negative relationship is not greater in magnitude for the top 25 banks compared to non-top 25 banks as shown in Table 3.2 and Table 3.3. In order to explore the linear inter-dependencies between loans, excess reserves, and reserve premiums, we employ a vector autoregression in the next Subsection 3.3.2.

Impulse Response Function

Using vector autoregression and H8 aggregated weekly banking data, I make a preliminary exploration on the first three predictions from Section 3.2.6, before conducting a comprehensive analysis using panel data. The first prediction is that a positive increase in the reserves premium will increase in aggregated excess reserves across the banking system while the second prediction is that an increase in aggregated excess reserves leads to a decrease in aggregated lending. These two predicted relationships form the core of the third prediction, an increase in reserves premium will lead to a decrease in aggregated lending. These three components comprise the three variable system:

$$y_t = \left\{ \begin{array}{ll} y_{1,t} & \text{Reserves Premium} \\ y_{2,t} & \frac{CashAssets}{Assets} \\ y_{3,t} & \frac{Loans}{Assets} \end{array} \right\}$$

Where $y_{2,t}$ is aggregated cash assets as a percentage of total aggregated assets in the banking system and $y_{3,t}$ is total aggregate lending as a percentage of total aggregated assets. An impulse response function with three variable recursive VAR is conducted to study the effect of one variable on another. To isolate such effects, suppose that all three variables assume their mean value prior to time $t = 0$, $y_t = \mu, t < 0$ and the shock increases by one unit in period $t = 0$.

We conduct a unit root test on the log differences of the the three variables and reject that there is a unit root for the first differences of the reserves premium $y_{2,t}$ or $\Delta\gamma_t$, first differences of $y_{2,t}$ or $\Delta\frac{CashAssets}{Assets}$, and the first differences of $y_{3,t}$ or $\Delta\frac{Loans}{Assets}$. Then after demeaning the variables, we estimate a reduced form VAR for $y_t = (\Delta\gamma_t, \Delta\frac{CashAssets}{Assets}, \Delta\frac{Loans}{Assets})'$. using the long run restriction suggested by [25]. The [25] technique is achieved by using the Choleski decomposition of:

$$(I_K - \hat{A}_1 - ... - \hat{A}_p)^{-1}\hat{\Sigma}_u(I_K - \hat{A}_1 - ... - \hat{A}_p)^{-1}$$

Matrix $\hat{A}$ for $i = 1, ..., p$ are assigned reduce form estimates. The order of $\gamma_t \rightarrow \Delta\frac{CashAssets}{Assets} \rightarrow \Delta\frac{Loans}{Assets}$ is implied for contemporaneous causality in the SVAR. Figure 3.5 outlines the impulse response function of our three variables to a one time shock. The dynamic system of $y_t = (y_{1,t}, y_{2,t}, y_{3,t})'$ where variables are endogenous functions of one another, responds to an impulse signal measuring 1 standard deviation. In Figure 3.5, y_i is responding across time to a one time shock of $\varepsilon_{j,t}$.

The first chart in Figure 3.5 shows that a one standard deviation shock in the reserves premium has an immediate positive effect on cash assets, which persists for about 8 weeks. This supports the first prediction of Section 3.2.6 of a positive impact of reserves premiums on bank holdings of excess reserves. The middle chart shows that a one standard deviation shock in cash assets has a negative and persistent effect on loans. This supports the second prediction of a negative relationship between excess reserves and loans. However, the cash assets variable is flawed because it includes items other than excess reserves, such as vault cash, cash items in process of collection

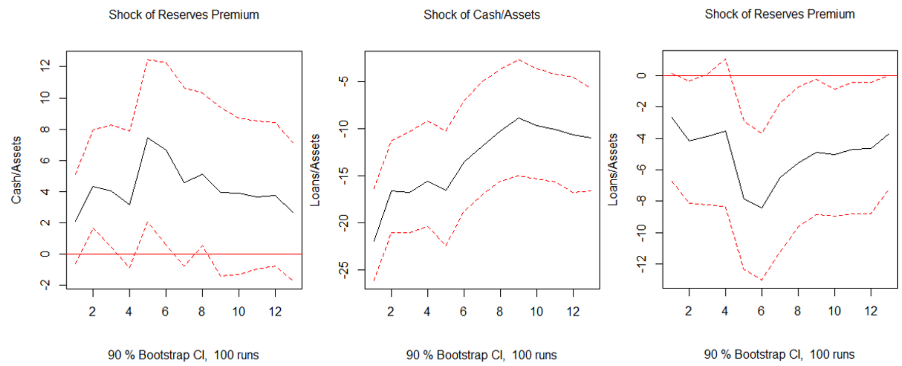


Figure 3.5: **Impulse Response Function**This table provides estimates of bank holdings of excess reserves as a percentage of cash assets. These estimates are also interacted with a reserve indicator for banks that hold more than \$1M of excess reserves. The results are from a panel data regression using bank fixed effects with White standard errors.

and balances due from depository institutions. The panel data variable for excess reserves will provide more accurate testing of the second prediction. Finally, the figure on the right shows that a one standard deviation shock in the reserves premium seems to be slightly significantly negative on impact and after about 4 weeks this negative effect becomes significant at the 90% level and persists for the duration of 12 weeks. This finding also supports the third prediction and the main hypothesis of this paper, where increasing reserve premiums will incentivize banks to lend less.

Overall the impulse response functions show support for the first three predictions of this paper's framework. As incentives to hold excess reserves rise, levels of cash assets should rise and lending as a percentage of cash assets should decrease. The next section conducts a more comprehensive analysis of at the panel data level.

3.3.3 Panel Data

Table 3.4 highlights summary statistics for bank panel data on a quarterly basis from 2008Q4 to 2017Q3. When total loans is scaled by total assets, the median $\frac{Loans}{Assets}$ ratio is similar for

T-banks and R-banks (66% vs. 65%) as is the lending risk aversion measure using $\frac{Loans}{Reserves}$ (965% vs 975%). This difference is highlighted by the much higher mean balance of excess reserves held by T-banks at $1.5B compared to R-banks at $8.25M. Holdings of excess reserves is also heavily right skewed as the median T-bank holds $23.29M in excess reserves, while the median R-bank holds none. Also, T-banks hold a greater mean percentage of their cash assets in excess reserves at 39% compared to R-banks at 12%. Loan volumes and total asset figures demonstrate that transactional banks are much larger than relationship banks. The median T-bank observation has $1.5B in assets compared to $150M for R-banks. When looking at macro variables, risk-adjusted loan premiums also take into account the default rate of loans, ranging from a value of 16 basis points to 93 basis points throughout the sample.

One Stage Panel Regressions

Table 3.5 tests the first and fourth prediction of the framework in Section 3.2.6 using bank level fixed effects, bank clustering and time clustering of standard errors, and interactions with a transactional dummy. The main variables of interest are the coefficients on the reserves premium and the transactional dummy. Results in (1) and (2) show that when reserve premiums rise by 100 bps, excess reserves increase by 3.1% and 2.6% for banks as a percentage of assets, which is economically and statistically significant. Adding the control variables loan premiums and QE in (2) reduces the coefficient of reserves premium, but the main variable of interest still provides strong support for the first prediction. (3) shows that the coefficient for the transactional dummy is not significant, implying that the sensitivity of excess reserves to the reserves premium is similar for both transactional and relationship banks, which does not support the fourth prediction. (4) employs the same specifications of (2), except for calculating the reserves premium with the effective fed funds rate (EFFR) instead of the 3-month treasury(3MT). The relationship between excess reserves and reserves premium breaks down when using the EFFR, and the significance shifts to the QE variable which is identified as a significant factor in the accumulation of excess reserves in [111, 41, 109]. These results are in line with this paper's risk adjusted returns framework which emphasizes the risk free nature of excess reserves and 3M treasuries because of US government backing, whereas EFFR incorporates additional counter party risk. The overall results of this table provide support for the first prediction and does not provide support for the fourth prediction.

Table 3.6 tests the second prediction of the framework that an increase in excess reserves is associated with a decrease in lending. In (1), using bank and time fixed effects as well as bank and time clustered standard errors, the coefficient of excess reserves is -0.409 with a t-stat of -9.53. When adding the control variables of loan premiums and QE in (2), the coefficient of excess reserves is -0.409 with a t-stat of -9.41, very similar to the results found in (1). The controls have very little effect on excess reserves indicating that control variables do not add much explanatory power to the bank and time fixed effects. Specification (3) adds the transactional bank dummy and find that similar to Table 3.5, the coefficient on the interaction between transactional bank and excess reserves is insignificant. Relationship banks have an excess reserves coefficient of -0.399 with a t-stat of -13.77 while transactional banks have a coefficient of -0.423 which is not significantly different from relationship banks. (4) compares the excess reserves variable against deposits to see which has more economic significance on lending, and the coefficient on excess reserves is -0.411 with a t-stat of -9.23 When compared to deposits, Panel A (3) shows that excess reserves is both economically and statistically more significant in predicting lending than deposits. Banking research generally assumes that bank lending is directly tied to bank deposits, so the fact that excess reserve holdings has an economic significance that is 6 times higher than deposits is surprising. The negative relationship of one dollar of excess reserves on lending is over 17 times greater than the effect of one dollar of deposits (-0.411 vs 0.023). Across all four specifications, excess reserves has been shown to have a negative relationship with lending, implying that $1 increase in excess reserves is associated with a decrease of about 40 cents in lending. This evidence shows [111, 126, 71] may have underestimated the level of reserves in conveying negative information about lending at the bank level. This negative information is supportive of the second prediction of this framework, and the insignificance of the interaction term is not supportive of the fourth prediction of this framework. If there is a difference in banking types, it seems to be a function of the size of excess reserves and not the sensitivity of lending to excess reserves.

Table 3.7 tests the main prediction of this model that reserve premiums has a negative association with lending. Specification (1) uses bank fixed effects and bank clustering of standard errors, and the reported coefficient of -0.094 and t-stat of -14.05 supports the main prediction. These results suggest that a 10 bps increase in reserve premiums decreases lending by 0.94% of total assets. Specification (2) adds time clustering of standard errors, reducing the t-statistic from -14.05 to -2.07, demonstrating that a large fraction of the variability in reserve premiums and the residual is due to time effects. Specification (3) adds control variables and finds that the coefficient on the reserves premium is -0.116 and still significant with a t-statistic of -2.32. This demonstrates that the negative relationship between the reserves premium and lending is robust even after controlling for other factors that affect lending like lending premiums, regulatory capital ratios, market volatility, and quantitative easing. In (3), the economic significance of reserve premiums on lending is nearly three times greater in magnitude than loan premiums (-0.116 vs. 0.044) on a per basis point comparison. This suggests that risk-adjusted returns of a risk free reserves premium plays a greater role in comparison to a nominal basis. Specification (4) adds the interaction between the reserves premium and transactional banks and finds it to be insignificant, similar to the tests of the first and second predictions in Table 3.5 and 3.6 respectively. Specification (5) uses the EFFR to calculate the reserves premium and its coefficient is -0.906 which is similar to (1) where reserves premium is calculated using the 3M treasury rate. However, the reserves premium coefficient in (5) and (6) are both insignificant. When adding control variables in specification (6), the magnitude of the reserves premium using EFFR drops to under half of the reserves premium using the 3M treasury (-0.051 vs -0.116) while the coefficient on (6) remains insignificant. Using the results in (3), one standard deviation increase in reserve premiums will lead to a 1.3% decrease in total lending for the mean transactional bank and a 1.1% decrease in total lending for the mean relationship bank. Given the median reserves premium of 20 bps, interest on excess reserves has reduced total lending by $510M (4.3%) for the mean transactional bank and $7.4M (3.5%) for the mean relationship bank.

These loan amounts are not economically insignificant, and the results of Table 3.7 suggest that the level of excess reserves and interest on excess reserves does significantly impact bank level lending. The results of Table 3.7 do support [130, 67, 69] which theorize that interest on excess reserves is a significantly negative factor in lending at the bank level. Overall, the support for the first three predictions of the framework are supported by the single stage panel regressions. The fourth prediction of transactional lending being more negatively sensitive to reserve premiums than relationship banks does not find support. Instead the magnitude of the drop in lending due to reserve premiums is larger for transactional banks because the mean transactional bank has about 57x more loans than the mean relationship bank.

Next is the measurement of the central findings of this paper. Given the potential inaccuracies of a one stage estimation due to measurement error and omitted variable bias, the next section uses a two-stage estimation technique to measure the relationship between the reserves premium and overall bank lending.

Two-Stage Estimation of Lending Sensitivity

The framework of this paper predicts that banks choose between excess reserves and lending by comparing the risk-adjusted returns of the reserve premiums and loans. One stage regressions in Table 3.5, 3.6, and 3.7 support three out of four predictions of this risk-adjusted framework. The one stage estimations of lending sensitivity to excess reserves may be biased from measurement error as the relationship between lending and excess reserves can be dynamic and contemporaneous. For instance, it can be that a lack of profitable lending opportunities is what is driving an increase in excess reserves. There may also be omitted variable bias in the one stage estimation. Using a two stage estimation to reduce measurement error and omitted variable bias requires two assumptions. The first assumption is that the reserves premium has a clear effect on excess reserves. Table 3.5 verifies this assumption. The second assumption is that the only reason for the relationship between the reserves premium and lending is through the first stage estimation of excess reserves. This second assumption is fundamental to this paper's framework as the only channel for reserve premiums to affect bank lending is through bank excess reserve holdings. In fact, reserve premiums provides a perfect setting for a two-stage estimation approach because this premium is only available to depository institutions and no other market participants. Table 3.8 estimates the lending sensitivity using a two-stage least squares approach. The first stage decomposes bank level holding of excess reserves (scaled by total assets) into systematic components of reserves premiums using the following specification:

(1) First Stage:

$$Excess\ Reserves_{i,t} = \alpha_i + \beta_1 Reserve\ Premium_t + X_t'\beta_2 + \varepsilon_{i,t}$$

$\widehat{Excess\ Reserves}_{i,t}$ is estimated in this first stage and this fitted value captures bank i's estimated level of excess reserves holdings for a level of reserve premiums. The second stage regression tests if bank i's bank lending is significantly negative on estimated excess reserve holdings. The following regression is implemented:

(2) Second Stage:

$$Total\ Loans_{i,t} = \lambda_i + \gamma_1 \widehat{Excess\ Reserves}_{i,t} + X_t'\gamma_2 + \varepsilon_{i,t}$$

where $\widehat{Excess\ Reserves}_{i,t} = \hat{\alpha}_i + \hat{\beta}_1 Reserve\ Premiums_t + X_t'\hat{\beta}_2 + u_{i,t}$

Table 3.8 shows four different specifications with all banks (1, 2), relationship banks (3), and transactional banks (4). Bank fixed effects are used and standard errors are clustered at the bank level and quarter level across all specifications. The underidentification test in (1, 2) reports a Kleibergen-Paap rk LM statistic of (6.4, 8.8) and a Chi-squared p-value of (0.01, 0.00) which rejects the null that the empirical model is underidentified, indicating that the model is identified. The Kleibergen-Paap rk Wald F Statistic of (15.2, 15.0) in (1) and (2) specifications represents an acceptable performance of the Wald test statistic at a true rejection rate of 5%, so that weak identification is not considered to be a problem under thresholds of both [145] and [143].

The coefficient of interest is γ which captures the sensitivity of bank lending and bank reserve holdings. Across all four specifications, γ is significant and negative with p-values at or below 0.001. In the univariate 2-stage least squares specification (1), the 2nd stage coefficient on the estimated excess reserves variable is -3.096 with a t-stat of -3.24, which supports the third prediction of this paper. After adding covariates in specification (2), for every dollar in excess reserves, banks will reduce lending by $6.7 (t-stat= -7.97), which is close to the required reserve ratio for lending. Adding the covariates that contribute lending due to risk adjusted profitability and additional capacity due to government purchase programs, explain why γ decreased from -3.096 to -6.672 when moving from specification (1) to (2). When estimating the relationship between reserve premiums and lending, for the mean level of reserve premiums (18 basis points), the average transactional bank will have reduced lending by $761M and the average relationship bank will have reduced lending by $13.6M. This means that the average transactional bank reduced lending by 6.0% and the average relationship bank reduced lending by 6.1%. This also supports the conclusions in Table 3.5, 3.6, and 3.7 which found no support for the fourth prediction of a more negative lending sensitivity in transactional banks, but a difference when lending was measured on a nominal basis.

The specifications in (3) and (4) repeat the 2-stage estimations using only R-banks and just T-banks by FDIC indentifier respectively. Results are in line with the specification in (2) with economically significant coefficients on excess reserves which are significantly negative with p-values of 0.00. When looking at the Kliebergen-Paap rk wald F Statistic of 15.0 and Chi-squared p-value of the Kleibergen-Paap rk LM Statistic of 0.00, this suggests that (3) is not underidentified and not wealy identified. Similar conclusions can be drawn for T-banks, but the Wald F-Statistic of 9.3 satisfies weak identification thresholds under [145] and come slightly under 10 as a threshold for [143]. Given that the lending sensitivities of R-banks and T-banks do not seem to be statistically different, this suggests that using all banks for lending sensitivity estimation purposes would be preferred.

Overall, the panel data shows strong support for the first, second, and third predictions of the paper's framework. There is a lack of support for the fourth prediction that transactional lending sensitivity to reserve premiums is stronger and instead this difference is in the magnitude of lending between T-banks and R-banks. Next, an anonymous conference referee inquired as to whether the significance of the reserves premium actually means that excess reserves are negatively associated with bank treasury holdings. This next Section 3.7, explores this question further by examining the differences in bank liquidity preferences and the sensitivity of excess reserves to treasuries between banks that hold over $1B in reserves compared to banks that hold less than $1B.

Heterogeneity in Liquidity Preference and Excess Reserves Sensitivity

In Figure 3.6, the bulk of excess reserves held at the Federal Reserve is held by banks with more than $1B in reserves. Also in Figure 3.7, the data shows that these excess reserves are mostly held by transactional banks. In Table 3.9, banks with large excess reserves have an average (median) of $180B ($63B) in assets, while banks with no excess reserves have an average (median) of $200M ($65M) in assets. However, the ratio of loans to assets do not differ greatly between banks with large, medium, and small amounts of excess reserves, as they are 55%, 66%, and 61% respectively. The question naturally arises whether these banks that hold much of the excess reserves in the system have liquidity preferences and lending sensitivities that differ from other banks. Table 3.10 tests whether liquidity preference for excess reserves is stronger for banks with significant excess reserves compared to banks with no reserves. Table 3.11 tests for excess reserve sensitivities to treasury holdings (RCON0211+RCON1286) and total securities (RCON1754+RCON1772) in univariate panel regressions under the tighest specifications for all banks and banks with over $1B in reserves.

Table 3.10 (1) tests for the liquidity preference of banks by looking at the sensitivity of excess reserves to changes in the reserves premium similar to Table 3.6 using bank fixed effects and clustering standard errors by bank and quarter. However, there are two major differences in that dummy variables are not of transactional banks and are instead dummy indicators of banks that hold excess reserves of more than $1M in (1) and $1B in (2). In both (1) and (2), the reserves bank dummy is significant, but the interaction term between reserves bank and the reserves premium is not. This means that while reserve banks do hold significantly more excess reserves as a percentage of total assets, they do are not significantly more sensitive to changes in the reserves premium. These results are similar to our previous findings that larger transactional banks do not have greater sensitivities to changes in the reserve premium, but do have greater amounts of excess reserves and lending compared to relationship banks. The greater amount of excess reserves as a percentage of assets could be an indicator of banking charter value for financial institutions that were closer to insolvency during the financial crisis. Specifications in (3) and (4) look at reserves as a percentage of cash assets, and the results are similar to (1) and (2). Specifications (5) and (6) look at reserves as a percentage of deposits, and find no significance in the coefficient for reserves premium. From these regressions it seems as though bank liquidity preference of excess reserves is unrelated to bank deposits.

Table 3.7 explores the answer to a question whether excess reserves is substituting for treasuries. Treasuries in this sample are amortized, scaled by total assets, and are a sum of treasuries that banks hold to maturity and are available for trading. The presence of heterogeneity in the independent variables calls for use of both bank and quarter fixed effects as well as clustering standard errors at the bank and quarter level. The results in (2) and (4) suggest that treasuries and excess reserves are not substitutes for banks, even when banks are restricted to those with over $1B in excess reserves. Treasury coefficients do not show significance, although the coefficient for banks with over $1B in excess reserves is -0.349 which is more negative than the coefficient for all banks which is -0.022. In the Schedule RC-B Securities of the Call Report, we add the variable total securities that are either held to maturity or available for trading. In specifications (1) and (3), the coefficients for securities are both significantly negative. The negative coefficient is larger for banks with reserves over $1B (-0.292) compared to all banks (-0.046). The regressions in Table 3.7 suggest that risk free excess reserves are substituting for securities other than risk free treasuries. This also suggests that banks are indeed substituting excess reserves with investments that differ in risk such as non-treasury securities as well as loans. Recent papers by [109] and [41] suggest that part of this substitutability of securities is due to mortgage backed security purchases by the Federal Reserve during quantitative easing.

3.4 Conclusion

This paper finds strong empirical support for [69, 126]'s theoretical negative relationship between excess reserves and lending. This paper constructs and uses a measurable variable, the *reserves premium*, to estimate the sensitivity of bank lending. The main empirical results highlight support for the first three predictions of this paper by estimating the effect of reserve premiums on excess reserves, excess reserves on lending, and finally reserve premiums on lending. These sensitivities are estimated using both one stage and two-stage estimations. The two stage results in Table 3.8 show that interest on excess reserves (measured by reserve premiums) led to a 6.0% decrease in total lending, or $761M for each transactional bank and $13.6M for each relationship banks. The total impact on the banking system as a whole is a reduction of $408.5 billion in bank lending. Surprisingly, lending sensitivity to excess reserves is similar for both transactional banks and relationship banks, with transactional banks holding over 95% of excess reserves as shown in Figure 3.7. Overall, there is strong support for this paper's main prediction that rising reserve premiums crowd out bank lending, as these results were consistent and highly significant across all different empirical models and specifications used.

The role of providing credit and liquidity is especially important for recovering markets during a recession. However, this consideration is also balanced with the need for precautionary excess reserves for financial stability. The role of reserve premiums in credit and liquidity restriction to market participants add another dimension to our understanding of lending during financial crises. The structural relationship of reserve premiums to lending provide a new paradigm for financial institutions and debtors as the "Sharpe Ratio" framework of this paper outlines the similarity of financial intermediaries to hedge funds and trading desks in search of optimal investments whether risk-free reserves or loans. In a "push-pull" dynamic where central bank increase liquidity while reserve premiums reduce liquidity, credit access in a financial crises presents a nuanced picture on the importance of market based incentives. This paper's results suggest that going forward, the reserves premium will be an important indicator of liquidity, credit conditions, and holdings of precautionary excess reserves.

Table 3.1: **Aggregated Banking Summary Statistics** Summary statistics are weekly and from H8 balance sheet data from the Federal Reserve. Panel A is aggregated data for the top 25 domestically chartered banks by asset size, while Panel B are defined as all other domestically chartered banks. MBS holdings are also published by the Federal Reserve and total outstanding MBS in the market is from Securities Industry and Financial Markets Association. Reserves Premium is the spread between reserves interest rates and the 3M T-Bill, while lending premiums are spreads between respective lending rates and the 10Y Treasury rate. Excess Tier 1 Ratios are derived from the SCAP, CCAR, and Dodd-Frank stress tests. Data ranges from October 2008 to August 2015.

Panel A: Top 25 Banks ($ Billions)

Variable	N	Mean	Std	Min	P25	P50	P75	Max
Total Loans	358	4,200	190	3,800	4,100	4,200	4,300	4,700
Total C&I Loans	358	770	120	610	660	770	840	1,000
Total Assets	358	7,500	520	6,900	7,100	7,300	7,800	8,800
Total Cash Assets	358	720	260	330	540	600	970	1,300
Total Deposits	358	5,000	750	3,900	4,200	5,000	5,700	6,300
Total Loans/Total Assets	358	0.56	0.02	0.52	0.55	0.56	0.57	0.59
Total Loans/Total Cash	358	6.40	1.77	3.50	4.43	6.89	7.61	13.09
Total Loans/Total Deposits	358	0.47	0.05	0.42	0.43	0.45	0.52	0.60
Total Cash/Total Assets	358	0.10	0.03	0.05	0.08	0.08	0.13	0.15

Panel B: Non Top 25 Banks ($ Billions)

Variable	N	Mean	Std	Min	P25	P50	P75	Max
Total Loans	358	2,400	190	2,100	2,200	2,300	2,400	2,800
Total C&I Loans	358	420	60	350	360	410	460	550
Total Assets	358	3,600	300	3,300	3,400	3,600	3,800	4,300
Total Cash Assets	358	280	56	120	250	290	320	400
Total Deposits	358	2,800	320	2,300	2,500	2,800	3,000	3,400
Total Loans/Total Assets	358	0.65	0.02	0.62	0.63	0.64	0.66	0.71
Total Loans/Total Cash	358	8.68	2.02	6.42	7.58	7.96	8.86	20.15
Total Loans/Total Deposits	358	0.85	0.06	0.79	0.81	0.83	0.88	1.04
Total Cash/Total Assets	358	0.07	0.01	0.03	0.07	0.08	0.08	0.09

Panel C: Macro Variables %

Variable	N	Mean	Std	Min	P25	P50	P75	Max
Reserves Premium (3MT)	364	0.16	0.11	-1.05	0.12	0.18	0.22	0.25
Reserves Premium (EFFR)	369	0.13	0.08	-0.21	0.09	0.13	0.16	0.87
Interest on Excess Reserves	369	0.27	0.10	0.25	0.25	0.25	0.25	1.00
Effective Fed Funds Rate	369	0.14	0.08	0.05	0.09	0.13	0.16	0.96
Mortgage Premium	364	1.71	0.29	1.19	1.55	1.65	1.80	2.96
Quantitative Easing	364	0.12	0.06	0.00	0.09	0.11	0.17	0.29
Excess Tier 1 Ratio	364	8.19	0.95	5.95	7.62	8.51	9.07	9.24
VIX	369	21.44	10.50	10.97	14.63	17.83	24.33	72.92

Table 3.2: **Aggregated Total Lending**

This table reports the significance of the Reserves Premium on total aggregated lending. Total loans are measured as log value, a percentage of Cash Assets, and a percentage of Total Assets. Control variables central bank open market purchases (QE), lending spreads, excess tier 1 ratio, and the VIX. Bank data is derived from weekly H8 data released by the Federal Reserve. QE is defined as Federal Reserve MBS holdings as a percentage of total MBS outstanding. Reserves Premium is the spread between reserves interest rates and the 3M T-Bill, while lending premiums are spreads between respective lending rates and the 10Y Treasury rate. Excess Tier 1 Ratios are derived from the SCAP, CCAR, and Dodd-Frank stress tests. Standard errors are Huber-White and t-statistic values are in parenthesis.

	Loans		Loans/Cash Assets		Loans/Assets	
	Top 25	Rest	Top 25	Rest	Top 25	Rest
Reserves Premium	-0.061***	-0.08***	-5.111***	-7.23***	-0.031***	-0.03***
	(-6.45)	(-5.91)	(-7.31)	(-10.24)	(-3.64)	(-3.68)
Loan Premiums	0.097***	0.103***	0.969***	0.463***	0.008***	0.017***
	(15.88)	(14.99)	(7.63)	(3.3)	(7.05)	(10.98)
Excess Tier 1 Ratio	-0.012***	-0.047***	0.347***	-1.07***	0.007***	-0.017***
	(-8.41)	(-24.04)	(8.67)	(-24.25)	(15.45)	(-35.08)
VIX	-0.002***	-0.003***	0.004	0.008	0.000***	0.000*
	(-8.99)	(-13.05)	(0.71)	(1.46)	(2.86)	(-1.75)
Quantitative Easing	0.548***	0.853***	-17.804***	-12.581***	-0.146***	-0.062***
	(17.3)	(20.4)	(-11.8)	(-11.27)	(-10.13)	(-5.86)
R^2	0.785	0.905	0.876	0.928	0.862	0.899
F-Statistic	355.95	653.55	289.01	414.31	267.24	482.79
Observations	358	358	358	358	358	358
Robust Standard Errors	Y	Y	Y	Y	Y	Y

Table 3.3: **Aggregated C&I Lending**

This table reports the significance of the Reserves Premium on aggregated C&I loans. C&I loans are measured as log value, a percentage of Cash Assets, and a percentage of Total Assets. Control variables central bank open market purchases (QE), lending spreads, excess tier 1 ratio, and the VIX. Bank data is derived from weekly H8 data released by the Federal Reserve. QE is defined as Federal Reserve MBS holdings as a percentage of total MBS outstanding. Reserves Premium is the spread between reserves interest rates and the 3M T-Bill, while lending premiums are spreads between respective lending rates and the 10Y Treasury rate. Excess Tier 1 Ratios are derived from the SCAP, CCAR, and Dodd-Frank stress tests. Standard errors are Huber-White and t-statistic values are in parenthesis.

	C&I Loans		C&I Loans/Cash		C&I Loans/Assets	
	Top 25	Rest	Top 25	Rest	Top 25	Rest
Reserves Premium	-0.137***	-0.169***	-1.012***	-1.42***	-0.013***	-0.013***
	(-2.75)	(-4.83)	(-8.64)	(-11.45)	(-4.12)	(-5.37)
Loan Premiums	0.339***	0.276***	0.235***	0.213***	0.022***	0.018***
	(16.47)	(18.23)	(11.07)	(7.22)	(15.42)	(18.23)
Excess Tier 1 Ratio	-0.083***	-0.073***	0.003	-0.215***	-0.006***	-0.006***
	(-14.74)	(-17.04)	(0.51)	(-25.74)	(-14.1)	(-19.51)
VIX	-0.009***	-0.008***	-0.005***	-0.003*	-0.001***	0***
	(-12.13)	(-12.35)	(-4.07)	(-1.79)	(-11.52)	(-9.62)
Quantitative Easing	1.165***	1.322***	-3.263***	-1.582***	0.035***	0.041***
	(9.18)	(12.44)	(-13.8)	(-7.92)	(4.26)	(5.68)
R^2	0.758	0.818	0.876	0.928	0.862	0.899
F-Statistic	394.69	418.22	289.01	414.31	267.24	482.79
Observations	358	358	358	358	358	358
Robust Standard Errors	Y	Y	Y	Y	Y	Y

Table 3.4: **Panel Data Summary Statistics**

Summary statistics are quarterly and from Call Reports and the Federal Reserve. Transaction banks are based on non-community bank identifiers from the Federal Deposit Insurance Corporation. Relationship banks are defined as community banks by the same FDIC identifier. MBS holdings are also published by the Federal Reserve and total outstanding MBS in the market is from Securities Industry and Financial Markets Association. Net interest margins are provided by the Federal Reserve while lending premiums are spreads between respective lending rates and the 10Y Treasury rate. Data ranges from 2008Q4 - 2017Q3.

Summary Statistics of Panel Data Variables

Variable	N	Mean	Std	Min	P25	P50	P75	Max
Transactional Banks								
Total Loans/Total Assets	20,193	0.59	0.24	0.00	0.50	0.66	0.76	1.06
Total Loans/Total Deposits	20,163	63.76	1,531	0.00	0.66	0.84	0.97	66,289
Total Loans/Cash Assets	20,110	103.74	3,320	0.00	4.55	12.08	27.37	410,000
Reserves Held at Fed ($M)	20,194	1,500	13,000	0.00	0.00	23.29	180.00	450,000
Excess Reserves/Total Assets	20,193	0.05	0.09	0.00	0.00	0.01	0.05	1.00
Excess Reserves/Cash Assets	20,110	0.39	0.36	0.00	0.00	0.34	0.74	1.00
Total Loans ($M)	20,194	12,000	62,000	0.00	200	900	4,000	950,000
Loans Held for Sale ($M)	20,194	210	1,600	0.00	0.00	0.31	10.58	42,000
Loans Held for Investment ($M)	20,194	11,000	60,000	0.00	190	860	3,900	920,000
C&I Loans ($M)	20,194	2,100	11,000	0.00	11.38	100	500	210,000
Total Assets ($M)	20,194	22,000	130,000	0.00	400	1,500	6,100	2,200,000
Relationship Banks								
Total Loans/Total Assets	221,510	0.63	0.16	0.00	0.53	0.65	0.75	1.04
Total Loans/Total Deposits	221,495	0.76	5.63	0.00	0.62	0.77	0.89	2,649
Total Loans/Cash Assets	221,502	14.95	34.27	0.00	4.91	9.58	18.75	9,959
Reserves Held at Fed ($M)	221,510	8.25	44	0.00	0.00	0.00	0.11	7,000
Excess Reserves/Total Assets	221,510	0.01	0.03	0.00	0.00	0.00	0.00	0.99
Excess Reserves/Cash Assets	221,502	0.12	0.26	0.00	0.00	0.00	0.01	1.00
Total Loans ($M)	221,510	210.00	480	0.00	44.21	96.31	210.00	32,000
Loans Held for Sale ($M)	221,510	2.60	58	0.00	0.00	0.00	0.10	18,000
Loans Held for Investment ($M)	221,510	200.00	460	0.00	43.25	94.02	210.00	31,000
C&I Loans ($M)	221,510	28.38	98	0.00	3.65	9.84	25.04	5,800
Total Assets ($M)	221,510	320.00	690	0.11	77.70	150.00	320.00	41,000
Independent Variables								
Reserves Premium	36	0.18	0.06	0.04	0.15	0.20	0.23	0.34
Risk Adjusted Loan Premium	36	0.49	0.24	0.16	0.30	0.41	0.70	0.93
Loan Premium	36	1.75	0.30	1.15	1.61	1.73	1.89	2.85
Interest on Excess Reserves	36	0.35	0.25	0.25	0.25	0.25	0.25	1.25
QE MBS as Mortgage Rates	36	4.24	0.56	3.35	3.86	4.14	4.69	5.42
3M T-Bill Rate	36	0.17	0.24	0.00	0.04	0.09	0.18	1.06
10Y Treasury Rate	36	2.49	0.64	1.49	1.94	2.40	2.97	3.85
Bank Net Interest Margin	36	3.29	0.25	2.95	3.09	3.20	3.47	3.83
Loan Delinquency Rate	36	4.38	1.84	1.83	2.49	4.65	5.96	7.40

Table 3.5: **Panel Data Activity of Reserves Premium on Excess Reserves**

This table provides estimates of excess reserves activity of transaction and relationship banks on reserve premiums on both 3-month treasury bills and the effective fed funds rate. This empirical model controls for excess reserves activity due to the Federal Reserve's quantitative easing program. The results are from a panel data regression using bank fixed effects with bank clustered standard errors. Transactional Bank represents a value of 1 for a transactional bank and a value of 0 for a relationship bank. Indicators are sourced from FDIC Community Banking Study Reference Data. T-statistics are in parenthesis.

	Excess Reserves			
	(1)	(2)	(3)	(4)
Reserves Premium			0.024	
× Transactional			(0.98)	
Reserves Premium	0.031***	0.026***	0.024***	0.012
	(14.64)	(2.63)	(2.63)	(1.11)
Loan Premiums		-0.003	-0.003	-0.002
		(-1.33)	(-1.32)	(-0.9)
Quantitative Easing		0.007	0.007	0.022**
		(0.61)	(0.62)	(2.46)
Risk Free Rate	3MT	3MT	3MT	EFFR
Observations	236,308	236,308	236,308	236,308
Bank FE	✓	✓	✓	✓
Bank Cluster	✓	✓	✓	✓
Time Cluster		✓	✓	✓
Adjusted R^2	0.64	0.64	0.64	0.64

Table 3.6: **Panel Data Activity of Excess Reserves on Lending**

This table provides estimates of lending senstivity to excess reserves. The results are from a panel data regression using bank and time fixed effects with bank and time clustered standard errors. Controls include loan premiums and quantitative easing. Transactional Bank represents a value of 1 for a transactional bank and a value of 0 for a relationship bank. Indicators are sourced from FDIC Community Banking Study Reference Data. T-statistics are in parenthesis.

	Total Loans			
	(1)	(2)	(3)	(4)
Excess Reserves × Transactional			-0.024 (-0.24)	
Excess Reserves	-0.409*** (-9.53)	-0.409*** (-9.41)	-0.399*** (-13.77)	-0.411*** (-9.65)
Deposits				0.023 (0.78)
Observations	236,308	236,308	236,308	236,308
Controls		✓	✓	
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓
Adjusted R^2	0.86	0.87	0.87	0.87

Table 3.7: **Panel Data Activity of Reserves Premium on Lending**

This table provides estimates of bank lending activity of transaction and relationship banks on reserve and lending premiums. This empirical model controls for lending activity due to the Federal Reserve's quantitative easing program. The results are from a panel data regression using bank fixed effects with firm clustered standard errors. Transactional Bank represents a value of 1 for a transactional bank and a value of 0 for a relationship bank. Indicators are sourced from FDIC Community Banking Study Reference Data. T-statistics are in parenthesis.

	Total Loans					
	(1)	(2)	(3)	(4)	(5)	(6)
Reserves				0.062		
× Transactional				(1.62)		
Reserves Premium	-0.095***	-0.095**	-0.116**	-0.121**	-0.096	-0.051
	(-14.09)	(-2.07)	(-2.32)	(-2.37)	(-1.23)	(-0.97)
Loan Premiums			0.044***	0.044***		0.032**
			(2.94)	(2.95)		(2.63)
Tier 1 Ratio			-0.023***	-0.023***		-0.026
			(-5.4)	(-5.4)		(-7.92)
VIX			0.00	0.00		0.00
			(0.52)	(0.53)		(0.51)
Quantitative Easing			0.144***	0.144***		0.143**
			(2.8)	(2.8)		(2.58)
Risk Free Rate	3MT	3MT	3MT	3MT	EFFR	EFFR
Observations	236,308	236,308	236,308	236,308	236,308	236,308
Bank FE	✓	✓	✓	✓	✓	✓
Bank Cluster	✓	✓	✓	✓	✓	✓
Time Cluster		✓	✓	✓	✓	✓
Adjusted R^2	0.85	0.85	0.87	0.86	0.86	0.86

Table 3.8: **Two-Stage Lending Sensitivity Estimation**

This table provides estimates of the relationship between lending and excess reserves. The empirical model of the two-stage ordinary least squares regression is as follows:

$$Excess\ Reserves_{i,t} = \alpha_i + \beta Reserves\ Premium_t + X'\Gamma + \varepsilon_{i,t} \qquad \text{1st Stage}$$
$$Total\ Loans_{i,t} = \lambda_i + \gamma \widehat{Excess\ Reserves}_{i,t} + X'\Gamma + \mu_{i,t} \qquad \text{2nd Stage}$$

$Excess\ Reserves_{i,t}$ and $Total\ Loans_{i,t}$ are scaled by book assets of bank i at time t. $Reserve\ Premiums_t$ is the difference between interest on excess reserves and the risk free rate. X represents the control variables of loan premiums and quantitative easing. Loan premiums are lending margins above the 10Y treasury rate, scaled by loan delinquencies, as reported by the Federal Reserve. Quantitative easing is a measure of MBS purchases by the Federal Reserve, scaled by total outstanding MBS in the market. $\widehat{Excess\ Reserves}_{i,t}$ is a predicted value from the first stage. Relationship banks are defined as community banks and Transactional banks are defined as non-community banks by the FDIC. The data is quarterly and covers all U.S. commercial banks from 2008Q4 to 2017Q3. Standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

Panel A: 1st Stage	*Excess Reserves*			
	All (1)	*All (2)*	*R-Banks (3)*	*T-Banks (4)*
Reserve Premiums	0.031***	0.035***	0.031***	0.076***
	(3.96)	(3.93)	(3.93)	(3.1)
Panel B: 2nd Stage	*Total Loans*			
	All (1)	*All (2)*	*R-Banks (3)*	*T-Banks (4)*
$\widehat{\text{Excess Reserves}}$	-3.096***	-6.672***	-7.611***	-2.53***
	(-3.24)	(-7.97)	(-7.95)	(-6.24)
Loan Premiums		0.013	0.018	0.014
		(1.18)	(1.65)	(0.86)
Quantitative Easing		0.127**	0.124**	0.097**
		(2.47)	(2.51)	(2.15)
Observations	236,308	236,308	216,134	20,174
Controls		✓	✓	✓
Bank FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓
Kleinbergen-Paap (p-value)	0.01	0.00	0.00	0.01
First Stage Wald F Statistic	15.2	15.0	15.0	9.3

Figure 3.6: **Breakdown of Excess Reserves by Size of Holdings Over Time**
Total excess reserves held at the Federal Reserve broken down by size of holdings. For instance, the dark blue bar represents total excess reserve holdings by banks that each hold an excess reserve balance of over $1 billion. The yellow bar represents total excess reserve.

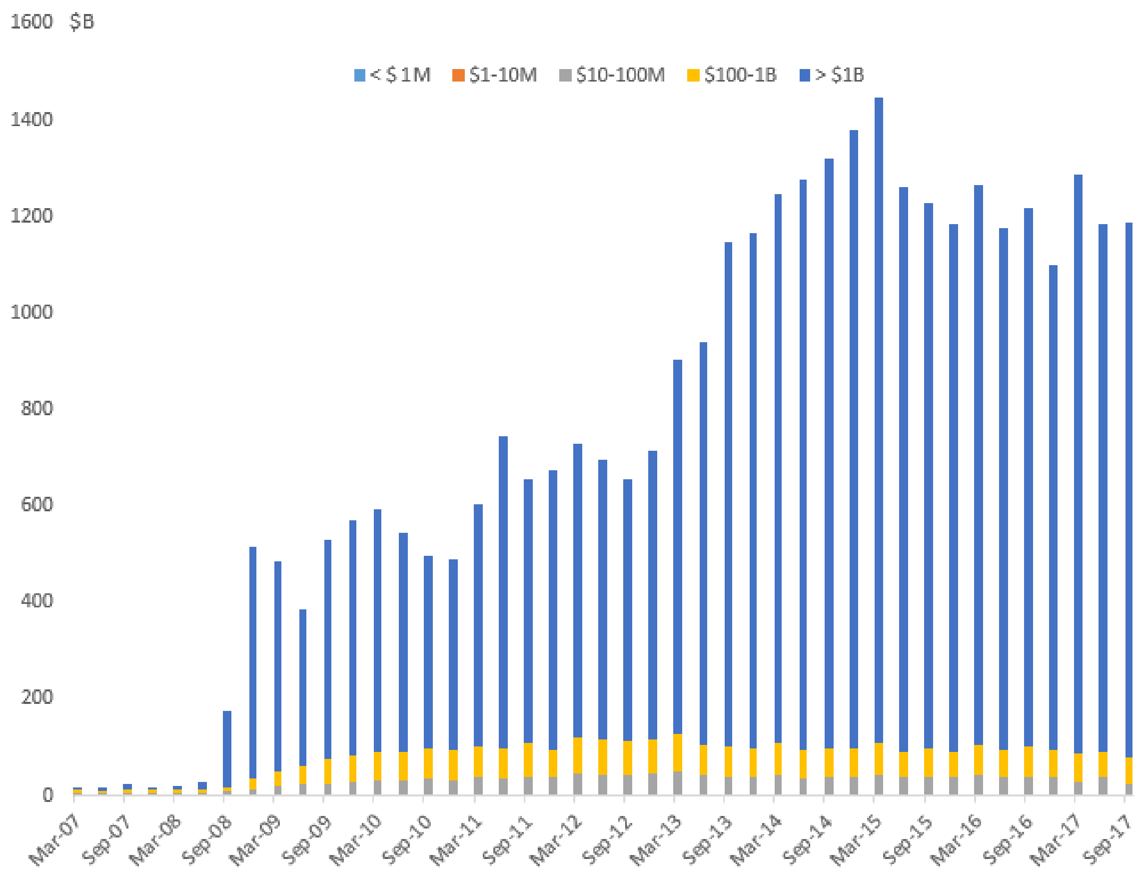


Table 3.9: **Summary Statistics of Bank Excess Reserves**Summary statistics are quarterly and from Call Reports and the Federal Reserve. MBS holdings are also published by the Federal Reserve and total outstanding MBS in the market is from Securities Industry and Financial Markets Association. Net interest margins are provided by the Federal Reserve while lending premiums are spreads between respective lending rates and the 10Y Treasury rate. Data ranges from 2008Q4 - 2017Q3.

Summary Statistics of Panel Data Variables

Variable	**N**	**Mean**	**Std**	**Min**	**P25**	**P50**	**P75**	**Max**
Large Excess Reserves ($1B<i)								
Total Loans/Cash Assets	1,986	7.45	7.48	0.00	2.14	4.93	10.58	46.70
Total Loans/Total Deposits	1,983	0.83	0.39	0.00	0.63	0.84	0.98	3.57
Total Loans/Total Assets	1,986	0.55	0.22	0.00	0.42	0.62	0.71	0.96
Reserves Held at Fed ($M)	1,986	15,000	40,000	1,000	1,700	3,300	9,800	450,000
Excess Reserves/Cash Assets	1,983	4.54	83.97	0.00	0.06	0.13	0.27	2,595
Excess Reserves/Total Deposits	1,986	0.14	0.14	0.00	0.04	0.09	0.17	1.00
Excess Reserves/Total Assets	1,986	0.77	0.22	0.03	0.65	0.83	0.94	1.00
Total Loans ($M)	1,986	89,000	180,000	0.00	11,000	29,000	72,000	950,000
Total Deposits ($M)	1,986	110,000	220,000	0.00	15,000	41,000	89,000	1,300,000
Total Assets ($M)	1,986	180,000	390,000	1,100.00	20,000	63,000	130,000	2,200,000
Loans Held for Sale ($M)	1,986	1,600	4,400	0.00	0	78	870	42,000
Loans Held for Investment ($M)	1,986	85,000	170,000	0.00	10,000	27,000	70,000	920,000
C&I Loans ($M)	1,986	16,000	31,000	0.00	590	4,900	18,000	210,000
Trading Assets ($M)	1,986	12,000	45,000	0.00	0	91	1,100	370,000
Medium Excess Reserves ($1M<i<$1B)								
Total Loans/Cash Assets	60,496	17.51	75.10	0.00	6.34	11.39	20.75	14,342
Total Loans/Total Deposits	60,488	4.21	310.83	0.00	0.70	0.83	0.93	43,834
Total Loans/Total Assets	60,496	0.66	0.14	0.00	0.59	0.68	0.76	1.02
Reserves Held at Fed ($M)	60,496	57	110	1.00	7.59	21.66	53.65	1,000
Excess Reserves/Cash Assets	60,488	0.91	154.84	0.00	0.01	0.04	0.08	37,904
Excess Reserves/Total Deposits	60,496	0.05	0.06	0.00	0.01	0.03	0.07	0.99
Excess Reserves/Total Assets	60,496	0.55	0.27	0.00	0.34	0.59	0.78	1.00
Total Loans ($M)	60,496	1,300	6,600	0.00	260.00	420.00	840.00	710,000
Total Deposits ($M)	60,496	1,500	6,700	0.00	330.00	510.00	1,000.00	750,000
Total Assets ($M)	60,496	2,000	11,000	5.61	400.00	620.00	1,300.00	1,500,000
Loans Held for Sale ($M)	60,496	22	280	0.00	0.00	0.26	3.07	32,000
Loans Held for Investment ($M)	60,496	1,300	6,300	0.00	250.00	400.00	810.00	680,000
C&I Loans ($M)	60,496	220	1,300	0.00	21.09	47.01	120.00	140,000
Trading Assets ($M)	60,496	8	550	0.00	0.00	0.00	0.00	130,000
Low Excess Reserves (i<$1M)								
Total Loans/Cash Assets	178,688	24.17	1,114.02	0.00	4.52	9.19	18.87	410,000
Total Loans/Total Deposits	178,737	6.70	481.99	0.00	0.60	0.75	0.88	66,289
Total Loans/Total Assets	178,761	0.61	0.17	0.00	0.51	0.64	0.74	1.06
Reserves Held at Fed ($M)	178,762	0.02	0.10	0.00	0.00	0.00	0.00	1.00
Excess Reserves/Cash Assets	178,737	0.00	0.01	0.00	0.00	0.00	0.00	1.00
Excess Reserves/Total Deposits	178,761	0.00	0.00	0.00	0.00	0.00	0.00	0.91
Excess Reserves/Total Assets	178,688	0.00	0.02	0.00	0.00	0.00	0.00	1.00
Total Loans ($M)	178,762	130	1,100	0.00	35.49	71.35	130.00	130,000
Total Deposits ($M)	178,762	150	490	0.00	54.46	98.81	170.00	43,000
Total Assets ($M)	178,762	200	1,300	0.00	64.86	120.00	200.00	150,000
Loans Held for Sale ($M)	178,762	2	130	0.00	0.00	0.00	0.00	21,000
Loans Held for Investment ($M)	178,762	130	1,000	0.00	34.77	69.77	130.00	120,000
C&I Loans ($M)	178,762	16	93	0.00	2.82	7.10	15.71	8,000

Table 3.10: **Bank Liquidity Preference for Excess Reserves** This table provides estimates of bank liquidity preference of excess reserves. These estimates are also interacted with a reserve indicator for banks that hold more than $1M of excess reserves. The results are from a panel data regression using bank fixed effects with two way clustering of standard errors using bank and quarter clusters. (1) indicate dummy variables of banks which hold excess reserves of $1M or more, while (2) indicates banks with excess reserves of $1B or more. Banks without excess reserves are assigned a value of 0, while banks with excess reserves are assigned a value of 1. Panel data covers the period from 2008Q4-2017Q3. T-statistics are in parenthesis.

Liquidity Preference of Banks

	$\frac{Reserves_{it}}{Total\ Assets_{it}}$		$\frac{Reserves_{it}}{Cash\ Assets_{it}}$		$\frac{Reserves_{it}}{Total\ Deposits_{it}}$	
	(1)	(2)	(1)	(2)	(1)	(2)
Reserves Bank Dummy	0.04***	0.123***	0.442***	0.365***	-3.861	14.424
	(7.64)	(7.68)	(18.3)	(10.98)	(-1.2)	(1.42)
Reserves Premium	0.016**	0.034***	0.057*	0.231***	-4.007	1.627
	(2.69)	(3.87)	(1.94)	(3.95)	(-1.11)	(0.71)
Reserves Premium × Reserves Bank	0.025	-0.013	0.161	-0.059	23.938	-1.888
	(0.98)	(-0.2)	(1.3)	(-0.47)	(1.57)	(-0.17)
Loan Premiums	-0.009***	-0.01***	-0.038***	-0.051**	1.815	1.996
	(-5.04)	(-3.6)	(-4.05)	(-2.25)	(1.25)	(1.3)
QE	0.011**	0.029***	0.094**	0.302***	-0.346	-0.736
	(2.08)	(3.58)	(2.41)	(4.06)	(-0.18)	(-0.37)
Observations	236,308	236,308	236,218	236,218	236,265	236,265
Bank FE	✓	✓	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.68	0.65	0.87	0.76	0.00	0.00

Table 3.11: **Excess Reserves and Security Holdings Sensitivity** This table provides estimates of bank holdings of excess reserves as a substitute for bank securities that are held to maturity (HTM) and available for sale (AFS) from the Call Report RC-B. T-statistics are reported in parenthesis. Bank FE refers to bank level fixed effects. Time FE refers to quarter fixed effects. Two way clustering of standard errors is used across all four specifications. All variables are scaled by total assets in the same period. Specification (1) and (2) covers all bank level data in Call Reports while specifications (3) and (4) only use bank observations where excess reserve holdings exceed $1B. Panel data covers the period from 2008Q4-2017Q3. T-statistics are in parenthesis.

	Excess Reserves			
	All Banks		Reserves > $1B	
	(1)	(2)	(3)	(4)
Securities	-0.046***		-0.292***	
	(-7.78)		(-3.18)	
Treasuries		-0.022		-0.349
		(-1.24)		(-1.24)
Observations	236,076	236,076	1,924	1,924
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓
Adjusted R^2	0.65	0.65	0.81	0.80

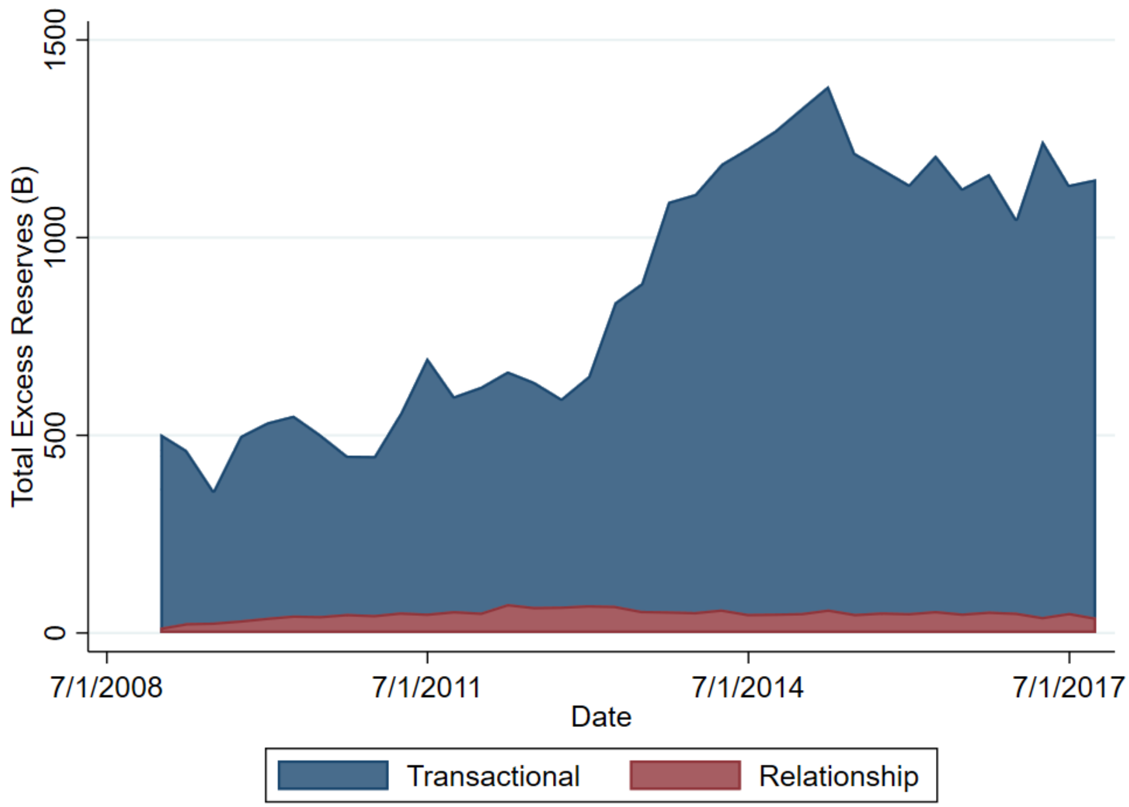


Figure 3.7: **Total Excess Reserves** Reported quarterly data is from the Call Reports. Total excess reserves aggregated according to lending technology specified as Transactional or Relationship. Identifier for lending technology is from the Federal Deposit Insurance Corporation (FDIC) Community Banking identifier. Total amounts are in the $ Billions.

3.5 Proof of Baseline Model

Proof. In order to prove that a Transactional Bank will be more risk averse than a Relationship Bank, we must prove that:

$$\frac{L_l}{\xi_l} < \frac{L_S}{\xi_S}$$

$$\begin{aligned} &L_i = \textit{number of loans funded by bank} i \in [l, S] \\ &\xi_i = n \in \mathbb{R}^+, \textit{representing deployable capital of bank} i. \end{aligned} \tag{A.1}$$

Depending on central bank actions:

$$\begin{aligned} &QE \textit{ is a constant } C \in [0, 1] \\ &\gamma > r_f,\ r_f \in [0, \gamma),\ \textit{and } \gamma \in (r_f, 1 - \kappa(QE)) \end{aligned} \tag{A.2}$$

Independent of central bank actions:

$$\begin{aligned} &\theta_j, \theta_\delta \in \mathbb{R}^+ \textit{ and is fixed } \forall\ L_i, B_i \\ &\xi_{Sj}, \xi_{Bj} \in (0, 1] \textit{ and is fixed } \forall\ L_i, B_i \end{aligned} \tag{A.3}$$

And I assume that $j = n : j, n \in \mathbb{R}^+$. I define:

$$\begin{aligned} &\rho_j = \frac{r_j(QE, \theta_j, \xi_j) - \gamma}{\lambda_{ij}(\theta_j, \xi_j)} \\ &\frac{\partial \rho}{\partial r} \cdot \frac{\partial r}{\partial QE} < 0\ \forall\ B_i \end{aligned} \tag{A.4}$$

$$\delta_i = \frac{\gamma - r_f}{\theta_\delta}, \frac{\partial \delta}{\partial \gamma} > 0\ \forall\ B_i \tag{A.5}$$

$$\rho_{ij} = \begin{cases} \rho_{ij} \sim U[0,1] \; when \; 1 \geq QE > 0 \\ \\ \rho_{ij} \sim U[0,1] \; when \; QE = 0 \end{cases} \tag{A.6}$$

I also define:

$$B_i = \begin{cases} \frac{\partial \rho}{\partial r} \cdot \frac{\partial r}{\partial \xi} > 0, \frac{\partial \rho}{\partial r} \cdot \frac{\partial r}{\partial \xi} > 0 \; for \; B_S \\ \\ \frac{\partial \rho}{\partial r} \cdot \frac{\partial r}{\partial \xi} = 0, \frac{\partial \rho}{\partial r} \cdot \frac{\partial r}{\partial \xi} = 0 \; for \; B_L \end{cases} \tag{A.7}$$

In the model economy, I define $1 \geq QE > 0$ and $1 \geq \xi > 0.$ I also define:

$$\alpha_i(\xi) = \begin{cases} \alpha_i(\xi) = 0 \; \forall \; \xi, for \; i = l \\ \\ \alpha_i(\xi) = \pi - \delta, \alpha_S(\xi) > 0, \frac{\partial \alpha}{\partial \xi} > 0 \; for \; i = S \end{cases} \tag{A.8}$$

I also define an identical function $\kappa(QE)$, $\frac{\partial \kappa}{\partial QE} > 0$ so that from A.6

$$V_i = \begin{cases} 1 - \kappa(QE) + \alpha_l(\xi) \quad for \quad i = Large \\ \\ \\ max[1 - \kappa(QE), \delta + \alpha_s(\xi)] \quad for \quad i = Small \end{cases} \tag{A.9}$$

I also define levels of $QE = [QE_1, QE_2, QE_3] \in [0,1]$ where $QE_1 \not\subseteq QE_2 \not\subseteq QE_3$

$$QE_i = \begin{cases} 1-\kappa(QE_i) > \alpha_S(\xi)+\delta \quad when \quad QE_i = QE_1 \\ 1-\kappa(QE_i) \approx \alpha_S(\xi)+\delta \quad when \quad QE_i = QE_2 \\ 1-\kappa(QE_i) < \alpha_S(\xi)+\delta \quad when \quad QE_i = QE_3 \end{cases} \tag{A.10}$$

I impose QE_3 conditions from A.10 and it is given that:

$$1-\delta > \alpha_S(\xi)+\delta > 1-\kappa(QE_i) > \ \forall \ \xi \tag{A.11}$$

By looking at A.6 and A.9, it is shown that for transactional banks that for post QE_3 risk-adjusted returns are $\rho^*_{lj} \sim U[0, 1-\kappa(QE)+\alpha_l(\xi)]$

$$\therefore \kappa(QE) - \alpha_l(\xi) = \rho_j - \rho^*_l \tag{A.12}$$

By looking at A.6 and A.9, it is shown that for relationship banks that for post QE_3 risk-adjusted returns are $\rho^*_{Sj} \sim U[0, \alpha_s(\xi)+\delta]$

$$\therefore 1-[\alpha_S(\xi)+\delta] = \rho_j - \rho^*_S \tag{A.13}$$

Therefore the amount of loans for transactional and relationship banks are:

$$\begin{aligned} L_l &= n(1-\kappa(QE)-\delta+\alpha_l(\xi)) \\ L_S &= n(\alpha_S(\xi)) \end{aligned} \tag{A.14}$$

I now prove $\frac{L_l}{\xi_l} < \frac{L_S}{\xi_S}$ by contradiction:

Suppose not, then it must be that

$$\frac{L_l}{\xi_l} = \frac{L_S}{\xi_S} \quad (i)$$

or

$$\frac{L_l}{\xi_l} > \frac{L_S}{\xi_S} \quad (ii)$$

Case (i)

Since $\frac{L_l}{\xi_l} = \frac{L_S}{\xi_S}$, then given that $\xi_l = \xi_S$, from A.1 it must be that:

$$L_l = L_S$$

and

$$n(1 - \kappa(QE) + \alpha_l(\xi) - \delta) = n(\alpha_S(\xi))$$

from A.14.

From A.8 and A.1, since $\alpha_l(\xi) = 0$ and n is a positive constant, it follows that $1 - \kappa(QE) - \delta = \alpha_S(\xi)$ and after adding δ to both sides:

$$1 - \kappa(QE) = \alpha_S(\xi) + \delta$$

However, this contradicts A.11 that $1 - \kappa(QE) < \alpha_S(\xi) + \delta$

$$\therefore L_l \neq L_S \text{ and Case (i) is false}$$

Case (ii)

Since $\frac{L_l}{\xi_l} > \frac{L_S}{\xi_S}$, then given that $\xi_l = \xi_S$, from A.1 it must be that:

$$L_l > L_S$$

and

$$n(1 - \kappa(QE) + \alpha_l(\xi) - \delta) > n(\alpha_S(\xi))$$

from A.14.

From A.8 and A.1, since $\alpha_l(\xi) = 0$ and n is a positive constant, it follows that $1-\kappa(QE)-\delta > \alpha_S(\xi)$ and after adding δ to both sides:

$$1 - \kappa(QE) > \alpha_S(\xi) + \delta$$

However, this contradicts A.11 that $1 - \kappa(QE) < \alpha_S(\xi) + \delta$

$$\therefore L_l \not> L_S \text{ and Case (ii) is false}$$

Conclusion

Since $L_l \neq L_S$, $\frac{L_l}{\xi_l} \neq \frac{L_S}{\xi_S}$ and $L_l \not> L_S$, $\frac{L_l}{\xi_l} \not> \frac{L_S}{\xi_S}$

$$\therefore \text{it must be the case that} : L_l < L_S, \frac{L_l}{\xi_l} < \frac{L_S}{\xi_S}$$

This completes the baseline proof.

Proof of Lemma 1

From the conditions in A.10 it is seen that:

When $QE_i = QE_2$, it follows that $1 - \kappa(QE_i) \approx \alpha_S(\xi) + \delta$

Then it follows that:

$$L_l = n(1 - \kappa(QE) - \delta + \alpha(\xi)) \text{ and } L_S = n(\alpha_S(\xi))$$

From A.8 and A.1, since $\alpha_l(\xi) = 0$ and n is a positive constant, it follows that

$$L_l = n(1 - \kappa(QE) - \delta) \text{ and } L_S = n(\alpha_S(\xi))$$

Then substitute $\alpha_S(\xi) + \delta$ for $1 - \kappa(QE_i)$ and get: $\alpha_S(\xi) \approx \alpha_S(\xi)$

$$\therefore \text{ it must be the case that: } L_l \approx L_S, \frac{L_l}{\xi_l} \approx \frac{L_S}{\xi_S}$$

3.6 Comparative Statics

The results show that the large bank will make loans only to the firms with risk-adjusted returns that are above the reserve interest rate. The model demonstrates that duration risk premiums are compressed by central bank quantitative easing $\kappa(QE)$, $\frac{\partial \kappa}{\partial QE} > 0$, and soft information risk premiums $\alpha_S(\xi)$ are not affected by central bank purchases and remain exploitable to only small relationship banks. So the upper bound of risk-adjusted returns differs for small and large banks. This upper bound is represented by V_i. Define V_i as:

$$V_i = \begin{cases} 1 - \kappa(QE_M) + \alpha_l(\xi) \quad for \quad i = Large \\ \\ max[1 - \kappa(QE_M), \delta + \alpha_s(\xi)] \quad for \quad i = Small \end{cases} \tag{3.13}$$

Since large banks cannot process soft information, $\forall\ \xi$ the value of $\alpha_l(\xi) = 0$ for $i = Large$. Large bank funded loans will span the range of risk-adjusted returns from the reserve interest rate:

$$F_L = [\delta, 1 - \kappa(QE_2)]$$

From δ to the new upper bound of risk-adjusted loans $1 - \kappa(QE_2)$. The small bank will fund loans $F_S = [\delta, \delta + \alpha(\xi)]$ between the reserve interest rate δ and the upper bound of risk-adjusted loans,$\delta + \alpha(\xi)$.

From Lemma 1, there exists a level of purchases where the central bank will be considered a dominant market maker in mortgage backed securities. At this level there exist loans where duration risk premiums will be lower than relationship risk premiums. This means that the upper bound of risk-adjusted loans is greater for a small bank than a large bank.

$$1 - \kappa(QE_M) < \delta + \alpha_S(\xi)$$

Now I can calculate the number of loans that can get funded by subtracting the lower bound δ from both sides and multiplying by n, the endowed loanable funds of both banks.

$$n(1 - \kappa(QE_2) - \delta) < n(\delta + \alpha(\xi) - \delta)$$

The results also hold when looking at unfunded loans. Define unfunded loans to be ϕ_i.

$$\phi_i = n(\delta + (1 - V_i))$$

By substitution in V_L and V_S, defined earlier in this section, it is trivial to show that $\phi_L > \phi_S$ unfunded loans of large banks will be greater than unfunded loans of small banks. These results hold in all situations when a central bank becomes a dominant market maker in mortgage backed securities. The uniform distribution of risk-adjusted returns before and after central bank actions prevents equilibrium corner solutions. The results show that a new equilibrium exists where a small bank will fund more loans than a large bank in our model. This is because the small bank can acess relationship lending premiums that large banks cannot. This also means that given the same pool of loans, the large bank will have more relative risk aversion than the small bank. In our model, QE_D represents a level of monetary policy where the central bank becomes a dominant market maker and transactional interest rates are compressed by a factor of $\kappa(QE_D)$ so that a large bank has fewer loans that exceed the opportunity cost of lending relative to the small bank. The small bank's net interest margins are protected by its access to higher margin relationship lending. This hypothesized relationship would mean that small banks are sensitive to its relatively greater lending margins, while large banks will be sensitive to QE and reserve premiums, especially after QE_D. This hypothesized relationship and timing is verified by empirical results in the next section. Empirical predictions of this model that are tested in this paper are the following and also discussed in Section 3.2.6:

1. Reserve premiums will have a negative relationship with bank lending.

2. Reserve premiums will have a positive relationship with excess reserve holdings.

3. Excess reserves will have a negative relationship with bank lending.

4. This negative relationship between reserve premiums and bank lending will be stronger in transactional banks compared to relationship banks.

The theory highlights two key dynamic relationships in the model. The first is the relationship between the reserves premium and level of cash held in reserves. As the reserves premium ρ_r increases, banks are incentivized to hold more excess reserves R at the Federal Reserve.

$$\frac{\partial R}{\partial \rho_r} \geq 0$$

The second is the dynamic relationship between risk-adjusted returns of loans and reserves. A bank will maximize risk-adjusted returns by allocating capital to either lending or reserves. With capital constraints, this bank allocation between reflects a negative relationship between lending and reserves as:

$$\frac{\partial L}{\partial R} \leq 0$$

So as banks hold more excess reserves, this will contemporaneously reflect higher lending risk aversion. Naturally, as risk-adjusted returns of excess reserves rise, this will also give incentive to lend less, reflecting higher lending risk aversion. This is represented as $\frac{\partial R}{\partial \rho_r} * \frac{\partial L}{\partial R} = \frac{\partial L}{\partial \rho_r} \leq 0$. In this three variable system:

$$y_t = \begin{Bmatrix} R_t \\ \rho_t \\ L_t \end{Bmatrix}$$

I look for the effect of innovations on reserves premium ρ_r in a VAR model and the corresponding impulse response function in Section 3.3.2.

3.7 QE3's Separation of Banking Risk Aversion

I use H8 balance sheet data from the Federal Reserve and financial institutional research which highlights QE3 crossing an important threshold of Federal Reserve MBS ownership [113], an event study was performed on whether or not QE3 was a turning point for divergence of risk aversion between big banks and small banks. Pre-QE3 is defined as December 1, 2008 to September 12, 2012, while Post-QE3 is defined as the day of announcement, September 13, 2012 to August 19, 2015. Different time periods were also tested using QE3 as the cutoff and consistently similar results. The null and alternative hypothesis of this model is defined as:

$$H_0 : \hat{\mu}^{PreQE3} = \hat{\mu}^{PostQE3}$$

$$H_a : \hat{\mu}^{PreQE3} \neq \hat{\mu}^{PostQE3}$$

The mean differences for the two time periods, before QE3, $\hat{\mu}^{PreQE3}$, and after QE3 $\hat{\mu}^{PostQE3}$ is defined as:

$$\hat{\mu}^{QE3} = \frac{1}{T} \sum_{t=1}^{T} \left(\frac{\sum_{l=1}^{n} Loans_{l,t}^{\text{T-Banks}}}{\sum_{l=1}^{n} Cash_{l,t}^{\text{T-Banks}}} - \frac{\sum_{l=1}^{n} Loans_{l,t}^{\text{R-Banks}}}{\sum_{l=1}^{n} Cash_{l,t}^{\text{R-Banks}}} \right)$$

Using Welch's t-test (results not shown in this paper), I compared the weekly difference between relative risk aversion of all large T-banks and all small R-banks. Large T-banks are defined as the the top 25 domestically chartered banks, ranked by domestic assets in Call Reports issued by the Federal Reserve. Small R-banks are defined as all domestically chartered commercial banks not included in the top 25.

This event study shows that there is a significant diversion in risk aversion between banks before and after QE3 in loan sectors such as residential real estate loans, commercial real estate loans, consumer loans, and other loans and leases as well as MBS securities holdings. This shows strong evidence of an existence of a threshold where large banks and small banks will diverge in their lending risk aversion as a result of QE3. This supports this paper's banking agent model that incorporates the effects of quantitative easing in its lending appetites. Considering that QE3 saw the Federal Reserve's holdings of MBS securities skyrocket from less than 10% to over 29% of all MBS outstanding in the market it should not be much of a surprise that QE3 would be an inflection point rather than QE1 or QE2.

Chapter 4

Disproportionate Costs of Uncertainty: Small Bank Hedging and Dodd-Frank

Hedging reduces uncertainty, but only for those who can afford it. Four years after Dodd Frank was signed into federal law on July 21, 2010, law makers were still shaping capital risk requirement policies, increasing uncertainty and information costs for bank compliance, especially for smaller community banks [50]. After the Recession of 2008, lawmakers were under little political pressure to differentiate between low risk "plain vanilla" interest rate swaps and riskier derivatives such as collateralized debt obligations (CDO's) and credit default swaps (CDS), which were often blamed for the financial crisis. However, interest rate derivatives are commonly used by small community banks and large transactional banks to hedge interest rate risks such as 60 day mortgage rate locks. This paper measures the costs of uncertainty by analyzing newly available mortgage securitization data from the Federal Financial Institutions Examination Council and whether this cost was disproportionately higher for community banks. I find that uncertainty surrounding Dodd

Frank is associated with a 35% loss in mortgage securitization income and a 49-55% reduction in hedging for community banks compared to transactional banks. The differences is evident in Fig **??** and Fig **??** [1] as community banks mostly use interest rate derivatives for non-trading while holding higher balances of residential mortgages.

This paper measures the costs of regulatory uncertainty by examining "vanilla" hedging activity around the deliberations of Dodd Frank. Initially, I expect to find less hedging during regulatory uncertainty when information costs are higher for banks. I also expect to find a disproportionate cost of regulatory uncertainty with community banks facing a higher information cost as a percentage of expenses. However, this is not entirely clear as larger banks may have higher costs due to financial lawsuits and targeted regulations. Since the financial crisis, banks such as Bank of America and JPMorgan Chase have been assessed fines of $76 billion and $44 billion respectively while smaller community banks have never been assessed such large fines. On the other hand, smaller community banks may have higher costs of regulatory uncertainty because of their lack of financial resources and higher regulatory expenses [50] expose more sensitivity to information costs. Higher information costs may reduce or delay interest rate hedging which may constrain credit availability.

The use of interest rate derivatives for hedging purposes is shown in Figure **??** where community bank's hedging activity closely tracks mortgage securitizations. Hedging mortgage rate risk from application until delivery to third parties is a crucial step in bank risk management. [2]. This

[1] Figure **??** demonstrates that community banks use interest rate derivatives for non trading purposes while holding a higher percentage of residential mortgages while larger transactional banks use interest rate derivatives for trading while holding a lower percentage of residential mortgages. All figures exclude TBTF banks and show even when excluding the largest banks, there still remains considerable heterogeneity in the use of derivatives between community and non-community banking models.

[2] Federal Housing Finance Agency has released guidance on how To Be Announced (TBA) mortgages are sold in the Agency MBS market and hedged with interest rate swaps.
https://www.fhfa.gov/SupervisionRegulation/Documents/Securitizations_Module_Final_Version_

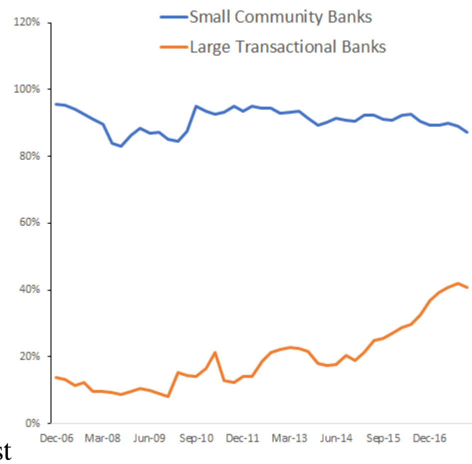
is supported by the aggregated data suggesting a strong positive relationship between non-trading IRD and securitized mortgages. In figure **??**, large transactional banks (not TBTF) exhibit a similar relationship, but a higher ratio of non-hedging IRD suggests that bank level differences may not be similar to community banks.

The Schedule RC-P 1-4 Family Residential Mortgage Banking Activities is a new mortgage banking reporting requirement that started in 2006 Q3[3]. One newly reported line item is RIADF184, which is non-interest income from mortgage securitization. This line item is especially informative as a dependent variable in measuring the effect of hedging mortgage securities. For hedging activities, I look at interest rate derivatives that banks use to hedge *held for sale* mortgages also reported in the Schedule RC-P. This new reporting requirement provides an instrument linking mortgage banking activities and hedging activities, which provides an ideal setting to examine the effects of derivative regulation on hedging and mortgage income. Hedging interest rate risk is integral for financial intermediation [62] and central in banks provision of credit access. As far as I am aware, this paper is the first to explore the role of hedging using new reporting requirements of the RC-P of the Call Reports.

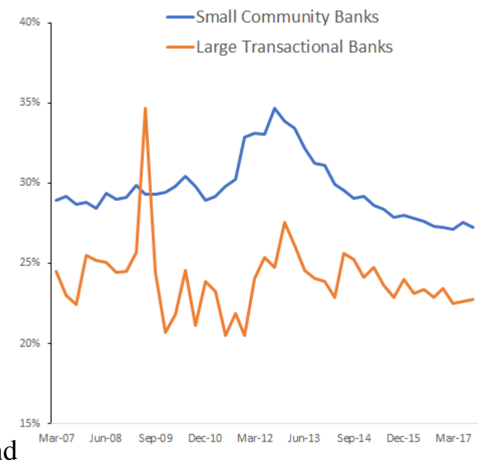
The rest of this paper is organized as follows: Section 4.1 covers the literature review on regarding banking uncertainty and the use of interest rate derivatives in banks, Section 4.2 covers the theoretical underpinnings of how banks consider risk weightings and risk adjusted returns in capital allocation, Section 4.3 and 4.4 goes over the data and empirical results, and lastly, Section 4.5 outlines the conclusions of this paper.

1.0_508.pdf

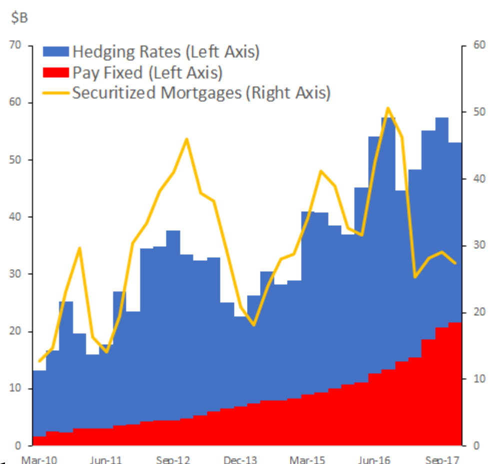
[3] The Federal Deposit Insurance Corporation (FDIC) and Financial Accounting Standards Board (FASB) under FAS 149 has outlined that interest rate swaps are recorded when banks hedge *held for sale* mortgages, not *held to maturity* mortgages. Both are listed in the RC-P Family Residential Mortgage Banking Activities.
https://www.fdic.gov/regulations/safety/manual/section3-8.pdf

figfirst 

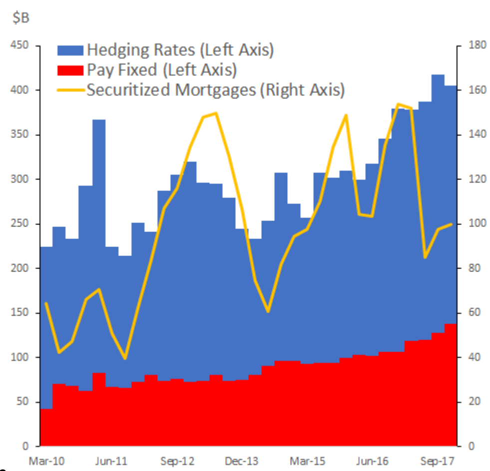
(a) Non Trading IRD/Total IRD %

figsecond 

(b) Residential Loans/Total Loans %

figthird 

(c) Small Community Banks

figfourth 

(d) Large Regional Banks

Figure 4.1: Subfigure (a) represents aggregated non trading interest rate derivatives (IRD) as a percentage of total interest rate derivatives as reported on the RC-L Derivatives and Off Balance Sheet Items section of the Call Reports. Subfigure (b) represents residential loans as a percentage of total loans as reported on the RC-C section of the Call Reports. Community banks and non-community banks are identified by the FDIC figures exclude TBTF banks as identified by the Federal Reserve. Subfigure (c) and (d) are represented by:

$$\textit{Non Trading IRD} = \textit{Hedging IRD} + \textit{Pay Fixed IRD}$$

Hedging IRD are non-trading interest rate derivatives where banks enter into an agreement to pay floating while Pay Fixed IRD are non-trading interest rate derivatives where banks agree to pay fixed interest rates to a counterparty. Securitized mortgages are the sum of residential mortgages sold and held for sale as reported in the RC-P of the Call Reports.

4.1 Literature Review and Discussion

Two strands of literature serve as the foundation for this paper. The first strand of literature highlights the fundamental mechanisms behind bank hedging, specifically the use of interest rate derivatives in hedging interest rate risk. This paper contributes to this literature by being the first show a direct hedging mechanism using new Federal Reserve reporting requirements containing data on mortgages sold to third parties and interest rate lock swaps. The mechanism used in this paper also contributes the literature on costs of uncertainty as it relates to regulations and economics. More specifically, a growing subsection of literature on the costs of regulatory uncertainty as it pertains to banks during Dodd-Frank.

Interest Rate Hedging in Banking

Banks are essentially repositories for interest rate risk [91], and risk management of this exposure is central to its function. Banks find it optimal to hedge all interest rate risk, leading to an improvement in it's financial intermediation capabilties [62] Financial intermediaries use of interest rate hedging provides a great setting to measure regulatory uncertainty, as interest rate derivatives are the most widely used derivative among banks, both small and large. The literature empirically demonstrates the positive relationship between derivative use and loan growth [35, 119][4] which allow banks to hedge exposure to macroeconomic, credit, and cash flow risks[5]. Cash flow risk can stem from many difference sources such as mismatched maturities [136], repricing risk, bankruptcy risk [142], financing risks [83], interest rate risk, monetary policy risks, and market

[4] [35] found that banks that use interest rate derivatives experience greater growth in their loan portfolios than banks that did not use them.

[5] Hedging their interest rate risk allows firms to increase firm value by lowering expected transaction costs of bankruptcy [142] as well as avoiding the costs of external financing during low internal cash flow states [83].

risks. Hedging allows for lending policies become less sensitive to macroeconomic shocks with the use of interest rate derivatives [136] and subsequently lend more than non-users of derivatives. This paper specifically focuses on banks hedging of interest rate risk of mortgage originations sold to third parties, which were new regulatory reporting requirements in the Call Reports starting in 2006 Q3, and has not been covered previously in the banking literature. Heterogeneity in hedging practices of mortgages held for sale is also explored for the first time in this paper, following the extensive literature on heterogeneity in banking practices.

Heterogeneity of banking models is reflected in differences between relationship lending in community banks transactional lending in larger non-community banks. This fundamental heterogeneity is also reflected in how community banks use "vanilla" interest rate swaps for mostly "interest rate locks" on mortgages while larger banks use interest rate derivatives for more complex tasks such as dealer intermediation [18][6] , and speculation [91][7]. This heterogeneity is also extended to differences in compliance costs for banks. It might be surprising to some that although larger banks have more complex financial intermediation to regulate, the relative burden of compliance costs is much higher for smaller community banks. This higher regulatory burden on smaller community banks has been well researched by academics, regulators, and practitioners. These sentiments were also confirmed by the Conference of State Bank Supervisors (CSBS) as eighty-five percent of bankers surveyed also cited that regulatory costs were important in considering acquisition offers [51] [8] This unique dataset by [50] documents surveyed compliance costs collected by the Conference of State Board Supervisors, documenting a clear trend of higher compliance costs in smaller banks

[6][18] find that banks use pay-fixed positions in swaps to insure against surprise interest rate increases, but did not find evidence of interest rate derivatives being used to hedge loans. [103] and [45] also show this empirically, while [108] use a theoretical framework to study why non-financial firms need pay-fixed swaps

[7] [91] find that agents claim that speculative risk taking was unintentional.

[8]Unfortunately, non-interest expenses in Call Reports do not break down compliance costs, making the task of quantifying the level of compliance burden difficult.

after the passage of Dodd Frank, supporting similar findings by [49]. [50] found heterogeneity of compliance costs as smaller banks faced compliance costs of 8.7% as a percentage of non interest expenses compared to 2.9% larger banks. These higher costs stem from fixed costs of compliance such as the Bank Secrecy Act, RESPA, TILA, Regulation Z, qualified mortgages, data reporting, accounting audit, and consulting and appraisal advisory services [86]. Survey responses showed that community bankers frequently hire outside consultants on an incremental, need to know basis, representing an information cost mechanism for regulatory uncertainty [9] Given that the cost of compliance is higher for community banks, I use the community banking classification to proxy for higher costs of uncertainty in the empirical model. This proxy is also confirmed in a logistic empirical test.

Costs of Regulatory Uncertainty

How does anticipation of regulatory uncertainty play into this heterogeneity across banks? As the uncertainty literature has shown, risk factors in the financial regulation peaked after the passage of Dodd Frank in 2010 Q3 [12], which can impose economic costs for banks as well. Restrictive regulation can lead to volatile events such as asset sales [33] used to satisfy capital requirements. Regulatory requirements can have the effect of shrinking balance sheets and given the complimentary nature of loans and interest rate derivatives, regulatory uncertainty surrounding IRD may disincentivize this symbiotic pairing and as a result, reduce hedging activities. This is precisely what I find in this paper. A reduction in hedging due to regulatory uncertainty would also be broadly consistent with literature on banking regulation and how uncertainty has negative effects

[9] The cost of compliance is not dependent on credit quality of a bank, as [50, 51] finds that bank regulatory burden varies by size among banks with similar CAMEL ratings, which is a measurement rating for bank asset quality and management.

on bank lending [90, 31], contributing to a growing importance on a banking perspective on effects of economic policy uncertainty [12, 36, 29, 116, 88] on the economy.

Regulatory rule making processes in banking allows for banks to comment on proposed rules, naturally favoring banks with the financial and legal resources to engage in a dialogue with regulators. Given the information cost asymmetry as a percentage of non-interest expenses [50], banks with high information costs can face significant periods of uncertainty while comments are considered and debated prior to the issuance of the final rule [102]. While [102] found that the SEC took an average of 313 days between a rule proposal and a final ruling, the period of uncertainty in this study took four years from the passage of Dodd Frank in 2010 until February 20, 2015 when the FDIC released the final rule to be used on March 31, 2015 [77]. This long period of regulatory uncertainty could have a particularly negative cost for banks with limited resources for compliance as the bank's benefits of waiting for a final ruling increases with a longer period of uncertainty. Until a final ruling is reached, banks may also engage in lobbying efforts to change proposals [34], as some consequences of meeting capital requirements are asset sales [33]. Information costs of regulatory uncertainty in banking is also compounded by three different regulators, the Federal Reserve, Office of the Comptroller of the Currency (OCC), and the Federal Deposit Insurance Corporation (FDIC) coordinating their efforts to pass a Basel III Final Rule in July 2013, which also considers changes required by the Dodd-Frank Act of 2010 [95].

Discussion

Uncertainty in banking regulations has already shown to have detrimental effects on lending. For instance, [90] looks at the period of uncertainty in mortgage regulations from 2011-2014 and documents its negative effects on bank lending at the firm level. Banks reaction towards uncertainty is in line with [102] who found that banks anticipate and adjust to regulatory uncertainty in real time. In a highly regulated industry like banking, academic literature also measures the costs of funding uncertainty and crisis regulations on different types of banks as [137] points to bank level differences in lending due to costs of funding uncertainty while [13] and [49] research the actual effects of Dodd-Frank and finds an increased regulatory burden for smaller banks. [12] also finds that at the firm and industry level, there can be heterogeneous effects of uncertainty. This paper extends this literature on the heterogeneous costs of uncertainty into the banking sector. As far as I know, this is the first paper to look at the effects of regulatory uncertainty on hedging activity and its varying impact at the bank level. Using new regulatory data on mortgage originations in the Call Reports, I examine a period of regulatory uncertainty regarding the undecided risk weightings of bank balance sheet assets, which impacted smaller banks that were well capitalized during the global financial crisis.

The period of uncertainty used in this study relates to Dodd Frank's Subpart D, Section 34 which outlines future changes for risk weighting of interest rate derivatives, such as eliminating the 50% risk weight cap on interest rate derivatives. On October 25, 2012, the American Banker's Association wrote in a letter to the Office of the Comptroller of the Currency and the Board of Governors of the Federal Reserve System "The impact of changing risk weight calculations [on assets] is surprising to many that have been and remain well capitalized through the most recent economic difficulties." This period of uncertainty starts from the passage of The Dodd-Frank Wall Street Reform and Consumer Protection Act in 2010 until February 2015 when risk weightings for regulatory capital were finally released by the Federal Insurance Deposit Corporation (FDIC) and the Federal Reserve [77] [10]. Dodd Frank's risk-based capital regulations were mostly centered

[10] ["Proposed changes starting March 31, 2015] will include an increased number of risk-weight categories to which

around regulating complicated large too-big-to-fail (TBTF) banks, which drew out the process of final rulings on various regulatory measures such as risk weightings for interest rate derivatives [139]. This unusually long period of regulatory uncertainty from 2010 to 2014 in a highly regulated industry provides a unique environment to study the costs of uncertainty on a banking services.

4.2 Framework

I present a simple model of a bank's objective function in optimizing between lending and market based trading similar to [30] using a maxmization of risk adjusted returns similar to [114]. Instead of market based trading in [30], I use hedging derivatives for non-trading purposes and instead of using just risk adjusted returns based on volatility and credit risk as in [**?**], I also consider the relative risk weighting ω of risk adjusted returns for each investment, defined as capital risk requirements defined by a regulatory body. Returns of derivative investments $r_{i,s}$ are defined by many of the fundamental assumptions in [87], [6], and [**?**].

In simple form, banks will maximize their capital allocation decision by considering the risk adjusted return of a loan and an interest rate derivative contract. $\tilde{R}$ is defined as risk adjusted returns and $\tilde{R}_\omega$ is the risk weighted risk adjusted returns defined in this simple model as:

$$\text{Risk Weighted-Risk Adjusted Return}_i = \frac{1}{\kappa}\sum_{i=1}^{\kappa} \max\left[\frac{\tilde{R}_i^{Loan}}{\omega_i^{Loan}}, \frac{\tilde{R}_i^{Derivative}}{\omega_i^{Derivative}}\right]$$

Consider an economy comprised of n firms (or individuals) with a measure of unity based

on-balance sheet assets, derivatives, off-balance sheet items, and other items subject to risk weighting would be allocated." in a news release by the FDIC on February 20, 2015 [77] normalization and bank i with with a level of bank equity $\kappa \in \{C, \rho\}$ representing a community bank and a regional bank, respectively. In this economy, each firm has unitary loan considerations with the bank, representing heterogeneous loans with a uniform based distribution of risk adjusted returns $\tilde{R}_j \in [0, 1]$. L is a transformation function that maps $\tilde{R}_j$ onto a uniform distribution of lending returns, $L \in [0, 1]$, from the perspective of the bank's treasury department, who additionally considers the balance sheet risk of the loan. The final consideration of risk weighting, $\omega_{\kappa,t}$ captures the standardized measure of risk weighting by an outside regulatory body. This risk weighting considers the bank's portfolio of loans and derivatives at time t, which is 50% for both types of assets and at time $t + 1$ which is 100% for just derivatives.

propositionDerivative skill" and compliance costs are a function of a bank's economy of scale α and banking type. As α increases, the marginal cost of derivatives and regulatory compliance decreases. Derivatives skill initially has a high fixed cost of acquisition. Fixed costs of compliance and the first derivatives trader employee is proportionately high and variable cost is low because of the scalability of derivatives transactions.

Interest rate derivative contracts are measured in a unity based normalization where the risk adjusted returns are represented by $\tilde{R}_r \in [0, 1]$. From the perspective of a bank's treasury department, risk adjusted returns are measured also in risk management gains from interest rate risk management, hedging maturity mismatch risk and portfolio repricing risk, as well as dealer broker activities. Purnanandam (2007) empirically equates derivative use as a way for a bank to manage the cost of financial distress.

propositionommunity banks with a level of bank equity C have a low derivatives skill and are mostly end users, implementing derivative strategies for simple hedging defined as mortgage forward contracts that lock in an interest rate for delivery in the future. This forward allows banks to offer interest rate locks to mortgage clients during the origination and underwriting process. Regional banks with a level of bank equity ρ have a higher rate of derivatives skill, and engage in dealer intermediation, derivatives trading, and a higher rate of derivatives usage relative to bank assets and loan holdings.

$\tilde{R}$ will take into consideration costs related to economies of scale and balance sheet exposures. The following framework allows for the additional interest rate and repricing risk that a loan acquisition adds to a bank's balance sheet, the risk weightings for each type of investment, and the costs related to acquiring "derivative skill" to hedge balance sheet risks. A bank i will deploy a unit of capital j at time t to either loans or interest rate derivatives, choosing to invest a unit of capital to the asset with a higher risk weighted return.

$$\tilde{R}^{\omega}_{i,j,t} = \max_{\theta,L}\left[\frac{\tilde{R}^{L}_{i,j,t}(r^m, I(L,\theta))}{\omega_t(L_{i,j})}, \frac{\tilde{R}^{\theta}_{i,j,t}(r^s, I(L,\theta))}{\tau^{\theta}_{i,t}(\alpha_{i,t})\times\omega_t(\theta_{i,j})}\right]$$

$\tilde{R}^{\omega}$ = *Risk Weighted Adj Return* r^m = *Mortgage rate*$_t$

θ = *Interest Rate Lock Swap* r^s = *Swap rate*

L = *Securitized Loan* τ^{θ} = *Information cost of derivative risk weightings*

I = *Balance Sheet Risk* α_i = *Scale of bank*

Before Dodd Frank, given the similar risk weightings of 50% for balance sheet first lien residential mortgages and a 50% maximum risk weighting given for off balance sheet interest rate derivatives, an equilibrium would be reached where the marginal benefit of interest rate derivatives would be equal to the marginal effect of derivative risk weighting in the context of overall risk weighted returns.

$$\frac{\partial I(L,\theta)}{\partial L} \geq 0 \quad (1) \qquad \frac{\partial I(L,\theta)}{\partial \theta} \leq 0 \quad (2)$$

$$\frac{\partial \tilde{R}^L}{\partial I} \leq 0 \quad (3) \qquad \frac{\partial \tilde{R}^\theta}{\partial I} \geq 0 \quad (4)$$

In equation (1), the partial derivatives show that balance sheet risk of a bank goes up as the bank takes on more loans, and equation (2) shows that balance sheet risk goes down with more interest rate lock derivatives. This assumes that balance sheet risk is comprised of mostly interest rate risk. Equation (3) shows that when interest rate risk of a bank balance sheet goes up, the risk adjusted return of an additional loan goes down. Likewise, equation (4) shows that when interest rate risk of a bank's balance sheet goes up, the risk adjusted return of an additional interest rate derivative goes up. Taking equations (2) and (3) the multiplicative result is that:

$$\frac{\partial \tilde{R}^L}{\partial \theta} \geq 0$$

As a bank increases its interest rate derivatives, it lowers the interest rate risk of a bank and increases (or keeps constant) the risk adjusted return of originating a mortgage, given all else equal. Taking equations (1) and (4) also similarly lead to $\frac{\partial \tilde{R}^\theta}{\partial L} \geq 0$ where an additional mortgage holding increases the interest rate risk of bank, thereby increasing the risk adjusted benefit of an interest rate derivative used for hedging.

The key insight of this paper is highlighted in the relationship between interest rate derivatives and mortgage originations. Banks that offer interest rate locks on mortgages to borrowers take on interest rate risk before a loan is closed. While a borrower "locks in" a mortgage rate, the time from approval to closing may take anywhere from 30-90 days, during which time the bank is exposed to interest rate volatility. In order to hedge this interest rate risk, banks can originate a loan intended for sale and enter into forward contracts with a third party buyer before delivery of the underlying loan to the buyer. This is important because banks will record a derivative contract before it records a loan. This means that a key relationship of the variable is:

$$\frac{\partial \tilde{R}_t^L}{\partial \theta_{t-1}} \geq 0 \implies \frac{\partial L_t}{\partial \theta_{t-1}} \geq 0$$

The partial derivatives show an increase in interest rate derivatives will lead to an increase in risk adjusted returns of a loan in the next period. This will increase lending. The use of interest rate derivatives can hedge interest rate exposures, so that a bank can take additional risk in the future, showing a positive link between derivatives and lending.

I then introduce the condition of a regulatory shock with a similar structure to Dodd Frank in Subpart D, Section 34 which outlines new rules for risk weighting of interest rate derivatives.

conditions regulatory risk weight increases are implemented from $\omega_t \rightarrow \omega_{t+1}$, the risk weightings of interest rate derivatives will increase from 50% to 100%, while remaining the same for loans.

After Condition 1, a bank will recalibrate the its optimal risk weighted return based on the optimal scenario framework.

theoremfter a regulatory shock reduces the risk weighted risk adjusted returns of an interest rate derivative, banks will use less interest rate derivatives leading to less lending in the new equilibrium.

As a regulatory risk weight increase is implemented, represented by $\omega_t \rightarrow \omega_{t+1}$, the risk weight of an interest rate derivative will rise from 50% to 100% and apply to both scenarios in this paper's framework. In the first scenario for a regional bank, $\tilde{R}^{\omega,\theta}_{regional}$, the marginal benefit of derivatives will fall as a result of this higher risk weighting, increasing the balance sheet risk and lowering $\tilde{R}^{\omega,L}_{regional}$, the risk weighted risk adjusted benefit of loans. Community banks with lower derivatives skills are more conservative and hold greater marginal benefits from derivative hedging than regional banks. Community banks will see a similar but stronger effect from an increase in risk weights of interest rate derivatives. Community banks will also have a greater effect because of the higher information cost during regulatory uncertainty. As a smaller bank gains more derivative skills, the balance sheet becomes more optimal and will eventually reach the same equilibrium as a regional bank where $\frac{\partial \tilde{R}^{\omega}}{\partial \theta} = \frac{\partial \tilde{R}^{\omega}}{\partial L}$.

Two key predictions that will be tested are that regulatory uncertainty regarding risk weights of interest rate derivatives will lead to lower usage of derivatives used for hedging, especially amongst community banks with higher information costs and lower derivative skills. The other prediction is that lower hedging derivative usage will lead to less lending in the future. The empirical section in section 4.4 will set up and test these predictions.

4.3 Data

I obtained the data for empirical testing from three main sources: 1) Federal Reserve's Call Reports which contain quarterly financial data of all US insured commercial banks, 2) Compliance cost data from the Conference of State Board Supervisors and 3) Chicago Board of Exchange for interest rate swap data, covering the period from 2006 Q3 to 2017 Q4. 2006 Q3 is the first quarter where the FDIC required banks to report detailed mortgage activities, including the amount of mortgages originated, sold, and held for sale or investment throughout the quarter. This detailed mortgage data is reported in the Schedule RC-P 1-4 Family Residential Mortgage Banking Activities and is central to this paper's analysis. The RC-P form (Figure 4.2) is also shown in on a graph in Figure **??**, **??**, **??**, **??** allows for a clean lending instrument for interest rate hedging because it is standard practice in the mortgage banking industry to offer borrowers an interest rate lock during the underwriting process of a mortgage application. In order to offer an interest rate lock without taking on additional interest rate risk, the bank enters into a forward interest rate contract to deliver the underlying mortgage in the future to a third party who will purchase the loan. When Dodd-Frank Act passed in 2010Q4, deliberations regarding final risk weightings for interest rate derivatives which include forward contracts to deliver mortgages for sale were not finalized and implemented until February 20, 2015, mandating 2015 Q1 as the first reporting quarter where regulatory certainty was established. Smaller banks such as community tend to use interest rate derivatives mostly for non-trading purposes as seen in Figure **??** and have higher information costs during times of regulatory uncertainty.

The data in this paper starts with all bank listed in the Call Reports from 2006Q3 to 2017Q4. This period was chosen because 2006Q3 was when the RC-P data was first collected. Banks were matched with FDIC Identifiers for Community Banks using the FDIC Certificate Number. TBTF banks were dropped from the data throughout the paper in order to study the effects of regulatory uncertainty on firms that were not subject to additional TBTF regulatory requirements such as stress tests. Banks that were not matched with Community/Non Community Banking identifiers were also dropped. Banks with missing IDRSSD were also dropped. Variables used in this paper were scaled by total assets and banks with total assets listed as zero or missing were also dropped. Banks that have zero or missing non-trading interest rate derivatives was also dropped from the sample. Non-trading derivatives are defined in this paper as total gross notional amount of derivative contracts held for purposes other than trading (RCON8725) as listed in the Schedule RC-L Derivative and Off Balance Sheet Items. Pay Fixed is defined as interest rate swaps where the bank has agreed to pay a fixed rate (RCONA589) and Hedging Derivatives are defined as non trading interest rate derivatives that are not pay fixed. Non trading interest rate derivatives include futures, forwards, written options, purchased options, over the counter options and swaps.

Consolidated and domestic bank data were merged and duplicates were eliminated. Due to various changes to reporting requirements such as the implementation of Dodd Frank, some call report variables are not consistent over time. Consistent time series were formed by looking at the Call Report forms and matching variables as they change from quarter to quarter. Summary statistics in Table 4.1, 4.2, 4.3, and 4.4 show that the median large regional bank has total assets that are over 3x larger than the median small community bank during uncertainty, and this difference grows after uncertainty ends. Small community banks do not use interest rate derivatives for trading, while the same is true for a majority of large regional banks. Smaller community banks are more conservative than larger regional banks as seen by lower overall non performing assets and smaller maturity gap rations across the board. Also, mortgage lending makes up a larger portion of community bank's business than it does for larger regional banks. Overall usage of interest rate derivatives for hedging is similar between the two types of banks. Compliance cost is also higher for smaller community banks.

In Table 4.5, compliance cost ratios were obtained from [50] and Call Reports. In [50], compliance cost data was collected from a survey conducted by state banking commissioners and the Conference of State Bank Supervisors (CSBS). The CSBS survey collected survey responses from 974 responders, and the final sample consisted of 469 banks. The survey asked bankers to identify five categories of expenses in 2014, in each of the following categories: 1) data processing; 2) accounting and auditing; 3) consulting and advising; 4) legal; and 5) personnel. Respondents were asked to specify the dollar amounts spent on compliance in these categories and these responses were used in Table **??**. Off balance sheet data on bank's use of interest rate derivatives were obtained from the Schedule RC-L of the quarterly Call Reports. Interest rate derivatives are defined as total gross notional amounts of interest rate derivative contracts held by either trading or non trading purposes. In examining the off balance sheet data, about 80-90% of derivative use consists of interest rate derivatives. Trading and non trading interest rate derivatives were combined for the variable "Interest Rate Derivatives". Total residential mortgages, residential mortgages sold, and residential mortgages held for sale are from the RC-P Family Residential Mortgage Banking Activities. C&I Loans are from the RC-C Loans and Lease Financing Receivables and Maturity Gap is calculated from the RC-A Cash and Balances Due from Depository Institutions, RC-C, RC-B Securities, and RC-E Deposit Liabilities. Non Performing Assets are from the RC-N Past Due and Nonaccrual Loans, Leases, and Other Assets. All variables are scaled by total assets except for compliance costs and the community banking identifier. The panel data used is on a quarterly basis and is from 2010Q4-2017Q4. Consolidated and domestic bank data were merged and duplicates were eliminated. Due to various changes to reporting requirements such as the implementation of Dodd Frank, some call report variables are not consistent over time. Consistent time series were formed by looking at the Call Report forms and matching variables as they change from quarter to quarter. All bank quarter observations reflect banks with active mortgage lending and derivatives divisions. The total number of bank quarter observations are 16,930 from 2010 Q4 to 2017 Q4. Summary statistics show that banks increased in asset size and all ratios after regulatory certainty was established. Concerns that increase in assets, lending and hedging are endogenous to an economic recovery are addressed by the use of two way and three way interaction variables between compliance burden, regulatory certainty, and covariates in Table **??**. management in regards to macro and interest rate risk in its long term balance sheet. Residential mortgages did not have it's risk weighting and capital treatment of 50% affected in Dodd Frank regulation. The first differences of this variable measures the change in willingness of banks to hold loans on it's long term balance sheet. This variable can be shown in simple form:

$$\text{Loans Held to Maturity}^{residential} = \text{Loans}^{total} - \text{Loans}^{heldforsale}$$

Loans Held to Maturity (LHM) represent a loan that is of higher credit quality and lower risk than a loan that is originated for sale. Low risk loans will also have little need for hedging, which is why the LHM shoud not and does not show any significant relationship with usage of interest rate derivatives used for hedgng. Mortgages originated for sale during the quarter will either be sold and listed in Mortgages sold or continued to be held in mortgages held for sale.

However, since mortgages that are held for sale can be held for more than one quarterly reporting period, there can be discrepancies in the total figures quarter to quarter. This is one reason why throughout the paper the left hand side and right hand side of mortgages above are not used in the same analysis. Also, interest rate derivatives used to hedge an ongoing loan application can be reported first because forward contracts are engaged before the closing and delivery of a loan to a third party. However, these issues seem to be minor and are not expected to cause any issues for this paper's main conclusions. In order to isolate the risk management function of derivatives to balance sheet risk, control factors were used. Banks mainly use interest rate derivatives for three reasons[11]: hedging [35], dealer intermediation [18] [103] [46][108], and speculation [91]. In order to control for dealer activity and speculation, Chicago Board of Options Exchange (CBOT) data consisting of the 10-Year Interest Rate Swaps and non-trading IRD are used.

4.4 Empirical Model and Results

4.4.1 Assumption Testing of Information Costs and Interest Rate Betas

First, I investigate the link between bank types and information costs. Banks with higher information costs will have more regulatory uncertainty. More regulatory uncertainty would mean less access and less informed decision making. In Table 4.5 a logit model was estimated where the dependent variable is the community banking classification and the predictor variable of interest is compliance cost as measured by [50, 51]. Compliance costs are estimated as a percentage of non-interest expenses.

The results of the regressions are as expected when looking across all specifications. Compliance costs, when looking at the z statistic values of 58.48 in the univariate (1) without clustered standard errors and 6.58 in the multivariate specification (5) with clustered standard errors, are the most significant in predicting a community banking identifier of a bank. These results allow for the use of community banking identifier as a proxy for high compliance costs and high

[11] Interest rate swaps are a core derivative product that banks use for dealer activities as well as hedging their balance sheet interest rate risk. [91] show that interest rate risk is non diversifiable and banks are repositories of interest rate risk. This interest rate risk is hedged using swaps ([91]) and in larger banks, swaps used for hedging are difficult to separate from speculation. Recent interest rate swap models are outlined in [18] and [149].

information costs. The results of this logistic regression also reinforce what the literature already tells us about the conservative and lending focused nature of community banks. In regression (5) you can see that the coefficients for maturity gap (-2.69) and non performing assets (-37.67) are still significantly negative after including bank cluster standard errors. A significant negative coefficient on total interest rate derivatives are not surprising because total interest rate derivatives include trading usage, and non-community banks have much higher usage of trading derivatives than community banks as seen in Figure **??**. One unexpected result is the positive significant result for Residential Mortgages Sold but no significance for Residential Mortgages Held for Sale in regression (5). This suggests that community banks seem to dispose of mortgage assets more quickly compared to non community banks. This would also fall into line with the overall more conservative nature of community banks with respect to risk.

Next in Table 4.6 I tested the assumptions used in this paper that market interest rates affect the risk adjusted returns for both loans and interest rate derivatives. This is an important empirical test in order to see how interest rates affect the composition of a bank's balance sheet over time. Because it may take anywhere from 30-90 days for a mortgage to close, if mortgage rates fall one quarter, it should affect mortgage closings in the future. In this multivariate panel data regression, you can see that it does hold true that falling mortgage rates are significant in increasing the volume of mortgages sold and held for sale in the current and future quarters. The combined beta of $\sum_{\tau=0}^{3} \beta^{MortSold} \Delta MortgageRates_{t-\tau}$ is (-.081) and $\sum_{\tau=0}^{3} \beta^{MortHeldSale} \Delta MortgageRates_{t-\tau}$ is (-.017) for community banks. This means that for every 100 basis point drop in mortgage rates in a quarter, it is expected to increase a community bank's mortgages sold as a percentage of assets by 8.1% and mortgages held for sale by 1.7% over the next few quarters. For larger banks the combined betas are (-.023) and (-.007) respectively. For every 100 basis point drop in mortgage rates in a quarter, larger banks are expected to increase mortgages sold as a percentage of assets by 2.3% and mortgages held for sale by .7% as a percentage of assets. Small banks have betas that are nearly 5x and 2x larger than larger banks respectively for mortgages sold and mortgages held for sale.

I also test the effect of 10Y swap rates on non-trading interest rate derivatives. Hedging IRD are also used when borrowers want a fixed interest rate instead of a floating interest rate on their loan. In order to convert their floating rate loan into a fixed rate loan, banks will offer to pay the borrower a "floating rate" and receive fixed from the borrower. This will effectively turn their floating rate loan into a fixed rate loan. The capability to offer fixed rate loans is especially important for banks, because when interest rates fall companies seek to lock in lower fixed interest rate payments and take a fixed rate loan with a bank. This is why we expect a banks interest rate derivative assets to increase when swap rates fall. Companies want to lock in lower interest rates and also hedge the volatility of their interest rate exposures. Later in Table To focus on hedging solely due to interest rate risk, maturity gap and non performing loans are used as covariates in order to control for potential use of derivatives due to mismatching of assets and liabilities due to balance sheet issues and also due to credit issues respectively. The combined beta of $\sum_{\tau=0}^{3} \beta^{HedgingIRD} \Delta SwapRates_{t-\tau}$ is (-.021) for small banks and (-.012) for larger banks. The R^2 for the estimated betas are low across Table 4.6, suggesting that interest rate betas are not the only explanation for the dependent variables that were tested. However, these tests do establish that market interest rates do play a part in understanding risk adjusted returns of mortgages and their respective hedging instruments.

4.4.2 Panel VAR

Next in Table 4.7 I test one of the main predictions in Section 4.2:

$$\frac{\partial L_t}{\partial \theta_{t-1}} \geq 0$$

An increase in hedging interest rate derivatives will increase lending in the future. This is because when a bank approves of a mortgage for a borrower, the bank offers an interest rate lock for a period of time. During this time, a bank will enter into a forward agreement with a third party to sell the mortgage to them in the future. This forward rate agreement increases the risk adjusted return of that mortgage asset because it hedges the bank from interest rate risk. This leads to more lending and more liquidity of mortgages sold in the future.

Key assumptions about the mortgage market hold in the Panel VAR. For instance, in (3) residential mortgages held for sale have a z-statistic of 4.36, confirming that the impact of RHS has a significant shock on time path of residential mortgages sold.. This makes sense because mortgages held for sale are sold in the future. In (4) mortgages held for sale is insignificant as expected, since mortgages that were sold are no longer able to be held for sale in the future. Regression (6) is where the main predictions is tested and confirmed with very strong results. $HedgingIRD_{t-1}$ has a z-statistic of 4.55, confirming that the impact of hedging derivatives in one quarter has a significant shock on the time path of residential mortgages originated for sale. In the Panel VAR (9) and (12), this same impact is confirmed in both small banks and larger banks. The impulse response is larger in larger banks, suggesting that the transactional nature of larger banks may be more timely and structured than smaller banks. Overall, the Panel VAR generally confirms the mechanics of the banking mortgage and hedging markets as outlined in this paper and do not produce any unexpected results.

4.4.3 Panel Data Regression with Three Way Interactions

This section will deal with the main empirical model in Table 4.8 and Table 3.5 which tests for the costs of regulatory uncertainty for banks with higher information costs. The specifications of the empirical model uses bank fixed effects, quarter fixed effects, bank and time clustered standard errors, and all bank specific continuous variables are scaled by total assets:

$$\frac{\textit{Hedging IRD}_{it}}{\textit{Assets}_{it}} = \alpha_i + \lambda_t + \textit{Community Bank}_i \times \textit{Regulatory Certainty}_t \times \frac{\textit{[Residential Mortgages Sold, Held for Sale]}_{it}}{\textit{Assets}_{it}} + X'\beta + \varepsilon_{it}$$

Control variables are maturity gap ratios for each bank and 10 year swap rates. There are two main hypothesis being tested. The first is that the costs of uncertainty is higher for banks with fewer resources and higher compliance costs. This will be tested by looking for evidence of "pent up demand" by looking at the three way interaction of two binomial dummies (one which is time invariant) with a continuous variable. In Table 4.8, the three way interaction term of Certainty × CB× Residential Mortgages Held for Sale has a coefficient of 1.196** and represents the additional amount of hedging that a community bank does when holding a mortgage intended for sale after uncertainty ends. This specification uses only bank fixed effects and bank clustering of standard errors. As I tighten the specifications in (2), (3), and (4) by adding time clusters, time fixed effects, and controls respectively, the significance of the three way interaction remains economically and statistically significant. The community bank identifier and the two way interaction of Community Bank × RMHS are not significant, suggesting that the difference in hedging between community banks and transactional banks occurs after Dodd-Frank rules are finalized and implemented. The three way interaction coefficient of 1.168** in (4) has the tightest specifications and shows that community banks increase hedging by 120.2% ($\frac{1.168+0.971}{0.971} - 1$) after final rules on risk weightings of interest rate derivatives are implemented. This suggests that hedging activity was muted by 54.6% during times of uncertainty for community banks ($1 - \frac{0.971}{0.971+1.168}$) This also suggests that smaller banks were exposed to 120.2% more interest rate risk due to residential mortgages held for sale during the four years of uncertainty when Dodd Frank rules were being debated and information costs were high.

In Table 4.9, residential mortgages sold is the dependent variable and the specifications are the same as Table 4.8. Here, the three way interaction term of Certainty × CB× RMS in (1) is 0.276* and this remains economically and statistically significant across all four specifications as the specifications are tightened in (2), (3), and (4) by adding time clusters, time fixed effects, and controls respectively. The community bank identifier and the two way interaction of Community Bank × RMS are not significant, suggesting that the difference in hedging between community banks and transactional banks occurs after Dodd-Frank rules are finalized and implemented. The three way interaction coefficient of 0.272* in (4) has the tightest specifications and shows that community banks increase hedging by 97.1% ($\frac{0.272+0.28}{0.28} - 1$) after final rules on risk weightings of interest rate derivatives are implemented. This suggests that hedging activity was muted by 49.3% during times of uncertainty for community banks ($1 - \frac{0.28}{0.28+0.272}$) This also suggests that smaller banks were exposed to 97.1% more interest rate risk due to residential mortgages sold during the four years of uncertainty when Dodd Frank rules were being debated and information costs were high.

In Table 4.10 a placebo test was conducted using trading interest rate derivatives in (3) and

(4). The hedging IRD dependent variable in (1) and (2) uses similar specifications in Table 4.8 and Table 4.9 in a combined panel regression using both RMHS and RMS. In the placebo test in (3) and (4), the trading dependent variable should not show significant relationships with the covariates and interactions that were found to be significant in (1) and (2). Trading IRD are used for non-hedging activities, and would not be expected to be associated with residential mortgages. The insignificant regressors in (3) and (4) confirms that the specifications used in the panel data in Table 4.8 and Table 4.9 apply to hedging derivatives and not to trading derivatives. Banks exposed to interest rate risk by offering a borrower an interest rate lock would need a forward delivery contract to hedge the mortgage, not a derivative used for trading purposes. The panel data specifications are confirmed with the placebo test in Table 4.10.

In Table 4.11, I test the assumption that income from mortgage securitizations are derived from mortgages that are originated for sale, held for sale, and sold. The left hand side variable across all four specifications is income from mortgage securitizations as listed in the RC-P. This is quarterly non interest income from the sale, securitization, and servicing of mortgages originated for sale as shown in Figure 4.2. Right hand side variables are also from the RC-P, mortgages originated for sale, mortgages held for sale, and mortgage loans sold. All specifications use bank and quarter fixed effects as well as clustering of standard errors at the bank and quarter level. Panel regressions in (1) indicate that every $100 of mortgages originated for sale, small banks have about 3.1% profit margin. In specification (2) and (3), mortgages held for sale and mortgage loans sold indicate a 4.4% and 1.4% profit margin respectively. When all three mortgage items are included in specification (4), mortgages originated for sale subsume the significance of the other two variables as mortgage originations are made up of mortgages held for sale and mortgage loans sold. Mortgages originated for sale on a yearly basis make up about 20-40% of a bank's total assets, suggesting that income from mortgage securitizations is a significant source of income for a bank.

In Table 4.12, similar to Table 4.11 the left hand side variable is income from mortgage securitizations as listed in the RC-P. The three right hand side variables are hedging, mortgages held for sale, and mortgage loans sold. Hedging is included in a three way interaction with a community banking dummy and a certainty dummy. All specifications use bank and quarter fixed effects as well as clustering of standard errors at the bank and quarter level. This table is estimating the cost of uncertainty for community banks on mortgage securitization income. Specification (1) estimates that every dollar in hedging contracts will eventually lead to a 1.2% increase in income from mortgage securitizations. This finding supports this paper in regards to TBA mortgages as banks issue a forward derivative contract for mortgage delivery to a third party upon closing of a mortgage. Uncertainty in utilizing forward contracts will increase the interest rate risk of a bank during the mortgage underwriting period which may last from 30 days to several months. The positive significance of the triple interaction term (0.006**) also supports the main findings of this paper, as community banks increase their securitization income by 53.4% ($\frac{0.012+0.006}{0.012} - 1$) for every unit of hedging after Dodd-Frank rules are implemented, while this effect was insignificant for larger banks. A similar effect is seen in (3) which uses lagged hedging as an independent variable. Since the mortgage approval process may take several months, lagged hedging variables will affect mortgage income variables in the next quarter when mortgages are sold and income is recorded.

4.5 Conclusion

Using a new identification strategy, this paper empirically tests bank's mortgage rate hedging practices during times of regulatory uncertainty. Among banks that use interest rate derivatives, the mortgage securitization division accounts for about 20-40% of total book assets, representing a significant source of interest rate risk when banks offer mortgage applicants an interest rate lock period that can last months. This mortgage rate risk can accumulate on a bank's balance sheet as shown in the interest rate betas in Table 4.6 Hedging this risk using interest rate derivatives is standard industry practice and shown to be the case even after controlling for asset liability mismatches and credit risk (Table 4.8 and 4.9. I find that smaller banks hedge 97-120% more mortgage rate risk compared to larger banks during times of regulatory certainty compared to periods of regulatory uncertainty. In Table 4.12 this increased hedging led to a 65.2% increase in mortgage securitization income for smaller banks, while this effect was insignificant for larger banks. Four years of discussion and commenting passed before final risk weightings for interest rate derivatives were implemented, representing a high information cost for many smaller banks.

This paper's findings of a decline in hedging as a result of regulatory uncertainty supports similar conclusions in [90] and [31] where they find that regulatory and policy uncertainty in banking led to less lending. This paper's contribution lies in the identification method of the hedging instrument and the hedged asset, which is unique to this literature. Previous papers looked at the effect of interest rate derivatives on balance sheet metrics and did not identify a direct channel for hedging. This direct channel allows for further testing in terms of the costs of uncertainty for Dodd Frank. This period of uncertainty regarding the implementation of risk weightings reduced interest rate hedging for small banks, contributing to a period of constrained credit availability.

This higher cost is likely from the higher regulatory burden that community banks face stemming from limited resources. From a policy standpoint, these findings support recent moves to tailor cost effective regulatory policies for smaller banks, which not only relieve constraints on interest rate hedging activities, but also relieve constraints on lending and credit availability.

Appendix

Figure 4.2:

Schedule RC-P—1–4 Family Residential Mortgage Banking Activities

Schedule RC-P is to be completed by (1) all banks with $1 billion or more in total assets[1] and (2) banks with less than $1 billion in total assets at which either 1–4 family residential mortgage loan originations and purchases for resale[2] from all sources, loan sales, or quarter-end loans held for sale or trading exceed $10 million for two consecutive quarters.

Dollar Amounts in Thousands	RCON	Amount	
1. Retail originations during the quarter of 1–4 family residential mortgage loans for sale:[2]			
a. Closed-end first liens	F066		1.a.
b. Closed-end junior liens	F067		1.b.
c. Open-end loans extended under lines of credit:			
(1) Total commitment under the lines of credit	F670		1.c.(1)
(2) Principal amount funded under the lines of credit	F671		1.c.(2)
2. Wholesale originations and purchases during the quarter of 1–4 family residential mortgage loans for sale:[2]			
a. Closed-end first liens	F068		2.a.
b. Closed-end junior liens	F069		2.b.
c. Open-end loans extended under lines of credit:			
(1) Total commitment under the lines of credit	F672		2.c.(1)
(2) Principal amount funded under the lines of credit	F673		2.c.(2)
3. 1–4 family residential mortgage loans sold during the quarter:			
a. Closed-end first liens	F070		3.a.
b. Closed-end junior liens	F071		3.b.
c. Open-end loans extended under lines of credit:			
(1) Total commitment under the lines of credit	F674		3.c.(1)
(2) Principal amount funded under the lines of credit	F675		3.c.(2)
4. 1–4 family residential mortgage loans held for sale or trading at quarter-end (included in Schedule RC, items 4.a and 5):			
a. Closed-end first liens	F072		4.a.
b. Closed-end junior liens	F073		4.b.
c. Open-end loans extended under lines of credit:			
(1) Total commitment under the lines of credit	F676		4.c.(1)
(2) Principal amount funded under the lines of credit	F677		4.c.(2)
5. Noninterest income *for the quarter* from the sale, securitization, and servicing of 1–4 family residential mortgage loans (included in Schedule RI, items 5.c, 5.f, 5.g, and 5.i):	RIAD		
a. Closed-end 1–4 family residential mortgage loans	F184		5.a.
b. Open-end 1–4 family residential mortgage loans extended under lines of credit	F560		5.b.
6. Repurchases and indemnifications of 1–4 family residential mortgage loans *during the quarter*:	RCON		
a. Closed-end first liens	F678		6.a.
b. Closed-end junior liens	F679		6.b.
c. Open-end loans extended under line of credit:			
(1) Total commitment under the lines of credit	F680		6.c.(1)
(2) Principal amount funded under the lines of credit	F681		6.c.(2)
7. Representation and warranty reserves for 1–4 family residential mortgage loans sold:			
a. For representations and warranties made to U.S. government agencies and government-sponsored agencies	L191		7.a.
b. For representations and warranties made to other parties	L192		7.b.
c. Total representation and warranty reserves (sum of items 7.a and 7.b)	M288		7.c.

1. The $1 billion asset-size test is based on the total assets reported on the *June 30, 2016*, Report of Condition.
2. Exclude originations and purchases of 1–4 family residential mortgage loans that are held for investment.

Table 4.1: **Summary Statistics for Small Community Banks During Uncertainty**
Data is from Call Reports (2010 Q4 - 2014 Q4). Ratios are scaled by total assets and are represented as percentages. Regulatory uncertainty centers around the risk weighting of assets for bank assets and liabilities which were unknown before Dodd Frank was fully implemented in 2015 Q1. Community banking identifiers are from the FDIC.

Variable	Obs	Mean	Std	Min	P25	P50	P75	Max
Total Assets ($M)	12,348	730	1,300	9	200	390	780	27,000
Interest Rate Derivatives (%)	12,348	5.37	14.36	0.00	0.42	1.23	4.08	241.43
Hedging Rates (%)	12,348	4.68	14.21	0.00	0.27	0.88	2.87	241.43
Fixed Swaps (%)	12,348	0.54	1.99	0.00	0.00	0.00	0.00	21.48
Trading Rates (%)	12,348	0.15	1.38	0.00	0.00	0.00	0.00	33.67
Mortgages Held for Sale (MHS) (%)	5,750	2.76	6.76	0.00	0.11	0.45	1.79	83.87
Mortgages Sold (MS) (%)	5,751	11.92	27.64	0.00	1.05	2.98	9.05	345.06
Mort Originated for Sale (%)	5,749	8.27	18.32	0.00	0.81	2.51	6.86	269.11
Other Loans Held for Sale (OLS) (%)	5,750	0.31	3.46	-12.95	0.00	0.00	0.00	72.40
Maturity Gap Ratio (%)	12,348	5.56	11.47	-54.12	-1.92	5.08	12.45	61.16
Compliance Cost (%)	12,348	0.11	0.10	0.00	0.05	0.09	0.14	2.54
Non Performing Assets (%)	12,348	0.09	0.36	0.00	0.00	0.00	0.05	9.26

Table 4.2: **Summary Statistics for Large Regional Banks During Uncertainty**
Data is from Call Reports (2010 Q4 - 2014 Q4). Ratios are scaled by total assets and are represented as percentages. Regulatory uncertainty centers around the risk weighting of assets for bank assets and liabilities which were unknown before Dodd Frank was fully implemented in 2015 Q1. Community banking identifiers are from the FDIC.

Variable	Obs	Mean	Std	Min	P25	P50	P75	Max
Total Assets ($M)	6,791	7,400	24,000	21	410	1,200	4,800	320,000
Interest Rate Derivatives (%)	6,791	10.80	39.11	0.00	0.85	2.81	9.12	1,182.44
Hedging Rates (%)	6,791	5.53	18.56	0.00	0.44	1.46	4.50	607.52
Fixed Swaps (%)	6,791	2.12	15.41	0.00	0.00	0.00	0.64	574.92
Trading Rates (%)	6,791	3.14	21.16	0.00	0.00	0.00	0.00	597.93
Mortgages Held for Sale (MHS) (%)	4,810	1.49	4.47	0.00	0.05	0.26	0.78	61.57
Mortgages Sold (MS) (%)	4,810	5.34	16.19	0.00	0.33	1.31	3.47	284.82
Mort Originated for Sale (%)	4,809	4.36	14.66	0.00	0.23	1.08	3.01	268.99
Other Loans Held for Sale (OLS) (%)	4,810	0.25	2.14	-13.66	0.00	0.00	0.00	56.44
Maturity Gap Ratio (%)	6,791	11.73	15.87	-52.81	1.41	9.43	20.12	91.49
Compliance Cost (%)	6,791	0.09	0.11	-0.05	0.04	0.07	0.10	3.34
Non Performing Assets (%)	6,791	0.26	1.23	0.00	0.00	0.00	0.08	21.27

Table 4.3: **Summary Statistics for Small Community Banks During Certainty**
Data is from Call Reports (2015 Q1 - 2017 Q4). Ratios are scaled by total assets and are represented as percentages. Regulatory uncertainty centers around the risk weighting of assets for bank assets and liabilities which were unknown before Dodd Frank was fully implemented in 2015 Q1. Community banking identifiers are from the FDIC.

Variable	Obs	Mean	Std	Min	P25	P50	P75	Max
Total Assets ($M)	11,653	940	1,800	16	230	460	950	43,000
Interest Rate Derivatives (%)	11,653	5.59	14.41	0.00	0.46	1.31	4.42	272.21
Hedging Rates (%)	9,775	4.70	14.81	0.00	0.23	0.84	2.61	272.21
Fixed Swaps (%)	9,775	0.93	2.92	0.00	0.00	0.00	0.00	59.65
Trading Rates (%)	11,653	0.19	1.65	0.00	0.00	0.00	0.00	46.75
Mortgages Held for Sale (MHS) (%)	4,821	2.63	7.16	0.00	0.08	0.31	1.51	82.20
Mortgages Sold (MS) (%)	4,821	10.27	27.42	0.00	0.70	1.92	7.01	448.47
Mort Originated for Sale (%)	4,820	8.10	22.74	0.00	0.50	1.73	5.44	367.06
Other Loans Held for Sale (OLS) (%)	4,821	0.39	3.80	-26.88	0.00	0.00	0.00	65.58
Maturity Gap Ratio (%)	11,653	8.10	12.48	-54.69	0.60	7.83	15.42	98.98
Compliance Cost (%)	11,653	0.11	0.20	0.00	0.05	0.08	0.12	9.92
Non Performing Assets (%)	11,653	0.06	0.20	0.00	0.00	0.00	0.03	3.89

Table 4.4: **Summary Statistics for Large Regional Banks During Certainty**
Data is from Call Reports (2015 Q1 - 2017 Q4). Ratios are scaled by total assets and are represented as percentages. Regulatory uncertainty centers around the risk weighting of assets for bank assets and liabilities which were unknown before Dodd Frank was fully implemented in 2015 Q1. Community banking identifiers are from the FDIC.

Variable	Obs	Mean	Std	Min	P25	P50	P75	Max
Total Assets ($M)	3,475	13,000	32,000	19	1,200	3,600	9,900	320,000
Interest Rate Derivatives (%)	3,475	13.38	34.36	0.00	1.33	5.14	14.16	545.68
Hedging Rates (%)	3,455	5.83	17.25	0.00	0.42	1.50	5.04	268.94
Fixed Swaps (%)	3,455	2.95	14.63	0.00	0.00	0.00	2.52	276.74
Trading Rates (%)	3,475	4.64	16.14	0.00	0.00	0.00	0.98	203.86
Mortgages Held for Sale (MHS) (%)	2,918	1.21	4.68	0.00	0.02	0.16	0.53	80.49
Mortgages Sold (MS) (%)	2,917	3.58	11.68	0.00	0.13	0.75	2.12	222.08
Mort Originated for Sale (%)	2,918	2.42	6.49	0.00	0.06	0.61	1.75	71.06
Other Loans Held for Sale (OLS) (%)	2,918	0.21	1.42	-1.07	0.00	0.00	0.00	25.51
Maturity Gap Ratio (%)	3,475	18.78	16.35	-42.08	7.78	16.52	28.51	93.41
Compliance Cost (%)	3,475	0.06	0.07	0.00	0.03	0.05	0.07	2.26
Non Performing Assets (%)	3,475	0.18	1.04	0.00	0.00	0.01	0.05	14.16

Table 4.5: **Panel Logistic Model of Community Banks and Compliance Costs**
A logit model was estimated where the dependent variable is a dummy that equals one if the bank is classified as a Community Bank by the Federal Deposit Insurance Corporation. Compliance costs were collected from a survey conducted by the Conference of State Bank Supervisors (CSBS) [50]. Total interest rate derivatives include both trading and non-trading interest rate derivatives from the RC-L Derivatives and Off Balance Sheet Items section of the Call Reports. Total residential mortgages, residential mortgages sold, and residential mortgages held for sale are from the RC-P Family Residential Mortgage Banking Activities. C&I Loans are from the RC-C Loans and Lease Financing Receivables and Maturity Gap is calculated from the RC-A Cash and Balances Due from Depository Institutions, RC-C, RC-B Securities, and RC-E Deposit Liabilities. Non Performing Assets are from the RC-N Past Due and Nonaccrual Loans, Leases, and Other Assets. All variables are scaled by total assets except for compliance costs and the community banking identifier. The panel data used is on a quarterly basis and is from 2010Q4-2017Q4.

	Community Bank Identifier				
	(1)	(2)	(3)	(4)	(5)
Compliance Costs	59.812***	58.521***	86.576***	72.694***	72.694***
	(58.48)	(10.84)	(7.95)	(28.37)	(6.58)
Total Interest Rate Derivatives		-1.175***		-3.091***	-3.091***
		(-3.87)		(-15.67)	(-3.55)
Total Residential Mortgages			1.589**	1.283***	1.283*
			(2.28)	(7.81)	(1.76)
Residential Mortgages Sold			3.162***	5.356***	5.356***
			(2.77)	(12.81)	(4.07)
Mortgages Held for Sale			-7.677***	-5.36***	-5.36
			(-2.63)	(-4.92)	(-1.46)
C&I Loans			-2.025*	0.212	0.212
			(-1.95)	(0.8)	(0.18)
Maturity Gap				-2.69***	-2.69***
				(-17.65)	(-4.46)
Non Performing Assets				-37.67***	-37.67**
				(-9.87)	(-2.2)
Observations	34,267	34,267	16,549	16,549	16,549
Bank FE		✓	✓		✓
Bank Clusters		✓	✓		✓
Pseudo R^2	0.102	0.110	0.106	0.154	0.154

Table 4.6: **Panel Interest Rate Betas of Small Banks and Larger Banks**

The panel data used is on a quarterly basis and is from 2006Q3-2017Q4. Mortgage rates 30Y fixed rate per quarter from the Primary Mortgage Market Survey from Freddie Mac. 10Y Swap Rates are on a quarterly basis from Bloomberg. Mortgages Sold and Mortgages Held for Sale are from the RC-P of the Call Reports. Hedge IRD and Pay Fixed IRD are non trading interest rate derivatives as reporeted in the RC-L of the Call Reports. Betas are estimated using the following empirical specification:

	$\Delta MortgagesSold_{I,t}$		$\Delta MortgagesHeldforSale_{I,t}$	
	Small Banks	Larger Banks	Small Banks	Larger Banks
ΔMortgageRates$_t$	-0.013***	-0.003***	-0.004***	-0.002***
	(-4.84)	(-3.36)	(-6.43)	(-4.29)
ΔMortgageRates$_{t-1}$	-0.048***	-0.019***	-0.01***	-0.005***
	(-9.92)	(-7.71)	(-9.74)	(-6.58)
ΔMortgageRates$_{t-2}$	-0.018***	-0.01***	0.002***	0
	(-7.33)	(-6.83)	(3.31)	(1)
ΔMortgageRates$_{t-3}$	0.002	0	-0.001	0
	(1.11)	(-0.08)	(-1.43)	(-0.58)
Observations	11,134	9,937	11,134	9,937
Bank FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
R^2	0.037	0.031	0.032	0.020

	$\Delta HedgeIRDRatio_{I,t}$		$\Delta PayFixedIRDRatio_{I,t}$	
	Small Banks	Larger Banks	Small Banks	Larger Banks
ΔSwapRates$_t$	-0.015***	-0.006***	0	0.001
	(-9.55)	(-3.6)	(0.93)	(1.38)
ΔSwapRates$_{t-1}$	-0.005***	-0.005***	0	0
	(-6.85)	(-4.77)	(0.86)	(0.36)
ΔSwapRates$_{t-2}$	0	0.001	0	0.001
	(-0.91)	(1.09)	(1.54)	(1.48)
ΔSwapRates$_{t-3}$	0.001**	0	0	0.001
	(2.36)	(0.3)	(0.16)	(1.51)
Observations	26,153	15,148	26,153	15,148
Bank FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
R^2	0.023	0.006	0.000	0.001

Table 4.7: **Panel VAR of Hedging and Mortgage Activities**

Panel Vector Autoregression is estimated using quarterly Call Report data from 2006Q3-2017Q4. Residential Mortgages are family residential loans that are closed end and revolving which are both held for sale and for investment. Non Trading IRD are interest rate derivatives that are not used for trading consisting of pay fixed swaps and hedging swaps (Hedging IRD). Residential sold are closed end and open end family residential loans that were sold during the quarter. Residential Held for Sale are closed end and open end family residential loans that are held for sale or trading at quarter end. Residential Originated for Sale are closed end and open end family residential mortgages originated for sale which excludes mortgages originated for investment. All banks with zero or missing Non Trading IRD and TBTF banks are excluded. Small Banks and Large Banks are defined as community banks and non community banks as identified by the FDIC.

	AllBanks(DependentVariable)					
	Resid Mort (1)	NonTrad IRD (2)	Resid Sold (3)	ResHeldSale (4)	HedgingIRD (5)	ResidOrigSale (6)
NonTrad IRD$_{t-1}$	-0.011	0.906***				
	(-1.69)	(17.11)				
Resid Mort$_{t-1}$	0.941***	0.409*				
	(17.26)	(2.31)				
Hedging IRD$_{t-1}$			0.183***	0.028**	0.829***	0.117***
			(4.29)	(2.93)	(16.97)	(4.55)
Resid Held Sale$_{t-1}$			1.264***	0.869***	0.389*	
			(4.36)	(13.95)	(1.98)	
Resid Sold$_{t-1}$			0.647***	0.006	0.03	
			(7.67)	(0.55)	(0.78)	
Resid Orig Sale$_{t-1}$						0.693***
						(3.76)
Observations	22,974	22,974	22,974	22,974	22,974	22,974

	SmallBanks(DependentVariable)			Larger Banks (Dependent Variable)		
	Resid Sold (7)	Hedging IRD (8)	ResOrigSale (9)	Resid Sold (10)	Hedging IRD (11)	Resid Orig Sale (12)
Hedging IRD$_{t-1}$	0.34***	0.86***	0.154***	0.117***	0.837***	0.672*
	(4.44)	(12.57)	(3.57)	(4.07)	(10.96)	(2.18)
Resid Sold$_{t-1}$	0.817***	0.1*		0.757***	-0.085	
	(8.38)	(2.44)		(3.59)	(-0.65)	
Resid OrigSale$_{t-1}$			0.717**			0.0698***
			(3.06)			(3.39)
Observations	11,950	11,950	11950	11,024	11,024	11,024

Note: *p < 0.05; **p < 0.01; ***p < 0.001

Table 4.8: **Panel Data: Residential Mortgages Held for Sale or Trading**
Using Panel Data from Call Reports (2010 Q4-2017 Q4) and community banking identifiers from the FDIC. I use the following empirical model:

$$\frac{Hedging\ IRD_{it}}{Assets_{it}} = \alpha_i + \lambda_t + Community\ Bank_i \times Regulatory\ Certainty_t \times \frac{Residential\ Mortgages\ Held\ for\ Sale\ or\ Trading_{it}}{Assets_{it}} + X'\beta + \varepsilon_{it}$$

Residential Mortgages Held for Sale or Trading (RCONF072+RCONF073+RCONF676+RCONF677) are 1-4 family residential mortgage loans held for sale or trading at quarter end as reported on the Schedule RC-P 1-4 Family Residential Mortgage Banking Activity from the Call Reports. Hedging Interest Rate Derivatives are reported on the Schedule RC-L Derivatives and Off-Balance Sheet Items (RCON8725-RCONA589). Each regression includes the main effects and first order interaction terms but these variables are not tabulated for clarity. Control variables are maturity gap ratios for each bank and 10 year swap rates. Maturity gap is a measure of mismatching between assets and liabilities. Certainty is a dummy variable with a value of 1 from 2015 Q1-2017 Q4 after Dodd Frank's risk weightings for derivatives were finalized, and a value of 0 from 2010 Q4-2014 Q4 during the four years of congressional deliberations and uncertainty. Community bank is a dummy variable with a value of 1 if the bank identified as a community bank by the FDIC, and a value of 0 if it is identified as a non-community bank. The three way interaction of Community Bank × Certainty × Residental Mortgages Held for Sale or Trading represents the amount of additional interest rate hedging per mortgage that a community bank implements after uncertainty ends. Time fixed effects are at the quarter level and standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

	Hedging Interest Rate Derivatives/Assets			
	(1)	(2)	(3)	(4)
Community Bank × Certainty ×	1.196**	1.196**	1.167**	1.168**
Residential Mortgages Held for Sale	(2.08)	(2.08)	(2.05)	(2.05)
Residential Mortgages Held for Sale	1.035***	1.035***	0.971***	0.971***
	(3.72)	(3.51)	(3.38)	(3.38)
Observations	18,254	18,254	18,254	18,254
Controls				✓
Bank FE	✓	✓	✓	✓
Time FE			✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters		✓	✓	✓
Adjusted R^2	0.79	0.79	0.79	0.79

Table 4.9: **Panel Data: Residential Mortgages Sold**
Using Panel Data from Call Reports (2010 Q4-2017 Q4) and community banking identifiers from the FDIC. I use the following empirical model:

$$\frac{Hedging\ IRD_{it}}{Assets_{it}} = \alpha_i + \lambda_t + Community\ Bank_i \times Regulatory\ Certainty_t \\ \times \frac{Residential\ Mortgages\ Sold_{it}}{Assets_{it}} + X'\beta + \varepsilon_{it}$$

Residential Mortgages Sold (RCONF070+RCONF071+RCONF674+RCONF675) are 1-4 family residential mortgage loans sold during the quarter as reported on the Schedule RC-P 1-4 Family Residential Mortgage Banking Activity from the Call Reports. Hedging Interest Rate Derivatives are reported on the Schedule RC-L Derivatives and Off-Balance Sheet Items (RCON8725-RCONA589). Each regression includes the main effects and first order interaction terms but these variables are not tabulated for clarity. Control variables are maturity gap ratios for each bank and 10 year swap rates. Maturity gap is a measure of mismatching between assets and liabilities. Certainty is a dummy variable with a value of 1 from 2015 Q1-2017 Q4 after Dodd Frank's risk weightings for derivatives were finalized, and a value of 0 from 2010 Q4-2014 Q4 during the four years of congressional deliberations and uncertainty. Community bank is a dummy variable with a value of 1 if the bank identified as a community bank by the FDIC, and a value of 0 if it is identified as a non-community bank. The three way interaction of Community Bank × Certainty × Residental Mortgages Sold represents the amount of additional interest rate hedging per mortgage that a community bank implements after uncertainty ends. Time fixed effects are at the quarter level and standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

	Hedging Interest Rate Derivatives/Assets			
	(1)	(2)	(3)	(4)
Community Bank × Certainty	0.276*	0.276*	0.275*	0.272*
× Residential Mortgages Sold	(1.83)	(1.86)	(1.87)	(1.85)
Residential Mortgages Sold	0.294***	0.294***	0.281***	0.28***
	(3.99)	(3.66)	(3.66)	(3.65)
Observations	18,252	18,252	18,252	18,252
Controls				✓
Bank FE	✓	✓	✓	✓
Time FE			✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters		✓	✓	✓
Adjusted R^2	0.79	0.79	0.79	0.79

Table 4.10: **Placebo Test of Hedging Covariates**
Using Panel Data from Call Reports (2010 Q4-2017 Q4) and community banking identifiers from the FDIC. I use the following empirical model:

$$\frac{\textit{[Hedging, Trading]}_{it}}{Assets_{it}} = \alpha_{it} + \textit{Community Bank}_i \times \textit{Certainty}_t \times \left[\frac{\textit{Mortgages Held for Sale}_{it}}{Assets_{it}} + \frac{\textit{Mortgages Sold}_{it}}{Assets_{it}}\right] + X'\beta + \varepsilon_{it}$$

Residential Mortgages Held for Sale or Trading (RCONF072+RCONF073+RCONF676+RCONF677) are 1-4 family residential mortgage loans held for sale or trading at quarter end and Residential Mortgages Sold (RCONF070+RCONF071+RCONF674+RCONF675) are 1-4 family residential mortgage loans sold during the quarter as reported on the Schedule RC-P 1-4 Family Residential Mortgage Banking Activity from the Call Reports. Each regression includes the main effects and first order interaction terms but these variables are not tabulated for clarity. Control variables are maturity gap ratios for each bank and 10 year swap rates. Maturity gap is a measure of mismatching between assets and liabilities. Certainty is a dummy variable with a value of 1 from 2015 Q1-2017 Q4 after Dodd Frank's risk weightings for derivatives were finalized, and a value of 0 from 2010 Q4-2014 Q4 during the four years of congressional deliberations and uncertainty.Time fixed effects are at the quarter level and standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

	Hedging(IRD)		*Trading(Placebo)*	
	(1)	(2)	(3)	(4)
Community Bank × Certainty × Residential Mortgages Held for Sale	1.271** (2.13)	1.207** (2.17)	0.052 (0.23)	0.065 (0.26)
Community Bank × Certainty × Residential Mortgages Sold	-0.045 (-0.26)	-0.03 (-0.2)	-0.087 (-1.12)	-0.095 (-1.09)
Residential Mortgages Held for Sale	0.838*** (2.83)	0.777*** (2.63)	-0.035 (-0.48)	-0.032 (-0.47)
Residential Mortgages Sold	0.117* (1.9)	0.119* (1.88)	0.021 (0.35)	0.02 (0.31)
Observations	18,251	18,251	18,251	18,251
Controls		✓		✓
Bank FE	✓	✓	✓	✓
Time FE		✓		✓
Bank Clusters	✓	✓	✓	✓
Time Clusters		✓		✓
Adjusted R^2	0.80	0.80	0.77	0.77

Table 4.11: **Panel Analysis of Income from Mortgage for Sale Activities**
Income from Mortgage for Sale Activities (RIADF184+RIADF560) is noninterest income from the sale, securitization, and servicing of mortgages originated for sale as shown in Figure 4.11 from the Schedule RC-P 1-4 Family Residential Mortgage Banking Activities. Residential Mortgages Held for Sale or Trading are 1-4 family residential mortgage loans held for sale or trading at quarter end and Residential Mortgages Sold are 1-4 family residential mortgage loans sold during the quarter. Quarterly data is from the Call Reports and are from 2006Q3-2017Q4.Time fixed effects are at the quarter level and standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

	Income from Mortgage Securitization/Assets			
	(1)	(2)	(3)	(4)
Mortgages Originated for Sale	0.031***			0.027***
	(7.64)			(6.61)
Mortgages Held for Sale		0.044***		0.003
		(4.22)		(0.42)
Mortgage Loans Sold			0.014***	0.003
			(4.05)	(1.44)
Observations	25,238	25,239	25,238	25,237
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓
Adjusted R^2	0.83	0.77	0.79	0.84

Table 4.12: **Panel Analysis of Income from Hedging Activities**
Income from Mortgage for Sale Activities (RIADF184+RIADF560) is noninterest income from the sale, securitization, and servicing of mortgages originated for sale as shown in Figure 4.11 from the Schedule RC-P 1-4 Family Residential Mortgage Banking Activities. Residential Mortgages Held for Sale or Trading are 1-4 family residential mortgage loans held for sale or trading at quarter end and Residential Mortgages Sold are 1-4 family residential mortgage loans sold during the quarter. The independent variable of interest is Hedging which are Non-Trading Interest Rate Derivatives which are used hedge mortgage originations for sale during the interest rate lock period, which is later sold to a third party. Certainty is a dummy variable with a value of 1 from 2006Q3-2010Q3 and 2015 Q1-2017 Q4 and a value of 0 from 2010 Q4-2014 Q4 during the four years of congressional deliberations and uncertainty. Community bank is a dummy variable with a value of 1 if the bank identified as a community bank by the FDIC, and a value of 0 if it is identified as a non-community bank.(1) and (2) represent the use of the contemporaneous hedging variable of interest while (3) and (4) represents using the lagged hedging variable. All variables are scaled by total assets. Quarterly data is from the Call Reports and are from 2006Q3-2017Q4.Time fixed effects are at the quarter level and standard errors are clustered at the bank and quarter level. T-statistics are in parenthesis.

	Income from Mortgage Securitization/Assets			
	$Hedging_t$ (1)	$Hedging_t$ (2)	$Hedging_{t-1}$ (3)	$Hedging_{t-1}$ (4)
Community Bank × Certainty × Hedging	0.006** (2.16)	0.006** (2.16)	0.007** (2.14)	0.006** (2.2)
Community Bank × Hedging	0.00 (0.01)	-0.003 (-0.63)	-0.001 (-0.13)	-0.003 (-0.5)
Hedging	0.012** (2.27)	0.008** (1.97)	0.014** (2.06)	0.01* (1.84)
Mortgages Sold		0.011** (2.28)		0.009* (1.69)
Mortgages Held for Sale		0.002 (0.16)		0.005 (0.45)
Observations	18,249	18,248	17,196	17,195
Bank FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Bank Clusters	✓	✓	✓	✓
Time Clusters	✓	✓	✓	✓
Adjusted R^2	0.80	0.82	0.84	0.86

Chapter 5

Conclusions

Thus concludes the three chapters of my dissertation. The relationship between cash and credit has been explored from the borrower and lender side in light of new financial frameworks to consider. I have also explored the impact of new financial frameworks on smaller institutions that cannot afford the higher costs of compliance and long periods of uncertainty due to the legislation of regulatory laws.

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