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ESSAYS ON FINANCIAL MARKETS AND MACROECONOMIC ACTIVITIES

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DEDICATION

I dedicate this dissertation to God. This dissertation would not have been possible without God having it in his plan for me. “But he knows the way that I take; when he has tested me, I will come forth as gold.” (Job 23:10)

I dedicate this dissertation to my loving wife Yunjung Kim, my son Eunchan Mok, and my parents for undying devotion, relentless support, and encouragement in helping me fulfill this aspiration. Throughout this education journey, I have had the loving and unconditional support of my family. My family has supported me both financially and spiritually with prayers, encouraging words that gave me strength to make this dream a reality.

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ABSTRACT

This thesis consists of three papers addressing different aspects of financial markets and macroeconomic activities.

Firm Risks, Credit, and Labor Market Fluctuations studies the effect of changes in firm risks on the cyclical properties of the labor market. I develop a general equilibrium model in which the adjustment of employment is costly. Financial frictions arise from the limited liability property of the contract between lenders and firms. The changes in firm risks alter the amount of debt that firms can borrow to finance their working capital. This mechanism amplifies labor market fluctuations and displays a countercyclical external finance premium, consistent with the empirical evidence.

Shadow Banks and Stabilization Policies studies the interaction between commercial banks and shadow banks and the effect of stabilization policies. I develop a general equilibrium model in which the shadow banks obtain loans from commercial banks in the form of short-term collateralized debt. The moral hazard creates volatile leverage of shadow banks, which makes the economy more vulnerable to economic

shocks. Upon an aggregate disturbance, a stabilization policy in the form of direct lending is relatively more efficient than policies aimed at the shadow-banking sector.

Bank Capital and Lending: An Analysis of Commercial Banks in the United States empirically evaluates the impact of bank capital on lending patterns of commercial banks in the United States. Using two different measures of capital, namely the capital adequacy ratio and tier 1 ratio, we find a moderate relationship between bank equity and lending. We also use an innovative instrumental variables methodology that helps us overcome the endogeneity issues that are common in such analyses.

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List of Abbreviations

ABS	Asset-Backed Security
AR	Auto Regressive
CAR	Capital Adequacy Ratio
CES	Center for Economic Studies
CPP	Capital Purchase Program
CRS	Constant Return to Scale
Corr.	Correlation
DSGE	Dynamic Stochastic General Equilibrium
ECB	European Central Bank
FRED	Federal Reserve Economic Data
GDP	Gross Domestic Product
HPI	House Price Index
i.i.d	Independent and Identically Distributed
IV	Instrumental Variable
NBER	National Bureau of Economic Research
SIC	Standard Industrial Classification
Std.	Standard Deviation
TARP	Troubled Asset Relief Program
TFP	Total Factor Productivity

Chapter 1

Firm Risk, Credit, and Labor Market Fluctuations

1.1 Introduction

With the onset of the recent financial crisis in 2007, the link between financial markets and real economic activities have drawn the attention of many scholars and policy-makers. A high unemployment rate was one of the outcomes of the crisis. To understand this phenomenon, one needs a macroeconomic model which focuses on labor market dynamics. However, relative to other aspects of macroeconomics, models related to unemployment are scarce.

The most well-known model is the Mortensen and Pissarides (1994) search and matching model of equilibrium unemployment. It abstracts from the flexible labor market and introduces a costly adjustment of employment. However, Shimer (2005) points out that this model fails to match the volatility and persistence of unemployment, vacancies, and market tightness. Subsequent research tries to explain what key factors are absent in the model in order to explain such mismatches.

One stream of literature has focused on the credit market frictions which create a wedge between the factor prices and the marginal products. The time-varying wedge generates amplified responses of hiring decisions to the aggregate shocks. Another stream of literature points out that the wage determination though the Nash bargaining model prevents the impact of aggregate shocks on labor market variables. The Nash bargaining process allows wages to absorb the most of macroeconomic fluctuations, so that workers' and firms' behaviors do not vary much. Thus, imposing wage rigidity is expected to change the labor-related decisions.

This paper presents a dynamic stochastic general equilibrium model with both labor and financial market frictions. This labor market model structure follows the standard labor search and matching model. Hiring workers is a costly process, so firms consider not only the contemporaneous marginal products but also the future expected value of additional workers.

In this model, the key difference arises from the financial market friction. Firms are exposed to firm-specific idiosyncratic shocks every period, thus their realized output is different from what they expect at the beginning of each period. However, they are constrained by their working capital needs, so they make decisions about capital demand and vacancy creation without knowing what their final outcome will be. Their working capital constraints make firms vulnerable to default depending on the realization of firm risk shocks. Knowing this, lenders are reluctant to provide credit, they limit the size of working capital, and they ask for higher finance premiums.

However, even though the model incorporates frictions, the standard aggregate TFP shock alone cannot generate enough volatility of labor market variables. If we allow the time-varying distribution of firm-specific shocks, which we interpret as firm risks, firms face even tighter financial conditions. Due to the limited liability property of debt, higher firm risks (*i.e.* more dispersed distribution of shocks) incentivize firms to use inferior substandard technology which produces lower mean output. Although using inefficient technology gives lower mean returns compared to using standard technology, the default option allows firms to enjoy only the upside risk and to transfer their downside risks to lenders. With proper assumptions about the distribution, firm risk shocks generate even more volatile responses compared to the model with the aggregate TFP shocks only.

This paper is closely related to recent literature that has attempted to resolve the inability of the Mortensen and Pissarides (1987) model to account for the unemployment fluctuation observed in the data. Chugh (2013) studies the spillover effect of idiosyncratic shocks on the average level of aggregate TFP shock. Similar to the "output model" in Carlstrom and Fuerst (1998), Chugh's model incorporates the asymmetric information problem. He shows that the spillover effect strengthens the financial friction and leads to more volatile fluctuations of labor market variables.

Petrosky-Nadeau (2013) also focuses on the asymmetric information and shows that the monitoring cost shocks may amplify the responses. Garin (2014) incorporates the working capital constraint as did Jermann and Quadrini (2000), in which the movement of collateral values alters the capacity of firms to raise funds.

The rest of the paper is organized as follows. Section 1.2 describes the model structure. Section 1.3 presents the calibration and simulation results, and Section 1.4 concludes.

1.2 Model

1.2.1 Labor Market

There is a unit mass of workers in the economy. All workers are either employed or unemployed.[1] Let n_{t-1} denote the number of employed workers at the beginning of period t. The employed workers supply labor inelastically to the entrepreneur. The entrepreneur posts vacancies v_t to recruit new workers. At the beginning of the period t, ρ^x fraction of the employed workers are exogenously separated from their jobs. The separated workers join the pool of job seekers immediately. Thus, the total number of job searchers in period t is:

$$u_t = 1 - (1 - \rho^x)n_{t-1} \tag{1.1}$$

Job matches are obtained from a Cobb-Douglas matching technology $m(u_t, v_t)$. Once the job match is formed, the existing workers and newly hired workers participate in production in the same period. With all the ingredients in place, the law of motion for aggregate employment can be written as:

$$n_t = (1 - \rho^x)n_{t-1} + m(u_t, v_t) \tag{1.2}$$

[1] It means that full participation is assumed.

For later use, one can define the probability of finding a job p_t, and filling a vacancy q_t as follows:

$$p(\theta_t) = \frac{m(u_t, v_t)}{u_t} \tag{1.3}$$

$$q(\theta_t) = \frac{m(u_t, v_t)}{v_t} \tag{1.4}$$

where $\theta_t \equiv v_t/u_t$ represents the labor market tightness from the firms' perspective.

The relevant unemployment statistics of the model that is comparable to data is

$$\tilde{u}_t = 1 - n_t \tag{1.5}$$

where $\tilde{u}_t$ denotes the measured unemployment. It corresponds to the number of workers who are not producing at time t.

1.2.2 Household

There is a representative household in the economy and it is composed of a continuum of measure one of family members.[2] Every member of the household is either employed or searching for jobs. As is common in many DSGE search models since Merz (1995) and Andolfatto (1996), there is perfect risk-sharing among members of household to ensure the same level of consumption regardless of employment status.

The household maximizes its expected lifetime discounted utility

$$E_t \sum_{t=0}^{\infty} \beta^t \left[u(c_t) - \psi n_t\right]$$

subject to a sequence of flow budget constraint

$$c_t + k_{t+1}^h + T_t = w_t n_t + k_t^h (1 + r_t - \delta) + s(1 - n_t) + \Pi_t. \tag{1.6}$$

[2] I use the terms "workers" and "family members" interchangeably.

where I impose a linearity in n_t. This assumption gives a constant marginal disutility of work ψ. The household's discount factor is $\beta \in (0,1)$, $u(\cdot)$ is standard strictly-increasing and strictly-concave utility function over consumption, c_t is household consumption, n_t is the measure of members who are employed at time t. The employed members receive wage income w_t and the unemployed receive the unemployment benefit s from the government which is financed through the lump-sum tax T_t. In addition to choosing consumption, the household can rent in capital k^h_{t+1}, earning the market rental rate r_{t+1} in the following period. δ is the depreciation rate of capital stock and Π_t is the dividends payments from firms.

The optimal choice of the household is characterized by the standard Euler equation:

$$u'(c_t) \quad = \quad \beta E_t \left[u'(c_{t+1})(1 + r_{t+1} - \delta)\right] \tag{1.7}$$

For the purpose of wage bargaining that will be discussed shortly, it is useful to write down the value of an employed and an unemployed worker to the household. Let the $\mathcal{H}_{N,t}$ and $\mathcal{H}_{U,t}$ denote the value of an employed worker and an unemployed worker at time t respectively. The value of an employed worker is:

$$\mathcal{H}_{N,t} = -\psi + u'(c_t)w_t + \beta E_t \left[(1 - \rho^x + \rho^x f(\theta_{t+1}))\mathcal{H}_{U,t+1} + \rho^x(1 - f(\theta_{t+1}))\mathcal{H}_{N,t+1}\right] \tag{1.8}$$

1.2.3 Firms

A continuum of unit mass firm uses the constant return-to-scale production technology to produce output in the economy. Firms are heterogeneous in their productivity. Firm j's production function can be written as:

$$y_{jt} = \omega_{jt} z_t k^{\alpha}_{jt} n^{1-\alpha}_{jt}$$

where ω_{jt} is the firm-specific productivity realization, z_t is the level of total factor productivity (TFP), k_{jt} is firm's purchase of physical capital on the spot markets, and n_{jt} is the number of employed worker for the production in period t. The TFP level is common to all firms and evolves according to

$$lnz_t = \rho^z lnz_{t-1} + \varepsilon_t^z$$

where $\varepsilon_t^z \sim \mathcal{N}(0, \sigma^z)$ and σ^z is the standard deviation of the innovation. ω_{jt} is a random variable, i.i.d across firms and time, drawn from a distribution function $\mathcal{F}(\omega)$ with a positive support, $E(\omega) = 1$ and a time-varying standard deviation σ_t. For later use, let $F(\omega; \sigma_t) \equiv F_t(\omega)$ denote the cumulative distribution function of firm-specific shocks. This time-varying standard deviation will be called firm risks.

I model the firm sector in the economy by drawing on the framework by Chugh (2013). Within this framework, firms are owned by households and maximize the expected present discounted value of dividends paid out to households. Firm j's dividends payment is composed of two components: a non-retained earnings Π_{jt}^e and an expected operating profit $E_\omega \Pi_{jt}^f$, where E_ω indicates an expectation conditional on the period t aggregate state but before idiosyncratic shocks are realized. The superscript "e" represents an entrepreneur who accumulates capital and borrows funds from outside lenders, while the superscript "f" represents a firm which is specialized in the production. Thus, the total dividends payment to households is $\Pi_{jt} = \Pi_{jt}^e + E_\omega \Pi_{jt}^f$. The intertemporal objective function of firm j can be expressed as:

$$E_0 \sum_{t=0}^{\infty} \gamma^t \Lambda_{t|0} \left[\Pi_{jt}^e + E_\omega \Pi_{jt}^f \right]$$

where $\gamma < 1$ is introduced to ensure that firms cannot accumulate capital to avoid financial constraints. By adding γ to the discount factor, firms are assumed to be more impatient than households.

Firm Financing

Firms are assumed to be required to raise funds before production due to a cash-flow mismatch. Therefore, I follow the recent literature by assuming that firms face working capital needs that have to be satisfied by obtaining an intra-period loan to cover the total operating cost of production. As demonstrated in Chugh (2013) and Garin (2014), payments to workers, capital rental costs, and hiring costs have to be accounted for before the realization of revenues. Let M_{jt} denote the total operating cost, then

$$M_{jt} = w_t n_{jt} + r_t k_{jt} + \varrho(v_{jt}) \tag{1.9}$$

where $\varrho(v_{jt})$ is the vacancy posting cost in terms of output goods, which can be linear, concave, or convex depending on whether the marginal cost of vacancy postings is constant, diminishing, or increasing.

As mentioned above, due to the firms' impatience, firms should finance a part of their operating costs by borrowing from lenders. The rest of costs are covered with their own accumulated net worth, which is held primarily in the form of capital. Firm j's capital holdings at the beginning of the period t are k^e_{jt}. They are rented on the spot market to other firms, earning $(1 + r_t - \delta)$, like households rent their capital on the spot market. This capital stock k^e_{jt} is related to the non-retained earnings, which reflects the firm's savings decision. It is different from k_{jt}, which reflects the firm's capital demand decisions for production purposes. Thus, firm j's net worth can be written as:

$$nw_{jt} = k^e_{jt}(1 + r_t - \delta) + e_t \tag{1.10}$$

where e_t is the amount of small 'start-up' funds transferred from households which allow bankrupted firms to continue their operation. Thus, the total borrowing by the firm in period t is $B_{jt} = M_{jt} - nw_{jt}$.

Capital Demand and Vacancy Creation

In this section, I focus on the expected operating profit components. Given certain financial conditions, the firm maximizes the expected operating profit

$$\underset{k_{jt},v_{jt},n_{jt}}{Max} E_{\omega}\left[\omega_{jt} z_t k_{jt}^{\alpha} n_{jt}^{1-\alpha} - \chi_t \left(w_t n_{jt} + r_t k_{jt} + \varrho(v_{it})\right)\right] \tag{1.11}$$

subject to the working capital constraint (1.9) and the law of motion for employment (2.25), where $\chi_t > 1$ is a "markup" on input costs that arises solely from the external financing needs of the firm.[3] It reflects the shadow value of the working capital to the firm.[4] Thus, for each unit of rented capital, wage payment and vacancy costs, the operating cost is multiplied by χ_t. Carlstrom and Fuerst (1998) interpret χ_t as a "markup" that drives a wedge between factor prices and marginal products, while Chugh (2013) interprets it as an external finance premium. Both interpretations can be applied to this model.

For the optimization conditions, I drop all j subscripts because I analyze a symmetric equilibrium across all firms. Also, since all decisions are made before the realization of idiosyncratic shocks, ω_{jt} is not shown in the optimization conditions.[5] Maximizing (1.11) with respect to capital rental k_t gives the capital demand condition:

$$r_t = \frac{\alpha z_t k_t^{\alpha-1} n_t^{1-\alpha}}{\chi_t} \tag{1.12}$$

This condition shows that the marginal product of capital is no longer equal to the rental rate, but is equal to the rate including the financing cost.

When firm j decides its vacancy posting, it takes as given the probability that a

[3]If there was no idiosyncratic shock, I would have $\chi_t = 1$ for all t, which means that financing issues are irrelevant.

[4]Precisely, $\chi_t = 1 + \tilde{\chi}_t$ where $\tilde{\chi}_t$ is the Lagrangian multiplier on the working capital constraint.

[5]This is due to the assumption $E(\omega) = 1$.

vacancy will be filled $q(\theta_t)$. Thus, maximizing (1.11) with respect to vacancy postings v_{jt} and employment n_{jt} gives the vacancy creation condition:

$$\frac{\varrho'(v_t)\chi_t}{q(\theta_t)} = (1-\alpha)z_t k_t^{\alpha} n_t^{-\alpha} - \chi_t w_t + (1-\rho^x)\gamma E_t \Lambda_{t+1|t} \frac{\varrho'(v_{t+1})\chi_{t+1}}{q(\theta_{t+1})} \tag{1.13}$$

Condition (1.13) equates the marginal cost of posting a vacancy with its discounted expected value of marginal benefit from the marginal job match net of wages. The marginal benefit is composed of the contemporaneous marginal product of labor and the value of a worker who is hired in period t and continues to work in period $t+1$. Note that in the absence of financial frictions, the working capital constraint disappears and χ_t becomes 1. The vacancy creation condition in a standard DSGE search model is a particular case of (1.13) with $\chi_t = 1$:

$$\frac{\varrho'(v_t)}{q(\theta_t)} = (1-\alpha)z_t k_t^{\alpha} n_t^{-\alpha} - w_t + (1-\rho^x)\gamma E_t \Lambda_{t+1|t} \frac{\varrho'(v_{t+1})}{q(\theta_{t+1})} \tag{1.14}$$

Financial Contract

Regarding the form of borrowing, firms borrows from lenders by means of collateralized risky debt contracts. Under the contract, at the beginning of the period t, firm j borrows B_{jt} using its output as collateral and agrees to pay back at a non-state-contingent price $\bar{B}_{jt}$ at the end of period t, *i.e* after the production. When making a contract in period t, both the firm and lender are not aware of the realization of idiosyncratic shocks, but they are aware of the aggregate state (z_t, σ_t).

The firm j's output is $\omega_{j,t}\chi_t M_{i,t}$. Once the idiosyncratic shock is realized, there is a cutoff threshold where the firm cannot pay its debt. Let $\bar{\omega}_t$ denote the threshold, then

$$\bar{\omega}_t = \frac{\bar{B}_{j,t}}{\chi_t M_{jt}} \tag{1.15}$$

If $\omega_{jt} \geq \bar{\omega}_t$ the firm honors its debt. If $\omega_{jt} \leq \bar{\omega}_t$ the firm defaults and the lender simply keeps the collateral which is the output $\omega_{j,t}\chi_t M_{i,t}$. Note that all firms, regardless of whether they default or not, do produce output up to their full capacity.

When borrowing from the lender, each firm faces two constraints. First, a *participation constraint* requires that the lender is willing to fund the firm. Since the loan is an intra-temporal loan, the opportunity cost to lend is the same as the amount of debt. Therefore, the participation constraint takes the form:

$$\chi_t M_{jt}\left[\int^{\bar{\omega}_{jt}} \omega_{jt} dF_t(\omega) + \bar{\omega}_{jt}\left[1 - F_t(\bar{\omega}_{jt})\right]\right] \geq M_{jt} - nw_{jt} \tag{1.16}$$

Second, the lender imposes an *incentive compatibility* (IC) constraint due to the moral hazard problem. To introduce a moral hazard problem, I modified the models of Adrian and Shin (2013) and Nuno and Thomas (2013). A firm is assumed to have the option to use one of two different technologies: a standard technology and a substandard technology. These technologies differ only in the distribution of idiosyncratic realization, given by $F_t(\omega)$ and $\tilde{F}_t(\omega) \equiv \tilde{F}(\omega; \sigma_t)$ respectively. The substandard technology has a lower average payoff, $\int \omega d\tilde{F}_t(\omega) < \int \omega dF_t(\omega) = 1$, and is thus inefficient. Moreover, $F_t(\omega)$ is assumed to first-order stochastically dominate $\tilde{F}_t(\omega)$, which means that $\tilde{F}_t(\omega) > F_t(\omega)$ for all $\omega > 0$. Therefore, the substandard technology has a higher downside risk. In order to induce the firm to use the standard technology, the lender should guarantee that standard technology brings higher returns to the firms than substandard technology. The IC constraint takes the following form:

$$\int_{\bar{\omega}_{jt}} \left(\omega_{jt}\chi_t M_{jt} - \bar{B}_{jt}\right) dF_t(\omega) \geq \int_{\bar{\omega}_{jt}} \left(\omega_{jt}\chi_t M_{jt} - \bar{B}_{jt}\right) d\tilde{F}_t(\omega) \tag{1.17}$$

Equation (1.17) requires a deeper analysis. The expected payoff of using the standard technology can be expressed as:

$$\int_{\bar{\omega}_{jt}} \left(\omega_{jt}\chi_t M_{jt} - \bar{B}_{jt}\right) dF_t(\omega) = \chi_t M_{jt} \int_{\bar{\omega}_{jt}} \left(\omega_{jt} - \bar{\omega}_{jt}\right) dF_t(\omega) \tag{1.18}$$

The integral part of the right hand side represents the value of a *call option* on the returns with strike price equal to the default threshold $\bar{\omega}_{jt}$. The limited liability arises from this non-state-contingent debt payment. Thus, the firm enjoys the upside risk in output over and above its debt, but does not bear the downside risk, which is transferred to the lender. We can rewrite the value of the call option as:

$$\int_{\bar{\omega}_{jt}} (\omega_{jt} - \bar{\omega}_{jt})\, dF_t(\omega) = \int \omega dF_t(\omega) + \int^{\bar{\omega}_{jt}} (\bar{\omega}_{jt} - \omega)\, dF_t(\omega) - \bar{\omega}_{jt} \tag{1.19}$$

Given the face value of its debt, the firm's expected net profit increases with (1) mean of idiosyncratic shock $\int \omega F(\omega)$, and (2) the value of the *put option* on the return with strike price $\bar{\omega}_{jt}$. Denote $\pi_t(\bar{\omega}_{jt})$ as the put option value, then

$$\pi_t(\bar{\omega}_{jt}) \equiv \pi_t(\bar{\omega}_{jt}; \sigma_t) = \int^{\bar{\omega}_{jt}} (\bar{\omega}_{jt} - \omega)\, dF_t(\omega) \tag{1.20}$$

Analogously, the put option value under the substandard technology, which is denoted by $\bar{\pi}_t(\bar{\omega}_{jt})$, is defined my a similar pattern, but with $\tilde{F}_t$ replacing F_t. The distribution assumptions give $\bar{\pi}_t(\bar{\omega}_{jt}) > \pi_t(\bar{\omega}_{jt})$.[6] Denote $\Delta\pi_t(\bar{\omega}_{jt}) \equiv \bar{\pi}_t(\bar{\omega}_{jt}) - \pi_t(\bar{\omega}_{jt})$ as the difference between two put option values, and then we have $\Delta\pi_t(\bar{\omega}_{jt}) = \tilde{F}_t(\bar{\omega}_{jt}) - F_t(\bar{\omega}_{jt}) > 0$, which shows that the incentive to use substandard technology increases with the debt commitment. Intuitively, when choosing between two different technologies, the firm trades off the higher mean return of using the standard technology against the lower put option value.

Asset Accumulation and Dynamic Profit Function

Based on the financial contract above, the firm makes a savings decision. The firm j starts period t with net worth given by (1.10). Then it borrows $M_{jt} - nw_{jt}$ against the value of these assets, and it expects to keep $\left[\int_{\bar{\omega}_{jt}} (\omega_{jt} - \bar{\omega}_{jt})\, dF_{t-1}(\omega)\right] \chi_t M_{jt}$ af-

[6] By integrating by part, it is possible to show that $\pi_t(\bar{\omega}_{jt}) = \int^{\bar{\omega}_{jt}} F_t(\omega) dw$. First-order stochastic dominance assumption of F_t over $\tilde{F}_t$ implies the second-order dominance: $\int^x \tilde{F}_t(\omega) d\omega > \int^x F_t(\omega) d\omega$ for all $x > 0$. Thus, $\bar{\pi}_t(\bar{\omega}_{jt}) > \pi_t(\bar{\omega}_{jt})$ for all $\bar{\omega}_{jt} > 0$

ter repaying its loan. The firm can either accumulate assets or make payment to households, that is

$$\Pi_{jt}^{e} + k_{t+1}^{e} = \left[\int_{\bar{\omega}_{jt}} (\omega_{jt} - \bar{\omega}_{jt})\, dF_t(\omega)\right] \chi_t M_{jt} \tag{1.21}$$

$$= [1 - \bar{\omega}_{jt} + \pi_t(\bar{\omega}_{jt})]\, \chi_t M_{jt} \tag{1.22}$$

If the participation constraint (1.16) binds, the asset accumulation equation can be written as

$$\begin{aligned} \Pi_{jt}^{e} + k_{t+1}^{e} &= \frac{\chi_t\,[1 - \bar{\omega}_{jt} + \pi_t(\bar{\omega}_{jt})]}{1 - \chi_t\,[\bar{\omega}_{jt} - \pi_t(\bar{\omega}_{jt})]} nw_{jt} \\ &= \frac{\chi_t\,[1 - \bar{\omega}_{jt} + \pi_t(\bar{\omega}_{jt})]}{1 - \chi_t\,[\bar{\omega}_{jt} - \pi_t(\bar{\omega}_{jt})]} \left(k_{jt}^{e}(1 + r_t - \delta) + e_t\right) \end{aligned}$$

where the last equation comes from the definition of net worth (1.10).

With all variables in place we can conclude that the firm j's dynamic profit function can be written as

$$E_0 \sum_{t=0}^{\infty} \gamma^t \Lambda_{t|0} \left[\Pi_{jt}^{e} + E_\omega \Pi_{jt}^{f}\right] \tag{1.23}$$

where

$$\begin{aligned} \Pi_{jt}^{e} &= \frac{\chi_t\,[1 - \bar{\omega}_{jt} + \pi_t(\bar{\omega}_{jt})]}{1 - \chi_t\,[\bar{\omega}_{jt} - \pi_t(\bar{\omega}_{jt})]} \left(k_{jt}^{e}(1 + r_t - \delta) + e_t\right) - k_{t+1}^{e} \\ E_\omega \Pi_{jt}^{f} &= E_\omega \left[\omega_{jt} z_t k_{jt}^{\alpha} n_{jt}^{1-\alpha} - \chi_t \left(w_t n_{jt} + r_t k_{jt} + \varrho(v_{it})\right)\right] \end{aligned}$$

Thus, the maximization of (1.23) with respect to the asset accumulation k_{t+1}^{e} gives the firm's capital Euler equation:

$$1 = \gamma E_t \left[\Lambda_{t+1|t} \frac{\chi_{t+1}\,[1 - \bar{\omega}_{jt+1} + \pi_{t+1}(\bar{\omega}_{jt+1})]}{1 - \chi_{t+1}\,[\bar{\omega}_{jt+1} - \pi_{t+1}(\bar{\omega}_{jt+1})]} (1 + r_{t+1} - \delta)\right] \tag{1.24}$$

1.2.4 Wage Bargaining

As is common in the labor search literature, the wage-determination mechanism is Nash bargaining between workers and firms. The wages of all workers, whether newly hired or not, are set each period through Nash negotiation, which implies that the cost associated with the recruiting procedure is paid before negotiation takes place. The detailed derivation of the wage-bargaining problem is presented in Appendix.

Let $\eta \in (0,1)$ be a worker's bargaining power and $1-\eta$ a firm's bargaining power. Then the wage is determined by

$$\begin{aligned} w_t \;&=\; \frac{\eta}{\chi_t}\left[(1-\alpha)z_t\left(\frac{k_t}{n_t}\right)^{\alpha} + (1-\rho^x)\gamma E_t\Lambda_{t+1|t}\frac{\varrho'(v_{t+1})\chi_{t+1}}{q(\theta_{t+1})}\right] + (1-\eta)\left[\frac{\phi}{u'(c_t)}+s\right] \\ &\quad -\frac{\eta}{\chi_t}(1-\rho^x)\left[E_t\Lambda_{t+1|t}\left(1-p(\theta_{t+1})\right)\frac{\varrho'(v_{t+1})\chi_{t+1}}{q(\theta_{t+1})}\right] \qquad (1.25) \end{aligned}$$

The wage equation (1.25) shows that the wage is a convex combination of the expected discounted value to the firms and workers. The first and the third terms represent the value to the firm: marginal revenue generated for the firm by a new employment match, deflated by the financing cost, and the forward-looking relationship value of employment net of the value for newly matched workers. The second term represents the value to the workers, the sum of marginal disutility and the unemployment benefit. Note that in the absence of financial friction and $\gamma = 1$, the wage would collapse to the wage equation in standard labor-search model

$$w_t = \eta\left[(1-\alpha)z_t\left(k_t/n_t\right)^{\alpha} + (1-\rho^x)E_t\Lambda_{t+1|t}\theta_{t+1}\varrho'(v_{t+1})\right] + (1-\eta)\left[\frac{\phi}{u'(c_t)}+s\right] \qquad (1.26)$$

1.3 Quantitative Analysis

1.3.1 Functional Forms and Calibration

The functional forms for preferences, job match and vacancy costs are presented in Table 1.1. All functional forms are commonly used in the literature.

Functional Forms	Description
$u(c_t) = ln(c_t)$	Consumption Subutility
$m(u_t, v_t) = m_0 u_t^{\zeta} v_t^{1-\zeta}$	Job Matching Technology
$\varrho(v_t) = \bar{\varrho} v_t^{\kappa}$	Vacancy Creation Costs

Table 1.1: Functional Forms

The baseline values for parameters can be seen in Table 1.2. The households' discount factor β is set to target an annual steady-state interest rate of 4% and the entrepreneur's additional discount $\gamma = 0.947$ is taken from Carlstrom and Fuerst (1998). The parameter that governs the disutility of labor ψ is chosen to match a steady-state unemployment rate of 10%. Several authors have argued that the targeted steady-state unemployment rate should be higher than the rate of workers counted as unemployed, as the model does not account for non-participation.[7] It can be interpreted as a sum of both unemployed and partially out of the labor force workers. The unemployment benefit is chosen to match a replacement ratio s/w of 0.4, which is the lower spectrum of the values in the literature.[8] The elasticity of capital in the production function α is set to 0.36, while the quarterly depreciation rate for capital δ is set to 2.5%. I assume an AR(1) process for the natural log of the TFP, shocks to which have quarterly persistence $\rho^z = 0.95$ as in the standard business cycle literature. The standard deviation is chosen to match the empirical volatility of GDP.

For parameters pertaining to the labor market, the exogenous separation rate ρ^x is set to 10%, which is consistent with the 0.034 monthly separation rate computed by Shimer (2005) and is within the range of values used in the literature, ranging from

[7] Chugh (2013), Petrosky-Nadeau (2013) and Garin (2014) use the same 10% unemployment rate for the calibration. Krause and Lubik (2007), Andofatto (1996) and Trigari (2009) use higher values, 12%, 43%, and 25.3%, respectively, while Gertler and Trigari (2009) use 7%.

[8] There is no definite value for the replacement ratio in the search literature. For example, Hagedorn and Manovskii (2008) choose 0.955 to match key labor market statistics in standard search model, which generates lower elasticity of a wage to productivity. Rotemberg (2006) uses a value of 0.9, while Petrosky-Nadeau (2013) set the rate at a lower 0.75.

Parameters	Description	Value
β	Households' subjective discount factor	0.99
γ	Entrepreneurs' (additional) subjective discount factor	0.947
ψ	Disutility of Labor	0.5153
s	Unemployment Benefit	0.8967
α	Share of capital in the production function	0.36
δ	Capital depreciation rate	0.025
ρ^x	Job Seperation rate	0.1
m_0	Matching function calibrating parameter	0.6529
ζ	Elasticity of matches w.r.t unemployment	0.5
η	Worker's Nash bargaining power	0.4
$\bar{\varrho}$	Vacancy cost calibrating parameter	0.2136
κ	Curvature of vacancy creation cost function	1
ρ^z	Persistence of aggregate productivity	0.95
ρ^σ	Persistence of risk shocks	0.9457
σ^z	Standard deviation of productivity shock	0.0079
σ^σ	Standard deviation of risk shock	0.0465
υ	Standard deviation of substandard technology	1.43
ν	Mean of substandard technology	0.0002
σ	Steady-state firm-risk volatility	0.0373

Table 1.2: Value of Parameters

0.07 in Merz (1995) to 0.15 in Andolfatto (1996). The matching function parameter m_0 is chosen to match a job-filling rate $q(\theta)$ of 0.9. The elasticity of matches with respect to unemployment is standard in the literature, and the worker's bargaining power is taken from Chugh (2013). I assume a linear vacancy cost function *i.e.* $\kappa = 1$, and the cost of posting vacancy $\bar{\varrho}$ is chosen so that the steady-state vacancy cost represents 0.65% of output ($\varrho(v)/y = 0.65\%$), corresponding to Garin (2014).

The model-specific parameters are calibrated according to the strategy of Nuno and Thomas (2013). I target a spread in the short-term debt of 25 annualized basis points. Thus, the gross interest rate is equal to $\bar{R} = R(1.0025)^{1/4}$. This implies a default threshold $\bar{\omega} = \frac{\bar{B}}{B}\frac{\phi-1}{\phi} = 0.5292$

The firm-specific shocks are assumed to be log-normally distributed as

$$ln\,\omega \sim i.i.d\mathcal{N}\left(\frac{-\sigma_t^2}{2}, \sigma_t^2\right) \quad ln\,\tilde{\omega} \sim i.i.d\mathcal{N}\left(\frac{-\upsilon\sigma_t^2 - \nu}{2}, \sqrt{\upsilon}\sigma_t^2\right)$$

both for the standard and substandard technologies, respectively. Both ν and υ control the mean and variance difference between two technologies. These distribution assumptions give $E[\tilde{\omega}] = e^{-\nu/2} < E[\omega] = 1$, $F(\omega;\sigma_t) = \Phi\left(\frac{log(\omega)+\sigma^2/2}{\sigma_t}\right)$, and $\tilde{F}(\omega;\sigma_t) = \Phi\left(\frac{log(\omega)+\frac{\nu+\upsilon\sigma_t^2}{2}}{\sqrt{\upsilon}\sigma_t}\right)$. The standard deviation of firm risk shocks is also assumed to follow AR(1) process in logs.

$$log(\sigma_t) = \rho^\sigma log(\sigma_{t-1}) + (1-\rho^\sigma)log(\sigma) + \varepsilon_t^\sigma, \quad \varepsilon_t^\sigma \sim i.i.d\;\mathcal{N}(0, \sigma_\sigma)$$

The parameters governing the dynamics for firm risk shocks are calibrated using the TFP series for all 4-digit SIC manufacturing industries constructed by the NBER and the US Census Bureau's Center for Economic Studies (CES)[9]. I calculate the cross-sectional standard deviation series of the industry-level TFP series in the log deviations from a linear trend. Then, I convert it into quarterly frequency and derive the persistence and standard deviation of the series. I set ν to 0.002 for analytic purposes and solve for $\upsilon = 1.43$. Shocks to the substandard technology are $\sqrt{\upsilon} = 1.2$ times more volatile than shocks to the standard one.

1.3.2 Impulse Responses

In this section, I present results from impulse response analysis of one standard deviation shocks to aggregate TFP and to firm risks. The scale represents percentage deviations (or log-deviations) from the steady state, except for the finance premium, which represents percentage point deviations.

Figure 1.1 compares the responses of key variables to each shock and both shocks at the same time. Following a negative TFP shock, firms reduce their hiring on im-

[9] Website: http://www.nber.org/data/nbprod2005.html

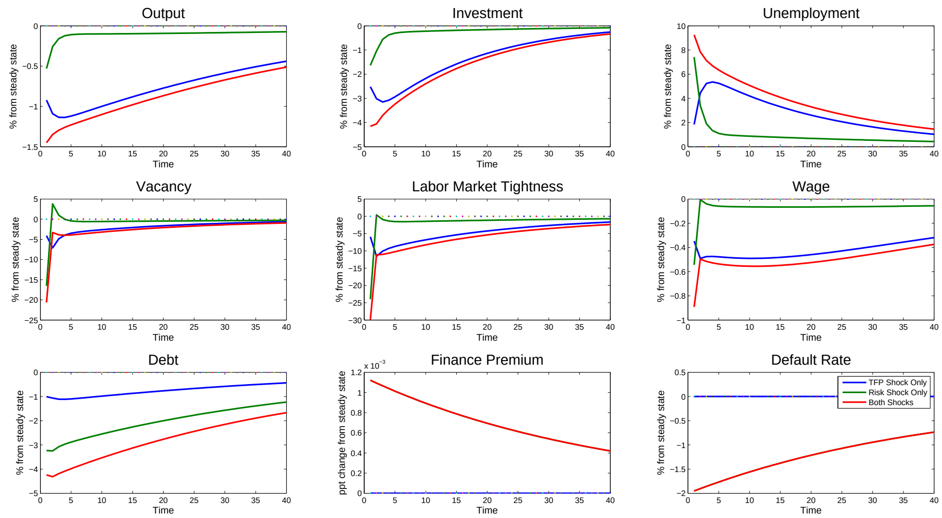

Figure 1.1: Impulse response of selected aggregate, labor market, and financial market variables in response to a one-time negative shock to aggregate TFP.

pact by 5%. Unemployment increases at the same time, consistent with the empirical evidence of the Beveridge curve. The lower value of collateral leads to the negative response of investment and debt. As financial constraints tighten, firms should postpone new recruitment.

Firm risk shocks amplify the responses of all labor market variables while they subdue those of output and investment. As the dispersion of the idiosyncratic shocks increases, lenders are reluctant to lend funds to firms. Due to the high risk of defaults, lenders ask for the higher finance premium which generates larger negative responses of vacancy postings. Since the risk shocks do not affect the mean of productivity directly, the aggregate production is less affected than in the case of TFP shocks. If both TFP shocks and risk shocks hit the economy at the same time, we see the reinforcement of responses.

1.3.3 Business Cycle Statistics

Table 1.3 compares standard business cycle statistics from Hodrick-Prescott filtered data with their counterparts from the model's simulations. Model simulation series

Data (1951Q1-2013Q2)

		GDP	Unemployment	Vacancy	Market Tightness	Investment
Std. (%)		1.5600	13.1267	14.0551	26.5871	6.9091
Corr. Matrix	y	1.0000	-0.8527	0.8990	0.8963	0.8857
	u		1.0000	-0.9133	-0.9766	-0.7253
	v			1.0000	0.9796	0.8200
	θ				1.0000	0.7916
	i					1.0000

Model Simulation

		GDP	Unemployment	Vacancy	Market Tightness	Investment
Std. (%)		1.5600	9.8259	18.0444	26.1108	4.6070
Corr. Matrix	y	1.0000	-0.8511	0.5682	0.7130	0.9913
	u		1.0000	-0.7321	-0.8823	-0.8665
	v			1.0000	0.9666	0.5657
	θ				1.0000	0.7170
	i					1.0000

Table 1.3: Business Cycle Statistics

are generated by simulating the model 5000 times around the deterministic steady state equilibrium. Each simulation is a length of 1000 periods, and we abandon the first 200 observations in order to abstract from the sensitivity to initial values. All moments are calculated from the log-deviation of each series filtered by a Hodrick-Prescott filter with a smoothing parameter 1600. Then, I choose the mean of the statistics across the simulation.

Data shows that the labor market statistics are much more volatile than output and investment. Unlike the standard labor search model, the baseline model matches the empirical moments fairly well. Unemployment and vacancy are roughly 6.3 times and 11.6 times more volatile than output, respectively. Although it fails to generate enough unemployment fluctuation and over-generates vacancy fluctuations, its performance is superior to other existing literature. Using a costly state verification problem, Petrosky-Nadeau (2013) presents a model that generates 2.37 times more

Model with only TFP shocks

		GDP	Unemployment	Vacancy	Market Tightness	Investment
Std. (%)		1.4691	6.7875	7.4602	13.4507	4.2619
	y	1.0000	-0.9370	0.8897	0.9663	0.9929
Corr.	u		1.0000	-0.7820	-0.9383	-0.9342
Matrix	v			1.0000	0.9493	0.9067
	θ				1.0000	0.9743
	i					1.0000

Model with only risk shocks

		GDP	Unemployment	Vacancy	Market Tightness	Investment
Std. (%)		0.4994	7.0894	16.4655	22.4072	1.6677
	y	1.0000	-0.9980	0.7601	0.8743	0.9879
Corr.	u		1.0000	-0.7741	-0.8852	-0.9864
Matrix	v			1.0000	0.9797	0.6596
	θ				1.0000	0.7968
	i					1.0000

Table 1.4: Business Cycle Statistics with one shock at a time

volatile unemployment and 8.95 times more volatile vacancy than output. In Garin (2013), the introduction of collateral constraint produces an unemployment that is 3.8 times and 6 times more volatile than output, respectively. Chugh (2013) uses the spillover effect between the aggregate TFP and idiosyncratic productivity to generate the ratio of the standard deviation of unemployment to that of output, which equals 8.63. However, the model in Chugh (2013) has an endogenous job searching decision for workers, which is absent in this model. Regarding the correlation, the model presented here also captures the strong negative relationship between vacancies and unemployment observed in the data.

To understand how much the risk shocks contribute to the generation of such fluctuations, I simulate the model with one shock at a time. Table 1.4 represents the same statistics generated by each shock. It is clear that the risk shocks amplify labor market variables much more than the aggregate TFP shocks. Meanwhile, the model with only TFP shocks does well in matching the statistics related to output and investment. Intuitively, the risk shocks determine the external financing cost of firms and in turn, affect the hiring decision. Thus, risk shocks contribute to the movement of labor market variables. The aggregate TFP shock directly affects the real (non-financial) sector of the economy.

1.4 Conclusion

I have developed a model in which shocks to the firm risk generate large fluctuations in labor markets, and the amplification is mediated through the short-term collateralized debt contract. This model is suitable to study how firms' financing conditions affect the decisions about job creation. Relative to the standard DSGE labor search model, this model performs well in matching the movements of key labor market variables.

The key features of the model are the risk shocks and the financial frictions. Financial frictions arise from the limited liability and the moral hazard property of the contract between lenders and firms. The higher dispersion of idiosyncratic shocks leads to the higher risk of defaults, which discourages lenders from providing loans to firms. It generates a counter-cyclical finance premium, consistent with the empirical evidence. Financially constrained firms postpone new recruitment and it becomes more difficult for unemployed workers to find jobs.

Several extensions can be made for future research. As this model focuses on the demand side of labor market, a different model may allow for endogenous job searching or endogenous job separation. Chugh (2013) and den Haan, Ramey, and Watson (2000) already have introduced such features in their work in order to explain many business cycle issues. Also, introducing active financial sector institutions may contribute details to the financial frictions. Wasmer and Weil (2004) presented a three-period model in which a bank is the intermediary between workers and firms. One can extend this idea into a DSGE model that includes a banking sector that actively manages its balance sheet and, in turn, affects the financial condition of firms.

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Chapter 2

Shadow Banks and Stabilization Policies

2.1 Introduction

The 2007-2009 financial crisis motivated many scholars and policy makers to investigate the causes and consequences of financial market disruption. This has led to an increase in both empirical and theoretical research that focuses on the vulnerability of financial markets and the connections among financial intermediaries.

After the 1990s, the shadow banking sector emerged and grew rapidly. Shadow banks are relatively free from regulatory supervision and rely on short-term debt. They take many of the same risks as traditional or commercial banks, but with far less capital. Thus, the shadow banking sector's excessive leverage increase may contribute to the financial instability and the substantial contraction of the financial markets.

This paper analyzes the interaction between commercial and shadow banks in situations where two types of banks are interconnected. I develop a general equilibrium model with financial intermediates who play a key role in supplying credit to firms. As the shadow bank is exposed to the uncertainty risk, the limited liability property of the debt may lead to an increase in macroeconomic volatility. Last, I suggest that government policy in the form of direct lending is relatively more efficient than policies aimed at the shadow banking sector.

The basic structure of the model can be summarized as follows. Shadow banks borrow from commercial banks in the form of short-term risky debt. Unlike commercial banks, shadow banks are segmented with firms across islands. When firms are hit by the island-specific idiosyncratic shocks, shadow banks are also exposed to these shocks. Depending on the realization of shocks, a fraction of shadow banks declare bankruptcy and default on their debt in each period.

The shadow banks' leverage is endogenously determined by market forces. Due to the limited liability, they enjoy the upside risk in their assets over and above the face value, leaving commercial banks to bear the downside risk. This possibility creates a moral hazard problem, so commercial banks impose a leverage constraint in order to induce shadow banks to invest efficiently.

On the other hand, commercial banks can raise deposits from households. They can either give loans directly to firms or purchase ABS from shadow banks. Commercial banks have an incentive to invest in ABS, because securitized assets, which are regarded as safer and more liquid and tradeable, are more pledgeable than the loans they have in their balance sheet. Thus, by holding good quality collateral, commercial banks can increase their leverages.

Although increased securitization helps the extend the credit supply, it also creates a vulnerability as the supply of ABS depends on the shadow banks' balance sheet. A negative aggregate shock has an impact on both sets of banks' net worth. The fall of shadow banks' net worth leads to a contraction in shadow banking activity. In turn, this further tightens the financing constraints of commercial banks, which results in the amplified responses of the economy.

The rest of the paper is organized as follows. Section 2.2 describes the model structure. Section 2.3 presents the calibration and simulation results, Section 2.4 performs policy analysis, and Section 2.5 concludes.

2.2 Model

The model economy consists of five types of agents: a representative household, commercial banks, shadow banks, firms, and capital good producers. We can divide the model framework into the real side and the financial side. The real side of the model is standard. Firms borrow funds from banks to purchase capital from capital producers. Using capital and labor, firms produce a final good, which is purchased by households for consumption and by capital producers. After production, firms sell the depreciated capital to capital producers and transfer operating profits to banks.

The financial side of the model is composed of two sectors: commercial banks and shadow banks. We assume that the household lacks the skills necessary to manage financial investment projects. As a result, both banks are the only entities that can finance a firm's investment and are efficient at evaluating and monitoring firms. These two types of banks are different in several ways. First, commercial banks can raise deposits directly from households, while shadow banks cannot. Thus, shadow banks borrow funds from commercial banks in the form of short-term debt. Second, commercial banks are assumed to be under regulatory supervision, so their loan provisions are limited to the standard firms. The definition of 'standard' firms will be explained below. However, shadow banks can freely choose to give loans to 'substandard' firms. Third, idiosyncratic uncertainty risks exists across sectors, or islands. Shadow banks are exposed to the risks, so they can default if the realized shock is bad enough. Commercial banks are safe from default, because they have superior technology to diversify risks. On the other hand, commercial banks are financially constrained. As explained in Gertler and Karadi (2011), commercial banks cannot raise deposits from households infinitely because they may divert assets for their benefit. Thus, they need to pledge a portion of their assets to raise deposits. Meanwhile, due to the uncertainty and the limited liability, the shadow banks have an incentive to invest in inferior projects and shift downside risks to the creditor commercial banks. The commercial banks cap the leverage of shadow banks in order to prevent the moral hazard.

We now analyze the behavior of each type of agents.

2.2.1 Firms

A continuum of competitive firms produces final goods. As in Kiyotaki and Moore (2008) and Gertler and Kiyotaki (2010), we assume that firms are segmented across a continuum of "islands" indexed by $j \in [0, 1]$. Firms in island j start a period with capital K_t^j which is purchased at the end of period $t-1$. In the beginning of the period, each island faces an idiosyncratic shock, ω_t^j, which changes the amount of effective capital to $\omega_t^j K_t^j$. The shock ω_t^j is i.i.d. over time and across islands.

Following Nuno and Thomas (2013), in each island there exist two types of firms which differ in the shock distribution they face. In every period after production has taken place, each firm's type follows an i.i.d. process over time, with probability one half each. Note that the type for time t is drawn at the end of $t-1$. As described above, at the beginning of period t, they faces idiosyncratic shocks to effective capital. Let ω_t^j and $\tilde{\omega}_t^j$ denote the shock received by each type of firm "standard" and "substandard" firms, respectively. Both shocks are i.i.d. over time and across islands. Let $F(\omega_t; \sigma_{t-1})$ and $\tilde{F}(\omega_t; \sigma_{t-1})$ denote the cumulative distribution functions in period t respectively, where σ_{t-1} is the exogenous process that governs the variance of both distributions and is known one period in advance. The average shock to standard firms is normalized to 1, $i.e$ $\int \omega dF_t(\omega) = 1$.

The role of the two different types of firms will be discussed in Section 2.2.3, when we describe the structure of shadow banking sector. Note that, in equilibrium the substandard firms do not operate and only standard firms produce output. Thus, "firms" refers to standard firms only, unless otherwise indicated.

Firms produce goods using capital and labor in a constant-return-to-scale Cobb-Douglas technology,

$$Y_t^j = Z_t(\omega_t^j K_t^j)^\alpha (L_t^j)^{1-\alpha} \tag{2.1}$$

where Z_t is an exogenous total factor productivity (TFP) process. Firms choose labor to satisfy:

$$W_t = (1-\alpha)\frac{Y_t^j}{L_t^j} = (1-\alpha)\, Z_t \left(\frac{\omega_t^j K_t^j}{L_t^j}\right)^\alpha \tag{2.2}$$

It follows that the effective capital-labor ratio is equalized across the island for all j,

$$\frac{\omega_t^j K_t^j}{L_t^j} = \left(\frac{W_t}{(1-\alpha)Z_t}\right)^{1/\alpha}$$

The firm's operating profits are given to $Y_t^j - W_t L_t^j = Z_t(\omega_t^j K_t)^\alpha L_t^{1-\alpha} - W_t L_t^j = \omega_t^j R_t^k K_t^j$ where

$$R_t^k = \alpha Z_t \left(\frac{(1-\alpha)Z_t}{W_t}\right)^{\frac{1-\alpha}{\alpha}} \tag{2.3}$$

is also equalized across the islands. Once the production is done, firms sell the depreciated capital $(1-\delta)\omega_t^j K_t^j$ to capital producer at price Q_t. Summing together, we can express the total return from the effective capital as

$$R_t^A = \frac{R_t^k + (1-\delta)Q_t}{Q_{t-1}}$$

Following Gertler and Karadi (2011), I assume that firms can only buy capital through issuing state-contingent debt. At the end of period $t-1$, the firm buys K_t^j unit of new capital for the production in period t. To finance this, firms issue a number A_{t-1}^j of claims on the gains in period t. Firms face the funding constraint at the end of period $t-1$, $Q_t K_t^j = Q_t A_{t-1}^j$, where Q_t is the price of capital. Thus, the payment for claims can be thought of as dividends from firms to lending banks.

2.2.2 Commercial Banks

The structure of commercial banks is a modified version of the banking sector modeled in Gertler and Karadi (2011) and Meek et al. (2013). Within this framework, there exists a continuum of commercial banks (mnemonic c) in the economy, which are owned by household. They have two investment options: (1) financing firms in the form of equity-like state-contingent debt, A_t^c (2) buying asset backed securities issued by shadow banks, B_t^c. Their portfolio is financed by a mix of deposits and inside equity (net worth). However, commercial banks face an agency problem because they cannot pledge the entire value of their assets to raise deposits from households. A shortage of pledgeable income is the source of the financial frictions in the economy.

Recall that our assumptions about commercial banks guarantee that they give loans only to standard firms and are able to diversify risks across islands. Commercial banks provide a bundle of loans across the islands, $i.e$ $A_t^c = \int A_t^{c,j} dj$. Thus, a continuum of commercial banks can be considered as a representative commercial bank. The balance sheet identity of the representative commercial bank at the end of the period t is given by:

$$Q_t A_t^c + B_t^c = D_t + N_t^c \tag{2.4}$$

where D_t is the deposits raised from household, and N_t^c is the net worth of the commercial bank.

Let R_t^B be the return from the ABS and R_t be the deposit rate. Then, net worth at time t is the retained earnings from assets funded at $t-1$, net borrowing costs, as follows:

$$N_t^c = R_t^A Q_{t-1} A_{t-1}^c + R_t^B B_{t-1}^c - R_t D_{t-1} \tag{2.5}$$

and using the balance sheet condition (2.4), we can re-write (2.5) as follows:

$$N_t^c = (R_t^A - R_t^B) Q_{t-1} A_{t-1}^c + (R_t^B - R_t) D_{t-1} + R_t^B N_{t-1}^c \tag{2.6}$$

A commercial bank maximizes its expected discount terminal net worth V_t^c by choosing the amount of assets to purchase and deposits to borrow:

$$V_t^c = \max_{A_t^c, B_t^c, D_t} E_t \Lambda_{t+1|t} \left[(1-\theta) N_{t+1}^c + \theta V_{t+1}^c \right] \tag{2.7}$$

where $\Lambda_{t+1|t}$ is the household's stochastic discount factor and θ is the survival rate of the bank. As discussed in next paragraph, banks are constrained to raise funds due to an agency problem. To prevent banks from avoiding the constraint by accumulating sufficient net worth, it is assumed that each period banks exit the market with the probability θ and transfer their earnings back to households upon exit. Thus, only $1-\theta$ fraction of the banks survive and can operate in the next period.

Following Gertler and Karadi (2011), I introduce a moral hazard problem between households and banks, which limits the size of bank's balance sheet. At the end of each period, banks may choose to divert κ fraction of all available funds from the projects and transfer it back to the households. If a bank diverts its funds, then depositors are able to force the banks into bankruptcy and recover the remaining $1-\kappa$ fraction of the assets. It is assumed that depositors cannot recover the diverted fraction of assets due to the high cost. We assume that the depositors regard balance sheet loans as worse collateral than asset backed securities. Thus, the value of divertible assets is a weighted fraction of the bank's end of period balance sheet value. To ensure banks do not have incentive to divert funds, the following incentive compatibility constraint must be satisfied at the end of period t:

$$V_t^c \geq \kappa\left(Q_t A_t^c + (1-\gamma) B_t^c\right) \tag{2.8}$$

where $\gamma \in [0,1]$ and ABS becomes perfectly pledgeable as γ is close to 1. Switching a marginal unit of funds from loans into ABS reduces the divertible assets by $\kappa\gamma$ and loosens the constraint. As Meek et al. (2013) discussed, the motivation behind (2.8) is that whereas loans held by banks are opaque, ABS are standardized, tradable, and backed by collateral.[1]

The commercial bank will maximize its expected return to its portfolio subject to the incentive compatibility constraint (2.8). Then, its demand for assets is fully

[1]Perotti (2010) suggests that the change in bankruptcy provisions led banks to demand ABS for its collateral value. Between 1998 and 2005, a series of amendments to bankruptcy laws in the United States and European Union led to exemption from bankruptcy stays for all secured financial credit used in repurchase agreements.

determined by its net worth position, and it will expand its balance sheet until the incentive compatibility constraint binds.

The value of a commercial bank V_t^c can be expressed as follows:

$$V_t^c = \left(\frac{\nu_t^A}{Q_t} - \nu_t^B\right) Q_t A_t^c + \left(\nu_t^B - \nu_t^D\right) D_t + \nu_t^B N_t^c \tag{2.9}$$

where ν_t^A, ν_t^B, and ν_t^D are the marginal value of an additional unit of each balance sheet item at the end of period t: loans, deposits, and net worth, respectively. Let the λ_t^c be the multiplier on the constraint (2.9), then the first-order conditions for optimal A_t^c, D_t, and λ_t^c are:

$$\frac{\nu_t^A}{Q_t} - \nu_t^B = \kappa\gamma \frac{\lambda_t^c}{1+\lambda_t^c} \tag{2.10}$$

$$\nu_t^B - \nu_t^D = \kappa(1-\gamma) \frac{\lambda_t^c}{1+\lambda_t^c} \tag{2.11}$$

$$\begin{aligned} 0 = {} & \left(\frac{\nu_t^A}{Q_t} - \nu_t^B - \kappa\gamma\right) Q_t A_t^c + \left(\nu_t^B - \nu_t^D - \kappa(1-\gamma)\right) D_t \\ & + \left(\nu_t^B - \kappa(1-\gamma)\right) N_t^c \end{aligned} \tag{2.12}$$

According to the equation (2.10), the marginal value of loans in terms of good $\frac{\nu_t^A}{Q_t}$ exceeds the marginal value of ABS to the extent that the incentive constraint is binding ($\lambda_t^c > 0$) and the ABS is pledgeable ($\gamma > 0$). Combining the conditions with the equation (2.4), we can derive the bank's ABS demand function:

$$B_t^c = \frac{1}{\gamma} D_t - \left(\frac{\nu_t^A/Q_t - \kappa}{\kappa\gamma - \mu_t^c}\right) N_t^c \tag{2.13}$$

where $\mu_t^c \left(\equiv \frac{\nu_t^A}{Q_t} - \nu_t^B\right)$ is the excess value of loans over ABS. The equation (2.13) shows that the demand for ABS is increasing in deposits and decreasing in net worth. A higher proportion of deposits leads banks to hold more ABS as the incentive constraint tightens, while a higher proportion of net worth increases the capacity of the bank to hold more loans.

The equation (2.10) gives an equation for the Lagrange multiplier:

$$\lambda_t^c = \frac{\mu_t^c}{\kappa\gamma - \mu_t^c} \tag{2.14}$$

We can see that λ_t^c represents the effect of relaxing the constraint by a marginal unit. One unit of goods can be leveraged into additional $1/(\kappa\gamma - \mu_t^c)$ unit of loans, which increases bank's value by μ_t^c per unit. As λ_t^c gets larger, it is more attractive for banks to hold loans, but banks are limited in expanding their balance sheet due to the incentive constraint.

Let the Ω_t be the marginal value of net worth at period t. Then after combining the value function (2.9) with the Bellman equation (2.7), we can verify the value function is linear in A_t^c, B_t^c, and D_t if μ_t^c, ν_t^B, and ν_t^D satisfy:

$$\mu_t^c = E_t\Lambda_{t+1|t}\Omega_{t+1}\left[R_{t+1}^A - R_{t+1}^B\right] \tag{2.15}$$

$$\nu_t^B = E_t\Lambda_{t+1|t}\Omega_{t+1}R_{t+1}^B \tag{2.16}$$

$$\nu_t^D = E_t\Lambda_{t+1|t}\Omega_{t+1}R_{t+1} \tag{2.17}$$

with

$$\Omega_{t+1} = 1 - \theta + \theta\left(\frac{\nu_t^A}{Q_t} + \lambda_t^c(\frac{\nu_t^A}{Q_t} - \kappa)\right) \tag{2.18}$$

The intuition behind the determination of Ω_{t+1} is the following: The bank exits and consumes its net worth with probability $1 - \theta$. The net worth of a surviving bank increases its value by ν_t^A/Q_t directly, since there is no cost for internal equity. On the other hand, the marginal unit of net worth relaxes the incentive constraint by $(\nu_t^A/Q_t - \kappa)$ and increases the value of banks by λ_t^c.

For later use, it is useful to derive the relationship between the excess return on loans over ABS and ABS over deposit. Combining the first-order conditions (2.10) and (2.11) with (2.15)-(2.17) gives the following equation:

$$E_t \Lambda_{t+1|t} \left[R^B_{t+1} - R^D_{t+1} \right] = \left(\frac{1-\gamma}{\gamma} \right) E_t \Lambda_{t+1|t} \left[R^A_{t+1} - R^B_{t+1} \right] \tag{2.19}$$

2.2.3 Shadow Banks

There is a representative shadow bank in each island which can only operate within the island. At the end of period $t-1$, the shadow bank (mnemonic s) j borrows $B^{s,j}_t$ from commercial banks and promises to pay back a non-state-contingent amount $\bar{B}^j_t$ at the beginning of period t. Here the claims on the proceeds from shadow bank assets are used as collateral. Thus, this debt can be interpreted as asset-backed security.

Like commercial banks, shadow banks finance firms in the form of equity-like state-contingent debt. But, unlike commercial banks, they are exposed to the island-specific idiosyncratic shocks. After the realization of idiosyncratic shock across islands, the shadow bank repays its debt to commercial banks. Depending on the realization, there exists a default threshold which equals the face value of debt, $\bar{B}^j_{t-1}$ and the proceeds from asset, $\omega^j_t R^A_t Q_{t-1} A^{s,j}_{t-1}$, where $A^{s,j}_{t-1}$ is the amount of loans that shadow banks made. The default threshold can be expressed as,

$$\bar{\omega}^j_t \equiv \frac{\bar{B}^j_{t-1}}{R^A_t Q_{t-1} A^{s,j}_{t-1}} \tag{2.20}$$

If $\omega^j_t \geq \bar{\omega}^j_t$, the shadow bank honors its debt and keep the rest. If $\omega^j_t < \bar{\omega}^j_t$, the shadow bank defaults and the commercial bank seizes the shadow bank's assets and liquidates the proceeds.

The shadow bank is financially constrained due to the moral hazard problem, which will be discussed shortly. Thus, to avoid the financial constraint, the shadow bank may find it optimal to accumulate its earnings to the point where the constraint is no longer binding. Like commercial banks, there is an exogenous random exit probability, $1-\theta$. Upon exiting, the shadow bank pays retained earnings to the household, which can be thought as dividends payment.

The surviving banks are assumed to not raise outside equity. This implies the existence of a non-negativity constraint on dividends

$$\omega_t^j R_t^A Q_{t-1} A_{t-1}^{s,j} - \bar{B}_{t-1}^j - N_t^{s,j} \geq 0 \tag{2.21}$$

where $N_t^{s,j}$ is the net worth after the dividend.

Based on the realization of idiosyncratic shock, the shadow bank decides how much net worth to hold. Then, shadow banks decide the size of liability $B_t^{s,j}$ to purchase the claims $A_t^{s,j}$ subject to the balance sheet constraint: $Q_t A_t^{s,j} = B_t^{s,j} + N_t^{s,j}$.

The shadow bank faces two financial constraints when borrowing from commercial banks. The first constraint is a participation constraint. The expected payoff to the commercial banks should exceed the expected payoff from the opportunity cost of lending. The participation constraint can be written as

$$\begin{aligned} & E_t \Lambda_{t,t+1} \left[R_{t+1}^A Q_t A_t^{s,j} \int^{\bar{\omega}_{t+1}^j} \omega dF_t(\omega) + \bar{B}_t^j \left[1 - F_t(\bar{\omega}_{t+1}^j) \right] \right] \\ \geq \quad & E_t \Lambda_{t,t+1} \left[(1-\gamma) R_{t+1}^A + \gamma R_{t+1} \right] \left[A_t^{s,j} - N_t^{s,j} \right] \end{aligned} \tag{2.22}$$

where the second line is derived from (2.19) and the balance sheet identity.

The second constraint is an incentive compatibility constraint from the moral hazard problem. We assume that, once the shadow bank has received the funding, it may choose to invest in either of the two firm types within its island. As explained in Section 2.2.1, these two types differ in the distribution of island-specific shocks. I assume that the distribution of island specific (substandard) shock $\tilde{\omega}_t^j$ first order stochastically dominates that of (standard) shock ω_t^j, $i.e$ $\tilde{F}(\omega_t^j;\sigma_{t-1}) > F(\omega_t^j;\sigma_{t-1})$ for all ω_t^j. Based on the distribution of shocks, it turns out that the substandard technology has a lower average return $\int \omega d\tilde{F}(\omega;\sigma_{t-1}) < \int \omega dF(\omega;\sigma_{t-1}) = 1$, and thus is inefficient. The moral hazard problem arises from the possibility of banks investing in 'substandard' technology.

When lending money to shadow banks, the commercial banks do not want shadow banks to invest in substandard firms. Thus, the commercial banks should adjust the face value of debt to guarantee the higher expected payoff to shadow banks when they invest in the standard type firm. Let $V_{t+1}(\omega, A_t^{s,j}, \bar{B}_t^j)$ denote the value function in period $t+1$ of a continuing shadow bank. Then, the incentive constraint can be written as

$$\begin{aligned} & E_t \Lambda_{t,t+1} \int_{\bar{\omega}_{t+1}^j} \left[\theta V_{t+1} \left(\omega_{t+1}^j, A_t^{s,j}, \bar{B}_t^j \right) + (1-\theta) \left(\omega_{t+1}^j R_{t+1}^A Q_t A_t^{s,j} - \bar{B}_t^j \right) \right] dF_t(\omega) \\ \geq \; & E_t \Lambda_{t,t+1} \int_{\bar{\omega}_{t+1}^j} \left[\theta V_{t+1} \left(\omega_{t+1}^j, A_t^{s,j}, \bar{B}_t^j \right) + (1-\theta) \left(\omega_{t+1}^j R_{t+1}^A Q_t A_t^{s,j} - \bar{B}_t^j \right) \right] d\tilde{F}_t(\omega) \quad (2.23) \end{aligned}$$

It is important to understand the shadow bank's incentive to invest in one firm or the other. The expected net payoff from investing the standard firm in the period $t+1$ can be expressed by $\left[\int_{\bar{\omega}_{t+1}} (\omega - \bar{\omega}_{t+1}^j) dF_t(\omega) \right] R_{t+1}^A Q_t A_t^{s,j}$. We can interpret the first integral as the call option value on island-specific return with the strike price equal to the default threshold $\bar{\omega}_{t+1}$, which in turn equals the ratio of face value of debt to asset, $\bar{B}_t^j / R_{t+1}^A Q_t A_t^{s,j}$. This means that the shadow bank enjoys the upside risk in the asset return above the face value of debt due to the limited liability. On the other hand, the downside risk is transferred to the creditor, the commercial banks, and the shadow bank does not bear any risk lower than the face value of debt.

We can rewrite the value of call option as

$$\int_{\bar{\omega}_{t+1}} (\omega - \bar{\omega}_{t+1}^j) dF_t(\omega) = \int \omega dF_t(\omega) - \bar{\omega}_{t+1}^j + \int^{\bar{\omega}_{t+1}} (\bar{\omega}_{t+1} - \omega) dF_t(\omega)$$

Notice that the last integral represents the value of put option on the returns with strike price $\bar{\omega}_{t+1}$. Denote the value of put option as

$$\pi(\bar{\omega}_{t+1}; \sigma_t) \equiv \int^{\bar{\omega}_{t+1}} (\bar{\omega}_{t+1} - \omega) dF_t(\omega) \quad (2.24)$$

Comparing the expected net payoff from investing in either type of firm, we can find that the difference between the mean return and put option value determines the shadow bank's decision. Our distribution assumption implies $\tilde{\pi}(\bar{\omega}_{t+1};\sigma_t) > \pi(\bar{\omega}_{t+1};\sigma_t)$ holds always. Recall that the mean return from substandard firm is always lower than that of standard firm, *i.e* $\int \omega d\tilde{F}_t(\omega) < \int \omega dF_t(\omega)$. Therefore, the shadow bank compares the higher mean return of investing in standard firms with the lower put option value.

Define $\Delta\pi_t(\cdot) \equiv \tilde{\pi}_t(\cdot) - \pi_t(\cdot)$ as the difference in put option. Our distribution assumption implies that $\Delta\pi_t(\bar{\omega}_{t+1}) = \tilde{F}_t(\bar{\omega}^j_{t+1}) - F_t(\bar{\omega}^j_{t+1}) > 0$, which means that the higher level of debt burden relative to assets increases the incentive to invest in substandard firms. In order to discourage shadow banks from investing in substandard firms, the commercial banks will refrain from asking for a too high face value of debt relative to collateralized asset value.

Now I will describe the bank's maximization problem. Let $V(\omega^j_t, A^{s,j}_t, \bar{B}^j_t)$ denote the value function of a non-defaulting shadow bank in the beginning of time t.

$$V(\omega^j_t, A^{s,j}_t, \bar{B}^j_t) = \underset{N_t}{max}\left[\omega^j_t R^A_t Q_t A^{s,j}_{t-1} - \bar{B}^j_{t-1} - N^{s,j}_t + J(N^{s,j}_t)\right]$$

subject to (2.21), where $J(N^{s,j}_t)$ denotes the value of the shadow bank after paying out dividends.

$$J(N^{s,j}_t) = \underset{A^{s,j}_t,\bar{B}^j_t}{max} E_t\Lambda_{t,t+1}\int_{\bar{\omega}^j_{t+1}}\left[\theta V_{t+1}\left(\omega^j_{t+1}, A^{s,j}_t, \bar{B}^j_t\right) + (1-\theta)\left(\omega^j_{t+1}R^A_{t+1}Q_t A^{s,j}_t - \bar{B}^j_t\right)\right]dF_t(\omega)$$

subject to (2.20), (2.23), and (2.22).

The solution of bank's problem gives three equations which determines shadow bank's decision on N^j_t, $A^{s,j}_t$, and $\bar{B}^j_t$. It is required for the model parameters to satisfy $0 < \beta R^A - 1 < (1-\theta)\beta R^A \int_{\bar{\omega}}(\omega - \bar{\omega})dF(\omega)$, where R^A and $\bar{\omega}$ are the steady-state value of R^A_t and $\bar{\omega}_t$. Let $\bar{b}^j_t \equiv \bar{B}^j_t / A^{s,j}_t$ denote the ratio of the face value of debt to the shadow bank's assets. Then,

- Optiamlly, the shadow bank does not pay dividends and retains all earnings,

$$N_t^j = \left(\omega_t^j - \frac{\bar{b}_{t-1}}{R_t^A}\right) R_t^A Q_{t-1} A_{t-1}^{s,j} \tag{2.25}$$

where $\bar{b}_{t-1}$ is equalized across islands, such that $\bar{\omega}_t^j = \bar{\omega}_t = \frac{\bar{b}_{t-1}}{R_t^A}$

- The IC constraint holds with equality. In equilibrium, IC constraint can be written as

$$1 - \int \omega \tilde{F}_t(\omega) = E_t \left[\frac{\Lambda_{t,t+1} R_{t+1}^A (\theta \bar{R}_{t+1}^B \lambda_{t+1} + 1 - \theta)}{E_t \Lambda_{t,t+1} R_{t+1}^A (\theta \bar{R}_{t+1}^B \lambda_{t+1} + 1 - \theta)} \left[\tilde{\pi}\left(\frac{\bar{b}_t}{R_{t+1}^A}; \sigma_t\right) - \pi\left(\frac{\bar{b}_t}{R_{t+1}^A}; \sigma_t\right) \right] \right] \tag{2.26}$$

where λ_{t+1} is the Lagrange multiplier to participation constraint, which is equalized across islands.

- The participation constraint also holds with equality,

$$A_t^j = \frac{1}{1 - E_t \Lambda_{t,t+1} R_{t+1}^A \left[\bar{\omega}_t - \pi(\bar{\omega}_{t+1}; \sigma_t)\right] / \bar{R}_t^B} N_t^j \equiv \phi N_t^j \tag{2.27}$$

where $\bar{R}_t^B = E_t \Lambda_{t+1|t} \left[(1-\gamma) R_{t+1}^A + \gamma R_{t+1}\right]$ is the expected discounted opportunity cost of lending.

According to (2.25), the shadow bank will retain all earnings because of the possible financial distress, and the ratio of face value of debt to asset size is the same across the islands. This implies that there is one default threshold which applies to all shadow banks. The equation (2.26) pins down $\bar{b}_t$ by equating the gain in the average return with the loss in put option values from investing in the standard firm. The equation (2.27) shows that all shadow banks have the same leverage ratio to determine the demand of assets. The increase of left-tail risk increases the put option value, which makes the commercial banks able to bear more down-side risks. Thus, commercial banks will impose a tighter leverage constraint.

2.2.4 Capital Good Producers

There is a continuum of competitive capital producers who produce capital goods by combining the input of final goods and a CRS adjustment technology. At the end of the period t, capital producers buy capital from final good producers and then repair depreciated capital and build new capital. Used capital is transformed into new capital on a one-to-one basis, while the price of new capital is Q_t. Following Christiano et al. (2003) and Smets and Wouter (2007), I assume that there is a convex investment adjustment cost and model the investment problem as follows,

$$max\, E_0 \sum_{t=0}^{\infty} \beta^t \Lambda_{t+1|t} \left[Q_t I_t - I_t - \frac{\bar{\chi}}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \right]$$

Capital producers maximize profits by equating the price of new capital with their marginal cost, which gives rise to an upward-sloping supply function:

$$Q_t = 1 + \frac{\bar{\chi}}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 + \bar{\chi} \left(\frac{I_t}{I_{t-1}} - 1 \right) \frac{I_t}{I_{t-1}} - \bar{\chi} E_t \Lambda_{t+1|t} \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \tag{2.28}$$

2.2.5 Household

There is a continuum of identical households. Each household is composed of a contingent of workers who supply labor, bankers who manage commercial banks, and brokers who manage shadow banks. Each household member consumes a final goods (C_t) and enjoys perfect consumption insurance with the other members. Over time, a member can switch between the occupations. In every period, a fixed proportion of households become bankers or brokers. They manage their institutions until exiting the industry at random. Upon exit, they pay all of their retained earnings back to household as dividends payment. Workers supply labor to firms and return the wages they earn to households.

The representative household has a utility function

$$E_0\Sigma_{t=0}^{\infty}\beta^t\left[u(C_t)-v(L_t)\right]=E_0\Sigma_{t=0}^{\infty}\beta^t\left[ln(C_t-hC_{t-1})-\frac{\chi}{1+\varphi}L_t^{1+\varsigma}\right]$$

subject to the budget constraint

$$C_t+D_t=W_tL_t+R_tD_{t-1}+\Pi_t$$

where C_t is consumption, D_t is deposit, L_t is labor supply, W_t is wage, and Π_t is the lump-sum dividend payment from both financial and non-financial firms. Households' claim on firms, or capital stock, is held indirectly through the financial system, either as deposits, or equity stakes in the financial institutions they manage. The first order conditions are standard as follows:

$$\begin{aligned} E_t\Lambda_{t,t+1}R_{t+1} &= 1 \\ v'(L_t)/u'(C_t) &= W_t \end{aligned}$$

2.2.6 Aggregation and Market Clearing

Aggregate net worth of commercial banks at the end of period t is the sum of the net worth of continuing banks and new banks. Assume that households supply a fraction of τ^c of total assets of commercial banks to new banks every period. Then, the law of motion for commercial banks' net worth is:

$$N_t^c=\theta(R_t^AQ_{t-1}A_{t-1}^c+R_t^BB_{t-1}^c-R_tD_{t-1})+(1-\theta)\tau^c(Q_{t-1}A_{t-1}^c+B_{t-1}^c) \quad (2.29)$$

Similarly, aggregating across islands, aggregate net worth of shadow banks can be written as:

$$N_t^s=\theta\int_{\bar{\omega}_t}(\omega-\bar{\omega}_t^j)dF_{t-1}(\omega)R_t^AQ_{t-1}A_{t-1}^s+\left(1-\theta\left[1-F_{t-1}(\bar{\omega}_t)\right]\right)\tau^sQ_{t-1}A_{t-1}^s \quad (2.30)$$

where τ^s is the fraction of household transfer to banks which are exited exogenously or defaulted, and $A_t^s = \int A_t^{s,j} dj$ is the total assets of shadow banks.

Market clearing condition for capital requires that total demand by firms equals total supply of capital producers, $\int_0^1 K_t^j dj = K_t$. The aggregate capital stock evolves as $K_t = (1-\delta)K_{t-1} + I_t$. The total issuance of state-contingent claims by firms must equal total demands by both commercial and shadow banks:

$$K_{t+1} = A_t^c + A_t^s$$

Aggregating firms' labor demand derived from (2.2), we have the labor market clearing condition:

$$\begin{aligned} \int_0^1 L_t^j dj &= \left(\frac{(1-\alpha)Z_t}{W_t}\right)^{1/\alpha} \int_0^1 \omega^j K_t^j dj \\ &= \left(\frac{(1-\alpha)Z_t}{W_t}\right)^{1/\alpha} K_t = L_t \end{aligned}$$

where the second line uses the fact that ω^j and K_t^j are independently distributed. With conditions above, aggregate supply of the final good by firms are:

$$Y_t = \int_0^1 Y_t^j dj = Z_t \left(\frac{L_t}{K_t}\right)^{1-\alpha} \int_0^1 \omega^j K_t^j dj = Z_t K_t^\alpha L_t^{1-\alpha}$$

Finally, the total supply of final good must equal consumption demand by households and investment demand by capital producers

$$Y_t = C_t + I_t + +\frac{\bar{\chi}}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t$$

2.3 Quantitative Analysis

2.3.1 Calibration and Steady State

We calibrate model to the main features of a financial system roughly comparable to that of the U.S. economy. The baseline values for parameters are shown in Table 2.1. The parameters fall into two groups. The parameters in the first group are standard in the real business cycle literature, while those in the second group are particular to this model.

The households' discount factor β is set to target an annual steady-state interest rate of 4%. Disutility of labor χ is set to match the labor supply 1/3 and the elasticity of labor supply is chosen in line with other macroeconomic studies. Conventional values are used for the capital share α, and the depreciation rate δ, and the habit persistence h.

The model-specific parameters are calibrated according to the strategy of Meek et al. (2013) and Nuno and Thomas (2013). I target the gross financial spread $R^A - R$ to 100 basis points, which is roughly equal to the spread between the yields on long-term corporate and government bonds. The steady state ABS spread $R^B - R$ is set to 50 basis points. The spread in the short-term debt is set to 250 annualized basis points, so that the gross interest rate is equal to $\bar{R} = R(1.025)^{1/4}$. This implies a default threshold $\bar{\omega} = \bar{b}\frac{\phi-1}{\phi} = 0.9564$

I set the survival probability of banks θ to 0.75, which implies that banks pay dividends once a year on average. Then, I use (2.29) and (2.30) to solve for $\tau^c = 0.0356$ and $\tau^s = 0.0064$. For the benchmark model, I set the divertibility of ABS to 0.95, meaning ABS is regarded as good collateral.

The firm-specific shocks are assumed to be log-normally distributed as

$$ln\,\omega \sim i.i.d\mathcal{N}\left(\frac{-\sigma_t^2}{2}, \sigma_t^2\right) \quad ln\,\tilde{\omega} \sim i.i.d\mathcal{N}\left(\frac{-\eta\sigma_t^2 - \psi}{2}, \sqrt{\eta}\sigma_t^2\right)$$

Parameters	Description	Value
β	Households' subjective discount factor	0.99
χ	Disutility of Labor	11.12
φ	Inverse labor supply elasticity	0.3
h	Habit persistence in consumption	0.7
α	Share of capital in the production function	0.36
δ	Capital depreciation rate	0.025
θ	Survival probability of banks	0.75
κ	Divertibility of commercial bank assets	0.2648
τ^c	Fraction of assets transferred to new commercial banks	0.0356
τ^s	Fraction of assets transferred to new shadow banks	0.0064
γ	Relative divertibility of ABS	0.95
ψ	Mean of substandard technology	0.01
η	Variance of substandard technology	1.5524
ρ^z	Persistence of aggregate productivity	0.9
σ^z	Standard deviation of productivity shock	0.01
ρ^σ	Persistence of island-specific volatility shocks	0.9
σ^σ	Standard deviation of island-specific volatility shock	0.05

Table 2.1: Value of Parameters

both for the standard and substandard technologies, respectively. Both ψ and η control the mean and variance difference between two technologies. These distribution assumptions give $E[\tilde{\omega}] = e^{-\psi/2} < E[\omega] = 1$, $F(\omega;\sigma_t) = \Phi\left(\frac{log(\omega)+\sigma^2/2}{\sigma_t}\right)$, and $\tilde{F}(\omega;\sigma_t) = \Phi\left(\frac{log(\omega)+\frac{\psi+\eta\sigma_t^2}{2}}{\sqrt{\eta}\sigma_t}\right)$. The standard deviation of firm risk shocks is also assumed to follow AR(1) process in logs.

$$log(\sigma_t) = \rho^\sigma log(\sigma_{t-1}) + (1-\rho^\sigma)log(\sigma) + \varepsilon_t^\sigma, \quad \varepsilon_t^\sigma \sim i.i.d\ \mathcal{N}(0,\sigma_\sigma)$$

I set ν to 0.01 for analytic purposes and solved for $\eta = 1.5524$. Shocks to the substandard technology are $\sqrt{\eta} = 1.246$ times more volatile than shocks to the standard one.

2.3.2 Impulse Responses

In this section, I present results from impulse response analysis of one standard deviation shocks to aggregate TFP. The scale represents percentage deviations (or log-deviations) from the steady state, except for the loan-ABS spread, which represents percentage point deviations.

Figure 2.1 shows the responses of key variables to the aggregate TFP shocks. Upon a negative TFP shock, capital demand shifts inward followed by the drop in capital prices and the expected return on capital increases. The fall in capital prices revalues the balance sheet of both financial intermediaries, causing their net worth to decline. The fall in commercial bank equity value increases the demand for ABS as shown in (2.13), while the fall in shadow bank equity value decreases the supply of ABS as shown in (2.27). For given R^A, the opposing shifts in demand and supply lower the ABS spread and the loan-ABS spread surges. On the other hand, for given R^B, the rise of expected return on capital relaxes the incentive compatibility constraint on both banks. It reverses the shifts in demand and supply and lowers the loan-ABS spread. However, as shown in Figure 2.1, it does not dominate the formal effect and results in the increase of the spread.

The TFP shock has a different effect on each bank. Since shadow banks hold the primary claims only, the fall in capital prices, triggered by the negative TFP shock, directly affect the shadow banks' net worth. Shadow bank net worth absorbs all losses and undergoes a substantial contraction on the size of balance sheet. However, the commercial banks' net worth is partially protected and they are able to extend their loan provisions, even when they demand less ABS.

Figure 2.1 also shows the different responses to different levels of bank assets' divertibilities. I set $\gamma = 0.95$ for the high divertibility case and $\gamma = 0.5$ for the low divertibility case. With the lower divertibility, ABS is less attractive for the commercial banks, which triggers a substantial contraction compared to the high divertibility case. The drop in ABS demand worsens the financial condition of the

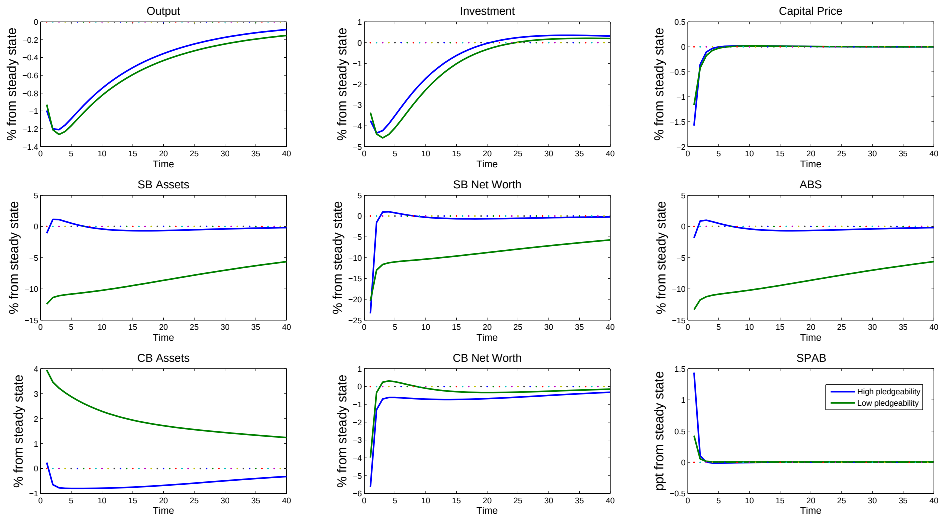

Figure 2.1: Impulse response of selected variables in response to a one-time negative shock to aggregate TFP.

shadow banks. Thus, they contract their asset holdings even more and cannot recover their net worth for long time.

2.4 Stabilization Policy

Based on the benchmark model, we can think of a crisis experiment in which the uncertainty in the economy increases and the depositors do not regard bank assets as good collateral. Although it abstracts from many other crisis phenomenons, it captures the main idea that the collateral value of assets become impaired and people were uncertain about the return on assets at the onset of the subprime crisis.

Suppose that there exists a representative government which has two options to intervene in the market in order to stabilize the economy: (1) direct lending to firms or (2) lending to shadow banks by purchasing ABS. These stabilization policies are financed by issuance of government debt, which is held by households as a substitute for bank deposits. Then, the government budget constraint takes the form:

$$G_t + Q_t A_t^g + B_t^g + R_t D_{t-1}^g = T_t + D_t^g + R_t^A Q_{t-1} A_{t-1}^g + R_t^B B_{t-1}^g \tag{2.31}$$

where the superscript g denotes government holdings, D_t^g is one-period government bonds, and the lump sum taxes on households T_t adjusts to ensure the budget balance. Rearranging the equation (2.31),

$$G_t - T_t = (R_t^A - R_t^B)Q_{t-1}A_{t-1}^g + (R_t^B - R^t)B_{t-1}^g \tag{2.32}$$

I assume that there is a real resource cost associated with government policies, which enables the government to impose a non-zero public expenditure, parameterized by τ:

$$G_t = \tau(A_t^g + B_t^g)$$

The new market clearing conditions are:

$$\begin{aligned} A_t^g + A_t^c + A_t^s &= K_{t+1} \\ B_t^g + B_t^c &= B_t^s \end{aligned}$$

Following Gertler and Kiyotaki (2010) and Gertler and Karadi (2013), we can write the government policies as a fraction of the total size of each asset. The policies take the form of the feedback rule on the spread between the return on each asset and the government bond. It captures the idea that the goal of the government policies is to bring down the lending spread in funding markets. The policies can be written as:

$$\xi_t^A = \bar{\xi}_0^A + \bar{\xi}_1^A \left[E_t(R_{t+1}^A - R_{t+1}) - (R^A - R) \right] \tag{2.33}$$

$$\xi_t^B = \bar{\xi}_0^B + \bar{\xi}_1^B \left[E_t(R_{t+1}^B - R_{t+1}) - (R^B - R) \right] \tag{2.34}$$

where $A_t^g = \xi_t^A K_{t+1}$ and $B_t^g = \xi_t^B B_t^s$.

In the crisis simulation, consider an increase of uncertainty risk by 5% and a drop in the divertibility of bank assets from 0.95 to 0.5. I set the resource cost of asset holdings τ to 0.002, as in Meek et al. (2013). The steady state fractions of government asset holdings $\bar{\xi}_0^A$ and $\bar{\xi}_0^B$ are set to 2.5%, while the strength of the responses $\bar{\xi}_1^A$ and $\bar{\xi}_1^B$ are set to 100.

Figure 2.2 compares the different responses of selected variables between government policies. When the government actively participates in the direct lending market, the immediate effects are the contraction in the commercial banks' loan holdings A_t^c and the lower drop in the asset prices Q_t compared to the no-policy case. The dampened response of the asset value protects the bank net worth. However, unlike the no-policy case, the bank net worth cannot be recovered immediately. The stabilized funding market results in the lower spread, which makes bank profit growth very slow. Thus, the net worth recovery remains low for a protracted period.

The government policy of purchasing ABS turns out to amplify the response of output and investment, although it succeeds in lowering the spread and cushioning the fall in asset prices. The main reason for this inefficient outcome is that the incentive compatibility constraint of the shadow banking sector is unaffected by the government policies. Even though the demand for ABS increases through government intervention, the shadow bank cannot expand its balance sheet. Thus, the increase of government ABS holdings is substituted by the decrease of commercial banks' ABS holdings. Meanwhile, the commercial banks cannot raise enough deposits because households now have other options to save in government bonds. As seen in (2.13), the reduction in deposits leads to lower ABS holdings. Combining these two negative effects, commercial banks' ABS holdings drop much more than in the other cases. To clear the market, the loan-ABS spread must fall. In turn, this hurts the growth of the net worth recovery.

It is shown that the direct lending policy helps to stabilize output, while the ABS purchasing policy amplifies the fall in output. They have the same goal of supporting asset prices, but the former turns out to be more effective.

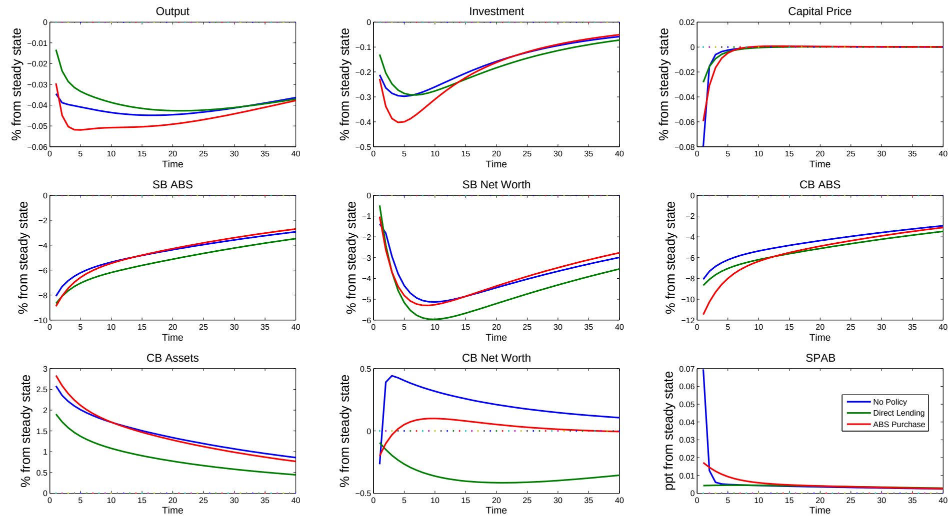

Figure 2.2: Impulse response of selected variables in response to a one-time negative shock to aggregate TFP.

2.5 Conclusion

I present a general equilibrium model with two sectors of financial intermediaries aimed at explaining the interaction between sectors. As the shadow banking sector raises funds from the commercial banks, the credit supply and credit spread changes depending on the health of each bank's balance sheet. The shadow bank is modeled to borrow in the form of short-term collateralized debt. In this case upon the aggregate disturbance, the reaction of shadow banks is shown to be very volatile.

For the policy analysis, I compare two types of government stabilization policies in the crisis experiment. With a higher uncertainty risk and lower pledgeable assets, the credit supply and economic activity undergoes a downturn. I show that direct government lending to firms is a relatively more effective tool than the indirect intervention of purchasing ABS.

Several extensions can be made for future research. This model only focuses on a partial segment of the shadow banking sector which only borrows from the commercial banks. It would be more empirically consistent if one can extend the size of shadow banks' balance sheet and the means of borrowing. Also, in order to analyze the effect of government policies on shadow banks, one can alter the model to make the supply of ABS be affected by government intervention.

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Chapter 3

Bank Capital and Lending: An Analysis of Commercial Banks in the United States

3.1 Introduction

The effect of changes in bank capital on lending decisions is one of the primary determinants of the linkage between financial conditions and real activity. This question has gained much importance in the aftermath of the financial crisis. During the financial crisis, when the likelihood of a credit crunch was still under debate, the relation between bank capital and bank lending was a key policy concern. Likewise, when the Troubled Asset Relief Program (TARP) moved to inject capital into banks through the Capital Purchase Program (CPP), the impact of the program on real activity largely focused on the effect of these injections on bank lending. More recently, this question has re-emerged in light of proposals announced by the Basel Committee on Banking Supervision to raise capital requirements for banks and limit leverage ratios.

In the aftermath of the 1990-91 recession, many observers debated whether the newly introduced capital regulations along the Basel guidelines were hindering lending. Although this debate did not yield a consensus, it did result in the development of empirical models that sought to quantify the effect of bank capital on bank lending.[1] There are not many recent estimates for the U.S of the impact of changes in bank capital on lending.

In this study, we ask how the bank capital ratio affects the lending decisions of banks. Our sample only includes commercial banks. The data mainly comes from the Call Reports database, maintained by the Federal Reserve Bank of Chicago. Our contribution in this paper is twofold. First, we quantify the relationship between bank capital ratios and our measure of lending. Second, we contribute methodologically by

[1]For example, Hancock and Wilcox (1993, 1994), Berger and Udell (1994) and Bernanke and Lown (1991), among others.

proposing an innovative instrumenting technique that helps us address the problems related to the simultaneous determination of capital and lending by banks. While our estimates appear to be small, we are following the example of Berropside and Edge (2010) in reconciling the small response of lending to capital For the benefit of the reader, we reproduce their justification here.

The statements from the US Treasury suggested that a \$1 increase in bank capital leads to a \$8 - \$10 increase in lending capacity. These magnitudes are reasonable once we make the assumption that banks actively manage their assets to maintain a constant leverage. This view is based on a scatter plot from Adrian and Shin (2010). We reproduce this figure below. The sample period used in Figure 3.1 is 1963 to

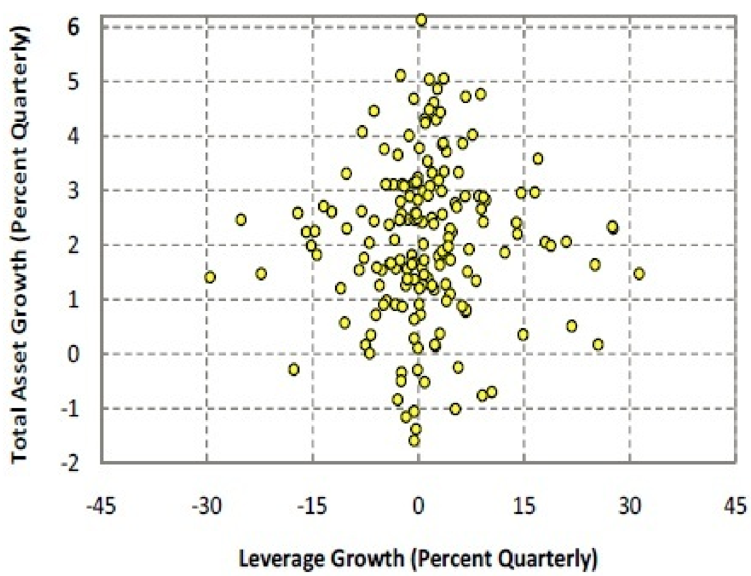

Figure 3.1: Asset and Leverage Growth (1963-2006)

2006, the same as that employed by Adrian and Shin. The constant leverage ratio is apparent from the scatter plot. This suggests a very active management of assets by commercial banks. This implies that any change in bank capital has a magnified effect on assets with the scaling factor equal to the leverage ratio.

Now, how do we compare our regression results with the Adrian and Shin scatter plots? We must acknowledge the major structural change that took place in the banking sector following the introduction of the 1989 Basel Banking Accord. Our sample starts from 1996 while the Adrian and Shin sample starts from 1963. To find out the effects of this choice of sample period on the analysis, consider Figure 3.2 below, from Berropside and Edge (2010).

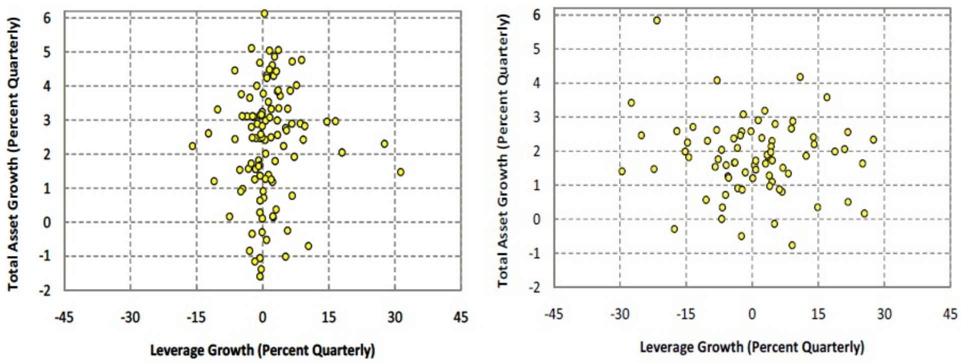

Figure 3.2: Asset and Leverage Growth (Pre & Post Basel)

The left panel shows the relation between asset and leverage growth prior to Basel (1963:Q1-1989:Q4) and this is consistent with Figure 3.1. The interesting part is the right panel which plots data post-Basel i.e 1990:Q1-2008:Q3. As can be seen from comparing these plots, the feature of the data that has led to the view that commercial banks actively manage their assets to maintain constant leverage is much more of an artifact of the early part of the sample and is considerably less evident in the latter part. Indeed, in the latter part of the sample, there is no obvious correlation between asset and leverage growth.

The rest of the paper is organized as follows. Section 3.2 surveys the literature, Section 3.3 describes the dataset we use, Section 3.4 explains the empirical model, variables and methodology, Section 3.5 presents the estimation results and Section 3.6 concludes. The graphs are placed in the Appendix B.

3.2 Related Literature

The impact of bank capital on lending is one of the key questions that arises when we explore macro-financial linkages. Hence, it is surprising that there are not many recent estimates for the United States of the impact of changes in bank capital on lending. In the aftermath of the 1990-91 recession, Hancock and Wilcox (1993, 1994) estimated models relating changes in individual banks' loan growth to measures of loan demand and bank capital. They measure response of lending to excess/shortfall of capital from a target ratio. Berger and Udell (1994) specified an equation relating the growth rate of various bank assets to different measures of bank capital ratios. Finally, Bernanke and Lown (1991) developed state-level equations linking bank loan growth to bank capital ratios and employment for a single state (New Jersey).

If we look beyond the United States, there are some studies that seek to quantify this relationship between bank equity and credit extension. Peek and Rosengren (1995) and Puri, Rocholl and Steffen (2010) use loan applications from German Landesbanks to examine the effect of shocks to capital on the supply of credit by comparing the performance of affected and unaffected banks. Gianetti and Simonov (2010) use Japanese data to perform a similar exercise concerning bank bailouts. These papers do find a relevant role for capital in determining loan volumes, although they do not explicitly compare the magnitudes of the effects they find with those implied by the constant leverage view. Another group of papers use firm and bank loan-level data. These include Jimenez, Ongena, and Peydro (2010), who use Spanish data, and Albertazzi and Marchetti (2010), who use data on Italy. These papers find sizable effects of low bank capitalization and scarce liquidity on credit supply.

The papers using Spanish and Italian data find a larger value for the impact of capital on loans. Santos and Winton (2013), using US loan level data (syndicated loans), obtain relatively small effects of bank capital on lending. Also, Elliott (2010) uses simulation based techniques to find small effects of capital ratios on loan pricing and loan volumes for U.S. banks. De Nicolo and Lucchetta (2010) use aggregate data for the G-7 countries and conclude that credit demand shocks are the main drivers of bank lending cycles.

3.3 Data and Stylized Facts

For this analysis we use an unbalanced panel of commercial banks' balance sheet data. Our data covers sixty quarters from 1996:Q1 to 2010:Q4. The data is obtained from the Consolidated Report of Condition and Income. The Federal Deposit Insurance Corporation requires all regulated financial institutions to file periodic information. These data are maintained and published by the Federal Reserve Bank of Chicago.[2]

The appendix provides a detailed documentation of the data. Regulatory capital requirements have undergone a few changes since their inception in the late 1980s. In 1985-1986, banks had to hold primary capital exceeding 5.5% of assets. By the end of the decade, this rose to 7%. Effective December 31, 1990, the banks were required to hold a total capital of 7.25% as a fraction of risk weighted assets with the Tier 1 capital being at least 3.25%. These ratios were further increased to 8% and 4% following the implementation of Basel I in the end of 1992. From then on, these ratios have remained fairly stable. We start the sample from 1996 to avoid such sudden changes.

Table 3.1 gives the summary statistics of the data. We have 343,752 observations on commercial banks in the United States. We ignore the top and bottom deciles. To elaborate, we rank the banks by average size (measured by log of total assets) over the sample period and then drop the top decile and bottom deciles. The reason for adopting this strategy stems from our instrumenting methodology. We use the real estate exposure of a bank times the change in real estate prices as an instrument for bank capital. The land price change acts as the exogenous shock in our model.

[2]Historic data from 1976 to 2010 is available at the Chicago Federal Reserve website. Beginning with the March 31, 2011, call reports are only available from the FFIEC Central Data Repository's Public Data Distribution site (PDD)

variable	All Mean	All Median	All SD	Big Mean	Big Median	Big SD	Small Mean	Small Median	Small SD
CAR	.1540	.1357	.0629	.1495	.1326	.0587	.1704	.1492	.0737
LTA	.6618	.6804	.1423	.6692	.6878	.1389	.6353	.6513	.1509
Tier 1 Cap	.0944	.0877	.0285	.0925	.0865	.0268	.1015	.0933	.0329
LTAR	.4728	.4787	.1691	.4905	.4978	.1641	.4087	.4013	.1712
LTANR	.1890	.1692	.1197	.1786	.1589	.1166	.2266	.2101	.1231
%Δ LTAR	.0052	.0034	.0602	.0046	.0034	.0567	.0069	.0035	.0711
%Δ LTANR	-.0062	-.0077	.0931	.0046	.0033	.0567	-.0045	-.0061	.0984
%Δ HPI	.0074	.0092	.0169	.0074	.0092	.0174	.0071	.0091	.0148
Liquidity	4.1156	4.1896	1.8572	4.6479	4.7361	1.8235	3.5333	3.6109	1.7135
Chargeoffs	.2102	.1830	.1447	.2028	.1772	.1357	.2175	.1902	.1528
%Δ GDP	.0064	.0067952	.0070901						

Table 3.1: Summary Statistics

The bigger banks in the US are sufficiently diversified and do not respond to local land price changes in the same way as their medium-sized counterparts. The idea behind dropping the smallest banks was that these banks show unusually high capital ratios. This is because they have limited or no access to capital markets and retain a substantial share of their earnings. Further, the smallest banks are extremely small as a percentage of total bank assets and do not add to our analysis. We think that it is only the relatively smaller/medium-sized banks that are more sensitive to local land price movements. We only include banks that have a capital adequacy ratio less than or equal to 25%. We also drop the banks if we find that the loan growth rate exceeds 50% in a particular quarter. Having said that, it is indeed interesting to see if there is a difference in behavior among banks of different sizes. As pointed out earlier, we found a major difference in assets once we sorted banks and the contrast was stark at the two points at which we truncated the data. Within the remaining 80% of banks, we divide them at the median and call them big and small for the rest of the analysis. To make it explicit, hereon when we refer to "whole sample" we mean the medium-sized banks. "Big" refers to the banks above the median in the sample and "small" refers to those below the median.

As the table shows, we study two different measures of capital ratios, namely the Capital Adequacy Ratio (CAR) and the Tier 1 capital ratio (Tier 1 Cap). We work with a host of loan to asset ratios in this paper. The loan data we gather comprises loans made to the real estate sector, commercial and industrial loans, agricultural loans and loans to households. $LTANR$ shows the loan to assets ratio where we leave out real estate loans and include the other three categories. $LTAR$ is the loans made to the real estate sector normalized by total assets. The mean real estate lending as a fraction of total assets is about 47% which is quite substantial. The banks are sufficiently exposed to the real estate sector, on average, and hence their bank capital should be a lot more sensitive to real estate price movements.

The other variables we have are the growth in the house price index (g_{HPI}). It shows that on average the real estate prices have risen by about 7.4%, in the sample period. This data was collected from the FRED database. The liquidity is the securities that the bank holds at any given point in time divided by total assets. Loans and securities are the two major components of the bank assets. Charge-offs are a measure of risk in the banks balance sheet. They are simply the natural logarithm of loan charge-offs in the given quarter. We use the GDP growth rate as a macro control variable in the regression analysis and as a control for the demand size effects that exist, as is common in the literature.

We now look at some stylized facts in the data. In our analysis, it is useful to look at some of the key variables for the U.S. at four different points in time within our sample. Figures B.1-B.3 show how the distribution of bank capital has changed over time.[3] It clearly shows that towards the end of the sample there are many more banks who report low capital ratios. The mass to the left of the 10% capital ratio level has increased irrespective of the measure of capital we use. Figures B.4 and B.5 show the time series of these variables. The grey bands show the NBER recession dates. This helps us understand the behavior of these variables over time. It is clear how the house prices and the bank capital fell dramatically during the recent financial crisis. We show all three measures of bank capital ratio as discussed earlier.

[3]We also report the equity asset ratio here. It is defined as the common equity normalized by total assets.

3.4 The Empirical Framework

The empirical model we wish to estimate is the following:

$$LTANR^s_{i,t} = \alpha_i + \nu_s + \beta K_{i,t} + \gamma_1 BSC_{i,t-1} + \gamma_2 Macro_{t-1} + u_{i,t} \tag{3.1}$$

where

- $LTANR^s_{i,t}$ is the loan to asset ratio of bank i at time t, with headquarters located in state s. Here the loans are all the loans made by the bank except the real estate loans. To elaborate on this point a little more, the loans included in this variable are the industrial/commercial loans, loans to individuals and the loans to agriculture. The only other major lending sector is the real estate sector which is not included in LTA, the reason for which will be outlined below.

- K is a measure of bank capital ratio. We will be working with two different measures of capital ratios. First, we use the capital adequacy ratio which is the Tier 1 + Tier 2 capital as a fraction of risk weighted assets. Second, we use the Tier 1 ratio.

- BSC consists of lagged bank specific controls which include liquidity and log of loan charge-offs.

- Macro controls for the state of the overall macroeconomy i.e. aggregate shocks. We use the growth rate of real GDP as the control. Following the literature, this also helps us account for demand side factors. We can thus exclusively focus on a supply sided mechanism.

- α_i and ν_s are the bank and state fixed effects respectively.

3.4.1 Endogeneity Issues and IV Estimation

We are aware that the equation above suffers from a potential endogeneity problem. The equation (3.1) above assumes that the bank sequentially decides first on how much capital to hold and then how many loans to make. In practice, however, this might not be a reasonable assumption. We think that such decisions are not sequential but simultaneous. Hence we find a suitable instrument for bank capital. Our instrument is the banks' exposure to the real estate sector. Our first stage regression is the following:

$$K_{i,t} = \alpha + \theta \overline{LTAR}^{s}_{i,t-1} * \%\Delta LP_t + controls_{i,t-1} + v_{i,t} \tag{3.2}$$

Here,

- $\overline{LTAR}$ is the average loans made to the real estate sector over total assets in the last three quarters. It measures the exposure of a bank to this particular sector. The greater the exposure, the greater the change that the bank capital will be sensitive to real estate price movements.
- LP is the real estate price index at the state level. We use the percentage change in LP.
- $controls_{i,t-1}$ includes bank specific and macro controls as discussed earlier.

Here we instrument bank capital by the interaction between the change in real estate prices and real estate exposure of the bank. If the real estate prices in a particular state increase, then the impact on bank capital depends on the banks' exposure to the real estate sector. If a bank has sufficient exposure to the real estate market, a rise in land prices means that the value of its assets has risen and that in turn means that the bank now has greater equity, assuming that liabilities remains roughly unchanged. On the other hand, if the bank has limited exposure to the real estate sector, this appreciation in land prices will have a much more subdued impact on its capital. We report the regression results later to prove the validity of the instrument but it is clear that our instrument is correlated with the bank capital and uncorrelated with the error because our dependent variable is the loans made to all sectors except the real estate sector. This is not correlated with land price movements or loans made to real estate in the last three quarters.

3.5 Regression Analysis

We report the fixed effects instrumental variable estimation results of the model. We also report the first stage regression results in the IV estimation.

Table 3.2 shows the first results for the impact of bank capital on lending. This is the baseline specification and we add controls sequentially here. Columns (1)-(4) use the capital adequacy ratio as the measure of capital while columns (5)-(8) use the tier 1 capital ratio. Columns (1) and (5) include no additional controls in the regression. The magnitude of β is significant at the 1% level. We see that on introducing controls, the coefficient remains significant at the 1% level.[4] The baseline results show a subdued impact of bank capital on lending. A 1% point increase in the CAR leads to an increase in the loan to asset ratio in the range of 0.04% and 0.08%. We think that is quite a small impact given that a 1% point increase in the capital adequacy ratio is quite a substantial increase.

Table 3.3 shows the results of our main IV estimation. The dependent variable is still the loan to asset ratio where the loans exclude those made to real estate sector. The first two columns show results from our entire sample which is all commercial banks except the top and bottom decile. The next two columns show results from banks above the median and the last two columns show results for banks which are below the median. We also use the two measures of capital for each of the three samples. We include state fixed effects in the regression to capture within state

[4]We use lagged liquidity and charge-offs as bank specific controls and lagged GDP growth as the macro control variable.

VARIABLES	(1) LTANR CAR	(2) LTANR CAR	(3) LTANR CAR	(4) LTANR CAR	(5) LTANR T1 Cap	(6) LTANR T1 Cap	(7) LTANR T1 Cap	(8) LTANR T1 Cap
Capital	0.039***	0.037***	0.064***	0.080***	0.236***	0.053***	0.125***	0.141***
	(0.002)	(0.002)	(0.007)	(0.012)	(0.037)	(0.003)	(0.018)	(0.025)
L.logcharge		-0.583***	-0.897***	-1.064***		-0.180***	-0.224***	-0.227***
		(0.030)	(0.085)	(0.137)		(0.007)	(0.019)	(0.022)
L.liqui			0.001	0.001*			0.012***	0.014***
			(0.001)	(0.001)			(0.002)	(0.003)
L.growth				-0.898***				-0.465***
				(0.189)				(0.154)
Observations	343,752	143,580	126,382	126,382	343,752	143,580	126,382	126,382
Number of id	9,027	6,882	6,735	6,735	9,027	6,882	6,735	6,735

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.2: IV Regression (Adding Controls Sequentially)

changes. We also include lagged macroeconomic and bank specific controls. However, before we discuss the results listed in this table, perhaps we should briefly comment on the first stage regression which is the direct estimation of equation (3.2). The results are shown in Table 3.4. We use the percentage change in real estate prices times the three quarter average of real estate loan to asset ratio as the instrument. The two columns predict the CAR and the tier 1 capital respectively. The sign on the instrument is positive and significant at the 1% level, which means that with a rise in asset values, bank capital increases, assuming that liabilities are roughly unchanged.

Now let us look at Table 3.3 in detail. The coefficient on the capital ratio remains positive and significant at the 1% confidence level, mostly. We find a moderate response of lending to bank capital. As discussed earlier, the magnitudes are much smaller than those suggested by Adrian and Shin (2007) but are in agreement with other papers that use US data and where the sample period starts after the intro-

VARIABLES	(1) LTANR CAR All	(2) LTANR T1 Cap All	(3) LTANR CAR Big	(4) LTANR T1 Cap Big	(5) LTANR CAR Small	(6) LTANR T1 Cap Small
Capital	0.080***	0.141***	0.135***	0.346	0.050***	0.077***
	(0.012)	(0.025)	(0.048)	(0.226)	(0.006)	(0.010)
L.logcharge	-1.064***	-0.227***	-1.630***	-0.206***	-0.752***	-0.229***
	(0.137)	(0.022)	(0.536)	(0.073)	(0.079)	(0.016)
L.liqui	0.001*	0.014***	0.001	0.034	0.002**	0.008***
	(0.001)	(0.003)	(0.002)	(0.025)	(0.001)	(0.001)
L.growth	-0.898***	-0.465***	-2.061**	-1.797	-0.292***	-0.035
	(0.189)	(0.154)	(0.836)	(1.363)	(0.106)	(0.077)
Observations	126,382	126,382	66,222	66,222	60,160	60,160
Number of id	6,735	6,735	3,343	3,343	3,392	3,392

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.3: Main IV Regression

duction of the Basel Banking Accord in 1989. The other thing to note is that the effect of capital on lending is bigger for the relatively bigger banks. The reason could be as follows. The bigger a bank gets and the more capital it has, the more loans it can make, as compared to a smaller bank. Bigger banks tend to enjoy greater access to financial markets and government guarantees than smaller banks. Hence their LTA responds more to capital than their smaller counterparts. For the whole sample, we find that a 1% increase in capital leads to an increase in the LTA which ranges between 0.08% and 0.14% depending on what measure of capital we use. For the sample above the median, the results are a bit mixed. This shows the effect of 0.13% for CAR and we lose significance when we use the tier 1 ratio. For the smaller banks, the range is between 0.05% and 0.07%. Berropside and Edge (2010) do not consider separate studies for the different groups of banks as we do but by using bank

VARIABLES	(1) CAR All	(2) T1 Cap All
$\overline{LTAR}$*%Δ LP	5.740***	3.258***
	(1.487)	(1.086)
L.logcharge	11.438***	0.537**
	(0.509)	(0.250)
L.liqui	-0.059***	-0.123***
	(0.008)	(0.006)
L.growth	14.924***	5.394***
	(1.077)	(0.662)
Constant	14.775***	10.913***
	(0.127)	(0.062)
Observations	126,467	126,467
Number of id	6,820	6,820

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: First Stage Regression

holding company data, they also suggest a low impact of bank capital on lending.

3.6 Conclusion

This paper seeks to quantify the impact of bank capital ratios on lending as this is one of the key policy questions when analyzing financial-real sector linkages. Using a subset of the commercial banks in the United States and an innovative instrumenting strategy, we find a modest impact of bank equity on lending behavior. Our estimates are broadly consistent with other recent studies in the literature that have worked on US data. Some earlier papers do report much higher estimates but they do not account for the structural change in the banking sector following the introduction of the Basel Core Banking Principles.

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Appendix A

Nash Wage Bargaining

Let $\mathcal{H}_{N,t}$ and $\mathcal{H}_{U,t}$ be the value of an additional unemployed and unemployed worker to the household, respectively:

$$\mathcal{H}_{N,t} = \psi + u'(c_t)w_t + \beta E_t\left[(1-\rho^x+\rho^x f(\theta_{t+1}))\mathcal{H}_{U,t+1} + \rho^x(1-f(\theta_{t+1}))\mathcal{H}_{N,t+1}\right] \tag{A.1}$$

$$\mathcal{H}_{U,t} = u'(c_t)s + \beta E_t\left[f(\theta_{t+1})\mathcal{H}_{N,t+1} + (1-f(\theta_{t+1}))\mathcal{H}_{U,t+1}\right] \tag{A.2}$$

The household's marginal surplus of a match is defined as:

$$\begin{aligned}\mathcal{H}_t &= \frac{\mathcal{H}_{N,t}-\mathcal{H}_{U,t}}{u'(c_t)} \\ &= \frac{-\psi}{u'(c_t)} + w_t - s + (1-\rho^x)E_t\Lambda_{t+1|t}(1-f(\theta_{t+1}))\mathcal{H}_{t+1}\end{aligned} \tag{A.3}$$

Similarly, the value of an additional employed worker to the firm $\mathcal{J}_t$ can be written as:

$$\mathcal{J}_t = (1-\alpha)z_t(k_t/n_t)^\alpha - \chi_t w_t + (1-\rho^x)\gamma E_t\Lambda_{t+1|t}\mathcal{J}_{t+1} \tag{A.4}$$

The Nash wage bargaining outcome maximizes the weighted average of the surplus from a job match

$$\max_{w_t} \mathcal{H}_t^{1-\eta}\mathcal{J}_t^{\eta}$$

where η is the bargaining power of workers. The solution to this problem is given by

$$\tilde{\eta}\mathcal{J}_t = (1-\tilde{\eta})\mathcal{H}_t \tag{A.5}$$

where $\tilde{\eta} = \frac{\eta}{\eta+(1-\eta)\chi_t}$. After rearranging terms the joint surplust of the match $\mathcal{S}_t$ is:

$$\begin{aligned}
\mathcal{S}_t &= \mathcal{J}_t + \mathcal{H}_t && \text{(A.6)}\\
&= (1-\alpha)z_t(k_t/n_t)^\alpha + (1-\chi_t)w_t - \left(\frac{\psi}{u'(c_t)} + s\right) + (1-\rho^x)\gamma E_t\Lambda_{t+1|t}\mathcal{J}_{t+1}\\
&\quad +(1-\rho^x)E_t\Lambda_{t+1|t}(1-f(\theta_{t+1}))\frac{\tilde{\eta}_t}{1-\tilde{\eta}_t}\mathcal{J}_{t+1} && \text{(A.7)}
\end{aligned}$$

Rearranging terms using (A.6) and (A.7) and substituting with (1.13), the Nash bargained wage can be expressed as

$$\begin{aligned}
w_t &= \frac{\eta}{\chi_t}\left[(1-\alpha)z_t\left(\frac{k_t}{n_t}\right)^\alpha + (1-\rho^x)\gamma E_t\Lambda_{t+1|t}\frac{\varrho'(v_{t+1})\chi_{t+1}}{q(\theta_{t+1})}\right] + (1-\eta)\left[\frac{\phi}{u'(c_t)} + s\right]\\
&\quad -\frac{\eta}{\chi_t}(1-\rho^x)\left[E_t\Lambda_{t+1|t}\left(1-p(\theta_{t+1})\right)\frac{\varrho'(v_{t+1})\chi_{t+1}}{q(\theta_{t+1})}\right] && \text{(A.8)}
\end{aligned}$$

which corresponds to the wage equation (1.25) in the main text.

Appendix B

Data Description and Regression Tables

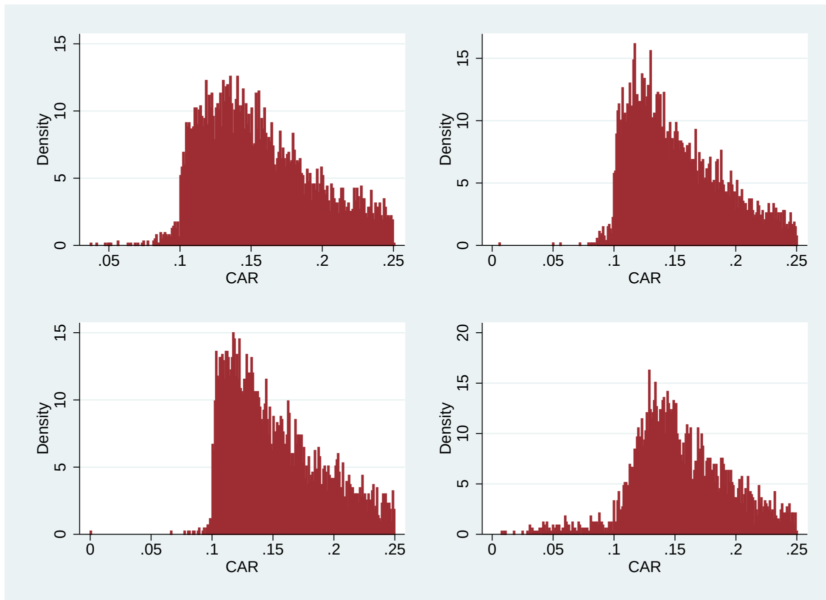

Figure B.1: Distributions of the Capital Adequacy Ratio

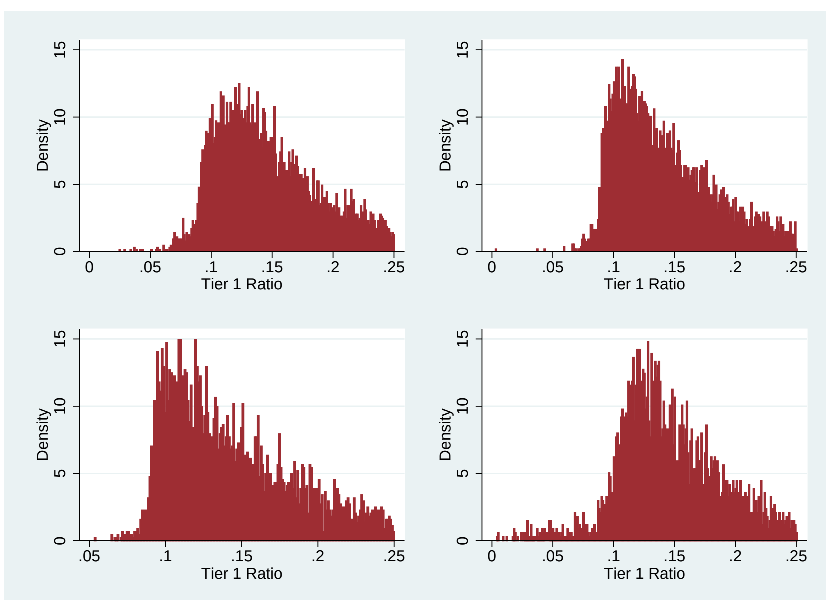

Figure B.2: Distributions of the Tier 1 Capital Ratio

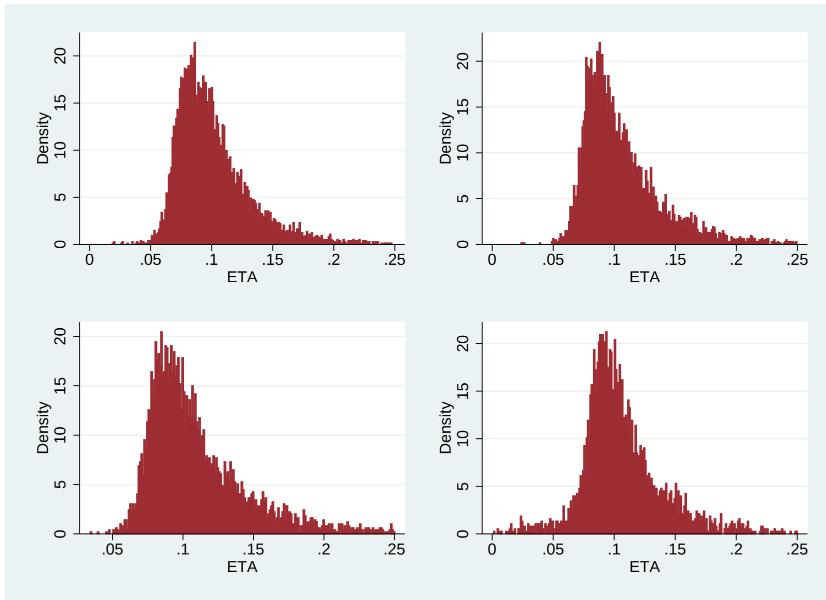

Figure B.3: Distribution of the Equity-to-Asset Ratio

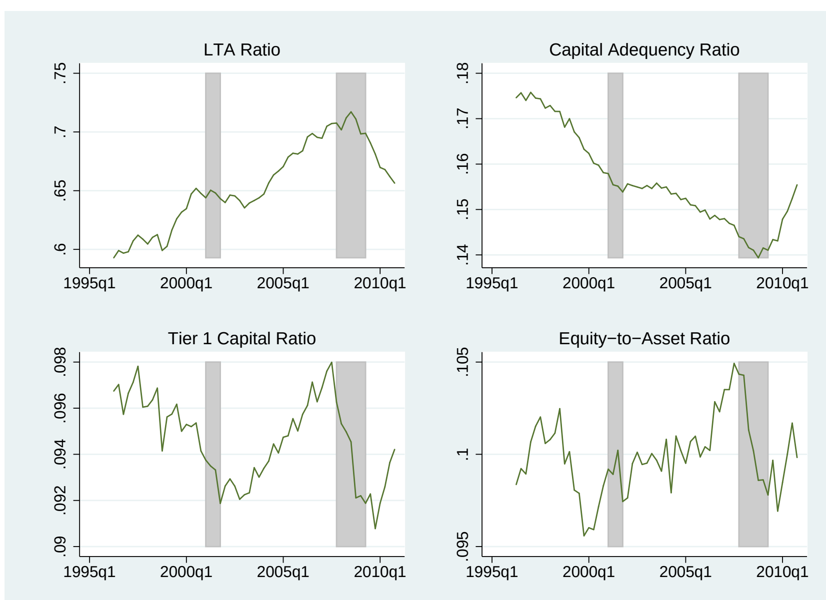

Figure B.4: Time Series of Key Variables (1)

Figure B.5: Time Series of Key Variables (2)

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