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# Banking and the State

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Submitted in total fulfillment of the requirements of  
the degree of Doctor of Philosophy

Submitted September 2018; Revised December 2018

ECONOMICS SECTION  
CARDIFF UNIVERSITY

## Abstract

Banks provide not one but two vital services. Bank deposits are the preferred form of safe assets used for transactions, and bank loans allow businesses to undertake risky endeavors. However, this creates a tension in bank business: deposit-holders require safety for bank liabilities to be liquid; while loan-holders want the freedom to take profitable business risks. A widely-used policy to guarantee the liquidity of bank deposits is the government provision of deposit insurance. This thesis considers some of the relative benefits and costs of deposit insurance relative to an alternative of ‘narrow banking’. This policy argues that a single bank liability structure cannot optimally provide both liquidity and credit. Instead, these two services should be provided by separate entities. These entities could share an owner, provided the safe ‘narrow’ business can be *credibly* ring-fenced from the risky ‘wide’ bank. Narrow banks issue safe, short-term, debt which can be used for transactions and are invested *solely* in safe assets so as not to necessitate insurance. To prevent runs, we suggest that wide banks issue longer-term equity contracts to fund risky business credit. Savers are informed of risks up-front and updated through regular markings-to-market. This thesis considers the ability of a narrow banking system to provide liquidity and credit.

## Acknowledgments

Throughout my PhD candidature at Cardiff University, I have received a tremendous amount of support and would like to devote a few paragraphs to expressing my gratitude to those who have contributed to my ability to submit today.

First and foremost, I would like to thank my co-authors Larry Kotlikoff and George Pennacchi who answered an email out-of-the-blue and have been extremely generous with their time in the past years. I have benefited tremendously from watching them work. I have also profited from collaborations and discussions with my supervisors Huw Dixon and Vo Phuong Mai Le, as well as Keqing Liu, Vito Polito, Mervyn King, Nobu Kiyotaki, Robert Townsend, Jeffrey Miron, John Cochrane, Tom Wilkenning, Steven Williamson, Kevin Hoskin, Ian Woolford, David Delacrétaz, Matthew Greenwood-Nimmo, Andrew Lilico, and Mike Wickens. Finally, I am grateful for the comments and criticism I received from my examiners Kent Matthews and Kevin Dowd. They have helped hone my ideas on this thesis and my future research.

I am grateful to all the professional staff in the business school, and in particular to Elsie Phillips, who have accompanied us throughout the past five years. Helen Walker has offered tremendous support as Director of the PhD programme and Melanie Jones as research panel convener.

It is hard to overstate the importance of the scholarships and travel funding I have received throughout my PhD candidature. Without the Economic and Social Research Council and Cardiff University, I would not have been able to conduct my Overseas International Visit to Boston University and other institutions in the United States to start the two papers that form the core of this thesis. I am also grateful to the Jim Perkins Traveling PhD Scholarship and everyone at the University of Melbourne who helped make a visit to the

Department so productive. The Money and Macro Finance Research Group also generously provided me a funded place on a workshop on Computational Methods from Jesús Fernández-Villaverde hosted by the University of Oxford which has proved very useful in understanding what DYNARE does behind the scenes. I was also very fortunate to receive funding to visit the Reserve Bank of New Zealand, the only country in the OECD that does not have deposit insurance. I benefited greatly from discussions with practitioners on policy details and the important task of justifying policy to successive governments.

My PhD colleagues have been essential to my candidature. Without Robert Forster and Luís Matos to share the ups and downs, and without Rachel Williams, James Wallace, Laura Reynolds, Emma Jones and Cassandra Bowkett, I am not sure I would have been able to complete.

Most importantly, I thank my girlfriend, Charlotte Cadman, for her constant support in the hardest years of the thesis. She continues to be the reason I can do something as ambitious as trying to get paid to think about things I find interesting. I am also grateful to both our families, particularly our parents – David and Wendy Jackson and Paul and Joanne Cadman – for their help throughout.

## Preface

This thesis contains original research in Chapters 2 through 4.

Chapter 2 is based on the following working paper:

JACKSON, T., AND PENNACCHI, G. (2018): “How Should Governments Create Liquidity?” Working Paper.

Chapter 3 is based on the following working paper:

JACKSON, T., AND KOTLIKOFF, L. (2018) “Banks as Potentially Crooked Secret Keepers,” Working Paper.

Chapter 4 is based on the following working paper:

DIXON, H., AND JACKSON, T. (2018) “A Tale of Two Bailouts,” Working Paper.

All co-authorship has taken place in accordance with the Graduate Research Training Policy of Cardiff University.

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# Chapter 1

## Introduction

*We introduce and motivate the class of problems considered in this thesis and survey the relevant economics literature*

At the end of their seminal book on bank regulation (Dewatripont, Tirole, et al. (1994)), the authors lay down a challenge for future research. As deposit insurance reduces incentives for savers to monitor bank risk, what would happen if insurance were restricted to only cover safe assets? This is a system known as narrow banking<sup>1</sup> – in contrast with the dominant policy<sup>2</sup> of ‘blanket’ coverage which does not restrict how insured deposits are invested. That the question remains unanswered speaks to the many facets that must be considered. A major challenge is the central role that banks play in the provision of both liquidity and credit. Both services link banks to the real economy – an area that has received intense attention since the Global Financial Crisis (GFC). Morley (2016) provides an excellent summary of the vast literature that has emerged. However, discussion of changes to the scope of deposit insurance has been limited, with notable exceptions from King (2016); Lilico (2010); Dowd (2013); Calomiris and Haber (2014) and Kotlikoff (2010).

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<sup>1</sup>First suggested by Fisher (1935), as ‘the Chicago Plan’, narrow banking has been supported by many economists (Hart (1935); Tobin (1987); Friedman (1960)) and is enjoying a recent resurgence (Kay et al. (2010); Benes and Kumhof (2012); Pennacchi (2012)).

<sup>2</sup>Demirgüç-Kunt, Kane, and Laeven (2014) document the geographic scope and extent of deposit insurance worldwide.

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Naturally, there is variation in opinion on the optimal alternative policy.<sup>3</sup> Regulatory change – especially for policies which directly connect savers to bank risks<sup>4</sup> – requires a burden of proof in the form of a substantial literature. This thesis takes a general stance on the form of the alternative system and is most concerned with providing theoretical results for a policy regime in which deposit insurance is restricted or removed completely. In particular, we focus on the ability for such a system to provide liquidity and credit.

Holmstrom (2015) defines a liquid asset as one that can be sold at face-value ‘no questions asked’ (NQA). Such assets are useful for transactions and trade with a liquidity premium (Stein (2012); Krishnamurthy and Vissing-Jorgensen (2012)). Chapter 2 focuses directly on liquidity provision in a simple micro-theory framework where banks can choose to exert monitoring effort to improve loan quality. We show that, relative to deposit insurance, the government can provide commensurate liquid assets by issuing government debt directly to narrow banks. In terms of lending, deposit insurance provides the highest *quantity* of loans but of a lower *quality*, relative to the case of narrow banking.

Townsend (1979) models the agency problem between a bank and an entrepreneurial borrower, where the entrepreneur has incentive to falsify returns. Chapter 3 uses an overlapping generations model to consider the same problem between savers and the bank. The long generational time-frame abstracts from liquidity issues thus this Chapter can be understood as focusing on the

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<sup>3</sup>Miron (2010) and Dowd (1992, 2013) come from a libertarian stance preferring a fully free-market solution, while King (2016) provides a transitional policy ceding greater power to the central bank. Kay et al. (2010) would allow narrow banks to invest in residential mortgages. Kotlikoff (2010) and Cochrane (2014) restate the policy of Jacklin (1989) of using equity-funded banking. Pennacchi (2012) points out the equity suffers from ‘cream-skimming’ (Gorton and Pennacchi (1990)) and the traditional definition of a narrow banking system which provides debt layered on government bonds is preferable for transactions.

<sup>4</sup>Another cause for concern is the re-introduction of ‘sunspot’ bank runs as in Diamond and Dybvig (1983). Jacklin (1989) and Dowd (2000) point out runs are a problem linked to insufficient capitalization.

‘wide’ sector of a narrow-wide banking system. We note the problems in charging actuarially fair insurance premia (Leonard (2013); Chan, Greenbaum, and Thakor (1992)) and assume that, in a crisis, government funds are necessary to ensure depositors are repaid in full. We show that if these funds are instead spent preventing the “cream-skimming” problem with equity savings contracts (Gorton and Pennacchi (1990)) then equity-funded banking can provide significant welfare improvements. Using government funds to promote bank disclosure contrasts with the proposal in Dang, Gorton, Holmström, and Ordoñez (2017) who argue that bank opacity is necessary for liquidity. We point out that government debt is an ample source of safe liquid assets for transactions. Opacity creates hard-to-measure risk. It is far simpler for governments to audit a transparent banking sector than a deliberately over-complicated one. We also consider *investor*-funded ratings unions but these suffer from the paradox that costly information suffers from free-riding (Grossman and Stiglitz (1980)).

It is common for large industries to extract government assistance when hit with potentially catastrophic losses. The scale, however, of assistance given to banks following the crisis was extraordinary. Chapter 4 attempts to quantify the real cost of bank recapitalization in the US and UK. Contrary to Treasury reports, our figures include inflation and the effect of Quantitative Easing on government costs of borrowing incurred from funding the emergency recapitalization of banks. The key finding is that differences in the treatment of equity-holders of recipient banks changed the outcome of the programmes. The treatment of equity-holders of recipient banks was not consistent. In the UK, Northern Rock’s shareholders received no compensation when the bank was nationalized, while the Royal Bank of Scotland and Lloyds Bank suffered no dilution despite the government taking a majority stake in each company. In the USA, all profits from Government Sponsored Enterprises – Fannie Mae and Freddie Mac – are transferred to the government, at the expense of its

shareholders. Without this ruling, the headline result that the Troubled Asset Relief Program (TARP) was profitable disappears. All other recipients were not subject to this ongoing profit transfer. Other differences between the two countries result from the lessons that the US regulators learned from the UK programme. Chiefly, US regulators mandated that recipient banks issue warrants so the taxpayer benefitted from capital gains. Secondly, the US program was able to corral a large number of healthier banks to join the program, which raised average returns. The UK results are dominated by the large losses which will result from the eventual sale of the government's stake in the Royal Bank of Scotland.

Chapters 2 to 4 form the core of the present thesis. Chapter 2 is based on a paper co-authored with George Pennacchi. Chapter 3 is based on a paper co-authored with Lawrence Kotlikoff. Chapter 4 is based on a paper co-authored with Huw Dixon. Chapter 5 concludes.

## Chapter 2

# How Should Governments Create Liquidity?

*Governments can create safe, liquid assets by issuing government debt or by insuring private debt, such as bank deposits. Yet this public liquidity creation is limited by the government's capacity to raise taxes to pay its liabilities. This paper analyzes the effects of safe asset creation in a financial system where individuals especially value default-free assets. It compares a banking system with fairly-priced deposit insurance to banking systems with both uninsured "broad" banks and "narrow" banks which invest only in government debt. We find that a system with deposit insurance maximizes the amount of bank system lending but leads to less efficient monitoring of bank borrowers. The alternative system with narrow and broad banks produces the same amount of government safe assets but more privately-created "quasi-safe" assets.*

### 2.1 Introduction

This paper analyzes the design of a country's banking system when its government's taxing capacity limits the amount of safe assets that can be created.

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A government can provide safe (default-free) assets by insuring bank deposits or by directly issuing government debt, such as Treasury bills. Yet it can do so only to a limited degree. A government's total liabilities are constrained by the amount of taxes that it can raise from its citizens.

We compare a system where the government provides limited deposit insurance to banks that make risky loans versus a system where the government requires that narrow banks invest only in the government's directly issued debt (Treasury bills) and uninsured "broad" banks make risky loans. In both systems, safe assets may be created by the government but "quasi-safe" assets can also be created privately. The distinction between government safe assets and private quasi-safe assets is that the former are fully default-free while the latter are default-free except during a severe financial crisis or "catastrophe." Individuals are willing to pay "liquidity" premiums to invest in safe assets, where the premium is greater for fully-safe assets compared to quasi-safe assets. Because individuals especially value liquidity, they accept lower rates of return on safe assets relative to the certainty-equivalent return on risky assets.

The banks in our model are local and separated, with similarities to the 'islands' models developed in Lucas Jr (1972, 1975), such that interbank network effects are precluded. Our model assumes that banks can improve the returns on their risky loans by costly monitoring of their borrowers. However, monitoring is not contractible so that the bank's owner-manager must be given incentives to monitor efficiently. Because the bank owner has limited liability, the bank's choice of leverage (deposit-to-equity capital ratio) affects its incentive to monitor. A bank that limits its leverage can signal its incentive to efficiently monitor, which can raise the bank's firm value and potentially lower its cost of deposit funding. Because monitoring costs are assumed to vary across banks, in general some lower-cost banks may limit leverage and

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<sup>0</sup>Compared to deposit-insured banks, uninsured broad banks might be considered a type of "shadow" bank.

efficiently monitor while other higher-cost banks choose high leverage and do not monitor. Our model also permits a bank to issue deposits with different seniorities, a process referred to as “tranching.” For some banks, issuing both senior and junior deposits can be profitable because the former can be made quasi-safe.

We use the model to investigate three regimes: a baseline, fully-private banking system with no government safe assets; a scheme of fairly-priced government deposit insurance; and a system combining narrow banks that invest in government debt and uninsured broad banks that make loans. We assume the tax base available to finance a government’s safe assets is identical in the latter two regimes to allow for a fair comparison.

We show that the creation of safe assets that derives from the government’s ability to impose future taxes can potentially improve welfare by providing more and higher-quality liquidity. However, government safe asset production can come at the cost of less-efficient bank monitoring or less total bank lending.

Government deposit insurance is profitable for banks because deposits that are completely safe, even during a catastrophe, are especially valued by savers and require the lowest risk-adjusted rate of return. However, sufficiently high levels of deposit insurance reduce the amount of efficient monitoring in the banking system and can crowd out quasi-safe deposits.

In a system with narrow banks and uninsured broad banks, narrow banks that take deposits and invest in government debt may, in some structures, reduce the deposits available to broad banks that make loans. As a consequence, banking system lending can decline. However, because fewer deposits limit the leverage of broad banks, the lending that does occur tends to be done with more efficient monitoring and possibly greater production of quasi-safe deposits. However, under a different narrow bank - broad bank structure,

narrow banks would not reduce deposits available to broad banks and would be equivalent to a system of fully-private lending banks but with the benefit of additional government safe assets.

Our paper contributes to a literature on the private and public provision of safe assets.<sup>1</sup> Prior research, including Gorton and Pennacchi (1990) and Dang, Gorton, Holmström, and Ordoñez (2017), notes that safe assets are especially valuable for making transactions due to their information-insensitivity. The “money-like” feature of safe assets can allow them to pay a lower rate of return compared to riskier, less-liquid assets. Such a liquidity premium is empirically documented by work including Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), and Nagel (2016).

Research shows that safe assets can be created privately via financial institutions such as banks (e.g., Diamond (2017)) or special purpose vehicles that invest in risky debt and issue tranching securities (e.g., DeMarzo and Duffie (1998) and DeMarzo (2005)). However, safe assets can also be created by governments in the form of sovereign debt or by insuring privately-issued debt, such as bank deposits (e.g., Greenwood, Hanson, and Stein (2015), He, Krishnamurthy, and Milbradt (2018), Gatev and Strahan (2006), and Pennacchi (2006)).

Most papers that analyze the co-existence of private and public safe assets concentrate on issues related to financial stability. Research by Holmström and Tirole (1998), Bolton, Santos, and Scheinkman (2009), and Stein (2012) present models where the provision of government safe, liquid assets can improve financial system stability relative to an economy with only private liquid assets.

Our paper also analyzes the interaction between private and public safe

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<sup>1</sup>See Gorton (2017) for an in-depth review of this literature.

assets, but our focus relates to issues of lending efficiency and the aggregate volume of private safe assets. As in Diamond (1984), banks in our model can create value by making loans and providing costly monitoring of borrowers. We study how the *form* of government safe assets affects monitoring efficiency and private liquidity creation. Our paper’s main contribution is to show that public safe assets in the form of government-insured deposits can have different implications compared to public safe assets in the form of directly-issued government debt. They have different effects with regard to a banking system’s aggregate lending, its lending efficiency, and its creation of private safe assets.

The next section introduces our basic model and considers a fully-private banking system with no role for government. Section 3 examines a banking system with government deposit insurance that is limited by the government’s capacity to tax agents’ future wages in order pay insurance losses. Section 4 considers a banking system where the government directly issues debt that is held by narrow banks that operate like “Treasury-only” money market mutual funds. In this system, uninsured broad banks make loans. As with deposit insurance, the amount of government debt that can be issued is limited by the government’s future taxing capacity. Section 5 provides numerical illustrations of the model’s results, and Section 6 briefly discusses the robustness of the model’s assumptions. Conclusions are given in Section 7.

## **2.2 Liquidity Creation in a Fully-Private Banking System**

This section presents our basic model of a private banking system that has no role for a government to create safe assets. Private banks can create only quasi-safe assets, which are default-free except in a financial catastrophe. The following sections will consider how a government can create fully default-free

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assets due to its ability to tax individuals' future endowments.

Consider a single-period economy with risk-neutral agents who obtain utility from their end-of-period consumption. Agents receive initial endowments that can be transformed into end-of-period consumption using two types of investment technologies. One is a risky investment technology that is available to all agents. The other is a superior risky investment technology that can only be accessed through lending intermediaries, which we call "banks."

There are two types of agents: agents who are capable of owning and managing banks and other agents who wish to save and value liquidity derived from investing in safe assets. We will refer to the former agents as "bankers" and the latter agents as "savers." Each banker has a fixed beginning-of-period endowment of inside equity equal to  $k$ . A banker can raise additional funds in the form of deposits from its local savers who can deposit only in their local bank.<sup>2</sup> We normalize the maximum amount of available local savings to 1 and the amount of total deposits actually issued by the bank is denoted by  $\gamma \leq 1$ . Therefore, a bank's beginning-of-period assets equals  $(\gamma + k) \leq (1 + k)$ .<sup>3</sup>

Banks are special due to their superior lending technology that funds identical projects in perfectly elastic supply. All projects, and therefore loans, are subject to only aggregate (macroeconomic) risk.<sup>4</sup> We consider three end-of-period states of the world: 'good,' 'bad,' and 'catastrophe.' The good state occurs with probability  $p_g$ , in which case each loan's end-of-period return per unit lent equals its promised return of  $R_L$ . The bad state occurs with probability  $p_b$ , in which case each loan defaults but has a positive recovery value.

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<sup>2</sup>Savers are limited to investing only in the bank's debt (deposits) and not its equity. In richer models where savers cannot verify the return on the bank's assets or have needs to trade, they may prefer bank deposits relative to bank equity. For example, see Diamond (1984); Townsend (1979); Gorton and Pennacchi (1990).

<sup>3</sup>As will become clear, a banker has the incentive to invest the entire amount of capital,  $k$ , in the bank because of its access to a superior investment technology.

<sup>4</sup>We focus on macroeconomic risk because, in general, idiosyncratic risks might be diversified away through pooling as in Diamond (1984).

Finally, the catastrophe state occurs with probability  $p_c = 1 - p_g - p_b$ , in which case the loan defaults and has a zero recovery value.

The banker is able to improve each loan's recovery value in the bad state by exerting beginning-of-period effort to monitor the borrower.<sup>5</sup> This recovery value is denoted by  $d(a)$ , where  $a$  is a banker's beginning-of-period level of effort per unit of loan. Recovery value per unit of loan is assumed to be the following increasing and concave function of banker effort:

$$d(a) = R_L \left(1 - \alpha e^{-\beta a}\right) \quad (2.1)$$

where  $0 < \alpha < 1$  and  $\beta > 0$ . Monitoring effort is assumed to be costly in terms of diminishing the banker's utility at a fixed marginal cost per unit of effort.<sup>6</sup> Denote Banker  $i$ 's marginal cost of effort by  $c_i$ . We assume the country's economy has a continuum of local bankers who differ in terms of their cost of monitoring, where  $c_i$  belongs to a continuous distribution having the range:

$$c_i \in [p_b \beta (R_L - 1), p_b \alpha \beta R_L] \equiv [\underline{c}, \bar{c}]. \quad (2.2)$$

As will be shown, this restriction on the range of monitoring costs ensures that each bank's first-best effort is positive but still results in a positive loss given default. Importantly, it is also assumed that each bank's effort level,  $a$ , is unobservable to savers and, hence, cannot be contracted upon.

While savers are risk neutral, they have an additional 'liquidity' demand for safe assets. Savers have direct access to a risky investment technology that funds projects in perfectly elastic supply and pays a return per unit investment of  $R_R/p_g$  only in the good state. Therefore, this non-intermediated investment

<sup>5</sup>We refer to this effort as monitoring, but it could also be interpreted as credit screening to determine which loan applicants have higher recovery value.

<sup>6</sup>Alternatively, one could assume bankers differ in terms of how efficient is their effort in improving recovery value,  $\beta$ .

technology has an expected return per unit investment of  $R_R < R_L$ .<sup>7</sup> However, savers will accept the expected return of  $R_C < R_R$  on an investment that is default-free in the good and bad states but not the catastrophe state. Thus, this ‘quasi-safe’ investment does not default with probability  $\wp \equiv p_g + p_b$  and defaults with probability  $p_c = 1 - \wp$ . Examples of these investments might include money market instruments such as A1/P1-rated commercial paper and wholesale, uninsured bank certificates of deposit.<sup>8</sup> Later we will consider government-created assets that are default-free in all states for which savers require a return that is even lower than  $R_C$ . As in Stein (2012), we assume that savers’ required return on quasi-safe assets is independent of their supply.

We can define a quasi-safe asset’s liquidity premium by  $l$  where  $R_C(1+l) = R_R$ . This liquidity premium can be considered a utility bonus due to a safe asset’s value in settling transactions and for use as collateral.<sup>9</sup>

Because loans return zero in the catastrophe state, the best that a private bank can do is to create quasi-safe deposits. Doing so allows it to reduce its cost of funding by the liquidity premium  $l$ . The bank can augment its quasi-safe deposits in two ways. One way is by increasing the recovery value of its loans in the bad default state by efficiently monitoring its borrowers. However, for depositors to find this credible, the bank must have an incentive to undertake this unobserved action. The bank can create this incentive by restricting its leverage so that bank equity receives the marginal benefit from its costly monitoring effort.

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<sup>7</sup>These projects may be the same types of projects that banks fund with loans. However, savers are not able to monitor borrowers and obtain inferior expected returns relative to those received by banks.

<sup>8</sup>This asset class might be considered a ‘near-money’ or what Moreira and Savov (2014) refer to as ‘shadow money.’

<sup>9</sup>Gorton and Pennacchi (1990) provide a theory for why safe assets are particularly valuable for transactions. Several recent models, such as Stein (2012), assume that the moneyiness feature of safe short-term gives it a lower required return than the certainty-equivalent return on risky assets.

The second way that a bank might increase its quasi-safe deposits is by “tranching” its debt, which means that it issues both senior deposits and junior deposits (or subordinated debt). Designed appropriately, the senior deposits can be made quasi-safe and supported by the additional assets that are funded by junior deposits. We defer consideration of tranching until the next section. For now, we assume that the bank issues only a single class of deposits of the amount  $\gamma$ .

Bankers are assumed to be the only equity investors (shareholders) of the bank. Their profit-maximizing choice of leverage and effort may result in savers’ deposits being either quasi-safe or default-risky. We now consider the possible equilibrium behavior of these limited-liability bankers and savers.

An *equilibrium* is defined as follows. First, a bank(er) announces that it will raise  $\gamma \leq 1$  in deposits, so that its total assets equals  $\gamma + k$ . Second, given this choice of leverage (deposits and total assets), the bank’s promised return on deposits,  $R_D$ , is set. Third, given this deposit rate, the bank chooses its unobserved effort level,  $a$ . An equilibrium is a choice of  $\gamma$  and  $a$  that maximizes the bank’s profits and a promised deposit rate  $R_D$  that satisfies depositors’ participation constraint given the bank’s announced  $\gamma$  and its equilibrium profit-maximizing choice of  $a$ .

Since Bank  $i$  has monitoring cost  $c_i$ , its profit maximization problem can be characterized as:

$$\max_{\gamma, a} p_g [(\gamma + k)R_L - \gamma R_D] + p_b \max [(\gamma + k)d(a) - \gamma R_D, 0] - c_i a (\gamma + k) \quad (2.3)$$

subject to the constraint that its deposits cannot exceed 1:

$$\gamma \leq 1 \quad (2.4)$$

and subject to depositors' participation constraint:

$$R_D \geq \begin{cases} \frac{R_R - p_b \frac{\gamma+k}{\gamma} d(a^*)}{p_g} & \text{if } (\gamma + k)d(a^*) < \gamma R_C / \wp \\ R_C / \wp & \text{otherwise} \end{cases} \quad (2.5)$$

Note that the expected profits given in (2.3) reflect the fact that the bank may or may not default in the bad state but will always default in the catastrophe state due to loans' zero recovery value in that state. Also, the depositors' participation constraint (2.5) reflects either default in the bad state (the first line on the right-hand side) or no default in the bad state (the second line on the right-hand side). In the former case, depositors' required expected return is  $R_R$ , but in the latter case it is  $R_C$  since deposits are quasi-safe.

The solution to the problem can be found by noting that whenever default occurs in the bad state,  $(\gamma + k)d(a^*) < \gamma R_C / \wp$ , then from the objective function (2.3) we see that the banker receives no benefit from monitoring and the bank's private effort choice will be  $a^* = a^l \equiv 0$ . Deposits' equilibrium promised return must then be  $R_D = \frac{R_R - p_b \frac{\gamma+k}{\gamma} d(a^l)}{p_g} = \frac{R_R - p_b \frac{\gamma+k}{\gamma} R_L (1-\alpha)}{p_g}$  and the bank's expected profit is

$$\pi^l = p_g [(\gamma + k)R_L - \gamma R_D] = (\gamma + k)[p_g R_L + p_b R_L (1 - \alpha)] - \gamma R_R. \quad (2.6)$$

Instead, whenever  $(\gamma + k)d(a^*) > \gamma R_C / \wp$  so that the banker obtains a return in the default state, then its optimal choice of effort will either be the same corner solution  $a^l = 0$  or the effort level implied by the first-order condition:

$$\frac{\partial d(a)}{\partial a} = \frac{c_i}{p_b}. \quad (2.7)$$

By substituting in the functional form for  $d(a)$  from equation (2.1), the effort satisfying this first order condition is  $a^* = a^h$  where

$$a^h \equiv \frac{1}{\beta} \ln \left( \frac{\beta \alpha p_b R_L}{c_i} \right) \quad (2.8)$$

which results in the loan's bad state recovery value equaling

$$d(a^h) = R_L - \frac{c_i}{\beta p_b} \quad (2.9)$$

In this case deposits are quasi safe,  $R_D = R_C/\wp$ , and the high-effort bank's expected profit is

$$\pi^h = (\gamma + k) \left[ p_g R_L + p_b d(a^h) - c_i a^h \right] - \gamma R_C \quad (2.10)$$

where  $p_b d(a^h) - c_i a^h > p_b R_L(1 - \alpha)$  is the expected recovery value net of monitoring costs. Thus,  $a^l = 0$  or  $a^h$  given by equation (2.8) are the only choices of effort that could possibly be profit-maximizing for the bank. The following lemma states that a bank's profit-maximizing choice of effort, and its equilibrium deposit interest rate, depends on whether its initial choice of leverage is below or above a particular threshold value which we refer to as  $\gamma^m$ .

**Lemma 1.** *If Bank  $i$  chooses initial deposits less than or equal to  $\gamma^m(c_i) \equiv k \frac{p_b d(a^h) - c_i a^h}{R_C/\wp - (p_b d(a^h) - c_i a^h)}$ , then the equilibrium is one where the bank supplies first-best effort (2.8),  $R_D = R_C/\wp$ , and has profits equal to equation (2.10). If it chooses initial deposits exceeding  $\gamma^m(c_i)$ , the equilibrium is characterized by no bank effort,  $R_D = \frac{R_R - p_b \frac{\gamma + k}{\gamma} R_L(1 - \alpha)}{p_g}$ , and profits equal to equation (2.6).*

The proof is given in Appendix A. Thus, the profit function is given by equations (2.6) and (2.10), where the switch point occurs at  $\gamma = \gamma^m$ . The bank's profit maximizing choice of  $\gamma$  is then the maximum of this profit function. As both profit functions, (2.6) and (2.10), are linear and increasing in  $\gamma$ , these maxima are at the endpoints,  $\gamma = \gamma^m$  and  $\gamma = 1$  respectively.<sup>10</sup> Banks simply compare profits at

$$\pi^l = (1 + k) [p_g R_L + p_b d(0)] - R_R \quad (2.11)$$

$$\pi^h = (\gamma^m + k) \left[ p_g R_L + p_b d(a^h) - c_i a^h \right] - \gamma^m R_C \quad (2.12)$$

and choose the  $(\gamma, a)$  combination  $(\gamma^m, a^h)$  if  $\pi^l \leq \pi^h$  and otherwise choose  $(1, 0)$ .

<sup>10</sup>We rule out parameter values for which profit is decreasing in  $\gamma$  since that implies that banks choose to issue zero deposits.

Now note from (2.11) and (2.12) that  $\pi^l$  does not depend on the banker's cost of effort, since no effort is expended. Moreover,  $\pi^h$  is a monotonically decreasing function of the banker's cost,  $c_i$ .<sup>11</sup> Assuming that

$$\pi^h(\bar{c}) < \pi^l < \pi^h(\underline{c}), \quad (2.13)$$

then there exists a unique  $c^*$  that is the value of  $c$  such that  $\pi^l = \pi^h$ . It satisfies the implicit equation:

$$c^* = \frac{\pi^l p_b (R_L - R_C / \varphi)}{\left(\frac{1}{\beta} + a^h(c^*)\right) (\pi^l - p_g k R_C / \varphi)} \quad (2.14)$$

where  $a^h(c^*) = \frac{1}{\beta} \ln \left( \frac{\beta \alpha p_b R_L}{c^*} \right)$ . This logic leads to the following proposition that is proven in Appendix A.

**Proposition 1.** *If Bank  $i$ 's cost of monitoring is  $c_i < c^*$ , it chooses leverage equal to  $\gamma^m(c_i)$ , provides first best effort of  $a^h(c_i)$ , sets  $R_D = R_C / \varphi$ , and has profits equal to equation (2.12). Instead, if its cost is  $c_i > c^*$ , it chooses  $\gamma = 1$ , provides no effort, sets  $R_D = \frac{R_R - p_b(1+k)R_L(1-\alpha)}{p_g}$ , and has profits equal to equation (2.11).*

Thus, only low monitoring cost banks, defined as having  $c_i < c^*$ , limit leverage, provide first-best effort, and create quasi-safe deposits.

Our results to this point assume that a bank issues only one class of deposits. The next section considers whether a bank might choose to issue both senior deposits and junior (subordinated) deposits. Interestingly, the process of *tranching* deposits can permit issuance of quasi-safe deposits by high-cost, no-effort banks.

### 2.2.1 Tranching

Consider a bank that offers two classes of deposits: senior deposits and junior deposits (or subordinated debt). Suppose that the bank restricts the amount

<sup>11</sup>See the proof in Appendix A.

of its senior deposits,  $\gamma^s$ , such that it has sufficient loan recovery value in the bad default state to pay off senior depositors in full. Intuitively, the bank may have an incentive to do so because it ensures that senior deposits are quasi-safe and their promised return is relatively low at  $R_C/\varphi$ . In addition, let the amount of junior deposits be  $\gamma^j$  and their promised return be  $R_{D,j}$ . For an equilibrium effort level,  $a$ , the amount of senior, quasi-safe debt that the bank could issue,  $\gamma^s$ , will satisfy:

$$(\gamma^s + \gamma^j + k)d(a) \geq \gamma^s R_C/\varphi \quad (2.15)$$

or, equivalently, senior leverage must be below a maximum,  $\bar{\gamma}^s$ , which is increasing in effort,  $a$ , and other forms of bank funding,  $\gamma^j + k$ ,

$$\gamma^s \leq \bar{\gamma}^s \equiv \frac{(\gamma^j + k)d(a)}{R_C/\varphi - d(a)}. \quad (2.16)$$

The bank's profit maximization problem is now characterized as:

$$\begin{aligned} \max_{\gamma^j, \gamma^s, a} \quad & p_g [(\gamma^s + \gamma^j + k)R_L - \gamma^s R_C/\varphi - \gamma^j R_{D,j}] \\ & + p_b \max [(\gamma^s + \gamma^j + k)d(a) - \gamma^s R_C/\varphi - \gamma^j R_{D,j}, 0] - ca(\gamma^s + \gamma^j + k) \end{aligned} \quad (2.17)$$

subject to the constraint (2.15) that senior deposits are quasi-safe and subject to junior depositors' participation constraint:

$$R_{D,j} \geq \begin{cases} \frac{R_R - \frac{p_b}{\gamma^j} [(\gamma^s + \gamma^j + k)d(a^*) - \gamma^s R_C/\varphi]}{p_g} & \text{if } (\gamma^s + \gamma^j + k)d(a^*) - \gamma^s R_C/\varphi < \gamma^j R_C/\varphi \\ R_C/\varphi & \text{otherwise} \end{cases} \quad (2.18)$$

To solve this problem, let us start by considering the bank's incentive to exert effort. Note that bank equity benefits from effort only if it receives the marginal profit from effort in the bad default state. That can only occur when

$$(\gamma^s + \gamma^j + k)d(a) - \gamma^s R_C/\varphi - \gamma^j R_{D,j} > 0. \quad (2.19)$$

But if inequality (2.19) holds, then junior deposits are also quasi-safe, can be paid a deposit interest rate of  $R_D = R_C/\varphi$ , and are no different from senior

deposits. Consequently, a bank that monitors at first best,  $a^* = a^h$ , cannot benefit from issuing more than one class of (senior) deposits. Thus, if a bank has a relatively low cost of exerting effort so that its optimal effort choice is first-best, then optimal effort, leverage, and profits are  $\{a^h, \gamma^m, \pi^h\}$ , the same as when it does not tranche.

Instead, consider a bank that has relatively high monitoring costs such that it is optimal not to exert effort and inequality (2.19) does not hold. Without tranching, Proposition 1 shows that this bank would choose maximum leverage,  $\gamma = 1$ , and all deposits suffer losses in the bad default state. Consequently, the bank's per unit expected cost of deposit funding is  $R_R$ . Tranching now allows the bank to reduce part of its deposit funding costs. Since quasi-safe senior deposits have the lower per unit expected cost of  $R_C < R_R$  while the expected cost of junior deposits is unchanged at  $R_R$ , the bank has the incentive to issue the maximum amount of quasi-safe senior deposits,  $\gamma^s = \bar{\gamma}^s$ . As a result, junior deposits receive nothing in the bad state so that their promised return is  $R_{D,j} = \frac{R_R}{p_g}$ .<sup>12</sup>

Since a bank that chooses no effort,  $a^l = 0$ , profits by maximizing total leverage,  $\gamma = 1$ , even when it does not tranche its deposits, its profit-maximizing amount of junior deposits is  $\gamma^j = 1 - \bar{\gamma}^s$ . Thus, tranching does not affect this bank's equilibrium effort or total leverage, but permits it to create quasi-safe assets equal to

$$\gamma^s = \frac{(1 - \gamma^s + k)R_L(1 - \alpha)}{R_C/\varphi - R_L(1 - \alpha)} = \frac{(1 + k)R_L(1 - \alpha)}{R_C/\varphi} \quad (2.20)$$

Doing so yields increased profits as a result of the reduced funding cost of senior deposits. Denoting the no-effort bank's profits under tranching as  $\pi_T^l$ ,

<sup>12</sup>The fact that in equilibrium junior deposits receive nothing in the bad state makes their payoff similar that of the banker's inside equity,  $k$ . In this sense, junior deposits might be considered similar to outside equity. However, the effort incentive of the banker depends his/her inside equity, so issuing more junior deposits is not equivalent to the banker starting with more inside equity.

we have

$$\begin{aligned}
\pi_T^l &= p_g \left[ (1+k)R_L - \gamma^s \frac{R_C}{\wp} - (1-\gamma^s) \frac{R_R}{p_g} \right] \\
&= (1+k) [p_g R_L + p_b R_L (1-\alpha)] - \gamma^s R_C - (1-\gamma^s) R_R \\
&= (1+k) [p_g R_L + (p_b + \wp l) R_L (1-\alpha)] - R_R, \tag{2.21}
\end{aligned}$$

where recall that the liquidity premium,  $l$ , is defined by  $R_R = (1+l)R_C$ . Compared to profits without tranching in equation (2.11), we see that tranching raises the no-effort bank's profits by the liquidity premium that it saves on its quasi-safe senior deposits:

$$\pi_T^l - \pi^l = \wp l (1+k) R_L (1-\alpha) = l \gamma^s R_C \geq 0.$$

This increase in no-effort profits alters the monitoring cost threshold above which banks choose no effort. By equating  $\pi_T^l$  in equation (2.21) to  $\pi^h$  in equation (2.12), the critical value of  $c_i$  is now:

$$c^T = \frac{\pi_T^l p_b (R_L - R_C/\wp)}{\left(\frac{1}{\beta} + a^h(c^T)\right) (\pi_T^l - p_g k R_C/\wp)}. \tag{2.22}$$

Since  $\pi_T^l > \pi^l$  and  $p_g k R_C/\wp > 0$ , we see that  $c^T < c^*$ . Intuitively, tranching deposits makes choosing no effort relatively more profitable than choosing high effort. Hence, there is a lower cost threshold at which banks choose no effort.

We summarize these results in the following proposition:

**Proposition 2.** *If Bank  $i$ 's cost of monitoring is  $c_i < c^T$ , it does not benefit from tranching and its leverage, effort, deposit rate, and profits are the same as without tranching. Instead, if its cost is  $c_i > c^T$ , it exerts no effort and issues senior deposits of  $\gamma^s$  and junior deposits of  $1 - \gamma^s$  where  $\gamma^s$  is given by equation (2.20). The deposit rates of senior and junior deposits are  $R_C/\wp$  and  $R_R/p_g$ , respectively, and the bank's profits are given by equation (2.21). Since,  $c^T < c^*$ , more banks choose no effort when tranching is possible than when it is not.*

It is interesting to note that if banks are not permitted to tranche deposits, low-cost, high-effort banks are the only ones that can produce quasi-safe deposits. However, if tranching is permitted, now high-cost, no-effort banks create quasi-safe deposits and, moreover, the amount that they create can exceed that of the low-cost, high-effort banks. That is, there are parameter values such that  $\gamma^s > \gamma^m(c_i)$  for a range of  $c_i < c^T$ . It may seem ironic that high-cost banks which do not monitor and have riskier loan portfolios are able to create more quasi-safe deposits. Of course they do so by issuing more risky junior deposits because they need not signal their incentive to monitor by having low total leverage. The next section considers the aggregate amount of quasi-safe assets produced by a private, uninsured banking industry.

### 2.2.2 Quasi-Safe Asset Production

The provision of quasi-safe, liquid assets may be considered a key measure of social welfare. Let  $f(c_i)$  be the economy's density of bankers with monitoring cost  $c_i$ . Then assuming tranching is permitted, the quantity of quasi-safe deposits produced by banks that choose first-best effort is

$$\int_{\underline{c}}^{c^T} \gamma^m(c_i) f(c_i) dc_i, \quad (2.23)$$

where each bank that exerts first best effort issues quasi-safe deposits equal to  $\gamma^m(c_i) = k \frac{p_b d(a^h(c_i)) - c_i a^h(c_i)}{p_b R_C / \phi - [p_b d(a^h(c_i)) - c_i a^h(c_i)]}$  and where the high effort - no effort monitoring cost threshold,  $c^T$ , is given by equation (2.22).

Each no-effort bank issues quasi-safe, senior deposits equal to  $\gamma^s$  given by equation (2.20). Thus, total quasi-safe deposit production combines both the high-effort banks' total deposits and the no-effort banks' senior deposits. Denoting the economy's total quasi-safe deposits under tranching as  $S_T^c$ , it satisfies

$$S_T^c = \int_{\underline{c}}^{c^T} \gamma^m(c_i) f(c_i) dc_i + \gamma^s \int_{c^T}^{\bar{c}} f(c_i) dc_i. \quad (2.24)$$

Assuming a uniform density for monitoring costs, equation (2.24) simplifies to

$$S_T^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^T} \gamma^m(c_i) dc_i + \gamma^s(\bar{c} - c^T) \right]. \quad (2.25)$$

Since quasi-safe deposits are vulnerable to losses in the catastrophe state, there is the potential for a government with taxing authority to improve welfare by producing assets that are safe in all future states, including severe crises. The next section considers this possibility by way of government deposit insurance.

## 2.3 Liquidity Creation with Government Deposit Insurance

In this section, we first discuss a feature that can give a governmental advantage to producing safe assets, namely, the government's ability to tax sources of income that may not be available to private creditors. We then consider the particular case of government-backed bank deposits.

### 2.3.1 Taxes as a Source of Public Liquidity

Relative to private entities, a government's power to tax can give it an advantage in producing safe assets. In particular, a government might raise revenue from sources of income that may be difficult to pledge under private contracts. Future revenue from human capital, i.e., wage income, may be an example. Payment from an individual's future wages may be difficult to collect under private contracts due to bankruptcy laws that provide limited protection to private creditors. Compared to the rights of private creditors, a government typically is in a stronger position to collect taxes that are owed.

We model a government's taxing authority by assuming that savers receive end-of-period wage income that is riskless and equal to  $\omega$  per unit of beginning-

of-period savings.<sup>13</sup> These wages are not pledgeable under private contracts, but a government is able to tax a proportion  $\bar{t} \leq 1$ .<sup>14</sup> This taxable proportion might be determined by moral hazard considerations: if the tax rate is too high, individuals may have an incentive to evade taxes.<sup>15</sup>

The government's taxing capacity gives it the ability to create assets that are default-free, even in the catastrophe state. Examples might include Treasury debt, such as Treasury bills, and government-insured debt or deposits. These assets' moneyness and liquidity are assumed to be particularly attractive to savers such that perfectly safe assets' required return equals  $R_F$  where  $R_F < R_C < R_R$ . Written in terms of liquidity premia, we have  $R_R = (1+l)R_C = (1+l)(1+l_f)R_F$ . Thus, increasing safety is associated with higher liquidity premia that reduce the returns required by savers.

The next section considers one way that a government can create a fully-safe asset, namely, deposit insurance. Following that, we consider safe asset production by a government that issues its own debt.

### 2.3.2 Deposit Insurance

Suppose that the government offers fairly-priced deposit insurance to private banks that permits insured deposits to be default-free in all end-of-period states, including both the 'bad' and 'catastrophe' states when loans default. Since deposit insurance is backed by the government's power to tax savers' end-of-period wages, the amount of these taxes is state-contingent. Yet for deposit

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<sup>13</sup>Our results are not sensitive to the assumption that wage income is riskless. What matters is that there is some strictly positive minimum level of wages that can be taxed even in the catastrophe state.

<sup>14</sup>If wages could be pledged under private contracts, individuals could underwrite insurance against a bank's default on its deposits; that is, savers could provide credit protection. Or, alternatively, individuals could issue riskless debt at the beginning of the period backed by their future wages. Both actions could increase the amount of safe assets.

<sup>15</sup>A similar, but alternative, assumption would be to have a direct cost to raising taxes that is increasing and convex in the amount raised. This cost would subtract from social welfare.

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insurance to be fully credible, it must insure deposits in case of catastrophe when each bank's assets are worthless. This worst-state scenario limits insured deposits to equal the government's maximum revenue that can be raised in taxes at the end of the period.

We assume that the insurer limits its maximum liability by restricting the quantity of deposits that it will insure at each bank. One can imagine that this policy is implemented by limiting insurance to small "retail" deposits, assumed to equal a proportion  $\gamma^r$  of total savings in each banking market. Consequently, we assume the maximum promised end-of-period payment to insured depositors is  $\gamma^r R_F$  for each bank.

Because our intent is to study the potential amount of safe assets that a government can create with deposit insurance, we do not consider the well-known distortions due to insurance mis-pricing.<sup>16</sup> Rather, we assume the government assesses a fair insurance premium payable by the bank at the end of the period, where  $\phi$  is the premium per promised payment on insured deposits.<sup>17</sup> Specifically, if a bank chooses to issue the maximum amount of insured deposits, then its total promised payment to insured depositors and the deposit insurer is  $\gamma^r R_F(1 + \phi)$ . Because deposit insurance is fairly priced, the premium  $\phi$  will vary across banks based on their default risk.

Not all banks may choose to issue the maximum amount of insured deposits. A bank's equilibrium choice can depend on its individual cost of monitoring,  $c_i$ . We begin by taking as given the government deposit insurance limit of  $\gamma^r$  for each banking market and determining an individual bank's profit-maximizing choice of insured deposits. Then we will aggregate over all

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<sup>16</sup>While extensive empirical evidence suggests deposit insurance is typically under-priced, it is possible that a government might want to set higher-than-fair deposit insurance premiums in order to capture the liquidity premium from its creation of fully-safe assets. Since governments do not seem to embrace this practice, we leave this issue for future research.

<sup>17</sup>We assume the premium is distributed as a lump sum payment to savers in the good state.

banking markets to determine the maximum level of  $\gamma^r$  that can be supported by the government's taxing power.

### High Cost Banks

Recall that in the absence of deposit insurance, banks with relatively high monitoring costs choose maximum leverage ( $\gamma = 1$ ), zero effort ( $a^l = 0$ ), and tranche their deposits such that the promised payment on senior deposits equals the bank's asset return in the bad state ( $\gamma^s$  given by equation (2.20)). In equilibrium, these banks' expected cost of quasi-safe senior deposits is  $R_C$  and their expected cost of junior deposits is  $R_R$ .

For the sake of both simplicity and realism, we assume that the maximum amount of insured deposits,  $\gamma^r$ , is such that  $\gamma^r R_F \geq \gamma^s R_C / \phi = (1+k)R_L(1-\alpha)$ . In other words, the maximum promised payment on insured deposits exceeds the no-effort bank's asset return in the bad state. Thus, if this bank issues the maximum amount of insured deposits, it has no incentive to issue senior deposits. Moreover, as will be shown, when the bank is charged a fair deposit insurance premium, its expected cost of insured deposits is  $R_F$  and its expected cost of uninsured deposits is  $R_R$ . Since, compared to the uninsured case, the bank's insured deposits exceeds senior deposits and its uninsured deposits are less than junior deposits, the bank is strictly more profitable under deposit insurance and, indeed, has an incentive to issue the maximum amount of insured deposits and total deposits.

To see this, consider the fair deposit insurance premium, which we assume the bank promises to pay at the end of the period.<sup>18</sup> We continue to use the superscript 'l' to denote the no-effort bank's quantities. Now when deposit insurance is fairly priced, the expected deposit insurance premium equals expected deposit insurance losses. In the 'bad' state, losses equal the shortfall

<sup>18</sup> Assuming a promised end-of-period payment makes the premium analogous to a credit spread on uninsured debt.

between insured deposits owed per bank,  $\gamma^r R_F$ , and the recovery rate. As in actual practice, the insurer has the same seniority (bankruptcy claimant status) as uninsured depositors. Thus the insurer only receives the proportion  $\gamma^r$  of the recovery value,  $(\gamma^l + k)d(a^l) = (1 + k)R_L(1 - \alpha)$ . In the catastrophe state, which occurs with probability  $p_c = (1 - p_g - p_b)$ , no assets are recovered. The premium is set such that:

$$p_g \phi^l \gamma^r R_F = p_b [\gamma^r R_F - \gamma^r (1 + k)R_L(1 - \alpha)] + p_c \gamma^r R_F. \quad (2.26)$$

Solving for the insurance premium, one can see that it is independent of the proportion of insured deposits:

$$\phi^l = \frac{(1 - p_g)R_F - p_b(1 + k)R_L(1 - \alpha)}{p_g R_F}. \quad (2.27)$$

As bank funding costs are linear in  $\gamma^r$ , banks will either insure up to the limit or not at all. However, since  $R_F < R_R$ , the funding cost of insured deposits is lower than that of uninsured deposits. Defining the promised return on uninsured deposits as  $R_{D,u}$ , it is straightforward to show that

$$(1 + \phi^l)R_F \leq R_{D,u} \quad (2.28)$$

where the uninsured deposit return is the same as under the no insurance, no tranching case:<sup>19</sup>

$$R_{D,u} = \frac{R_R - p_b(1 + k)R_L(1 - \alpha)}{p_g}. \quad (2.29)$$

The intuition is that even when a bank pays a fair premium that covers the deposit insurer's expected loss, there is still a benefit that accrues to the bank because depositors require a lower interest rate when deposits are fully default-free and liquid. The no-effort bank's profit with deposit insurance, denoted as  $\pi_{DI}^l$ , equals

$$\begin{aligned} \pi_{DI}^l &= p_g \{ (1 + k)R_L - \gamma^r (1 + \phi^l)R_F - (1 - \gamma^r)R_{D,u} \} \\ &= (1 + k)[p_g R_L + p_b R_L(1 - \alpha)] - \{ \gamma^r R_F + (1 - \gamma^r)R_R \} \end{aligned} \quad (2.30)$$

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<sup>19</sup>See Proposition 1.

Comparing the bank's profit relative to the case of no insurance but tranching deposits, we obtain:

$$\begin{aligned}\pi_{DI}^l - \pi_T^l &= \gamma^r (R_R - R_F) - l\gamma^s R_C \\ &= l(\gamma^r - \gamma^s)R_C + \gamma^r l_f R_F > 0.\end{aligned}\quad (2.31)$$

Insurance allows banks to reduce their funding costs and is increasing in the liquidity premia,  $l$  and  $l_f$ , and the deposit insurance coverage  $\gamma^r$ .

### Least Cost banks

There may be banks with the lowest costs that choose total leverage,  $\gamma$ , satisfying  $\gamma^r \leq \gamma \leq \gamma_{DI,L}^m$ , where  $\gamma_{DI,L}^m(c_i)$  is a maximum level of total leverage that gives these least cost banks an incentive to exert high effort,  $a^h(c_i)$ . In other words, these very low cost banks limit their leverage, but this limited leverage is still above the deposit insurance limit. These banks would not default on their insured or uninsured deposits in the bad state, so that insurance only needs to cover the catastrophe state. Consequently, these banks would pay a reduced premium per insured deposit,  $\phi^h$ , in both good and bad states that satisfies:

$$\wp \phi^h \gamma^r R_F = (1 - \wp) \gamma^r R_F \quad (2.32)$$

This premium is equal to the simple ratio of the probability that the catastrophe occurs to the probability that it does not

$$\phi^h = \frac{1 - \wp}{\wp} = \frac{p_c}{1 - p_c}. \quad (2.33)$$

In the absence of deposit insurance, these high-effort banks paid  $R_D = R_C/\wp$  on all deposits in both the good and bad states. They continue to pay that amount on their currently uninsured deposits that equal  $\gamma - \gamma^r$ . However, on their  $\gamma^r$  of insured deposits they pay  $(1 + \phi^h)R_F = R_F/\wp$  in both the good and bad states. Hence, they obtain a per deposit savings of  $(R_C - R_F)/\wp$  on their insured deposits, which reflects the savings of the liquidity premium  $l_f R_F/\wp$ .

The lower promised payment on insured deposits allows these banks to increase their total leverage beyond the amount  $\gamma^m(c_i)$  which was their maximum in the absence of deposit insurance. Appendix A shows that their new maximum leverage under deposit insurance is

$$\begin{aligned}\gamma_{DI,L}^m &= \frac{p_b \gamma^r (R_C - R_F) / \wp + k(p_b d(a^h) - c_i a^h)}{p_b R_C / \wp - [p_b d(a^h) - c_i a^h]}, \\ &= \gamma^m + \gamma^r \frac{p_b [R_C - R_F] / \wp}{p_b R_C / \wp - [p_b d(a^h) - c_i a^h]}.\end{aligned}\quad (2.34)$$

With this higher leverage, the bank's profits are now

$$\pi_{DI,L}^h = (\gamma_{DI,L}^m + k)[p_g R_L + p_b d(a^h) - c_i a^h] - \gamma_{DI,L}^m R_C + \gamma^r (R_C - R_F).\quad (2.35)$$

Comparing the profit in equation (2.35) to that of no insurance case, we obtain

$$\pi_{DI,L}^h - \pi^h = (\gamma_{DI,L}^m - \gamma^m)(p_g R_L + p_b d(a^h) - c_i a^h - R_C) + \gamma^r (R_C - R_F) > 0\quad (2.36)$$

### Moderately-Low Cost Banks

There may be banks with moderately-low costs that choose total leverage,  $\gamma$ , satisfying  $\gamma \leq \gamma_{DI,M}^m \leq \gamma^r$ , where  $\gamma_{DI,M}^m(c_i)$  is the maximum total leverage that gives these moderately-low cost banks an incentive to exert high effort,  $a^h(c_i)$ . Hence, these banks maximize profits by limiting leverage to a level that is below the deposit insurance limit. Therefore they issue only insured deposits so that their expected cost of all of their deposits falls from  $R_C$  to  $R_F$ . The lower deposit rate and premium of  $R_F/\wp$  compared to  $R_C/\wp$  allows them to raise maximum leverage relative to the no deposit insurance case:

$$\gamma_{DI,M}^m = k \frac{p_b d(a^h) - c_i a^h}{c_i a^h + p_b [R_F/\wp - d(a^h)]} > \gamma^m(c_i).\quad (2.37)$$

One can see that  $\gamma_{DI,M}^m$  takes the exact same form as  $\gamma^m$  except that the smaller value  $R_F$  replaces  $R_C$  in the denominator, making it larger than  $\gamma^m$ .

Given this higher leverage, profits for these moderately-low cost banks are

$$\pi_{DI,M}^h = (\gamma_{DI,M}^m + k)[p_g R_L + p_b d(a^h) - c_i a^h] - \gamma_{DI,M}^m R_F, \quad (2.38)$$

which is, of course, greater than profits in the no-insurance case:

$$\pi_{DI,M}^h - \pi^h = (\gamma_{DI,M}^m - \gamma^m)[p_g R_L + p_b d(a^h) - c_i a^h - R_F] + \gamma^m l_f R_F > 0 \quad (2.39)$$

### 2.3.3 Cost Threshold for Effort under Deposit Insurance

The maximum leverage levels for moderately-low cost and least-cost banks are defined by being on either side of the insurance limit,  $\gamma^r$ ; that is  $\gamma_{DI,M}^m \leq \gamma^r \leq \gamma_{DI,L}^m$ . Since, by definition, moderately-low cost banks have higher screening costs than the least-cost banks, the cost threshold between high-effort and no effort is defined as  $c^{DI}$  that sets the profits associated with moderately-low cost banks under insurance equal to that of insured no-effort banks:

$$\pi_{DI,M}^h(c^{DI}) = \pi_{DI}^l(\gamma^r). \quad (2.40)$$

We can now state the following proposition:

**Proposition 3.** *If deposit insurance is sufficiently generous such that  $\gamma^r > \gamma^{r*}$ , then  $c^{DI} < c^T$ ; that is, more banks make no effort to monitor compared to the case of no deposit insurance. Moreover, in this case total leverage and lending is greater when deposits are insured.*

*Proof:* See Appendix A which also gives the value of  $\gamma^{r*}$  in equation (A.22).

An implication of this proposition is that while greater deposit insurance coverage creates more fully-safe assets, it comes at a cost of less efficient monitoring by the banking industry. Note that since  $c^T < c^*$ , sufficiently generous deposit insurance reduces bank effort relative to the no deposit insurance case whether or not banks tranche their deposits.

The second result of the proposition, namely that total leverage and lending is greater under deposit insurance, follows from two of our prior results. First, we showed that for any given level of monitoring cost, high effort least cost banks and high effort moderately-low cost banks choose higher leverage (and enjoy higher profits) under deposit insurance. Second, since no effort banks choose maximum leverage of  $\gamma = 1$  and there are more no effort banks under deposit insurance when  $\gamma^r > \gamma^{r*}$ , then leverage is always greater in equilibrium for any given bank's level of monitoring cost. Consequently, the greater deposit cost saving from sufficiently generous deposit insurance expands total lending, even though a greater proportion of banks lend inefficiently.

#### 2.3.4 The Maximum Level of Deposit Insurance

If the catastrophe state occurs, banks' assets equal zero and the deposit insurer's liability equals the total quantity of all insured deposits. Deposit insurance will be credible *ex ante* only if tax revenue can cover these catastrophic insurance claims. This is achieved by limiting insurance to small "retail" deposits so that the maximum promised end-of-period payment to insured depositors is  $\gamma^r R_F$  for each bank. However, we know that moderately-low cost banks do not insure up to the limit, and this fact needs to be accounted for when setting the maximum insurance level,  $\gamma^r$ , that in equilibrium is consistent with the deposit insurer's total liability being no greater than the government's taxing capacity.

Define the maximum liability of the deposit insurer per unit of initial savings as  $L(\gamma^r)$ . It must equal the government's taxing capacity per initial savings:

$$L(\gamma^r) = \bar{t}\omega. \quad (2.41)$$

It is assumed that the tax base  $\bar{t}\omega$  is large enough such the equilibrium value

of  $\gamma^r$  implies that no effort banks have no desire to tranche their deposits. In other words, as was assumed earlier  $\gamma^r R_F \geq \gamma^s R_C / \phi$ . Therefore, no effort banks' uninsured deposits will then equal  $1 - \gamma^r$ .

Banks with the lowest and highest monitoring costs will issue the maximum insured deposits, but banks with moderately-low monitoring costs will choose to restrict their leverage to  $\gamma_{DI,M}^m < \gamma^r$ . Let  $c^m$  be the cost threshold which sets  $\gamma_{DI,M}^m = \gamma^r$  and distinguishes a least cost bank from a moderately-low cost bank. The total liability of the insurer is

$$L(\gamma^r) = \int_{\underline{c}}^{c^m} \gamma^r R_F \cdot f(c_i) dc_i + \int_{c^m}^{c^{DI}} \gamma_{DI,M}^m(c_i) R_F \cdot f(c_i) dc_i + \int_{c^{DI}}^{\bar{c}} \gamma^r R_F \cdot f(c_i) dc_i, \quad (2.42)$$

or, if we assume a uniform distribution for  $c_i \in (\underline{c}, \bar{c})$ ,

$$L(\gamma^r) = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{c^m}^{c^{DI}} \gamma_{DI,M}^m(c_i) dc_i + \gamma^r (c^m - \underline{c} + \bar{c} - c^{DI}) \right] R_F. \quad (2.43)$$

Equating the right-hand sides of equations (2.42) and (2.41) and using equation (2.40) determines the equilibrium values of  $c^{DI}$  and  $\gamma^r$ . Appendix A.2 sets out the strategy for computing the solution.

### 2.3.5 Aggregate Liquidity under Deposit Insurance

Government deposit insurance provides catastrophe-proof, safe assets. Least cost banks and no-effort banks both insure up to the limit,  $\gamma^r$ . Moderately-low cost banks issue only  $\gamma_{DI,M}^m(c_i) < \gamma^r$  insured deposits. Together, safe assets are produced in quantity  $S_{DI}^f$ ,

$$S_{DI}^f = \gamma^r \int_{\underline{c}}^{c^m} f(c_i) dc_i + \int_{c^m}^{c^{DI}} \gamma_{DI,M}^m(c_i) f(c_i) dc_i + \gamma^r \int_{c^{DI}}^{\bar{c}} f(c_i) dc_i \quad (2.44)$$

or, if costs are distributed uniform,

$$S_{DI}^f = \frac{1}{\bar{c} - \underline{c}} \left[ \gamma^r (c^m - \underline{c}) + \int_{c^m}^{c^{DI}} \gamma_{DI,M}^m(c_i) dc_i + \gamma^r (\bar{c} - c^{DI}) \right]. \quad (2.45)$$

The quantity of ‘quasi-safe’ assets,  $S_{DI}^c$ , produced by least-cost banks is

$$S_{DI}^c = \int_{\underline{c}}^{c^m} (\gamma_{DI,L}^m(c_i) - \gamma^r) f(c_i) dc_i, \quad (2.46)$$

or with uniform costs,

$$S_{DI}^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^m} \gamma_{DI,L}^m(c_i) dc_i - \gamma^r (c^m - \underline{c}) \right]. \quad (2.47)$$

Having analyzed deposit insurance, the next section considers an alternative means by which governments can create safe assets.

## 2.4 Liquidity Creation with Government Debt and Narrow Banking

Instead of providing deposit insurance, suppose the government utilizes its taxing authority to offer default-free Treasury securities that pay the fully risk-free return per unit investment of  $R_F$ . Treasury securities could be sold directly to savers, but to enhance their liquidity it might be more realistic to think that these securities are sold to financial institutions that use them to back deposit-like accounts. We refer to these institutions as “narrow banks.” Narrow banks are assumed to have a mutual fund structure, hold only Treasury securities as assets, and issue accounts that are proportional ownership interests in the securities. In other words, they operate exactly like actual “Treasury-only” money market mutual funds.

These narrow banks are assumed to be uniformly distributed across the economy’s banking markets. Since, by law, they must hold only government securities, the maximum amount of deposits that they can issue per unit savings is

$$\gamma^n = \frac{\bar{t}\omega}{R_F} \quad (2.48)$$

where the parametric condition  $\bar{t}\omega < R_F$  is assumed, so that  $\gamma^n < 1$ . We assume that each narrow bank in each market issues the maximum amount of

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deposit accounts,  $\gamma^n$ , because savers have a (slight) preference for completely-safe assets, even at the lower required return of  $R_F$ .

Since each banking market continues to have a banker capable of making loans, uninsured “broad” banks still operate in each market. We assume that these broad banks operate similarly to the private banks of our baseline model analyzed in Section 2. In particular, it is assumed that they are permitted to tranche their deposits. Now the amount of deposits that these broad banks can raise from savers depends critically on what the government is assumed to do with the revenue that it receives from selling its Treasury securities to narrow banks.

One possibility is to assume that the revenue raised per unit savings in each market,  $\gamma^n$ , is invested by the government in the publicly-available risky investment technology which returns  $R_R/p_g$  per unit investment in the good state. When the good state occurs, the government returns the amount  $\gamma^n R_R/p_g$  in a lump sum to savers at the end of the period. Under this assumption, the maximum amount of deposits per market that is available to fund broad banks would be  $1 - \gamma^n$ . We refer to this assumption as the ‘Government Investment’ assumption.

Another possibility is to assume that the government’s revenue from Treasury sales,  $\gamma^n$ , is instantly rebated in a lump sum to savers at the beginning of the period. Under this assumption, the deposits issued by narrow banks have no net effect on each market’s savings that can be tapped by broad banks. Consequently, the maximum amount of deposits available to broad banks is 1.<sup>20</sup> We refer to this assumption as the ‘Government Rebate’ assumption.

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<sup>20</sup>An equivalent assumption is that the government does not rebate the revenue to savers but offers to deposit it in broad banks. In markets where broad banks choose deposits of  $\gamma < 1$ , then the government invests its residual revenue in the risky investment technology. Any deposit and investment returns received by the government at the end of the period is returned to savers in a lump sum.

The next section considers the equilibrium under the Government Investment assumption. Following that, we discuss the equilibrium under the Government Rebate assumption.

### 2.4.1 Equilibrium with Narrow Banks and Government Investment

With a government investing its Treasury revenue in the risky technology, the maximum amount of savings that an uninsured broad bank can attract for deposits is  $\gamma^d \equiv 1 - \gamma^n < 1$  rather than  $\gamma = 1$ . So one sees that the effect of narrow banks taking market share is to limit the leverage of broad banks. This market-induced leverage limit changes the incentives for expending effort by broad banks because profits in the no-effort case are less. With tranching permitted, the analysis is similar to that in Section 2.1. Only no effort banks have an incentive to tranche their deposits. They issue ‘quasi-safe’ deposits at rate  $R_C/\wp$  up to the reduced limit  $\gamma_{NB}^s = \frac{(\gamma^d+k)R_L(1-\alpha)}{R_C/\wp}$ . Their profits are

$$\begin{aligned} \pi_{NB}^l &= p_g \left[ (\gamma^d + k)R_L - \gamma_{NB}^s R_C/\wp - (\gamma^d - \gamma_{NB}^s)R_R/p_g \right] \\ &= (\gamma^d + k) [p_g R_L + p_b R_L(1 - \alpha)] - \gamma_{NB}^s R_C - (\gamma^d - \gamma_{NB}^s)R_R \\ &= (\gamma^d + k) [p_g R_L + (\wp(1 + l) - p_g) R_L(1 - \alpha)] - \gamma^d R_R < \pi_T^l. \end{aligned} \quad (2.49)$$

High effort banks limit leverage to the same level,  $\gamma^m(c_i) = k \frac{p_b d(a^h) - c_i a^h}{R_C/\wp - (p_b d(a^h) - c_i a^h)}$  as before unless  $\gamma^m(c_i) > \gamma^d$ , in which case they choose  $\gamma^d$ .

#### Threshold for Effort under Government Investment

Define  $\pi^h(c_i)$  as the high effort profit of banker  $i$  given in equation (2.10) when  $\gamma_i = \min[\gamma^m(c_i), \gamma^d]$ . Then assuming  $\pi^h(\bar{c}) < \pi_{NB}^l$ , we can define the critical value of  $c$  such that a given bank’s profits are equal when it provides high versus no effort. Profits at this critical value,  $c^n$ , satisfy  $\pi^h(c^n) = \pi_{NB}^l$ . It can be written as

$$c^n = \frac{\pi_{NB}^l p_b (R_L - R_C/\wp)}{(\frac{1}{\beta} + a^h(c^n))(\pi_{NB}^l - p_g k R_C/\wp)} \quad (2.50)$$

Suppose that the model parameters are such that  $\gamma^m(c^n) \leq \gamma^d$  so that the bank which is indifferent between high effort and no effort limits its leverage under high effort to less than  $\gamma^d$ . Since  $\pi_{NB}^l < \pi_T^l$ , then based on the same logic as in Proposition 2, we have  $c^n > c^T$ . In other words, a greater proportion of broad banks choose high effort compared to the proportion choosing high effort under tranching with no deposit insurance.

### Liquidity Provision under Government Investment

Fully safe deposits are now produced only by narrow banks. Since they are limited by the government's taxing authority, the maximum that can be produced is

$$S_{NB}^f = \gamma^n. \quad (2.51)$$

Note that, in aggregate, the maximum fully-safe deposits that can be produced under narrow banking is exactly the same as under deposit insurance. This is because under deposit insurance, the government needs to have enough taxes to pay off the entire amount of insured deposits in the catastrophe state. Similarly under narrow banking, the government requires enough taxes to pay off narrow banks in all states. In both cases the government's tax capacity,  $\bar{\omega}$ , limits the maximum level of fully-safe deposits.

However, quasi-safe asset production differs under narrow banking and deposit insurance. Under narrow banking, one source of quasi-safe deposits comes from high-effort broad banks which provide

$$\int_{\underline{c}}^{c^n} \min[\gamma^m(c_i), \gamma^d] f(c_i) dc_i. \quad (2.52)$$

The second source is the senior deposits of no-effort banks who add

$$\gamma_{NB}^s \int_{c^n}^{\bar{c}} f(c_i) dc_i. \quad (2.53)$$

Together, total quasi-safe deposits equal

$$S_{NB}^c = \int_{\underline{c}}^{c^n} \min[\gamma^m(c_i), \gamma^d] f(c_i) dc_i + \gamma_{NB}^s \int_{c^n}^{\bar{c}} f(c_i) dc_i. \quad (2.54)$$

If a uniform distribution of costs is assumed, we have

$$S_{NB}^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^n} \min[\gamma^m(c_i), \gamma^d] dc_i + \gamma_{NB}^s (\bar{c} - c^n) \right]. \quad (2.55)$$

Recall that under deposit insurance only least cost banks produce quasi-safe deposits, given by  $S_{DI}^c$  in equation (2.46). Moreover, under some parametric assumptions least cost banks do not exist and only moderately-low cost banks exert first-best effort. Consequently, it is highly likely that quasi-safe deposits are greater under narrow banking with Government Investment compared to deposit insurance. As a result, total liquidity creation is also greater.

## 2.4.2 Equilibrium with Narrow Banks and Government

### Rebate

If a government's beginning-of-period proceeds from Treasury sales are instantly rebated to savers, the constraint on the amount of deposits raised by broad banks is  $\gamma \leq 1$ . Therefore, *the equilibrium for broad banks is exactly the same as the fully-private banking system analyzed in Section 2*. Thus, all of the results from that section apply to broad banks, but now the banking system produces the maximum amount of fully-safe deposits issued by narrow banks.

Comparing this narrow bank with Government Rebate system to the deposit insurance system analyzed in Section 3, we can immediately draw the following conclusions. First, the amount of fully-safe deposits are exactly the same under the two systems, since they are limited by the same government constraint on tax capacity. Second, quasi-safe deposits are unambiguously greater under narrow banking relative to deposit insurance. This follows because under deposit insurance only high-effort least cost banks produce quasi-safe deposits. Under narrow banking, quasi-safe deposits of broad banks comprise the tranching senior deposits of no effort banks and the total deposits of

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all high effort banks. Consequently, total public and private liquidity creation is greater under narrow banking versus deposit insurance.

Third, when deposit insurance is sufficiently generous such that  $\gamma^r > \gamma^{r*}$ , then a higher proportion of broad banks exert effort and lend efficiently compared to banks with deposit insurance. This result follows from Proposition 3 which compares deposit insurance to an uninsured banking system, which now applies to broad banks. A fourth conclusion also follows from Proposition 3: a system with sufficiently generous deposit insurance leads to greater leverage and total lending compared to a system of narrow and bank broad banks.

Why does a system of narrow banking with a government rebate produce the same amount of fully-safe deposits as under a system of deposit insurance but far more quasi-safe deposits? The intuition is as follows. In terms of liquidity creation, a government's power to tax allows it to create assets that are fully default-free in all future states, even the catastrophe state. Banks, on the other hand, can create quasi-safe assets that are default-free in all states except for the catastrophe state. By insuring a bank's deposits, a government starts with a financial structure that is already capable of producing quasi-safe assets and adds safety in only one additional state, the catastrophe state. Hence, the government's special ability to create safety via taxation adds a small margin of additional safety to deposits that are already quasi-safe.

This mechanism for creating fully-safe assets is inefficient relative to narrow banking with a government rebate. By issuing Treasuries purchased by narrow banks, a government creates fully-default free deposits from scratch. By not layering on already existing banks, the government does not extinguish the existing quasi-safe deposits produced by the private banking system. If there is, indeed, value to quasi-safe deposits, the system with narrow banking and a government rebate generates is more efficient in expanding total liquidity.

## 2.5 Numerical Illustrations

This section provides numerical comparisons of aggregate welfare measures for the three previously-discussed government regimes: deposit insurance, narrow banks with government investment, and narrow banks with government rebates.

### 2.5.1 Welfare Measures

We assume that banks are able to tranche deposits and that the density of bank monitoring costs is distributed uniform. Using the fully-private banking system as a baseline, we consider the following measures of social welfare, set out explicitly in appendix A.3.

1. Quasi-safe deposit production and its aggregate surplus.
2. Total bank loans and the surplus from financing projects.
3. Total monitoring effort exerted by banks.
4. Bank profits.

The surplus from issuing quasi-safe deposits for regime  $r$  is equal to the quantity produced multiplied by their liquidity premium,  $(R_R - R_C) = lR_C$ :

$$Surplus_r^S = (R_R - R_C)S_r^c. \quad (2.56)$$

Loan surplus is defined as the expected loan revenue less the costs of monitoring and funding at  $R_R$ . That is, a bank with monitoring cost, effort and total leverage  $\{c_i, a_i, \gamma_i\}$  has surplus equal to  $(\gamma_i + k)[p_g R_L + p_b d(a_i) - c_i a_i] - \gamma_i R_R$ . In the fully-private bank system, this is simply equal to aggregate profits,  $\Pi_T$ , less the reduction in funding costs due to the liquidity premium from issuing quasi-safe deposits:

$$Surplus_T^L = \Pi_T - Surplus_T^S. \quad (2.57)$$

This is also the loan surplus for the case of narrow banking with a government rebate since broad banks operate the same as banks in the fully-private system. For the case of narrow banking with government investment, loan surplus is

$$Surplus_{NB,I}^L = \Pi_{NB,I} - Surplus_{NB,I}^S. \quad (2.58)$$

Under deposit insurance, some loans are funded by fully-safe deposits that generate extra surplus for banks

$$Surplus_{DI}^L = \Pi_{DI} - Surplus_{DI}^S - (R_R - R_F)S_{DI}^f. \quad (2.59)$$

Note that deposit insurance and narrow banking produce equal amounts of safe deposits, so there is no need for comparing this aggregate welfare measure.

### 2.5.2 Calibration

Table 2.1 reports the benchmark parameter values used in our illustrations. We set the fully-safe return at 1.02, the expected quasi-safe return at 1.03, and the expected risky return at 1.04. These rates imply a liquidity premium of 100 basis points for each increase in safety. The promised loan return is assumed to be 1.10, and the probabilities of the good, bad, and catastrophe states are 90%, 9%, and 1%, respectively. The amount of banker capital per unit of market savings,  $k$ , is set at 10%. The recovery rate with no effort is assumed to be 50%, implying a value of  $\alpha = 0.5$ . The coefficient on bank effort,  $\beta$ , is set to 1. The maximum tax rate  $\bar{t}$  equals 40% of end-of-period endowment of  $\omega = 1.5$ .<sup>21</sup>

<sup>21</sup>The choice of taxation is made to arrive at reasonable values of maximum insured deposits,  $\gamma^r$ . Note that FDIC data from 2017 Quarter 3 imply a ratio of insured domestic U.S. deposits to total bank debt of 0.78.

Table 2.1: Parameter Values

Parameter		Value
Risk-free return	$R_F$	1.02
Safe liquidity premium	$l$	0.01
Quasi-safe liquidity premium	$l_f$	0.01
Promised loan return	$R_L$	1.10
Probability of good state	$p_g$	0.90
Probability of bad state	$p_b$	0.09
Bank capital per savings	$k$	0.10
Loan loss parameter	$\alpha$	0.50
Monitoring effort parameter	$\beta$	1.00
Tax limit	$\bar{t}$	0.40
Endowment	$\omega$	1.50

Table 2.2 reports particular deposit limits implied by the parameters in Table 1. The maximum level of insured deposits,  $\gamma^r$ , is 0.63 and the maximum level of deposits available to broad banks under narrow banking with government investment,  $\gamma^d$ , is 0.41. Recall that under government investment, narrow banks' deposits 'crowd out' the deposits available to broad banks. Narrow banking with a government rebate avoids this problem. The proportion of banks exerting high effort under the regime of narrow banking with government rebate is 0.49. In addition, Proposition 3 holds for these parameter values, so that under deposit insurance a smaller 0.35 proportion of banks exert high effort.<sup>22</sup> Narrow banking with government investment has the largest proportion of (broad) banks exerting high effort, 0.73. This occurs because less deposit availability makes choosing the highest leverage and no effort less profitable.

Table 2.2: Implied Deposit Limits and Effort Levels

Parameter		Deposit Insurance	Narrow Banking with Investment	Narrow Banking with Rebate
Tax-limit on leverage	$\gamma^r, \gamma^d$	0.63	0.41	1.00
Proportion of high effort banks	$\frac{c^*}{\bar{c}-c}$	0.35	0.73	0.49

<sup>22</sup>The restriction on insurance,  $\gamma^r = 0.63$  is greater than the threshold,  $\gamma^{r*} = 0.39$ .

Figure 2.1 illustrates the structure of the banking system under each regime.<sup>23</sup> Banks with relatively low monitoring costs,  $c_i$ , find it optimal to exert high effort and have profits shown in black. Banks with relatively high monitoring costs exert no effort, with profits in red. Under deposit insurance, for this baseline calibration, only moderately-low cost banks exist. Their profits are illustrated by the dashed black line.

Note that no effort banks profit the most under deposit insurance because the fully-safe liquidity premium makes their cost of deposit funding the least. No effort broad banks under the narrow bank system with government investment make the least profit because their leverage,  $1 - \gamma^n$ , is less due to crowding out from narrow banks.

Figure 2.1: Individual Bank Profits Under Each Regime.

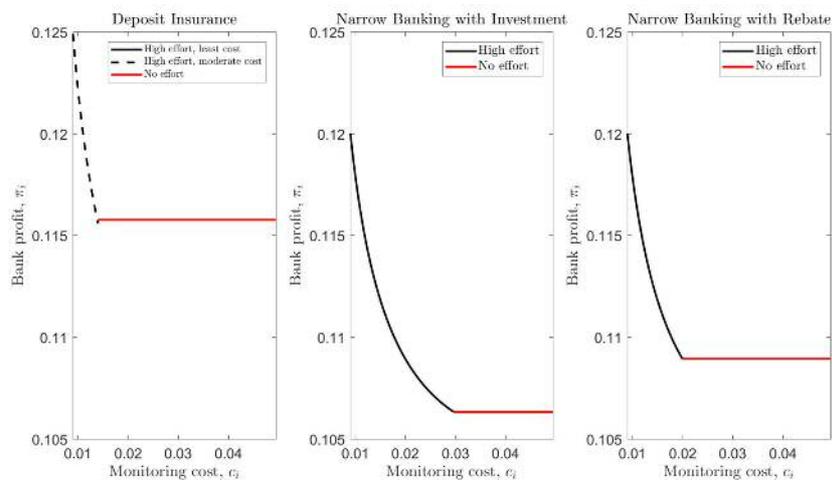


Table 2.3 compares various measures of welfare under the three government regimes. These measures are averages per loan-making bank. As discussed earlier, for this calibration the only high effort banks that exist under deposit

<sup>23</sup>Of course for narrow banking systems, these graphs refer to only broad banks. Narrow banks extend no loans and issue no quasi-safe deposits. They issue fully-safe deposits (or money market mutual fund shares) and invest in Treasury debt, making zero profit.

insurance are those with moderately-low costs. Since only least cost banks would issue quasi-safe deposits, there are no quasi-safe deposits under this deposit insurance regime. Under narrow banking regimes, quasi-safe deposits are issued by broad banks, and since there is more deposit availability under narrow banking with a government rebate, this regime produces the most.

Due to the low cost of insured deposits and less incentives to limit leverage, the table also shows that insured banks make the most loans. Among narrow bank regimes, broad banks make more loans when there is a government rebate due to the greater availability of deposits. One also sees that monitoring effort is highest under narrow banking with government investment. Yet with a rebate, effort is still substantially higher than under deposit insurance. The last line of Table 2.3 aggregates the bank profits that were illustrated in Figure 2.1 and shows that average bank profits are greatest under deposit insurance.

Table 2.3: Welfare Comparisons

Measure of Social Welfare		Deposit Insurance	Narrow Banking with Investment	Narrow Banking with Rebate
Quasi-safe deposits	$S^c$	0.000	0.241	0.494
Liquidity surplus	$Surplus^S$	0.000	0.002	0.005
Loans	$L$	1.016	0.699	0.900
Loan surplus	$Surplus^L$	0.128	0.111	0.115
Monitoring effort	$A$	0.182	0.506	0.340
Profit per bank	$\Pi$	0.116	0.108	0.110

### 2.5.3 Comparative Statics

This section considers how the aggregate production of quasi-safe deposits, loans, and bank profits are affected by variation in key parameters. We begin by adjusting the liquidity premium on quasi-safe deposits which allows banks to fund loans at less than the expected return  $R_R$ , which is held constant. In Figure 2.2 the premium on quasi-safe deposits,  $l$ , varies by plus or minus 100

basis points while holding the premium on fully-safe deposits,  $l_f$ , constant. Equivalently,  $R_C$  changes while changing  $R_F$  by the same amount.<sup>24</sup> The results show that increasing the quasi-safe liquidity premium leads broad banks to issue more quasi-safe deposits and more loans. Profits rise, but the proportion of high-effort banks falls. Apparently, the higher liquidity premium gives a relative advantage to high leverage and tranching of deposits, rather than high effort. Under deposit insurance, insured banks issue no quasi-safe deposits but the reduction in  $R_F$  leads to greater profits and slightly less high effort banks.

Figure 2.2: Varying the Quasi-safe Liquidity Premium,  $l$ , Holding  $l_f$  Constant

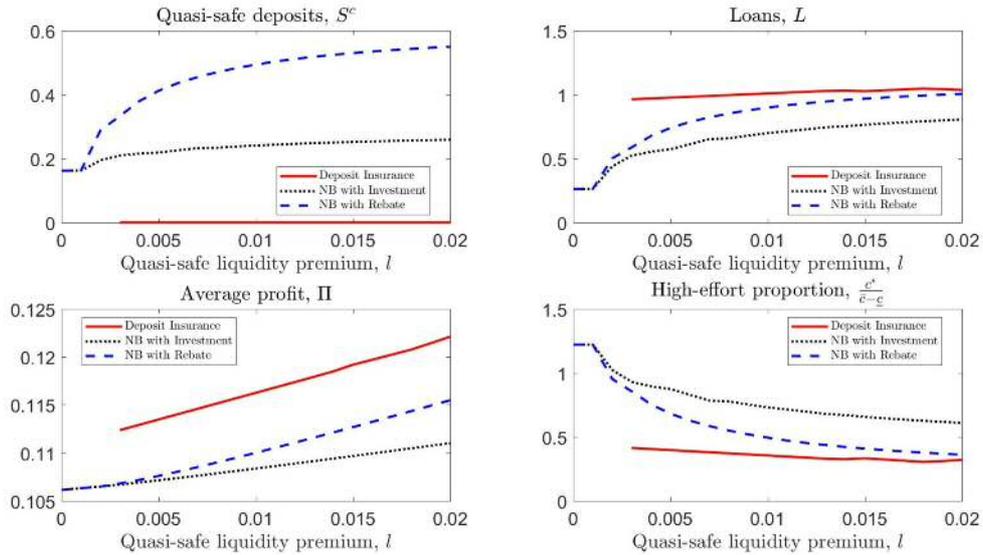


Figure 2.3 demonstrates that an increase in banker capital,  $k$ , raises average bank profits and the proportion of high effort banks in all three regimes.<sup>25</sup> However, broad banks' quasi-safe deposit and loan production is not monotonic in capital. Ceteris paribus, more capital increases total assets available

<sup>24</sup>The results are very similar if we vary  $R_C$  while holding  $R_F$  constant.

<sup>25</sup>Due to the restriction that  $\gamma^r > \gamma^s$ , there are no solutions for deposit insurance when capital is higher than 15%.

to banks, but as greater capital makes high effort relatively more attractive, a greater proportion of banks limit their leverage such that quasi-safe deposit and loan production can decline.

Figure 2.3: Varying Bank Capital,  $k$

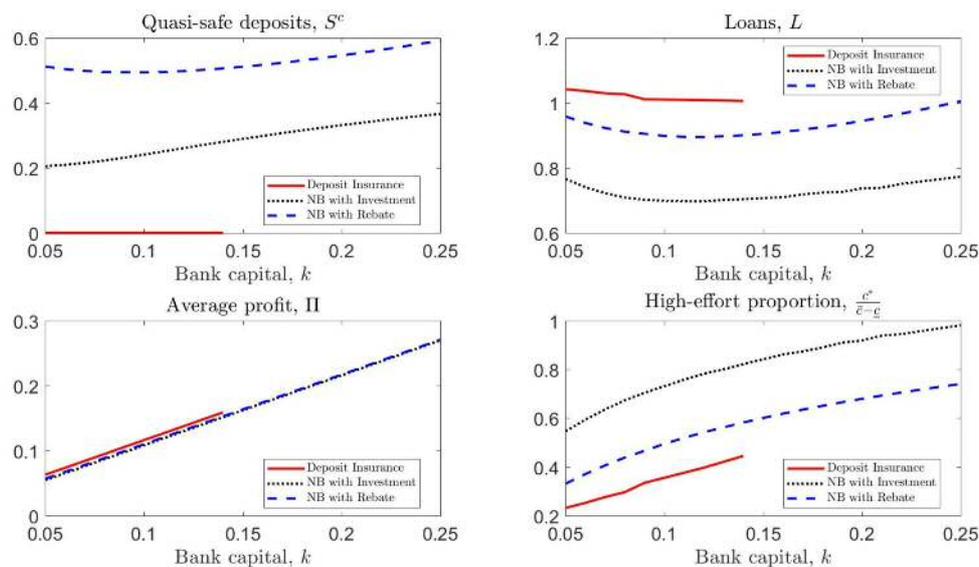
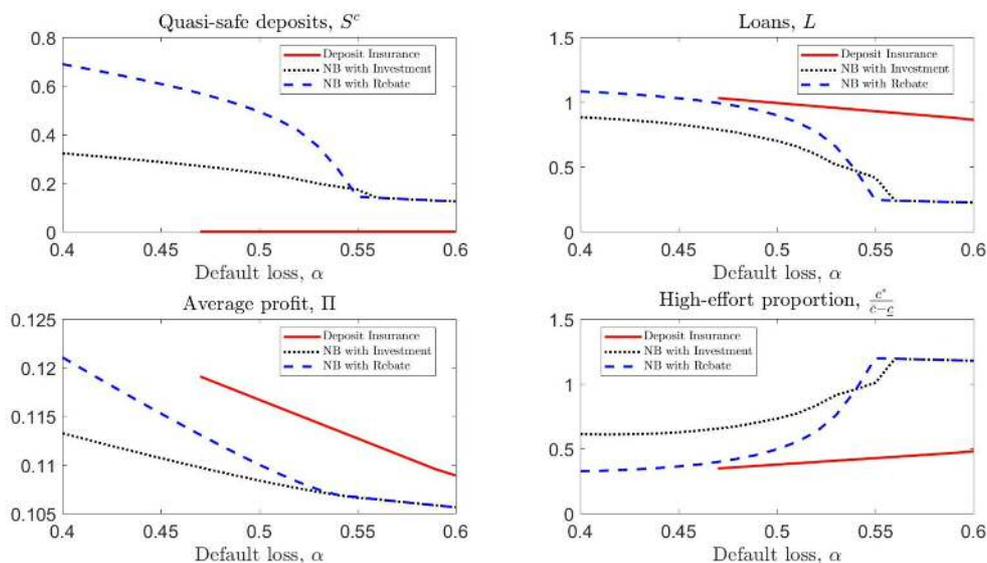


Figure 2.4 shows that increasing the loss rate reduces profits and increases the relative benefit of high effort monitoring.<sup>26</sup> Since collateral for senior tranching deposits of no effort broad banks declines and more broad banks limit leverage, the result is that quasi-safe deposits and loans decline.

<sup>26</sup>Note that for values of  $\alpha$  exceeding 0.55, all broad banks find it optimal to exert high effort; that is,  $c^h = \bar{c}$ .

Figure 2.4: Varying the Default Loss Rate,  $\alpha$ 

## 2.6 Robustness of the Model's Results

This section discusses the robustness of our results to reasonable changes in the model's assumptions. One stark assumption is that bank loans are worthless in the catastrophe state. Instead, one might expect that loans have a positive minimum recovery value, even if a catastrophe occurs. If that were the case, then our model with zero recovery over-estimates a government's deposit insurance losses. Thus, for a given tax capacity, a government could create more fully-safe deposits under deposit insurance if there was a positive recovery value in the catastrophe state.

However, if there was a strictly positive minimum recovery value to bank loans, then even uninsured broad banks could issue some fully-safe deposits. They could do so by tranching deposits, where the most senior, fully-safe deposits would be limited to the minimum recovery value of the bank's loans. As a result, when the maximum fully safe deposits of narrow banks and broad

banks are combined, they would equal the same amount of fully-safe deposits created by a deposit insurance system. Therefore, assuming a positive minimum recovery value does overturn the result that the amount of fully-safe deposits is independent of the government regime.

In our model's system of narrow banking, broad banks produce quasi-safe deposits which, in aggregate, exceed the amount of quasi-safe deposits that are produced by a system of government deposit insurance. Under government deposit insurance, only least cost, high effort banks produce quasi-safe deposits. As discussed earlier, the low production of quasi-safe deposits occurs because government deposit insurance crowds out what would have been quasi-safe deposits in the absence of deposit insurance. However, in principle one might imagine a slightly different system where a government offers two types of deposit insurance: fully-safe and quasi-safe. In this case, more quasi-safe assets could be produced under government deposit insurance.

Such a system would work as follows. As in our model, a government provides a similar level of fully-safe deposit insurance limited to some level  $\gamma^r$ . In addition, it would offer supplemental, quasi-safe deposit insurance that covers losses in all states except the catastrophe state. A government is able to offer such supplemental quasi-safe insurance because banks' positive recovery value in the bad state provides unused taxing capacity relative to the catastrophe state where there is zero recovery. This bad state taxing capacity would allow for limited, supplemental quasi-safe deposit insurance. While such a system could replace some risky, uninsured deposits with quasi-safe insured deposits, it might be implausible to think that a government would offer two classes of insurance where for one class it fails to provide protection for some depositors in some states. Hence, it is not clear that this two-class deposit insurance system would be politically feasible and that it should be taken seriously.

A related issue is whether quasi-safe deposits are truly a social good. Our analysis implicitly assumed that the greater private liquidity under narrow banking compared to government deposit insurance was a net social benefit. However, in richer models that incorporate additional frictions, a competitive private banking system might inefficiently over-issue quasi-safe deposits Gersbach (1998), creating negative externalities such as firesale costs when a crisis occurs Stein (2012). When deposits are not fully-safe, coordination failures can lead to inefficient bank run equilibria as in Diamond and Dybvig (1983) and Goldstein and Pauzner (2005).

While our model neglects these adverse consequences of quasi-safe deposits, it also does not account for potential costs of government liquidity. It was assumed that a government always respects its limit on tax capacity so that its debt and bank deposit guarantees are fully safe. But as Reinhart and Rogoff (2009) documents, history provides numerous examples of government defaults. Even without default, government liquidity in the form of deposit insurance may create inefficiencies due to bank risk-shifting.<sup>27</sup> Mitigating this moral hazard may require costly bank regulation. So while we acknowledge that our model misses potential costs of private liquidity, it also neglects other costs of government liquidity. A more complete modeling of these costs is needed to provide a definitive answer to the question of how governments should create liquidity.

## 2.7 Conclusions

This paper considers constraints on a financial system's liquidity. The amount of liquid deposits that can be created by private, uninsured banks is limited by their assets' recovery values in bad states of nature. Recovery values can

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<sup>27</sup>Our model assumes deposit insurance is risk-sensitive and fairly priced. In practice, deposit insurance tends to be risk-insensitive and under-priced, which can worsen risk-shifting incentives.

be enhanced by a bank limiting its leverage, thereby instilling incentives to efficiently monitor borrowers. Alternatively, banks can maximize leverage and not monitor borrowers but create liquid senior deposits using the extra collateral provided by junior deposits (subordinated debt).

The amount of liquidity provided by a government is limited by its future taxing capacity since ultimately taxes are needed to cover a government's liabilities. Importantly, the method that a government uses to create its liquid assets has consequences for private liquidity creation. Government liquidity created via bank deposit insurance crowds out private liquidity. It also reduces bank monitoring incentives but maximizes bank lending due to the government liquidity premium that minimizes banks' cost of funding.

In contrast, a system by which governments create liquidity by issuing debt held by narrow banks allows narrow banks to create public liquidity while uninsured broad banks create private liquidity. Such a system avoids the crowding out of private liquidity while maintaining broad banks' incentives to monitor borrowers. Yet since broad banks' cost of funding is higher, they do not match the quantity of lending made by government-insured banks.

## Chapter 3

# Banks as Potentially Crooked Secret-Keepers

*Bank failures are generally liquidity as well as solvency events. Whether it is households running on banks or banks running on banks, defunding episodes are full of drama. This theater has, arguably, lured economists into placing liquidity at the epicenter of financial collapse. But loss of liquidity describes how banks fail. Bad news about banks explains why they fail. This paper models banking crises as triggered by news that the degree (share) of banking malfeasance is likely to be particularly high. The malfeasance share follows a state-dependent Markov process. When this period's share is high, agents rationally raise their probability that next period's share will be high as well. Whether or not this proves true, agents invest less in banks, reducing intermediation and output. Deposit insurance prevents such defunding and stabilizes the economy. But it sustains bad banking, lowering welfare. Private monitoring helps, but is no panacea. It partially limits banking malfeasance. But it does so inefficiently as households needlessly replicate each others' costly information acquisition. Moreover,*

*if private audits become public, private monitoring breaks down due to free-riding. Government real-time disclosure of banking malfeasance mitigates, if not eliminates, this public goods problem leading to potentially large gains in both non-stolen output and welfare.*

### **3.1 Introduction**

Banks (our name for financial institutions, broadly defined) have traditionally been modeled as honest entities satisfying liquidity needs via issuance of demand deposits and other short-term liabilities (Gorton and Pennacchi (1990)). Banking crises have been viewed as runs motivated by the fear that others will appropriate one's money (Diamond and Dybvig (1983) and Goldstein and Pauzner (2005)). But deposit insurance has largely eliminated concern about transaction balances. Indeed, the financial crisis of 2007-2008 saw essentially no traditional commercial bank runs (Financial Crisis Inquiry Commission (2011)) by non-institutional investors.<sup>1</sup> Instead, as Covitz, Liang, and Suarez (2013) and others document, banks stopped funding one another based on perceptions, some true, some false, that financial institutions had gone bad. The serial collapse of large, highly opaque banks raised concern about the defunding of surviving, but equally opaque, banks. Attempts to pay creditors led to fire sales of "troubled" assets. This fed the defunding panic, producing more implicit and explicit failures. Overnight, bank secret-keeping, which left potential refunders in the dark about each-other's true solvency, went from a sign of collective trust to one of financial distress, if not financial fraud.

Bankruptcies, financial or not, are typically liquidity as well as solvency

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<sup>1</sup>The Northern Rock run was quickly ended by the extension of deposit insurance by the Bank of England. Similarly, the U.S. Treasury stopped the run on money market funds by backing their bucks.

events.<sup>2</sup> The 29 global financial institutions that failed, either explicitly or implicitly, during the Great Recession, all lost or were about to lose external funding in the run up to their demises. The drama of financial firms running short of cash – J.P. Morgan’s dramatic 2007 rescue of Wall Street, the serial collapse of 9,000 commercial-banks in the Great Depression, California’s shocking seizure of Executive Life, the panicked resolution of Long Term Capital Management, the Fed’s emergency weekend meetings that “saved” Bear Sterns and let Lehman Brothers collapse, the remarkable nationalizations of Fannie Mae, Freddie Mac and AIG, the last minute passage of the Trouble Asset Relief Program, the urgent IMF-ECB bailout of Cypriot banks, etc. – naturally focuses attention on banks’ death throes. Yet, how banks fail does not tell us *why* banks fail. Short of pure coordination failure (switching spontaneously to a bad equilibrium), bank failures are triggered by bad news. Historically, this has been bad news about bad banking, where “bad” includes fraudulent, irresponsible, negligent, and incompetent behavior. The ability of runs to weed out bad banks is interfered by the provision of deposit insurance Kaufman (1987).

Actual or suspected malfeasance has instigated many, perhaps most financial crises. In 1720, insider trading and fraudulent misrepresentation led to collapses of both the South Sea and Mississippi bubbles. The attempted cornering of the U.S. bond market kindled the Panic of 1792. The embezzlement of assets from the Ohio Life and Trust Co. instigated the Railroad Crisis of 1857 (Gibbons (1907)). Jay Gould and James Fisk’s cornering of the gold market precipitated the 1869 Gold Panic. Cooke and Company’s failure to disclose losses on Northern Pacific Railroad stock sparked the Panic of 1873. A failed cornering of United Cooper’s stocks instigated the Panic of 1907. The Hatry Group’s use of fraudulent collateral to buy United Steel, the sale of Florida swamp land, the Match King Hoax, the Samuel Insull fraud and the

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<sup>2</sup>Illiquidity can, if sufficiently severe, trigger insolvency.

disclosure of other swindles ushered in the Great Depression.<sup>3</sup> Insider trading and stock manipulation brought down Drexel Burnham Lambert, precipitating the largest insurance failure in U.S. history. And revelation of liar loans, no-doc loans, and NINJA loans laid the groundwork for the demise of major U.S. and foreign financial firms and the Great Recession.<sup>4</sup>

This paper focuses on why banks fail. The reason considered is malfeasance. We treat *intermediation*, not liquidity provision via maturity transformation, as the *raison d'être* for banks, and the loss of intermediation services, not the loss of liquidity or maturity transformation, as the economic essence of a financial crisis. Our demurral on liquidity and maturity transformation seems justified by theory and fact. As shown by Jacklin (1983, 1986, 1989) and Jacklin and Bhattacharya (1988), bank's heralded role as maturity transformers can be either fully or largely replicated by financial markets alone.<sup>5</sup> But unlike banks, when financial markets transform maturity, they do so without risk of financial panic, which destroys the very liquidity banks are said to provide.<sup>6</sup> There is also scant evidence that banks are effective in transforming maturities.

Our framework is simple – a two-period OLG model with two sectors – farming and banking. Both sectors produce an identical good, corn. Farming is small scale and done by sole proprietors. The banking sector gathers resources from multiple investors and engages in large-scale and more efficient farming. Production in farming is certain. Production in banking is uncertain due to banker malfeasance. Specifically, each period every bank has an identical but random share of dishonest, negligent or incompetent bankers, labeled

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<sup>3</sup>See Pecora Commission (1934).

<sup>4</sup>See Financial Crisis Inquiry Commission (2011).

<sup>5</sup>We include mutual funds, which Jacklin calls “equity deposits”, as a financial-market instrument.

<sup>6</sup>Ironically, banks are heralded for providing liquidity, yet have, historically, precipitated its loss precisely at times when it is of most value.

bad bankers, in their employ. These bankers steal or lose all output arising from investments placed with them.<sup>7</sup> Consequently, if 20 percent of bankers are bad, the banking industry will produce 20 percent less output. An equivalent interpretation of our model is that a share of banks is fully malfeasant. I.e. these bank steal or lose all output from investments and arise in the same proportion as our posited share of bad bankers. In what follows, we reference “the share of bad bankers.” But one can substitute these words, “the share of bank output lost due to bad banks.”

The share of bad bankers obeys a state-dependent Markov process. On average, the share is low enough and banking is productive enough for banking to generate a higher expected return than farming and, thereby, attract considerable investment. But when a larger than expected number of bad bankers surfaces, the projected future share of bad bankers rises. This causes investors to shift out of banking, potentially abruptly, until sufficient time has passed to lower the expected share of malfeasant bankers. This process produces not just periodic and, potentially, extended banking crises, but also a highly inefficient economy.

Introducing deposit insurance eliminates one problem and introduces another. It ends banking crises but at the price of keeping bad bankers (equivalently, bad banks) in business. This moral hazard is raised in multiple studies including Gertler, Kiyotaki, and Queralto (2012); Demirgüç-Kunt and Detragiache (1997, 1998, 2002); Calomiris and Haber (2014) and Calomiris, Flannery, and Laeven (2016). The result is higher total output, but more stolen output. Since the government levies taxes to fund its insurance of purloined or lost output, the insurance does nothing to reduce bad-banker risk. Nor does it insure anything real. It simply induces households to invest with banks

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<sup>7</sup>There are lots of legal ways to “steal,” including charging hidden fees, churning portfolios to generate higher fees, cream-skimming the purchase of assets, buying assets at above-market price from reciprocating bankers, and taking on excessive risk.

regardless of the risk. Like a compensated tax, deposit insurance distorts behavior, producing an excess burden.<sup>8</sup>

Monitoring banking practices is another option. But information, once released, becomes a public good. Since households have no incentive to keep the results of their monitoring private, they will likely share what they know. In this case, each household will free-ride on the monitoring of others. This reduces, if not eliminates, monitoring. The first-best policy – disclosure – addresses the opacity problem directly by shutting down malfeasant bankers' modus vivendi, namely operating in the dark. Turning on the lights requires government provision of the missing public good, namely public revelation, either in full or in part (depending on cost), of the malfeasance. This weeds out bad banking, raising non-stolen output and welfare. The practical counterpart of this policy prescription is real-time, government disclosure and verification of all bank assets and liabilities to ensure that the net capital invested in banks is actually being used to produce output that's paid to investors and workers.<sup>9</sup>

### 3.2 Literature Review

The seminal Bryant (1980) and Diamond and Dybvig (1983) articles modeled bank deposits as insurance against unexpected liquidity needs and bank runs as a switch from a good to a bad equilibrium. These papers sparked a major literature connecting banking to liquidity. Examples include Jacklin (1983), Jacklin and Bhattacharya (1988), Holmström and Tirole (1998), Rochet and Vives (2004), Goldstein and Pauzner (2005), He and Xiong (2012)

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<sup>8</sup>In our model, bad bankers extract resources from the economy, which cannot be reclaimed by the government. Their theft represents aggregate risk against which the government cannot insure. Hence, insurance payments made to households are exactly offset by taxes to cover those payments.

<sup>9</sup>As noted by Kotlikoff (2010), this work can be performed by private firms working exclusively for the government.

and Acharya, Gale, and Yorulmazer (2011).

Liquidity is a key element of the financial system. But is it really at the heart of banking? And is maturity transformation as important as its prevalence in the literature suggests? The Bryant and Diamond-Dybvig liquidity-insurance/maturity-transformation models predict investment-like returns on demand and other short-term deposits. Yet real returns on transaction accounts have historically been very small, if not negative. Moreover, modern economies are replete with health, accident, auto, homeowners, malpractice, longevity, property and casualty, disability, long-term care insurance, credit cards, and equity lines of credit – all of which provide liquidity in times of personal economic crisis. Then there are financial markets, whose securities can be sold as needed to provide liquidity and transform maturities. Indeed, Jacklin (1989) argues that equity markets can provide as much liquidity insurance as bank deposits and transform maturities just as well. Moreover, they can do so with no danger of bank runs or any other type of financial crisis.<sup>10</sup>

Still, liquidity risk continues to stimulate research. Dang, Gorton, Holmström, and Ordoñez (2017) add a new wrinkle to Diamond and Dybvig (1983), namely the staggered arrival of participants to the liquidity insurance market. They show that banking opacity permits late arrivals to participate in the market since opacity leaves them with no more information than early arrivals. The work by Dang, Gorton, Holmström, and Ordoñez (2017) echoes Hirshleifer (1971), who points out that disclosure is detrimental to those holding claims on overvalued assets. Other researchers, including Holmström and Tirole (1998), Andolfatto (2010), Gorton (2009) and Gorton and Ordonez (2014) warn that public audits, while providing a public good, namely public

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<sup>10</sup>Jacklin's proviso is that information between investors and banks not be asymmetric in the context of aggregate risk. We suggest that the asymmetry of information can be eliminated, either fully or largely in the presence or absence of aggregate risk, by real-time government-orchestrated or supervised verification and disclosure of bank assets and liabilities.

information, comes at the price of market crashes. Whether policymakers are deliberately limiting audits to protect malfeasant banks is an open question. Either way, today's limited, quasi-voluntary disclosure is of limited value. As Johnson and Kwak (2010) state, "Lehman Brothers ... was more than adequately capitalized on paper, with Tier 1 capital of 11.6 percent, shortly before it went bankrupt in September 2008. Thanks to the literally voluminous report by the Lehman bankruptcy examiner, we now know this was in part due to aggressive and misleading accounting."

Like Stiglitz and Weiss (1981); Diamond (1984); Brealey, Leland, and Pyle (1977), we treat the problems incumbent in providing intermediation as arising from asymmetric information – bad bankers know they are bad, household investors do not. However, those studies stress differential knowledge between bankers and borrowers whereas our focus is on differential knowledge between bankers and savers (equivalently, investors). In the former studies, the unobservable was the trustworthiness of borrowers. In our study, the unobservable is the trustworthiness of bankers.

Gertler and Karadi (2011) and Gertler and Kiyotaki (2010) also model financial malfeasance. However, bankers do not steal or otherwise misappropriate output in equilibrium. Borrowing thresholds and the exposure of equity holders to losses keep such behavior from happening. In our model, bad bankers expropriate or lose output in equilibrium unless they are disclosed ex-ante. Disclosure is a natural remedy in our model, but faces real-world objection from a surprising source, namely regulators. Regulators worry that too much disclosure in the midst of a financial meltdown can fuel asset fire sales.<sup>11</sup> But this concern is about ex-post disclosure. Our focus is on ex-ante disclosure, i.e., preventing malfeasance in advance via, in part, initial and ongoing, real-time asset verification.

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<sup>11</sup>See [www.sec.gov/spotlight/fairvalue/marktomarket/mtmtranscript102908.pdf](http://www.sec.gov/spotlight/fairvalue/marktomarket/mtmtranscript102908.pdf).

Our paper extends Chamley, Kotlikoff, and Polemarchakis (2012), which sets aside the liquidity-insurance/maturity-transformation rationale for banking. Instead it justifies banks based on their principal economic role – financial intermediation. And it models bank runs as arising from actual or perceived malfeasance in the provision of intermediation services. The Chamley, Kotlikoff, and Polemarchakis (2012) model has a quite different structure and is static. Ours is dynamic. We consider how current malfeasance undermines future financial intermediation, productivity and welfare since current malfeasance generates lingering doubts about the trustworthiness of bankers. The banking “runs” considered here are simply decisions to invest less, at least in the short run, in banks. The associated contraction of the banking sector can be labeled a liquidity crisis. But the crisis is triggered by news of a larger than expected share of bad bankers, not the sudden need for money by of a large segment of the public.

Banks have generally been modeled as honest institutions, which, in their efforts to provide a full, if risky, return to investors, are occasionally stymied by panicked or misinformed creditors. Moreover, bad news about banks is about poor investment returns, not the theft, scams, swindles, Ponzi schemes, excess fees, etc., recorded in, for example, the Security and Exchange Commission’s Division of Enforcement’s annual reports. The SEC’s enforcement actions now total over two per week.<sup>12</sup> Of course, the SEC only reports frauds the agency detects.<sup>13</sup> It is impossible to say how much financial fraud goes undetected. Moreover, there are other federal and state government agencies and branches, such as Massachusetts’ Financial Investigations Division, which investigate and prosecute financial crime, but do not provide annual listings of their enforcement actions. And explicit fraud, such as the Madoff or the Stanford Ponzi schemes, is not the only type of fraud at play. Much financial

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<sup>12</sup><https://www.sec.gov/news/newsroom/images/enfstats.pdf>

<sup>13</sup>A separate metric for financial fraud is provided by [www.ponzitracker.com](http://www.ponzitracker.com), which suggests the discovery of one new Ponzi scheme per week in recent years.

fraud takes subtle forms that is rarely viewed, even by economists, as such. An example is a bank that legally operates based on proprietary information to the detriment of the public. Townsend (1979) models this behavior, albeit without the pejorative connotation. He posits informed agents that force uninformed agents to enter a debt contract to limit the extent to which they must pay to investigate cheating. He applies this to borrowers' incentives to renege on loans but it could equally be applied to banks' incentives to cheat investors.

The obvious policy solution is exposing malfeasant bankers and banking. Such disclosure, as proposed by Kotlikoff (2010) and to a lesser extent by Pagano and Volpin (2012) and Hanson and Sunderam (2013), would go far beyond current practices. It would largely entail real-time verification of bank assets. Take, for example, mortgage verification. Verifying a mortgage application requires determining the employment status, earnings, outstanding debts, and credit record of the mortgagee and appraising the value of the house being purchased. Now, as before the Great Recession, U.S. mortgage verification is in the hands of private lenders, such as the former Country Wide Financial, a company heavily fined for originating and selling fraudulent mortgages.<sup>14</sup> But such verification could readily be done by the government or private companies working solely for the government. Indeed, thanks to its tax records, the government can better verify income on mortgage applications than the private sector. Had such government mortgage verification been in place prior to 2007, there would, arguably, have been few, if any, liar, no-doc, and NINJA loans – all of which appear to have produced a major rise in the perceived and actual share of bad banks.

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<sup>14</sup>See <https://www.sec.gov/news/press/2010/2010-197.htm>

### 3.3 The Model

Agents in our OLG framework work full-time when young and are retired when old. They consume in both periods. Agents born at time  $t$  maximize their expected utility,  $EU_t$ , given by

$$EU_t = \beta \log c_{y,t} + (1 - \beta)E_t \log c_{o,t+1}, \quad (3.1)$$

over  $c_{y,t}$ ,  $c_{o,t+1}$  and  $\alpha_{s,t}$ , subject to

$$c_{o,t+1} = A_{t+1}[(1 - \alpha_{s,t})(1 + r_{f,t+1}) + \alpha_{s,t}(1 + \tilde{r}_{b,t+1})], \quad (3.2)$$

and

$$c_{y,t} + A_{t+1} = w_t. \quad (3.3)$$

The terms  $c_{y,t}$  and  $c_{o,t+1}$  reference consumption when young and old at  $t$  and  $t+1$ ,  $w_t$  is the time- $t$  wage,  $A_{t+1}$  equals the time- $t$  saving of generation  $t$ , and  $r_{f,t+1}$  and  $\tilde{r}_{b,t+1}$  are the safe and risky returns to farming and banking. The share of generation  $t$ 's assets invested in banking is  $\alpha_{s,t}$ . The  $s$  subscript references the state of mean malfesance this period, which affects the allocation decision. Capital does not depreciate. Optimization entails

$$C_{y,t} = \beta w_t, \quad (3.4)$$

$$A_{t+1} = (1 - \beta)w_t, \quad (3.5)$$

$$E_t \frac{r_{f,t+1} - \tilde{r}_{b,t+1}}{1 + (1 - \alpha_{s,t})r_{f,t+1} + \alpha_{s,t}\tilde{r}_{b,t+1}} = 0. \quad (3.6)$$

Investment in the two sectors satisfies

$$K_{f,t+1} = (1 - \alpha_{s,t})A_{t+1}, \quad (3.7)$$

$$K_{b,t+1} = \alpha_{s,t}A_{t+1}. \quad (3.8)$$

Output is Cobb-Douglas with labor's share equaling  $1 - \theta$  in each industry. Farm output at time  $t$ ,  $F_t$ , is given by

$$F_t = Z_f K_{F,t}^\theta L_{F,t}^{1-\theta}. \quad (3.9)$$

A proportion,  $m_t$ , of banking output is stolen or lost each period. Henceforth, we reference such lost output simply as “stolen.” Non-stolen banking output is, thus

$$B_t = (1 - m_t)Z_b K_{b,t}^\theta L_{b,t}^{1-\theta}, \quad (3.10)$$

and non-stolen output is

$$Y_t^u = F_t + B_t. \quad (3.11)$$

Total output is

$$Y_t = F_t + Z_b K_{b,t}^\theta L_{b,t}^{1-\theta}. \quad (3.12)$$

Returns to investing in farming and banking satisfy

$$r_{f,t} = \theta Z_f K_{f,t}^{\theta-1} L_{f,t}^{1-\theta}, \quad (3.13)$$

and

$$\tilde{r}_{b,t} = (1 - m_t)\theta Z_b K_{b,t}^{\theta-1} L_{b,t}^{1-\theta}. \quad (3.14)$$

Agents invest in banking because the sector is more productive, i.e.,  $Z_b > Z_f$ . But, absent deposit insurance, they diversify due to the risk that banking malfeasance is greater than expected. Malfeasance,  $m_t$ , is the sum of two components – its time- $t$  mean,  $\bar{m}_t$ , plus an i.i.d. shock,  $\epsilon_t$ , i.e.,

$$m_t = \bar{m}_t + \epsilon_t. \quad (3.15)$$

Mean malfeasance is either high,  $\bar{m}_H$ , or low,  $\bar{m}_L$ , and obeys a Markov process.

If  $\bar{m}_{t-1} = \bar{m}_H$ ,

$$\bar{m}_t = \begin{cases} \bar{m}_H & \text{with probability } q_H \\ \bar{m}_L & \text{with probability } 1 - q_H. \end{cases} \quad (3.16)$$

If  $\bar{m}_{t-1} = \bar{m}_L$ ,

$$\bar{m}_t = \begin{cases} \bar{m}_H & \text{with probability } q_L \\ \bar{m}_L & \text{with probability } 1 - q_L, \end{cases} \quad (3.17)$$

where  $q_H > q_L$ . The additional shock,  $\epsilon_{t+1}$ , is uniformly distributed with the same support,  $a$  and  $b$ , regardless of the state, i.e.,

$$\epsilon_{t+1} \sim U(a, b). \quad (3.18)$$

When monitoring is feasible, households can pay to learn about this second shock,  $\epsilon_{t+1}$ . Households observe the malfeasance share at  $t$  and infer the current state of the world,  $s_t \in \{L, H\}$ , and the transition probability,  $q_{s,t} \in \{q_L, q_H\}$ . Their optimal allocation choice,  $\alpha_{s,t}$ , will change given this information. A high state of malfeasance this period will likely persist leading households to invest less in banking. Given eqs. (3.1) to (3.8) and (3.13) to (3.18), the optimal portfolio choice,  $\alpha_{s,t}$ , satisfies

$$\begin{aligned} 0 = & q_{s,t} \int_a^b \frac{\tilde{r}_{b,t+1}^H(\alpha_{s,t}, \epsilon_{t+1}) - r_{f,t+1}^H(\alpha_{s,t}, \epsilon_{t+1})}{1 + \alpha_{s,t} \tilde{r}_{b,t+1}^H(\alpha_{s,t}, \epsilon_{t+1}) + (1 - \alpha_{s,t}) r_{f,t+1}^H(\alpha_{s,t}, \epsilon_{t+1})} d\epsilon_{t+1} \quad (3.19) \\ & + (1 - q_{s,t}) \int_a^b \frac{\tilde{r}_{b,t+1}^L(\alpha_{s,t}, \epsilon_{t+1}) - r_{f,t+1}^L(\alpha_{s,t}, \epsilon_{t+1})}{1 + \alpha_{s,t} \tilde{r}_{b,t+1}^L(\alpha_{s,t}, \epsilon_{t+1}) + (1 - \alpha_{s,t}) r_{f,t+1}^L(\alpha_{s,t}, \epsilon_{t+1})} d\epsilon_{t+1}, \end{aligned}$$

where superscripts reference expected returns if the high and low malfeasance states arise at time  $t + 1$ .<sup>15</sup> These returns depend on the malfeasance share (both its mean at  $t + 1$  and  $\epsilon_{t+1}$ ) as well as the allocation of capital to banking,  $\alpha_{s,t}$ . Reduced forms for these returns are derived in appendix B.1.

Capital's allocation between the two sectors is determined at the beginning of each period based on agents' portfolio choice. The allocation of labor, in contrast, is determined at the end of each period such that workers earn the same wage net of malfeasance in both sectors. This condition, our normalization of total labor supply at 1 and the allocation of labor between the two sectors are specified by

$$L_{b,t} + L_{f,t} = 1, \quad (3.20)$$

<sup>15</sup>The first (second) term of eq. (3.19) captures the marginal effect on utility of increasing the allocation to banking provided the mean malfeasance share at  $t + 1$  is high (low). Both terms integrate over the possible realizations of  $\epsilon_{t+1}$ . The optimal choice of  $\alpha_{s,t}$ , must be solved numerically. To rule out short-sales, we calibrate the model such that  $\alpha_{s,t} \in (0, 1)$ .

$$w_t = (1 - \theta)Z_f(K_{f,t}/L_{f,t})^\theta = (1 - \theta)Z_b(1 - m_t)(K_{b,t}/L_{b,t})^\theta, \quad (3.21)$$

and

$$L_{f,t} = \frac{Z_f^{\frac{1}{\theta}}(1 - \alpha_{t-1})}{[(1 - m_t)Z_b]^{\frac{1}{\theta}}\alpha_{t-1} + Z_f^{\frac{1}{\theta}}(1 - \alpha_{t-1})}, \quad (3.22)$$

$$L_{b,t} = \frac{[(1 - m_t)Z_b]^{\frac{1}{\theta}}\alpha_{t-1}}{[(1 - m_t)Z_b]^{\frac{1}{\theta}}\alpha_{t-1} + Z_f^{\frac{1}{\theta}}(1 - \alpha_{t-1})}, \quad (3.23)$$

where  $\alpha_{t-1}$  references the portfolio share chosen at time  $t - 1$ .

### 3.4 Calibration

Table 4.3 reports our calibration. The time-preference factor,  $\beta$ , is set to 0.5 and capital's share,  $\theta$ , is set to 0.3. Our assumed mean malfeasance shares are  $\bar{m}_H = .50$  and  $\bar{m}_L = .22$ . The two assumed TFP levels are  $Z_f = 10$  and  $Z_b = 16$ . In combination, these parameters satisfy

$$(1 - \bar{m}_H)Z_b < Z_f < (1 - \bar{m}_L)Z_b.$$

This restriction ensures interior solutions to the share of assets invested in banks. We allow the shock,  $\epsilon_{t+1}$ , to raise or lower the malfeasance share by .1, i.e.,  $\{a, b\} = \{-0.1, 0.1\}$ . Finally, we set the probabilities of a high mean malfeasance share at  $t + 1$  to be 0.6 when the mean malfeasance share is high at time  $t$  and 0.4 when the mean malfeasance share is low at time  $t$ . I.e.,  $q_H = .6$  and  $q_L = .4$ .

Parameter	Description	Value
$\beta$	Time preference	0.5
$\theta$	Capital share	0.3
$Z_f$	Farm productivity	10
$Z_b$	Bank productivity	16
$\bar{m}_H$	Mean malfeasance share in high malfeasance state	0.50
$\bar{m}_L$	Mean malfeasance share in low malfeasance state	0.22
$q_H$	Probability of high malfeasance at $t + 1$ , given high malfeasance at $t$	0.6
$q_L$	Probability of high malfeasance at $t + 1$ , given low malfeasance at $t$	0.4
$a$	Maximum reduction in malfeasance	-0.1
$b$	Maximum increase in malfeasance	0.1

Table 3.1: Parameter Values

### 3.5 Base Model Results

The model's average values in its stochastic steady state are reported in table 3.2. Table 3.3 and table 3.4 report averages for low and high mean malfeasance states, respectively. The values in these tables are based on a 10,020-period transition. We simulated our model for 10,020 periods, but consider only data after the first 20 periods in tables 3.2 to 3.4. This removes the effect of initial conditions. Assets at  $t = 0$  in this simulation were set at the mean level of assets arising in periods 21 through 10,020.  $\bar{m}_0 = \bar{m}_L$ . We iterated to ensure that mean assets used for  $A_0$  equal mean assets over the 10,000 periods since the path of assets depends on  $A_0$ . In simulating alternative banking policies as well as private monitoring over 10,020 periods, we use the same period-by-period draws of mean malfeasance and  $\epsilon_t$ .

Given our calibration, banking malfeasance has a major economic cost. Across all states, 21.8 percent of output is stolen. In low mean malfeasance states, 17.2 percent is stolen. In high mean malfeasance states, 27.2 percent is stolen. Moreover, average non-stolen output when mean malfeasance is high is 24.7 percent lower than when mean malfeasance is low. Since wages are

proportional to output and consumption when young is proportion to wages, both variables are also, on average, 24.7 percent lower in high compared to low states. Consumption when old is only 15.5 percent lower across the two types of states. The reason is that consumption when old includes not just the income on assets, but the principal as well. And the principal is not impacted by banker malfeasance.

Agents respond to bad times in banking by moving their assets into farming. When malfeasance is high, only 28 percent of assets are allocated to banking. When low, the figure is 86 percent. We refer here to the value of  $\alpha$ , which determines capital's allocation in the subsequent period. The share of capital in the high state is larger – 54.9 percent, while the share in the low state is smaller – 67.3 percent than suggested by these values for  $\alpha$ . This reflects the fact that the high (low) state emerges, in part, from states that are low (high) in the prior period. But when agents see higher prospects for bad (good) times, they take cover (leave their shelter) by setting their values of  $\alpha$  appropriately. The fact that agents cannot tell for sure what is coming when it comes to the state of mean malfeasance means that capital is perpetually mis-allocated. This is another economic cost arising from bad bankers in addition to their direct theft of output and their general negative influence on investment in banking. The misallocation of capital is partially offset by the reallocation of labor. On average, banking accounts for 56 percent of total employment. In periods of high mean malfeasance, this figure is 38 percent. It is 74 percent when there is low mean malfeasance.

The average annualized return to investing in banking is 2.04 percent compared with 2.01 percent in farming.<sup>16</sup> Although their mean returns are similar, as the table's standard deviation of returns shows, investing in banking is far riskier than investing in farming. This explains why farming always attracts

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<sup>16</sup>In forming annualized returns, we assume each period corresponds to 30 years.

a goodly share of investment.

Variable		Mean	Std.	Min	Max
Output	$Y$	23.12	4.25	16.46	29.86
Non-Stolen Output		18.08	3.19	12.38	25.95
Consumption when Young	$C_y$	6.33	1.11	4.33	9.08
Consumption when Old	$C_o$	11.75	1.78	8.85	16.51
Annualized Bank Returns		2.04	0.77	0.72	4.01
Annualized Farm Returns		2.01	0.58	0.94	3.52
Allocation to Banking	$\alpha$	0.57	0.29	0.28	0.87
Bank Capital	$K_b$	3.88	2.42	1.20	7.93
Farm Capital	$K_f$	2.45	1.47	0.84	4.60
Savings	$A$	6.33	1.12	4.33	9.08
Bank Labor	$L_b$	0.56	0.32	0.08	0.95
Wages	$w$	12.66	2.23	8.67	18.16

Table 3.2: Average Values in Model's Stochastic Steady State

Variable		Mean	Std.	Min	Max
Output	$Y$	24.90	3.81	18.64	29.86
Non-Stolen Output		20.62	2.48	16.17	25.95
Consumption when Young	$C_y$	7.22	0.87	5.66	9.08
Consumption when Old	$C_o$	12.74	1.79	9.24	16.51
Annualized Bank Returns		2.68	0.51	1.88	4.01
Annualized Farm Returns		1.53	0.34	0.94	2.3
Allocation to Banking	$\alpha$	0.86	0.01	0.85	0.87
Bank Capital	$K_b$	4.41	2.39	1.21	7.85
Farm Capital	$K_f$	2.14	1.44	0.84	4.60
Savings	$A$	6.55	1.12	4.39	8.99
Bank Labor	$L_b$	0.74	0.24	0.34	0.95
Wages	$w$	14.44	1.74	11.32	18.16

Table 3.3: Average Values when Mean Malfeasance Share is Low at  $t$

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Variable		Mean	Std.	Min	Max
Output	$Y$	21.33	3.92	16.46	28.79
Non-Stolen Output		15.52	1.04	12.38	18.33
Consumption when Young	$C_y$	5.43	0.37	4.33	6.41
Consumption when Old	$C_o$	10.76	1.08	8.85	14.00
Annualized Bank Returns		1.40	0.34	0.72	2.14
Annualized Farm Returns		2.48	0.30	1.84	3.52
Allocation to Banking	$\alpha$	0.28	0.00	0.28	0.28
Bank Capital	$K_b$	3.34	2.34	1.20	7.93
Farm Capital	$K_f$	2.76	1.44	0.85	4.58
Savings	$A$	6.10	1.06	4.33	9.08
Bank Labor	$L_b$	0.38	0.28	0.08	0.85
Wages	$w$	10.87	0.73	8.67	12.83

Table 3.4: Average Values when Mean Malfeasance Share is High at  $t$

Figure 3.1 plots returns in the two sectors for different values of  $\epsilon_{t+1}$  and realizations of the time- $t+1$  malfeasance state assuming  $A_t$  equals its average value. The dotted red line shows returns, for different values of  $\epsilon_{t+1}$ , if the malfeasance state at  $t + 1$  is high. The solid black line shows returns, for different values of  $\epsilon_{t+1}$ , if the malfeasance state at  $t + 1$  is low. The top panels shows annualized returns if the malfeasance state is high at time  $t$ . The bottom panels shows returns if the malfeasance state is low at time  $t$ .

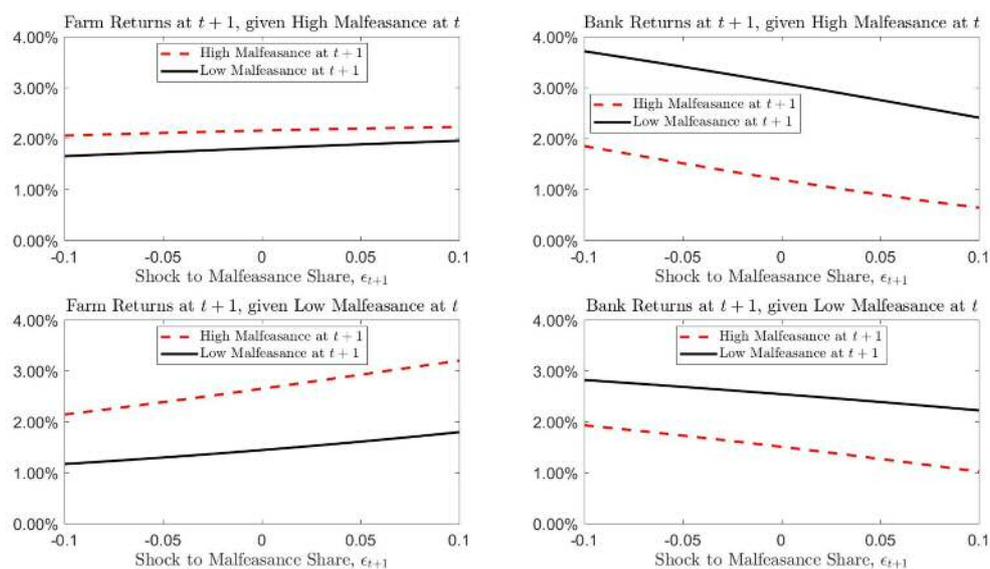


Figure 3.1: Annualized Returns at  $t + 1$  Conditional on the Shocks to the Mean Malfeasance Share at  $t + 1$

The right-hand side panels show that higher malfeasance, whether caused by a) moving to or staying in a high malfeasance state at  $t + 1$  or b) a high draw on  $\epsilon_{t+1}$ , implies lower returns to banking at  $t + 1$ ; i.e., the dotted red curves lie below the solid black curves and both slope downward.

The left-hand side panels show the opposite in the case of the returns to farming. This reflects a greater allocation of labor to farming the greater the share of malfeasance in banking. More labor in farming means a higher marginal product of capital and, thus, a higher return. This effect of labor moving into farming is stronger the smaller the degree of malfeasance at time  $t$  — the case when relatively little capital will be invested in farming in  $t + 1$ . This explains the larger gap between the red and black curves in the bottom left panel than in the top left panel.

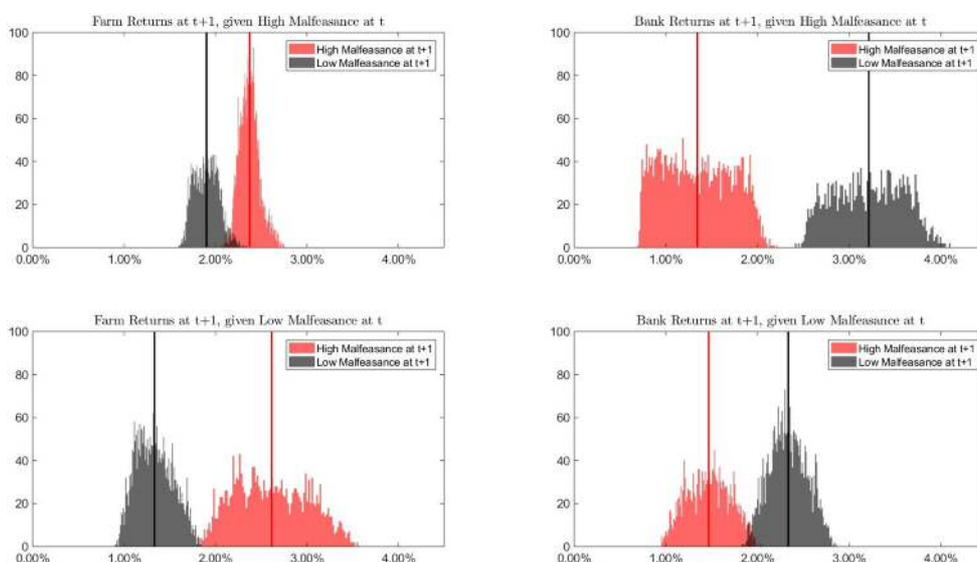


Figure 3.2: Histograms of Realized Returns conditional on Mean Malfeasance State,  $\bar{m}_s$

Figure 3.2 plots the distribution of realized returns in period  $t + 1$  simulated in the 10,000-periods referenced above. This figure, while organized like Figure 3.1, incorporates changes in  $A_t$  from from period to period. The panels on the right consider bank returns. Those on the left consider farm returns. The top (bottom) panels consider returns at  $t + 1$  when the malfeasance state is high (low) in period  $t$ . Finally, the red (black) histogram references high (low) malfeasant states arising at time  $t + 1$ . The vertical bar shows mean returns in each time  $t + 1$  state.

As expected, bank (farm) returns are lower (higher) at  $t + 1$  when the  $t + 1$  malfeasant state is high (low). The position of the histograms reflects different allocations, at time  $t$ , in capital between the two sectors. The variance in the histograms reflects the impact of movements of labor across sectors on the return to capital in the two sectors. The impact on a sector's return from employing more labor is greater the smaller the initial allocation of capital to that sector.

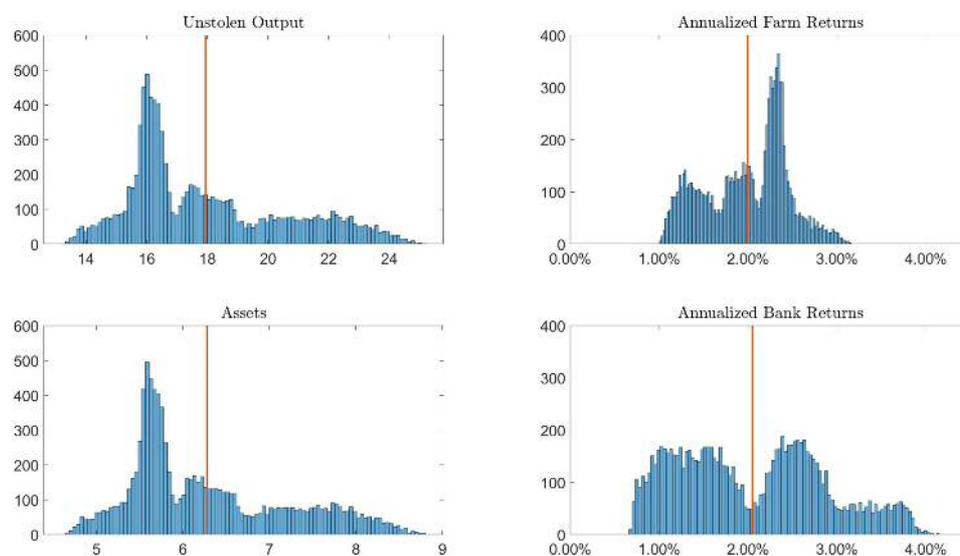


Figure 3.3: Histograms of Assets, Non-Stolen Output and Returns to Banking and Farming

Figure 3.3 shows histograms of non-stolen output, assets, annualized farm and banking returns. The histograms' results are unconditional, i.e., they include both high and low malfeasance states in the prior period which explains why they are multi-modal. They are also quite dispersed suggesting that banking malfeasance can produce peaks and troughs in non-stolen output, wages, and assets that are very far apart.

As expected, a switch in the mean malfeasance state from one period to the next produces much greater changes in macro conditions than no switch. Figure 3.4 records the transition beginning with high average malfeasance, switching to low average malfeasance in period 3, and then switching back to and remaining at high average malfeasance in periods 4 through 10. Figure 3.5 illustrates the opposite – i.e., a temporary switch from low to high and then back to low average malfeasance. The path of the additional shock to the malfeasance share,  $\epsilon_t$ , is kept at 0 in both transitions. Consider fig. 3.4. In period 3, when mean banking malfeasance declines, more labor is allocated to

banking and there is an increase in non-stolen output. But since the shock hits after capital has been allocated, there is no immediate impact on the capital stock. There is a major impact in period 4 reflecting agents' decisions to invest more in banking given its higher expected return. Given that high mean malfeasance reoccurs in period 4, this investment decision is an ex-post mistake. But once the capital is allocated, it cannot be reallocated. The ex-post excessive investment in banking draws additional labor into banking. Hence, there is a mis-allocation, again, on an ex-post basis, of labor as well as capital.

Notwithstanding the additional capital and labor allocated to banking, non-stolen output is smaller in period 4 than in, for example, period 2. The fact that the economy is so different in period 4 from, for example, period 2 indicates the importance of beliefs about mean malfeasance – whether those beliefs are correct or, as in this case, incorrect. Indeed, as a comparison of the change in  $Y_t$  between periods 2 and 3, on the one hand, and period 3 and 4, on the other, shows, the change in beliefs about the malfeasance shock produces larger output fluctuations than does the shock itself. Another interesting point about the two impulse-response transitions is that one is not the obverse of the other. Consider, for example, the impact on wages. In fig. 3.4, wages rise above their initial value and then fall below it following the temporary reduction in mean malfeasance. In contrast, in fig. 3.5 wages fall and gradually return to their period-2 value following a temporary rise in mean malfeasance.

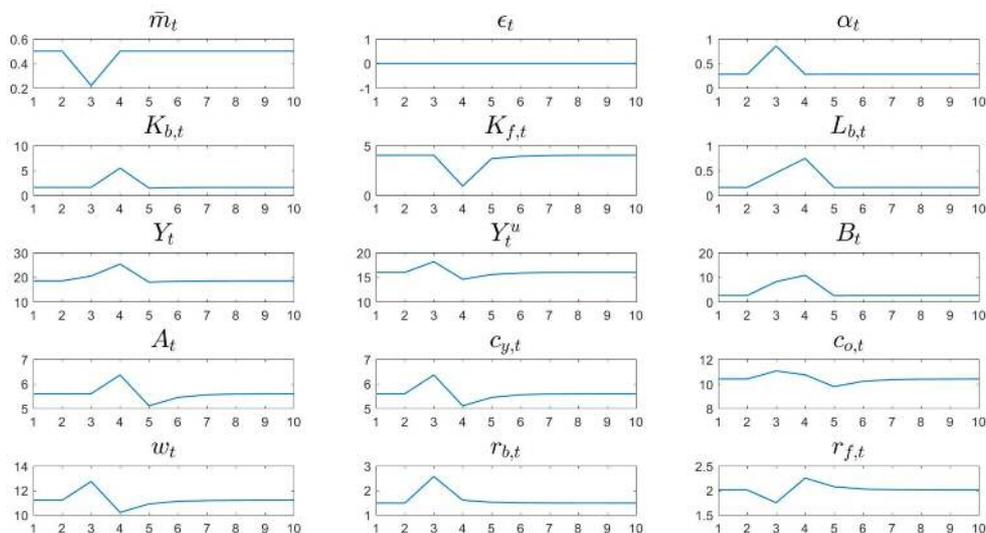


Figure 3.4: The Economy's Transition – High to Low to High Mean Malfeasance

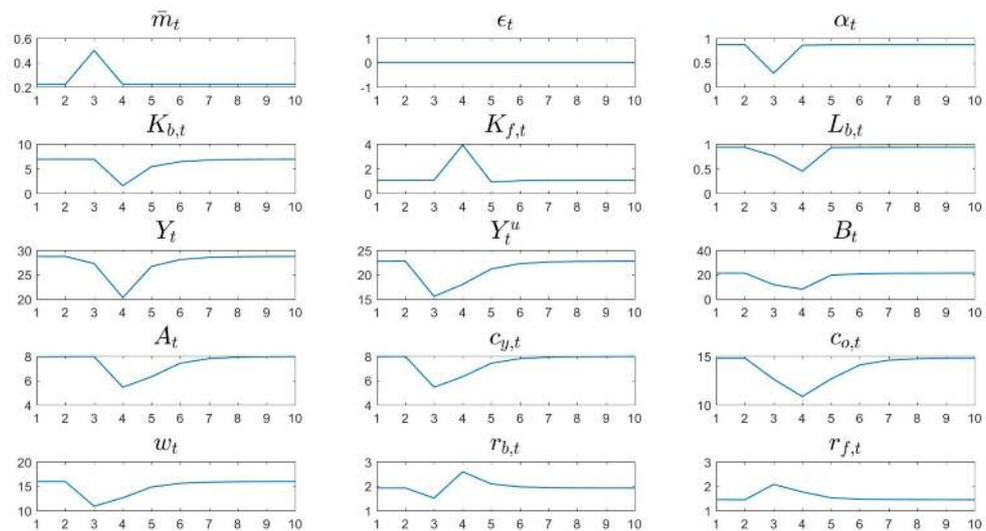


Figure 3.5: The Economy's Transition – Low to High to Low Mean Malfeasance

Figure 3.6 records a third controlled experiment, this one with a prolonged improvement in mean malfeasance. Like the prior two,  $\epsilon_t$  is set to zero. The economy starts with high mean malfeasance, followed by low mean malfea-

sance for 6 periods, followed by high mean malfeasance for 2 periods. As a comparison with fig. 3.5 shows, the economy's path is highly sensitive to the exact sequence of mean malfeasance shocks. This sensitivity, as we've seen, reflects immediate impacts, but, more importantly, the formation of beliefs about the economy's future.

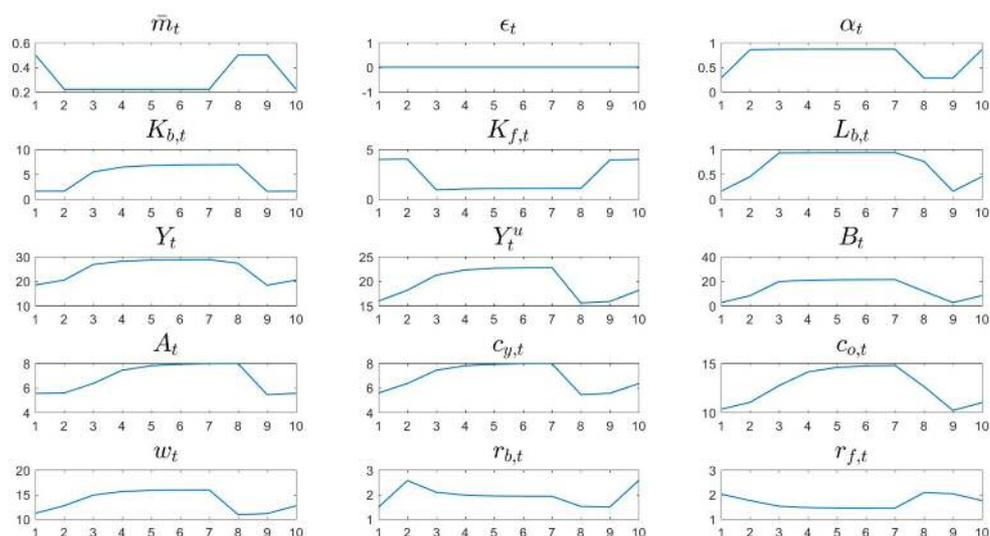


Figure 3.6: Transition to High Mean Malfeasance after Extended Low Mean Malfeasance

Adding  $\epsilon_t$  shocks to the mean malfeasance share, we arrive at our baseline transition, fig. 3.7. The path of these added shocks for the first 10 periods is reported in table 3.5. We use the same path of shocks to mean malfeasance and  $\epsilon_t$  in our comparisons below of the baseline economy with the baseline economy augmented to include alternative government banking policies or private monitoring.

t	1	2	3	4	5	6	7	8	9	10
$\epsilon$	-0.078	-0.050	0.093	0.026	0.063	0.013	0.027	0.062	0.085	0.083

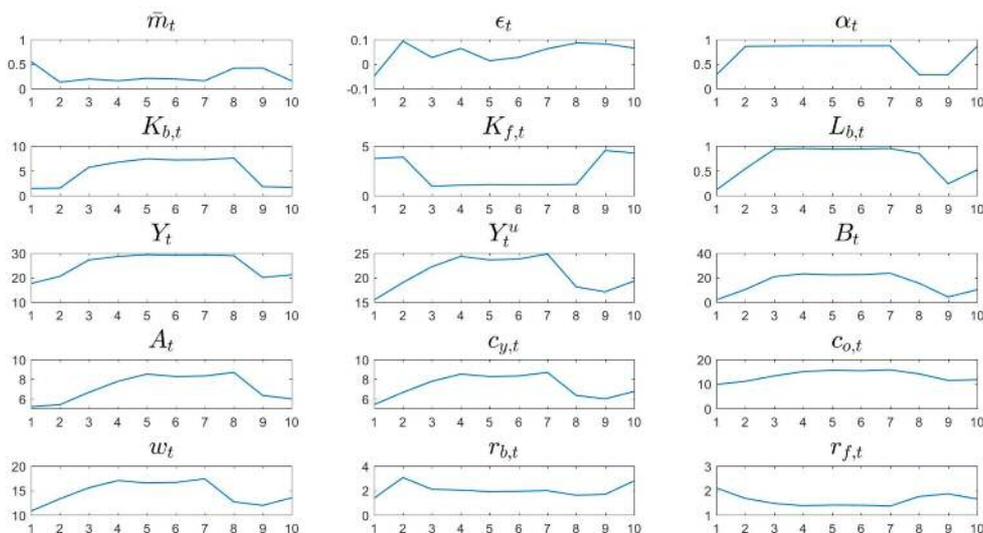
Table 3.5: Path of  $\epsilon_t$  for First Ten Periods of Transition

Figure 3.7: Baseline Transition

### 3.6 Deposit Insurance

Deposit insurance insulates savers from losses due to bad bankers, leading to exclusive investment in banking. If the mean share turns out to be low, the insurance succeeds in generating more non-stolen output than would otherwise arise if savers shied away from banks.<sup>17</sup> But if the mean malfeasance share turns out to be high, savers are actually worse off than without deposit insurance. Yes, they are compensated for their losses, but they have to pay taxes to cover the compensation. In short, since the share of malfeasance is an aggregate risk, deposit insurance provides no real insurance in the aggregate. Instead, it simply induces savers to invest exclusively in banking even in times

<sup>17</sup>This may explain why deposit insurance is often introduced during crises. Another explanation is that voters do not internalize the need to pay taxes to cover insurance claims.

when its highly risky from a macro prospective. Getting savers to over invest in banking when they should engenders, of course, an excess burden.

Under deposit insurance, households receive

$$r_{b,t}^{DI} = (1 - m_t)\theta Z_b K_{b,t}^{\theta-1} L_{b,t}^{1-\theta} + m_t\theta Z_b K_{b,t}^{\theta-1} L_{b,t}^{1-\theta} = \theta Z_b K_{b,t}^{\theta-1} L_{b,t}^{1-\theta}. \quad (3.24)$$

This is financed by a lump-sum tax,  $\tau_{DI,t}$ , levied on the elderly to prevent redistribution across generations.

$$c_{o,t} = A_t(1 + r_{b,t}^{DI}) - \tau_{DI,t}, \quad (3.25)$$

where

$$\tau_{DI,t} = A_t m_t \theta Z_b K_{b,t}^{\theta-1} L_{b,t}^{1-\theta}. \quad (3.26)$$

With deposit insurance, we have,

$$\{K_{f,t+1}, L_{f,t+1}, K_{b,t+1}, L_{b,t+1}\} = \{0, 0, A_{t+1}, 1\} \quad (3.27)$$

Figure 3.8 shows the path of the economy with deposit insurance using the same path of shocks as the baseline transition in fig. 3.6. Although total output is higher, non-stolen output and consumption is lower in bad states.

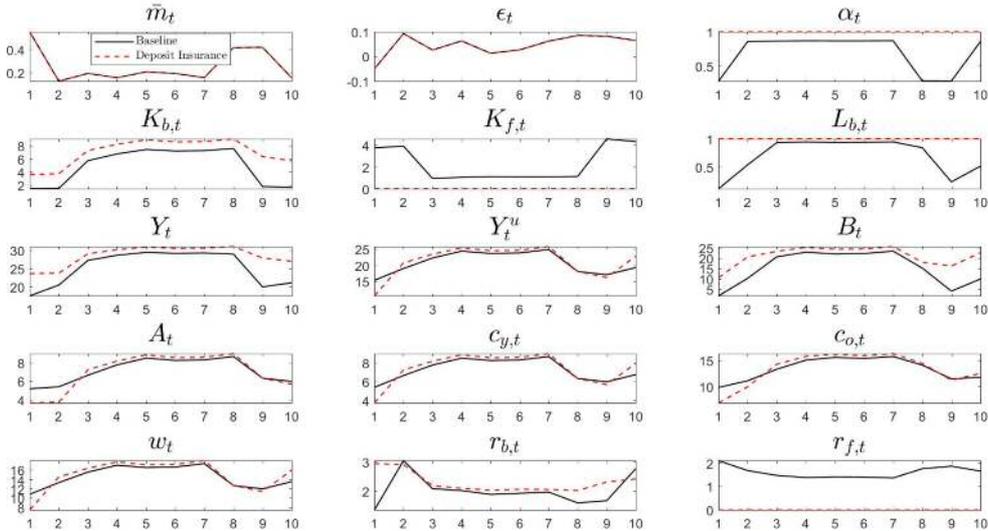


Figure 3.8: Economy's Transition With and Without Deposit Insurance.

Table 3.6 compares deposit insurance to the baseline. All assets are, as indicated, now allocated to banking in all periods. When the share of bad bankers is low, non-stolen output, wages and consumption are higher. But when the share is high, wages, consumption and saving are lower than would be true absent deposit insurance.<sup>18</sup> Thus, increased allocation to banking due to deposit insurance *increases* the volatility of consumption and non-stolen assets. This accords with findings of Demirgüç-Kunt and Detragiache (1997, 1998, 2002).

Variable		Baseline		Insurance		% Change	
		Mean	Std.	Mean	Std.	Mean	Std.
Output	$Y$	23.12	4.25	27.44	2.26	+19	-47
Non-Stolen Output		18.08	3.19	17.71	4.75	-2	+49
Consumption when Young	$C_y$	6.33	1.11	6.20	1.66	-2	+49
Consumption when Old	$C_o$	11.75	1.78	11.51	2.66	-2	+49
Annualized Bank Returns		2.04	0.77	2.94	0.39	+44	-50
Annualized Farm Returns		2.01	0.58	-	-	-100	-100
Allocation to Banking	$\alpha$	0.57	0.29	1.00	0.00	+75	-100
Bank Capital	$K_b$	3.88	2.42	6.19	1.66	+60	-31
Farm Capital	$K_f$	2.45	1.47	0.00	0.00	-100	-100
Savings	$A$	6.33	1.12	6.19	1.66	-2	+49
Bank Labor	$L_b$	0.56	0.32	1.00	0.00	+77	-100
Wages	$w$	12.66	2.23	12.40	3.32	-2	+49

Table 3.6: Average Values with Deposit Insurance

We next calculate the factor,  $\lambda$ , needed to compensate both the old and the young, in all states, to make their expected utility in the baseline, denoted  $EU_{s,t}$ , equal to their expected utility under deposit insurance, denoted  $EU'_{s,t}$ ,

$$EU'_{s,t} = \beta \log \lambda c_{y,t} + (1 - \beta) \int_a^b \{q_{s,t} \log \lambda c_{o,t+1}(\bar{m}_H, \epsilon_{t+1}) + (1 - q_{s,t}) \log \lambda c_{o,t+1}(\bar{m}_L, \epsilon_{t+1})\} \frac{1}{b-a} d\epsilon_{t+1}, \quad (3.28)$$

$$= EU_{s,t} + \log \lambda.$$

<sup>18</sup>With all output being produced in the banking sector, more output is lost when the share of bad bankers is high.

Hence  $\lambda = \exp(EU'_{s,t} - EU_{s,t})$ . Expected lifetime utility in the model's stochastic steady state is measured by average realized lifetime utility over 10,000 successive generations born after the 20th period of the transition. For deposit insurance, the value of  $\lambda$  is 1.041 implying households must be compensated with 4.1 percent more consumption in all states to make them as well off as under the baseline case. Stated differently, the excess burden of deposit insurance is a sizable 4.1 percent of consumption.

## 3.7 Monitoring Banks

### 3.7.1 Private Monitoring

As the behavior of rating companies leading up to the 2008 crisis showed, bank-funded monitoring suffers from the “ratings shopping” examined in Skreta and Veldkamp (2009a); Sangiorgi, Sokobin, and S. Spatt (2009) and Bolton, Freixas, and Shapiro (2012). Even if we assume ratings are unbiased, they may be too imprecise to help (Goel and Thakor (2015); Doherty, Kartasheva, and Phillips (2009)).<sup>19</sup> As an alternative, we consider monitoring financed by investors, that is, by households. Specifically, we assume young agents can purchase a report that indicates, with probability  $p$ , the realization of  $\epsilon_{t+1}$ .<sup>20</sup> With probability  $(1 - p)$  no information is gained. In this case, agents make uninformed investment choices.

Let  $n_t$  be the percentage of wage income spent on reports. We assume additional expenditure increases the likelihood of receiving information,  $p$ , with decreasing marginal effect,<sup>21</sup> i.e.,  $p = p(n_t)$ , where  $p(0) = 0$ ,  $p(\infty) = 1$ ,

<sup>19</sup>In our model, this is analogous to assuming households cannot determine the accuracy (or honesty) of a rating paid for by banks.

<sup>20</sup>Thus, informed agents know the malfeasance share at  $t + 1$  will be either  $\bar{m}_H + \epsilon_{t+1}$  or  $\bar{m}_L + \epsilon_{t+1}$ .

<sup>21</sup>This can be micro-founded by assuming that  $n_t$  buys many reports with each providing a noisy estimate of the true realization of the shock,  $\epsilon_{t+1}$ . With likelihood,  $p(\bar{x}|\epsilon_{t+1})$ , where  $\bar{x}$  is the mean estimate given  $n$  reports, the precision of the estimate will be increasing in  $n$ , parameterized by the variance of the data-generating process for the reports.

$p'(n) > 0$  and  $p''(n) < 0$ , which we capture via<sup>22</sup>

$$p(n_t) = \frac{100n_t}{100n_t + 1}. \quad (3.29)$$

Households purchase the welfare-maximizing quantity of information,  $n_t$ . Returns to capital depend on the aggregate allocation to banking, designated by a bar, which depends on the mix of the two types of agents, informed and uninformed, per

$$\bar{\alpha}_{s,t}(\epsilon_{t+1}) = p\alpha_{I,s,t}(\epsilon_{t+1}) + (1-p)\alpha_{U,s,t}, \quad (3.30)$$

where  $\alpha_{I,s,t}(\epsilon_{t+1})$  is the asset allocation of informed agents and  $\alpha_{U,s,t}$  is the asset allocation of uninformed agents. With probability  $p(n_t)$ , individuals receive information about  $\epsilon_{t+1}$  and allocate according to

$$0 = q_{s,t} \frac{\tilde{r}_{b,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1}) - r_{f,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1})}{1 + \alpha_{s,t}\tilde{r}_{b,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1}) + (1 - \alpha_{s,t})r_{f,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1})} + (1 - q_{s,t}) \frac{\tilde{r}_{b,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1}) - r_{f,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1})}{1 + \alpha_{s,t}\tilde{r}_{b,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1}) + (1 - \alpha_{s,t})r_{f,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1})}, \quad (3.31)$$

where subscript  $s \in \{L, H\}$  indicates the state at  $t$ .<sup>23</sup>

With probability  $[1 - p(n_t)]$ , individuals purchase reports, but receive no information. Their optimal allocation choice,  $\alpha_{U,s,t}$ , solves a similar first-order condition to the no-monitoring case (eq. (3.19)) by integrating over the support of  $\epsilon_{t+1}$  and the possibility of the two states of the world next period, high and low. All returns are evaluated using aggregate allocation  $\bar{\alpha}_{s,t}(\epsilon_{t+1})$  given by eq. (3.30).

$$0 = q_{s,t} \int_a^b \frac{r_{f,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1}) - \tilde{r}_{b,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1})}{1 + (1 - \alpha_{U,s,t})r_{f,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1}) + \alpha_{U,s,t}\tilde{r}_{b,t+1}^H(\bar{\alpha}_{s,t}, \epsilon_{t+1})} d\epsilon_{t+1} + (1 - q_{s,t}) \int_a^b \frac{r_{f,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1}) - \tilde{r}_{b,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1})}{1 + (1 - \alpha_{U,s,t})r_{f,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1}) + \alpha_{U,s,t}\tilde{r}_{b,t+1}^L(\bar{\alpha}_{s,t}, \epsilon_{t+1})} d\epsilon_{t+1}. \quad (3.32)$$

<sup>22</sup>The coefficient, 100, is chosen so that households can spend one percent of income on monitoring and receive information fifty percent of the time. This is sufficient to induce households to monitor.

<sup>23</sup>In (eq. (3.31)), we reference  $\bar{\alpha}_{s,t}$  rather than  $\bar{\alpha}_{s,t}(\epsilon_{t+1})$  to limit notation.

To recapitulate, with monitoring, households learn with probability  $p(n_t)$  the realization of  $\epsilon_{t+1}$  and choose the optimal allocation,  $\alpha_{I,s,t}(\epsilon_{t+1})$ , which solves eq. (3.31). With probability  $[1 - p(n_t)]$ , households receive no information and make an uninformed allocation,  $\alpha_{U,s,t}$ , which is the implicit solution to eq. (3.32). Both solutions must be solved simultaneously. The solution is detailed in appendix B.2. Optimal expenditure on monitoring,  $n_t$ , is chosen to maximize expected utility

$$\begin{aligned} EU(n_t) = & \beta \log c_{y,t}(1 - n_t) + (1 - \beta) \log A_{t+1}(1 - n_t) \quad (3.33) \\ & + p(n_t)(1 - \beta) \int_{-a}^b \{q_{s,t} \log R_{I,t+1}^H(\epsilon_{t+1}) + (1 - q_{s,t}) \log R_{I,t+1}^L(\epsilon_{t+1})\} \frac{1}{b - a} d\epsilon_{t+1} \\ & + [1 - p(n_t)](1 - \beta) \int_{-a}^b \{q_{s,t} \log R_{U,t+1}^H(\epsilon_{t+1}) + (1 - q_{s,t}) \log R_{U,t+1}^L(\epsilon_{t+1})\} \frac{1}{b - a} d\epsilon_{t+1}, \end{aligned}$$

where the gross portfolio return if informed, given state  $S$  and  $\epsilon_{t+1}$ , is

$$R_{I,t+1}^S(\epsilon_{t+1}) = 1 + [1 - \alpha_{I,s,t}(\epsilon_{t+1})] r_{f,t+1}^S(\bar{\alpha}_{s,t}(\epsilon_{t+1}), \epsilon_{t+1}) + \alpha_{I,s,t}(\epsilon_{t+1}) r_{b,t+1}^S(\bar{\alpha}_{s,t}(\epsilon_{t+1}), \epsilon_{t+1}), \quad (3.34)$$

and the gross portfolio return if uninformed, given state  $S$  and  $\epsilon_{t+1}$ , is

$$R_{U,t+1}^S(\epsilon_{t+1}) = 1 + [1 - \alpha_{U,s,t}] r_{f,t+1}^S(\bar{\alpha}_{s,t}(\epsilon_{t+1}), \epsilon_{t+1}) + \alpha_{U,s,t} r_{b,t+1}^S(\bar{\alpha}_{s,t}(\epsilon_{t+1}), \epsilon_{t+1}). \quad (3.35)$$

In eq. (3.33), the first two terms account for the sure cost to consumption when young and old. The third and fourth terms represent the net gains from monitoring.

Under our calibration, if mean malfeasance is low at time  $t$ , households spend 1.13 percent of their income on learning  $\epsilon_{t+1}$ . This corresponds to a 53.1 percent chance of learning the true potential bad-bank share. If mean malfeasance is high at time  $t$ , households do not find it optimal to monitor. This is because the state of mean malfeasance affects returns more than the realization of  $\epsilon_{t+1}$  so learning is of less value when malfeasance is likely to be high at  $t + 1$ .

When monitoring is optimal at time  $t$  (i.e., when the time- $t$  mean malfeasance state is low), table 3.7 shows that information on an impending negative shock to  $\epsilon_{t+1}$  reduces investment in banking, on average, to 45 percent of savings. News of a positive shock triggers a corner solution and individuals invest all their assets in banking, as opposed to an average of 86 percent in the no-monitoring case. The effect of informed individuals on the aggregate allocation also makes this corner solution optimal even for agents for whom monitoring generates no information.

Average allocation to banking	Informed of increased stealing $\epsilon_{t+1} > 0$	No information on $\epsilon_{t+1}$	Informed of decreased stealing $\epsilon_{t+1} < 0$
$\alpha_{H,t}$	—	0.28	—
$\alpha_{L,t}$	0.45	1.00	1.00

Table 3.7: Effect of Information on Allocation to Banking.

Figure 3.9 and table 3.8 show that monitoring makes relatively little difference to the economy. Consumption when young and old does tend to be higher with monitoring. But the equilibrium is inefficient as agents replicate their efforts to learn the value of  $\epsilon_{t+1}$ . Moreover, the downside to early information is more economic volatility. Still, calculated as a compensating variation using eq. (3.28), households are 1.2 per cent better off in terms of lifetime expected utility than in the baseline if they can monitor. Relative to deposit insurance, however, monitoring improves welfare by 5.4 per cent. This is a substantial differential. Unfortunately, monitoring can suffer from free-riding.

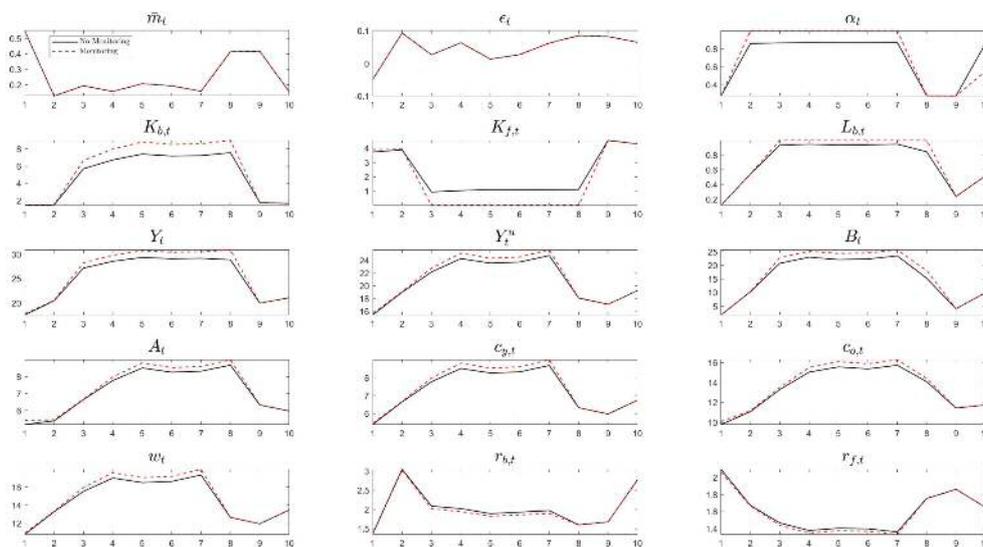


Figure 3.9: An Example Transition With and Without Monitoring

Variable		Baseline		Monitoring		% Change	
		Mean	Std.	Mean	Std.	Mean	Std.
Output	$Y$	23.12	4.25	23.16	4.56	0	+7
Unstolen Output		18.08	3.19	18.31	3.24	+1	+2
Consumption when Young	$C_y$	6.33	1.11	6.41	1.13	+1	+2
Consumption when Old	$C_o$	11.75	1.78	11.9	1.83	+1	+3
Annualized Bank Returns		2.04	0.77	2.01	0.78	-2	+1
Annualized Farm Returns		2.01	0.58	1.96	0.53	-2	-7
Allocation to Banking	$\alpha$	0.57	0.29	0.57	0.32	0	+10
Bank Capital	$K_b$	3.88	2.42	3.93	2.63	+1	+9
Farm Capital	$K_f$	2.45	1.47	2.48	1.77	+1	+20
Savings	$A$	6.33	1.12	6.41	1.14	1	+2
Bank Labor	$L_b$	0.56	0.32	0.56	0.35	-1	+10
Wages	$w$	12.66	2.23	12.82	2.27	+1	+2

Table 3.8: Average Values with Monitoring

### 3.7.2 Information as a Public Good

Previously, report results were assumed to be private. We now allow some households who did not receive information to learn the value of  $\epsilon_{t+1}$  at zero cost with probability  $l$ . The decision to purchase reports takes into account the probability of receiving information for free. The probability of receiving

information is now  $d$

$$d(n_t) = l + (1 - l)p(n_t) \quad (3.36)$$

Households take  $l$  as given. The marginal increase in the probability of learning the value of  $\epsilon_{t+1}$  from purchasing an additional report is now reduced based on the extent of these leaks, i.e.,

$$\frac{\partial d}{\partial n_t} = p'(n_t)(1 - l). \quad (3.37)$$

Clearly, as the fraction of leaked reports,  $l$ , increases, the marginal benefit of purchasing reports decreases. This leads to fewer reports in equilibrium. Figure 3.10 illustrates how the prospect of learning the true value for free reduces private monitoring.

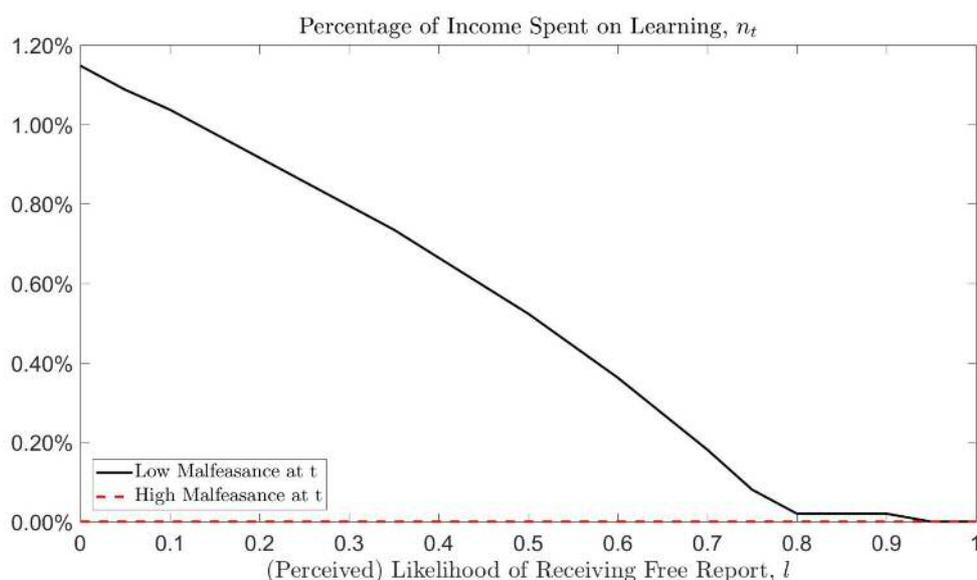


Figure 3.10: The Effect of Free Reports on Monitoring Expenditure

If households expect the probability of a leak to be above 0.8, only .02 percent of wages is spent on monitoring, yielding a probability of learning of just .02. Sufficiently high free-riding eliminates monitoring, i.e., the economy reverts to the baseline case where no information on the realization of  $\epsilon_{t+1}$

is available. The free-riding problem of investor-funded ratings is noted in Warwick Commission (2009).

### 3.8 Regulation Through Disclosure

Suppose the government can pay a cost to reduce the average malfeasance share by  $\phi$ , replacing eq. (3.15) with

$$m_t = (\bar{m}_t - \phi) + \epsilon_{t+1}. \quad (3.38)$$

To pay for this, we impose a lump sum tax on the old equivalent to the average cost of deposit insurance,  $\tau_{Disc,t} = \bar{\tau}_{DI} = 2.93$  or  $12.7$  percent of output.

$$c_{o,t+1} = A_{t+1}[1 + (1 - \alpha_t)r_{f,t+1} + \alpha_t\tilde{r}_{b,t+1}] - \tau_{Disc,t}. \quad (3.39)$$

Figure 3.11 considers the impact of this expenditure assuming the government is able to reduce malfeasance by either  $\phi = 0.2$  or  $\phi = 0.4$  after spending  $\tau_{Disc,t}$ . Recall that  $\bar{m}_s$  is either  $\bar{m}_H = 0.50$  or  $\bar{m}_L = 0.22$ . The comparison economy is that with deposit insurance.

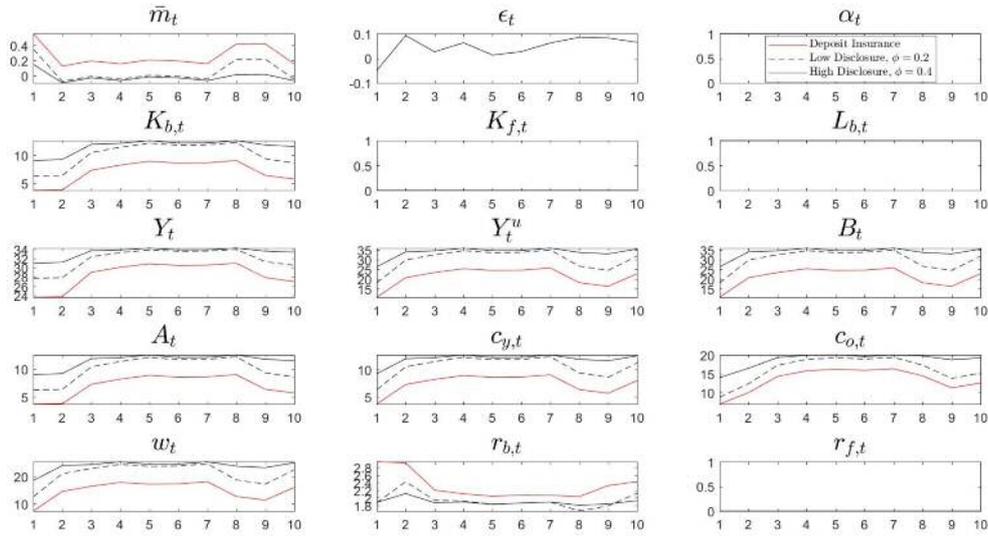


Figure 3.11: Economies with Low and High Disclosure and Deposit Insurance.

Disclosure raises non-stolen output, wages, capital formation and consumption. Increasing the share of honest bankers encourages households to enter the banking sector in much the same way as deposit insurance. However, deposit insurance does nothing to eliminate fraud. As expected, the economy does far better if government disclosure is high. Average results for both levels of disclosure are reported in tables 3.9 and 3.10.

Variable		Baseline		Low Disclosure		% Change	
		Mean	Std.	Mean	Std.	Mean	Std.
Output	$Y$	23.12	4.25	30.94	1.92	+34	-55
Non-Stolen Output		18.08	3.19	26.14	5.33	+45	+67
Consumption when Young	$C_y$	6.33	1.11	9.15	1.87	+45	+67
Consumption when Old	$C_o$	11.75	1.78	14.06	2.99	+20	+68
Annualized Bank Returns		2.04	0.77	2.11	0.33	+3	-57
Annualized Farm Returns		2.01	0.58	-	-	-100	-100
Allocation to Banking	$\alpha$	0.57	0.29	1.00	0.00	+75	-100
Bank Capital	$K_b$	3.88	2.42	9.14	1.87	+136	-23
Farm Capital	$K_f$	2.45	1.47	0.00	0.00	-100	-100
Savings	$A$	6.33	1.12	9.14	1.87	+44	+67
Bank Labor	$L_b$	0.56	0.32	1.00	0.00	+77	-100
Wages	$w$	12.66	2.23	18.30	3.73	+45	+67

Table 3.9: Average Values with Low levels of Disclosure,  $\phi = 0.2$

Variable		Baseline		High Disclosure		% Change	
		Mean	Std.	Mean	Std.	Mean	Std.
Output	$Y$	23.12	4.25	32.75	0.88	+42	-79
Non-Stolen Output		18.08	3.19	31.20	2.79	+73	-12
Consumption when Young	$C_y$	6.33	1.11	10.92	0.98	+73	-12
Consumption when Old	$C_o$	11.75	1.78	17.35	1.54	+48	-14
Annualized Bank Returns		2.04	0.77	2.09	0.15	+2	-81
Annualized Farm Returns		2.01	0.58	-	-	-100	-100
Allocation to Banking	$\alpha$	0.57	0.29	1.00	0.00	+75	-100
Bank Capital	$K_b$	3.88	2.42	10.92	0.98	+181	-60
Farm Capital	$K_f$	2.45	1.47	0.00	0.00	-100	-100
Savings	$A$	6.33	1.12	10.92	0.98	+73	-12
Bank Labor	$L_b$	0.56	0.32	1.00	0.00	+77	-100
Wages	$w$	12.66	2.23	21.84	1.96	+73	-12

Table 3.10: Average values with High Levels of Disclosure,  $\phi = 0.4$

Figure 3.12 compares average output, non-stolen output and lifetime consumption in the regimes discussed. Deposit insurance boosts output, but not non-stolen output or consumption. Monitoring, even ignoring free riding, makes little difference to the equilibrium. Low disclosure references a government-instigated reduction in the share of bad bankers of  $\phi = 0.2$ . This reduces non-stolen output and consumption considerably despite the high cost of regulation, assumed to be equal to the cost of deposit insurance. High disclosure, reducing the malfeasance share by  $\phi = 0.4$ , produces further gains.

The downside to a modest reduction in malfeasance is that it encourages investment in banking while still permitting shocks to malfeasance to cause volatility. Volatility under limited disclosure is similar to that under deposit insurance. This is illustrated in fig. 3.13, which depicts the standard deviation of key variables compared to the baseline. Significant disclosure solves this problem.

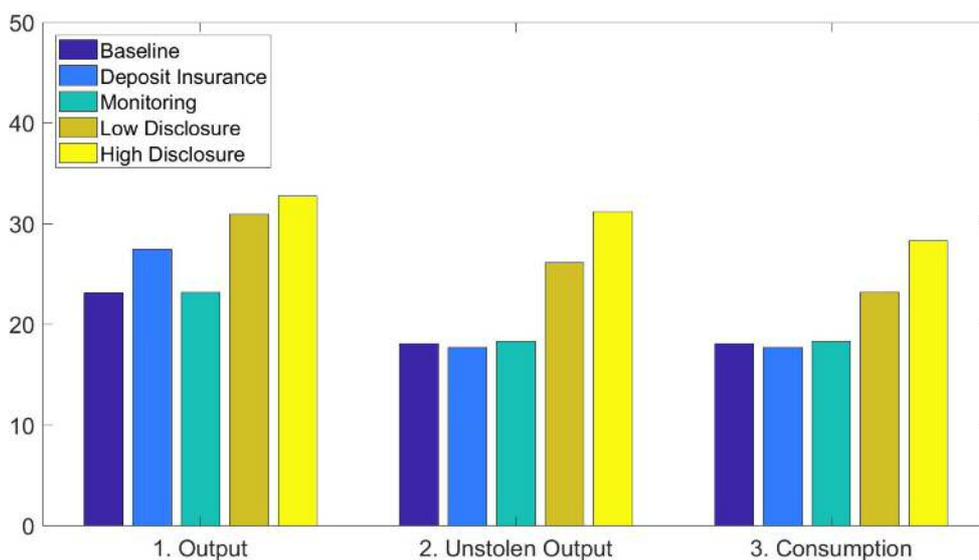


Figure 3.12: Comparing Means of Aggregates in Different Regimes.

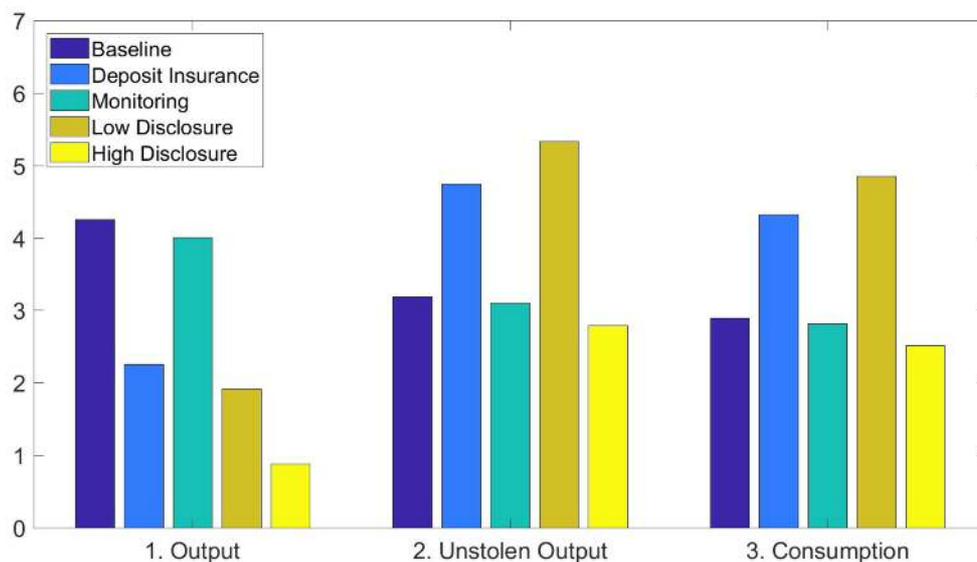


Figure 3.13: Comparing Variability of Aggregates in Different Regimes.

Table 3.11 reports compensating variations. They are calculated as the percentage change in consumption, in all states, needed to produce the same expected utility as in the baseline, measured by averaging realized lifetime utility over 10,000 generations beginning after the economy has been operating for 20 periods.<sup>24</sup> The table shows that, compared with the baseline, deposit insurance is 4.1 percent less efficient, monitoring is 1.2 percent more efficient, a low level of government disclosure is 23.3 percent more efficient, and a high level of government disclosure is 37.9 percent more efficient.

Regime	Percentage Compensating Differential
Deposit insurance	-4.1%
Monitoring	1.2%
Low disclosure, $\phi = 0.2$	23.3%
High disclosure, $\phi = 0.4$	37.9%

Table 3.11: Percentage Compensating Variations

<sup>24</sup>In making these calculations we consider the same sequence of shocks for each setting.

### 3.9 Conclusion

Banking crisis, throughout the ages, have been precipitated by the exposure of bad/malfeasant banks (bankers). This news leads the public to defund the banks, often precipitously, which is termed a liquidity crisis. Under this, our paper's view, liquidity crises are the result of, not the cause of financial retrenchment with its attendant economic decline. The medium for financial malfeasance in all its manifestations is financial opacity. Leading up to 2008, opacity provided full cover for liar loans, no-doc loans, NINJA loans, Mad-off's swindle, originate-to-distribute abuses, CDOs-squared and other highly complex tranching derivatives, unreported CDS positions, ratings shopping, failures (with government approval) to mark assets to market<sup>25</sup> and the list goes on. The revelation of financial fraud amidst the financial fog produced the rush to liquidity that eventuated in the downfall of so many high profile banks. Had there been no malfeasance there likely would have been no crisis.

If, as modeled here, the revelation of "good" bankers gone bad rather than of bad things happening to good banks is the source of financial crisis, dramatically expanding the government's role in verification and disclosure of assets may be the answer. This prescription is the polar opposite of those who tout opacity as essential for maintaining liquidity of bank liabilities. The difference in perspective arises in the case of counterfeit currency. If no one knows that some currency is counterfeit, both bad and good currency will be sources of liquidity. Disclosing the counterfeits can produce a run on, actually, a run away from the currency. Is society better off suppressing news of the counterfeits and letting them continue to circulate? Doing so maintains liquidity, but permits ongoing theft and risks financial panic if news leaks out. The answer, in practice, is no. Counterfeiters are disclosed and prosecuted as a public service.

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<sup>25</sup>See Andolfatto and Martin (2013)

No one would expect private citizens to actively investigate counterfeiters. But when it comes to banking, many have faulted investors, the vast majority of whom are quite small, for failing to keep track of their banks' behavior. Indeed, the central premise of Dodd-Frank – that public funds will no longer be used to bail out private banks – appears predicated on the assumption that investors, knowing they are at risk, will better monitor their financial institutions. This flies in the face of the free riding problem. Just as government is needed to monitor, uncover, and disclose counterfeiting, our model suggests that government is needed to verify and disclose, in real time, all bank assets and liabilities.

## Chapter 4

# A Tale of Two Bailouts

*Capital losses from government investments during the crisis turned out to be smaller than expected. Funding costs from these investments were reduced by quantitative easing but include a bill, yet to be paid, from unwinding QE. We estimate the cost of both, in real terms, for the U.S. and U.K. We are careful to separate fees from services rendered, such as insurance provision and underwriting, from repayments. The US bailout is dominated by the effect of the GSEs, without whom, the program would have made losses. The UK bailout is dominated by the funding arrangement with the Bank of England by which it receives payments today which will be reversed later. In both countries, the funding rate paid by banks is significantly lower than the rate paid to bank equity during the same period, with adverse consequences for incentives. We model the drag on growth due to government indebtedness as a result of actions taken during the GFC. We advocate and model a market solution to prevent crises known as ‘narrow banking’.*

## 4.1 Introduction

A decade on since recapitalization of banks in 2008, we are in a position to calculate the taxpayer's return on investment. This Chapter has 3 parts. The first part is a discussion of the effect of large scale bond purchases (\$2.3 trillion (11.6% GDP) in the US, £435 bn (22% GDP) in the UK) in reducing the cost of funding the emergency bank recapitalization programmes. However, because government bonds were bought 'above par' so as to reduce the rate, unwinding these schemes will invoke a considerable cost proportionate to the *stock* of bonds outstanding. In section 4.2, we illustrate this little-known cost and use Bank of England projections to estimate the QE 'exit bill'.

The second part uses data from SEC filings in the US<sup>1</sup> and annual reports of the British government holding company, UKFI Ltd, to track payments between governments and financial intermediaries.<sup>2</sup> Unlike Treasury reports, we include the effects of inflation and are careful to separate fees received as the result of a separate program to underwrite bank liabilities. The coverage of these guarantees was staggering and led to taxpayers taking on huge risk<sup>3</sup> Fortunately, much of this insurance did not need to pay out as many banks were averted from failure, due in large part to recapitalization program. Proceeds from this guarantee programs of \$10.9bn in the USA and £5.2bn in the UK (Schich (2009)) do not relate to the recapitalization programs and reflect risk taken by the taxpayer. Section 4.3 reports the results. In the U.S., we agree with headline results that these programs have been profitable, even in

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<sup>1</sup>We thank Paul Kiel at ProPublica for making the data available.

<sup>2</sup>Figures are verified using Congressional Budget Office (CBO) and Office of Budget Responsibility (OBR) reports in each country.

<sup>3</sup>The Temporary Liquidity Guarantee Program of the F.D.I.C. offered loan guarantees on \$345.8bn of bank debt. In addition, Bank of America obtained \$100bn of guarantees and Citigroup \$306bn guarantees. The program closed, with no payment made, on 23 December 2009. The U.K. government also temporarily underwrote all new bank debt with £250bn guarantees. In addition, the Asset Protection Scheme covered £280 billion of the government controlled RBS. The UK government estimates that peak coverage was £1,029bn or 61% of 2009 GDP. <https://www.nao.org.uk/highlights/taxpayer-support-for-uk-banks-faqs/>.

real terms. In the U.K., the government's stake in the Royal Bank of Scotland is yet to be sold, but will likely make a large loss, rendering the whole program loss-making. In both countries, returns are below the average return on bank equity during the same period. The aim of producing figures on funding costs during the crisis is to be mindful of its effects on incentives. Bank executives can reasonably use these figures to forecast the cost of funding in the event of another crisis, which they can weigh against potential reward. Given that funding costs were not high, such rates imply it is profitable for banks to bet heavily on risky assets when an economic boom arrives. Macro-prudential policy should be aware that counter-cyclical buffers may have to be large to combat this change in incentive. This will happen at exactly the time it will be difficult to do so, for fear of stalling a nascent recovery.

In Section 4.4, we provide a theoretical model of a narrow banking system<sup>4</sup> where government assistance is ruled out. Liquidity is provided by narrow banks who may only hold government bonds. We compare a system with a government guarantee policy. Our results capture both the regressive nature of the government guarantee policy and the tax burden it implies. An argument that runs through Treasury reports is that the aim of emergency recapitalization was not investment but stabilization. Even negative returns are preferable to the 'melt-down' scenario which would have occurred without the policy. However, this is a counter-factual scenario conditional on balance sheet position of banks in 2008. Prior to the GFC, banks priced in the fact that the Federal Reserve had previously intervened to prevent failure. For example, Continental Illinois received federal funds in 1984 to ensure bondholders did make losses and Long Term Capital Management were able to reject a private deal in favor of a Fed loan in 1998 (Van Duyne, Brewster, and Tett (2008)). Given bank leverage at the time, a decision to not intervene

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<sup>4</sup>See Fisher (1935); Tobin (1987); Friedman (1960); Kay et al. (2010); Benes and Kumhof (2012); Cochrane (2014); Pennacchi (2012).

allow banks to fail is likely to have led to a dramatic loss in confidence as was feared at the time. However, the unconditional counter-factual is to compare to a scenario where banks did not expect assistance and took sufficient precautions to prevent their failure.

## 4.2 Quantitative Easing

Normalization requires either selling the bonds purchased during QE or allowing the bonds to mature, equivalent to ‘selling’ the bond for its face, or ‘par’, value. Central Banks then ‘destroy’ cash received in exchange for these bonds, reducing the money supply. The real return to these bond holdings is the difference in price after taking into account coupon payments and inflation. As the purpose of QE is to drive up prices by mass buying, the price paid was high. Similarly, the price these bonds sell for could be low, depending on how fast the reverse QE is conducted and the response of financial markets. Central banks could well make large losses on these investments.

Of course, profit was not the aim of QE but the cost must be accounted for. Treasury reports compare these costs to the counterfactual of the Great Depression, when such interventions were not undertaken and the economy suffered. We posit that the true counterfactual is an economy in which measures had been taken to prevent catastrophic bank loss in the first place. Certainly, the swift response of central banks worldwide in 2008 to 2009 prevented a far worse outcome. However, this is because investors expected to be rescued and no system was in place to maintain liquidity throughout bank failures. Indeed, by providing capital on favourable terms, governments have demonstrated the power of the ‘Too Important To Fail’ to extract emergency support.<sup>5</sup>

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<sup>5</sup>Brewer III and Jagtiani (2013), Freixas and Rochet (2008) suggests this policy encourages mergers so that banks become “systemically important”. Minsky (1986) argues that such policies create ‘perceptions of safety’ which leads to further financial instability.

If reverse QE is conducted by simply allowing bonds to mature, the return will be the difference in price paid and the face value of the bonds.

#### 4.2.1 US

In the USA, QE is often referred to as “Large scale asset purchases”, which is carried out by SOMA (System Open Market Account Holdings), the New York based Federal Reserve agency for the conduct of open market operations. The policy has been rather different in the US than in the UK, mainly because in the US a large part of assets purchased have been mortgage debt, either purchased directly from the two Government Sponsored Enterprises (GSEs) Freddie Mac and Fannie Mae<sup>6</sup>, or in the form of Mortgage Backed Securities (MBS). In 2018, these two assets accounted for over 42% of SOMA assets.

Prior to QE, SOMA assets had totalled \$650bn in 2003 and \$750bn in 2006. The assets in this period were mainly treasury notes and Bonds<sup>7</sup> (62%), treasury Bills (36%) and the rest TIPS<sup>8</sup> (2%), held for the conduct of open market operations. Unlike the UK, the Federal Reserve is not restricted in its ability to directly buy government assets, and so no new institution like the Asset Purchase Facility needed to be set up to conduct QE. QE in the US was implemented in three waves . In 2008, the assets of SOMA fell to a low of less than \$500bn, as the Fed reduced its holdings of Treasury Bills from \$227bn to just \$18.4bn. The QE started at the end of 2008, firstly with an increase in Treasury notes and bonds (TNB) followed by a larger increase in MBS in early 2009, with Treasury bills held constant. The total assets of SOMA stood at about \$2 trillion from March 2010 to the end of that year, with MBS almost reaching 55% of the total in July 2010. QE2 started in

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<sup>6</sup>The official names are Federal Home Loan Mortgage Corporation (FHLMC) and Federal National Mortgage Association (FNMA)

<sup>7</sup>Treasury Bonds have a maturity of 30 years. Treasury Notes maturities of 2,3,5 or 10 years.

<sup>8</sup>Treasury Inflation Protected Securities, with maturities of 5,10 or 30 years.

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late 2010 and ended in mid-2011, with large scale purchases of Treasury notes and bills of \$600bn. By June 2011, the SOMA assets stood at \$2.6 trillion<sup>9</sup>. QE3 took a different form to the previous two rounds: it was an open ended commitment to purchase \$40bn assets per month which was later raised to \$80bn. The purchases commenced in April 2013 and continued until October 2014, bringing total SOMA assets to \$4.2 trillion, where it has remained to the present day. QE3 saw an increase in holdings of both TNB and MBS. In February 2018 55% of SOMA assets were TNB, 42% MBS with 2.7% in TIPS and the rest in other assets. Since US nominal annualized GDP in the last quarter of 2017 at \$19.7 trillion, QE represented 21% of US GDP.

Total federal debt is \$20.9 trillion, of which \$5.7 trillion is held by government institutions (social security being the largest, along with various retirement funds and medicare). The remaining \$15.2 trillion is classified as “Debt held by the public” (DHBP) which includes the Fed’s SOMA assets<sup>10</sup>. Hence SOMA assets represent about 15.7% of DHBP (which excludes the holdings of MBS).

The Fed was started paying interest on its reserves in 2008 (called “Interest on Excess Reserves”), for which new legislation was required from Congress<sup>11</sup>. The rate was 0.25% until 2015, since when it has been raised as a floor to the FOMC target rate. Since June 14th 2018 the IOER is 1.95%.

The Fed has outlined its plan for the Federal Reserve’s Balance Sheet Normalization in several policy documents, the most recent being in January 2018.

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<sup>9</sup>For details of QE 1 and 2, see Ihrig et al (2012), Expectations about the Federal Reserve’s Balance Sheet and the Term Structure of Interest Rates, <https://www.federalreserve.gov/pubs/feds/2012/201257/201257pap.pdf>

<sup>10</sup>For most recent figures see <https://treasurydirect.gov/NP/debt/current>. The figures in the text were valid on March 2nd 2018

<sup>11</sup>The Financial Services Regulatory Relief Act of 2006 allowed for this to start in 2011. It was bought forward in the Emergency Economic Stabilization Act of 2008.

In September 2014, The FOMC outlined the process of normalization. The general principles can be summarised as:

1. The Federal funds rate will gradually be raised to its target by raising the rate it pays on central bank reserves.
2. “The Committee intends to reduce the Federal Reserve’s securities holdings in a gradual and predictable manner primarily by ceasing to reinvest repayments of principal on securities held in the SOMA.”
3. The FOMC does not intend to reduce holdings of MBS. If it does decide to do so, it will be announced in advance.
4. “The Committee intends to reduce the Federal Reserve’s securities holdings in a gradual and predictable manner primarily by ceasing to reinvest repayments of principal on securities held in the SOMA.”

The first step was undertaken in December 2015 when the Federal policy rate target range was increased from 0.00-0.25% to 0.25-0.5%, with five subsequent rises taking the range to 1.5-1.75% by March 2018<sup>12</sup>.

In 2017, the plan took more shape, as explained in a release on November 9th<sup>13</sup>. There was to be tapering of re-investment of sales with re-investment being done only when resales exceeded a cap (initially \$6bn rising to \$30bn per month) and also extending the tapering of re-investment to MBS (starting at \$4bn and rising to \$20bn per month). The FOMC also made explicit that whilst reserve balances would decrease significantly as securities holdings are reduced, the demand for reserves would probably be greater than prior to the crisis.

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<sup>12</sup><https://www.federalreserve.gov/newsevents/pressreleases/monetary20180321a.htm>

<sup>13</sup>FOMC Communications related to Policy Normalization, November 9th 2017. This includes earlier minutes decisions <https://www.federalreserve.gov/monetarypolicy/policy-normalization.htm>

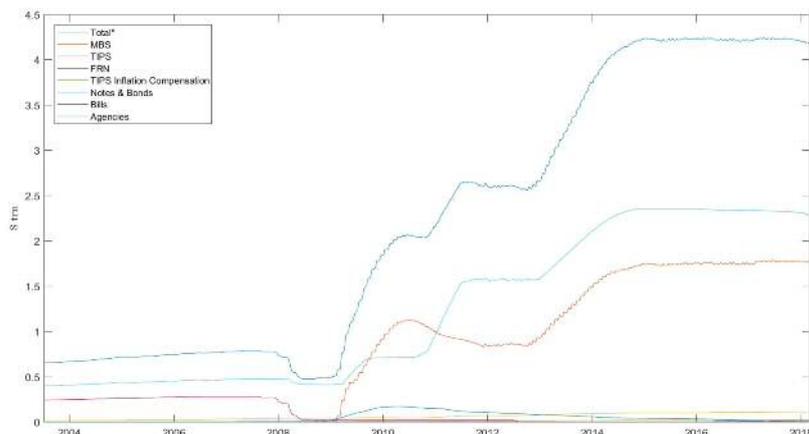


Figure 4.1: SOMA

#### 4.2.2 UK

QE was introduced in March 2009, as a method of reducing long-term interest rates. The official policy “Bank Rate” is a short-term interest rate. This was reduced to 0.5 in 2008. QE was seen as a way of forcing down longer run interest rates: by purchasing bonds it raised their price and hence lowers interest rates.

The formal framework for achieving this was to set up the Asset Purchase Facility (APF): the Bank of England created reserves, which it loaned to the APF for the purpose of purchasing assets under the QE scheme (for most stages of QE, the assets have been predominantly government bonds). Since central bank reserves never rarely leave the Bank, the asset-purchases by the APF resulted in equivalent increases in central bank reserve holdings by commercial banks (the mechanism being that when the bonds were purchased, the bank accounts of the bond-sellers were credited and the reserves moved from the APF). The decisions about QE were taken by the Monetary Policy Committee (MPC), to be carried out by the APF. However, the Treasury (HM government) indemnifies the whole operation and is responsible for the profits

Income £m	2015-16	Balance sheet	
Interest received	18	Assets	
Net gains (losses) on financial instruments	6,652	Cash	1,332
Coupon income received	14,032	Debt Securities	413,346
Total Income	20,702	Total Assets	414,668
Expenditure		Liabilities	
Interest paid on loan from BoE	-1,881	Loans and other Borrowings	375,326
Admin	-2	Due to Treasury under indemnity	39,342
Indemnity due to (from) Treasury	-18,819	Total Liabilities.	414,668
Total Expenses	-20,702		

or losses resulting from QE.

The financial flows between the Bank of England, the APF and the Treasury are as follows. The bank pays the coupons on the bonds owned by the APF to the APF. These constitute the revenue of the APF. After costs, the APF then pays interest on its loan to the Bank of England. The Bank of England then uses this to pay interest (at the policy rate) on central bank reserves (central Bank reserves are approximately equal to the loan to the APF). The excess is paid back to the Treasury by the APF under the heading “Net indemnity to HM Treasury”. This means that one of the effects of QE in the short-run is to improve government finances. In effect, the Treasury is currently only paying 0.25% on that part of its debt owned by the APF. If the debt were still in private hands, the coupons would be based on market conditions prior to QE and would be larger. The 2015-2016 financial statement from the APF has the following figures for the magnitudes of these flows and corresponding stocks<sup>14</sup>: The benefits of QE to the government finances are not fully captured by the money-go-round captured in the APF income-expenditure statement. Normal government bonds issued since the advent of QE will also have a lower interest rate. The low long-term interest rates that QE has bought about greatly aid the government in terms of its re-financing

<sup>14</sup>Annual Report 2015/16, Asset purchase facility fund limited, <http://www.bankofengland.co.uk/publications/Documents/other/markets/apf/boeapfannualreport1606.pdf>.

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needs and funding of deficits.

### 4.2.3 Unwinding QE

However, a nasty cost will need to be paid when QE is reversed and the balance sheet run down or “normalized”, although the story is somewhat different in the UK and US for various reasons we will discuss. Essentially, unwinding QE is the reverse of the initial expansion. We will first consider the UK case in detail. It is first worth noting that unlike the US, the UK MPC has not outlined a plan for unwinding QE. Whilst it is widely assumed that the Bank of England will implement something similar to the Fed plan, there has been no clear road-map and even the basic step 1 (raise interest rates) has been promised, delayed and promised again with no clear forward guidance given. Of course, the Brexit process was initiated with the referendum in June 2016, but as of 21 June 2018 the interest rate remains at 0.5%, the same level it was in March 2009. Whilst individual members of the MPC have called for unwinding<sup>15</sup>, the subject has scarcely been touched on in the MPC minutes.

The APF can sell bonds to the private sector. The APF then uses this cash to pay off the loan from the Bank, resulting in a canceling out of central Bank reserves. To see how this works, when investors buy the bonds, their private sector banks will pay the cash to the APF resulting in a fall in private banks’ reserves at the central bank equal in value to the purchase price of the bond. However, this process can lead to a cost because the long-term interest rate on the bonds will be higher when the bonds are sold. The process of asset purchases was started once the policy interest rate was at 0.5%, and the process of sale will not start until the policy rate has risen to a value of perhaps 1.5% (if we take the American experience as a model). Furthermore, the act of selling bonds will probably exert a downward pressure on bond prices.

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<sup>15</sup>see for example <https://www.independent.co.uk/news/business/news/bank-of-england-quantitative-easing-programme-end-435-billion-ian-mcafferty-interest-rates-qe-a7838581.html>

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To illustrate this most simply, suppose we have a consol, which pays a fixed amount in perpetuity. Its market value is simply the annual rate divided by the interest rate. Take a £100 pound annual coupon. With interest rates at 0.5%, this is worth £20,000. However, if the interest rate rises to 4% as bonds are sold, this is worth only £2,500. There is a large potential loss as the unwinding of QE leads to higher interest rates. Indeed, even if QE is not unwound, but the short term policy rate is raised and this leads to a rise in long-term rates there is still a loss in terms of the change in the value of the asset on the balance sheet. In practice, the calculation of this loss is rather more complicated than the simple example of consols: each bond is a schedule of payments stretching over a period of time (as long as 30 years) and bonds are at different stages in their life-cycle. However, the losses involved will be very large.

At the end of 2012, the APF started to pay the coupon payments from the Treasury on its bonds back to the treasury<sup>16</sup>. Prior to this, the Bank of England had been saving the coupons so that it could repurchase debt as it matured or was sold back to the public<sup>17</sup>. The value of a bond is the net present value of its coupon payments and its redemption value. If interest rates are constant, you will need to reinvest all of the coupons so that when the bond matures you can replace it with an equivalent bond using the redemption value plus cumulated coupons (with interest). However, the British Treasury preferred the payback arrangement as it reduced the size of the current government deficit. It should be noted that the whole of the coupon was

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<sup>16</sup>Larry Elliot, “Bank of England to hand over gilts interest payments to slash national debt”, Guardian 9th November 2012. <https://www.theguardian.com/business/2012/nov/09/bank-of-england-gilts-interest>

<sup>17</sup>In the same article, Larry Elliot quotes Mervyn King “While transferring the APF’s net income to the exchequer will result initially in payments from the APF to the government, it is likely to lead to the need for reverse payments from the government to the APF in the future as bank rate increases and the APF’s gilt holdings are unwound by the monetary policy committee (MPC). Indeed, under reasonable assumptions, it is likely that the majority of any transfer of funds to the government will eventually need to be reversed.

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not repaid to the Treasury: the Bank of England only paid the coupon *after deducting the interest payments on commercial bank reserves at the central bank*. However, if we consolidate the public sector, the fact that the Treasury receives this income means that it has to issue less new debt to fund the government debt now, but may have to issue further debt to make up for the loss incurred by the APF.

The Bank of England has calculated the size of this final bill under several scenarios. The first was an interactive spreadsheet published on the Bank of England website in 2013, but subsequently taken down<sup>18</sup>, the second a listing of alternative scenarios put up in 2016. If we assume that nominal interest rates rise to a new normal of inflation target plus 2%, i.e. 4%, then the Bank of England's own figures estimate the end cost to be £60-100bn (scenarios 10 and 14), assuming a 200bp effect on interest rates. The Treasury and the tax-payer are responsible for this final bill.

If we take the whole history of QE, it has been argued that the Treasury will have come out a winner: the flow of payments to the Treasury during QE will have given the Treasury the ability to pay off this final bill with quite a lot left over. Whilst the final bill might be as much as £60-100bn, the cumulated revenues will be greater being over £100bn. If we take the the most recent update provided by the Bank of England.<sup>19</sup> The Bank Rate is projected to increase to 2 percent over a period of 5 years. Stock reduction is assumed to begin when Bank Rate reaches 2%, following previous MPC judgements, and proceeds at a pace of £10bn of gilts per quarter. The start of stock reduction is assumed to have a 400bp impact on gilt yields. Figures are based on data as at 31st March 2017. These assumptions result in a net gain to the Treasury of £5.2bn. This is the result of a forecasted £103.3bn rebated from the APF

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<sup>18</sup>The Excel spreadsheet is available from the authors on request.

<sup>19</sup><https://www.bankofengland.co.uk/quarterly-bulletin/2013/q1/the-profile-of-cash-between-the-apf-and-hmt>

to the Treasury, and a subsequent £98.1bn returned as QE is unwound.

Since the unwinding of QE will have a major negative impact on public finances. Perhaps we could just leave the balance bloated balance sheets as they are indefinitely. There are two problems here. First, if policy rates are normalized but QE left in place, then the APF will be in a position where the market value of its assets is less than the book value. It will become insolvent. This may not be a problem because the Bank of England is the only creditor of the APF and it can be expected to keep its loan in place. However, the other problem is the potential for an explosion in the money supply.

QE was often reported in the press as “printing money”: the bonds were purchased by money created by the Bank. This could have led to a big increase in the money supply and hence inflation. However, it did not. The reason for this is that the financial crisis had led to a collapse in commercial bank lending, lending being the main driver behind creating money (we are talking about M4, the broad money supply that includes bank deposit accounts). The “money multiplier” is the process by which the banking system creates money: deposits are made by firms and households into banks, which are then lent out again by banks (subject to some reserves held by banks to cover depositor’s cash needs). The banking system takes a relatively small amount of cash (plus reserves) and turns it into the broad money supply. In 2006, the size of the money supply M4 was £1.5 trillion, equal to the size of nominal GDP. When banks stopped lending (both to each other and to firms and households) during the financial crisis this created a gap into which the government could step, buying up its own debt without causing an explosion in M4.



Figure 4.2: QE and Balances at Bank of England, authors' calculations

The overall behaviour of the broad money supply is depicted in fig. 4.3. The left hand axis gives magnitudes in millions. The dotted line is nominal GDP, which simply serves as a reference value. On the bottom right corner you can see the same amounts for QE and reserves as were shown in fig. 4.2. We show the M4 quantity as the grey line, and the blue line is M4 net of QE.

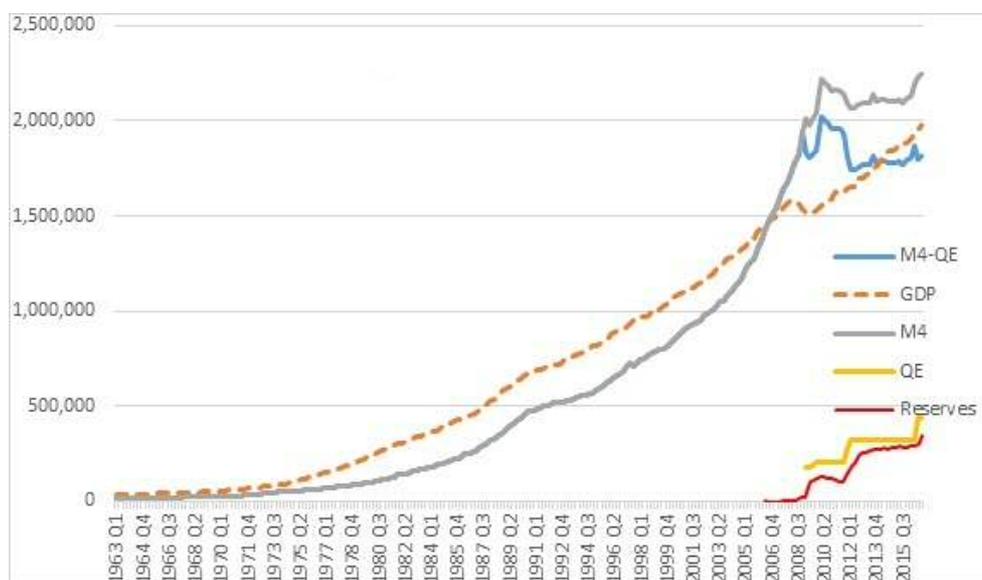


Figure 4.3: M4 and QE, authors' calculations

As we can see, although there was a big increase in M4 during the height of the crisis in 2009 up to a peak in the first quarter of 2011, after that the level of the money supply fell and remained more or less constant until 2016 during which it has resumed growth. If we net out the money generated by QE, we can see that since the crisis the money supply has been fairly level at around its pre-crisis value.

The level and growth of the money supply have not been targeted by the Bank of England since the monetarist experiment in the 1980s, but are an essential statistic. The money supply captures the creation of money via loans within the banking system and also injections from the public sector. The money supply is increased by the public sector when the fiscal deficit is not funded by issuing new bonds (a process called monetization), and more recently by QE.

If the money supply increases at a sustained rate which is significantly greater than the growth of nominal GDP, this can lead to future inflation,

both as reflected in CPI (the price of goods and services) and also asset prices. Even if CPI inflation is not generated, asset price inflation can lead to bubbles (for example in housing or the stock market) which can, as we have learned, have adverse consequences.

This means that QE may be storing up problems for the future. If banks decide to start lending more the money to households and firms, then without policy changes there could be an explosion in the money supply. This could happen very quickly. Thankfully, QE can provide its own solution to this problem. The Bank of England can sell back the bonds it owns in order to maintain a target ceiling of growth in the money supply. For example, since inflation is 2% and the real economy is growing at around 2%, nominal GDP should grow at around 4% per annum. This would indicate that the annual money supply growth should be kept (for example) to no more than 5% - nominal GDP growth plus 1% (as is clear from fig. 4.3, there is a long-run trend for M4 growth to exceed nominal GDP growth, reflecting natural variations in the “velocity of circulation”). The exact “upper bound” or ceiling for monetary growth would need to be decided by the MPC, the figure of 5% is simply a ball park illustration. The rate at which QE is unwound will then depend on the behavior of the private sector – essentially bank lending<sup>20</sup>. Note that QE may not be completely reversed. It may be that due to changes in regulations and lessons learned, the money multiplier has permanently decreased. In that case, part of the QE assets may remain on the Central Banks balance sheet for a long time (until they naturally mature).

We have discussed the UK scenario for unwinding QE in some detail. The US case is different in two major ways. simpler. First, the size of FED bonds held by SOMA are a much smaller percentage of GDP than the Bank

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<sup>20</sup>There is a flow of funds equation determining monetary growth. The three main factors are monetization by the government (the deficit less net new bonds), new bank lending to the private sector, and capital inflows.

of England's. Also, the US treasury bond market is much larger than the UK market relative to GDP. US bonds have a much shorter life than UK bonds: in 2016 the flow of bonds coming to maturity in the US and needing to be refinanced was 16% of GDP, in the UK just 6.2%. Thus the impact of unwinding QE on interest rates might be small in the US compared to the UK. The second difference is the fact that a large part of the SOMA balance sheet is constituted by MBS. These have an uncertain value (although the Fed may have an accurate internal valuation). It is hard to make an estimate of the potential loss (or gain) from the resale of these assets.

In the US the process of unwinding has just started, so it will soon become clearer what the impact of normalization might be. Long-term interest rates have indeed been rising: in September 2017 the rate on 10 year treasuries was 2.2%, in May 2018 it was 3.0%.

Name	Start	End	Total Spent (\$bn)	Assets Bought	Notes
QE 1	Nov 08	Mar 09	100	GSE debt	
QE 1	Nov 08	Mar 09	500	Agency MBS	
QE 1 (extended)	Mar 09	Mar 10	750	Agency MBS	
QE2	Nov 10	Jun 11	600	Long-term Treasury bonds	\$75bn per month
Operation Twist	Sep 11	Jun 12	400	Long-term Treasury bonds	Sold short-term treasuries.
QE3	Sep 12	Dec 12	120 *	Agency MBS	\$40bn per month.
QE3	Dec 12	Dec 13	1020 *	Agency MBS	\$85bn per month.
Tapering QE3	Dec 13	Oct 14	320 *	Agency MBS	Reduced by \$10bn per month

Table 4.1: QE in the USA. \* indicates authors' calculations.

## 4.3 Bank Recapitalization and Nationalization

### 4.3.1 USA

The USA assisted 976 entities - including the automotive industry. The first entry in fig. 4.4 reports the real value of total funds dispersed in the form of loans and purchases under US programs as \$668.5bn. On top of this, a further \$29.7bn was made available under the Making Home Affordable program bringing the total to \$698.2bn. These subsidies were not expected to be returned and we do not include them when calculating returns.

The second entry reports the real value of funds returned under all programs at \$758.1bn, indicating a healthy real profit of \$89.6bn. This figure includes repayments, dividends and interest payments, plus proceeds from the sale of warrants and provision of loan guarantees. However, proceeds were revenue for services rendered separate from the recapitalization programs and should not be included in returns. Excluding investment proceeds, US programs returned \$737.2bn, a real profit of \$68.6bn. Figure 4.5 illustrates the importance of Government-Sponsored Enterprises to the success of the programs. Excluding GSEs from the analysis and program profits drop to \$18.2bn, and excluding investment proceeds, the program actually made a loss of \$2.7bn. In total, \$207.4bn was dispersed to Fannie Mae and Freddie Mac, which have since repaid \$278.8bn, a profit of \$71.4bn – enough to turn a loss-making program into a profitable one. Figure 4.6 illustrates the timeline of all programs and the effect of omitting investment proceeds and GSEs on the final outcome. Figure 4.7 reports the timeline of repayments of both Fannie Mae and Freddie Mac.



Figure 4.4: Breakdown of US repayments



Figure 4.5: Breakdown of US repayments, excluding GSEs

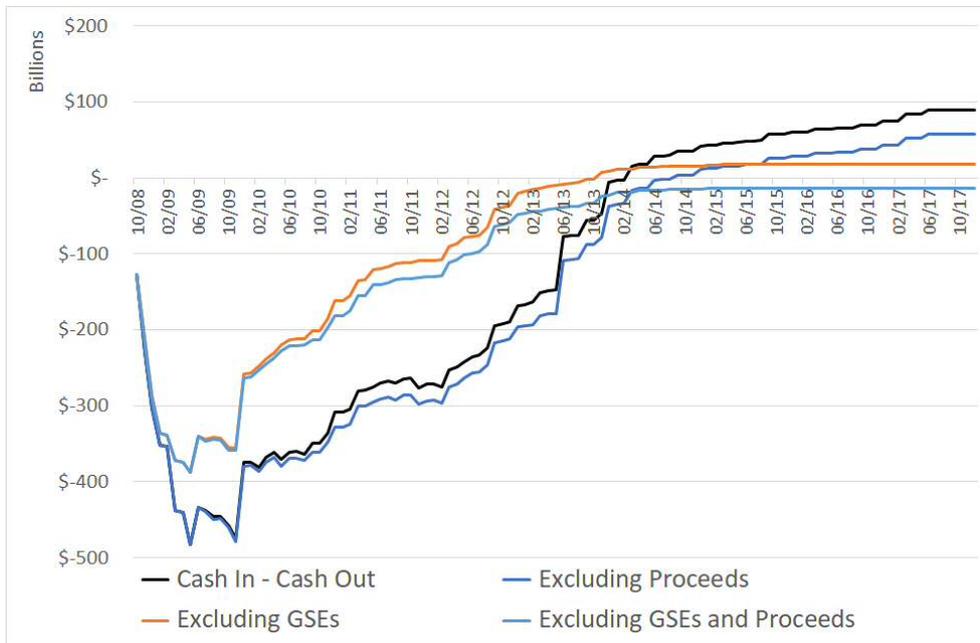


Figure 4.6: USA monthly

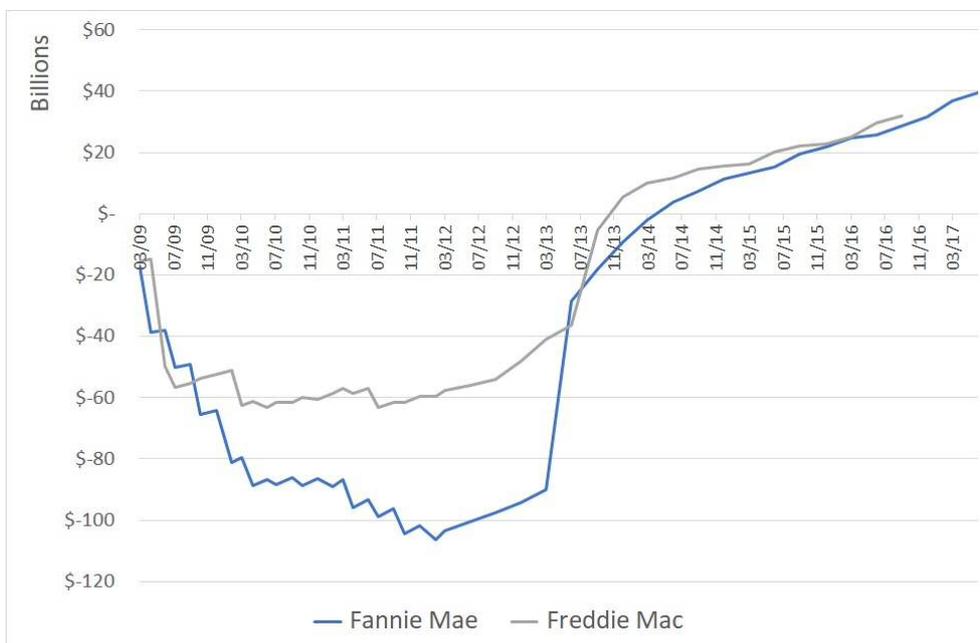


Figure 4.7: GSE graph

Finally, fig. 4.8 illustrates recipients who returned more than their ini-

tial outlay, fig. 4.11, illustrates those who returned less. These figures are ‘cash-in-cash-out’ and include all funds both to and from recipients, including investment income. As described, GSEs are the main ‘winners’ while General Motors is the main loser. figs. 4.9 and 4.10 report the results excluding proceeds from insurance guarantees reveal that AIG, Citigroup and GMAC actually returned less than their investment. The taxpayer took on considerable risk in providing guarantees to these companies and received fees in return. Counting these fees as part of the repayment of recapitalization implies that the companies received loan guarantees for free.



Figure 4.8: Winners \$bn

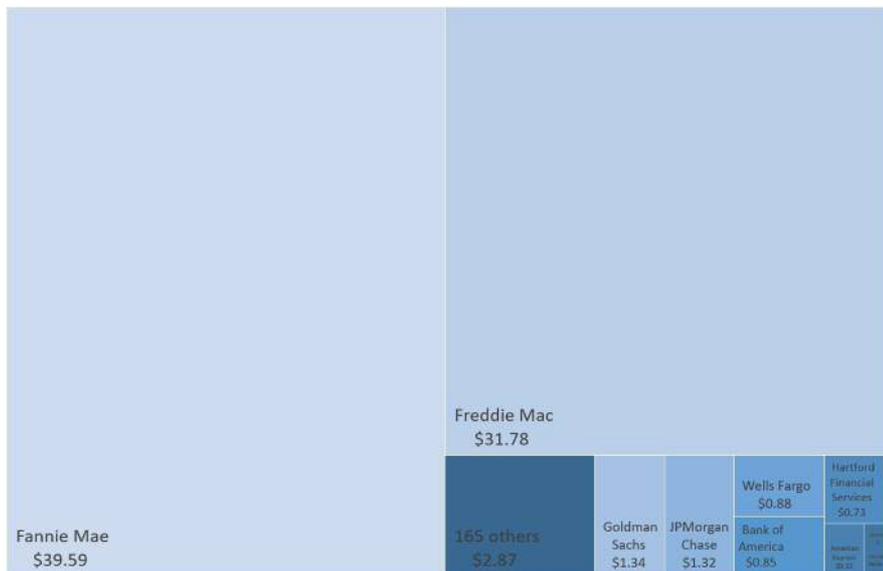


Figure 4.9: Winners, excluding fees from insurance guarantees \$bn



Figure 4.10: Losers, excluding fees from insurance guarantees \$bn

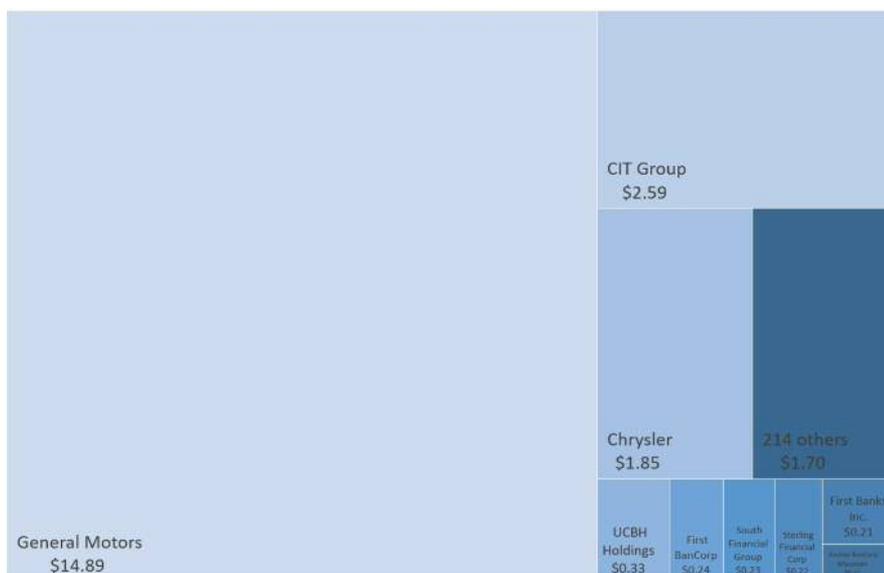


Figure 4.11: Losers \$bn

### 4.3.2 UK

The British program was far smaller, providing recapitalization to only 4 banks<sup>21</sup>. The British government also provided loans to the deposit insurer (the Financial Services Compensation Scheme) to provide compensation for 5 troubled banks<sup>22</sup>. All US stakes have been sold and only the Royal Bank of Scotland is yet to be returned to private hands, which will crystalize a loss to the UK taxpayer of £27.4 billion.

Figure 4.12 illustrates the returns to recapitalization in the UK. Even under the most generous assumption that proceeds ought to be included in measures of return, the program will make significant losses. As stakes in RBS are yet to be sold, we cannot exactly calculate the result of the program. We make a forecast by assuming the government's stake in RBS can be sold at market prices. Table 4.2 reports the losses from each bank as a

<sup>21</sup>Lloyds and Royal Bank of Scotland, plus the full nationalization of Northern Rock and Bradford & Bingley.

<sup>22</sup>Bradford & Bingley, Heritable Bank, Kaupthing Singer & Friedlander Limited, Landsbanki Islands (Icesave), London Scottish Bank

result of the recapitalization program both including and excluding proceeds from insurance guarantees. The first result is that losses due to the Royal Bank of Scotland account for 99 percent of losses including proceeds or 96 percent of losses without. The second result is Lloyds only turns a profit if insurance proceeds of £3.2bn in real terms are used to offset losses from the recapitalization program.



Figure 4.12: Breakdown of UK repayments

Recipient	Inc. Proceeds	Ex. Proceeds
Royal Bank of Scotland	-32,844.66	-34,364.02
Lloyds	+1,960.07	-1,278.18
Bradford & Bingley	-35.05	-35.05
NRAM	-7.41	-7.41
Landsbanki Islands (Icesave)	-0.14	-0.14
Kaupthing Singer & Friedlander	-0.10	-0.10
London Scottish Bank	-0.03	-0.03
Heritable Bank	-0.01	-0.01

Table 4.2: Net gains (losses) from the UK recapitalization program, £m

Figure 4.13 presents the timeline of total funds dispersed and returned

under UK programs which lasted far longer than US programs and are likely to end in a net-loss to taxpayers. The dotted line indicates projected returns from a sale of RBS at market value.

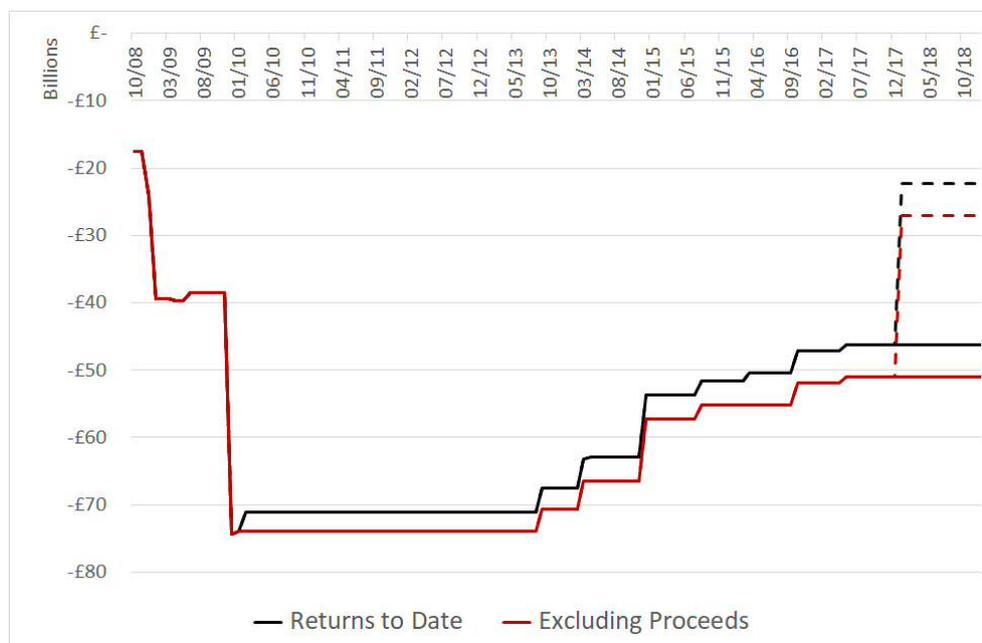


Figure 4.13: UK monthly

### 4.3.3 Return on Investment

Bagehot (1873) suggested central banks should lend freely, guaranteeing a supply of funds at high rates. The rate should be high to prevent moral hazard; to encourage interbank lending (Bignon, Flandreau and Ugolini, 2012); and to protect the central bank from risk. To quantify the conjecture that emergency action during the crisis could lead to moral hazard in the future, fig. 4.14 compares return on equity for US taxpayers<sup>23</sup> to the average real return on US bank equity during the same period of 7.8 percent, shown in black.

<sup>23</sup>Calculated as the geometric average of dividends paid to funds invested over the duration of government intervention.

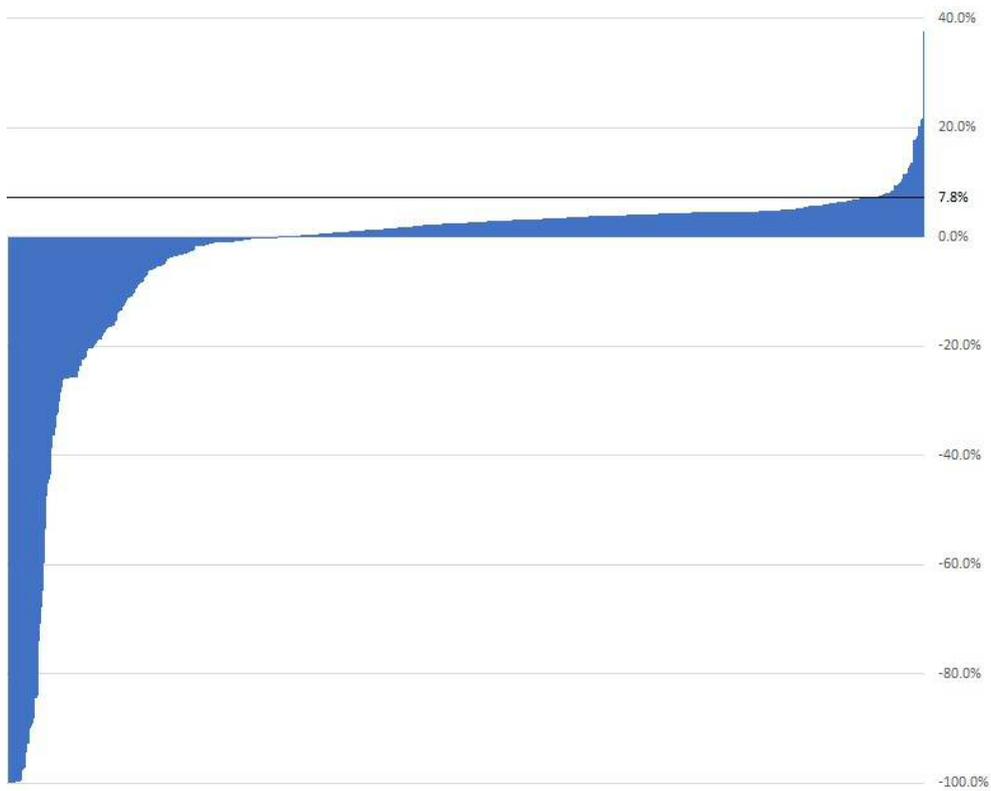


Figure 4.14: Real return on bank equity for US participants of bank recapitalization programs.

Excluding proceeds, 34 US banks paid above average equity while the remaining 746 banks paid below average returns. In the UK, all banks made losses hence all paid below the average return on bank equity of 0.72 percent. The striking difference between the two countries is that healthy banks took funds at high rates (Goldman Sachs, Wells Fargo) while the UK only helped stricken banks at low rates. Culpepper and Reinke (2014) argue this is due to differences in relative size of the domestic market such that US regulators over banks had more bargaining power than their British counterparts. However, this factor is small compared to the big effect of Government Sponsored Enterprises (GSEs) for which there is no British equivalent. As of 17/08/12, the US government receives all profits from Fannie Mae and Freddie Mac,

leaving its private shareholders out of pocket (case in court, 3rd amendment). Together these GSEs have returned \$71.2bn to the US government.

On average, the US government subsidized failing banks by 4%, halving their funding costs. This indicates that in a crisis, a bank can reasonably expect to be able depend on cheap government funding, with adverse implications for future bank conduct. We now provide a theoretical model of an alternative system where government intervention is credibly ruled out, narrow banking.

## 4.4 Theoretical Model

### 4.4.1 Model

The household is a representative small investors<sup>24</sup> with power utility

$$U(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma} - 1. \quad (4.1)$$

Households choose consumption,  $c_t$ , bonds,  $b_{t+1}$  and risky assets,  $d_{t+1}$ , to maximize their continuation value,  $V_t$ ,

$$\max_{c_t, b_{t+1}, d_{t+1}} V_t = U(c_t) + \beta E_t[V_{t+1}], \quad (4.2)$$

subject to the budget constraint

$$c_t + w_{t+1} = \omega + (1 + r_b)b_t + (1 + r_{d,t})d_t, \quad (4.3)$$

where  $\omega$  is the household's fixed outside income. Household investment in bonds at  $t - 1$  is  $b_t$  which each yield safe return  $r_b$ . Investment in risky deposits at  $t - 1$  is  $d_t$  which each return  $r_{d,t}$  which is not known at  $t - 1$ . Define allocation to deposits at  $t$  as  $\alpha_{t+1} \equiv d_{t+1}/(b_{t+1} + d_{t+1})$ . Households choose consumption at  $t$  according to the Euler equation

$$c_t^{-\gamma} = \beta E_t c_{t+1}^{-\gamma} [1 + \alpha_{t+1} r_{d,t+1} + (1 - \alpha_{t+1}) r_b]. \quad (4.4)$$

<sup>24</sup>Their investment decisions have no effect on returns.

The quantity of assets to allocate to risky deposits,  $\alpha_{t+1}$ , satisfies

$$0 = E_t U'(c_{t+1}) [\tilde{r}_{d,t+1} - r_b]. \quad (4.5)$$

Following Cochrane (2009) and Wickens (2011), we use a deterministic consumption point to approximate this condition. Specifically, if the household invests only in safe bonds,  $\alpha_{t+1} = 0$ , her consumption at  $t + 1$  is

$$c_{t+1}^B = \omega + w_{t+2}[1 + r_b] - w_t, \quad (4.6)$$

which does not depend on the realization of risky deposits,  $\tilde{r}_{d,t+1}$ . Taking a first-order Taylor expansion of eq. (4.5) about this deterministic consumption level,  $c_{t+1}^B$ , yields

$$0 = U'(c_{t+1}^B) E_t (\tilde{r}_{d,t+1} - r_b) + E_t [d_{t+1} (\tilde{r}_{d,t+1} - r_b)^2 U''(c_{t+1}^B)], \quad (4.7)$$

or

$$\alpha_{t+1} = \frac{1}{\sigma_t} \cdot \frac{E_t r_{d,t+1} - r_b}{\text{Var}(\tilde{r}_{d,t+1}) + E_t [\tilde{r}_{d,t+1} - r_b]^2}. \quad (4.8)$$

where  $\sigma_t$  is co-efficient of relative risk aversion with respect to wealth

$$\sigma_t \equiv -\frac{U''(c_{t+1}^B) w_{t+1}}{U'(c_{t+1}^B)} = \frac{\gamma w_{t+1}}{c_{t+1}^B}. \quad (4.9)$$

The share of wealth at risk increases with expected return on deposits, decreases with risk aversion and decreases with variance.

The approximation of eq. (4.5) by eq. (4.7) results in lifetime consumption-smoothing. Investment in risky assets,  $d_{t+1}$ , increases with household wealth,  $W_t = b_t + d_t$ . However, the proportion invested in risky assets,  $\alpha_{t+1}$ , *decreases* as wealth increases. This is robust to any preference structure with diminishing marginal utility implying a concave utility function. There is evidence that poorer households are willing to risk higher proportions of their savings in Bosch-Domènech and Silvestre (2003); Paravisini, Rappoport, and Ravina (2010); Kuznar (2001); Dillon and Scandizzo (1978); Page, Savage, and Torgler (2014) and Binswanger (1980).

### Narrow Banking

Narrow banks only invest in safe bonds,  $b_t$ , and return  $r_b$ . Wide banks accept deposits,  $d_t$ , at  $t$  and invest in projects which return  $\tilde{r}_{k,t+1}d_t$  at  $t + 1$ . We assume this return stochastically dominates the return that households receive if they invest directly in projects.<sup>25</sup> The bank sector is competitive so project returns are passed onto depositors in full

$$\tilde{r}_{d,t+1} = \tilde{r}_{k,t+1}. \quad (4.10)$$

Project return is subject to aggregate (macroeconomic risk)<sup>26</sup> such that bank return is identical for all banks. For simplicity, we model a one-off shock to capital return from its steady state,  $\bar{r}_k$ ,

$$\tilde{r}_{k,t+1} = \bar{r}_k - e_t. \quad (4.11)$$

### Government Guarantees

Without support, competition also ensures that capital losses are also passed onto depositors. Consider a government policy to prevent negative deposit returns such that eq. (4.10) is replaced with

$$\tilde{r}_{d,t+1} = \tilde{r}_{k,t+1} + g_{t+1}, \quad (4.12)$$

where

$$g_t = \max[0, -\tilde{r}_{k,t+1}]. \quad (4.13)$$

This support can be understood as an amalgamation of deposit insurance and the indemnity of that insurer by the Treasury. In this way, we capture both the explicit and implicit guarantees of the financial sector.<sup>27</sup> By guaranteeing a floor on deposit returns, the total value of the government subsidy to savers

<sup>25</sup>This can be motivated using delegated monitoring (Diamond (1984)) or costly state verification as employed in Townsend (1979); Bernanke, Gertler, and Gilchrist (1999).

<sup>26</sup>As in Diamond (1984), banks pool projects to diversify away from idiosyncratic risk.

<sup>27</sup>The value of this implicit guarantee is estimated in Noss and Sowerbutts (2012).

is proportion to risky savings,  $d_t$ ,

$$s_t = g_t d_t. \quad (4.14)$$

Governments fund this subsidy through foreign borrowing at interest rate,  $r_g$ . A proportion  $\delta$  of this debt is paid off each period through lump-sum taxation,  $\tau_t$ . Government borrowing to fund guarantee payments is

$$F_t = (1 + r_g)F_{t-1} - \tau_{t-1} + s_t \quad (4.15)$$

where

$$\tau_t = \delta F_{t-1}. \quad (4.16)$$

Households take taxation as given and their budget constraint is

$$c_t + w_{t+1} + \tau_t = \omega + (1 + r_b)b_t + (1 + r_{d,t})d_t. \quad (4.17)$$

Households may continue to invest in safe bonds, but the effect of the government guarantee is to both increase expected return on risky deposits and decrease deposit variance. This increases a household's optimal allocation to risky assets.

## 4.4.2 Results

### Regressive Wealth Transfer

By eq. (4.14), the government guarantee of deposits induces a transfer proportional to the size of investment in risky deposits at  $t$ ,  $d_t$ . This is funded by lump-sum taxation,  $\tau_t$ , levied equally among households. We now consider households which are heterogeneous in the size of their outside income,  $\omega$ . Lump-sum taxation will result in a regressive transfer from low-endowment households to high-endowment households.

Let there be  $n$  households with a continuum of endowments, the vector  $\omega$ . We assume the economy begins in equilibrium such that each household

invests a fixed proportion,  $\Psi = \frac{(\bar{r}_p - r_b)}{(\bar{r}_k - r_b)\{\gamma(\bar{r}_p - r_b) - r_b\}}$ , of her endowment in risky deposits,  $\bar{d}_i$

$$\bar{d}_i = \omega_i \Psi. \quad (4.18)$$

Let there be a realization of the shock to capital at  $t = 1$  which results in negative returns,  $e > \bar{r}_k$ . The government transfer to each saver is equal to

$$s_{i,1} = g_t \bar{d}_i = (e - \bar{r}_k) \omega_i \Psi. \quad (4.19)$$

This increases linearly with the endowment,  $\omega_i$ . Meanwhile lumpsum taxation,  $\tau_t$ , is levied equally on all households. We can rewrite the government's accumulation of borrowing (eq. (4.15)) as

$$F_t = (1 + r_g)F_{t-1} + \sum_{i=1}^n s_{i,1} - n\tau_t, \quad (4.20)$$

where each households repays a portion,  $\delta/n$ , of total debt each period

$$\tau_t = \frac{\delta}{n} F_{t-1}. \quad (4.21)$$

We assume the shock and transfer only occurs once. Each household pays tax

$$\sum_{t=1}^{\infty} \tau_t = \frac{\delta}{n(\delta - r_g)} \sum_{i=1}^n s_{i,1}. \quad (4.22)$$

The effect of the government guarantee, net of taxation, for each household is

$$NetTransfer_i = s_{i,1} - \sum_{t=1}^{\infty} \tau_t = (e - \bar{r}_k) \Psi \left[ \omega_i - \frac{\delta}{\delta - r_g} \bar{\omega} \right], \quad (4.23)$$

where  $\bar{\omega}$  is the mean household endowment. If we assume that the government's real cost of borrowing,  $r_g$ , is zero,<sup>28</sup> this reduces to

$$NetTransfer_i = s_{i,1} - \sum_{t=1}^{\infty} \tau_t = (e - \bar{r}_k) \Psi [\omega_i - \bar{\omega}]. \quad (4.24)$$

The government policy only benefits households with above-average endowments, at the expense of households with below-average endowments. This

<sup>28</sup>For example, the government engages in Quantitative Easing to reduce its costs of funding.

regressive wealth transfer would only increase if we allow the moral hazard effect to increase the shock  $\epsilon$  as government support increases bank risk taking. Though it is a value judgment, the Pigou-Dalton principle (Dalton (1920)) would argue that such a poor-to-rich transfer is welfare reducing. Such transfers are supported in empirical evidence by Araten and Turner (2013); Ueda and di Mauro (2013); Schich and Lindh (2012); Baker, McArthur, et al. (2009) and Noss and Sowerbutts (2012). Calomiris and Jaremski (2016) also argue that the transfer could also go into bank profits or to subsidizing borrowers.

In this set-up, income and wealth are synonymous and taxation is lump-sum, which are oversimplifications. As such, this problem could be resolved using a Pigouvian tax on wealth equal to the value of the transfer, estimated at \$365bn for the years 2007 to 2010 (Tsesmelidakis and Merton (2012)). However, this baulking sum and unpopular taxation could be far more easily resolved by simply removing the government subsidization of risk premium for deposit savers, as under the narrow-wide banking system.

### **Short Sharp Shocks**

We now provide a dynamic illustration of the model. Table 4.3 reports our calibration. We use a 3<sup>rd</sup> order perturbation method and make use of the pruning algorithm by Andreasen, Fernández-Villaverde, and Rubio-Ramírez (2013) to solve the model.

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Parameter	Description	Value
$\beta$	Time preference	0.95
$\gamma$	Risk aversion	2
$\omega$	Endowment	1
$\delta$	Rate of deficit reduction	.05
$\bar{r}_k$	Steady state return to capital	.07
$r_b$	Risk-free rate	.01
$r_g$	Government funding cost	0
$\sigma_e$	Shock to capital return	.01

Table 4.3: Parameter Values

Figure 4.15 compares narrow banking, the dotted black line, to the system with government guarantees, the solid red line. Under narrow banking, depositors lose money when the one-off shock to  $r_k$  is realized in period 1. Consumption falls on impact. Households do not expect further crises and want to restore their consumption to pre-crisis levels. They achieve this by investing more of their wealth in the risky assets shown by the sharp increase in  $\alpha$ . Unburdened by taxation, the economy returns quickly to equilibrium, a short, sharp shock. With the guarantee, depositors do not lose money but consumption still falls on impact due to the expected taxation burden required to fund the government transfer. Moreover, the distorting effect of smoothing losses over several periods leads to reduced incentive to re-invest in risky assets – shown by the markedly slower increase in  $\alpha$ . Both the taxation burden and reduced incentives to invest lead to a much longer recession. This story can be summed up in the discussion of how best to remove a band-aid.

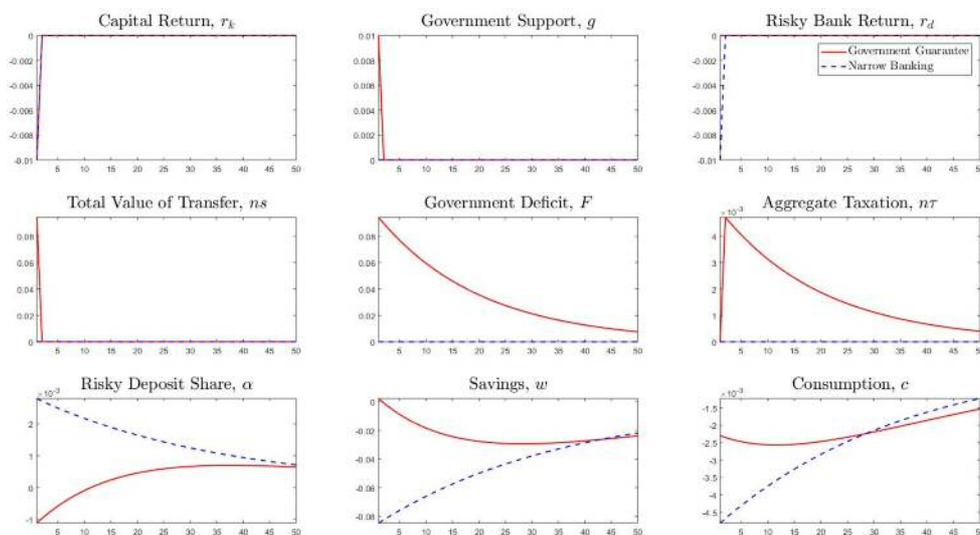


Figure 4.15: IRF results comparing slow recovery with government support to a ‘short sharp shock’ without.

## 4.5 Conclusion

We have modeled a representative household’s investment decision between these two assets using portfolio theory (Markowitz (1952)). In reality, banks may choose to model investment accounts on Money Market Mutual Funds, or have investors hold equity rather than deposits, as suggested by Kotlikoff (2010); Cochrane (2014). Other possible strategies are for banks to require notice on withdrawals; use Contingent Convertible bonds (Calomiris and Herring (2011)); specialize in particular asset classes; agree emergency interbank lines of credit or produce high-quality information for investors. The advantage of narrow banking is that it allows the markets to decide on the best structure for their investment business with reduced regulation and reduced government guarantee.

We have concerns for ability of regulation to prevent crises. For example, the U.K. is attempting to ‘ring-fence’ deposits but as Paul Volker as-

tutely observed “Ring-fencing... only works in fair-weather”<sup>29</sup>. Indeed, the 2008-9 experience underlined the difficulties regulators face: Kay et al. (2010) notes that banks were within their prescribed regulatory limits when the crisis struck. Regulation requires political will to maintain, especially in the face of booms, international arbitrage, regulatory capture (Stigler (1971); Laffont and Tirole (1991)), lobbying budgets and ratings agency grade inflation (Skreta and Veldkamp (2009b)). As Admati and Hellwig (2013) write instead of preventing failure, “[Bank]... liquidations should be seen as normal occurrences in a market economy.”

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<sup>29</sup><http://www.telegraph.co.uk/finance/newsbysector/banksandfinance/9561624/Paul-Volcker-ring-fencing-banks-is-not-enough.html>

## Chapter 5

# Conclusion

The availability of governmental insurance – explicit or expected implicitly – has incentive consequences. Demirgüç-Kunt and Detragiache (1997, 2002) provide empirical evidence that deposit insurance is associated with an increase in financial instability. However, the consequences of limiting or removing deposit insurance are not sufficiently understood. This thesis makes some progress in answering some common challenges provided by proponents of the dominant deposit insurance paradigm. In particular, we show that a narrow-wide banking system can provide liquidity and credit to the economy, with the shift to improving loan *quality* over *quantity*. Moreover, we show that the costs of supporting banks can be better spent at improving bank transparency for its investors. Far more is left to be done. In particular, the consequences of connecting bank savers *directly* to bank risk should be considered carefully. Fears of an increase in macroeconomic volatility are widespread and must be answered satisfactorily. Furthermore, the practicalities of providing sufficient and accurate information so that non-expert savers can distinguish good investments from bad explored in Kaufman, Benston, Eisenbeis, Horvitz, and Kane (1986) continue to provide challenges for future work.

The current system promotes moral hazard and distorts incentives by pro-

viding public insurance to a private liability. It is not a free-market solution. It is important to note that in the US, deposit insurance was enacted with the Glass-Steagall provisions that completely separated investment from retail banking (Alper (1933)). As subsequent decades have shown, strong regulation requires political will to maintain – especially in the face of booms, international arbitrage, lobbying, and regulatory capture (Laffont and Tirole (1991)). Moreover, regulating an industry whose complexities are constantly evolving is difficult. A prime example is the fact that banks were well within their prescribed regulatory limits in 2008 when the crisis struck (Kay et al. (2010)). Policies which re-instate market discipline on the financial sector are deserving of the increased academic attention they are receiving, as in Acharya and Thakor (2015) and Calomiris, Flandreau, and Laeven (2016).

# Appendix A

## Appendices for Chapter 2

### A.1 Proofs

#### A.1.1 Proof of Lemma 1

For some values of leverage,  $\gamma$ , the effort choice that is profit-maximizing becomes apparent since the banker will either always get a return in the default state or it will never get a return in the default state, independent of whether it monitors at  $a^l = 0$  or  $a^h$ . For example, suppose the bank's choice of leverage (deposits) is sufficiently low such that  $\gamma < \gamma^{low}$  where

$$(\gamma^{low} + k)d(a = 0) = \gamma^{low} R_C/\wp \quad (\text{A.1})$$

or

$$\gamma^{low} = \frac{kR_L(1 - \alpha)}{R_C/\wp - R_L(1 - \alpha)} \quad (\text{A.2})$$

Since in this case deposits are default-free even if the bank made no effort, bank equity receives the entire benefit from effort. Consequently, given the parametric restriction in (2.2), the profit-maximizing choice of effort is  $a^h$  and  $R_D = R_C/\wp$ . For this case of  $\gamma < \gamma^{low}$ , the bank's expected profit is (2.10). In contrast, suppose that the bank's choice of leverage is very high such that

$\gamma > \gamma^{high}$  where

$$(\gamma^{high} + k)d(a^h) = \gamma^{high} R_C / \varphi \quad (\text{A.3})$$

$$\gamma^{high} = k \frac{\beta p_b R_L - c}{c - \beta p_b (R_L - R_C / \varphi)} \quad (\text{A.4})$$

In this case even if effort was at the first-best level  $a^h$ , bank equity would receive none of the benefit from monitoring effort. Therefore, because effort is not contractible, the profit-maximizing effort level is  $a^l = 0$  and  $R_D = \frac{R_R - p_b \frac{\gamma+k}{\gamma} d(a^l)}{p_g} = \frac{R_R - p_b \frac{\gamma+k}{\gamma} R_L (1-\alpha)}{p_g}$ . For this case of  $\gamma > \gamma^{high}$ , the bank's expected profit is (2.6).

Now for  $\gamma^{low} < \gamma < \gamma^{high}$ , we can determine whether effort  $a^l = 0$  or  $a^h$  given in (2.8) is chosen by comparing the difference in the bank's expected profits under these two choices. Hence, for a bank's given choice of  $\gamma$  and depositors' given choice of  $R_D$ , the difference in the bank's expected profits from effort level  $a^h$  versus  $a^l$  is

$$p_b \max[(\gamma+k)d(a^h) - \gamma R_D, 0] - c a^h (\gamma+k) - p_b \max[(\gamma+k)d(a^l) - \gamma R_D, 0] \quad (\text{A.5})$$

Now note that since  $d(a^l) = R_L(1-\alpha) < R_C / \varphi \leq R_D$ , we have

$$(\gamma+k)d(a^l) - \gamma R_D = k R_L (1-\alpha) - \gamma (R_D - R_L(1-\alpha)) \quad (\text{A.6})$$

which is always negative for  $\gamma > \gamma^{low}$ . Using this result and substituting in for  $a^h$ , the difference in expected profit becomes

$$p_b \max \left[ (\gamma+k) \left[ R_L - \frac{c}{\beta p_b} \right] - \gamma R_D, 0 \right] - \frac{c(\gamma+k)}{\beta} \ln \left( \frac{\beta \alpha p_b R_L}{c} \right) \quad (\text{A.7})$$

The rise in expected profit from effort in (A.7) is weakly decreasing in  $R_D$ . Moreover, for any  $\gamma \leq \gamma^{high}$ , deposits are default-free when the bank chooses the first-best effort level  $a^h$ . Therefore, for  $\gamma \leq \gamma^{high}$ , a rational expectations equilibrium in which a bank supplies first-best effort obtains if and only if

$$p_b \left( (\gamma+k) \left[ R_L - \frac{c}{\beta p_b} \right] - \gamma R_C / \varphi \right) - \frac{c(\gamma+k)}{\beta} \ln \left( \frac{\beta \alpha p_b R_L}{c} \right) > 0. \quad (\text{A.8})$$

Re-writing this condition in terms of first-best effort,  $a^h$ ,

$$p_b \left[ (\gamma + k)d(a^h) - \gamma R_C / \wp \right] - (\gamma + k)ca^h > 0, \quad (\text{A.9})$$

we can define the threshold leverage  $\gamma^m$  for which this condition binds as

$$\gamma^m = k \frac{p_b d(a^h) - ca^h}{p_b R_C / \wp - [p_b d(a^h) - ca^h]}. \quad (\text{A.10})$$

### A.1.2 Proof that high effort profits are decreasing in cost

$$\pi^h = (\gamma^m + k) \left[ p_g R_L + p_b d(a^h) - c_i a^h \right] - \gamma^m R_C \quad (\text{A.11})$$

Define  $\Psi \equiv p_b d(a^h) - c_i a^h$  so that  $\gamma^m = k \frac{\Psi}{p_b R_C / \wp - \Psi}$ .

$$\begin{aligned} \pi^h &= \left( k \frac{\Psi}{p_b R_C / \wp - \Psi} + k \right) [p_g R_L + \Psi] - k \frac{\Psi}{p_b R_C / \wp - \Psi} R_C \\ &= k p_g R_C / \wp \frac{p_b R_L - \Psi}{p_b R_C / \wp - \Psi} \end{aligned} \quad (\text{A.12})$$

$$\frac{\partial \pi^h}{\partial \Psi} = k p_g R_C \frac{p_b [R_L - R_C / \wp]}{\{p_b R_C - \Psi / \wp\}^2} > 0 \quad (\text{A.13})$$

We then use  $\frac{\partial d(a^h)}{\partial c_i} = -\frac{1}{\beta p_b}$  and  $\frac{\partial a^h}{\partial c_i} = -\frac{1}{c_i \beta}$  to show that

$$\frac{\partial \Psi}{\partial c_i} = p_b \frac{\partial d(a^h)}{\partial c_i} - a^h - c_i \frac{\partial a^h}{\partial c_i} = -a^h < 0. \quad (\text{A.14})$$

Hence  $\frac{\partial \pi^h}{\partial c_i} = \frac{\partial \pi^h}{\partial \Psi} \frac{\partial \Psi}{\partial c_i} < 0$ .

### A.1.3 Proof of Proposition 1

To prove Proposition 1, we start by showing that there is a unique value of  $c_i$  that equates  $\pi^l$  to  $\pi^h$ . Equating (2.11) to (2.12), one obtains equation (2.14) that can be re-written as

$$F(c_i) \equiv c_i \left( \frac{1}{\beta} + a^h(c_i) \right) = \frac{\pi^l p_b (R_L - R_C / \wp)}{\pi^l - p_g k R_C / \wp} \quad (\text{A.15})$$

where  $a^h(c_i) = \frac{1}{\beta} \ln \left( \frac{\beta \alpha p_b R_L}{c_i} \right)$ . Now note that

$$\frac{\partial F(c_i)}{\partial c_i} = a^h(c_i) > 0 \quad (\text{A.16})$$

Consequently, the left-hand-side of equation (A.15) is an increasing function of  $c_i$ . Given that the right-hand-side of (A.15) is independent of  $c_i$  and condition (2.13) holds, there is a unique value  $c_i$  for which the left-hand-side of (A.15) equals the right-hand-side of (A.15). This is equivalent to there existing a single critical value of  $c_i = c^*$  such  $\pi^l = \pi^h(c^*)$ , and values of  $c_i$  below  $c^*$  imply  $\pi^l < \pi^h(c_i)$  while values of  $c_i$  above  $c^*$  imply  $\pi^l > \pi^h(c_i)$ . Therefore, given Lemma 1, the value  $c^*$  in (2.14) is the cut-off between choosing high effort, limited leverage, and quasi-safe deposits versus choosing no effort, maximum leverage, and risky deposits.

#### A.1.4 Proof of Lowest-cost bank leverage limit

Least cost banks can limit total deposits to a maximum of  $\gamma_{DI,L}^m > \gamma^r$  while still having an incentive to provide high effort. These banks issue insured deposits up to the limit  $\gamma^r$  at a funding cost of  $(1 + \phi^h)R_F = R_F/\wp$  per deposit. On top of this, they issue uninsured deposits equal to  $\gamma_{DI,L}^m - \gamma^r$  which promise to return  $R_C/\wp$ . Compared to eq. (A.9), the condition for which high effort binds is now

$$p_b \left[ (\gamma + k)d(a^h) - (\gamma - \gamma^r)R_C/\wp - \gamma^r R_F/\wp \right] - (\gamma + k)ca^h > 0, \quad (\text{A.17})$$

Solving for  $\gamma$ , we obtain

$$\gamma_{DI,L}^m = \frac{p_b \gamma^r (R_C - R_F)/\wp + k[p_b d(a^h) - ca^h]}{p_b R_C/\wp - [p_b d(a^h) - ca^h]}. \quad (\text{A.18})$$

#### A.1.5 Proof of Proposition 3

Recall that  $c^T$  is the cost of effort such that a bank is indifferent between no effort and high effort when there is no deposit insurance and no effort banks can tranche their deposits. In other words,  $\pi_T^h(c^T) = \pi_T^l$ . If with deposit insurance, this bank's increase in profits is greater by choosing no effort compared to choosing high effort, then it will unambiguously choose no

effort. In that case, the cost at which a bank is indifferent between no effort and high effort must be less; that is,  $c^{DI} < c^T$ .

Now note that from equation (2.31), the increase in profit from no effort after deposit insurance is independent of cost and can be written as

$$\pi_{DI}^l - \pi_T^l = (\gamma^r - \gamma^s)(R_R - R_C) + \gamma^r(R_C - R_F) \quad (\text{A.19})$$

For the bank with cost  $c_i = c^T$ , equation (2.39) shows that the corresponding increase in profit from high effort after deposit insurance is

$$\left(\pi_{DI,M}^h - \pi_T^h\right) |_{c_i=c^T} = (\gamma_{DI,M}^m - \gamma^m) \left[ p_g R_L + p_b d \left( a^h(c^T) \right) - c_T a^h(c^T) - R_F \right] + \gamma^m (R_C - R_F) \quad (\text{A.20})$$

where  $a^h(c^T) = \frac{1}{\beta} \ln(\beta \alpha p_b R_L / c^T)$ . The difference in this increase in profit from no effort versus high effort is

$$\begin{aligned} \pi_{DI}^l - \pi_T^l - \left(\pi_{DI,L}^h - \pi_T^h\right) |_{c_i=c^T} &= (\gamma^r - \gamma^s)(R_R - R_C) + (\gamma^r - \gamma^m)(R_C - R_F) \quad (\text{A.21}) \\ &\quad - (\gamma_{DI,M}^m - \gamma^m) \left[ p_g R_L + p_b d \left( a^h(c^T) \right) - c_T a^h(c^T) - R_F \right] \end{aligned}$$

The first line of equation (A.21) includes two terms that are both positive and increasing in  $\gamma^r$ . The second line of equation (A.21) is negative and independent of  $\gamma^r$ . Thus, the higher is  $\gamma^r$ , the greater is profit difference. The threshold value of  $\gamma^r$  at which  $\pi_{DI}^l - \pi_T^l - \left(\pi_{DI,L}^h - \pi_T^h\right) |_{c_i=c^T} = 0$  is then

$$\gamma^{r*} = \frac{\left(\gamma_{DI,M}^m - \gamma^m\right) \left[ p_g R_L + p_b d \left( a^h(c^T) \right) - c_T a^h(c^T) - R_F \right] + \gamma^s (R_R - R_C) + \gamma^m (R_C - R_F)}{R_R - R_F} \quad (\text{A.22})$$

## A.2 Deposit insurance solution

Recall that the tax-limit on insured deposits is  $\gamma^r$  and that banks with cost below  $c^{DI}$  will exert effort. Least-cost banks are the subset of high-effort banks with costs below  $c^m$  whose low costs puts their leverage limit above the insurance limit,  $\gamma^m > \gamma^r$ . These banks issue uninsured quasi-safe deposits of

$\gamma^m - \gamma^r$ . Moderate cost banks are the subset of high-effort banks with costs between  $c^m$  and  $c^{DI}$  who restrict their leverage,  $\gamma^m < \gamma^r$ , such that they only issue insured deposits.

The threshold between the two types of high-effort banks,  $c^m$ , is the implicit solution to  $\gamma_{DI,M}^m(c^m) = \gamma^r$ . This solution exists if  $\gamma^r \in \left( \gamma_{DI,M}^m(\bar{c}), \gamma_{DI,M}^m(\underline{c}) \right)$ . If the insurance restriction is high such that banks with lowest possible costs are still able to issue within this limit,  $\gamma^r > \gamma_{DI,M}^m(\underline{c})$  then least cost banks do not exist and  $c^m = \underline{c}$ . If  $\gamma^r$  is low such that high-effort banks are able to offer leverage above this restriction even at the highest cost,  $\gamma^r < \gamma_{DI,L}^m(c^{DI})$ , then moderate cost banks do not exist and  $c^m = c^{DI}$ . Further, if  $c^{DI} = \underline{c}$  then no banks choose to exert effort.

We consider all three cases when simulating over the parameter space, creating potentially three solutions for  $\{\gamma^R, c^{DI}\}$ . However, our calibration assumes a tax-base large enough to support high levels of  $\gamma^r$  seen in the data. This rules out least-cost banks hence our solution for deposit insurance reflects the case where only moderate cost banks exist.

We assume a uniform distribution throughout.

1. Start with initial guesses of  $c_0^{DI} \in (\underline{c}, \bar{c})$  and  $\gamma_0^r \in \left( \gamma_{DI,M}^m(\bar{c}), \gamma_{DI,M}^m(\underline{c}) \right)$  to ensure both least-cost and moderate banks exist.
2. Compute  $c^m$  as the implicit solution to  $\gamma_{DI,M}^m(c^m) = \gamma_0^r$ .
3. Compute the insurance limit  $\gamma^r = \frac{1}{c^m - \underline{c} + \bar{c} - c_0^{DI}} \left[ \frac{\bar{t}\omega(\bar{c} - \underline{c})}{R_F} - \int_{c^m}^{c_0^{DI}} \gamma_{DI,M}^m(c_i) dc_i \right]$ .
4. Check that  $\gamma^r > \gamma^s$  which ensures that insured banks do not issue uninsured, junior deposits.
5. Check that  $\gamma^r \in \left( \gamma_{DI,M}^m(\bar{c}), \gamma_{DI,M}^m(\underline{c}) \right)$  to be consistent with the assumption that both moderate and least cost banks exist. Check that

$\pi_{DI,M}^h(\underline{c}) \leq \pi_{DI}^l(\gamma^r) \leq \pi_{DI,M}^h(\underline{c})$  so that  $c^{DI}$  exists.

6. Compute the threshold  $c^{DI}$  as the implicit solution to  $\pi_{DI,M}^h(c^{DI}) = \pi_{DI}^l(\gamma^r)$ .
7. Check that  $c^{DI} \geq c^m$  to verify that moderate cost banks exist.
8. Minimize sum of squared difference between solutions to  $c^{DI}$  and  $\gamma^r$  and their initial guesses.

Repeat step 1 with  $\gamma_0^r \in (\gamma_{DI,M}^m(\underline{c}), 1)$  for the case where least-cost banks do not exist and  $\gamma^r = \frac{1}{\bar{c} - c_0^{DI}} \left[ \frac{t\omega(\bar{c} - \underline{c})}{R_F} - \int_{\underline{c}}^{c_0^{DI}} \gamma_{DI,M}^m(c_i) dc_i \right]$ . Restrict solutions (if any) to be in  $(\gamma_{DI,M}^m(\underline{c}), 1)$ .

If moderate cost banks do not exist, then  $\gamma^r = \frac{t\omega}{R_F} = \gamma^n$  as all banks insure up to the limit. Provided  $\gamma^r \in (0, \gamma_{DI,L}^m(\bar{c}))$  and this solution is possible, compute steps 4 and 5 using least-cost profits  $\pi_{DI,L}^h$  instead of  $\pi_{DI,M}^h$ .

### A.3 Welfare Measures

Government intervention produces safe assets equal to  $\gamma^n$  under both deposit insurance and narrow banking. Aggregate production of quasi-safe assets under each regime is

$$S_T^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^T} \gamma^m(c_i) dc_i + \gamma^s(\bar{c} - c^T) \right], \quad (\text{A.23})$$

$$S_{DI}^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^m} \gamma_{DI,L}^m(c_i) dc_i - \gamma^r(c^m - \underline{c}) \right], \quad (\text{A.24})$$

$$S_{NB,I}^c = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^n} \min[\gamma^m(c_i), \gamma^d] dc_i + \gamma_{NB}^s(\bar{c} - c^n) \right], \quad (\text{A.25})$$

$$S_{NB,R}^c = S_T^c, \quad (\text{A.26})$$

where the limits on tranching are given by  $\gamma^s = \frac{(\gamma+k)R_L(1-\alpha)}{R_C/\varphi}$  and  $\gamma_{NB}^s = \frac{(\gamma^d+k)R_L(1-\alpha)}{R_C/\varphi}$ . Under narrow banking without the rebate, maximum leverage

is  $\gamma^d = 1 - \gamma^n$ . The surplus from issuing quasi-safe assets for regime  $r$  is

$$Surplus_r^S = (R_R - R_C)S_r^c. \quad (\text{A.27})$$

No-effort banks issue default-risky junior deposits equal to

$$R_T = \frac{\bar{c} - c^T}{\bar{c} - \underline{c}}(1 - \gamma^s), \quad (\text{A.28})$$

$$R_{DI} = \frac{\bar{c} - c^{DI}}{\bar{c} - \underline{c}}(1 - \gamma^r), \quad (\text{A.29})$$

$$R_{NB,I} = \frac{\bar{c} - c^{NB}}{\bar{c} - \underline{c}}(\gamma^n - \gamma_{NB}^s), \quad (\text{A.30})$$

$$R_{NB,R} = R_T. \quad (\text{A.31})$$

The quantity of loans provided by the banking industry is equal to total liabilities, except for narrow banks who do not extend loans

$$L_T = k + S_T^c + R_T, \quad (\text{A.32})$$

$$L_{DI} = k + \gamma^n + S_{DI}^c + R_{DI}, \quad (\text{A.33})$$

$$L_{NB,I} = k + S_{NB,I}^c + R_{NB,I}, \quad (\text{A.34})$$

$$L_{NB,R} = k + S_{NB,R}^c + R_{NB,R} = L_T. \quad (\text{A.35})$$

As only first-best banks exert effort, total monitoring effort is

$$A(c^*) = \frac{1}{\bar{c} - \underline{c}} \int_{\underline{c}}^{c_r^*} a^h dc_i, \quad (\text{A.36})$$

where  $c_r^*$  is the threshold cost above which banks do not exert effort in each of the regimes  $\{c^T, c^{DI}, c^n, c^T\}$ . Based on previous logic, we have effort  $A(c^n) > A(c^T) > A(c^{DI})$ . Total expected bank profit is given by

$$\Pi_T = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^T} \pi^h(c_i) d(c_i) + (\bar{c} - c^T) \pi_T^l \right], \quad (\text{A.37})$$

$$\Pi_{DI} = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^m} \pi_{DI,L}^h(c_i) d(c_i) + \int_{c^m}^{c^{DI}} \pi_{DI,M}^h(c_i) d(c_i) + (\bar{c} - c^{DI}) \pi_{DI}^l \right], \quad (\text{A.38})$$

$$\Pi_{NB,I} = \frac{1}{\bar{c} - \underline{c}} \left[ \int_{\underline{c}}^{c^n} \pi^h(c_i) d(c_i) + (\bar{c} - c^n) \pi_{NB,I}^l \right], \quad (\text{A.39})$$

$$\Pi_{NB,R} = \Pi_T. \quad (\text{A.40})$$

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Loan surplus is

$$Surplus_T^L = \Pi_T - Surplus_T^S, \quad (\text{A.41})$$

$$Surplus_{DI}^L = \Pi_{DI} - Surplus_{DI}^S - (R_R - R_F)S_{DI}^f, \quad (\text{A.42})$$

$$Surplus_{NB,I}^L = \Pi_{NB,I} - Surplus_{NB,I}^S, \quad (\text{A.43})$$

$$Surplus_{NB,R}^L = \Pi_{NB,R} - Surplus_{NB,R}^S = Surplus_T^L. \quad (\text{A.44})$$

## Appendix B

# Appendices for Chapter 3

### B.1 Deriving Sectoral Returns

Recall that returns to investment in both sectors are given by

$$\begin{aligned}r_{f,t+1} &= \theta Z_f K_{f,t+1}^{\theta-1} L_{f,t+1}^{1-\theta}, \\r_{b,t+1} &= (1 - m_{s,t+1}) \theta Z_b K_{b,t+1}^{\theta-1} L_{b,t+1}^{1-\theta},\end{aligned}$$

and capital allocation is

$$\begin{aligned}K_{b,t+1} &= \alpha_{s,t} A_{t+1}, \\K_{f,t+1} &= (1 - \alpha_{s,t}) A_{t+1}.\end{aligned}$$

Both the malfeasance share at  $t + 1$  and optimal allocation to banking,  $\alpha_{s,t}$ , depend on the malfeasance share at  $t$ , denoted by subscript  $s \in \{L, H\}$ . Let superscript  $S \in \{L, H\}$  denote the realization at  $t + 1$  of the mean malfeasance share,  $\bar{m}_s \in \{\bar{m}_L, \bar{m}_H\}$ . After substituting for capital, returns in each sector conditional on the state realized at  $t + 1$  are

$$r_{f,t+1}^S = \theta Z_f (1 - \alpha_{s,t})^{\theta-1} (A_{t+1})^{\theta-1} (L_{f,t+1}^S)^{1-\theta}, \quad (\text{B.1})$$

$$r_{b,t+1}^S = \theta (1 - m_{s,t+1}) Z_b (\alpha_{s,t})^{\theta-1} (A_{t+1})^{\theta-1} (L_{b,t+1}^S)^{1-\theta}. \quad (\text{B.2})$$

Labor supply in each industry, conditional on the realized state of the world,  $s$ , is

$$L_{f,t+1}^S = \frac{Z_f^{\frac{1}{\theta}}(1 - \alpha_{s,t})}{Z_{t+1}^S}, \quad (\text{B.3})$$

$$L_{b,t+1}^S = \frac{[(1 - m_{s,t+1})Z_b]^{\frac{1}{\theta}} \alpha_{s,t}}{Z_{t+1}^S}. \quad (\text{B.4})$$

where we define the average productivity in the two sectors conditional on the realization of state  $S$  at  $t+1$  as

$$Z_{t+1}^S = (1 - \alpha_{s,t})Z_f^{\frac{1}{\theta}} + \alpha_{s,t} [(1 - \bar{m}_S - \epsilon_{t+1})Z_b]^{\frac{1}{\theta}}. \quad (\text{B.5})$$

Substituting eq. (B.5) into conditional returns, eqs. (B.1) and (B.2) yields

$$r_{f,t+1}^S(\alpha_{s,t}, \epsilon_{t+1}) = \theta [A_{t+1}Z_{t+1}^S]^{\theta-1} Z_f^{\frac{1}{\theta}}, \quad (\text{B.6})$$

$$r_{b,t+1}^S(\alpha_{s,t}, \epsilon_{t+1}) = \theta [A_{t+1}Z_{t+1}^S]^{\theta-1} [(1 - \bar{m}_S - \epsilon_{t+1})Z_b]^{\frac{1}{\theta}}. \quad (\text{B.7})$$

These returns depend on the malfeasance share - both its mean state  $\bar{m}_S$  and  $\epsilon_{t+1}$  - and on the *aggregate* allocation to banking,  $\alpha_{s,t}$ .

## B.2 Solving for Allocation Decision with Private Monitoring.

The following steps were used to solve for allocation decisions with private monitoring.

1. Informed individuals begin by guessing the uninformed optimal allocation,  $\alpha_{U,s,t}$ .
2. Use eqs. (3.30) and (3.31) to calculate optimal informed allocation,  $\alpha_{I,s,t}$ , for *any* realization of  $\epsilon_{t+1}$  in the support  $[a, b]$ . That is, we construct  $\alpha_{I,s,t}(\epsilon_{t+1})$ .

3. Use this function to compute aggregate allocation  $\bar{\alpha}_{s,t}(\epsilon_{t+1})$ , given by eq. (3.30).
4. The first order condition, eq. (3.32), gives optimal uninformed allocation,  $\alpha_{U,s,t}$ .
5. Iterate until the initial guess for optimal uninformed allocation matches the solution, yielding  $\alpha_{U,s,t}$  and  $\alpha_{I,s,t}(\epsilon_{t+1})$ .

Repeating steps 1-5 over a range of values for  $n_t$ , and substituting into eq. (3.33) allows us to find the optimal  $n_t$  to maximize expected utility.

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