Banking on Reciprocity: Deposit Insurance and Insolvency *

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March 5, 2020

Abstract

There is an empirical connection between deposit insurance, risk-taking, and insolvency. We argue that if banks maximize profit this amounts to a puzzle (even taking into account that deposit insurance decreases incentives for customers to monitor bankers). However, we show that the empirical regularities can be well captured if bankers are motivated by reciprocity towards their customer base.

KEYWORDS: Deposit Insurance, Reciprocity, Banking, Insolvency, Moral Hazard

JEL Classifications: D28, G03, G21

1 Introduction

Two oft-proposed reasons for banking crises are runs and insolvency; see Calomiris (2008). On the former account banks get in liquidity trouble if all depositors withdraw funds (Diamond and Dybvig, 1983). The latter one may be linked to moral hazard; for example, government legislation may create incentives for excessive risk-taking, something Calomiris (2009) forcefully argues is particularly relevant for understanding the 2008+ US financial crisis.

Deposit insurance (DI) is a policy tool that speaks to both crisis reasons. Diamond and Dybvig show theoretically how DI can help avoid bank runs, while Calomiris (1990, 2008) interprets historical records to indicate that DI often caused insolvency by inviting excessive risk-taking. Indeed, numerous studies found evidence suggesting a link between DI and bank risk-taking.[1] Our paper is concerned with this latter phenomenon. There are two distinct senses in which DI may lead to excessive risk-taking. First, DI may invite higher leverage, which puts banks at greater risk of insolvency in the event of a market downturn (see, e.g., Calomiris, 1990). On this point we are silent. Second – and the focus of our paper – is that, holding the degree of leverage constant, DI may lead to an erosion in the quality of a bank's asset portfolio (throughout this paper when we refer to "risk-taking" we mean in this sense). We argue that from the viewpoint of traditional economic thought, the relationship between DI and this form of excessive risk is a puzzle.

The traditional explanation for the relationship between DI and excessive risk-taking is that DI leads to a breakdown in market discipline and the resulting moral-hazard problem invites banks to engage in riskier business

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[1]See, e.g., Grossman (1992); Demirgüç-Kunt and Detragiache (2002); Ioannidou and Penas (2010).

activities.[2] In order to accept the market-discipline explanation, it is first necessary to accept that depositors have the ability to observe and understand bank risk, which is not at all obvious. As a testament to the opaqueness of the banking sector in general, Morgan (2002) provides evidence that professional credit-rating agencies disagree more often when it comes to bankers, than they do for firms in other industries. Moreover, in a recent article in *The Atlantic*, Frank Partnoy and Jesse Eisinger (2013) speak to the challenges of understanding bank risk portfolios:

> The financial crisis had many causes – too much borrowing, foolish investments, misguided regulation – but at its core, the panic resulted from a lack of transparency. The reason no one wanted to lend to or trade with the banks during the fall of 2008, when Lehman Brothers collapsed, was that no one could understand the banks' risks. It was impossible to tell, from looking at a particular bank's disclosures, whether it might suddenly implode.

Even if one believes that customers could acquire and understand this information to some degree, arguably the banking experts at the FDIC could acquire more accurate information at a lower cost. Just as any insurance provider has an incentive to monitor the behavior of their customers, the FDIC would have the incentive to monitor the level of risk undertaken by the bank. The introduction of deposit insurance would shift the monitoring role from the customers to the insurer, and in this paper our working assumption is that the FDIC is at least as adept at this task as the customers. Hence, if so, the bank would be more heavily monitored with DI than without. This

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[2]See, e.g., Calomiris (1999), Cooper and Ross (2002); Gropp and Vesala (2004), Demirgüç-Kunt and Kane (2002), Demirgüç-Kunt and Detragiache, Demirgüç-Kunt and Huizinga (2004).

constitutes our puzzle. Classical theory is hard-pressed providing a reasonable explanation for the observed link between DI and risk-taking.

We identify a novel link between DI and risk-taking. If the monitoring account is deemed wanting, our perspective provides an alternative; if the monitoring account makes sense after all (say because the market is better informed than the regulator, or if the regulator is corrupt), then we offer a complementing argument.

Our key train of thought is this: A banker's payoff is that of a residual claimant; he gets what is left after depositors' demandable debt is serviced. His leveraged position invites heavier risk-taking than would benefit depositors, enough to make insolvency loom. But bankers owe their livelihood to their customers. Without deposits bankers would not be in business. Is it not plausible that this makes them somewhat protective of their customer base, and disinclined to hurt them? Without DI there is an obvious way to do that: hold back on risk-taking. With DI, by contrast, there is no need to hold back. Even if a banker is grateful, risk-taking won't hurt depositors, so the banker throws caution to the wind. In other words, if bankers are motivated by reciprocity – so that they avoid hurting those that helped them – the empirical link between DI and insolvency can be explained.

Our goal is to tell this story precisely. In a model of depositor-banker-insurer interaction, we incorporate preferences for reciprocation using the approach of Dufwenberg and Kirchsteiger (2004) (henceforth, D&K), which in turn owes its intellectual foundation to the pioneering work by Rabin (1993), but the D&K approach is needed to treat games with a non-trivial dynamic structure. We explore properties, including variations that concern the degree of DI coverage, whether a bank's risk is observable, and how fragmented is the depositor community.

Reciprocal bankers do not have the objective of maximizing profit. Does that really make sense? First, let us note that there is empirical evidence to suggest that financial decisions are, in fact, influenced by non-monetary considerations (see, e.g., Hirshleifer and Shumway, 2003; Hirshleifer et al., 2018). Moreover, consider a recent experiment from Cohn et al. (2014). The authors explore the honesty of bankers compared to people in other professions. Subjects were given strong monetary incentives to be dishonest, and while the degree of dishonesty among bankers appeared to increase when they were reminded of their profession, they nevertheless did not maximize profit; a finding inconsistent with bankers as the purely selfish "economic man".[3] To boot, much experimental and empirical evidence suggests that many people are motivated by reciprocity.[4] Prior work has shown that incorporating such preferences in new contexts can have important consequences and bring to light new considerations.[5] In the context of financial decision-making, Hirshleifer (2015) notes, "There is need for more theory and testing of the effects of feelings on financial decisions and aggregate outcomes." Here, we attribute such motivation to bankers and explore what this implies.

Section 2 introduces the game form on which our analysis builds. Section 3 introduces reciprocity and derives main results. Section 4 considers variations. Section 5 revisits and expounds on the issue of monitoring (by depositors or the FDIC). Section 6 concludes.

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[3]In the experiment, subjects privately tossed a coin 10 times and self-reported the results to the experimenter. Subjects were informed prior to reporting their results that particular flips ('heads' or 'tails') that they reported would pay out $20. The bankers whose identities were made salient reported a 'successful' flip 58% of the time, statistically significantly more than the expected 50% associated with honest reporting, but way less than the 100% they would have chosen had they maximized profit.

[4]For relevant reviews, see e.g. Fehr and Gächter (2000) or Sobel (2005).

[5]Hahn (2009), for example, shows that reciprocity has important consequences for the political process.

2   Setting the stage

Diamond and Dybvig's classic model of bank runs trivializes bankers' choice of risk; given \$1 of deposits there is a sure-fire way of investing, which yields return $R > 1$ for sure, with a delay. The interesting part of their analysis instead concerns coordination intricacies that occur when a collective of depositors consider withdrawing deposited funds. We shift focus, abstracting away from bank run coordination while making bankers' choice of risk non-trivial. We attempt to formulate the simplest structure rich enough to highlight key economic insights that emerge. The benchmark case has just one depositor, and a banker with some freedom to control the riskiness of investment.[6]

Consider a customer (he) and a banker (she) who engage in a three-stage game. The customer is initially endowed with $\pi < 1$ units of money. In the first stage, he faces the decision of whether or not to deposit his endowment in the bank. If the customer chooses not to deposit then the game ends; the payoff to the customer is π, and the payoff to the banker is 0. If the customer chooses to deposit, then in the second stage the banker may invest in a risky asset. There is a continuum, $[0, 1]$, of possible assets available to the banker. If the banker invests the deposit in asset $x \in [0, 1]$, then in the third stage the asset pays 0 (fails) with probability x, and pays $1 + Kx$ (succeeds) with probability $1 - x$ where $K > 0$. Thus, a higher x increases the potential return of the asset, but also increases the likelihood with which the asset fails. For this reason, x may be thought of as the level of risk undertaken by the banker.[7]

If the customer deposits, the banker pays the customer an interest payment

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[6]An extension in section 4.2 allows for more depositors, but the purpose is to explore how this influences the bankers' incentives and we still abstract away from withdrawal panics.

[7]By "risk" we do not mean the variance of the payout of the asset. The payout of the asset choice $x = 1$, for instance, has zero variance since it pays nothing with probability one. Rather, we mean that higher values of x carry a greater chance of insolvency.

of $1 - \pi$; the customers' payoff is then: $\pi + (1 - \pi) = 1$. If the asset fails, the bank becomes insolvent and is unable to meet its obligation to the customer. We assume that it then goes bankrupt such that the payoff to the banker is zero. The payoff to the customer is $a \in [0, 1]$. The parameter a represents the degree to which the customers' deposit is insured. We will examine both the case where $a = 0$ (no deposit insurance) and the case where $a > 0$ (the deposit is partially or fully insured). If the customer deposits and the asset is successful, the banker keeps the residual earnings, Kx, as profit.

Figure 1 shows the resulting game. We now first analyze it under classical assumptions, focusing on sub-game perfect equilibrium. If the banker chooses risk level $x \in [0, 1]$ the probability of success is $1 - x$ and her payoff in the event of success is Kx, so that the expected payoff is $(1 - x)Kx$. Thus, the banker solves:

$$\max_{x \in [0,1]} (1 - x)Kx,$$

so the profit-maximizing asset is $x^b = \frac{1}{2}$. Should the customer deposit, his expected payoff would thus be $\frac{1}{2}a + \frac{1}{2} = \frac{a+1}{2}$. Hence, if $\pi > \frac{a+1}{2}$, in equilibrium, the customer does not deposit, whereas if $\pi < \frac{a+1}{2}$ he deposits.

Notice that the equilibrium amount of risk taken by the banker does not depend on the degree to which the customers' deposit is insured (i.e. on a). Since a affects only the customers' payoff and not the banker's, in our model, classical theory suggests no connection between the banker's asset choice and the presence or absence of DI.

In Section 3, we instead take a "non-classical" approach. Before proceeding, it will be useful to define a notion of social welfare equal to be the total surplus generated. So, if the customer deposits and asset x is chosen, welfare
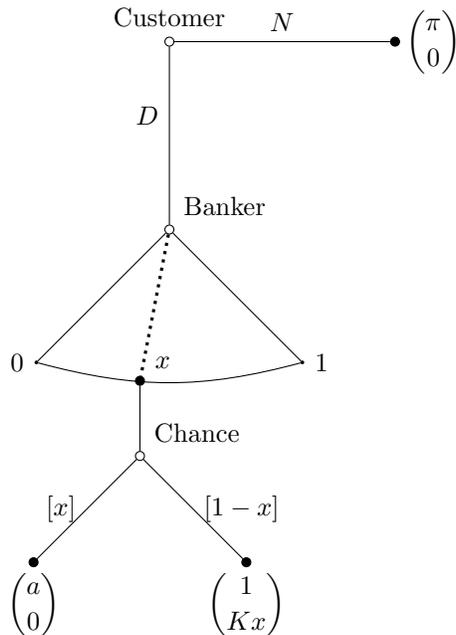
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Figure 1: Game Schematic

is given by:

$$W(x) = (1-x)(1+Kx)$$

Maximizing $W(x)$, we find that the socially optimal asset is $x^s = \max\{\frac{K-1}{2K}, 0\}$. Note that for all K it holds that $x^s < \frac{1}{2}$. Interpreting x as the level of risk undertaken by the banker, it is clear that the banker takes on more risk than is socially optimal. Also note that the customer's payoff is strictly decreasing in x. From his perspective the best choice of x is $x^c = 0$. For any $K > 1$, it holds that $x^s > x^c$. This leads to three distinct benchmark choices: x^c, x^s, and x^b where for all K, $x^c \leq x^s < x^b$ and for $K > 1$ all inequalities are strict.

3 Reciprocity and deposit insurance

We now proceed with our analysis assuming that the banker has a preference for reciprocity. Across sections 3.2-3.4 we explore what happens with three different degrees of DI: none, partial, and full. Before that, in an effort to make the paper self-contained, we provide a brief introduction to D&K's model. We cover formalities only as far as needed to handle our specific games. Readers interested in a more general treatment are referred to D&K.

3.1 D&K's reciprocity model

In this section, as well as in sections 3.2-3.3, we focus on the case of less than full DI, so that $a < \pi$. When $a \geq \pi$, the application of D&K's theory differs in technical details while being similar in spirit, as we explain in section 3.4.

We start by providing a general description of the banker's utility function according to D&K's reciprocity model. Let $s \in \{D, N\}$ denote an action for the customer, where D is deposit, and N is not deposit. Also, let $x \in [0, 1]$ denote an asset choice made by the banker, in the event the customer deposits. In classical theory, given s, and x, one could easily calculate the utility level of the banker. However, a key feature of D&K's model is that a reciprocally-motivated player's utility depends, not only on the actions taken in the game, but also on the player's beliefs about the intentions of others.[8]

Should he choose to deposit, the customer's kindness to the banker depends on how much he thinks his decision benefits the banker, which depends on the asset he believes the banker will choose (the customer's "first-order belief"). The banker cannot observe the customer's first-order belief, and therefore, she

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[8]This reflects how reciprocity theory is formulated within the framework of so-called psychological game theory (cf. Geanakoplos et al., 1989; Battigalli and Dufwenberg, 2009).

does not know the customer's "true" kindness. So, the banker forms a (point) belief, denoted $x'' \in [0,1]$, about the customer's belief; this is the banker's "second order belief". When the customer deposits, the banker's utility then depends on her action, x, as well as her belief, x''; it is defined as follows:

$$U_B(D, x, x'') = m_B(D, x) + Y \cdot \kappa(x) \cdot \lambda(x'')$$

The term, $m_B(D, x)$ is the material payoff earned by the banker, Y is a parameter reflecting her sensitivity to reciprocity, κ is a real-valued function of the banker's asset choice, and it captures her kindness to the customer. λ is a real-valued function of the banker's second-order belief, and it captures her (point) belief about the customer's kindness. $\kappa(x)$ is positive (negative) if the banker is kind (unkind) to the customer. Similarly, $\lambda(x'')$ is positive (negative) if the banker *believes* the customer was kind (unkind). Reciprocity is captured by the fact that, all else equal, the banker will want to be kind (unkind) to the customer if she believes the customer was kind (unkind).

We now provide definitions for the functions κ and λ. When the customer deposits and the banker chooses the asset, x, $\kappa(x)$ is defined as the difference between the expected material payoff the banker gives the customer by choosing x, and the "equitable payoff" of the customer. The equitable payoff of the customer is a number, defined as the average of the maximum and minimum payoffs the banker can give the customer when he deposits. Note, however, that any x greater than the profit-maximizing asset choice of $\frac{1}{2}$ is strictly worse for both the banker and the customer than choosing $x = \frac{1}{2}$. So, when calculating the minimum payoff the banker can give the customer, we restrict attention to $x \in [0, \frac{1}{2}]$, as any $x > \frac{1}{2}$ is sub-optimal for both parties.[9]

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[9]In D&K's reciprocity theory any $x > \frac{1}{2}$ is called "inefficient", which requires a cumber-

Let m_C^e denote the equitable payoff of the customer when depositing. Also, let $m_C(D, x) = xa + (1 - x)$ denote the payoff to the customer when he deposits and the banker chooses x. Then,

$$m_C^e = \frac{1}{2}\left(\max_{x \in [0,1]}\{m_C(D, x)\} + \min_{x \in [0,\frac{1}{2}]}\{m_C(D, x)\}\right) \quad (1)$$

Finally, when the customer deposits, and the banker chooses x, the kindness of the banker to the customer, $\kappa(x)$, is defined as follows:[10]

$$\kappa(x) = m_C(D, x) - m_C^e. \quad (2)$$

Recall that for a given second-order belief, x'', $\lambda(x'')$ is the banker's (point) belief about the customer's kindness. Before defining this term, it will be instructive to derive the customer's "true" kindness. The customer's kindness depends on his (point) belief about the banker's asset choice. Denote this belief by x'. The customer's kindness is defined as the difference between the material payoff he believes he gives the banker when he deposits, and his belief of the equitable payoff of the banker. The customer's belief of the equitable payoff of the banker, denoted $m_B^e(x')$, is the average of the maximum and minimum payoffs he believes he could give the banker:

$$m_B^e(x') = \frac{1}{2}\left(\max_{s \in \{D,N\}}\{m_B(s, x')\} + \min_{s \in \{D,N\}}\{m_B(s, x')\}\right)$$

Then, the kindness of the customer when he deposits and believes the

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some definition. We avoid this detail here, but for a discussion of efficient strategies, and their relevance in other contexts, see D&K pp. 275-277.

[10]Readers familiar with D&K's theory will know that, in many games, a player's kindness may depend not only on his feasible choices but also on his beliefs about other players' choices. This does not happen in our game (which simplifies our notational task) because no player (except chance) moves after the banker. As will be seen shortly, we will, however, need to consider certain beliefs when we define λ.

banker will choose x' is,

$$m_B(D, x') - m_B^e(x').$$

The banker cannot directly observe the customer's kindness since she does not know his belief, x'. So, the banker forms a (point) belief, x'', about the customer's (point) belief, x'. We let $m_B^e(x'')$ denote the banker's belief of its equitable payoff and define this term:

$$m_B^e(x'') = \frac{1}{2}\left(\max_{s \in \{D,N\}} \{m_B(s, x'')\} + \min_{s \in \{D,N\}} \{m_B(s, x'')\} \right).$$

Finally, $\lambda(x'')$, the banker's belief about the customer's kindness, is defined:

$$\lambda(x'') = m_B(D, x'') - m_B^e(x'').$$

Notice that $\lambda(x'')$ takes an analog mathematical form as the customer's kindness. The former depends on the customer's belief about x, while the latter depends upon the banker's belief about the customer's belief about x.

D&K's equilibrium concept is called sequential-reciprocity equilibrium (SRE). It requires that players maximize utility in each stage, given their beliefs, which are correct. If there are no concerns for reciprocity ($Y = 0$) then SRE coincides with subgame perfection (with an explicit account of beliefs to boot).

3.2 No deposit insurance ($a = 0$)

We first address the case where the customer's deposit is uninsured, $a = 0$. Using the definition provided in (1) and noting that the customer's material payoff (when she deposits), $m_C(D, x) = 1 - x$, is strictly decreasing in x we see that the equitable payoff of the customer is given by:

$$m_C^e = \frac{1}{2}\left[m_C(D,0) + m_C\left(D,\frac{1}{2}\right)\right] = \frac{1}{2}\left(1 + \frac{1}{2}\right) = \frac{3}{4}.$$

Using the definition in (2), the kindness of the banker to the customer from choosing x is,

$$\kappa(x) = m_C(D,x) - m_C^e = 1 - x - \frac{3}{4} = \frac{1}{4} - x.$$

Next, calculate the banker's belief about the kindness of the customer when the customer deposits. Consider the belief held by the banker about her equitable payoff. The customer's least kind choice is to not deposit; this gives the banker a payoff of 0. The customer's kindest choice is to deposit. If the customer holds the first-order belief, x', he believes the banker will receive $Kx'(1 - x')$. The average is the equitable payoff for the banker, equal to $\frac{1}{2}Kx'(1 - x')$. Given a second-order belief, x'', held by the banker, we can define the banker's belief about her equitable payoff:

$$m_B^e(x'') = \frac{1}{2}(0 + Kx''(1 - x'')) = \frac{1}{2}Kx''(1 - x'')$$

When the customer deposits, the banker's belief about the material payoff the customer is giving to the banker is $m_B(D, x'') = Kx''(1 - x'')$. The second-order belief held by the banker about the kindness of the customer now is:

$$\lambda(x'') = m_B(D, x'') - m_B^e = Kx''(1 - x'') - \frac{1}{2}Kx''(1 - x'') = \frac{1}{2}Kx''(1 - x'')$$

Given x'', the utility to the banker when choosing x is:

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$$U_B(D, x, x'') = m_B(D, x) + Y \cdot \kappa(x) \cdot \lambda(x'') = Kx(1-x) + Y\left(\frac{1}{4} - x\right)\left(\frac{1}{2}Kx''(1-x'')\right)$$

The banker takes her belief, x'', as given and chooses $x \in [0, 1]$ to maximize its utility. $U_B(\cdot)$ is strictly concave in x; hence, the first-order condition is sufficient to characterize the optimal asset choice. It is:

$$1 - 2x^* - Y\frac{1}{2}x''(1 - x'') = 0$$

In any SRE, the second-order belief must be correct, and hence $x'' = x^*$. Making this substitution and solving for x^*, we obtain the banker's optimal asset choice:

$$x^* = \frac{4 + Y - \sqrt{16 + Y^2}}{2Y} \tag{3}$$

To provide some intuition, suppose the banker holds second order belief $x'' > x^*$, which is close to the material payoff maximizing choice of $\frac{1}{2}$. Such a choice would be particularly good for the banker (as it provides a high material payoff), but it is bad for the customer. Given this belief, the banker thinks the customer is being very kind; affording the banker a high material payoff when he deposits. As a result, the banker would not make its asset choice equal to x'', but rather take on less risk in order to reciprocate the customer's kindness. This would mean the banker's second-order belief were incorrect; hence, such a belief could not be part of a SRE.

On the other hand, suppose the banker held the second-order belief $x'' < x^*$, which is close to zero. Such an asset would be particularly good for the customer, but give the banker a low material payoff. When the banker holds

this belief, a deposit decision is not perceived as particularly kind since the banker thinks the customer is not expecting the banker to earn a high material payoff. The banker would have less reason to be kind to the customer (than in the case where x'' were higher), and would choose a higher level of risk. The equilibrium asset choice balances the banker's belief about the customer's kindness with her desire to reciprocate; when the banker holds the second-order belief, $x'' = x^*$, it chooses optimally and has correct beliefs.

The payoff to the customer, should he deposit, is $1 - x^*$. Hence, the customer will choose to deposit only if $1 - x^* \geq \pi$. Plugging the expression for x^* into this inequality, we find that the customer chooses to deposit only if:

$$Y > \frac{2(2\pi - 1)}{\pi(1 - \pi)} \tag{4}$$

This leads to our first observation (all proofs are contained in the appendix):

Observation 1. *In an SRE, the banker's asset choice, given by (3), is strictly decreasing in Y, approaches zero as Y becomes large, and approaches the profit-maximizing level as Y approaches zero. The customer deposits if $\pi < \frac{1}{2}$, or if Y is sufficiently large (see (4)).*

To provide intuition for Observation 1, note that when the customer deposits he has done something nice for the banker. He has provided an opportunity to generate profit, something he would have denied the banker had he not deposited. When the banker has a preference for reciprocity, she will want to reciprocate this kindness. Since the customer's payoff is decreasing in the risk taken by the banker, this preference for reciprocity leads the banker to take on less risk than the profit-maximizing level. As the banker's sensitivity to reciprocity increases, she will wish to be kinder to the customer when he deposits. This leads the banker to take less risk.

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As the banker's sensitivity to reciprocity approaches zero, her reciprocity payoff becomes irrelevant as compared to the material payoff. As a result, the banker's asset choice approaches the profit-maximizing level. On the other hand, as the banker's sensitivity to reciprocity becomes large, her material payoff becomes irrelevant compared to the reciprocity payoff. As a result, the banker's optimal asset choice approaches the asset that is best for the customer. Note, however, that an asset choice of $x = 0$ could never be part of an SRE. To understand this, suppose the banker holds the corresponding second-order belief, $x'' = 0$. When the customer deposits the banker believes the customer believes the banker will choose to generate zero profit. The decision to deposit would therefore not be construed as kind since the banker believes the customer thinks he is giving the banker nothing! The banker would therefore not wish to be so kind and would want to deviate to a higher level of risk.

We now discuss the welfare implications of reciprocity. Recall that when the banker acts as a profit-maximizer, her asset choice is more risky than is socially optimal. Observation 1 demonstrates that a banker motivated by reciprocity takes on less risk than the profit-maximizing level. So long as the banker's preference for reciprocity is not too large, this leads to a welfare improvement as compared to the case where the banker has selfish preferences. Before stating our next observation, consider the following bound on the banker's sensitivity to reciprocity:

$$Y < \frac{8K}{K^2 - 1} \tag{5}$$

Observation 2. *If $K < 1$ or if Y is sufficiently small (the precise bound is given by (5)) then equilibrium welfare is increasing in Y.*

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Figure 2 shows overall welfare as a function of the banker's risk choice when $K = 2$. The profit-maximizing choice is $x = \frac{1}{2}$ and welfare is maximized at $x = \frac{1}{4}$. Observation 2 says that welfare is increasing in Y so long as Y is sufficiently small. When $K = 2$, this occurs when $Y < \frac{16}{3}$. Examining Figure 2, $Y < \frac{16}{3}$ means $x^* > \frac{1}{4}$. In this case, a small increase in Y moves us closer to the welfare-maximizing level, and increases overall welfare (since x^* is decreasing in Y). Note, however, that in this example welfare is higher than the profit-maximizing level, for any $Y > 0$.

3.3 Partial deposit insurance $(0 < a < \pi)$

Suppose that an outside agency insures part of the customer's deposit: if the customer deposits and the asset fails then the payoff to the customer is $a \in (0, \pi)$. The insurance program is financed entirely by the bank. The observability of x by the insurance agency is a critical determinant in how the bank will be charged for the insurance. In this section it is assumed that x is unobservable by the insurance provider; the DI fee is therefore independent of the banker's asset choice. For simplicity, we take this fee as sunk.[11] One may think of this version of the model in the following way: prior to the interaction between the banker and customer, the bank pays a fixed fee to participate in the insurance program. Thus, at the time of customer-banker interaction, this cost does not affect the incentives of the banker. For ease of analysis, we therefore leave the material payoffs of the banker unchanged from the case with no deposit insurance. In section 4.1 we examine a version of the model in which the banker's asset choice is observable by the insurance provider, and

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[11]One could envision an alternative formulation in which the banker could choose whether or not to pay F and enter in the first place. That formulation would not change the nature of play following a decision to enter. For simplicity, we abstract away from this consideration.
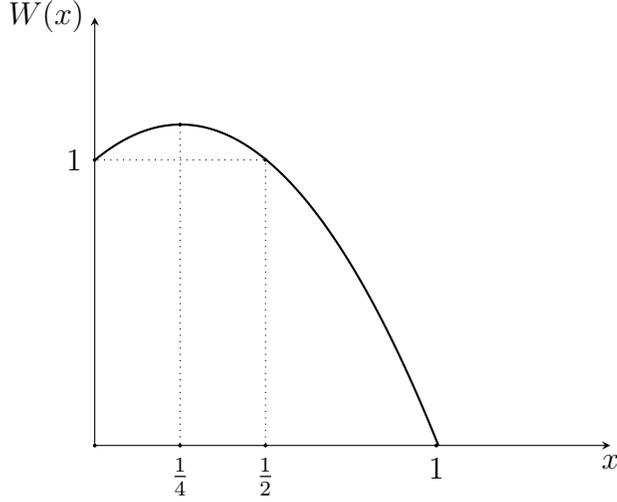
Figure 2: Welfare for $K = 2$. The banker's profit-maximizing asset choice is $x^b = \frac{1}{2}$. The socially optimal asset choice is $x^s = \frac{1}{4}$. For $0 < Y < \frac{16}{3}$, the banker's optimal asset choice satisfies, $\frac{1}{4} < x^* < \frac{1}{2}$.

the DI fee may depend on the asset choice.

Now, suppose the customer deposits and the banker chooses $x \in [0, \frac{1}{2}]$.[12] The payoff to the customer is $m_C(D, x) = ax + 1 - x$. Since $a < \pi < 1$, $m_C(D, \cdot)$ is strictly decreasing. So, the equitable payoff of the customer is the average of her payoff when the banker chooses $x = 0$ and her payoff when the banker chooses $x = \frac{1}{2}$. Hence,

$$m_C^e(x) = \frac{1}{2}\left(1 + \frac{1}{2}a + 1 - \frac{1}{2}\right) = \frac{3 + a}{4}$$

If the banker chooses $x \in [0, \frac{1}{2}]$ then her kindness to the customer is:

$$\kappa(x) = m_C(x) - m_C^e(x) = ax + 1 - x - \frac{3 + a}{4} = \left(\frac{1}{4} - x\right)\left(1 - a\right)$$

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[12]Recall from section 3.1 that any asset choice greater than $\frac{1}{2}$ is ignored for the purposes of utility calculations.

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Let x'' be the second-order belief held by the banker about her asset choice if the customer deposits. Recall that the material payoffs of the banker are unchanged from the case with no deposit insurance. It follows that the banker's belief about the kindness of the customer should he deposit, $\lambda(x'')$, is unchanged from the section with no deposit insurance:

$$\lambda(x'') = \frac{1}{2}Kx''(1 - x'')$$

Then, when the customer deposits, the banker solves the following problem:

$$\max_{x \in [0,1]} Kx(1 - x) + Y\left(\frac{1}{4} - x\right)\left(1 - a\right)\frac{1}{2}Kx''(1 - x'').$$

The maximand above is strictly concave in x; thus, the optimal choice of x is characterized by the first-order condition. Using the fact that in a SRE we must have $x'' = x^*$ it becomes:

$$x^* = \frac{4 + Y(1 - a) - \sqrt{16 + Y^2(1 - a)^2}}{2Y(1 - a)} \tag{6}$$

Given such second-stage behavior of the banker, the customer will deposit if:

$$ax^* + 1 - x^* > \pi$$

Substituting (6) into this inequality, the customer deposits if:

$$Y > \frac{2\left[2\pi - (1 + a)\right]}{(1 - \pi)(\pi - a)} \tag{7}$$

Observation 3. *With $a \in (0, \pi)$, the banker's asset choice, given by (6), is strictly decreasing in Y, approaches zero as Y becomes large, and approaches the profit-maximizing level as Y approaches zero. For fixed Y, the banker's*

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asset choice is strictly increasing in a. Finally, the level of risk taken by the banker is strictly greater than in the absence of deposit insurance.

Observation 3 shows that the banker takes more risk with DI than without. Intuitively, in the absence of DI the banker takes less risk (than the profit-maximizing level) in order to reciprocate the customer's kind action of depositing; by taking less risk, the banker reduces the likelihood of insolvency and increases the expected return to the customer. DI protects the customer in the event of insolvency and reduces the amount of harm the banker inflicts on the customer when she takes greater risk. This reduces the banker's incentive to hold back on risk-taking as compared to the case where the deposit is uninsured. As a increases, the customer is afforded more protection in the event of insolvency and this leads to additional risk-taking. Still, note that for any $a < \pi$ the amount of risk undertaken by the banker is less than if she acted as a profit-maximizer.

Our final observation in this section examines the welfare impact of DI. We assume that the lump-sum fee paid by the banker is a transfer of wealth and does not affect welfare. Similarly the amount, a, paid to the customer by the insurance agency if the asset fails, is a transfer of wealth from the insurance agency to the customer and does not affect welfare.

Observation 4. *If Y is sufficiently small (the precise bound is given by (5)) then equilibrium welfare is strictly decreasing in the degree to which the customer's deposit is insured, a.*

To understand Observation 4 recall the result discussed in Observation 2 with no DI. The banker's preference for reciprocity leads her to take less risk than if she had selfish preferences. For Y sufficiently small, this decrease in

risk-taking increases welfare. Introducing DI leads the banker to take on more risk than without DI, and decreases welfare.

3.4   Fully insured deposit $(a \geq \pi)$

When $a \geq \pi$ the full amount of the customer's initial deposit, π, is insured. Therefore, the customer is (weakly) better off depositing than not depositing, regardless of the banker's asset choice. Moreover, the banker is always better off when the customer chooses to deposit. Therefore, a decision not to deposit seems quite unreasonable when $a \geq \pi$. In essence, the customer faces no trade off between depositing and not depositing. It's better for everyone, no matter what the banker does, when the customer deposits.

Under these circumstances, a decision to deposit by the customer is no longer perceived as a kind (or unkind) action by the banker in the D&K model;[13] the kindness of the customer is zero. Since the customer is neither kind nor unkind to the banker when he deposits, the banker acts as if she is a profit-maximizer. This leads to our next observation:

Observation 5. *If $a \geq \pi$ then there is a unique SRE in which the customer deposits and the banker chooses the profit-maximizing asset.*

Observation 5 is straightforward, but the implication nevertheless significant. When the customer's initial deposit is fully insured, the insurance program counteracts any incentive provided by reciprocity for the banker to hold back on its risk-taking. While the banker may be motivated by reciprocity, her behavior is no different from that of a profit maximizer. This result may

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[13]Technically, the decision to not deposit is no longer (what D&K call) an efficient strategy for the customer. As mentioned in section 3.1 we refer an interested reader to D&K for a thorough treatment of efficient strategies.

provide a partial explanation for the casual observation that bankers maximize profit with little regard for the well-being of their customers.

4   Extensions

We next consider two variations of the model presented above. We first examine an environment in which the insurance provider observes the bank's risk. We then examine versions of the model with an arbitrary number of customers.

4.1   Observable asset choice

The previous analysis assumes that the risk taken on by the banker is unobservable by the insurance provider. In practice, fees paid by members of the FDIC partially depend upon the amount of risk a member banker undertakes. In this section, we assume that x is costlessly observed by the insurance provider. The insurance provider then charges a fee that depends on the asset choice. Let $C(x)$ be the fee paid by the banker when it chooses asset x. It is assumed that the banker only pays this fee in the event that the customer deposits and the asset is successful. If the customer does not deposit then the banker has taken no risk and is not charged. If the customer deposits but the asset fails, it's assumed that a bankruptcy rule applies and the fee is not paid.[14]

The insurance agency wishes to remain budget balanced (in expectation). If the banker chooses x, the expected cost to the agency is ax while the expected payment to the agency is $(1 - x)C(x)$. Budget balancedness implies that for all $x : (1 - x)C(x) = ax$. Hence, $C(x) = \frac{ax}{1-x}$. In this section, we

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[14]This bankruptcy rule imposed is innocuous. The analysis is unchanged if the banker must pay the fee even in the event of asset failure, provided the fee is actuarially fair

assume that $K > 1$ and allow for any $a \in [0,1]$.[15]

The profit maximizing choice of x then solves solves:

$$\max_{x \in [0,1]} (1-x)\left(Kx - \frac{ax}{1-x}\right)$$

It is easily verified that the profit-maximizing choice of x is $\hat{x}^b = \frac{K-a}{2K}$ (which is positive since $K > 1 \geq a$).

Any choice of $x > \hat{x}^b$ gives both the banker and the customer a strictly lower material payoff than $x = \hat{x}^b$. So, when calculating the minimum payoff the bank can give the customer, we restrict attention to $x \in [0, \hat{x}^b]$.[16] Modifying the definition given in (1), the equitable payoff of the customer is given by:

$$m_C^e \equiv \frac{1}{2}\left(\max_{x \in [0,1]} \{m_C(D,x)\} + \min_{x \in [0,\hat{x}^b]} \{m_C(D,x)\} \right)$$

Since the customer's payoff is decreasing in x when he deposits, it follows,

$$m_C^e = \frac{1}{2}\left[m_C(D,0) + m_C(D,\hat{x}^b) \right] = \frac{1}{2}\left[1 + a\hat{x}^b + 1 - \hat{x}^b \right].$$

The kindness of the banker to the customer is then given by,

$$\kappa(x) = ax + 1 - x - \frac{1}{2}\left[1 + a\hat{x}^b + 1 - \hat{x}^b \right].$$

Plugging in for $\hat{x}^b$ and re-arranging,

$$\kappa(x) = (a-1)\left(x - \frac{K-a}{4K} \right).$$

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[15]When x is non observable and $a \geq \pi$ (i.e. section 3.4) a decision not to deposit is inefficient. In this section, this is not true. The reason is that the banker is not *necessarily* better off when the customer deposits. If, for instance, the customer deposits and the banker chooses x close to 1, her payoff would be negative, and she would have been better off if the customer did not deposit.

[16]As defined in D&K, any $x > \hat{x}^b$ is inefficient. See footnote 9.

Now, if the banker holds the second-order belief x'', then the material payoff the banker believes the customer believes he is giving the banker when he deposits is $m_B(D, x'') = (1 - x'') \left(Kx'' - \frac{ax''}{1-x''} \right)$. By not depositing, the customer gives the banker 0. Hence, the equitable payoff of the banker is $\frac{1}{2} m_B(D, x'')$. So, the banker's belief of the kindness of the customer is $\lambda(x'') = m_B(D, x'') - m_B^e(x'') = \frac{1}{2} m_B(D, x'')$. Thus,

$$\lambda(x'') = m_B(D, x'') - m_B^e(x'') = \frac{1}{2}(1 - x'')\left(Kx'' - \frac{ax''}{1 - x''} \right).$$

The banker solves the following problem:

$$\max_{x \in [0,1]} \ (1 - x)\left(Kx - \frac{ax}{1 - x} \right) + \frac{1}{2} Y \left[(a - 1)\left(x - \frac{K - a}{4K} \right) \right] \left[(1 - x'')\left(Kx'' - \frac{ax''}{1 - x''} \right) \right].$$

Taking the first-order condition and using the fact that in any SRE $x'' = x$ we obtain the optimal asset choice:

$$x^* = \frac{4K + Y(1 - a)(K - a) - \sqrt{16K^2 + Y^2(1 - a)^2(K - a)^2}}{2YK(1 - a)}. \tag{8}$$

Given the second-stage behavior of the banker following a decision to deposit, the customer deposits only if $ax^* + 1 - x^* \geq \pi$. This leads to our next observation:

Observation 6. *When DI is financed via a variable charge, the banker's equilibrium asset choice (given by 8) is strictly decreasing in Y, approaches zero as Y becomes large, and approaches the profit-maximizing level as Y approaches zero. In the equilibrium, the customer deposits if Y is sufficiently large.*

This observation shows that the comparative statics with respect to the banker's reciprocity sensitivity are consistent with the model where x is unobservable. In contrast, the relationship between the optimal asset choice and the degree to which deposits are insured is less clear in this version of the model.

Observation 7. *When DI is financed via a variable charge, the banker's optimal asset choice may be increasing or decreasing in a. If $Y > 4$ then the banker's equilibrium asset choice is strictly increasing in a for a sufficiently small.*

When DI is financed via a variable charge, an increase in a has two competing effects. First, it provides additional protection to the customer and decreases the amount of harm the banker can inflict when she takes greater risk; this leads the banker to desire a higher x. However, an increase in a also increases the material cost of taking greater risk, since, for any x, the fee paid by the banker is increasing in a. Observation 7 shows that when the banker's sensitivity to reciprocity is sufficiently large, the reciprocity effect dominates the material effect for small values of a.

4.2 Multiple customers

In this section, we consider versions of the model with $n \geq 1$ identical customers, each of whom makes their deposit decision simultaneously. We assume that the banker's preference for reciprocity is the same with respect to each customer and that the banker's asset choice is unobservable by the insurance provider.

There are two distinct ways in which additional customers may be introduced. First, one could consider a version in which we introduce many

customers, each of whom is endowed with π units of money at the start of the game. This version of the model may be thought of as an expansion in the size of the banker; not only do we have more customers, but the banker now has a larger volume of deposits. Under such an expansion, it can easily be shown that the banker's optimal asset choice is independent of the number of customers. Moreover, our results from sections 3.2 - 3.4 remain completely unchanged. Intuitively, the degree to which the banker would like to reciprocate depends on how kind the banker perceives each customer to be. The banker's belief of the kindness of each customer depends on the additional payoff it thinks each customer has chosen to give the banker by depositing. The "gift" given by each customer, when he chooses to deposit, is unchanged from the case of a single depositor. Hence, the degree to which the banker would like to reciprocate does not change. As a result, the banker's equilibrium asset choice does not depend on the number of customers.

Alternatively, one could consider a version of the model in which our previously single customer, with π units of money to deposit, is fragmentized into many customers while the total amount of money endowed in the economy is unchanged. That is, each of n customers is endowed with $\frac{\pi}{n}$ units of money. We first study the case where $a \in [0, \pi)$; the case where $a \geq \pi$ is similar in spirit but differs in its technical details and will be addressed later in this section. If the asset fails, the payoff to any customer who deposited his endowment is $\frac{a}{n}$. Finally, if the banker's asset is successful then the payoff to the customer is $\frac{1}{n}$. If m customers deposit, and the asset is successful then the profit earned by the banker is $\frac{m}{n} Kx$.

Let $s_i \in \{D, N\}$ denote an action for customer i, and let $\mathbf{D} = (D, \cdots, D)$ denote the strategy profile of the customers corresponding to the case where all customers deposit. Let x_i'' denote the banker's second-order belief regarding

customer i, and let $\mathbf{x}'' = (x_1'', \cdots, x_n'')$ denote the vector of second-order beliefs held by the banker. Let $\kappa_i(x)$ be the kindness of the banker to customer i when the banker chooses asset x, and let $\lambda_i(x_i'')$ be the banker's belief of the kindness of customer i. We begin by analyzing the banker's behavior when all customer's deposit. Following D&K, if all customer's deposit, the banker's utility is:

$$U_B(\mathbf{D}, x, \mathbf{x}'') \equiv m_B(\mathbf{D}, x) + Y \sum_i \kappa_i(x) \lambda_i(x_i'').$$

The functions λ_i and κ_i are defined in a similar manner as in the single customer case. Consider some customer i. If customer i deposits and the banker chooses some $x \in [0, 1]$ then the kindness of the banker to customer i is,

$$\kappa_i(x) \equiv m_i(D, x) - m_i^e.$$

Here, $m_i(D, x) = x\frac{a}{n} + (1 - x)\frac{1}{n}$ is the material payoff of customer i when the banker chooses x. m_i^e is the equitable payoff of customer i. As in the single customer case, $m_i^e = \frac{1}{2}\left[m_i(D, 0) + m_i\left(D, \frac{1}{2}\right)\right]$. Hence, the kindness of the banker to customer i is,

$$\kappa_i(x) = \frac{1}{n}(ax + 1 - x) - \frac{1}{2n}\left(1 + \frac{a+1}{2}\right) = \frac{1}{n}\left(\frac{1}{4} - x\right)(1 - a).$$

Consider some customer, i, and suppose each of the other $n - 1$ customers choose to deposit. If i does not deposit, then the banker believes i thinks the banker's payoff will be: $(1 - x_i'')\frac{n-1}{n}Kx_i''$. If i deposits, the banker believes i believes the banker's material payoff will be: $(1 - x_i'')Kx_i''$. The equitable payoff

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of the banker with respect to customer i is the average of these two material payoffs: $\frac{1}{2}\left[(1 - x'')\frac{n-1}{n}Kx_i'' + (1 - x_i'')Kx_i''\right] = \frac{1}{2n}Kx_i''(2n - 1)(1 - x_i'')$. If all customers deposit the banker's belief of the kindness of customer i is then,

$$\lambda_i(x_i'') = (1 - x_i'')Kx_i'' - \frac{1}{2n}Kx_i''(2n - 1)(1 - x_i'') = \frac{1}{2n}Kx_i''(1 - x_i'').$$

If each customer deposits then the banker's optimal asset choice solves:

$$\max_{x \in [0,1]}(1 - x)xK + \frac{Y}{n^2}\sum_i \left[\left(\frac{1}{4} - x\right)(1 - a)\right]\left[\frac{1}{2}Kx_i''(1 - x_i'')\right].$$

The maximand above is strictly concave in x. Hence, the optimal asset choice is characterized by the first-order condition. Using the fact that in any SRE we must have $x_i'' = x^*$ we thus obtain the banker's optimal asset choice:

$$x^* = \frac{4 + (\frac{Y}{n})(1 - a) - \sqrt{16 + (\frac{Y}{n})^2(1 - a)^2}}{2(\frac{Y}{n})(1 - a)}. \tag{9}$$

Given the behavior of the banker when each customer deposits, each customer will deposit in an SRE if $x^*\frac{a}{n} + (1 - x^*)\frac{1}{n} > \pi$. Substituting our expression for x^* into this inequality we see that the customer deposits if:

$$Y > \frac{2n\left[2\pi - (1 + a)\right]}{(1 - \pi)(\pi - a)} \tag{10}$$

Observation 8. *For any fixed number of customers $n \geq 1$, the banker's equilibrium asset choice (given by 9) is strictly decreasing in Y, approaches zero as Y becomes large, and approaches the profit-maximizing level as Y approaches zero. For fixed Y, the banker's asset choice is strictly decreasing in a. In*

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equilibrium, the customer deposits if Y is large enough (see (10))

Observation (8) shows that in this version of the model the comparative statics results with respect to the sensitivity to reciprocity and a remain the same as in the single customer case. We now move on to investigate the impact on the banker's optimal asset choice.

Observation 9. *For fixed Y and a, the banker's equilibrium asset choice is strictly increasing in the number of customers and approaches the profit-maximizing level as the number of customers becomes large.*

Observation 9 demonstrates that as the degree of customer fragmentation increases, the banker takes greater risk. Intuitively, as n increases this decreases the stakes of the game; each customer has less money at stake. This reduces the harm the banker can cause each customer, and leads her to take greater risk. At the same time, the banker is inflicting harm on a larger number of customers when it takes greater risk; all else equal this leads the banker to take less risk. It turns out that the first effect always dominates the second. The reason is that the banker's utility is nonlinear with respect to the monetary stakes, but linear in the number of customers. As n increases, the stakes of the game diminish at the rate of $\frac{1}{n^2}$ while the number of customers grows at the rate n. As a result, the banker takes greater risk when the customer base becomes more fragmentized. In essence, the banker is more comfortable causing a little harm to many customers than causing significant harm to a few customers. Our final observation considers the case where $a \geq \pi$

Observation 10. *If $a \geq \pi$ then for any $n \geq 1$ there is a unique SRE in which each customer deposits and the banker chooses the profit-maximizing asset.*

As in the single-customer case, note that when $a \geq \pi$, choosing not to deposit is worse than depositing for both the customer and the banker. The

logic of Observation 10 then follows exactly as in Observation 5. For this reason, we do not include a proof of this statement.

5 Deposit insurance, market discipline, and moral hazard

We now discuss a leading alternative theory that connects DI and risk-taking, which is based on the relationship between DI, market discipline (MD) and moral hazard.[17] The essence of what we will refer to as the "market-discipline hypothesis" (MDH) is that, absent DI, debt-holders have strong incentives to monitor bank behavior. Moreover, debt-holders may, through some means, induce their banks to take less risk than they would otherwise. The introduction of DI protects customers/investors in the event of insolvency, decreases incentives for the market to engage in costly monitoring activities, thereby leading bankers to take greater risk. Cooper and Ross provide a formal account of the MDH, but take for granted the ability of debt-holders to observe/understand banker risk (market monitoring) and their ability to affect bank behavior (market influence). These abilities are essential for market discipline to be effective (Bliss and Flannery, 2002), and are therefore necessary conditions for the MDH. In fact, Cordella et al. (2018) show that if debt-holders are not willing and able to exert market discipline, then the introduction of government guarantees may lead banks to choose *less* risky assets. So, we begin our discussion by describing some of the relevant empirical literature on MD (both market monitoring and influence). A more in-depth survey of this literature can be

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[17]Yet another plausible explanation is that bankers hold inside debt (Cassell et al., 2012; Bennett et al., 2015; Van Bekkum, 2016), which leads them to internalize the consequences of their risk-taking behavior. DI may interfere with this incentive. The empirical relevance of this hypothesis has been less thoroughly explored as far as we are aware.

found in Demirgüç-Kunt and Kane (2002)

The typical study examines the relationship between proxies of banker risk-taking and either deposit growth, or interest rates (interest rates on deposits, yield spreads on subordinated debt, or spreads on new bond issues). A negative (positive) relationship is consistent with market participants that are at least able to understand measures of bank risk-taking. Generally speaking, the evidence on MD appears to be mixed. Focusing on yield spreads on subordinated debt, a number of studies in the 1980s find little-to-no evidence in support of MD (e.g., Avery et al., 1988; Gorton and Santomero, 1990). Yet, also focusing on yield spreads on subordinated debt, evidence in support of MD was found in several studies from the 1990s and early 2000s (e.g., Flannery and Sorescu, 1996; Sironi, 2003).[18] Focusing on spreads of new bond issues, Morgan and Stiroh (2001) find that bankers holding riskier portfolios tend to have greater spreads.

Yet at the heart of the MDH is whether bank managers actually *change* their behavior in response to, say, stock or bond prices. Bliss and Flannery specifically address this question and find no support, writing (p. 361): "Day-to-day market influence remains, for the moment, more a matter of faith than of empirical evidence." More recently, Berger and Turk-Ariss (2014), focusing on deposit growth, find a negative relationship between measures of risk and deposits leading up to the recent crisis, but no relationship during the crash.[19]

In addition to the ability of depositors to discipline their bankers, the MDH also requires that MD weakens after the introduction of DI. In the affirmative,

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[18]Several authors, including Flannery and Sorescu and Sironi attribute the difference in these findings to a changing regulatory environment. In the early to mid 80s, they argue, implicit safety nets that protected holders of banker liabilities, and decreased incentives to monitor; these safety nets vanished in the late 80s and early 90s.

[19]The lack of a significant relationship during the crash is attributed to government interventions in the market.

Demirgüç-Kunt and Huizinga study the connection between DI, measures of risk-taking, and interest rates on deposits; the authors find that the presence of DI makes interest rates less sensitive to risk. Furthermore, Ioannidou and Penas (2010) examine the riskiness of bank loan profiles before and after the introduction of DI in Bolivia. They show that, prior to the introduction of DI, banks with a high share of large depositors take less risk, but this effect disappears after DI is introduced. The authors explain this by arguing that large depositors have the greatest incentives (and ability) to monitor bank behavior; the introduction of DI then leads to a breakdown in MD, as these large depositors lose the incentive to monitor.[20] Martinez Peria and Schmukler (2001) study the relationship between the volume of deposits, interest rates on deposits, and bank risk-taking in Argentina, Chile, and Mexico, and find no evidence that DI decreases MD. The authors point to two particular reasons why. The first reason is related to the credibility of the insurance provider; if the insurance provider lacks credibility, then DI need not lead to less MD. Second, insured depositors may wish to avoid any costly delays in the event their bank becomes insolvent.

Finally, even if depositors can monitor/influence their banker's behavior, and depositor discipline weakens after DI is introduced, the MDH still requires that government regulators do not share this same ability, or face other political constraints, which hamper their willingness to charge appropriate risk-based premiums (Pennacchi, 2009). Otherwise, DI would merely shift the burden of discipline from depositors to government agencies like the FDIC. Demirgüç-Kunt and Kane present evidence consistent with this conjecture.

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[20]Our results on customer base fragmentization (Section 4.2) also imply that bankers with a high share of large depositors take less risk in the absence of DI. Our model predicts that this effect completely disappears if the DI program offers full coverage of deposits.

The authors study the relationship between DI and the stability of the banking system (as measured by the likelihood of a banking crisis). The authors find that the presence of DI is associated with more frequent crises, and that a crisis is more likely when the degree of coverage is higher (findings consistent with our results). However, it is also shown that in countries with better established regulatory institutions, the impact of DI is much less pronounced. Also speaking to this issue, Sironi (p. 446) writes, "...the available empirical research on the U.S. banking industry indicates that financial markets participants and banker supervisors both produce value-relevant information about the future soundness of bankers and that neither the market nor supervisors possess clearly superior quality information."

All in all, on our reading, the evidence on monitoring is ambiguous enough to justify consideration of our alternative (or complementary) reciprocity-based account.

6   Concluding remarks

Empirically, there appears to be a connection between deposit insurance (DI), risk-taking, and insolvency. From the perspective of classical economic theory, at first glance this seems puzzling. If banks decide how much risk to take then DI should not affect their choice, since DI affects the payoffs of depositors and not that of bankers.

A commonly cited hypothesis contends that DI decreases customers' incentives to monitor their bankers, and therefore leads to more risky bank behavior. One may, however, be skeptical of this idea because monitoring by the FDIC would seem to be an adequate substitute for depositor monitoring. Also, the empirical support for the monitoring hypothesis is not overwhelming

(cf. section 5).

We propose an alternative, or complementary, theory. The observed connection between DI, risk-taking, and insolvency can be explained if bankers are motivated by reciprocity. We note that different types of institutions may differ in terms of their desire to protect their customers. For small local banks, in which bankers have personal relationships with their customers, reciprocity may have more "bite" than with large international banks. That is, the banker's sensitivity to reciprocity (in our model, this is captured by the parameter, Y) may be greater for local banks than international institutions. Indeed, this might provide one testable hypothesis that could distinguish our story from that of the MDH.

Some economists will find it hard to accept the notion that professional bankers would not have the pure objective to maximize profit. They may look back at recent market turmoil and interpret it in terms of greed & profit rather than quid-pro-quo reasoning. However, we defend our assumption in three ways: First, much recent experimental and empirical evidence suggests that many people are motivated by reciprocity (cf. footnote 4), and in this paper we allow ourselves to apply such an assumption to bankers to explore what it implies. Second, this assumption turns out to get the predictions right. Third, *with DI*, if bankers are motivated by reciprocity they do in fact appear to be all about greed & profit. That is, with DI, reciprocal bankers will act *as if* they maximize profit.

We have purposely chosen to analyze the simplest model that is rich enough to deliver our main message. However, two potentially too strong abstractions are worth pointing out. First, we have assumed that the banker takes the interest rate on deposits as given and that this rate is independent of the risk taken by the bank. This modeling assumption can be justified on the basis

of observed "stickiness" of deposit rates (Driscoll and Judson, 2013). Still, one could alternatively imagine a model in which this interest rate is another choice variable of the banker. This additional choice variable would potentially give the banker an additional means of reciprocation; namely, she can change the interest rate to increase the customer's expected payoff. Note, however, that holding back on risk would still be another means of reciprocation with such alternative specification. Second, we focused on the case of a single bank. In order to attract deposits in a setting with competition between banks, banks must behave in a way that is more favorable to customers. In the presence of DI customers will likely be less concerned about insolvency (since they are protected), and may demand higher interest rates, which might consequently induce greater risk-taking. We leave a thorough investigation of these possibilities for future work.

Appendix

Proof of Observation 1

Proof. The fact that there exists a unique SRE in which the customer deposits when Y exceeds the threshold in (4) is immediate. Multiplying the numerator and denominator of the expression for x^* by $\left(4+Y+\sqrt{16+Y^2}\right)$, it may easily be checked that we may re-write x^* as

$$x^* = \frac{4}{4 + Y + \sqrt{16 + Y^2}}$$

Examining this expression, it is clear that the banker's optimal asset choice is strictly decreasing in Y approaching 0 as $Y \to \infty$ and approaching $\frac{1}{2}$ (the profit-maximizing asset choice) as $Y \to 0$. Finally, since $\lim_{Y\to 0} x^* = \frac{1}{2}$ and

x^* is strictly decreasing in Y it is clear that $x^* < \frac{1}{2}$ for all $Y > 0$.

$\square$

Proof of Observation 2

Proof. When $K < 1$ welfare is strictly decreasing in x for all $x \in [0, 1]$. Since x^* is strictly decreasing in Y, the result immediately follows. If $K > 1$ then the socially optimal level of risk is $\frac{K-1}{2K} < \frac{1}{2}$. Clearly, welfare is strictly decreasing in x for all $x \in (\frac{K-1}{2K}, \frac{1}{2})$. It is easily verified that when the inequality given by (5) is satisfied, we have $x^* \in (\frac{K-1}{2K}, \frac{1}{2})$. Since x^* is decreasing in Y, the result follows.

$\square$

Proof of Observation 3

Proof. Multiplying the numerator and denominator of $x^*(Y, a)$ by $\left(4 + Y(1 - a) + \sqrt{16 + Y^2(1 - a)^2} \right)$ we obtain:

$$x^*(Y, a) = \frac{4}{4 + Y(1 - a) + \sqrt{16 + Y^2(1 - a)^2}}$$

Since $a < 1$ it is clear from this expression that $x^*(Y, a)$ is strictly decreasing in Y, approaching 0 as $Y \to \infty$ and approaching $\frac{1}{2}$, the profit-maximizing asset choice, as $Y \to 0$. It is also easily seen that the denominator in the expression above is strictly decreasing in a which means $x^*(Y, a)$ is strictly increasing in a. Finally, note that $x^*(Y, 0)$ is the asset choice in the case where deposits are uninsured. Since $x^*(Y, a)$ is strictly increasing in a, clearly the banker takes on more risk than when the customer's deposit is uninsured. $\square$

Proof of Observation 4

Proof. First note that $x^*(Y,0)$ corresponds to the banker's optimal asset choice when the customer's deposit is uninsured (this is the optimal asset choice from section 3.2). Then recall from the proof of Observation 2 that, for $Y \in (0, Y^*)$ we have $x^*(Y,0) > x^s$, where x^s is the welfare maximizing asset choice. Fix $Y \in (0, Y^*)$ and note that for any $a, a' \in (0, \pi)$ with $a' > a$, Observations 2 and 3 together imply $x^*(Y, a') > x^*(Y, a) > x^*(Y, 0) > x^s$. By the strict concavity of $W(\cdot)$ we must have $W(x^*(Y, a)) > W(x^*(Y, a'))$.

$\square$

Proof of Observation 5

Proof. When $a \geq \pi$, both the customer and the banker are weakly better off when the customer deposits for any asset choice $x \in [0, 1]$. Moreover, the banker is strictly better off when the customer deposits for any asset choice $x \in (0, 1)$. Thus, following D&K's definition of efficient strategies, not depositing is no longer an efficient strategy for the customer. It follows that, when the customer deposits, this action is neither perceived as kind nor unkind (so $\lambda(x'') = 0$), since depositing is the only efficient strategy. Therefore, the banker will choose the asset which maximizes its expected material payoff (profit). When the banker chooses the profit-maximizing asset, the customer is strictly better off depositing for any $a \geq \pi$. Hence, there is a unique SRE in which the customer deposits and the banker chooses the profit-maximizing asset.

$\square$

Proof of Observation 6

Proof. Multiplying the numerator and denominator of (8) by

$$4K + Y(1-a)(K-a) + \sqrt{16K^2 + Y^2(1-a)^2(K-a)^2}$$

We obtain the equivalent expression:

$$x^* = \frac{4(K-a)}{4K + Y(1-a)(K-a) + \sqrt{16K^2 + Y^2(1-a)^2(K-a)^2}}$$

Since $a < 1 < K$ it is clear from this expression that x^* is strictly decreasing in Y, approaching 0 as $Y \to \infty$ and approaching $\frac{K-a}{2K}$, the profit-maximizing asset choice, as $Y \to 0$.

$\square$

Proof of Observation 7

Proof. Differentiating $x^*(Y, a, K)$ with respect to a and evaluating at $a = 0$ we obtain:

$$\left.\frac{\partial x^*(Y, a, K)}{\partial a}\right|_{a=0} = \frac{(4K - Y)\sqrt{Y^2 + 16} + (Y^2 - 16K)}{2KY\sqrt{Y^2 + 16}}$$

Clearly $\left.\frac{\partial x^*(Y,a,K)}{\partial a}\right|_{a=0} > 0$ if and only if the numerator of the expression above is positive. Let $\Gamma(Y, K) \equiv (4K - Y)\sqrt{Y^2 + 16} + (Y^2 - 16K)$ ($=$ the numerator in the expression above). It is easily verified that $\Gamma(Y, K)$ is strictly increasing in K for any $Y > 0$. Since $K > 1 \implies \Gamma(Y, K) > \Gamma(Y, 1)$. Finally, note that $\Gamma(Y, 1) > 0$ if and only if:

$$(Y - 4)\left[(Y + 4) - \sqrt{Y^2 + 16}\right] > 0 \iff Y > 4$$

Thus, if $Y > 4$ then for a sufficiently small $\frac{\partial x^*(Y,a,K)}{\partial a} > 0$. $\qquad\square$

Proof of Observation 8

Proof. Multiply the numerator and denominator of (9) by

$$4 + \left(\frac{Y}{n}\right)(1 - a) + \sqrt{16 + \left(\frac{Y}{n}\right)^2 (1 - a)^2}$$

The remainder of the proof is analogous to the proofs of Observations 3 and 4.

$\qquad\square$

Proof of Observation 9

Proof. Let $x^*(Y, a)$ denote the banker's optimal asset choice in the model examined in section 3.3 with a single customer. Examining our expression for $x_n^*(Y, a)$ it is clear that $x_n^*(Y, a) = x^*\left(\frac{Y}{n}, a\right)$. Letting $\hat{Y} \equiv \frac{Y}{n}$ we have,

$$\frac{\partial x_n^*(Y, a)}{\partial n} = \left(\frac{\partial x^*(\hat{Y}, a)}{\partial \hat{Y}}\right)\left(-\frac{Y}{n^2}\right)$$

By observation 3 we know $\frac{\partial x^*(\hat{Y},a)}{\partial \hat{Y}} < 0$ which means $\frac{\partial x_n^*(Y,a)}{\partial n} > 0$. Finally, note that $\lim_{n\to\infty} x_n^*(Y, a) = \lim_{\hat{Y}\to 0} x^*(\hat{Y}, a) = \frac{1}{2}$ by Observation 3.

$\qquad\square$

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