Trust in Lending*

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Abstract

We develop a theory of trust in lending, distinguishing between trust and reputation, and use it to analyze the competitive interactions between banks and non-bank lenders. Trust enables lenders to have assured access to financing, whereas a loss of investor trust makes this access conditional on market conditions and lender reputation. Banks endogenously have stronger incentives to maintain trust. When borrower defaults erode trust in lenders, banks can survive the erosion of trust when non-bank lenders do not. Trust is also asymmetric in nature—it is more difficult to gain it than to lose it.

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1 Introduction

This paper examines the effect of trust on the cost of lending and credit market competition between banks and non-banks. Trust in financial products and institutions is often essential for financial markets to function efficiently. Since the origins of banking, trust has played a foundational role, with "my word is my bond" defining the very essence of banks with regard to their safekeeping and depository functions. This notion of trust in financial institutions also has deep implications for the credit that lenders provide, since intermediaries use the funds they raise from depositors and investors to make loans. For example, a bank that makes a bad loan endangers the trust of its depositors and hence its access to future funding. In line with this, trust has been part of the policy discussions regarding the potential impact of non-intermediated credit—such as that provided by financial technology (fintech) lenders such as peer-to-peer (P2P) lending platforms—and the credit market (see He et al. (2017)). This suggests that practitioners and market participants understand the role of trust in enabling fintech firms to compete with banks.[1]

Trust in lending is therefore pivotal to the ability of banks and other intermediaries to sustain their funding models. But analyzing trust can also generate a perspective on the future evolution of the credit market as non-depository lending grows. Shadow banking experienced significant growth before the 2007-2009 financial crisis, and since then P2P lending platforms and other types of lending by non-banks has been growing at a rapid clip.[2] Buchak et al. (2018) report that more than half of new U.S. residential mortgage lending is now done by shadow banks. This non-bank lending growth has come at a time

[1]For example, Rhydian Lewis, co-founder and chief executive of RateSetter, says "Banks can currently access money more cheaply than marketplace lenders and, in order to be truly competitive, this gap must reduce. The route to this for lending platforms is to build trust and acceptance, which comes with a strong track record" (see Green (2016)). Consistent with this, international data reveal that private credit provision goes down as trust declines. One can see a negative relationship between the credit-to-GDP ratio (from World Development Indicators) and the lack of trust indicator (from the Findex dataset) in 2017. We thank Nicola Limodio for providing this data.

[2]While it initially started as non-intermediated platform-assisted credit transactions between peers, the investors in these platforms are now mainly institutional investors; during the first quarter of 2016, only 15% of Lending Club's loans came from individuals investing on their own (see Salisbury (2016)).

when the lending capacity of depository institutions seems to not be growing (see Fenwick, McCahery, and Vermeulen (2017)). This has been observed not only in the U.S. but also in Europe, causing many to debate the future of banks in performing lending and other functions (e.g. Sorkin (2016)). While there have not yet been any major recent scandals in non-bank lending, there are many ways in which these lenders can create suspicion of being untrustworthy.[3] Our analysis suggests that the growth of fintech firms and shadow banks may be halted if there is an event that erodes trust; this would cause funding to dry up and their borrowers to return to banks. We therefore posit that understanding the role of trust in lending is central to understanding the future evolution of the credit market.

These developments raise the following research questions: What is the effect of trust on the access to and cost of financing for lenders? How is trust related to and different from lender reputation? What incentives do lenders have to maintain trust and what can erode it? How do these incentives differ across banks and non-bank lenders?

We develop a theoretical model to address these questions. As a starting point, we note that from a functional perspective (e.g. Merton (1990, 1993, 1995) and Merton and Bodie (1995, 2005)), the lending *functions* of banks and non-bank lenders are similar—both provide debt financing to clients.[4] However, these lenders have different institutional features. We therefore take an institutional perspective to examine the differences between banks and non-banks in terms of their ability to *endogenously* sustain trust.

In so doing, we focus on one key difference between banks and non-banks, which is that banks raise significant financing through deposits, whereas non-banks do not.[5] In our model, although deposits differ from other types of financing, there is no meaningful economic

[3]For example, Lending Club sold a major portfolio of $22 million to a large investor and subsequently discovered the loans were neither what Lending Club had advertised nor what the investors had asked for. Lending Club bought back the loans and launched an investigation that led to the firing of three senior executives. See Wallace (2016).

[4]Henceforth, we will refer to all non-depository financial firms, such as shadow banks and fintech firms, as "non-banks". The term "banks" refers to depository institutions.

[5]Not all fintech lenders are all-equity financed, but the key is they are non-banks with no access to deposits. Thus, the crucial distinction between banks and fintech that our analysis relies on is that banks have access to lower-cost funding via deposits, but fintech lenders lack this access.

distinction between non-deposit debt and equity; the Modigliani-Miller capital structure irrelevance theorem applies. Thus, in order to include both fintech firms and shadow banks, we assume non-banks are all-equity financed, as noted by Philippon (2015, 2016).[6] We draw upon the earlier work of Merton (1993, 1995, 1997) and Merton and Thakor (forthcoming) in which the bank's depositors are viewed as customers who are provided valuable liquidity services and are insulated from the bank's credit risk through a combination of deposit insurance and the bank's actions, whereas non-banks have no such "customer relationship" with their financiers.[7] This gives banks a potential funding cost advantage over non-bank lenders as well as an endogenous economic motivation to act in a more trustworthy manner in investing their funds.[8] Thus, unlike the usual distortionary effect of deposit insurance, in our model deposit insurance contributes to improved asset choice incentives for the bank. Given our focus on deposit funding as the key distinguishing feature between banks and non-banks, we abstract from other institutional differences between banks and non-banks, such as in regulation and in information-gathering processes. Apart from the fact that these features are not central to our theory, we discuss later that incorporating these differences will strengthen our results.

We recognize that trust has two dimensions: (i) being trustworthy, and (ii) being competent. Trustworthiness is about intent, whereas competence is about skills. A completely trustworthy but incompetent entity can make decisions that are as bad as those of an untrustworthy entity. Our focus is on trustworthiness, which is why we assume that banks and non-banks are equally competent in collecting and processing information. In order to specifically model this notion of trust, we follow Fehr (2009), who argues that a behavioral definition of trust is the most appropriate and that the development or erosion of trust is

[6]Philippon (2015, 2016) notes that fintech platforms can be viewed as all-equity financed. Shadow banks are highly leveraged, of course, but since capital structure irrelevance obtains when excluding deposits, it does not matter whether non-banks in the model are debt or equity financed.

[7]There are other ways in which deposits can be made safe, e.g., through liquidity requirements; see Limodio and Strobbe (2018).

[8]Recent empirical evidence supports the idea that deposits give banks a funding cost advantage, and that this is a source of enhanced profitability and value. See Egan, Lewellen, and Sunderam (2017), and Drechsler, Savov, and Schnabl (2018).

often more than just inferring *a priori* unknown types from observations.[9] Indeed, trust often has a 0-1 property—you either trust someone or you do not. Unlike Fehr (2009), however, we model trust using Ortoleva's (2012) model of (partly) non-Bayesian belief revision in which agents face uncertainty both about the correct model of the world ("is the lender trustworthy or self-interested?") as well as about the lender's "type" within a given model (if self-interested, is the lender still worth financing?). Within-model uncertainty is a reputational effect and is captured by the usual prior beliefs, whereas uncertainty about the true model is captured by a *prior over priors*. This then leads to a belief revision process that is Bayesian in some states and non-Bayesian in others, providing an ideal framework for analyzing lender reputation and trust simultaneously. In this framework, a lender is trusted if agents adopt a model of the world that the lender will never make a bad loan; this leads to an analysis in which market conditions and lender performance do not affect the lender's cost of funding. But in the face of sufficiently strong ex post evidence that this model is incorrect, trust is lost (via non-Bayesian belief updating)—lenders are viewed as self-interested, and market conditions and lender performance (reputation) influence the cost and availability of financing to lenders, with post-model-shift beliefs revised in a Bayesian manner.[10]

We motivate our modeling of trust by noting a remarkable feature of the 2007-2009 crisis, namely the alacrity with which the effect of stress was manifested. Gorton and Metrick (2012) document that the average haircut on bilateral repo transactions (excluding U.S. Treasuries) rose from zero in early 2007 to almost 50% at the peak of the crisis in late 2008, with several

[9] Fehr (2009, p. 238) notes: "An individual...trusts if she voluntarily places resources at the disposal of another party (the trustee) without any legal commitment from the latter. In addition, the act of trust is associated with an expectation that the act will pay off in terms of the investor's goals. In particular, if the trustee is trustworthy the investor is better off than if trust were not placed, whereas if the trustee is not trustworthy the investor is worse off than if trust were not placed."

[10] Our modeling of within-model uncertainty is somewhat similar to Hartman-Glaser (2017), where there is asymmetric information about issuer preferences for honestly revealing quality. In that model, asset retention by an issuer selling the asset acts as a signal of asset quality, and reputation induces pooling, in contrast to the static case in which the equilibrium is separating. Ordonez (2013) models fragile reputation in credit markets that results in correlated risk-taking by reputable firms in response to small changes in aggregate conditions. A similar idea appears in Ordonez (2018) wherein the viability of securitization depends on the confidence the parties to a contract have that counterparties will behave as expected, even absent explicit contractual provisions. In our model, there is no securization or loan retention decision, and uncertainty about the true model plays a central role.

classes of assets having 100% haircuts, i.e., they were excluded entirely from being used as collateral.[11] Similarly, Iyer, Lopez, Peydro, and Schoar (2013) documented an unexpected and sudden freeze of the European interbank market in August 2007. These are examples of discontinuities in pricing that suggest non-Bayesian belief revision by agents about the economic environment—agents believing in a particular model of the economic environment and then, faced with unexpected news, switching to a different model. Such behavior is plausibly understood in a trust framework—economic agents trust that the financial products and institutions they are dealing with have certain attributes, but then that trust is lost when unexpectedly bad news arrives that is incompatible with the initial trust. This can induce a sharp and discontinuous change in prices and trading volume.

This modeling of trust captures three features. First, trust reduces an investor's perception of the riskiness of a given investment (as in Gennaioli, Shleifer, and Vishny (2015)), making the pricing of credit seem disassociated from the risk in the environment. Thus, when lenders are trusted, risk will—from an *ex post* perspective—appear to be underestimated. For example, Coval, Jurek, and Stafford (2009) document that investors underestimated the probability of mortgage defaults in pricing mortgage-backed securities.[12] Min (2015) and Stephanou (2010) note that *none* of the key market metrics that should have provided signals about the increasing risks at financial firms showed *any* indications of higher risk until August 2008 or later, even though risks had been rising. Similarly, Lee, Miller, and Yeager (2015) collected the yields on subordinated debt issues from 2002 to 2007, and found no

[11] In addition to explaining this sharp increase in haircuts on bilateral repos, the trust perspective also helps to shed light on a puzzling stylized fact. During the 2007-2009 crisis, in sharp contrast to haircuts on bilateral repos, haircuts on tri-party repos remained roughly constant (see Copeland, Martin, and Walker (2011), and Sanches (2014)). One possible reason for this is that there are two banks—Bank of New York Mellon and JP Morgan—that act as third-party agents for U.S. tri-party repo transactions, and these institutions maintained the trust of investors during the crisis. Since tri-party agents are involved in collateral selection, payment and settlement as well as essentially financing collateral sellers (borrowers) for most of the day during intraday unwinding and resetting of contracts, investor trust in these tri-party agents is important. Such agents are absent in bilateral repos.

[12] A reason for trust being placed in these types of lenders and financial technologies in the first place is likely due to a combination of the technologies being opaque and yet working well to begin with. Indeed, if such technologies were transparent, then there may be no need for trust for them to be adopted.

correlation between these yields and commonly-used risk measures.[13]

Second, trust may be lost with a minor perturbation of observed outcomes, but when it is lost it can precipitate a crisis that involves a drying up of funding to lenders, consistent wtih sharp discontinuities in prices and trading.

Third, a crisis generated by the loss of trust will have the feature that the risks being penalized during the crises were not even contemplated by investors when there was trust.[14] Lack of contemplation of positive probability events that lead to very risk-insensitive pricing, followed by episodes of pricing spikes and funding dry-ups for some institutions when a crisis occurs, are phenomena that are easily comprehended within our framework.[15] The use of model uncertainty in Ortoleva's (2012) non-Bayesian framework allows us to capture all these three features of trust, but in a way that differs from previous approaches.

Our theory produces the following main results. First, trusted lenders can raise financing at the lowest cost regardless of their *prior* loan default experience and market conditions, so default risk will appear to be underpriced. Second, the lender's ability to *maintain* the trust of its financiers depends on its post-trust default experience and market conditions—trust can be eroded when lenders experience (significant) defaults during an economic boom. We show that when trust is lost, banks may survive the loss of trust and hence continue to operate when non-bank lenders are forced to shut down. That is, while trust is important for all lenders, it is essential for non-banks. Third, banks have stronger endogenous incentives

[13] They noted that "[m]arket participants rewarded good performance but did not punish increased risk."

[14] In the context of the 2007-2009 crisis, evidence presented by Foote, Gerardi, and Willen (2012) indicates that investors did not even contemplate the magnitude of the home price declines that actually occurred.

[15] Discontinuities may also arise in moral-hazard-based reputation models with *known* types in which the threat of future punishment deters bad behavior and generates trigger strategy equilibria. For example, Winton and Yerramilli (2015) create a model of loan securitization by a bank, in which the moral hazard is that the bank may not monitor the borrower. Reputation acts as a sanctioning mechanism that operates purely through the threat of future punishment imposed on the bank for poor loan performance. In equilibrium, both the punishment threat and loan retention by the bank combine to provide monitoring incentives. There are some key differences between these models and ours. One is that our model features both private information and moral hazard and the key to both reputation and trust is the intertemporal learning that occurs about the lender's type, with price adjustments predicated on this learning. Second, we focus on providing a way to distinguish between credit market reputation and trust in a private-information setting (with unknown types) with the feature that in equilibrium, trust *insulates* lenders against performance-based risk pricing adjustments, whereas reputation does not.

to maintain trust, so a potential advantage of banks is that they are *trusted lenders*. Finally, investor trust has an "asymmetry" property—it is easier to lose than to gain.

The intuition for the results is as follows. When lenders are trusted, they are able to obtain the cheapest possible funding. But because banks finance with deposits and provide depositors liquidity services, they share in the associated liquidity benefits and can raise financing at a lower cost than non-banks, all else equal. The associated higher profitability is available only when the bank remains solvent, which provides the bank a stronger incentive than non-banks to make good loans with a higher solvency probability. When loans repay, trust is maintained and funding costs are unchanged since trusted lenders are believed to unconditionally make only good loans. However, if loans default, then investors may question their assumed model of the world that lenders are trustworthy. Trust may still be maintained if default occurs in a "bad" macro state in which such default is more likely, but trust will be lost if default occurs in a relatively "good" macro state in which it was unlikely to occur with a trusted lender.[16] A loss of trust means that investors' initially-adopted model is discarded, and investors will now believe that lenders are self-interested. This model switching causes a discontinuous increase in the funding costs of lenders, with funding possibly drying up for non-banks. The reason is that among self-interested lenders, banks have stronger reputational incentives to make good loans. Recognizing this, investors may finance self-interested banks, but not self-interested non-banks, giving banks a greater ability to survive a loss of trust.[17]

In a nutshell, our basic idea is that trust insulates lenders from the adverse reputational consequences of loan defaults, and the degree of insulation depends on market conditions.[18]

[16]The intuition is that ex ante loan defaults are more likely in bad macro states than in good ones, so on average there will be more defaults in bad macro states. Trust is lost when the observed defaults significantly exceed what was expected in that macro state with a trusted lender.

[17]Our analysis does not consider the contagion effects of a loss of trust or reputation, a feature that may amplify the effects we model. For example, in a reputation model, Morrison and White (2013) model the regulator's reputation and show that this can give rise to contagion effects, whereby the failure of one bank may indicate regulatory incompetence and induce investors to withdraw funding from other banks.

[18]In a sense, when there is trust, depositors are "liability insulators" in the sense of Chodorow-Reich, Ghent, and Haddad (2018)—the cost of the bank's liabilities (and hence the value of the bank's equity) is insulated from fluctuations in asset "market values".

Whether they are trusted or must rely on reputation, the depository (customer) relationships banks have are a source of rents—unavailable to non-bank lenders—that influence banks to make good loans in some states even when they are self-interested. This is what enables banks to survive when trust is lost, a circumstance in which non-banks shut down.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 develops the formal model. Section 4 provides an analysis of the first best. Section 5 analyzes the second best. Section 6 discusses extensions and the implications of introducing additional institutional differences between banks and fintech lenders. Section 7 concludes. All proofs are included in the Appendix. The Appendix also contains a simple example that compares our modeling of trust to a standard Bayesian reputation framework. The example shows that our model provides a way to sharply distinguish between trust and reputation as concepts within the same model, and sheds light on phenomena that would otherwise be difficult to explain. It shows that in some states of the world, a trusted lender can survive default on its debt unscathed without impacting its funding cost, whereas a lender in a standard reputation setting would be shut down.

2 Related Literature

Our paper is also related to work on the role of trust in financial markets. Guiso, Sapienza, and Zingales (2008) develop a model in which the individual's trust that he will not be cheated determines whether he will participate in the stock market. Less trusting individuals are less likely to buy stock, and buy less when they do participate. Their calibration of the model indicates that mistrust is sufficiently severe to explain limited participation in the U.S. and differences across countries. Sapienza and Zingales (2011) review this literature. Our work is complementary in the sense that whether institutional lenders have the trust of investors affects whether investors are willing to fund these lenders.[19] However, there

[19]Recently, Gurun, Stoffman, and Yonker (forthcoming) provide evidence that communities exposed to the Madoff Ponzi scheme withdrew assets from investment advisers and increased deposits at banks, and

are numerous differences, the key one being our focus on the role of trust in determining the cost and availability of financing to institutional lenders and the resulting nature of the competitive interaction between banks and non-banks. Other differences are our modeling of the way trust can be lost and the asymmetric nature of trust.

Another paper in which trust plays a role is Gennaioli, Shleifer, and Vishny (2015a). In that model, trust in investment advisors helps to reduce the risk that risk-averse investors perceive in investing in assets recommended by the advisor. Net of advisors' fees, investors do worse than the market, but they still prefer to pay fees. When investors have biased expectations and chase hot stocks, even trusted advisors pander to their clients' beliefs rather than correcting them. This is quite a different notion of trust from what we model, in at least three respects. First, in our model, all agents are risk neutral, so trust plays no role in reducing risk-aversion-related anxiety. Second, a lender that is truly a trusted lender never violates the trust; it is only self-interested lenders mistaken as trusted lenders that violate trust at times. And finally, our focus is on a very different set of issues, including incentives to maintain trust that differ across lenders and the asymmetric nature of trust in the sense that it is easier to lose than to gain it.[20]

Our theory is complementary to the "neglected risks" argument in Gennaioli, Shleifer, and Vishny (GSV, 2012, 2015b), who develop models of financial crises in which investors overweight "representative events" (based on the Tversky and Kahneman (1974) idea of "representativeness"), thereby underestimating security risk during good times.[21] While their theory is about the security-related beliefs of investors, our theory is about *lender-specific* beliefs of investors. This leads to numerous differences. First, in the GSV models, when the neglected risks of a security are eventually recognized, all firms holding that security

provide evidence that services which built up more trust experienced fewer withdrawals. Although their focus is money management, this is broadly consistent with the mechanism in our model that banks are trusted and that there will be flight towards more trusted entities following a loss of trust.

[20]Our paper is also related to the literature that examines the interaction between reputation and trust. See, for example, Bohnet, Frey, and Huck (2001) and Bohnet and Huck (2004). These papers examine the conditions under which short-term reputational incentives affect the development of trust.

[21]With representativeness, agents ignore the prior probability or "base-rate frequency" of outcomes.

experience a negative shock. By contrast, in our model the loss of trust is a lender-specific phenomenon, so only the lenders suffering from a loss of trust are adversely affected. Second, in the GSV models, belief revisions are always non-Bayesian, whereas in our model belief revision coincides with Bayes rule in "normal" times (i.e. when there is uncertainty resolution within the initially-adopted model) and departs from it only for "unexpected" or zero-probability events (uncertainty resolution that rejects the initially-adopted model).[22] Third, the GSV models predict that a crisis will be preceded by a sufficiently long string of bad news, whereas in our model a crisis can occur suddenly following an economic boom, with high defaults experienced by lenders.[23] Finally, the prediction of our model about the asymmetry of lender trust is unique.

In our model, deposits give banks a funding cost advantage that is a source of profitability and value, which is a well-known argument in banking, with recent empirical support.[24] Drechsler, Savov, and Schnabl (2017) document that banks have market power in deposit markets, and hence deposit rates are low and insensitive to market interest rate changes. They argue that this enables banks to engage in maturity transformation without interest rate risk. Egan, Lewellen, and Sunderam (2016) show that a significant portion of the cross-sectional variation in bank value comes from differences in deposit franchises.

Our paper is part of a growing literature on the role of non-depository lenders *vis a vis* banks and how this is affecting the credit market. One part of this literature is mainly empirical or descriptive. See, for example, Buchak et. al. (2018a,b), Fenwick et. al. (2017), Greenwood and Scharfstein (2013), Phillipon (2016), and Zetzsche et. al. (2017).[25]

[22]The evidence provided by Weinstein (2011) is consistent with this kind of belief revision.

[23]In their model, investors use extrapolative expectations, so they initially under-react to bad news, but then over-react to it when there is a sufficiently long sequence of such news. In our model, erosion of trust is not necessarily the same as the commencement of a crisis, since banks may still carry on. While we do not model a financial crisis *per se*, our analysis implies that trust will be lost *before* a crisis starts. Subsequent to losing trust, the price of risk will rise sharply and the pricing and availability of funding to lenders will be sensitive to observed performance, so further defaults could cause funding even to banks to dry up, precipitating a crisis.

[24]See, for example, Merton (1978) and Keeley (1990), who argue that deposit-related rents create high charter values for banks that can overcome the risk-shifting incentives caused by deposit insurance.

[25]The notion of trust has been explored in the empirical literature on peer-to-peer lending, but in the context of trustworthy *borrowers*, e.g. Duarte, Siegel, and Young (2012).

There is also a theoretical literature that explains the existence of banks and non-banks in equilibrium. Donaldson, Piacentino, and Thakor (2017) develop a theory of "intermediation variety" in which banks co-exist with non-banks (private equity firms) in equilibrium, and show that banks finance entrepreneurs with conventional technologies and non-banks finance more innovative projects. That is, they provide a microfoundation for banks and non-banks to co-exist when banks have access to cheaper financing than non-banks. Chrétien and Lyonnet (2017) assume that banks have access to insured deposits, whereas non-banks do not. In a crisis, shadow banks sell assets at fire sale prices to banks that buy them with insured deposits. Banks and shadow banks co-exist in equilibrium and deposit insurance leads to a larger-than-optimal shadow banking sector. Gennaioli, Shleifer, and Vishny (2013) develop a model in which the shadow banking system is stable and welfare enhancing under rational expectations, but crisis-prone when investors ignore tail risks. Plantin (2014) focuses on regulation in banking and hosws that it pushes banking activities into shadow banking, hurting financial stability. Huang (forthcoming) extends this work by examining capital regulation and shows that an endogenous leverage constraint emerges for shadow banks. Similarly, Martinez-Miera and Repullo (2018) also study the effects of capital requirements and show that safe entrepreneurs borrow from non-banks and risky entrepreneurs borrow from banks. Like these papers, we too take insured deposits as a key difference between banks and non-banks, but to the best of our knowledge, ours is the first paper to theoretically model trust-based intermediation and use it to characterize the impact of non-banks on the credit market.[26]

3 The Model

There are two time periods. The first period begins at $t = 0$ and ends at $t = 1$, while the second period begins at $t = 1$ and ends at $t = 2$. All agents are risk neutral, and the

[26]Our analysis does not focus on capital regulation, although we point out that heavier prudential regulation of banks relative to non-banks will strengthen our results.

one-period riskless rate is $r > 0$. Since the riskless asset is accessible to all agents, the reservation rate of return on providing financing is r for lenders as well as the financiers of lenders. That is, a lender can always obtain an expected return of r by investing in the market. The economy has individual agents who can be borrowers or savers (or both), banks that intermediate between borrowers and savers by raising money from depositors and shareholders at $t = 0$ and funding loans with that money, and non-bank lenders that provide both intermediated (shadow banks) and non-intermediated financing (e.g. P2P lending). While lenders exist for both periods, each borrower, depositor, and shareholder lives for one period. Thus, there are first-period borrowers and financiers and second-period borrowers and financiers. This means all claims are settled at the end of each period and the only "long-lived" entity is the lender. This allows us to focus on the role of reputation and trust without complications from multiperiod debt contracting issues.

3.1 Agents

Borrowers: At the start of each period, there are agents who have projects, with each project requiring L at the start of the period and paying off at the end of the period. The agents with projects are penniless and need loans to finance these projects—so we call them borrowers. Each borrower has a good (socially efficient) project that pays off $x \in \mathbb{R}_+$ with probability $q \in (0, 1)$ at the end of the period and 0 with probability $1 - q$, with:

$$qx > L[1 + r] \tag{1}$$

A loan to a borrower with such a project is referred to as a "G loan".

The Loan Contract: Each first-period borrower takes a loan of L at $t = 0$ and promises to repay the lender some amount R at $t = 1$; this amount can be repaid only if the borrower's project pays off x. Thus, q can also be viewed as a measure of the borrower's default risk, with higher q implying lower default risk. Similarly, each second-period borrower takes a loan of L and promises to repay some R at $t = 2$.

Depositors: These are agents who have liquidity at the start of each period that they can either deposit in a bank or invest in a riskless security that delivers a return of r. If D is deposited in the bank at $t = 0$, it produces liquidity, safekeeping, and transaction services worth $\overline{\varphi}(D) > 0 \ \forall D > 0$ at $t = 1$ if the bank is solvent and fully repays depositors, $\hat{\varphi}(D) > 0 \, \forall D > 0$ at $t = 1$ if the bank fails and depositors are paid off by the insurer, and zero at $t = 1$ if the bank fails and the depositors receive nothing.[27] Here, $\overline{\varphi}(D) > \hat{\varphi}(D)$ $\forall D > 0$, $\overline{\varphi}' \geq \hat{\varphi}' > r$, and $\overline{\varphi}(0) = \hat{\varphi}(0) = 0$. The same assumptions apply to second-period deposits that arrive at $t = 1$ and are paid off at $t = 2$. We take the available supply of deposits as exogenously fixed at $D < L$.

Depositors play two roles—they provide financing and they consume services provided by the bank. As in Merton and Thakor (forthcoming), we refer to them as "customers" of the bank. This is in contrast to shareholders who are pure financiers of the bank. This feature distinguishes banks from non-banks—banks receive substantial financing from customers.

Banks: There are regulated entities that operate in a competitive credit market, designing loan contracts that maximize the expected utilities of borrowers subject to the participation constraints of depositors and investors. We assume that each bank is operated by a (penniless) insider who seeks to maximize his own expected utility. Each bank raises $D \in (0, L)$ in deposits at the start of each period and the rest of the needed funding from shareholders who require an expected return of r on the funds they provide. Shareholders who provide funding at $t = 0$ are paid off fully at $t = 1$, conditional on the bank being solvent, at which

[27] Donaldson, Piacentino, and Thakor (2018) provide a foundational theory of banking in which banks exist to provide safekeeping depository services in an economy with no pledgeability of output. There are deposit-related rents and banks create funding liquidity and private money via the lending process, with incentives for prudent behavior provided by bank capital. The notion that the value of depository services is lower when the bank fails and depositors are paid off than when the bank is solvent is meant to capture the idea that when a bank fails and the deposit insurer has to step in, there is some disruption in the services that depositors receive, some of it possibly arising from weaker incentives that a bank on the verge of insolvency will have in providing services to its customers (see Merton and Thakor (forthcoming)).

time funds are raised from a new group of shareholders. Deposits are completely insured to guarantee depositors' payoff in the event of bank insolvency.[28] If the bank is insolvent, the claims of the bank's shareholders are worthless, and after the depositors are paid of by the deposit insurer, equity financing for the second period is raised from a new group of shareholders.[29] Without loss of generality, we set the deposit insurance premium at zero.[30]

Note that banks raise all of their funding at $t = 0$ from only two sources—deposits and equity. This is without loss of generality since our model distinguishes between deposits and funds provided by investors, but there is no difference between the expected returns that need to be provided to shareholders and subordinated debtholders, so the mix of equity and "sub" debt in the bank's capital structure is irrelevant. Financing to each bank is in perfectly elastic supply, and the return to each group of financiers satisfies the participation constraints of that group, i.e., gives that group an expected return of at least r.[31]

Non-bank Lenders: As noted earlier, these lenders may be non-banks such as shadow banks or P2P lenders, that provide no depository services to customers. All financing is raised from investors and loaned to borrowers. In the case of shadow banks, this would be non-depository debt, and in the case of P2P platforms it would be equity (Philippon (2016)).[32] Each non-bank is also operated to maximize the expected utility of the insider owner (residual claimant after investors are paid off).[33] In line with our previous discussion of focusing on trustworthiness, we assume that non-banks have access to the same information

[28] This is for simplicity; our results are unchanged if we assume partial deposit insurance.

[29] That is, the previous shareholders of the failed bank no longer have any claim on the bank's cash flows.

[30] This is consistent with the institutional reality for U.S. banks over long periods of time. Moreover, as long as the premium is risk-insensitive, it reduces to a constant and does not affect the analysis.

[31] We will show later that the participation constraint of shareholders will hold tightly in equilibrium, whereas depositors' participation constraint will be slack.

[32] Given the equivalence between non-deposit debt and equity, no generality is lost in assuming that non-banks are all-equity financed.

[33] Investors who provide a fintech platform, such as a P2P lender, with funding for the loan must receive an expected rate of return commensurate with the usual no-arbitrage market pricing conditions. As the collector of fees and servicing revenues, the platform owner is the residual claimant. A standard compensation agreement is for the platform owner to collect part of the loan repayment as a fee and pass along the rest to investors, so its objective is to maximize the expected loan repayment, similar to a shadow bank. In addition, the platform owner also typically collects a fee that is increasing in loan volume. This may create additional incentive problems, but these exist similarly for banks as well.

technology that banks have access to, and are just as skilled at processing information.

3.2 Agent Types, Models of the World, and Uncertainties

Models of the World: There are two models of the world that financiers (investors and depositors) can have: (1) lenders are trustworthy (Model I), and (2) lenders are self-interested (Model II). In Model I, the lender chooses to always make the G loan. The lender's type in Model I is referred to as τ_0. In Model II, the lender maximizes a type-dependent utlility function that could lead the bank to make a different loan.

There are three possible lender types in Model II: τ_1, τ_2, and τ_3. All three types of lenders can invest in an inefficient loan ("PB" loan) in each period that generates a private benefit, $\tilde{\beta}$, in any period in which it is chosen.[34] The choice of loan is unobservable. For type τ_1, in any period $\tilde{\beta}_1 \in \{\beta_l^1, \beta_h^1\}$, with $0 < \beta_l^1 < \beta_h^1$, with $\Pr\left(\tilde{\beta}_1 = \beta_1^l\right) = \nu$, and $\Pr\left(\tilde{\beta}_1 = \beta_h^1\right) = 1 - \nu$. For type τ_2, in any period $\tilde{\beta}_2 \in \{\beta_l^2, \beta_h^2\}$, with $\beta_l^1 < \beta_l^2 < \beta_h^1 < \beta_h^2$, $\Pr\left(\tilde{\beta}_2 = \beta_l^2\right) = \nu$, and $\Pr\left(\tilde{\beta}_2 = \beta_h^2\right) = 1 - \nu$. In addition to generating these private benefits, the inefficient loan of types τ_1 and τ_2 pays off a pledgeable amount x with probability $p < q$ and zero with probability $1 - p$, with

$$px + \beta_h < L[1 + r]. \tag{2}$$

This means that the PB loan of type-τ_2 is more attractive than that of type-τ_1 when both have low private benefits and also when both have high private benefits. For type τ_3, $\tilde{\beta}_3 = B > \beta_h^2$ in any period. The PB loan for type-τ_3 lender has a pledgeable payoff of zero almost surely. We assume that B is so large that the type τ_3 lender will always make the type-τ_3 PB loan.[35]

[34] There are many ways to interpret $\tilde{\beta}$. One is that it is a private cost of monitoring the good loan that is avoided with the PB loan which pays the lender less because it is not monitored. The other is that it is literally a rent that accrues to the lender because the loan is made to a friend or relative of the manager of the lender.

[35] The reason for having type-τ_3 in the model despite this is that in some of the equilibria we characterize, both types τ_1 and τ_2 choose the same strategies in the first period. This pooling means that the first-period outcome would not affect agents' perceptions of the lender's type in terms of distinguishing between τ_1 and τ_2. Having τ_3 means that both τ_1 and τ_2 have a reputational incentive for avoiding default to separate from τ_3.

Beliefs and Preferences: Conditional on the "correct" model of the world being Model II, the common prior belief of financiers and borrowers at $t = 0$ is that $\Pr(\tau_1) = \gamma_1 \in (0,1)$, and $\Pr(\tau_2) = \gamma_2 \in (0,1)$ and $\Pr(\tau_3) = 1 - \gamma_1 - \gamma_2$. In Model II, the lender has the following utility function in each period:

$$u_{ij}^t = \alpha_j \left[1 - s_i^t\right] z_{ij}^t + \left[1 - \alpha_j\right] \tilde{\beta}_j \tag{3}$$

where the superscript t designates the time period, the subscript j designates the lender's "type" in Model II—where $j \in \{1, 2, 3\}$ with $j = 1$ designating τ_1, $j = 2$ designating τ_2, and $j = 3$ designating τ_3—and $i \in \{b, n\}$ designates "bank" (b) or "non-bank" (n). In addition, z_{ij}^t is the payoff to the shareholders of the lender, s_i^t is the share of that payoff that the insider i must sell to raise the equity needed in period t, and $\alpha \in (0,1)$ is a weighting factor.

The common prior belief of borrowers and financiers at $t = 0$ is that the probability is $\zeta^0 \in (0,1)$ that the true model of the world is Model I and $1 - \zeta^0$ that it is Model II. Whatever model of the world is adopted by borrowers and financiers ("agents" henceforth when referred to collectively as a group), it applies to banks as well as non-banks. This "model uncertainty" plays a key role in the analysis.

Lender Maximization Programs and Information: Let $l_{ij}^t \in \{G, PB\}$ be the choice of loan in period t by type $j \in \{\tau_1, \tau_2, \tau_3\}$ of lender $i \in \{b, n\}$ in Model II. Then in the second period:

$$l_{ij}^2 \in \arg \max_{\{G,PB\}} u_{ij}^2 \tag{4}$$

and in the first period:

$$l_{ij}^1 \in \arg \max_{\{G,PB\}} U_{ij}^0 \tag{5}$$

where

$$U_{ij}^0 = u_{ij}^1 + \mathbb{E}\left[u_{ij}^2\left(l_{ij}^2\right)\right] \tag{6}$$

is the expected utility of the bank decisionmaker over two periods, and it takes as a given the subgame perfect choice l_{ij}^2 in the second period. The maximizations above are subject to the participation constraints of the financiers of the lenders and borrowers.

We assume that while each lender can observe the borrowers' type, the lender's financiers cannot tell whether the lender made a G or a PB loan.

Macro Uncertainty: The model also has a macro uncertainty whose realization is observed at the end of each period. The uncertainty represents the state of the overall economy, namely a systematic risk, and we delineate it as a random variable $\tilde{m}$ with probability density function η. Let supp $\eta = [\underline{m}, \overline{m}]$. The realization of $\tilde{m}$ is publicly observed and has a multiplicative effect on the success probability of any investment by the lender. That is, there exists a function:

$$C : [\underline{m}, \overline{m}] \times (0,1) \to (0,1) \tag{7}$$

such that for a $q \in (0,1)$ and a realized $m \in [\underline{m}, \overline{m}]$, the repayment probability of the good loan becomes $C(m,q) \in (0,1)$, with $\partial C/\partial m > 0$, $C(\underline{m}, q) < q$, $C(\overline{m}, q) > q$. This means the better the macro state, the higher the success probability of the good project and hence the repayment probability of the good loan. Similarly, for the PB loan of the type τ_1 lender in Model II,

$$C : [\underline{m}, \overline{m}] \times (0,1) \to (0,1) \tag{8}$$

and again for any $p \in (0,q)$, $C(m,q) > C(m,p) \in (0,1)\, \forall m$, and we have $\partial C(m,p)/\partial m > 0$.

Let

$$\overline{q} \equiv \int_{\underline{m}}^{\overline{m}} C(m,q)\eta \, dm \tag{9}$$

$$\overline{p} \equiv \int_{\underline{m}}^{\overline{m}} C(m,p)\eta \, dm \tag{10}$$

Both (1) and (2) are assumed to hold with $\overline{q}$ and $\overline{p}$ replacing q and p, respectively.

The Use of Model Uncertainty in the Equilibrium Concept: Introducing model uncertainty and using Ortoleva's (2012) equilibrium concept allows us to model the possible loss of trust in lenders as a *discontinuous* shift in beliefs about their type or motives. Within-model uncertainty captures the normal Bayesian revision of beliefs about types that occurs once agents have (re)selected their model of the world based on their posterior beliefs about the lender's type. Since banks and non-banks are observationally distinct, belief revision occurs for each as a distinct entity.

3.3 Competitive Structure of the Credit Market

Borrowers search for lenders. We assume that a borrower can find only one lender with probability $1-\theta$, and can find two or more lenders with probability $\theta \in (0,1)$. When the borrower can find two or more lenders, these lenders engage in Bertrand competition and the pricing of the loan is competitive, in that the lender's participation constraint holds tightly. When the borrower can find only one lender, the pricing is monopolistic, so the repayment obligation on the loan is set at the maximum pledgeable cash flow on the borrower's project, x. We can thus view θ as a measure of how competitive the credit market is, with higher values of θ representing greater credit market competitiveness.[36] As mentioned previously, lenders are able to raise financing at competitive terms if their financiers' participation constraints are satisfied.

Bank Regulator: There is a regulator who provides complete deposit insurance.[37] Although we take this as given, we also provide a microfoundation for it. In reality, insured banks are subject to a host of regulations that entail compliance costs. We ignore these for now but discuss their implications in a later section. Because non-banks do not have access

[36]This specification is a way to provide for an ex ante sharing of the project surplus between the bank and the borrower. An alternative specification would be a Nash bargaining game.

[37]The justification for this specification is that depositor insurance is provided to enhance social welfare by insulating the bank's depository customers from the bank's credit risk (see Merton and Thakor (forthcoming)).

to deposits, they are not subject to regulation.

Zero Lower Bound: We assume that all interest rates have a zero lower bound.[38]

3.4 Summary of Timing and Actions

There are two time periods, period 1 and period 2, and three dates: $t = 0$, $t = 1$, and $t = 2$. At the start of each period, there are banks and fintech lending platforms that can potentially make loans to borrowers. Banks finance themselves in each period with a mix of deposits and equity. The deposits are completely insured, where D is the amount of deposits. The non-bank finances itself entirely with equity raised from investors.

Agents can put their beliefs on two possible economic models of the world: that lenders are all trustworthy and will make good loans (Model I), or that lenders are self-interested and will take into account their private benefits in choosing loans (Model II). Agents' beliefs are common knowledge at $t = 0$. These beliefs determine lenders' costs of financing and hence the repayment obligations for borrowers in the first period.

At $t = 0$, each borrower searches for a lender, and with probability θ it finds two or more lenders who are willing to lend, whereas with probability $1-\theta$ only one lender is found. The borrower cares only about the price of credit, not whether the lender is a bank or a non-bank. Also at $t = 0$, banks raise whatever financing they need from deposits and equity to make the first-period loan and satisfy regulatory capital requirements, and non-banks raise their necessary financing from investors. Then each lender privately observes its realized $\tilde{\beta}$ and chooses between the good loan and the PB loan, being aware that its financiers cannot tell whether it is a good loan or a PB loan.[39]

At $t = 1$, the macro state $\tilde{m}$ is realized and it determines the success probability of the loan made by the bank at $t = 0$. The borrower repays or defaults on its loan and the

[38]This assumption helps to simplify the algebra, but is not crucial to the analysis. Essentially, it leads to depositors receiving a zero interest rate on deposits in equilibrium.

[39]If the bank wishes to make a PB loan, it does not approach a good borrower, so that borrower has no ability to learn the bank's "type".

lender settles the claims of its financiers, with the deposit insurer stepping in for the bank if the borrower defaults. Borrowers and financiers revise their beliefs about the true model of the world, and then arrive at their posterior beliefs about the lender's type within the model of the world chosen for the second period. Trust in lenders is either maintained or lost. This then determines each lender's cost of financing in the second period, and hence the price at which the second-period loan can be offered. It is possible that the first-period outcome is such that financiers are unwilling to provide second-period financing. That is, the first-period outcome may cause a loss of trust that shuts out the lender in the second period. If lending occurs, then all second-period claims are settled at $t = 2$. See *Figure 1*, which summarizes the sequence of events.

Note that all lenders start out with the same prior beliefs about whether they are trustworthy or self-interested, and the same prior beliefs over types conditional on being self-interested. Hence, if Model I prevails, then *all* lenders are trusted at $t = 0$, and if Model II prevails, then *all* lenders are considered self-interested at $t = 0$. However, at $t = 1$, whether an initially-trusted lender continues to be trusted depends on the information set at $t = 1$, so some lenders may be trusted at $t = 1$ and others may not be.

4 Preliminary Analysis

In this section we present some premliminary analysis. We start by describing the first best, then present results regarding the deposit interest rate and the extent of risk exposure for depositors. We then characterize the non-bank's and the bank's loan obligations in the first-best case. This is followed by a discussion of the equilibrium.

4.1 First Best

In this case, the borrower's project choice and the bank's loan choice are both observable. The first-best outcome can be trivially shown to be the bank making the good loan, and the

Figure 1: **Time Line**

$t = 0$	$t = 1$	$t = 2$
▶ Borrowers and financiers share common prior beliefs about the true model of the world (i.e. the probability that lenders are trustworthy) and the lender's type within each model. ▶ These beliefs determine the prices at which bank and non-bank lenders raise financing. ▶ Each lender observes its realized private benefit from the PB loan and decides whether to make that loan or the good loan.	▶ The macro uncertainty $\tilde{m}$ is realized and it affects first-period success probabilities. ▶ Borrowers pay off or default on first-period loans. Lenders settle claims with financiers. If the lender collects a profit, it is paid off to shareholders as a dividend. In the case of banks that fail, the deposit insurer covers part of the claim. ▶ Economic agents revise their beliefs about the true model of the world, and their beliefs about lender types within the model. Lenders may lose trust. ▶ Second period begins with new borrowers and new depositors. Shareholders may or may not choose to provide more financing.	▶ Second-period claims are settled after second-period $\tilde{m}$ is realized and loans are repaid or default.

borrower investing in the good project. This outcome for a single period is the same as the single-period outcome with trustworthy lenders. Next we have:

Lemma 1: *The deposit interest rate is zero if we assume that depositors' financial claims are completely insulated from the bank's credit risk, i.e., deposits are riskfree.*

The idea that depositors do not wish to be exposed to the bank's credit risk builds on the insights of Merton (1989, 1993, 1995, 1997), and most recently, Merton and Thakor (forthcoming). In the next result, we will establish that this is indeed the efficient outcome.

The reason why the deposit interest rate is zero is that depositors receive bank services that are valued more highly, conditional on bank solvency, than the riskless rate r. Absent the zero lower bound on interest rates, depositors would even accept a negative interest rate. Thus, with a zero interest rate, the depositors receive an expected total return (including services) that exceeds their reservation expected return of zero (i.e. their participation constraint is slack).

Lemma 2: *The social welfare benefit of the regulator providing complete deposit insurance relative to providing no insurance is*

$$[1-\overline{q}]\,[\hat{\varphi}(D)-D]>0. \tag{11}$$

The intuition is that the value of depository services to the depositors when they are fully paid off in the state in which the bank fails is $\hat{\varphi}(D)$, and this exceeds the net cost of the provision of this insurance, rD. This makes it socially efficient for complete deposit insurance to be provided. Next we turn to the borrower's first-best repayment obligations.

Lemma 3: *The borrower's (first-best) repayment obligation when faced with only one lender is:*

$$R_1^{FB}=x \tag{12}$$

and when faced with two or more lenders, it is:

$$R_2^{FB} = \{L[1+r]\} \{\overline{q}\}^{-1}. \tag{13}$$

The repayment obligation is independent of whether the lender is a bank or a non-bank.

This result follows from the fact that the lender fully extracts all project surplus when it is a monopolist, but offers a price to the borrower at which the loan yields an expected return of r to the lender when there are two or more competing lenders. The reason why no lender prices the loan lower is that r is each lender's reservation expected return on lending, since this is the return that can be obtained by investing in the riskless asset.

4.2 Second Best: Equilibrium Concept

We now define the equilibrium we will use to characterize the strategies of banks and non-banks in the second best. One of our main goals is to examine the role that financier trust plays in influencing lender behavior. Many seem to believe that the usurping of bank market share by non-banks is only the tip of the iceberg and that eventually banks will lose at least most of their transaction lending to their non-bank rivals. Our point is that trust will be an important mediating variable in this dynamic and that banks have a potential advantage as "trusted lenders".

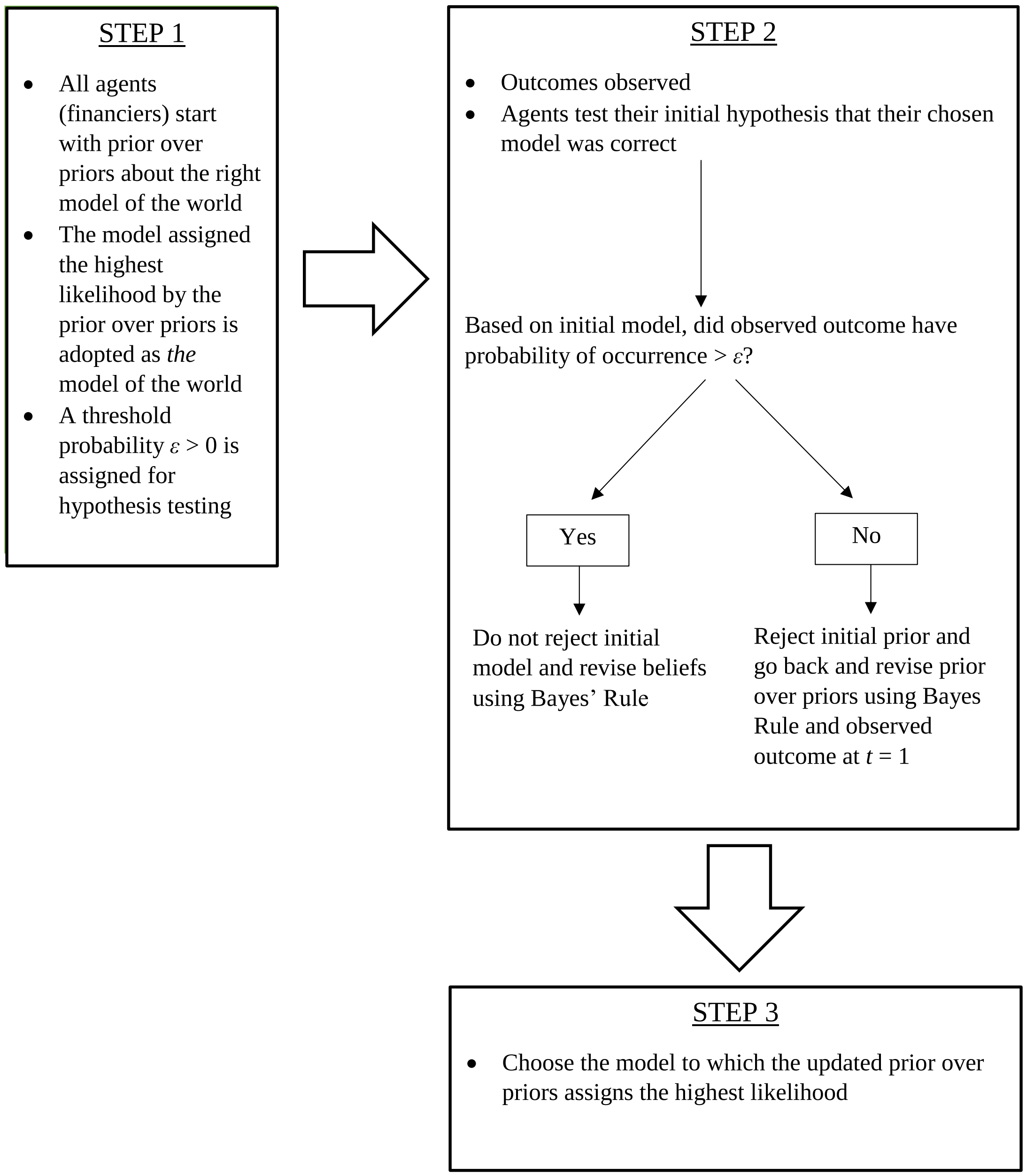
Since trust is typically all-or-nothing—one either trusts an agent or does not—if we observe an outcome that seems patently incompatible the trust initially placed in a lender, then we are essentially observing a zero-probability event, and Bayes rule for belief revision cannot be used. To model such behavior and its implications for the strategies of lenders, we rely on Ortoleva's (2012) *Hypothesis Testing Representation* (henceforth HTR) to characterize belief revision. We embed this model in the definition of our equilibrium, which follows a discussion of how beliefs are formed and revised.

Discussion of Equilibrium Belief Formation: At $t = 0$, all financiers and borrowers ("agents" henceforth) have common prior beliefs that if Model I is the true model of the world, then all lenders are trustworthy, and if Model II is the true model of the world, then there is a probability $\gamma_1 \in (0, 1)$ that the lender is of type τ_1, a probability γ_2 that the lender is of type τ_2, and a probability $1 - \gamma_1 - \gamma_2$ that the lender is type τ_3. All financiers also have a prior over priors and believe that $\zeta^0 \in (0, 1)$ is the probability that Model I is the correct model and $1 - \zeta^0$ is the probability that Model II is the correct model. In Step 1, at $t = 0$ the agents choose the model to which the prior over priors assigns the highest likelihood, i.e., they adopt Model I for their beliefs if $\zeta^0 \geq 0.5$ and Model II if $\zeta^0 < 0.5$. They also choose the threshold probability $\varepsilon \in (0, 1)$ for a future revision of their prior over priors. Given these beliefs, agents determine the price at which financing will be provided to lenders so as to yield each group of financiers an expected return of at least r, with the expectation taken over the beliefs adopted in Step 1.

At $t = 1$, the macro state realization is observed and also whether the borrower has repaid or defaulted on the first-period loan. Based on this information, in Step 2 agents test their priors to determine if the correct model of the world was used in Step 1. If the probability that the agents' prior assigned to the observed repayment/default outcome at $t = 1$ is *above* the threshold ε, then the prior belief chosen in Step 1 is *not* rejected, and beliefs are now updated using Bayes rule, thereby determining the second-period financing costs for lenders and the terms at which the lenders will make second-period loans to borrowers.

If, however, the probability that the agents' prior assigned to the new information observed at $t = 1$ is below the threshold ε, then the prior is *rejected* and agents go back to their prior over priors ζ^0, update it using Bayes' rule using the information at $t = 1$, and then in Step 3 chooses the model to which the *updated* prior over priors assigns the highest likelihood. With these new beliefs, financiers determine the cost at which lenders can raise financing, and lenders determine the terms at which they will lend to second-period borrowers. A visualization of this process is provided in *Figure 2*.

Figure 2: Hypothesis Testing Representation



This means that if the prior "chosen" at $t = 0$ is rejected by the data, agents reconsider the prior to use by choosing the new maximum likelihood prior, which is extracted by examining the prior over priors after its updating using Bayes' rule. The idea is that ε is some arbitrarily small positive number, and we will assume throughout that this is the case. As Ortoleva (2012) points out, when $\varepsilon = 0$, belief revision follows Bayes' rule.[40]

Note that in our setting, a model is itself a prior belief over the lender's type, and ζ is the prior over these prior beliefs. Using Ortoleva's (2012) notation, we therefore define π as the prior belief, which in our model is a vector of two probability distributions over lender types, $\pi = \{\pi_T, \pi_N\}$, where

$$\pi_T = \langle \Pr(\tau_0) = 1,\, \Pr(\tau_1) = 0,\, \Pr(\tau_2) = 0,\, \Pr(\tau_3) = 0 \rangle, \tag{14}$$

$$\pi_N = \langle \Pr(\tau_0) = 0,\, \Pr(\tau_1) = \gamma_1 \in (0,1),\, \Pr(\tau_2) = \gamma_2 \in (0,1),\, \Pr(\tau_3) = 1 - \gamma_1 - \gamma_2 \in (0,1) \rangle, \tag{15}$$

where τ_0 denotes that the lender is trustworthy, τ_i denotes that the lender is self-interested and of type τ_i, with $i \in \{1,2,3\}$. Then the prior over priors says that ζ^0 is the prior belief that the correct prior is π_T and $1 - \zeta^0$ is the prior belief that the correct prior is π_N.

Before we define the equilibrium formally, some additional notiation is useful. We will use the time superscript on the prior to designate the date at which the prior is chosen, i.e., π^0 is the prior chosen at $t = 0$ and π^1 the prior chosen at $t = 1$. We will use the same date nomenclature in assigning superscripts to all the other variables. Let ω be the observed outcome at $t = 1$, where ω is the realization of a pair of random variables: $\omega = \{\text{borrower defaults or repays}, m\}$. Let Ω be the set of ω's for all lenders.

Definition of Competitive Equilibrium: A competitive equilibrium consists of a vector of beliefs, prices, and strategies at $t = 0$ and a vector of beliefs, prices, and strategies at $t = 1$ that can be described as follows:

[40]See Ortoleva (2012) for an analysis of the uniqueness properties of this representation.

(i) At $t = 0$, the equilibrium consists of $\langle \varepsilon, \pi^0, R_1^0, R_2^0, \phi_i^0(\tau_j) \rangle$ where it is common knowledge that ε is the threshold probability chosen by agents, $\pi^0 \in \{\pi_T, \pi_N\}$ is the prior belief chosen by agents over lenders' types, R_1^0 and R_2^0 are the repayment obligations of the borrower when faced with a single lender and when faced with two or more lenders, respectively, $\phi_i^0(\tau_j)$ is the strategy of a lender $i \in \{b, f\}$ of type τ_j, $j \in \{0, 1, 2, 3\}$, where the lender's strategy is a choice of loan from $\{G$, PB$\}$, conditional on making a loan, as well as the decision of whether to make a loan. Here π^0 is chosen by agents using the HTR; and ϕ_i^0 is chosen by each lender to maximize its expected utility over two periods, given π^0 and $\pi^1(\omega)$ in each future $\omega \in \Omega$.[41]

(ii) At $t = 1$, each $\omega \in \Omega$, the equilibrium consists of $\langle \pi^1(\omega), R_1^1, R_2^1, \phi_i^1(\tau_j) \rangle$, where $\pi^1(\omega) \in \{\pi_T, \pi_N\}$is the updated prior belief over lenders' types chosen by agents at $t = 1$ based on the HTR; R_1^1 and R_2^1 are the repayment obligations of the borrower in the second period when finding only one lender and when it finds two or more lenders, respectively; and $\phi_i^1(\tau_j)$ is the strategy of a lender in the second period, defined in a manner similar to $\phi_i^0(\tau_j)$. Note that $\phi_i^1(\tau_j)$ also includes not extending a loan because the lender may be unable to raise financing at $t = 1$. All strategies are subgame perfect in the sense that: the lender's choice of loan solves (4) and the loan prices is determined as in Lemma 3, subject to the participation constraints of lenders' second-period financiers, taking $\pi^1(\omega)$ as given.

Our analysis focuses on a situation in which agents use the HTR and at $t = 0$ choose the prior that lenders are trustworthy.[42] We will then examine the behavior of banks and non-banks in the first period when they are trusted. Then we characterize conditions under which trust can be lost in the second period, which leads to an analysis of how the potential to lose trust in the future influences lender behavior at $t = 0$.

[41] Agents here are all financiers of lenders and those who borrow from the lenders.

[42] In a sense, we can think of this as corresponding to the current credit market situation in which lenders are trusted by financiers to make good loans.

5 Analysis of the Second-Best Equilibrium with Trust

5.1 Evolution of Beliefs and Trust

In this section, we solve for the equilibrium. We establish four general results about trust, how it can be lost, and how banks have an advantage over non-banks because of their traditional role as trusted lenders. Our first result has to do with how a lender chooses its second-period strategy, conditional on the strategy it chose in the first period and the first-period outcome.

In preparation for this result, we need to introduce some notation. Recall that ζ^1 is the prior over priors at $t = 1$ and $\pi^1(\omega)$ is the prior belief chosen by agents at $t = 1$ using the HTR. Thus, using the notation from (14) and (15):[43]

$$\pi^1(\omega) = \begin{cases} \pi_T & \text{if agents believe lender is trusted} \\ \pi_N = \langle \mu^i_\omega(1), \mu^i_\omega(2), 1 - \mu^i_\omega(1) - \mu^i_\omega(2) \rangle & \text{if agents believe at } t = 1 \\ & \text{that lender is self interested} \end{cases} \tag{16}$$

where

$$\mu^i_\omega(j) \equiv \Pr(\text{lender } i \text{ is type } \tau_j \mid \pi^2 = \pi_N, \omega, j = 1, 2) \tag{17}$$

where $i \in \{b, f\}$, and recall that $\omega \in \Omega$ is the composite state that includes the realized $\tilde{m}$ and whether the first-period borrower repaid the loan or defaulted. To simplify notation, let $\mu^i_\omega(3) = 1 - \mu^i_\omega(1) - \mu^i_\omega(2)$.

We now introduce some additional notation that is useful in the subsequent analysis. Let λ_i (with $i \in \{b, n\}$) be the net payoff to the lender's shareholders when the G loan repays,

[43] Specifically, $\pi_i = \langle \Pr_i(\tau_0), \Pr_i(\tau_1), \Pr_i(\tau_2) \rangle \; \forall \, i \in \{1, 2\}$.

and define an indicator function indicating that Model I is chosen:

$$I^t_{\{\pi_T\}} = \begin{cases} 1 & \text{if } \pi^t(\omega) = \pi_T,\ t \in \{0,1\} \\ 0 & \text{otherwise} \end{cases} \tag{18}$$

and an indicator function related to the choice of the G loan:

$$I^t_i(j) = \begin{cases} 1 & \text{if the strategy } \phi^t_i(\tau_j) \text{ chooses the } G \text{ loan} \\ 0 & \text{otherwise} \end{cases} \tag{19}$$

Note that

$$\lambda_b = \theta R_2^{FB} + [1-\theta]x - D \tag{20}$$

$$\lambda_f = \theta R_2^{FB} + [1-\theta]x \tag{21}$$

where R_2^{FB} is available in (13). Both the bank and the non-bank need to raise equity financing to fund the loan. Let $s^t_i(\omega)$, $i \in \{b, n\}$, be the share of ownership that a type-i lender must sell in order to raise the financing needed at $t \in \{0,1\}$ when the state ω is observed (this observation is only relevant for $t = 1$). We now have the following result:

Lemma 4: $R^t_1 \equiv R_1 \equiv R_1^{FB} = x\ \forall\ t \in \{0,1\}$ *and* $R^t_2 \equiv R_2 = R_2^{FB} = \{L[1+r]\}\{\overline{q}\}^{-1}\ \forall\ t \in \{0,1\}$. *Moreover, for any set of beliefs about the lender's type, in each period we have:*

$$s^t_b(\omega) = \frac{[L-D][1+r]}{\left[\overline{q} I^t_{\{\pi_T\}} + \left[1 - I^t_{\{\pi_T\}}\right] \sum_{j=1}^{3} \overline{q}\mu^b_\omega(j) I^t_b(j)\right]\lambda_b} \tag{22}$$

$$s^t_f(\omega) = \frac{L[1+r]}{\left[\overline{q} I^t_{\{\pi_T\}} + \left[1 - I^t_{\{\pi_T\}}\right] \sum_{j=1}^{3} \overline{q}\mu^f_\omega(j) I^t_f(j)\right]\lambda_f} \tag{23}$$

where $\mu^i_\omega(j)$ *is defined in (17).*

This lemma says that the borrower's repayment obligation depends only on whether there is just one lender or there are two or more lenders. This is because that is the only factor that affects loan pricing. Investors' beliefs about the bank's type affect the cost and availability of funds as well as the lender's participation constraint, but not loan pricing. That is, investors' beliefs influence the shares of ownership that lenders must sell to raise financing for the loan.

Theorem 1: *Suppose that lenders start out at $t = 0$ with agents choosing*

$$\zeta^0 \in \left(0.5, \left[1 - \overline{\mu}_{\overline{m}} C\left(\overline{m}, q\right)\right]\left[2 - \overline{\mu} C\left(\overline{m}, q\right) - C\left(\overline{m}, q\right)\right]^{-1}\right) \tag{24}$$

where

$$\overline{\mu}_{\overline{m}} \equiv \sum_{j=1}^{2} \frac{\left[1 - C\left(\overline{m}, q\right)\right]\gamma_j}{\left[1 - C\left(\overline{m}, q\right)\right]\sum_{j=1}^{2}\gamma_j + 1 - \gamma_1 - \gamma_2} \tag{25}$$

Then lenders will be viewed as trustworthy at $t = 0$ under the HTR. Whether they lose this trust at $t = 1$ is sensitive to the realization of $\tilde{m}$ and whether the lender experiences default. Trust will not be lost if the borrower repays the lender at $t = 1$, but it may be lost if the lender experiences default, depending on $\tilde{m}$. If

$$1 - C\left(\overline{m}, q\right) < \varepsilon < 1 - C\left(\underline{m}, q\right) \tag{26}$$

then $\exists\, m^* \in \left(\underline{m}, \overline{m}\right)$ such that a lender that experiences borrower default at $t = 1$ will lose trust in the second period if $m > m^*$ and not lose trust if $m \leq m^*$.

This result shows that lenders that fail at the end of the first period are more likely to lose trust if the failure occurs when the macroeconomic state is better.[44] The intuition is that even a good loan is more likely to default in a recession than in a boom, so the hypothesis testing under the HTR at $t = 1$ will reject the initial prior over priors that led agents to view the lender as trustworthy in the first period when the bank fails in a boom, but may

[44]Note that (26) is not a very restrictive condition. It simply states that $\left[C\left(\underline{m}, q\right), C\left(\overline{m}, q\right)\right]$ is a sufficiently large subset of [0,1].

not do so in a recession. We next have a corollary of this theorem.

Corollary 1: *Suppose ζ^0 is as in (24)–(26) holds. Then, conditional upon experiencing borrower default at $t = 1$: (i) in states $m > m^*$, all lenders experiencing default lose trust; and (ii) in states $m \leq m^*$, no lender experiencing default loses trust.*

The intuition is that if agents believe that lenders are trustworthy in the first period, then they are believed to have made G loans in the first period. The probability of failure with the G loan is the same for every lender. Hence, the HTR either rejects the initial prior over priors for all lenders experiencing default or for none. Note that since the G loans have outcomes that are not perfectly correlated, at $t = 1$ there are lenders who experienced default and lenders that did not. Hence, at $t = 1$, it is possible to have some lenders who are trusted and some who are not. Henceforth, we will assume that (24) and (26) hold.

Theorem 2: *Conditional on being funded, for any set of beliefs of investors about the bank's type, the following are true:*

(i) A bank and a non-bank lender have the same incentive to choose loan G if both are type τ_0 (Model I); and

(ii) A bank always has a stronger incentive to make (higher profitability from making) the G loan than does a non-bank, conditional on both being type τ_i, $i \in \{1, 2\}$ (in Model II), and have the same incentive if both are type τ_3.

This result says that, when it comes to choosing between a G loan and a PB loan, a self-interested bank always has a stronger incentive than a self-interested non-bank to make the G loan, as long as it is type τ_1 or τ_2. If they are type τ_3, then they clearly have the same incentive to choose the PB loan.

This result arises from the access that banks have to insured deposits and the valuable services they provide to depository customers. The surplus generated by these services gives banks a powerful incentive to make the efficient (G) loan. This result will play an important role in the subsequent analysis.

5.2 Lender Strategies

We now turn to the strategies of lenders starting with the second period. Before this analysis, we state some restrictions on the parameter values; the formal expressions related to these restrictions are placed in the Appendix.

Restriction 1: The bank's incremental expected utility from investing in the G loan relative to the PB loan at the first-best financing cost is between the high private benefits of the PB loans of the type-τ_1 and type-τ_2 banks. In addition, the high private benefit of the type-τ_2 bank is not excessively high.

This is essentially a restriction on the private benefits of the PB loan for the type-τ_1 and type-τ_2 banks. Having type-τ_1 lenders have lower private benefits is one of the key features distinguishing the type-τ_1 lenders from type-τ_2 lenders. Moreover, if the private benefit of the PB loan for the type-τ_2 is too high, this type would be indistinguishable from the type-τ_3 lender.

Restriction 2: The non-bank's incremental expected utility from investing in the G loan relative to the PB loan at the first-best financing cost is high in value relative to the low private benefit of the PB loan for the type-τ_1 lender, and low in value relative to the low private benefit of the type-τ_2 lender. Moreover, the high private benefit of the type-τ_1 lender is not too high, but the high private benefit of the type-τ_2 lender is high relative to the non-bank's utility.

This is a restriction on the private benefits of the PB loan for the type-τ_1 and type-τ_2 fintech lenders, similar to Restriction 1 for banks.

Restriction 3: The bank's incremental expected utility from investing in the G loan relative to the PB loan at the second-best (no trust) financing cost is high relative to the high private benefit of the PB loan for the type-τ_1 bank.

This is a restriction on the high private benefit of the type-τ_1 bank relative to the bank's incremental expected utility from investing in the G loan at a financing cost higher than the second-best. If such a restriction were not in place, no bank (or any other type of lender) would be able to operate when there is no trust.

Restriction 4: Investors' prior belief that the lender is type-τ_1 and the success probability of the G loan are intermediate in value.

The reason for this condition is as follows. Lenders lose trust at the beginning of the second period (assuming they had it in the first period) only if they experience defaults on first-period loans. This restriction ensures that, conditional on losing trust, the posterior probability that the lender is type-τ_1 is neither too high nor too low. We wish to focus on separating equilibria in which second-period lending strategies differ based on lender type and loss of trust is consequential in terms of an increase in funding costs and possibly lack of access to second-period funding. Since the type-τ_1 lender makes prudent loans in more states of the world than the other types, if the posterior probability of type τ_1 is sufficiently high, the loss of trust will have little impact on access to financing and its cost. If the posterior probability of type τ_1 is too low, all lenders will get shut out of the market in the second period. Restriction 4 helps us to focus on the (subgame perfect) Nash equilibria of interest.

Lemma 5: *Suppose agents adopt Model I and lenders are trusted in the second period (at $t = 1$). Then the optimal second-period strategies of lenders in equilibrium are as follows:*

Bank/Non-bank	*Lender's Type*	*Lending Strategy*
Bank:	τ_0	*G with probability 1*
	τ_1	$G \ \forall\ \beta \in \{\beta_l^1, \beta_h^1\}$
	τ_2	*G for $\beta = \beta_l^2$ and PB for $\beta = \beta_h^2$*
	τ_3	*PB with probability 1*
Non-bank:	τ_0	*G with probability 1*
	τ_1	*G for $\beta = \beta_l^1$ and PB for $\beta = \beta_h^1$*
	τ_2 *and* τ_3	*PB with probability 1*

The intuition for this lemma comes from Theorem 2. When lenders are trusted, they can raise funding at the lowest cost possible because investors believe that the G loan will be made with probability 1. In other words, each lender has the highest expected second-period surplus from making the G loan under these circumstances. Nonetheless, given Theorem 2, we also know that a type τ_i ($i \in \{1,2\}$) bank always finds it more profitable to make the G loan than a type τ_i non-bank lender does. Thus, the set of states in which a type τ_i ($i \in \{1,2\}$) bank makes the G loan is no smaller than the set of states in which a type τ_i non-bank lender makes the G loan, and for some sets of parameter values, the set of states in which the bank makes the G loan is strictly larger.

The next result deals with what happens in the second period if there is no trust:

Lemma 6: *Suppose agents adopt Model II and lenders are not trusted in the second period (at $t = 1$). Then the optimal stategies of lenders in the second period are as follows:*

Bank/Fintech	*Lender's Type*	*Types of Loan Made*
Bank:	τ_0	*G with probability 1*
	τ_1	*G for $\beta = \beta_l^1$ and PB for $\beta = \beta_h^1$*
	τ_2 *and* τ_3	*PB with probability 1*
Fintech Lender:	τ_0	*G with probability 1*
	All τ_i, $i \in \{1,2,3\}$	*PB with probability 1*

Consequently, conditional upon loss of trust, banks will be able to raise second-period financing. But non-bank lenders that have lost trust will be unable to raise second-period financing.

This lemma has two striking implications. First, banks may be able to weather a loss of trust, but non-banks cannot. Second, reputation becomes important when trust is lost. In a sense, trust insulates lenders against the adverse reputational consequences of bad outcomes. But once that shield is lost, a lender needs a sufficiently strong reputation to survive.

Comparing Lemmas 5 and 6, we see that agents' beliefs about whether lenders are trustworthy or self-interested affect the equilibrium strategies of lenders. The reason is that these beliefs then impact the attractiveness of the G loan relative to the PB loan. When lenders are not trusted, their financing costs are higher than when they are trusted. This means that the PB loan is preferred by lenders in more states of the world when lenders are trusted than when they are not. Thus, lenders make the G loan in fewer states when there is no trust than when there is trust.

5.3 First-period Strategies and Overall Equilibrium

We can now characterize the overall equilibrium, including first-period strategies.

Theorem 3: *Suppose agents adopt Model I and lenders are trusted in the first period (at $t = 0$). Then there exists $\underline{m}$ high enough such that lenders choose the following strategies in the first period:*

Bank/Non-banks	*Lender's Type*	*Lending Strategy*
Bank:	τ_0	*G with probability 1*
	τ_1 *and* τ_2	*G with probability 1*
	τ_3	*PB with probability 1*
Non-banks:	τ_0	*G with probability 1*
	τ_1	*G with probability 1*
	τ_2	*G for* $\beta = \beta_l^2$, *PB for* $\beta = \beta_h^2$
	τ_3	*PB with probability 1*

If a lender makes a loan at $t = 0$ that repays at $t = 1$, trust is maintained in the second period. Similarly, if $m \leq m^*$ (Theorem 1) and a loan made at $t = 0$ defaults at $t = 1$, trust in the lender is maintained in the second period. In this case, the lender's second-period strategies are as described in Lemma 5. If a lender makes a loan at $t = 0$ that defaults at $t = 1$ and $m > m^*$, trust is lost in the second period. In this case, the lender's second-period strategies are as described in Lemma 6.

This theorem reveals a temporal dimension trust, which is that a self-interested lender makes the G loan in more states of the world in the first period when it is trusted than in the second period when it is trusted. The reason is that maintaining trust through its first-period lending strategy has value in terms of reducing the cost of second-period financing; this added value is absent in the second period because it is the last period. That is, investor trust has a stronger incentive effect on the lender when there are more periods to go.

Next we turn to the nature of the equilibrium when there is no trust in the first period.

Theorem 4: *Suppose agents adopt Model II at $t = 0$ and lenders are not trusted. Also assume that it is impossible to become trusted at $t = 1$ if the lender started out not being trusted at $t = 0$. Then for $\underline{m}$ high enough, in equilibrium banks are able to raise financing at $t = 0$ and they have the following equilibrium strategies in the first period:*

Bank Type	*Lending Strategy*
τ_0	*G with probability 1*
τ_1	$G \; \forall \; \beta \in \{\beta_l^1, \beta_h^1\}$
τ_2	*G for* $\beta = \beta_l^2$, *PB for* $\beta = \beta_h^2$
τ_3	*PB with probability 1*

No non-bank lender is able to raise financing at $t = 0$.

This theorem asserts that trust is important for all lenders, but it is *essential* for non-banks to operate. This result is an extension of Lemma 6, but it goes further—a non-bank lender will not even be able to begin to operate at $t = 0$ if there is no trust. The intuition is as follows. We know from Lemma 6 that if a non-bank lender is not believed to be trustworthy at $t = 1$ by investors, then investors will not be willing to finance it. Given the assumption that a lender who is not trusted at $t = 0$ will not be able to gain trust at $t = 1$, the non-bank knows at $t = 0$ that it will be out of the market in the second period regardless of the first-period outcome. Hence, its lending strategy at $t = 0$ is a single-period strategy, identical to its second-period strategy. Since it is unable to raise financing with this strategy in the second period, it is also unable to raise financing in the first period.

In Theorem 4, it was assumed that if lenders start out not having the trust of investors, then it is impossible for them to win that trust in the second period. In our next result, we validate this assumption.

Theorem 5: *Consider parameter values such that in equilibrium, lenders start out being trusted at $t = 0$ and lose trust at $t = 1$. Then, for the same parameter values, lenders can never regain trust at $t = 1$ if they start out being considered self-interested at $t = 0$.*

This result shows that trust is asymmetric—it is easier to lose trust that exists than to gain trust when it does not exist in the first place. The intuition is as follows. Suppose lenders do not have trust at $t = 0$, and the equilibrium at $t = 0$ is one in which the type-τ_1 lenders make good loans for all realizations of its private benefit from the PB loan. Then if the lender experiences loan repayment at $t = 0$, it may merely "confirm" that the lender is a type-τ_1 lender, especially if the prior probability attached to the lender being type-τ_1 was high, i.e., if it had a strong reputation ex ante. And of course this reputation must be high enough or else the lender would not have been able to raise financing at $t = 0$. In other words, the HTR will not reject the initial model II based on the repayment outcome. Thus, a lender with a strong reputation but no trust is unable to become trusted by experiencing good outcomes. However, if it starts out with trust and experiences borrower default, the HTR may reject the initial Model I and trust will be lost.

6 Additional Institutional Features and Model Extensions

In this section, we discuss how including additional differences between banks and non-banks may affect our analysis. We also provide a discussion of additional applications of the model, and suggestions for future work.

6.1 Other Institutional Differences between Non-banks and Banks

In our main model, the only difference between banks and non-bank lenders is that banks are able to obtain funding via deposits, while non-bank lenders are all-equity financed, or more generally financed with a mix of equity and non-deposit debt. In practice, there are also other institutional differences between non-banks and banks.

One such difference is regulation—banks are heavily regulated, whereas non-banks, including fintech lenders such as P2P platforms, are less regulated.[45] It is worth thinking about how this might affect our analysis. On the one hand, regulatory compliance is costly for banks, which reduces profits. On the other hand, regulation also has a material benefit—it is often intended to *foster* greater trust in the regulated entities, whether it is banking, the FDA, or the FAA. Indeed, this aspect of regulation is of first-order importance in terms of distinguishing between banks and non-banks. There is a reason why we have capital requirements and other prudential regulation. For example, Morrison and White (2005) point out that regulatory screening of banks improves the quality of banks given operating licenses. Thus, the overall effect of introducing regulation differences would likely be to provide an additional impetus for banks to lend more prudently and be more trustworthy than non-banks.

Another institutional difference is with regard to information acquisition and processing. Fintech may give non-bank lenders a temporary advantage over banks. However, in the real world, technology is a competitive industry and available to every entity, including banks. The same is true for technology-assisted processes by which hard information is gathered from loan applicants. Banks can buy any technology that fintech firms and shadow banks utilize, and can also hire any people that these competitors can. Indeed, big banks have resources

[45] While there are some regulations that affect P2P platforms, they are far less than what banks face. Each U.S. state has different rules for the regulation of P2P borrowers and investors. Residents of all states except Iowa, Maine, and North Dakota can apply for P2P loans, whereas investors in 30 states can invest in Prosper loans and investors in 26 states can invest in Lending Club. Other than being "accredited investors" ($1 million or more in new worth), there are no specific regulations on these investors. See Knowledge@Wharton, January 8, 2014. Shadow banks are subject to a variety of regulations, but none of the regulations that are explicitly tied to deposit insurance.

that startups do not, which allows them to eventually adopt the new technology. Thus, there is no reason to expect one kind of lender to have a long-run technological advantage. Add to this the fact that, as relationship lenders, banks have access to proprietary soft information about borrowers that non-banks lack. Thus, introducing this institutional difference is likely to give banks a further advantage in the long-run when it comes to trust, in the sense that they will dominate non-banks on both competence and trustworthiness.[46]

6.2 Application to Financial Innovation

Our analysis of trust also provides a perspective on the future evolution of fintech innovations such as "robo advisors" and cryptocurrency like bitcoin. Many of these technologies are quite opaque to investors, especially households. Thus, accoding to our analysis, their acceptance by consumers and their long-run viability depend on the extent to which these technologies are trusted. In this case, trust pertrains not so much to risk-shifting behavior by the platform operator, but to the *security* of the technology. Events such as hackers stealing large amounts of cryptocurrency erode trust. In our analysis, we posit that trust is a 0-1 phenomenon, so if investors lose trust in these innovations, there will not be a gradual Bayesian belief revision. Rather, there will be a massive flight away from these new technologies. In other words, as long as investors trust these technologies, periodic episodes of breaches and failures will have no apparent effect on the popularity of fintech. But if trust is lost, there will be a sharp drop-off in the acceptance of these technologies.

[46]Buchak, Matvos, Piskorski, and Seru (2018a) point out that the growth of fintech has been facilitated by information technology, including techniques to analyze big data, and that fintech lenders seem more proficient in analyzing big data. However, they define fintech as all lenders that use financial technology (i.e. online banking), including traditional banks, so it is not a comparison of depository institutions and non-banks, as in our model, and their findings refer primarily to U.S. mortgage lending. But even if applied to banks versus non-banks as defined in our model, one should not treat existing institutions as static and non-reactive. If non-banks are using better credit-risk-processing technology, banks will eventually adopt it too.

7 Conclusion

This paper has developed a theory of trust in lending. Trust enables lenders to have access to financing at rates that are insulated from the adverse reputational consquences of prior loan defaults as well as market conditions. However, trust can be broken. It is most likely to be eroded when the lender experiences high borrower defaults during an economic boom. Trust is asymmetric—it is easier to lose it than to gain it. The importance of trust varies across banks and non-banks such as fintech lenders and shadow banks. While banks may be able to operate without trust, investor trust is essential for non-banks to operate.

From a functional perspective, banks and non-banks perform similar lending functions. Our analysis of trust and a characterization of the difference between banks and non-banks relies on an essential institutional difference between these lenders—banks have access to insured deposits and they provide valuable depository services to their customers, whereas non-banks are entirely investor-financed. This distinction makes banks innately more trustworthy than non-banks, and provides them with a competitive advantage over non-depository lenders on the trust dimension.

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Appendix

A. A Simple Example of Trust versus Reputation within the Model

A natural question that arises is: why do we need a non-Bayesian model of trust? There are two main reasons. First, it provides a simple way to sharply distinguish between trust and reputation as concepts that co-exist within the same model. Second, the model sheds light on the otherwise difficult-to-explain empirical evidence cited earlier. To illustrate these points, we develop a simple example which captures some elements of our model, but does not reflect its full richness. We then compare the main result to a setting with only Bayesian updating (e.g. a standard reputation model).

A.1 Basic Setup

Suppose there are four types of lenders: τ_0, τ_1, τ_2, and τ_3, and two "models" of the world. In Model I, only τ_0 lenders exist and these lenders are all trustworthy in that they only invest in good loans. In Model II, lenders can be either τ_1, τ_2, or τ_3. These lenders will either make good loans or bad loans that provide them private benefits, depending on the realized value of the private benefit. Thus, the expected loan repayment probabilities for these types of lenders are lower than for the τ_0 lenders. There are two possible macroeconomic states at the end of the first period, each equally probable. In the boom macro state, the probabilities of loan repayments for types τ_i, $i \in \{0, 1, 2, 3\}$ are $q_0^h = 0.999$, $q_1^h = 0.95$, $q_2^h = 0.9$, and $q_3^h = 0$. In the recession macro state, these probabilities are: $q_0^l = 0.981$, $q_1^l = 0.85$, $q_2^l = 0.7$, and $q_3^l = 0$. Investors have a prior belief that there is a 0.7 probability that Model I is the correct model and 0.3 probability that Model II is the correct model. Conditional on being in Model II, the prior belief is that the probabilities ν_i of type $i \in \{1, 2, 3\}$ are $\nu_1 = 0.5$, $\nu_2 = 0.3$, and $\nu_3 = 0.2$. All agents are risk neutral.

The rank-ordering of loan repayment probabilites in Model II is a reduced-form way of representing higher private benefits from bad loans for lenders with lower repayment probabilities. In Model I, the lender is trustworthy and always invests in a good loan, so the repayment probability is the highest. Each lender operates in two periods, and raised \$1 from debtholders to lend to a borrower. On a good loan, the borrower either repays the lender \$2 or defaults. The lender can repay its investors only if its borrower repays. The riskless rate is 10% and lenders raise financing at rates that give investors an expected return of 10%. The terms at which the lender can raise $1 for its second-period loan depends on the outcome of its first-period loan.

A.2 Model with Trust

We will now examine two scenarios to illustrate how the results we obtain are driven by the hypothesis testing representation of Ortoleva (2012) and would be difficult to obtain in a purely Bayesian setting. Consider first the set-up in which investors—those who provide financing to lenders—consider two models of the world possible and, based on their prior over priors, decide to adopt Model I. Now the expected repayment probability on the loan across the two macro states (for type τ_0) is 0.99. Thus, when it raises $1 at the start of the first period, the lender's repayment obligation to its investors at the end of the first period is $1.1/0.99 = 1.11$, or an interest rate of 11%.

Now imagine that the loan defaults. What should investors believe? If the macro state is a boom, the default has a 0.001 probability of occuring, whereas if the macro state is a recession, this probability is 0.019. Given that a default is this likely in a recession with even a trusted lender, suppose investors choose to hold on to their prior over priors about the model of the world despite a default.[47] Then in the second period, the lender's cost of funding remains the same as in the first (11%) since investors continue to believe the lender is trustworthy. However, if the macro state is a boom, then investors may conclude that the likelihood of a default by a trusted lender was so low that they picked the wrong model initially, and would switch to Model II, and no funding would be available to the lender (the repayment obligation is 6.03, which exceeds the lender's maximum repayment capacity).

A.3 Model with Only Reputation

We now consider how things would look in a reputation model with complete Bayesian rationality. Now we can simply view this as a situation with four types of agents and prior beliefs about types given by $\Pr(\tau_0) = 0.7$, $\Pr(\tau_1) = 0.3 \times 0.5 = 0.15$, $\Pr(\tau_2) = 0.09$, and $\Pr(\tau_3) = 0.06$. In

[47] This is the "threshold probability", as formalized in Ortoleva (2012).

the first period, the expected repayment probability across the two macro states is $0.7 \times 0.99 + 0.3\,[0.5 \times 0.9 + 0.3 \times 0.8] = 0.9$. Thus, the lender's repayment obligation is 1.22, or an interest rate of 22%. Clearly, replacing trust with reputation increases the lender's funding cost.

What happens now with a loan default in a recession? Investors will come up with their posterior beliefs about the lender's type using Bayes rule. In particular, the posteriors will be: $\Pr(\tau_0 \mid \text{default}) = 0.1083$, $\Pr(\tau_1 \mid \text{default}) = 0.1832$, $\Pr(\tau_2 \mid \text{default}) = 0.2199$, and $\Pr(\tau_3 \mid \text{default}) = 0.4886$. Thus, the expected loan repayment probability across the two macro states in the second period will be $0.1083[0.99] + 0.1832[0.9] + 0.2199[0.8] = 0.4476$. The lender's repayment obligation will be $1.1/0.4476 = 2.4576$. Since the borrower only repays the lender \$2, it is impossible for the lender to raise financing in the second period. Clearly, things will be even worse for the lender conditional on default in a boom. Thus, while the model with trust allows lenders to continue to operate after default in one state of the world, the model with reputation cuts off all funding after lender default.

B. Parametric Restrictions

We present below the formal restrictions on the parameters of the model. We first need some notation as a prelude to the restrictions. Let the lowest possible shares of ownership the bank and the fintech lender must sell to raise the necessary external financing be (respectively):

$$s_b^* = \frac{[L-D][1+r]}{\overline{q}\lambda_b} \qquad \text{(bank)} \tag{A.1}$$

$$s_n^* = \frac{L[1+r]}{\overline{q}\lambda_f} \qquad \text{(non bank)} \tag{A.2}$$

and define the incremental expected utilities from investing in the G loan relative to the PB loan at the first-best financing costs as:

$$u_b^* = \alpha\,[\overline{q}-\overline{p}]\,\lambda_b\,[1-s_b^*] \qquad \text{(bank)} \tag{A.3}$$

$$u_f^* = \alpha\,[\overline{q}-\overline{p}]\,\lambda_f\,\left[1-s_f^*\right] \qquad \text{(bank)} \tag{A.4}$$

Also define the incremental expected utility of bank insiders from investing in the G loan at the second-best financing cost as:

$$\overline{u}_b = \alpha\,[\overline{q} - \overline{p}]\,\lambda_b \left[1 - s_b^*\,[\nu\gamma_1]^{-1}\right] \tag{A.5}$$

and let the bank's adjusted expected utility differential be defined as:

$$D \equiv u_b^* - \overline{u}_b \tag{A.6}$$

We can now state our restrictions on the parameters:

Restriction 1:

$$[1-\alpha]\beta_h^1 < u_b^* < [1-\alpha]\beta_h^2 < u_b^* + D \tag{A.7}$$

Restriction 2:

$$[1-\alpha]\beta_l^1 < u_n^* < [1-\alpha]\beta_l^2 < [1-\alpha]\beta_l^1 < 2u_n^* < [1-\alpha]\beta_h^2 \tag{A.8}$$

Restriction 3:

$$\overline{u}_b > [1-\alpha]\beta_h^1 \tag{A.9}$$

Restriction 4:

$$\gamma_1 \text{ and } C(m,q) \text{ are intermediate in value } \forall\, m \tag{A.10}$$

C. Proofs

Proof of Lemma 1: Since $\hat{\varphi}' > r$, it follows that

$$\int_0^D \hat{\varphi}'(y)\,dy > \int_0^D r\,dy \tag{A.11}$$

which means that $\hat{\varphi}(D) > rD$. The depositors' participation constraint (with riskless deposits) is:

$$D\,[1 + r_D] + \overline{q}\,\overline{\varphi}(D) + [1 - \overline{q}]\,\hat{\varphi}(D) \geq D[1+r] \tag{A.12}$$

Since the zero-lower-bound assumption implies that $r_D \geq 0$, if (A.12) holds for $r_D = 0$, then the competitive equilibrium solution must be $r_D = 0$ because maximizing the lender's utility implies minimizing the left-hand side of (A.12) while satisfying (A.12). At $r_D = 0$, (A.12) becomes:

$$\overline{q}\,\overline{\varphi}(D) + [1-\overline{q}]\,\hat{\varphi}(D) \geq rD \tag{A.13}$$

Now, $\overline{q}\,\overline{\varphi}(D) + [1-\overline{q}]\,\hat{\varphi}(D) > \hat{\varphi}(D) > rD$ by (A.11). Thus, (A.13) holds with $r_D = 0$. ■

Proof of Lemma 2: If deposits are riskless, the value of the bank's depository services to its customers is

$$\overline{q}\,\overline{\varphi}(D) + [1-\overline{q}]\,\hat{\varphi}(D) \tag{A.14}$$

where we recognize that when the borrower defaults and deposit insurance kicks in, depositors value the bank's services only at $\hat{\varphi}(D)$ even though their financial claim is fully covered. If the bank is unable to fully pay off depositors when the borrower defaults, the value of the bank's depository services to its customers is:

$$\overline{q}\,\overline{\varphi}(D) \tag{A.15}$$

Thus, the welfare gain due to making deposits riskless is:

$$[1-\overline{q}]\,\hat{\varphi}(D) \tag{A.16}$$

Now by providing deposit insurance, relative to not providing it, the deposit insurer increases the expected payoff to depositors by

$$[1-\overline{q}]\,[\hat{\varphi}(D) + D] \tag{A.17}$$

The expected cost of providing deposit insurance is

$$[1-\overline{q}]\,D[1+r] \tag{A.18}$$

Thus, the net welfare benefit of complete deposit insurance provision is the difference between

(A.17) and (A.18):

$$\triangle \equiv [1-\overline{q}]\,[\hat{\varphi}(D)-rD] \tag{A.19}$$

From the proof of Lemma 1, we know that $\hat{\varphi}(D) > rD$, which means

$$\triangle > 0 \tag{A.20}$$

This completes the proof. ■

Proof of Lemma 3: When there is only one lender, it can act as a monopolist with respect to the borrower, so the repayment obligation is set at the maximum pledgeable cash flow, x. When there are two or more lenders, the repayment obligation must be set to yield the lender an expected return of r on the loan, which is the minimum return the lender will accept, given its ability to invest its funds at r. Thus, R_2^{FB} solves:

$$\overline{q}R_2^{FB} = L[1+r] \tag{A.21}$$

which yields (13). ■

Proof of Lemma 4: The result that $R_1^t \equiv R_1 = R_1^{FB} = x\,\forall\, t \in \{0,1\}$ and $R_2^t \equiv R_2 = R_2^{FB} = \{L[1+r]\}\,\{\overline{q}\}^{-1}\,\forall\, t \in \{0,1\}$ follows from the fact that the lender's loan pricing depends only on whether lenders are competing and the lender's participation constraint (minimum return of r) and not on the beliefs of investors about the lender's type.

Now $s_b^t(\omega)$ will be determined to satisfy the outside shareholders' participation constraint, which holds tightly in equilibrium:

$$\begin{aligned} s_b^t(\omega)\left\{\overline{q}I^t_{\{\pi_T\}} + \left[1-I^t_{\{\pi_T\}}\right]\sum_{j=1}^{3}\overline{q}\mu_\omega^b(j)I_b^t(j)\right\}\lambda_b \\ = [L-D][1+r] \end{aligned} \tag{A.22}$$

where the bank's strategy is restricted to lending (since financing is needed only if the bank decides to make a loan). Solving (A.22) yields (22). Similarly, for the fintech lender, $s_n^t(\omega)$ solves:

$$s_n^t(\omega)\left\{\overline{q}I^t_{\{\pi_T\}} + \left[1 - I^t_{\{\pi_T\}}\right]\sum_{j=1}^{3}\overline{q}\mu_\omega^f(j)I_f^t(j)\right\}\lambda_f$$
$$= L[1+r] \tag{A.23}$$

Solving (A.23) yields (23). ■

Proof of Theorem 1: By the HTR, since $\zeta^0 > 0.5$, the agents' prior over priors will select $\pi^0 = \pi_T$ and lenders will be viewed as trustworthy in the first period. Since $1 - C(\overline{m}, q) < \varepsilon$, it follows that if the lender experiences default and $\tilde{m} = \overline{m}$, then by the HTR agents will *reject* their initial prior π_T and go back to their prior over priors to update using Bayes' rule. They will compute the posterior belief

$$\zeta^1 = \frac{[1 - C(\overline{m}, q)]\,\zeta^0}{[1 - C(\overline{m}, q)]\,\zeta^0 + q_F(\overline{m})\,[1 - \zeta^0]} \tag{A.24}$$

where $q_F(\overline{m})$ is the expected failure probability in macro state $\overline{m}$ if the lender is self-interested, given the optimal strategies untrustworthy lenders would have chosen in the first period (with the expectation taken over lender types in Model II) when faced with agents believing them to be trustworthy.

Note that ζ^1 is decreasing in $q_F(\overline{m})$. The higher the probability that a type-τ_j ($j \in \{1, 2\}$) lender makes the G loan in the first period, the lower is $q_F(\overline{m})$ and hence the higher is ζ^1. The maximum probability that a type-τ_j lender will make the G loan is 1. Thus, if we can establish that $\zeta^1 < 0.5$ with this conjectured first-period strategy chosen by type τ_j, then $\zeta^1 < 0.5$ with *any* first-period strategy chosen by the type-τ_j lender.

Now if the type-τ_j makes the G loan with probability 1 in the first period $\forall\, j \in \{1, 2\}$, then

$$q_F(\overline{m}) = 1 - C(\overline{m}, q)\sum_{j=1}^{2}\mu_{\overline{m}}(j) \tag{A.25}$$

where $\mu_{\overline{m}}(j)$ is defined in (25), with the superscript i dropped, $\omega = \overline{m}$, and recognizing that the posterior is after observing default at $t = 1$, it can be written as:

$$\mu_{\overline{m}}(j) = \frac{\left[1 - C\left(\overline{m}, q\right)\right] \gamma_j}{\left[1 - C\left(\overline{m}, q\right)\right] \sum_{j=1}^{2} \gamma_j + 1 - \gamma_1 - \gamma_2} \tag{A.26}$$

with $j \in \{1, 2\}$. Substituting this in (A.25), the condition for $\zeta^1 < 0.5$ becomes:

$$\frac{\left[1 - C\left(\overline{m}, q\right)\right] \zeta^0}{\left[1 - C\left(\overline{m}, q\right)\right] \zeta^0 + \left[1 - \mu_{\overline{m}}(j) C\left(\overline{m}, q\right)\right]\left[1 - \zeta^0\right]} < 0.5 \tag{A.27}$$

where

$$\overline{\mu}_{\overline{m}} \equiv \sum_{j=1}^{2} \mu_{\overline{m}}(j) \tag{A.28}$$

Simplifying this yields

$$\zeta^0 < \frac{1 - C\left(\overline{m}, q\right) \overline{\mu}_{\overline{m}}}{2 - C\left(\overline{m}, q\right)\left[1 + \overline{\mu}_{\overline{m}}\right]} \tag{A.29}$$

Note that since $\overline{\mu}_{\overline{m}} < 1$, the quantity on the right-hand side of (A.29) is bigger than 0.5. Thus, the interval defined in (24) has positive Lebesgue measure.

So we have proven that at $\tilde{m} = \overline{m}$, if the lender experiences borrower default, by HTR the prior over priors will reject the intially chosen Model I as the correct belief and the revised prior over priors at $t = 1$ will choose Model II as the correct prior for the second period. This holds for any first-period strategy chosen by the lender. By continuity, $\exists\, m^*$ in the neighborhood of $\overline{m}$ for which this will be true as well. Further, given $\varepsilon < 1 - C\left(\underline{m}, q\right)$ in (26), it also follows that the initial prior is not rejected if $\tilde{m} = \underline{m}$. Thus, $m^* \in (\underline{m}, \overline{m})$.

It is straightforward that the initial prior will not be rejected for any $\tilde{m}$ if the lender experiences success (borrower-repayment) at $t = 1$. ■

Proof of Corollary 1: At $t = 0$, agents believe that all lenders are trustworthy. Thus, all make G loans and the probability of failure for every lender is $1 - C\left(m, q\right)$ in every $m \in [\underline{m}, \overline{m}]$. By Theorem 1, if $m > m^*$, then the HTR will reject the initial hypothesis that the lender is trustworthy if default is experienced, and if $m \leq m^*$, the HTR will not reject the initial hypothesis. Moreover, since every trustworthy lender had the same strategy in the first period, ζ^1 (see (A.24)) is also the same for every lender. The result now follows from Theorem 1. ■

Proof of Theorem 2: Part (i) of the theorem is clear, given that the type-τ_0 lenders always choose G. To prove part (ii), note that the expected utility of the insider of a type-τ_i ($i \in \{1, 2\}$) bank from making the G loan is

$$\alpha \left[1 - s_b^t\right] \lambda_b \overline{q} \tag{A.30}$$

where ω, the argument of s_b^t, is suppressed. The expected utility from a PB loan is

$$\alpha \left[1 - s_b^t\right] \lambda_b \overline{p} + [1 - \alpha]\beta_j^i \tag{A.31}$$

where $j \in \{l, h\}$ and $i \in \{1, 2\}$. Thus, the incentive compatibility (IC) constraint for the bank to prefer the G loan to the PB loan is:

$$\alpha\lambda_b \left[1 - s_b^t\right] [\overline{q} - \overline{p}] > [1 - \alpha]\beta_j^i \tag{A.32}$$

The analogous IC constraint for the non-bank lender is:

$$\alpha\lambda_n \left[1 - s_n^t\right] [\overline{q} - \overline{p}] > [1 - \alpha]\beta_j^i \tag{A.33}$$

Thus, to show that the bank has a stronger incentive to make the G loan than a comparable non-bank lender, we need to show that:

$$\left[1 - s_b^t\right] [\overline{q} - \overline{p}] \lambda_b > \left[1 - s_n^t\right] [\overline{q} - \overline{p}] \lambda_f \tag{A.34}$$

For this comparison, we need to have the same posterior belief about the lender's type for both the bank and the non-bank lender. That is, let

$$\begin{aligned} \xi &\equiv \overline{q} I^t_{\{\pi_T\}} + \left[1 - I^t_{\{\pi_T\}}\right] \sum_{j=1}^{3} \overline{q} \mu_\omega^b(j) I_b^t(j) \\ &= \overline{q} I^t_{\{\pi_T\}} + \left[1 - I^t_{\{\pi_T\}}\right] \sum_{j=1}^{3} \overline{q} \mu_\omega^n(j) I_b^t(j) \end{aligned} \tag{A.35}$$

Then using (22) and (23) we can write:

$$s_b^t = \frac{L[1+r] - D[1+r]}{\lambda_b \xi} \tag{A.36}$$

$$s_n^t = \frac{L[1+r]}{\lambda_n \xi} \tag{A.37}$$

with (using (20) and (21)):

$$\lambda_b = \lambda_n - D \tag{A.38}$$

(A.35) thus requires showing that:

$$\left[1 - s_b^t\right] \lambda_b > \left[1 - s_n^t\right] \lambda_n \tag{A.39}$$

Substituting in (A.39) from (A.36) and (A.37):

$$\frac{\{\xi\lambda_b - L[1+r] + D[1+r]\}}{\lambda_b \xi} \lambda_b > \frac{\{\xi\lambda_n - L[1+r]\}}{\lambda_n \xi} \lambda_n \tag{A.40}$$

or, re-writing this:

$$\xi\lambda_b - L[1+r] + D[1+r] > \xi\lambda_n - L[1+r] \tag{A.41}$$

And substituting in (A.41) from (A.38) we have:

$$\xi\left[\lambda_n - D\right] + D[1+r] > \xi\lambda_n \tag{A.42}$$

which requires:

$$D\{1 + r - \xi\} > 0 \tag{A.43}$$

which is true since ξ is a probability. ■

Proof of Lemma 5: Given Theorem 2, we know that, conditional on identical investor beliefs about their types, banks have stronger incentives to make G loans than non-bank lenders. Here lenders are trusted in the second period, so $\xi = \overline{q}$ for both banks and non-banks. The strategies of the type-τ_0 bank and non-bank lender stated in the lemma are clear. The same is true for the type-τ_3 bank and non-bank lender.

For the type-τ_1 bank the IC constraint associated with the conjectured strategy is (using (A.33)):

$$\alpha\lambda_b\left[1-s_b^t\right][\overline{q}-\overline{p}] > [1-\alpha]\beta_h^1 \tag{A.44}$$

whereas for the type-τ_2 we need:

$$\alpha\lambda_b\left[1-s_b^t\right][\overline{q}-\overline{p}] > [1-\alpha]\beta_l^2 \tag{A.45}$$

and

$$\alpha\lambda_b\left[1-s_b^t\right][\overline{q}-\overline{p}] < [1-\alpha]\beta_h^2 \tag{A.46}$$

Since $\beta_l^2 < \beta_h^1 < \beta_h^2$, and (A.7) holds, it is possible for (A.44), (A.45), and (A.46) hold simultaneously.

In the case of the non-bank lender, for the conjectured strategies to hold, we need:

$$\alpha\lambda_n\left[1-s_n^t\right][\overline{q}-\overline{p}] > [1-\alpha]\beta_l^1 \tag{A.47}$$

$$\alpha\lambda_n\left[1-s_n^t\right][\overline{q}-\overline{p}] < [1-\alpha]\beta_h^1 \tag{A.48}$$

and

$$\alpha\lambda_n\left[1-s_n^t\right][\overline{q}-\overline{p}] < [1-\alpha]\beta_l^2 \tag{A.49}$$

Given (A.8), we know that (A.47), (A.48), and (A.49) hold at the same time. Thus, the optimal second-period strategies of lenders are as described in the lemma. ■

Proof of Lemma 6: Consider banks first. We will show that the strategies characterized in the lemma constitute a (subgame perfect) Nash equilibrium. Without trust, given the conjectured strategies of banks stated in the lemma, investors set:

$$\xi = \mu_\omega^b(1)\nu\overline{q} \tag{A.50}$$

Note that types τ_0 and τ_3 will obviously follow the lending strategies stipulated in the lemma, so we can focus on types τ_1 and τ_2. For the type-τ_1 bank to find this lending strategy optimal, the IC constraints below must be satisfied:

$$\alpha\lambda_b \left[1 - s_b^1\right] [\overline{q} - \overline{p}] > [1-\alpha]\beta_l^1 \tag{A.51}$$

$$\alpha\lambda_b \left[1 - s_b^1\right] [\overline{q} - \overline{p}] < [1-\alpha]\beta_h^1 \tag{A.52}$$

where λ_b is given by (20) and

$$s_b^1 = \frac{L[1+r] - D[1+r]}{\lambda_b \left\{\mu_\omega^b(1)\nu\overline{q}\right\}} \tag{A.53}$$

For the type-τ_2 bank, the analogous IC constraint is:

$$\alpha\lambda_b \left[1 - s_b^1\right] [\overline{q} - \overline{p}] \leq [1-\alpha]\beta_l^2 \tag{A.54}$$

Since $\beta_l^1 < \beta_l^2$ and $\beta_l^1 < \beta_h^1$, note that if (A.54) holds, so will (A.52). Given the parametric restrictions in Appendix A, (A.51), (A.52), and (A.54) hold simultaneously. Hence, the bank's strategies and investors' beliefs constitute a Nash equilibrium.

Now consider the fintech lender's strategy. Suppose counterfactually that investors believe that a fintech lender of type τ_i ($i \in \{1, 2\}$) will follow the same lending strategy as a bank of that type. We know by Theorem 2 that a fintech lender has a weaker incentive to make a G loan than a bank of the same type, given the same investor beliefs, so the fintech lender can never be believed to invest in G with a higher probability than a bank (for the same ω realization). Then the relevant IC constraint for the non-bank lender correpsonding to the strategy stipulated in the lemma is:

$$\alpha\lambda_n \left[1 - s_n^1\right] [\overline{q} - \overline{p}] \leq [1-\alpha]\beta_l^1 \tag{A.55}$$

where λ_n is given by (21) and

$$s_n^1 = \frac{L[1+r]}{\lambda_n \left\{\mu_\omega^b(1)\nu\overline{q}\right\}} \tag{A.56}$$

if we assume (counterfactually) that investors have the same beliefs about the non-bank lender's types and strategies as they do about the bank.

Now solve for the value of $\mu_\omega^b(1)$, call it $\hat{\mu}_\omega^b(1)$, such that (A.55) holds as an equality. If we choose $\mu_\omega^b(1) = \hat{\mu}_\omega^b(1) - \bar{\varepsilon}$, where $\bar{\varepsilon} > 0$ is arbitrarily small, then (A.55) will hold and (A.51) will hold since $\lambda_b > \lambda_n$. Next, find the value of $\mu_\omega^b(1)$, call it $\widetilde{\mu}_\omega^b(1)$, such that (A.54) holds as an equality. Choose $\mu_\omega^b(1) = \min\left\{\hat{\mu}_\omega^b(1), \widetilde{\mu}_\omega^b(1)\right\} - \bar{\varepsilon}$. Then (A.54) will hold, and (A.51) and (A.55) will continue to hold.

Thus, investors will believe that a type τ_i ($i \in \{1,2,3\}$ non-bank lender will not invest in loan G with a positive probability. Given the absence of trust, the non-bank lender will therefore be unable to raise financing. Finally, note that since (A.51) holds, $s_b^1 < 1$, which means $\mu_\omega^b(1)$ cannot be too small, i.e., it takes an intermediate value. Restriction 4 ensures that $\mu_\omega^b(1)$ is intermediate in value. ■

Proof of Theorem 3: We will focus on the strategies of types τ_1, τ_2, and τ_3. Let u_{ij}^2 be the second-period utility of lender $i \in \{b,n\}$ of type $j \in \{1,2,3\}$ (where 1 represents τ_1, 2 represents τ_2, and 3 represents τ_3), when the lender is trusted in the second period and $\hat{u}_{ij}^2$ be the corresponding utility when the lender is not trusted. The theorem assumes the condition that all lenders are trusted in the first period. We will now validate that the strategies stipulated in the theorem represent a Nash equilibrium, given investors' beliefs.

Consider banks first. Since type-τ_1 banks have a stronger incentive than type-τ_2 banks to make G loans, and since a bank has a stronger incentive than a non-bank lender to make a G loan, to validate the strategies of the banks of types τ_1 and τ_2, and the non-bank lender of type τ_1, it suffices to check that the following IC constraints are satisfied. The first is that the type-τ_2 bank prefers G to PB $\forall$ β:

$$\alpha\left\{\left[1-s_b^0\right]\bar{q}\lambda_b+\left\{\bar{q}+[1-\bar{q}]\int_{\underline{m}}^{m^*}\eta\,dm\right\}u_{b2}^2+[1-\bar{q}]\left[\int_{m^*}^{\overline{m}}\eta\,dm\right]\hat{u}_{b2}^2\right\}$$
$$\geq \alpha\left\{\left[1-s_b^0\right]\bar{p}\lambda_b+\left\{\bar{p}+[1-\bar{p}]\int_{\underline{m}}^{m^*}\eta\,dm\right\}u_{b2}^2+[1-\bar{p}]\left[\int_{m^*}^{\overline{m}}\eta\,dm\right]\hat{u}_{b2}^2\right\}+[1-\alpha]\beta_h^2 \quad \text{(A.57)}$$

The second is that the type-τ_1 non-bank lender prefers G to PB $\forall\ \beta$:

$$
\begin{aligned}
&\alpha \left\{ \left[1 - s_n^0\right] \overline{q} \lambda_n + \left\{ \overline{q} + [1 - \overline{q}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n1}^2 + [1 - \overline{q}] \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \hat{u}_{n1}^2 \right\} \\
\geq\ &\alpha \left\{ \left[1 - s_n^0\right] \overline{p} \lambda_n + \left\{ \overline{p} + [1 - \overline{p}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n1}^2 + [1 - \overline{p}] \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \hat{u}_{n1}^2 \right\} + [1 - \alpha] \beta_h^1
\end{aligned} \tag{A.58}
$$

The third is that the type-τ_2 non-bank lender prefers G to PB for $\beta = \beta_l^2$:

$$
\begin{aligned}
&\alpha \left\{ \left[1 - s_n^0\right] \overline{q} \lambda_n + \left\{ \overline{q} + [1 - \overline{q}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n2}^2 + [1 - \overline{q}] \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \hat{u}_{n2}^2 \right\} \\
\geq\ &\alpha \left\{ \left[1 - s_n^0\right] \overline{p} \lambda_n + \left\{ \overline{p} + [1 - \overline{p}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n2}^2 + [1 - \overline{p}] \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \hat{u}_{n2}^2 \right\} + [1 - \alpha] \beta_l^2
\end{aligned} \tag{A.59}
$$

And the fourth is that the type-τ_2 non-bank lender prefers PB to G for $\beta = \beta_h^2$:

$$
\begin{aligned}
&\alpha \left\{ \left[1 - s_n^0\right] \overline{q} \lambda_n + \left\{ \overline{q} + [1 - \overline{q}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n2}^2 + [1 - \overline{q}] \left[\int_{m^*}^{\underline{m}} \eta \, dm \right] \hat{u}_{n2}^2 \right\} \\
<\ &\alpha \left\{ \left[1 - s_n^0\right] \overline{p} \lambda_n + \left\{ \overline{p} + [1 - \overline{p}] \int_{\underline{m}}^{m^*} \eta \, dm \right\} u_{n2}^2 + [1 - \overline{p}] \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \hat{u}_{n2}^2 \right\} + [1 - \alpha] \beta_h^2
\end{aligned} \tag{A.60}
$$

The relevant second-period utilities with and without trust were derived in the proofs of the previous results. From those proofs, we know that

$$
u_{ij}^2 > \hat{u}_{ij}^2 \tag{A.61}
$$

$$
u_{bj}^2 > u_{nj}^2 \tag{A.62}
$$

$$
\hat{u}_{bj}^2 > \hat{u}_{nj}^2 \tag{A.63}
$$

Noting that $\alpha \left[\overline{q} - \overline{p}\right] u_{b2}^2 = u_b^*$, $\alpha \left[\overline{q} - \overline{p}\right] u_n^2 = u_n^*$ for $i \in \{1, 2\}$, and $\alpha \left[\overline{q} - \overline{p}\right] \hat{u}_{b2}^2 = \overline{u}_b$, and that a non-bank lender lacking trust is locked out of the market in the second period, we can write (A.57), (A.58), and (A.60) respectively as:

$$
u_b^* + \left[1 - \int_{\underline{m}}^{m^*} \eta \, dm \right] u_b^* + \left[\int_{m^*}^{\overline{m}} \eta \, dm \right] \overline{u}_b \geq [1 - \alpha] \, \beta_h^2 \tag{A.64}
$$

$$u_n^* + \left[1 - \int_{\underline{m}}^{m^*} \eta \, dm\right] u_n^* \geq [1-\alpha]\,\beta_h^1 \tag{A.65}$$

$$u_n^* + \left[1 - \int_{\underline{m}}^{m^*} \eta \, dm\right] u_n^* \geq [1-\alpha]\,\beta_l^2 \tag{A.66}$$

$$u_n^* + \left[1 - \int_{\underline{m}}^{m^*} \eta \, dm\right] u_n^* < [1-\alpha]\,\beta_h^2 \tag{A.67}$$

Now, in the limit as $m^* \to \underline{m}$, we see that (A.7) guarantees that (A.64) holds and (A.8) guarantees that (A.65), (A.66), and (A.67) hold. By continuity, therefore, these inequalities will hold for $m^* > \underline{m}$, given a small enough measure of $[\underline{m}, m^*]$, i.e., for $\underline{m}$ high enough. The rest of the theorem follows from the previous proofs. ■

Proof of Theorem 4: Consider first the strategies of banks, Given the arguments in the proof of Theorem 3, we need to show that it is possible for (A.57) to hold and for the following IC constraints to hold (where the beliefs of investors at $t = 0$ are consistent with the conjectured equilibrium strategies of banks) and we utilize the assumption that if a lender does not have trust at $t = 0$, it can never gain it at $t = 1$). The first is that the type-τ_1 bank prefers the G loan $\forall\ \beta$:

$$\alpha\left\{\left[1-\hat{s}_b^0\right]\overline{q}\lambda_b + \hat{u}_{b1}^2\right\} \geq \alpha\left\{\left[1-\hat{s}_b^0\right]\overline{p}\lambda_b + \hat{u}_{b1}^2\right\} + [1-\alpha]\beta_h^1 \tag{A.68}$$

The second is that the type-τ_2 bank prefers the G loan for $\beta = \beta_l$:

$$\alpha\left\{\left[1-\hat{s}_b^0\right]\overline{q}\lambda_b + \hat{u}_{b2}^2\right\} \geq \alpha\left\{\left[1-\hat{s}_b^0\right]\overline{p}\lambda_b + \hat{u}_{b2}^2\right\} + [1-\alpha]\beta_l^2 \tag{A.69}$$

The third is that the type-τ_2 bank prefers the PB loan for $\beta = \beta_h$:

$$\alpha\left\{\left[1-\hat{s}_b^0\right]\overline{q}\lambda_b + \hat{u}_{b2}^2\right\} < \alpha\left\{\left[1-\hat{s}_b^0\right]\overline{p}\lambda_b + \hat{u}_{b2}^2\right\} + [1-\alpha]\beta_h^2 \tag{A.70}$$

In the above,

$$\hat{s}_b^0 = \frac{[L-D][1+r]}{\overline{q}\left[\gamma_1 + \nu\gamma_2\right]\lambda_b} \tag{A.71}$$

Now, following steps similar to those in the proof of the previous theorem, we can write (A.68)-

(A.70) as:

$$\alpha\left[1-\hat{s}_b^0\right]\left[\overline{q}-\overline{p}\right]\lambda_b \geq [1-\alpha]\beta_h^1 \tag{A.72}$$

$$\alpha\left[1-\hat{s}_b^0\right]\left[\overline{q}-\overline{p}\right]\lambda_b \geq [1-\alpha]\beta_l^2 \tag{A.73}$$

$$\alpha\left[1-\hat{s}_b^0\right]\left[\overline{q}-\overline{p}\right]\lambda_b < [1-\alpha]\beta_h^2 \tag{A.74}$$

Now note that

$$\hat{s}_b^0 < s_b^*\left[\nu\gamma_1\right]^{-1} \tag{A.75}$$

which means that

$$\alpha\left[1-\hat{s}_b^0\right]\left[\overline{q}-\overline{p}\right]\lambda_b > \overline{u}_b > [1-\alpha]\,\beta_h^1 \tag{A.76}$$

where (A.76) follows from (A.5). Given this, (A.72) holds. Moreover, (A.73) also holds since $\beta_l^2 < \beta_h^1$. Finally, since

$$\alpha\left[1-\hat{s}_b^0\right]\left[\overline{q}-\overline{p}\right]\lambda_b < u_b^* \tag{A.77}$$

and $u_b^* < [1-\alpha]\beta_h^2$ by (A.7), we see that (A.77) guarantees that (A.75) holds. Thus, the strategies in the theorem constitute a Nash equilibrium.

For the fintech lenders, given that it is impossible to gain trust in the second period once it is absent in the first period and the result in lemma 6 that absent trust, a fintech lender is shut out of the market in the second period, the first-period problem is the same as the second-period problem without trust. But we know from Lemma 6 that in this case, no financing is available to the lender. ■

Proof of Theorem 5: Assume (26) holds. Then we have already established in Corollary 1 that a lender who starts out being trusted can lose trust if default is experienced at $t = 1$ at $m > m^*$. So what we need to prove is that, for the *same* set of parameter values, a lender who starts out not being trusted can never gain trust in the future.

So suppose agents start out at $t = 0$ with Model II. The only way for lenders to gain trust at $t = 1$ is if they experience first-period loan repayment. Suppose this happens when $m = \underline{m}$, so the repayment probability of the G loan is $C\left(\underline{m}, q\right)$. Clearly, if trust cannot be regained with loan repayment when $m = \underline{m}$, it cannot be regained with $m > \underline{m}$. The HTR will reject the initially-adopted Model II if

$$[\gamma_1 + \nu\gamma_2]\, C\,(\underline{m}, q) > \varepsilon \tag{A.78}$$

where it is recognized that with Model II only the type-τ_1 lenders and type-τ_2 lenders with $\tilde{\beta}_2 = \beta_2^l$ choose loan G, so $\gamma_1 + \nu\gamma_2$ is the probability measure of lenders choosing loan G (Theorem 4). Since ε is arbitrarily small, (A.78) holds. Thus, trust will never be gained at $t = 1$. ■