Opaqueness and Optimal Intermediary Financing*

Kumar Rishabh† Christian Wipf‡

January 18, 2021

Abstract

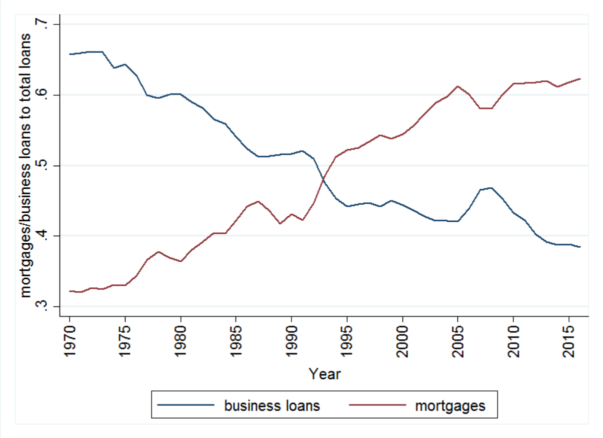
In recent decades bank loan portfolios strongly shifted from business loans to mortgages which are arguably easier to value (less "opaque") than business loans. Against this background we study the optimal financing structure for opaque and less opaque assets, especially the use of demandable versus non-demandable liabilities. We show that while demandable liabilities can be optimal to finance opaque assets (in line with the existing literature on the disciplining role of demandable debt), less opaque assets like mortgages or securities should be financed with non-demandable liabilities. Empirically we document a small but positive correlation between opaque assets (business loans) and (non-insured) demandable liabilities in US bank balance sheet data for small and medium sized banks (up to the 75th percentile) but no correlation for lager banks.

JEL: G21, D86

*We thank Cyril Monnet and Chao Gu for their comments and suggestions.
†University of Basel, Switzerland. kumar.rishabh@unibas.ch
‡University of Bern, Switzerland. christian.wipf@vwi.unibe.ch

1 Introduction

Bank loan portfolios strongly shifted from business loans to mortgages in the last decades. The figure shows the share of mortgages in aggregated bank loan portfolios of 13 advanced economies. The share of mortgages roughly doubled from 32% to 62% while the share of business loans decreased from 65% to 38% since 1970.[1]



As mortgages seem to be easier to value than business loans, one implication from this shift is that bank assets became less opaque.[2] While real estate values are relatively accessible it is much harder for a bank to observe the factors which determine the value of a small (and unlisted) firm, for example the human capital and the effort of an entrepreneur. This relative transparency of mortgages is e.g. apparent in the fact that for mortgages there is platform lending and a secondary market (both is not the case for business loans) and mortgage contracts are standardized and short while business loan contracts are much more detailed and specific. This hints at lower monitoring costs.[3]

Despite this shift towards more opaque assets the theoretical banking literature mainly builds on the premise that banks are the providers of finance for opaque (small) businesses and many theoretical results rely on the "opaqueness" of bank loans (or of bank assets more generally). An example is Calomiris and Kahn [1991] (CK in the following)[4] which provide an explanation why banks use demandable liabilities as means of financing. CK argue that demandable liabilities are useful to finance opaque assets because these contracts have a "disciplining role". Banks have the possibility to misuse the funds entrusted to them in their model and demandable liabilities give the investors the option to withdraw their funds if they fear this might happen. Thus demandable

[1]Calculations based on data by Jordà et al. [2016]. Loan data of the individual countries were converted into USD and then aggregated.

[2]This is even more true if we take into account that the other main categories of bank assets, securities and cash, can be valued directly by their market price.

[3]A widely used metric for the opaqueness of loans is the distance between bank and borrower. Recent studies for the US found the average distance for mortgages to be 2.5 times the average distance for small business loans, i.e. 90 miles vs. 241.8 miles, see Granja et al. [2018] and Eichholtz et al. [2019]

[4]Other examples include Diamond [1984], Holmstrom and Tirole [1997] or Dang et al. [2017]

contracts mitigate the agency problem and allow for socially beneficial investment which would otherwise be impossible. But using demandable liabilities also has a cost, because it sometimes involves a liquidation of the bank and the investments.

In our paper we revisit the argument of CK introducing less opaque assets into their environment, i.e. assets who's value can be better observed by the investors (in CK the value of the bank assets is unobservable by the investors, i.e. these assets are fully opaque). As we show demandable liabilities are not optimal to finance more transparent assets although the agency problem applies to these assets as well. The reason is that if investors are able to better observe the value of the asset they can use this information to design non-demandable contracts, which allows to mitigate the agency problem too but without the costs of liquidation. Giving investors the option to withdraw their funds if they fear the bank will misuse them is not necessary for more transparent assets.

This theory suggests that opaque assets like business loans should be financed with demandable liabilities (like demand deposits) while less opaque assets like mortgages, securities or cash should be financed with non-demandable liabilities (like non-demandable debt or equity). In a second step we thus look at US balance sheet data of individual banks to see whether there is a correlation between the share of opaque assets, which we quantify as the share of business loans, and the share of demandable liabilities. As our measure of demandable liabilities we use a variable called *volatile liabilities* provided by the FDIC which essentially contains demand deposits not covered by deposit insurance and other very short-term liabilities.[5] We document a small but positive correlation between opaque assets (business loans) and volatile liabilities for small and medium sized banks (up to the 75th percentile) but interestingly no correlation for lager banks. This is consistent with the interpretation that the disciplining role of demandable liabilities is more important for smaller banks and big banks might enjoy insurance beyond deposit insurance (e.g. in the form of implicit too-big-to-fail guarantees) which reduce investor incentives to monitor and "discipline" the banks even for deposits not covered by deposit insurance.

The rest of the paper is organized as follows: In section 2 we introduce the theoretical model and derive the optimal contracts for assets with different degrees of opacity (section 3). In section 4 we derive the optimal choice of opaque and transparent assets for a financial intermediary and in section 5 we relate our theoretical findings to US data.

2 Environment

There is a financial intermediary referred to as *bank* and an investor who interact over three periods (0,1,2). Both agents are risk neutral. The investor has an endowment normalized to 1 but

[5]The use of total demand deposits is complicated by deposit insurance which largely eliminates the incentives for investors to monitor the bank and thus also the need for contracts with a disciplining role. However, investors holding uninsured deposits and other very short term liabilities should have better incentives to monitor and discipline the issuing bank.

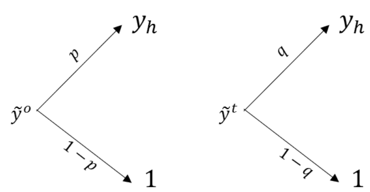
no investment opportunity except storage. The bank has no endowment but can invest in two risky assets in period 0: an opaque asset and a transparent asset. The bank chooses the composition of these two assets to form an asset portfolio of size one.

The asset returns realize in period 2. The returns of the transparent asset, denoted by $\tilde{y}^t$, are *publicly observable*. As discussed above, these assets can be thought of as securities or mortgages. The returns of opaque assets, denoted by $\tilde{y}^o$, such as business loans are only observable by the bank. Suppose a bank invests a fraction α of her funds into transparent assets. Then the expected return of total bank assets $\tilde{y}$ is a weighted average between the transparent and the opaque asset:

$$\tilde{y} = \alpha \tilde{y}^t + (1 - \alpha)\tilde{y}^o \tag{1}$$

Through its choice of weight α, the intermediary chooses the degree of opaqueness of the asset side of its balance sheet. The parameter α is thus a measure of the transparency (opaqueness) of the bank assets. The higher α, larger is the share of transparent assets on the balance sheet. Our model would be identical to the basic model in CK if we would only allow for an opaque asset (set $\alpha = 0$).

The realizations on the two assets are independent from each other. To keep the analysis simple we assume they both have a two-point distribution with identical support. Either they take a high value y_h or a low value y_l where $y_h > y_l$. We equalize the low realization to the return on storage, i.e. $y_l = 1$, thus clearly investment is always efficient from a social point of view. Suppose p (q) is the probability of the high value for the opaque (transparent) asset. We assume that $p \geq q$, and therefore $\mathbb{E}[\tilde{y}^o] \geq \mathbb{E}[\tilde{y}^t]$ i.e. the expected return of the opaque assets might be higher than the transparent assets. For further discussion we define the difference between the probabilities as $d := p - q$. If $d = 0$ the returns of both assets are identical, if $d > 0$ the expected return of the opaque asset is higher.



Thus for a choice of α, there are four possible realizations (or states s) of $\tilde{y}$ where $\Delta y := y_h - y_l$.

$y_1 = y_h$	with probability	pq
$y_2 = y_h - \alpha\Delta y$	with probability	$p(1-q)$
$y_3 = 1 + \alpha\Delta y$	with probability	$(1-p)q$
$y_4 = 1$	with probability	$(1-p)(1-q)$

The following figure shows bank asset returns in the four states as a function of asset transparency α:

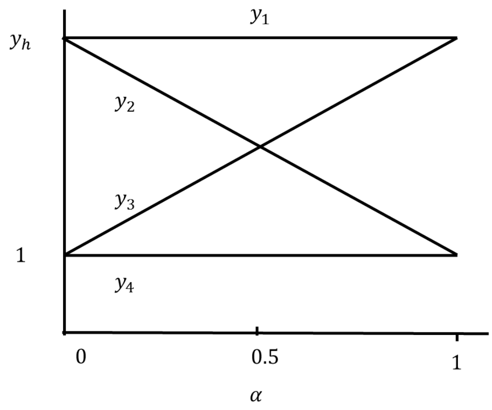


Figure 1: Returns in the four states as a function of α

Note that in states 1 and 4 the opaqueness of the bank assets does not matter for the return. Opaque and transparent assets both yield the same high or low return (either y_l or y_h). This is different for states 2 and 3. If the bank has an opaque portfolio (low α) she has a high return in state 2 but a low return in state 3 and vice versa for a transparent portfolio. Also note that if the expected return of opaque assets is higher (i.e. if $d > 0$) the problem is not symmetric in terms of expected returns. The bank profits more in expected terms in state 2 if she has an opaque portfolio. The expected value of the portfolio decreases in α as $d > 0$:

$$\mathbb{E}[\tilde{y}] = \mathbb{E}[\tilde{y}^o] - \alpha \Delta y d \tag{2}$$

In return to the investor's endowment, the intermediary promises to pay z goods to the investor in period 2. Since the realization of the transparent asset is observable by both agents, z can be made contingent on $\tilde{y}^t$, which we denote as $z(\tilde{y}^t)$. When $\alpha = 0$, the bank only invests into the opaque asset and thus the payment is just z. As in CK, we assume there is an agency problem between the intermediary and the investor in the sense that the bank cannot commit to pay back what she promised. If she defaults she can run away (or abscond) with a fraction $1 - A$ of the return in the given state where $A \in (0, 1)$. $A = 1$ implies the bank can perfectly commit and there is no agency problem, $A = 0$ implies the bank cannot commit at all and run away with all the assets. If the intermediary absconds, the investor gets zero. Thus absconding in state s implies a welfare loss of Ay_s.[6]

A method to prevent absconding is useful in this environment. For this purpose we introduce the

[6]With this formulation we do not link absconding to the opaqueness of the asset. We could do this e.g. by assuming that the bank can only abscond with a fraction $1 - A$ of the opaque asset $(1 - \alpha)(1 - A)\tilde{y}^o$, and the investor can always capture the return of the transparent asset $\alpha\tilde{y}^t$. This would give transparent assets a direct advantage against the absconding problem.

possibility to liquidate the investment in the middle period 1. We assume that if the investment (in either asset) is liquidated in period 1 the investor gets a payment $r < 1$ for sure and the intermediary gets zero. So liquidation in all states yields a lower return than the outside opportunity (storage) and it is not efficient to always liquidate. Further, liquidation is wasteful in any state i.e. even in state 4 where $y_4 = 1$, liquidation yields less than if the investment was allowed to mature. The welfare losses in any state s are given by $y_s - r$.

To allow for contracts where the investor has the option of demanding liquidation in the middle period we assume the investor gets a signal on the realization of the opaque asset in the middle period 1. The signal is private information for the investor so contracts contingent on the signal are not possible.[7] The signal structure is as follows: in period 1 the investor gets a signal *good* or *bad* on the state of the opaque asset. To keep things simple we assume that the signal is perfect, i.e. in the middle period the investor learns the outcome of the opaque asset in period 2 and the probability of getting a good signal is just p. In the appendix we show that our main results are unaffected if we introduce an imperfect (or costly) signal.

We can summarize the model as follows: In period 0 the intermediary offers the investor a contract outlining (i) a payment of $z(\tilde{y}^t)$ in period 2 to the investor and (ii) whether there is a possibility of early liquidation of the investment by the investor in return for the amount r in period 1. The intermediary also chooses an α simultaneously. Based on this offer the investor decides whether to invest in the intermediary or exercise her outside opportunity. Conditional on the investment, in period 1 the investor obtains a signal about the state of the opaque asset. Based on this signal she decides whether she should withdraw and get r if the contract allows this. If the investor liquidates the investment, the intermediary and its assets are liquidated. If the investment is not liquidated in period 1, in period 2 the project return $\tilde{y}$ realizes and the bank decides whether to abscond or pay back the investor. We call contracts without the option to withdraw in period 1 *non-liquidation contracts* and interpret them as non-demandable liabilities like long-term debt or equity (or a mixture of the two). We call contracts *with* the option to withdraw in period 1 *liquidation contracts* and interpret them as demandable liabilities like demand deposits or short term liabilities.

3 Optimal liabilities for a given asset structure

In this section we look at the optimal contract on financing the intermediary when the opacity of the asset structure – captured by α – is given. That is we determine optimal liability structure of the intermediary for a given α. Think of this as intermediaries raising financing after having inherited an asset structure.

[7] In this respect we differ from CK who assume payments can be contingent on the signal although the signal is private information.

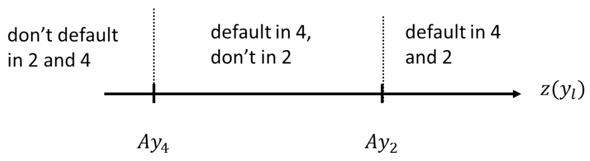
We first look at the incentives of the bank to pay back in period 2 given payments $z(\tilde{y}^t)$. If the bank defaults she can run away with $(1-A)y_s$ in any state $s \in \{1,2,3,4\}$. If she repays, she gets $y_s - z(\tilde{y}^t)$. Thus, for any payment $z(\tilde{y}^t)$ and state s, the intermediary will honour its commitment to pay if and only if

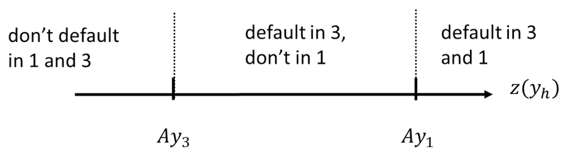
$$y_s - z(\tilde{y}^t) \geq (1-A)y_s$$

which gives us the incentive compatibility condition (IC) of the bank,

$$z(\tilde{y}^t) \leq Ay_s \tag{3}$$

In general, the higher the payments, the higher the incentives of the bank to abscond. Denote the payments given that the transparent asset takes the high (low) state as $z(y_h)$ $(z(y_l))$. So payment $z(y_h)$ applies to states 1 and 3 (which both have a high realization of the transparent asset) and payment $z(y_l)$ to states 2 and 4 (which both have a low realization of the transparent asset). The following figure depicts the payment functions and the absconding thresholds Ay_s.





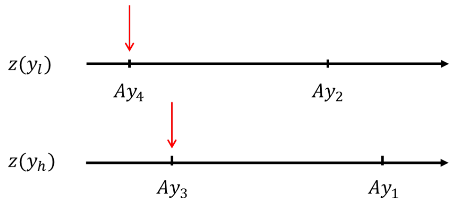
Depending on how high the payments are we can define four *situations* describing the states in which the bank absconds. These are denoted with S_j where j is an element of the power set of the set of states $\{1,2,3,4\}$. For ease of notation we will denote by S_0 the state where the intermediary never absconds.

- S_0: bank never absconds, $z(y_l) \leq Ay_4, z(y_h) \leq Ay_3$
- S_4: bank absconds in state 4, $Ay_4 < z(y_l) \leq Ay_2, z(y_h) \leq Ay_3$
- S_3: bank absconds in state 3, $z(y_l) \leq Ay_4, Ay_3 < z(y_h) \leq Ay_1$
- $S_{3,4}$: bank absconds in states 4 and 3, $Ay_4 < z(y_l) \leq Ay_2, Ay_3 < z(y_h) \leq Ay_1$

There are five additional situations where the bank also absconds in states 1 or 2. For example situation $S_{2,3,4}$, where the bank absconds in states 2,4, and 3 with $z(y_l) > Ay_2$ or situation $S_{1,2,3,4}$

where the bank always absconds and $z(y_h) > Ay_1, z(y_l) > Ay_2$. Below we will show that payments in these situations are strictly lower than in the four situations defined above.

Now we look at the incentives for the investor to invest in the bank. Clearly, for the investment to take place, the investor must get repaid at least 1 in expectation. This is the investor participation constraint (PC). Let us denote the maximal expected payments to the investor in a situation with $\bar{z}_j$. Clearly, this requires setting the payments $z(y_l)$ and $z(y_h)$ to the highest possible values (the absconding thresholds) in a given situation. For example in situation S_0 where the bank never absconds we set $z(y_l) = Ay_4$ and $z(y_h) = Ay_3$.



Thus the maximal expected payments in situation S_0 are to pay $z(y_l) = Ay_4$ in states 2 and 4 and $z(y_h) = Ay_3$ in states 1 and 3 which yields:

$$\bar{z}_0 = qAy_3 + (1 - q)Ay_4$$

Now we are in the position to define *feasible contracts*: A contract is feasible if it satisfies the PC of the investor in a given situation or if $\bar{z}_j \geq 1$. We can also show that maximal expected payments in the five situations which involve absconding in states 1 or 2 are strictly lower compared to the other four contracts. Clearly, situation $S_{1,2,3,4}$ where payments are so high that the bank always absconds and the investor gets zero in every state, $\bar{z}_{1,2,3,4} = 0$, is dominated by all other contracts. Also for example, the maximal expected payments in situation $S_{2,3,4}$, $\bar{z}_{2,3,4} = pqAy_1$, are strictly lower than the maximal expected payments in situation $S_{3,4}$, $\bar{z}_{3,4} = pqAy_1 + p(1-q)Ay_2$ and similarly $\bar{z}_{3,4} > \bar{z}_{1,3,4}$, $\bar{z}_3 > \bar{z}_{1,3}$ and $\bar{z}_4 > \bar{z}_{2,4}$. Looking for feasible contracts we can thus ignore the situations (or contracts) where banks abscond in states 1 or 2 and focus on the four situations from above $S_0, S_3, S_4, S_{3,4}$. The feasible contract with the highest expected welfare is called *optimal contract*.

3.1 Non-liquidation contracts

We will first study how the interactions of the two constraints shape the outcomes when the possibility of liquidation is not available. We look at the maximal expected payments in the four situations $\bar{z}_0, \bar{z}_3, \bar{z}_4, \bar{z}_{3,4}$. These are given by:

$$\begin{aligned}
\bar{z}_0 &= pqAy_3 + p(1-q)Ay_4 + (1-p)qAy_3 + (1-p)(1-q)Ay_4 \\
\bar{z}_4 &= pqAy_3 + p(1-q)Ay_2 + (1-p)qAy_3 + 0 \\
\bar{z}_3 &= pqAy_1 + p(1-q)Ay_4 + 0 + (1-p)(1-q)Ay_4 \\
\bar{z}_{3,4} &= pqAy_1 + p(1-q)Ay_2 + 0 + 0
\end{aligned}$$

Absconding has two opposing effects on maximal expected payments. Compare for example maximal expected payments when the bank never absconds, $\bar{z}_0$, and maximal expected payments when the bank absconds in state 4, $\bar{z}_4$. On one hand the investor looses going from $\bar{z}_0$ to $\bar{z}_4$ because she gets 0 in state 4 instead of Ay_4. On the other hand however, the investor also gains because the bank can pay more in state 2, Ay_2 instead of Ay_4. In general absconding lowers the payments in the state where the bank absconds but increases payments in the state where the contingent payment also applies. In the following we want to assume that absconding, e.g. going from $\bar{z}_0$ to $\bar{z}_4$ or $\bar{z}_3$ always lowers maximal expected payments at any α. Specifically we assume:

Assumption 1 $py_h < y_l = 1$

This brings us to our first result.

Lemma 1 *Under assumption 1 maximal expected payments are highest in the situation where the bank never absconds or* $\bar{z}_0 > \bar{z}_4, \bar{z}_3 > \bar{z}_{3,4}$.

Proof. tbd. QED

Lemma 1 establishes that contract S_0 dominates the other non-liquidation contracts in terms of maximal expected payments. $\bar{z}_0$ is feasible where the other payments are feasible and beyond. Situation (contract) S_0 also dominates the other situations (contracts) in terms of welfare. The other three contracts involve absconding in state 3, 4 or both. Thus they also involve welfare losses from absconding while contract S_0 involves no absconding and thus also no welfare losses. It implements the first best and is the optimal contract where it is feasible. Let us rewrite $\bar{z}_0$ and determine when it is feasible:

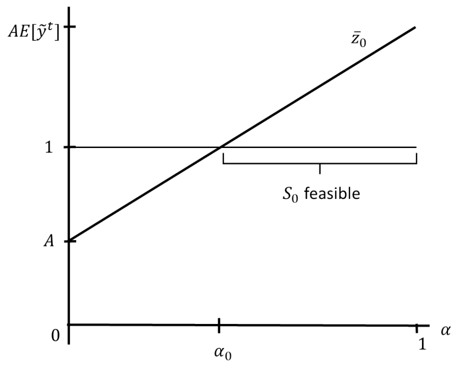
$$\bar{z}_0 = A + qA\Delta y\alpha \tag{4}$$

Proposition 1 *If* $A > \frac{1}{\mathbb{E}[\tilde{y}^t]}$, *i.e. the agency problem is not too severe, the non-liquidation contract* S_0 *is feasible for sufficiently transparent assets with* $\alpha \in (\alpha_0, 1)$ *and*

$$\alpha_0 := \frac{1-A}{Aq\Delta y} \tag{5}$$

Proof. $\bar{z}_0$ is increasing in α, thus we need $\bar{z}_0(1) \geq 1$ for feasibility. This implies $A\mathbb{E}\left[\tilde{y}^t\right] \geq 1$. α_0 is given by solving for α from $\bar{z}_0 \geq 1$. QED

The following figure graphically illustrates proposition 1:



What is the relation between the agency problem and the feasibility of this contract? If $A = 0$ the bank can abscond with all the assets, i.e. the agency problem is maximal. This means the bank can only pay zero to the investor in any situation or, $\bar{z}_0 = \bar{z}_3 = \bar{z}_4 = \bar{z}_{3,4} = 0$. No non-liquidation contract is feasible and the investor will never invest in the bank although investment would be socially desirable. On the other hand if $A = 1$ the bank cannot abscond with anything. In this case there is no agency problem. $\bar{z}_0$ and the other non-liquidation contracts are always feasible. Note that as A goes to 1 α_0 goes to zero, i.e. the optimal non-liquidation contract S_0 is feasible for the whole range of α. Thus it must be that S_0 becomes feasible at some intermediate degree of the agency problem.

Why is the non-liquidation contract S_0 feasible for a transparent portfolio (with a high α) but not for an opaque one? Or in other words why is $\bar{z}_0$ increasing with α? The short answer is that payments contingent on the realization of the transparent asset are much more useful for transparent portfolios with a high α since their return is largely determined by the publicly observable transparent asset. This is mirrored in the evolution of the returns in states 3 and 2. As figure 1 shows both move to the realization of the transparent asset with increasing α. For opaque portfolios it would be much more effective to tie the payments to the realization of the (dominant) opaque asset. But this is impossible because they are only privately observable. The better public observability of the returns for transparent assets allows to mitigate the agency problem by contingent contracts if the agency problem is not too severe.

In summary, our results so far point out that in the universe of non-liquidation contracts only sufficiently non-opaque assets can be financed. For investment in opaque assets we need some other instrument to deal with the problem of limited commitment of the intermediary. This brings us to another possibility – liquidation contracts.

3.2 Liquidation contracts

We consider contracts with liquidation in the middle period after the bad signal for the same four situations as in the section before. We denote the situations as S_j^L where "L" stands for "liquidation". With a perfect signal the investor knows for sure that after the bad signal (w.p. $1-p$) states y_3 or y_4 occur where the bank might abscond. Thus if the investor liquidates after the bad signal this perfectly prevents absconding.[8] However, liquidation is costly in terms of welfare. The welfare loss is the difference of the expected return without liquidation and r. In expectation they are given by:

$$(1-p)(qy_3 + (1-q)y_l - r) \tag{6}$$

As liquidation costs do not depend on the situations S_j all liquidation contracts are equivalent in terms or welfare. The maximal feasible payments of each of the liquidation contracts are given by:

$$\begin{aligned}
\bar{z}_0^L &= p(qAy_3 + (1-q)Ay_4) + (1-p)r \\
\bar{z}_4^L &= p(qAy_3 + (1-q)Ay_2) + (1-p)r \\
\bar{z}_3^L &= p(qAy_1 + (1-q)Ay_4) + (1-p)r \\
\bar{z}_{3,4}^L &= p(qAy_1 + (1-q)Ay_2) + (1-p)r
\end{aligned}$$

Since $y_1 \geq y_3$ and $y_2 \geq y_4$ maximal feasible expected payments must be highest with contract $\bar{z}_{3,4}^L$ when the bank pays Ay_1 in the good aggregate state and Ay_2 in the bad. This is a situation where the payments are so high that the banks would abscond in states 3 and 4 but this never happens because the investor always liquidates in these states. As already pointed out above, the perfect prevention of absconding is only possible with a perfect signal on the realization of the opaque asset. Since all contracts are equivalent in terms of expected welfare and $\bar{z}_{3,4}^L$ dominates the others in terms of expected payments we can focus on this liquidation contract and ignore the others. We can rewrite $\bar{z}_{3,4}^L$ as follows:

$$\bar{z}_{3,4}^L = p(Ay_h - (1-q)A\Delta y\alpha) + (1-p)r \tag{7}$$

Thus $\bar{z}_{3,4}^L$ decreases in the transparency of the portfolio, α. The more transparent the asset the less the bank can pay with this contract. Why is this? There are two reasons: First, the gains from paying Ay_2 instead of Ay_4 in state 2 decrease with α since y_2 decreases to y_l. So the advantage of contingent payments decreases. On the other hand the costs of liquidation increase with more

[8] With an imperfect signal states y_3 or y_4 might also occur after the good signal and the bank might abscond there.

transparent assets. For low α the costs of liquidation in state 3 are low because y_3 is close to y_l. But as y_3 increases towards y_h with α increasing liquidation in state 3 gets more and more costly. The following proposition establishes the feasibility of this contract.

Proposition 2 *If liquidation is sufficiently productive such that $r > \underline{r}$ a liquidation contract is feasible even for opaque assets with $\alpha \in (0, \alpha_L)$ where*

$$\underline{r} = \frac{1 - pAy_h}{1 - p} \tag{8}$$

$$\alpha_L = \frac{pAy_h + (1-p)r - 1}{Ap(1-q)\Delta y} \tag{9}$$

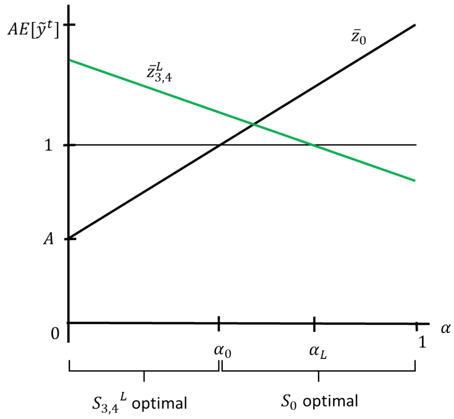
Proof. Feasibility implies $\bar{z}^L_{3,4} \geq 1$ which yields (9) and for the interval of the contract to be non-empty we need $\alpha_L > 0$ which yields (8). QED

Why do liquidation contracts work for opaque assets? Remember that without liquidation absconding had two opposing effects on maximal expected payments. On one hand the investor gets less in the state(s) where the bank absconds but on the other hand the bank can pay more in the state with the same realization of the transparent asset. With liquidation this tradeoff is improved in the sense that the investor gets r instead of 0 in the state(s) where the bank would abscond. This allows to increase the payments into regions where the bank would abscond (but actually never does because the investment is liquidated) without incurring the downside of absconding (zero payments). Such an arrangement is especially useful for a very opaque portfolio. In this case the states where the investment is liquidated (3 and 4) are both close to 1. Thus the cost of liquidation, which is the difference between what the bank could pay otherwise and r are small. On the other hand the returns in states 1 and 2 are close to y_h which makes payments contingent on these states very useful. Both advantages decrease with α. Liquidation gets more costly with the rising return in state 3 and the benefits of contingency decrease with the lower return in state 2. This is why $\bar{z}^L_{3,4}$ decreases with α. Intuitively liquidation depending on a signal about the realization of the opaque asset allows – in a crude way – for payments contingent on the return of the opaque asset. Thus it can mitigate the inefficiencies from limited commitment and incomplete contracts.

Combined with the results from proposition 1 we can now describe optimal contracts. Note that since the non-liquidation contract S_0 implements first-best, it is optimal where it is feasible (for $\alpha \in (\alpha_0, 1)$) and liquidation contract $S^L_{3,4}$ which is costly due to liquidation is only optimal where S_0 is not feasible.

Proposition 3 *If conditions for propositions 1 and 2 hold liquidation contract $S^L_{3,4}$ is optimal for opaque assets where $\alpha \in (0, \min(\alpha_L, \alpha_0))$ and non-liquidation contract S_0 is optimal for sufficiently* *transparent assets where* $\alpha \in (\alpha_0, 1)$.

The following figure graphically illustrates optimal contracts. Note that the position of $\bar{z}^L_{3,4}$ is somehow arbitrary. Depending on how high or low r is $\bar{z}^L_{3,4}$ can intersect 1 before or (as shown here) after α_0. If $\bar{z}^L_{3,4}$ intersects 1 before α_0 there is a region for portfolios with intermediate α where none of the contracts is feasible and there will be no investment.



4 Optimal opacity

In this section we derive the optimal portfolio of opaque and transparent assets which maximizes expected welfare, denoting it with α^*. We first look at the liquidation contract $S^L_{3,4}$. From proposition 3 we know it is optimal for $\alpha \in (0, \min(\alpha_L, \alpha_0))$. Expected welfare under this contract ($W^L(\alpha)$) is given by total expected return (2) minus liquidation costs given by (6).

$$W^L(\alpha) = \mathbb{E}\left[\tilde{y}^o\right] - \alpha d \Delta y - (1-p)(q y_3 + (1-q) y_l - r) \tag{10}$$

Since the expected return decreases in α (if $d > 0$) and liquidation costs increase in α, expected welfare clearly decreases with a more transparent portfolio and within this contract it is optimal to set α as low as possible or $\alpha = 0$. Thus within this contract it is optimal to choose a totally opaque asset structure. Indirect expected welfare is then given by:

$$W^L(0) = \mathbb{E}\left[\tilde{y}^o\right] - (1-p)(y_l - r) \tag{11}$$

Now we look at the non-liquidation contract S_0. Since there are no welfare losses with this contract expected welfare ($W(\alpha)$) is just given by the total expected return (2) in the feasible range $\alpha \in (\alpha_0, 1)$. By the same logic as above (the expected return of the portfolio decreases with

α as $d > 0$) we want to set α as low as possible also here. This implies the optimal choice of α within this contract is α_0. Indirect expected welfare is then given by:

$$W(\alpha_0) = \mathbb{E}\left[\tilde{y}^o\right] - \frac{1-A}{qA}d \tag{12}$$

Indirect expected welfare of the liquidation contract is higher than with the non liquidation contract if the welfare losses from liquidation are lower than the losses in terms of return because of a more transparent portfolio:

$$(1-p)(1-r) < \frac{1-A}{qA}d \tag{13}$$

This leads us to the following proposition:

Proposition 4 *If liquidation costs are sufficiently low such that* (13) *holds the optimal portfolio of the intermediary is a fully opaque asset structure* ($\alpha^* = 0$) *financed with liquidation contracts* $S^L_{3,4}$. *If liquidation costs are higher the optimal portfolio of the intermediary is a mix between opaque and transparent assets* ($\alpha^* = \alpha_0$) *financed with non-liquidation contracts* S_0.

Note that as either the intermediary can fully commit (A goes to 1) or there is no higher return for opaque assets ($d = 0$) inequality (13) will never hold and the intermediary will always choose $\alpha^* = \alpha_0$ financed with non-liquidation contracts S_0.

5 Empirical Analysis

In this section we link our theoretical considerations to the data. The theoretical model suggests that banks should finance opaque assets like business loans with demandable liabilities and less opaque assets like mortgages or securities with non-demandable liablities (which we could interpret as long-term debt or equity). However, the model we used was extremely stylized. It ignores other factors why banks might hold demandable liabilities (which could also be linked to the asset side) and it takes the asset side as given. In a more complete approach the bank would choose the asset side as part of a portfolio choice problem. Thus the conclusions we can draw from empirical correlations between opaque assets (business loans) and demandable liabilities are limited. Specifically we cannot interpret them as a test on the "disciplining theory" of demandable debt in the sense that if we don't observe a strong, or even one-to-one correlation between these variables the theory must be rejected. However, we still believe that if the disciplining role of demandable liabilities is economically important we should somehow see that banks with more opaque assets also issue more demandable liabilities.

We use yearly US bank (holding company) and savings and thrift institutions data from 1992 to 2018 provided by the call reports from the FDIC.[9] As our variable for opaque assets we use commercial and industrial (C&I) loans. As a measure of demandable liabilities we would ideally use uninsured deposits, i.e. demand deposits not covered by deposit insurance. The reason is that deposit insurance reduces (or even eliminates) the incentives for investors to monitor banks [Calomiris and Jaremski, 2019, Demirgüç-Kunt and Huizinga, 2004] and also makes deposits a cheaper source of funding [Admati and Hellwig, 2014]. Therefore, if there is a link between business loans and demand deposits because demand deposits have a disciplining role this link is most likely distorted by deposit insurance.[10] To address this we will use what the FDIC calls *volatile liabilities* as our measure of demandable liabilities. Volatile liabilities are essentially non-insured demand deposits plus some other very short-term liabilities (also see the appendix for a more detailed explanation). We first look at some aggregate statistics for the two variables. The following graphs show the evolution of business loans and volatile liabilities to total assets in the aggregate and for four bank sizes: small banks (below the 25th percentile), medium sized banks (between the 25th and the 75th percentile), big banks (between the 75th and the 99th percentile) and very big banks (above the 99th percentile). We use the last category because the US banking system has a highly skewed size distribution. For instance, *community banks*, that are defined as banks with assets less than USD 10 Billion,[11] account for about 97.5% of all the banks but only about 15% total banking sector assets. The top four banks – viz. JPMorgan Chase, Bank of America, Citigroup and Wells Fargo & Co.) account for about 44% of banking sector assets with an average asset of about USD 1.8 Trillion each.

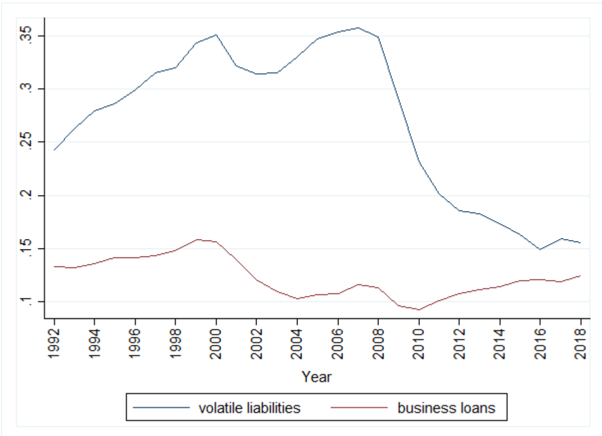


Figure 2: Aggregate evolution of the share of volatile liabilities and business loans to total assets

[9] In the appendix we provide a more comprehensive description of the data.

[10] CK also stress this point and emphasize that their model should capture a historical, pre-deposit-insurance economy. The current levels of bank deposits and business loans holdings make a link in terms of levels very implausible. The average share of deposits to total assets in the sample is roughly ten times the average share of business loans (84.2% vs. 8.9%).

[11] https://www.federalreserve.gov/supervisionreg/community-and-regional-financial-institutions.htm (accessed on June 18, 2020)

Over most of the sample period volatile liabilities are more than twice as high as business loans but after 2010 they decrease massively. This is most likely due to a change in the cap of deposit insurance which went up from 100′000 USD to 250′000 USD. This suddenly and strongly reduced the amount of uninsured deposits which are the essential part of volatile liabilities. In terms of variation there seems to be quite a close co-movement between volatile liabilities and business loans until 2010 after which the correlation is reversed (volatile liabilities go down and business loans go up).

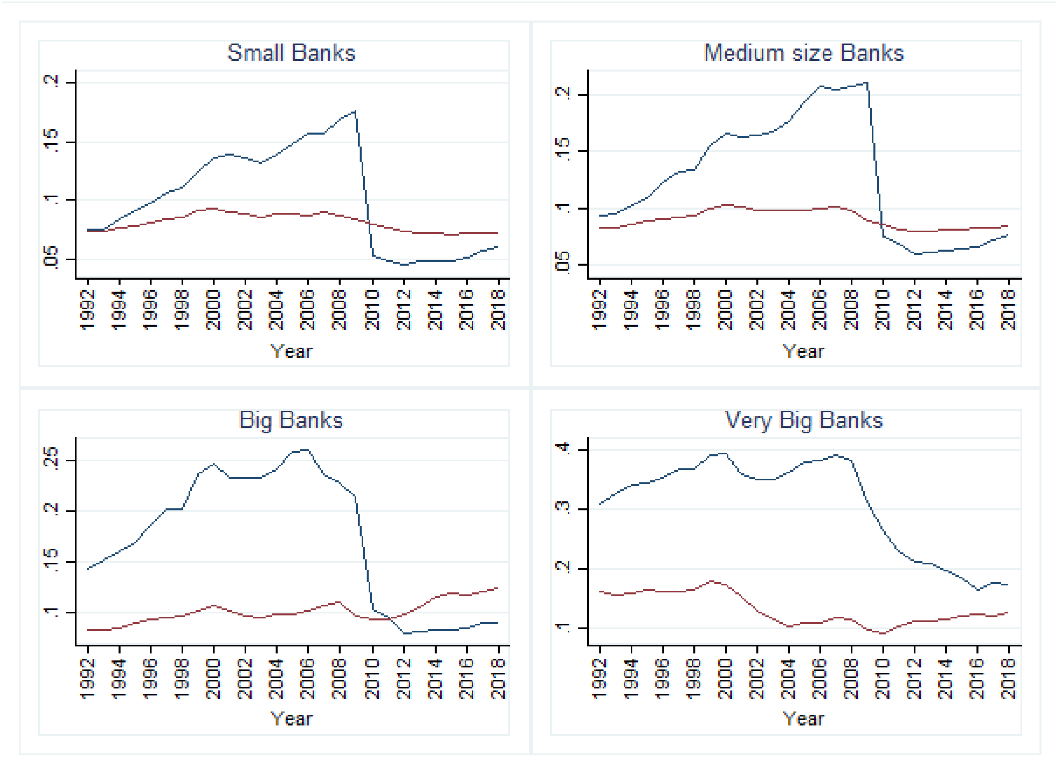


Figure 3: Evolution share of volatile liabilities (blue) and business loans (red): Size classes

For the four size groups the big drop of volatile liabilities in 2010 is apparent in all four graphs. The reversed correlation after 2010 seems to be especially pronounced for the very big banks but less so for the other three size groups. In terms of levels the divergence between volatile liabilities and business loans before 2010 seems to increase with size (note the different scale of the y-axis in the graphs). For small banks the two levels are much closer together than for the very big banks.

Now we look at the correlations between opaque assets and volatile liabilities more closely. To do this we regress the ratio of volatile liabilities to total assets on the ratio of business loans to total assets. With this specification a coefficient of one would correspond to a one-to-one relationship between the two variables. If also the intercept of this relationship is zero then even in levels business loans and volatile liabilities move together (i.e. the fitted values would lie on a 45-degree line going through the origin). We run this regression for the cross-section of banks in each year between 1992 and 2018. This should capture the strong drop in volatile liabilities in 2010. We first plot the estimated coefficient on the share of business loans in total assets and the intercept first without making any distinction across sizes (the dashed lines show the 95%-confidence bands).

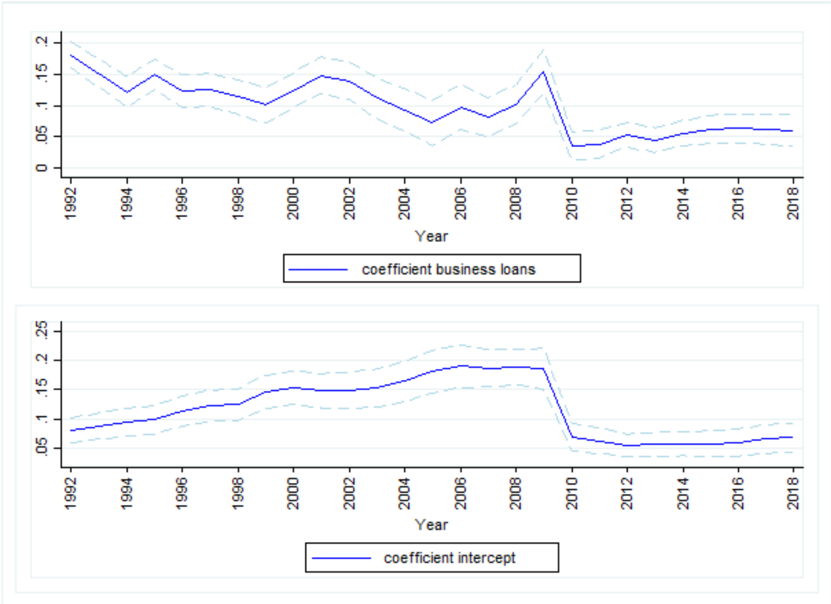


Figure 4: Regression coefficients: whole sample

We see the coefficient on business loans is positive for all years but quite small and certainly less than one. Between 1992 and 2008 it trends down from 0.18 to 0.10 and in 2010 the coefficient sharply drops to 0.035 so it seems the change in the cap of deposit insurance significantly lowered the correlation. The average coefficient on business loans before 2010 is 0.12 and after 2010 it is 0.05. On the other hand the intercept trends upwards from 0.08 in 1992 to 0.19 in 2009 (the average before 2010 is 0.14) and then sharply falls to a lower level of 0.07 in 2010 (the average after 2010 is 0.06). The intercept is close (but statistically different) from 0. What do these numbers tell us? Suppose we have two groups of banks, one group with a share of business loans of 0.1 and the other with 0.2 of total assets. What shares of volatile liabilities do the coefficients predict for these groups before and after 2010 on average? Before 2010 we take the average intercept (0.14) and ad the average coefficient on business loans (0.12) times the share of business loans. On average we would expect the banks with a share of 0.1 to have a ratio of volatile liabilities of 0.152 and the banks with a share of 0.2 to have a ratio of 0.164. As the coefficient on business loans is close to zero, these estimates are still close to the intercept of 0.14 although the difference in the share of business loans between the two groups is sizeable. But since the coefficient is so low, sizeable variation in terms of opaque assets does not translate into sizeable variation in terms of volatile liabilities. After 2010 the predicted shares of volatile liabilities are even closer to the intercept because the average coefficient on business loans (0.05) is very close to zero. We get a predicted share of volatile liabilities of 0.065 (0.07) for the banks with a share of 0.1 (0.2).

Now we plot the estimated coefficient on the share of business loans to total assets and the intercept for the different size classes. We restrict attention to the small and the big banks though. The results for the medium sized banks are very similar to the small banks and the aggregate estimates and the results for the very big banks are similar to the results of the big banks. Also, the estimates for the very big banks are not very precise because we don't have so many observations. We put those estimates in the appendix.

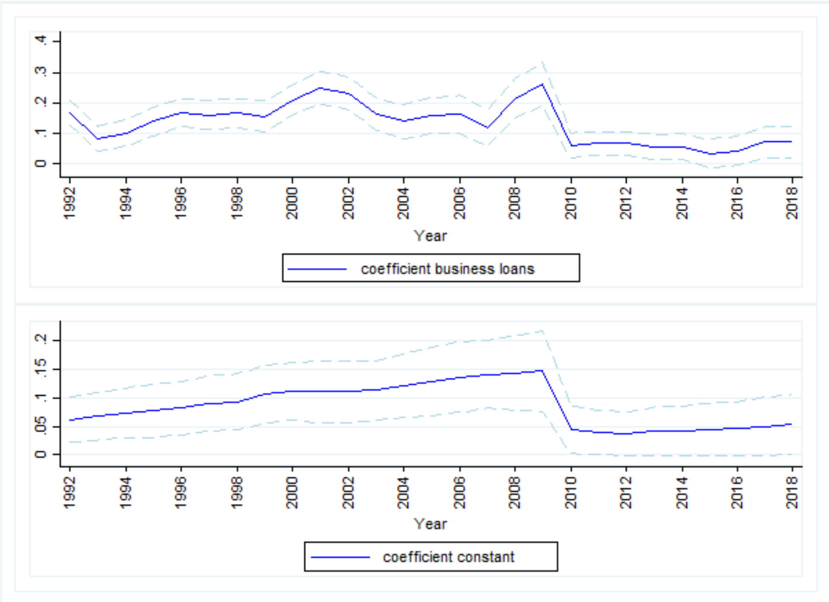


Figure 5: Regression coefficients: small banks

For the small (and the medium sized) banks the general pictureis quite similar to the aggregate estimates. The average coefficient on business loans is small but positive and higher before 2010 (0.17 on average) than after 2010 (0.06 on average). The constant trends upwards from 0.06 in 1992to 0.15 in 2009 and then drops to under 0.05 in 2010, where the confidence band includes zero for most of the years after 2010. For the big banks however, the picture is different. Except in 1992 the coefficient on business loans is not significantly different from zero anymore (the coefficient of the constant is similar to the other estimates). This is also true for the very big banks. Thus for big banks variations in business loan ratios are unconnected to variations in volatile liabilities.

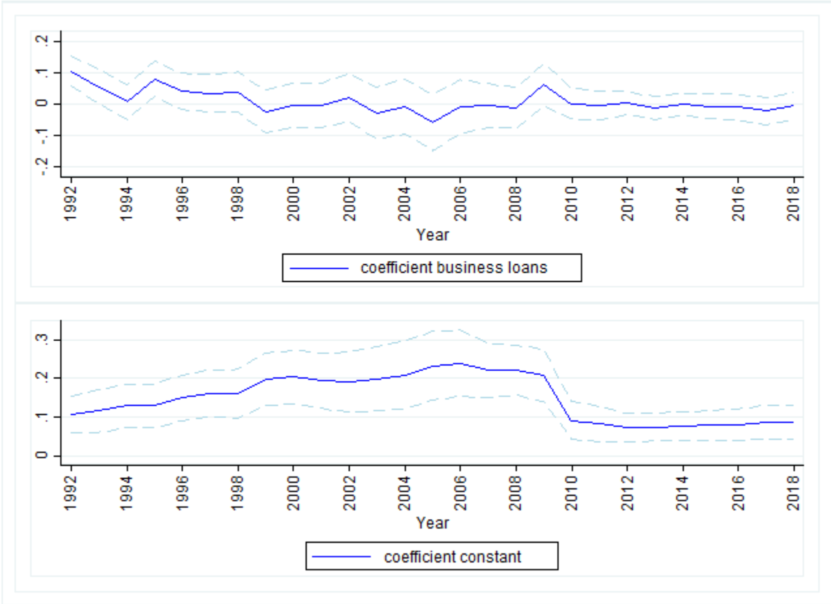


Figure 6: Regression coefficients: big banks

So we find a small but positive correlation between opaque assets (business loans) and our measure of (uninsured) demandable liabilities for small and medium sized banks up to the 75th percentile but no correlation for the 25% biggest banks. From the perspective of our model it seems that the disciplining role of demandable liabilities is more important for smaller banks although the magnitude is small. The missing link for larger banks could be interpreted in the sense that these banks might enjoy insurance beyond deposit insurance in the form of implicit too-big-to-fail guarantees. Investors will take this into account and this reduces - similar to deposit insurance - their incentives to monitor and "discipline" the banks.

Bibliography

Anat Admati and Martin Hellwig. *The Bankers' New Clothes: What's Wrong with Banking and What to Do about It-Updated Edition*. Princeton University Press, 2014.

Charles W Calomiris and Matthew Jaremski. Stealing deposits: Deposit insurance, risk-taking, and the removal of market discipline in early 20th-century banks. *Journal of Finance*, 74(2): 711–754, 2019.

Charles W Calomiris and Charles M Kahn. The role of demandable debt in structuring optimal banking arrangements. *American Economic Review*, pages 497–513, 1991.

Tri Vi Dang, Gary Gorton, Bengt Holmström, and Guillermo Ordonez. Banks as secret keepers. *American Economic Review*, 107(4):1005–29, 2017.

Asli Demirgüç-Kunt and Harry Huizinga. Market discipline and deposit insurance. *Journal of Monetary Economics*, 51(2):375–399, 2004.

Douglas W Diamond. Financial intermediation and delegated monitoring. *Review of Economic Studies*, 51(3):393–414, 1984.

Piet Eichholtz, Nagihan Mimirogluz, Steven Ongena, and Erkan Yonder. Distance eects in cmbs loan pricing. *Unpublished*, 2019.

João Granja, Christian Leuz, and Raghuram Rajan. Going the extra mile: Distant lending and credit cycles. Technical report, National Bureau of Economic Research, 2018.

Bengt Holmstrom and Jean Tirole. Financial intermediation, loanable funds, and the real sector. *The Quarterly Journal of Economics*, 112(3):663–691, 1997.

Òscar Jordà, Moritz Schularick, and Alan M. Taylor. The great mortgaging: housing finance, crises and business cycles. *Economic Policy*, 31(85):107–152, 01 2016. ISSN 0266-4658.

Appendix A

A.1 Imperfect signal

In this section we solve for the optimal liability structure when the signal about the realization of the opaque asset for the investor is imperfect in the middle period. With an imperfect signal the signal structure is as follows: If the signal is *good* the probability of the high state of the opaque asset is $p_g = Pr(\tilde{y}^o = y_h|good)$ and if the signal is *bad* the probability of the low state of the opaque asset is $p_b = Pr(\tilde{y}^o = y_l|bad)$. p_g and p_b can be interpreted as the precision of the signal. To be informative they must be higher than the ex-ante probabilities p and $1-p$. Thus we need $p_g \geq p$ and $p_b \geq 1-p$. Given these conditional probabilities we can derive the unconditional probabilities of getting a good or a bad signal denoted as π and $1-\pi$:

From rational expectations we have:

$$p = \pi p_g + (1-\pi)(1-p_b)$$
$$1-p = \pi(1-p_g) + (1-\pi)p_b$$

Giving us,

$$Pr(good) := \pi = \frac{p+p_b-1}{p_g+p_b-1}$$
$$Pr(bad) := 1-\pi = \frac{p_g-p}{p_g+p_b-1}$$

Note the assumptions $p_g \geq p$ and $p_b \geq 1-q$ imply that $0 \leq \pi \leq 1$. Also note that the case of a perfect signal would imply $p_g = p_b = 1$ and $\pi = p$ and $p_g, p_b < 1$ implies $\pi < p$.

The following figure summarizes the signal structure with the four states:

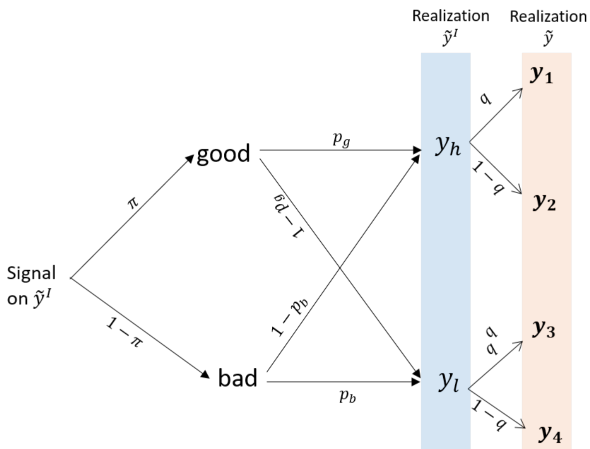


Figure 7: Signal structure

We consider contracts with liquidation in the middle period after the bad signal for the same 4 situations as in the main text. With an imperfect signal liquidation does not prevent absconding perfectly. When the investor does not liquidate (after the good signal) with probability $1 - p_g$ the economy still ends up in states 3 or 4 where the bank might abscond. Also, liquidation losses are higher than before because when the investor liquidates (after the bad signal) with probability $1 - p_b$ the economy ends up in states 1 or 2 where welfare losses from liquidation are lower. The expected liquidation costs are the difference of the expected return without liquidation and r. They are given by:

$$(1 - \pi)\left[(1 - p_b)(qy_h + (1 - q)y_2) + p_b(qy_3 + (1 - q)y_l) - r\right] \tag{14}$$

With probability $1 - p_b$ states 1 or 2 occur and the expected losses are $qy_h + (1 - q)y_2 - r$. With probability p_b states 3 or 4 occur and expected losses are $qy_3 + (1 - q)y_l - r$. The expected welfare losses due to absconding are given by $\pi(1 - p_g)Ay_s$ if the bank absconds in state s. Since the welfare costs from absconding are different in the four situations liquidation contracts are not equivalent in terms of welfare anymore.

$$\begin{aligned}
\bar{z}_0^L &= \pi(qAy_3 + (1 - q)Ay_4) + (1 - \pi)r \\
\bar{z}_4^L &= \pi(qAy_3 + p_g(1 - q)Ay_2) + (1 - \pi)r \\
\bar{z}_3^L &= \pi(p_g qAy_1 + (1 - q)Ay_4) + (1 - \pi)r \\
\bar{z}_{3,4}^L &= \pi p_g(qAy_1 + (1 - q)Ay_2) + (1 - \pi)r
\end{aligned}$$

With a perfect signal $\bar{z}_{3,4}^L$ always dominated the other contracts in terms of feasibility. We will assume that p_g is high enough such that this also holds with an imperfect signal. This implies $p_g > y_l/y_h$. In this case the result from the case of a perfect signal also holds, $\bar{z}_{3,4}^L > \bar{z}_3^L > \bar{z}_0^L$ and $\bar{z}_{3,4}^L > \bar{z}_4^L > \bar{z}_0^L$.

optimal contracts:

- welfare is lowest in $\bar{z}_{3,4}^L$, only optimal if no other contract feasible
- $\bar{z}_0^L$ has highest welfare of liquidation contracts, however, can show dominated in terms of feasibility by non-liquidation contract $\bar{z}_0$ which implements first-best. Thus can ignore this
- other three contracts can be optimal depending on r and welfare comparison between $\bar{z}_4^L$ and $\bar{z}_3^L$

A.2 Data sources and description

We obtain bank level data from the US Federal Deposit Insurance Corporation (FDIC). FDIC provides comprehensive quarterly bank level data collected through the *call reports*. Since we are interested in mainly stock variables, we work with the fourth quarter data for each of these years from 1992 through 2018. As the data is provided at the bank, we aggregate the data at the bank holding company (BHC) level for each year using the FRB ID Number for the Band Holding Companies ('rssdhcr'). The idea behind aggregation is that the decision on assets and liabilities structure are made at the BHC level rather than at the bank level. In the following we will refer to BHCs also as *banks*. We cleaned the data dropping bank-year pairs if the share of loan ratios are above 90% or below 0.1%. The idea is to drop banks that specialize to the extreme as most likely these would be banks created for special purposes by local of federal governments. After cleaning the data, we are left with a total of about 186,600 bank-year observations.

Volatile liabilities, according to the FDIC, include:

1. Time deposits that are *uninsured* and foreign office deposits
2. Federal funds purchased and repo borrowings
3. Demand notes issued to the US Treasury and other borrowed money with remaining maturity of 1 year or less, including Federal Home Loan Bank (FHLB) advances
4. Trading liabilities less trading liabilities revaluation losses on interest rate, foreign exchange rate, and other commodity and equity contracts.

The definition of *volatile liabilities* changed with effect from March 2010 as deposit insurance was expanded to cover deposits upto USD $250,000$ from USD $100,000$. Thus, uninsured deposits were redefined to all time deposits above USD $250,000$.

A.3 Estimates for other size classes

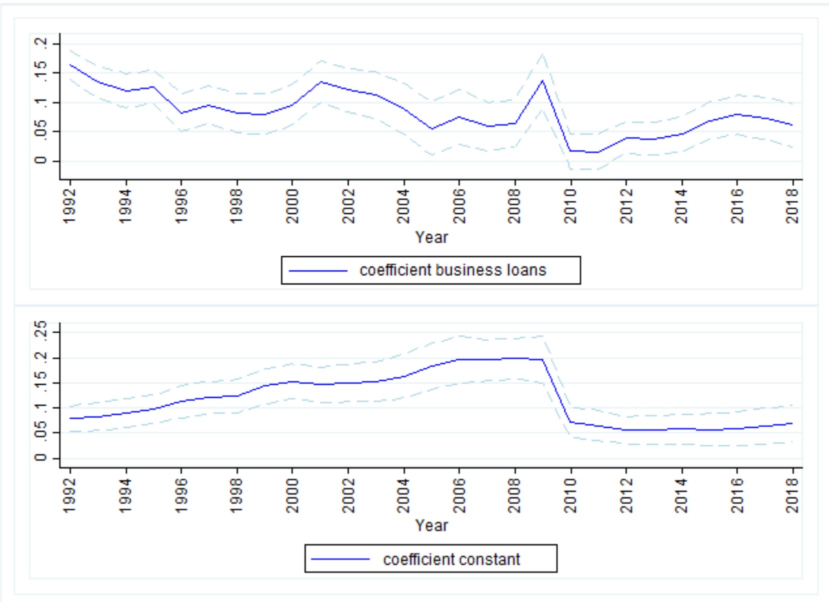


Figure 8: Regression coefficients: medium sized banks

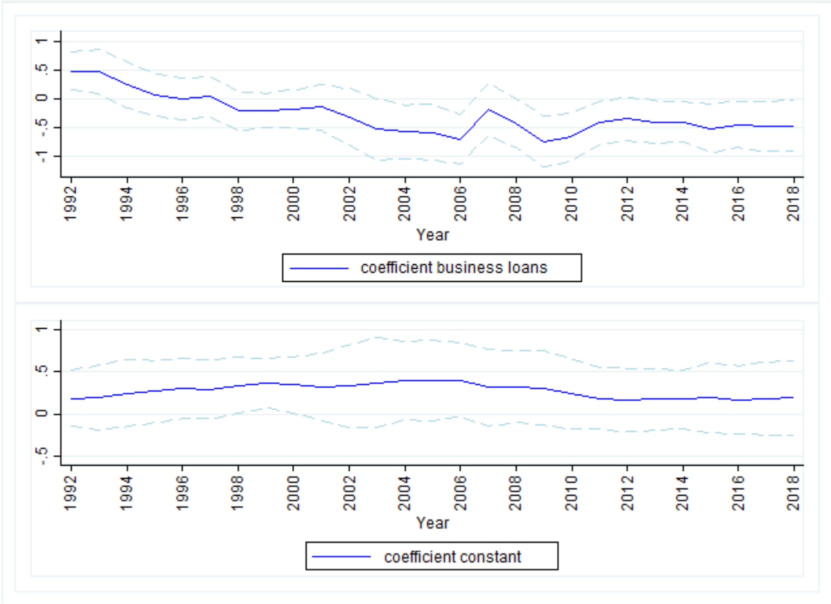


Figure 9: Regression coefficients: very big banks