Securitization and Compensation in Financial Institutions*

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Abstract. We analyze the interaction between financial institutions’ internal compensation policy, the quality of loans, and their securitization decision. We show when mandatory deferred bonus pay makes incentives more commensurate with the longer term risk of their transactions and hence improves the quality of loans. We also show when it has the opposite effect. We further analyze when mandatory deferred compensation can complement a policy that requires financial institutions to retain a minimum exposure to their originated loans, and we discuss the impact of a tax on short-term bonus pay. Generally, our framework allows us to study the interaction of financial institutions’ internal agency problems with the external agency problem that arises from securitization.

JEL Classification: G21, G28

1. Introduction

The financial industry’s bonus-driven compensation has been singled out as a key suspect responsible for the ongoing financial crisis. Consequently, both practitioners and academics demand regulatory intervention.1 Arguably, at least in hindsight, financial institutions have taken on too much risk. Highly “front-loaded” compensation for (investment) bankers, traders, or mortgage brokers may have played a key role in this. Agents who are paid commissions, fees, or a bonus based mainly on yearly, or even shorter term, revenues take little account of longer term risk—e.g., the long-term performance of a loan.

Such compensation may be optimal for financial institutions that have a high appetite for risk. However, we show that when financial institutions securitize deals, they may end up with a compensation structure that, from the perspective of maximizing long-term profits, is too high powered and too

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short-term-oriented. Thus, one contribution of this article is to provide a consistent rationale for regulating compensation in the financial industry, even when we abstract from the presence of noninternalized “systemic effects” of risk taking. However, we also derive conditions under which mandatory deferred compensation can “backfire” and even reduce the quality of loans, thereby increasing the likelihood of subsequent default. We further study how restrictions on compensation can complement restrictions that are imposed on securitization—e.g., by requiring financial institutions to keep a minimum exposure to their originated transactions.

We consider the compensation of an agent who could be an investment banker or loan officer, and we discuss below how our insights also apply, more broadly, to the compensation of financial institutions’ senior management as the agent of shareholders. When processing a potential transaction, which involves costly effort, the agent acquires private information about the quality of the transaction. In the language of Berger and Udell (2002), the agent’s information is “soft”—i.e., “hard to quantify, verify and communicate through the normal transmission channels of a banking organization.” The quality of transactions and loan making can be improved when the bank makes use of this information. This is, however, costly for the following reason. In our model, generating a new transaction is costly for the agent. However, providing the agent with the respective incentives in the form of bonus payments biases him toward overstating the benefits from new transactions. Thereby he would increase the probability of finalizing a transaction and ultimately receiving a bonus. In contrast, when revealing the type of an inferior transaction, the agent bears the risk of not being compensated for the effort costs, which he incurred to generate the respective transaction. Providing countervailing incentives for this requires to pay the agent a rent and is hence costly for the bank. Much of our analysis will hinge on when the necessary incremental compensation costs are high—and on how this depends on regulation.

As we also discuss below in more detail, our model is more generally applicable, as it requires only that the agent can take private actions to

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2 In particular, absent the failure of governance mechanisms, it seems not entirely convincing that financial institutions should be unable to choose optimal compensation schemes because they are in a rat race to attract the best staff (See, e.g., Wolf, Martin, Regulators should intervene in bankers’ pay, Financial Times, January 16 2008). In fact, standard agency theory would predict, instead, a positive relationship between contractual efficiency and competition for labor when competition increases agents’ reservation value. In Acharya and Volpin (2010) and Dicks (2012), a firm’s choice of governance, which serves as a substitute for incentive pay, affects the outside option of other executives.
influence loan quality. For instance, he could also conspire with potential borrowers and distort seemingly “hard” information.³

The agent’s information advantage vis-à-vis the principal (the financial institution) constitutes a key measure of the internal agency problem. Such an internal agency problem arises, as the agent does not directly bear the risk associated with a new transaction. However, the originating institution may not remain fully exposed either, as it could securitize the generated assets or cash flows. In this case, there is an additional external agency problem. Our model studies the interaction of financial institutions’ internal agency problem with their external agency problem arising from securitization.

In the model, the agent can receive an early bonus or a deferred bonus. Further, the financial institution controls how steep the agent’s compensation is.⁴ When compensation is deferred, it can be made contingent on more information about the quality of the transaction—e.g., whether a borrower ultimately defaulted. However, deferring compensation is costly, as, in line with much of the literature (cf. Section 2), we presume that the agent has a higher time (or liquidity) preference than the principal—i.e., the financial institution.

The financial institution’s second decision is whether and to what extent to securitize. We deal with both the case where the retained stake is observable by investors and the case where this is not observable, and we also discuss how the financial institution would optimally structure the issued securities. Securitization may benefit the financial institution by allowing it to diversify risk or relax funding constraints—in particular, in the face of regulatory capital requirements. For financial firms, securitization has become increasingly important and, compared to nonfinancial firms, is directly linked to credit origination as one of their primary fields of operations (cf. also, Martín-Oliver and Saurina, 2007; Loutskina, 2011).

The anticipated level of securitization determines the optimal compensation strategy, while the price of the issued securities depends on the market’s expectations about the internal incentives that the firm provides to its own agents. We first solve for the market equilibrium when regulators do not interfere. When the bank remains fully exposed to a new loan, as it does not securitize, it trades off the benefits of higher asset quality with higher costs of compensation. Benefits are, however, diluted when the bank anticipates

³ For instance, with mortgage or consumer lending, this could involve providing borrowers with fake income slips or pretending that, if the actual income were low, the borrower was self-employed (cf. FSA bans mortgage brokers for submitting false loan applications, FSA, February 21 2008; or Correct title: Twelfth periodic mortgage fraud case report, Mortgage Asset Research Institute, 2010).

⁴ Steep compensation refers to high-powered incentives through a steep bonus pay.
securitizing a large fraction of its loans. In equilibrium, the bank will incentivize the agent to screen loans only when it retains a sufficiently large exposure. Also, only in this case will the bank possibly defer compensation so as to tie it more closely to the performance of loans or any other information on loan quality that may be revealed over time—e.g., through an internal loan review. Otherwise, given the agent’s impatience, compensation will always be short-term.

The last observation suggests that through forcing the bank to defer compensation, the bank could be induced to use the additional information on the loan’s performance and to incentivize the agent accordingly. We provide conditions for when this is, indeed, the case. Then, regulating compensation leads to an increase in loan quality. It mitigates a commitment problem that the originating institution has vis-à-vis the buyers of its securities. However, the opposite result also may arise, in which case, mandatory deferred pay reduces average loan quality and increases the likelihood of future default. We also find that, in our model, the risk of such unintended consequences is larger with a bonus tax compared to an outright requirement to defer bonus pay.

The intuition for why interference with banks’ optimal compensation strategy can backfire is somewhat subtle. In our model, providing agents with incentives to screen loan-making opportunities is costly due to the above explained tension between his two tasks. Precisely, to incentivize the agent to screen, he will have to receive both a higher base wage, which provides incentives to forego bad loan-making opportunities and also a higher bonus, so that he still has incentives to generate new opportunities in the first place. Hence, the costs of delaying the agent’s bonus payment—arising from the different time preferences of the bank and the agent—are strictly higher if he is incentivized to screen than if he is not incentivized to screen. In other words, the incremental compensation costs of deferred compensation are strictly higher in the “good regime” than in the “bad regime.” Since the trade-off between the costs and benefits of deferred compensation is not resolved optimally from the bank’s perspective, mandatory deferred compensation can, somewhat counterintuitively, induce the bank to expand loans at the expense of decreasing average loan quality.

The interplay of the internal and external agency problems in our model allows us to study, as a second policy instrument, the imposition of a mandatory retention requirement for the originating firm. Such a policy is a part of a recent directive by the European Commission (EC, 2009), the Frank Act of the US Congress, passed in July 2010. In our model, such a policy is more effective because it can not “backfire.” However, we show that it could still be complemented by a policy of mandatory deferred
pay, as that may allow for a reduction in the minimum retention requirement.

Our model also yields, next to these normative implications, a number of positive predictions. If gains from securitization are high and the internal agency problem is severe, without regulation, the agent’s compensation will be high powered with a steep bonus, short term, and based only on loan volume. This should go hand-in-hand with a high level of securitization and low average loan quality and, thus, high subsequent default rate. The internal agency problem is more severe when it is harder for the bank to control the agent—e.g., given his closeness to the potential borrower or his “soft” information, or when (early) performance indicators of loan quality are less reliable, such as when loans are of longer term maturity. Instead, if gains from securitization are relatively low and the internal agency problem is less severe, the agent’s compensation will be deferred and contingent on loan performance (or the outcome of internal loan reviews) rather than on loan volume alone. As the agent then screens out bad loans early on, aggregate loan volume will be smaller, but subsequent defaults will become less likely.

As discussed below in more detail, our predictions refer jointly to the level of securitization, loan quality, and compensation. A key novelty of our model is the thereby derived predictions on the optimal use of deferred incentive pay. We then relate these predictions to more fundamental primitives, such as the benefits from securitization, e.g., arising from differences in regulation imposed on the sellers and buyers of securities or the severity of the bank’s internal agency problem. The severity of the bank’s internal agency problem depends, for instance, on whether there is (early) reliable feedback about loan quality. Our model predicts that if the bank’s internal agency problem is more severe or the benefits from securitization are higher, it is more likely that the bank provides the agent with only volume-oriented and short-term incentives, thus inducing him not to screen loans. In this case, the bank then fully securitizes its loans.

1.1 RELATED LITERATURE

In our model, financial institutions can perform an important intermediary service by screening borrowers. But to perform this role, they must provide the respective incentives to their own agents, which is a departure from most papers on intermediation, such as the seminal contributions by Campbell and Kracaw (1980) or Boyd and Prescott (1986), in which a bank also performs an evaluation service. We further analyze how the performance of such intermediation services interacts with the decision to securitize loans.
This relates to a recent literature that shows how banks’ incentives to closely monitor borrowers can erode through loan sales or hedging (cf. Morrison, 2005; Parlour and Plantin, 2008; Parlour and Winton, 2012). In a seminal earlier contribution, Gorton and Pennacchi (1995) show how this incentive problem can be mitigated either by issuing an implicit guarantee against default or by restricting the fraction that is sold.

With regard to the internal agency problem, the banking literature has documented the conflict of interest that arises when agents can exert influence on the loan-approval decision, often based on their private “soft” information (e.g., Udell, 1989). We use a model of a multitask agency problem, as the agent must exert effort and possibly also reveal private information truthfully. The analysis of a multitask principal–agent problem follows the seminal contribution of Holmström and Milgrom (1991). More specifically, the interaction of an ex ante moral-hazard problem with a problem of interim private information borrows from Levitt and Snyder (1997), as well as from the literature on “delegated expertise” (e.g., recently Gromb and Martimort, 2007). Inderst and Heider (2012) relate this to banks’ choice of lending technology and Inderst and Ottaviani (2009) to consumer protection.

Our focus on the time structure of compensation relates to the discussion of how short terminism in top management compensation affects corporate policy (e.g., Murphy, 2000). In our model, the bank may fail to choose a compensation scheme that maximizes long-term profits, as it behaves opportunistically with respect to future buyers of its securities. Hence, our model shares with the empirical analysis in Cheng, Hong, and Scheinkman (2009), the view that excessive risk taking, namely through expanding loan volume at the expense of a reduction in quality, is not driven by a governance problem between the management and the shareholders.

1.2 ORGANIZATION

The rest of this article is organized as follows. Section 2 introduces the baseline model. We solve for the optimal compensation contract in Section 3. Section 4 characterizes the equilibrium outcome and provides a comparative analysis. Section 5 characterizes the equilibrium when there is mandatory deferred bonus pay and assesses the case for a tax on short-term bonuses. Section 6 introduces a policy that prescribes a minimum retention

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5 Chiesa (2008) emphasizes, instead, the positive effect of credit risk transfer on banks’ lending capacity. Benmelech, Dlugosz, and Ivashina (2012) show empirically when this effect should be less severe.
level. We provide some concluding remarks in Section 7. All proofs are relegated to the Appendix A.

2. Model

Consider an agent who has to originate, process, and potentially close a deal for a financial institution (the principal). To be specific, in what follows, we frame our internal agency problem as a contractual problem between a bank and its loan officer (See, however, the wider discussion below). Loans can be of two different types, \( \theta \in \{G, B\} \), where \( a \text{ priori} \) a loan is of type \( G \) with probability \( 0 < \mu < 1 \). The agent must exert effort at cost \( c \) to be able to process a loan, which also allows him to learn the loan’s quality.\(^6\) The agent’s information is private and “soft”—i.e., in the language of Berger and Udell (2002), it is “hard to quantify, verify and communicate through the normal transmission channels.” As discussed below, our model also extends to the case where the agent can affect the quality of supposedly “hard” information. It is key, however, that the agent can affect the bank’s ability to screen borrowers.

2.1 LOAN MAKING AND SECURITIZATION

A loan requires the up-front capital \( \kappa > 0 \), which the bank has at its disposal, and yields a repayment of either \( R = R_l \) or \( R = R_h \), with \( R_h > \kappa > R_l \geq 0 \). In what follows, we say that the respective borrower defaults when \( R = R_l \) is realized.\(^7\) The bank’s discount factor is normalized to one. All parties are risk-neutral. A loan of type \( \theta \) results in a repayment of \( R_h \) with probability \( \gamma_\theta \) and in a repayment of \( R_l \) with probability \( 1 - \gamma_\theta \). Denote \( \eta_\theta := \tilde{R}_\theta - \kappa \), where \( \tilde{R}_\theta := \gamma_\theta R_h + (1 - \gamma_\theta) R_l \) is the loan’s expected repayment. We stipulate that \( \gamma_G > \gamma_B \), such that \( \tilde{R}_G > \tilde{R}_B \) and, thus, in particular, \( \eta_G > \eta_B \). In what follows, it is convenient to refer to \( \theta = G \) as a “good loan” and to \( \theta = B \) as a “bad loan,” though this assessment is based not on the loan’s ultimate performance but on the information that is available when the loan is made.

After a loan is made, the bank securitizes the fraction \( \psi \) of the resulting proceeds \( \{R_h, R_l\} \), thereby transforming the underlying risky payoff into a sure and immediate cash payment \( p \). The endogenization of \( p \) is the part of

\(^6\) In the Supplementary appendix to this article, we provide, in addition, an analysis of the case where the agent observes only a noisy and continuous signal about loan quality.

\(^7\) Hence, \( R_h \) covers the principal plus the stipulated interest, whereas \( R_l \) is the value of loan recovery.
the equilibrium characterization. When this is derived in Section 4, we will also be more explicit about the rationale for securitization.\(^8\)

2.1.1 Timing

The precise timing in our model is as follows. For simplicity, all actions are taken sequentially in a first period, \(t = 1\), whereas repayments from the loan are realized in period \(t = 2\). We now specify the timing in period \(t = 1\). At the beginning of \(t = 1\), the agent is offered a compensation contract, which we describe below. Immediately afterward, the agent can exert effort, which is necessary to subsequently process a loan and which allows the agent to learn the loan’s quality (“type”). In what follows, we will distinguish between the case where the bank chooses to ignore the agent’s information and the case where the bank wants to harness his information to improve the quality of loan making. At the end of period \(t = 1\), when a loan has been undertaken, it may be fully or partially securitized.

2.2 COMPENSATION

The agent can be compensated at two points in time: at the end of \(t = 2\), after the loan has possibly been repaid, and at the end of \(t = 1\), when the bank observes a verifiable but noisy repayment forecast \(s \in \{h, l\}\), with \(q := \Pr(h|R_h) = \Pr(l|R_l) > 0.5\). The forecast could come from accounting figures or an internal loan review.\(^9\) Deferring compensation is costly, as the agent is more impatient than the bank: he discounts compensation received in \(t = 2\) with the factor \(0 < \delta < 1\). This assumption is common in the literatures on labor, executive compensation, and contracting.\(^{10}\) Note that the agent is also unable to borrow against his future (expected)

\(^8\) Note, also, that when \(R_l > 0\), we restrict attention to the case where the bank sells a proportional share \(\psi\) of \(R\). In the Supplementary appendix, we show that all our results survive when the bank optimally chooses which security, backed by the loan, it wants to issue. In fact, as we argue there, if the bank retains some exposure, then it follows from standard security-design arguments that it optimally retains the most risky (“equity”) tranche. A sale of a fixed portion of the loans, albeit possibly backed up by a guarantee against the default of each loan, is considered in Gorton and Pennacchi (1995). Parlour and Plantin (2008) consider the sale of the whole loan.

\(^9\) Note that when \(t = 2\) lies “too far” in the future (cf. below, on the agent’s time preferences), we can stipulate, instead, that the bank observes at some intermediate period, say \(t = 1.5\), another signal. While this is still noisy, it should be more informative than \(s\).

\(^{10}\) Cf. Rogerson (1997), Ray (2002), Grenadier and Wang (2005). In the literature, this common assumption is justified on various grounds. For instance, employees may have higher liquidity preferences than the firm does, as they are (more) credit-constrained. In addition, deferred compensation, unless it is securely “ring-fenced,” carries the additional
income, as this would undermine his incentives and, thereby, his future ability to repay such a loan.

As we show below, when the bank does not want to harness the agent’s information, it needs to compensate the agent only for his effort. Without the agent’s effort, the bank cannot make a new loan. However, when the bank wants the agent to screen loans, it also has to ensure that the agent provides this information truthfully. Note that under truth telling, in our model, this will give the agent effective control over the loan-approval decision. In this case, the two agency problems of exerting effort and of providing information truthfully interact.

Compensation can be made contingent only on, first, whether a loan was made or not and, second, on the repayment realization in $t = 2$ or its forecast in $t = 1$, respectively. Thus, let $\bar{w} \geq 0$ be the agent’s base wage when no new loan is made, where we invoke a limited liability constraint. As noted below, $\bar{w}$ will optimally not be deferred. Note that $\bar{w}$ is paid irrespective of why no new loan was made. When the bank wants to induce the agent not only to make loans, but also to use his information to screen out bad loans, this will give rise to a multitask problem. In a model of static contracting only, where the issue of deferring compensation does not arise, Inderst and Heider (2012) provide various arguments why it is not realistic to separate the two tasks, i.e., that of generating loan-making opportunities and soft information and that of feeding information into the loan-making process. In the Supplementary appendix, we analyze also the case where the agent must exert unobservable effort to generate information, while loan-making opportunities arise exogenously. Then, our main results survive.

If a loan is made, the agent receives compensation $w_1(s)$ and $w_2(s, R)$ in the respective periods, conditioning on the early signal $s$ and the final performance of the loan $R$. As at $t = 2$, when $R$ has been realized, the forecast $\hat{s}$ is no longer informative, we can stipulate that $w_2(s, R) = w_2(R)$. Furthermore, without loss of generality, we can suppose that all compensation that is made in $t = 1$ but that the bank can credibly claw back later—i.e., that is risk for the agent that the employer may, through opportunistic behavior, fail to honor his commitment in the future.

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11 It is also straightforward to introduce “hard,” i.e., verifiable, information. When the bank still wants to rely on the agent’s “soft” information, the agent continues to have effective control over the loan-making decision, although compensation will now also optimally depend on “hard” information that is obtained before the loan is approved. When “soft” information is particularly important, as in the case of commercial loans to small- and medium-sized businesses, loan officers may even be given “formal” (instead of only “real”) authority over the loan-approval decision, provided that loans satisfy some minimum conditions based on the available hard information (cf. Keys et al., 2010).
not “vested”—is postponed until \( t = 2 \). Together with limited liability, this implies that \( w_1(s) \geq 0 \) and \( w_2(R) \geq 0 \).

We will distinguish between the case where the agent is induced only to make loans, but not to use his information to screen out bad loans, and the case where the agent is also induced to screen. We will then be more specific about the shape of the *early* bonus pay \( w_1(s) \) and the *deferred* bonus pay \( w_2(R) \). To the extent that the bonus does not condition on loan performance—i.e., \( s \) or \( R \)—we may say that it is contingent only on loan volume. If it conditions on loan performance, so as to induce the agent to screen loans, from limited liability it will be immediate that, \( w_1(l) = w_2(R_l) = 0 \). For instance, paying zero, \( \bar{w} \), or an early bonus could reflect the practice of sharing a year-end bonus pool, based on the performance in the preceding year. Hertzberg, Liberti, and Paravisni (2010) document how compensation for loan officers of a large US bank in Argentina consists of a fixed wage and a year-end bonus. With explicit incentives, as specified in our model, we could also envisage that the bank places a deferred bonus into a separate account, which becomes “vested” only when the respective loans are not in default or, alternatively, when the internal loan review did not reveal negative information.

Altogether, in our model, the bank can decide whether to make compensation contingent only on loan volume or also on loan performance, and whether it wants to defer some or all of it. Casual evidence suggests, at least in the US, some variation in the compensation that loan officers receive, with some receiving more high-powered incentives than others (cf., also, the discussion of our empirical implications in Section 4.4).\(^{12}\)

### 2.2.1 Discussion

In our model, we stipulate that the agent can improve the loan-approval decision by screening borrowers based on his privately observed “soft” information. Alternatively, we could conceive that the agent must be induced not to distort supposedly “hard” information. For instance, the agent could

\[^{12}\text{Cf. the following job description of loan officers by the US Department of Labor (http://www.bls.gov/oco/ocos018.htm):}

In many instances, loan officers act as salespeople. Commercial loan officers, for example, contact firms to determine their needs for loans. If a firm is seeking new funds, the loan officer will try to persuade the company to obtain the loan from his or her institution. [...] The form of compensation for loan officers varies. Most are paid a commission that is based on the number of loans they originate. In this way, commissions are used to motivate loan officers to bring in more loans. Some institutions pay only salaries, while others pay their loan officers a salary plus a commission or bonus based on the number of loans originated.
help an applicant for a consumer loan or a mortgage to fake income slips or to otherwise “gamble” the bank’s approval process. In general, our model should, thus, be more applicable the more the respective agent can positively or negatively affect the quality of the bank’s approval decision. This should be more likely when commercial loans are made to small- and medium-sized enterprises, as opposed to large businesses, and in the case of subprime instead of prime mortgages and consumer loans.

Further, while we frame our model in terms of contracting with a bank’s loan officer, its insights are more widely applicable, in particular to the compensation of a bank’s senior management. As we discuss below in more detail, the bank’s main strategy choice will be between making fewer and only good loans or more loans at the expense of a deterioration of average quality. The different business strategies will be associated with different securitization levels, as well as with different compensation contracts. Applying our model more generally, say to the bank’s senior management, we may suppose that the respective agent’s effort is necessary to expand the bank’s business. Whether the agent then ensures that only good quality \((\theta = G)\) “deals” or “deals” of both good and bad quality are undertaken, depends on his compensation contract. The preferences of the bank depend, in turn, on what fraction of the generated risk stays on the bank’s books and on what fraction is, instead, off-loaded through securitization.

In what follows, we first solve the bank’s internal agency problem (Section 3). This analysis is then embedded into the bank’s overall problem to choose jointly its loan making, securitization, and compensation strategy (Section 4). Note also that, for now, we abstract from any regulatory interference, which is dealt with in Section 5.

3. Internal Agency Problem

Recall that a loan of type \(\theta\) results in a high repayment in \(t = 2\) with a probability \(\gamma_\theta\) and, thus, in a high (forecast) signal in \(t = 1\) with a probability

\[
\rho_\theta := q\gamma_\theta + (1 - q)(1 - \gamma_\theta).
\]  

13 Cf., on faking income slips, “FSA bans mortgage brokers for submitting false loan applications,” FSA, February 21 2008). There is also anecdotal evidence that to obtain NINA (no income, no asset verification) loans, brokers claimed an income that was high enough for the borrower to obtain a loan (cf. Washington Post, “Lies are growing in loan process,” July 30 2005, and “Twelfth periodic mortgage fraud report,” Mortgage Asset Research Institute, 2010).
Making a loan of type \( \theta \), therefore, yields for the agent the expected compensation

\[
U_\theta := [\rho_\theta w_1(h) + (1 - \rho_\theta)w_1(l)] + \delta[\gamma_\theta w_2(R_h) + (1 - \gamma_\theta)w_2(R_l)].
\]  

(2)

(Recall that the agent discounts compensation received in \( t=2 \) by \( \delta \).) We proceed by supposing first that the agent is induced to make only good loans. Subsequently, we consider the case where the agent no longer discriminates between good loans and bad loans. In Section 4, we analyze which of the two cases arises in equilibrium.

3.1 MAKING ONLY GOOD LOANS

The agent will make good loans if

\[
U_G \geq \bar{w}
\]

and he will refrain from making bad loans if

\[
U_B \leq \bar{w}.
\]

In addition, the agent’s compensation must ensure that he exerts effort as, otherwise, it is not feasible to make a new loan. Provided that Conditions (3) and (4) are satisfied, the agent will exert effort if his expected utility from doing so, \( \mu U_G + (1 - \mu)\bar{w} - c \), does not fall short of his utility from shirking, which is \( \bar{w} \). From this, we have the requirement that

\[
\mu(U_G - \bar{w}) \geq c.
\]

(5)

Since Condition (5) implies that the agent strictly prefers to make good loans, we can ignore Condition (3). Thus, an optimal compensation scheme that leads to only good loans minimizes the bank’s expected wage costs

\[
K := \mu[\rho_G w_1(h) + (1 - \rho_G)w_1(l) + \gamma_G w_2(R_h) + (1 - \gamma_G)w_2(R_l)] + (1 - \mu)\bar{w}
\]

subject to, first, the incentive Constraints (4) and (5) and, second, the limited liability constraints \( w_t(\cdot) \geq 0 \).

**Proposition 1.**

Suppose that the bank wants to induce the agent to make only good loans. Then, it always maximally punishes the agent for the bad performance of a loan: \( w_1(l) = w_2(R_l) = 0 \). Further, there exists a cutoff \( 0 < \tilde{\delta} < 1 \), given by
\[ \delta := \left[ 1 + \frac{1}{\mu} \left( \frac{1 - q}{2q - 1} \right) \frac{1}{\gamma G} \right]^{-1}, \]  

such that the agent’s optimal compensation is characterized as follows:

1. If \( \delta < \tilde{\delta} \), the agent receives the base wage
   \[ \bar{w} = \frac{c}{\mu \rho_B - \rho_B}, \]  
   an early incentive component that conditions on the signal \( s \),
   \[ w_1(h) = \frac{1}{\mu \rho_B - \rho_B}, \]  
   and no deferred compensation: \( w_2(R_h) = 0 \).

2. If \( \delta > \tilde{\delta} \), the agent receives the base wage
   \[ \bar{w} = \frac{c}{\mu \gamma_B - \gamma_B \delta}, \]  
   a deferred incentive component that conditions on the ultimate performance of the loan,
   \[ w_2(R_h) = \frac{1}{\mu \gamma_B - \gamma_B \delta}, \]  
   and no early compensation: \( w_1(h) = 0 \).

3. If \( \delta = \tilde{\delta} \), either compensation scheme, as characterized in (1) and (2), is optimal.

### 3.1.1 Early compensation

Now, take Case (1), where there is no deferred compensation. By making a loan, the agent has the chance to obtain a bonus of \( w_1(h) \). Instead, the base wage \( \bar{w} > 0 \), which the agent could also realize by shirking, represents a sure rent. The agent’s expected compensation is, thus, given by \( c + \bar{w} \): the sum of the agent’s private disutility from exerting effort, for which he has to be compensated, and his rent. We refer to this, after substituting from Equation (8), as

\[ K_1 := c + \left( \frac{c}{\mu} \right) \left( \frac{\rho_B}{\rho_B - \rho_B} \right). \]  

The agent’s rent \( \bar{w} \) in Equation (8) is strictly increasing in \( c/\mu \), which shows up in the second term in Equation (12). This has the following intuition. When exerting effort is more costly (higher \( c \)) or less likely to ultimately
result in a loan (lower $\mu$), the agent must be paid a higher bonus. When $w_1(h)$ increases, however, it is necessary to also increase $\tilde{w}$. Otherwise, the agent would want to make also bad loans [cf. incentive constraint (4)]. Finally, note that the agent’s rent decreases when the signal $s$ becomes more informative (higher $q$).\(^{14}\)

What shapes the form of the optimal compensation scheme and what determines the preceding comparative analysis is the interaction of the two incentive Constraints (4) and (5). The agent’s effort is necessary for loan making to be feasible. The compensation that he must receive to cover the respective costs of effort biases the agent toward making even bad loans. To counteract this tendency, the bank must leave the agent with a rent $\tilde{w} > 0$.

The fact that incentivizing the agent along both “tasks” is costly for the bank is the key for all our following results. Arguably, our theory is less applicable when the agent has little scope to generate private “soft” information or to otherwise influence the quality of the loan-approval decision (cf. the discussion in Section 2).

3.1.2 Deferred compensation

Next, take Case (2) in Proposition 1, where compensation is optimally deferred. Intuitively, the rent that is left to the agent, $\tilde{w}$, is now strictly lower, given that the bank can condition the bonus on the actual repayment $R$, which is a more informative signal than the forecast $s$. On the other hand, deferred compensation creates a “deadweight loss,” as the agent is more impatient. Taking this into account, once we substitute for $w_2$ and $\tilde{w}$ from Proposition 1, the expected costs of compensating the agent are now given by:

$$K_2 := c + \left( \frac{c}{\mu} \left( \frac{\gamma_B}{\gamma_G - \gamma_B} \right) + c \left( \frac{1 - \delta}{\delta} \right) \left( \frac{\gamma_G}{\gamma_G - \gamma_B} \right) \right).$$

The last term in Equation (13) captures the “deadweight loss.” This is strictly decreasing in $\delta$ and disappears altogether for a perfectly patient agent, as $\delta \to 1$.

For $\delta = \tilde{\delta}$, the bank is indifferent between early and deferred compensation (Case 3 in Proposition 1). There, the information gain and the “deadweight loss” ($\delta < 1$) under deferred compensation offset each other

\(^{14}\) Formally, note that after substituting from Equation (1) and differentiating, we have:

$$\frac{d}{dq} \left( \frac{\rho_B}{\rho_G - \rho_B} \right) = - \frac{1}{(2q - 1)^2} \frac{1}{\gamma_G - \gamma_B} < 0.$$
exactly (Formally, the respective expressions (12) and (13) are then just equal: $K_1 = K_2$). Note, also, that the critical value $\tilde{\delta}$ in Equation (7) increases in $q$: when $s$ is more precise (higher $q$), less information can be gained by waiting for the true performance of the loan, as captured by $R$. Deferred compensation then becomes less attractive compared to early compensation. In the limit, as $q \to 1$, the information gain vanishes: $\tilde{\delta} \to 1$.

For future reference, it is convenient to use a short-hand expression for the expected costs of compensation—i.e., the minimum of $K = K_1$ in Equation (12) and $K = K_2$ in Equation (13). As we presently consider the case where only good loans are made, we refer to this as

$$K_G := \min\{K_1, K_2\}.$$ 

3.2 MAKING GOOD AND BAD LOANS

When loans of either quality are made, the agent needs to be incentivized only to exert effort. The optimal compensation scheme minimizes the bank’s expected wage costs. As deferring compensation is costly, the agent is compensated only in $t = 1$: there are no benefits, only costs, from deferred compensation. The agent simply receives an early bonus $w_1 = c$ when a new loan is made, implying also that no rent is paid: $\tilde{w} = 0$. Without “deadweight loss” from deferred compensation and without a rent for the agent, the bank’s costs of compensation are equal to the agent’s costs of effort, $c$. For ease of reference, we denote these costs by

$$K_{GB} = c.$$ 

4. Market Outcome

The bank may choose either a compensation scheme that leads to only good loans or one under which both good and bad loans are made (While the bank might also randomize between the two compensation schemes, we show below that this will never be the case in equilibrium.). Since outsiders do not observe the bank’s compensation scheme, the price that a rational investor is willing to pay for a share of the bank’s (securitized) loans depends on his beliefs about the bank’s chosen compensation scheme. As we will see, the bank’s optimal choice of compensation and, thus, the quality of loans depend, in turn, on the price $p$ that it receives for the issued securities. The following equilibrium analysis studies this interaction.
4.1 SECURITIZATION

Benefits from securitization may arise as the bank has access to some profitable private investment opportunity, which it cannot fund otherwise because it is, at least to some extent and in the short run, financially constrained. Alternatively, gains from securitization may arise from risk diversification, either because the bank’s owners are not fully diversified or because of costs arising from the threat of bankruptcy or binding regulatory constraints.\(^{15}\)

While nonfinancial firms also may choose to securitize future cash flows, either for funding or for risk management purposes, this is arguably more important for financial firms. As nonfinancial firms typically borrow against receivables that accrue from their productive securities, their securitization activity is limited by the scope of their real operations (cf., also, ECB, 2007 on the relatively small size of securitization activity by nonfinancials). For financial firms, however, securitization is more directly linked to credit origination as one of their primary fields of operations (cf., also, Martín-Oliver and Saurina, 2007; Loutskina, 2011).

We denote by \(\tau \geq 0\) the bank’s gains from securitization that arise as the market in \(t=1\) has a higher willingness to pay for claims due in \(t=2\).\(^{16}\) Suppose that the bank makes both good and bad loans and that these are fully securitized at fair value, which is then \((1 + \tau)\tilde{R}_{GB}\) with \(\tilde{R}_{GB} := \mu \tilde{R}_G + (1 - \mu)\tilde{R}_B\). We stipulate that the expected proceeds exceed the (effort) cost that it takes to originate and close a loan:

\[
\tau \tilde{R}_{GB} + \mu \eta_G + (1 - \mu)\eta_B > c. \tag{14}
\]

(Recall that \(\eta_0 := \tilde{R}_0 - \kappa\).) Bad loans are assumed to be always loss making:

\[
\eta_B < 0. \tag{15}
\]

\(^{15}\) For an analysis of the benefits of credit risk transfer, see Froot and Stein (1998). In Morrison (2005), risk-averse banks buy credit insurance against their loans. Parlour and Plantin (2008) argue that when keeping loans on their balance sheet, banks may be prevented from exploiting private redeployment opportunities, due to either their own insufficient liquidity or binding capital requirements.

\(^{16}\) Alternatively, albeit with additional notational complications, we could capture different time preferences through a set of discount factors \(\delta_A < \delta_B < \delta_M\), where \(\delta_A\) represents the agent, \(\delta_B\) represents the bank, and \(\delta_M\) represents the market (For convenience, we have set \(\delta_B = 1\)).
Conditions (14) and (15) jointly ensure that there is scope for both an equilibrium where the bank makes only good loans, and an equilibrium where it makes good and bad loans.\(^{17}\)

### 4.1.1 Price of securities

Investors compete themselves down to zero profits. If they believe that the bank makes only good loans, the securities’ price is equal to

\[
p_G := (1 + \tau)\tilde{R}_G. \tag{16}\]

If investors believe that the bank makes both good and bad loans, the price is equal to

\[
p_{GB} := (1 + \tau)\tilde{R}_{GB}. \tag{17}\]

For a given level of securitization \(\psi\) and a given price \(p\), the bank’s payoff when only good loans are made equals

\[
V_G := \mu [\psi (p - \tilde{R}_G) + \eta_G] - K_G. \tag{18}\]

Note that this is net of the respective costs of compensation, \(K_G\). The term \(\psi (p - \tilde{R}_G)\) in Equation (18) denotes the benefits from securitizing the fraction \(\psi\). When the price is fair, \(p = p_G\), these benefits are equal to \(\psi \tau \tilde{R}_G\). We obtain analogously the bank’s payoff when loans of both types are made and when a fraction \(\psi\) is sold at price \(p\):

\[
V_{GB} := \psi (p - \tilde{R}_{GB}) + \mu \eta_G + (1 - \mu)\eta_B - K_{GB}. \tag{19}\]

### 4.1.2 Plan of analysis

Recall that the securitization decision is made only after the bank has chosen a compensation scheme, which gives rise to a game of private information between the bank and outside investors. However, it proves useful to first consider an auxiliary game where the bank can commit to a (maximum) level of securitization ex ante, that is, before it chooses its compensation scheme. Then, in a second step, we show that the equilibrium outcome for the auxiliary game is the unique (refined) equilibrium outcome also in the original game.

\(^{17}\) Instead, when \(\eta_B \geq 0\), all loans would always be made and would be fully securitized, while for \(\tau \tilde{R}_{GB} + \mu \eta_G + (1 - \mu)\eta_B < c\), there could only be an equilibrium with only good loans.
4.2 EQUILIBRIUM OF THE “COMMITMENT GAME”

In the auxiliary game, the bank first chooses an observable level of securitization. We now take first some level of securitization $\psi$ and solve for the rational expectations equilibrium in the ensuing game, when investors correctly anticipate the subsequently chosen compensation structure and, thus, average loan quality.

When only good loans are made, we have $p = p_G$. Once we substitute this into Equations (18) and (19), we see that the bank, indeed, has an incentive to induce the agent to screen loans when

$$\psi \leq \tilde{\psi} := \left( -\eta_B - \frac{\Delta_K}{1 - \mu} \right) \frac{1}{p_G - R_B},$$

(20)

where

$$\Delta_K := K_G - K_{GB}$$

denotes the incremental cost of incentivizing the agent to screen loans. From Equation (20), there exists a maximum level of securitization, $\psi$, such that the outcome with only good loans can be supported as long as $\psi \leq \tilde{\psi}$.\(^{18}\)

Next, we ask when the bank prefers that both good and bad loans are made, while this is correctly anticipated by the purchasers of its securities: $p = p_{GB}$. From substitution into the bank’s payoff in Equation (19), this outcome can be supported for a given level of securitization $\psi$, when $\psi$ is sufficiently high:

$$\psi \geq \tilde{\psi} := \left( -\eta_B - \frac{\Delta_K}{1 - \mu} \right) \frac{1}{p_{GB} - R_B}.$$

(21)

The right-hand side of Equation (21) is strictly smaller than one. Thus, when the level of securitization is too high, the bank will no longer care about the quality of loans. This is intuitive. What will, however, interest us more is whether this case will also arise when $\psi$ is chosen endogenously and how the outcome depends on the chosen compensation scheme.

As the threshold $\psi$ in Equation (20) is strictly smaller than $\tilde{\psi}$ in Equation (21), there exists an intermediate range $\psi \in (\psi, \tilde{\psi})$ for which the bank mixes between inducing the agent to make only good loans or both good and bad loans.

\(^{18}\) The threshold $\psi$ in Equation (20) can be negative when the additional cost of providing incentives to make only good loans becomes too high. In this case, even if the bank retained 100% of all loans, it would still not induce the agent to make only good loans.
Lemma 1.
Consider the “commitment game,” where the bank chooses the level of securitization $\psi$ before it determines the agent’s compensation scheme. Then, for given $\psi$, the unique continuation equilibrium is characterized as follows:

1. If Condition (20) holds, such that $\psi \leq \bar{\psi}$, only good loans are made.
2. If Condition (21) holds, such that $\psi \geq \bar{\psi}$, both good and bad loans are made.
3. If Conditions (20) and (21) both fail, such that $\psi \in (\bar{\psi}, \bar{\psi})$, the bank mixes between inducing the agent to make only good loans and inducing him to make both good and bad loans.

As we will show, the bank optimally considers only the following two strategies. The first strategy is to fully off-load the risk from new loans, such that $\psi = 1$. We know that this implies that both good and bad loans will be made (as $\bar{\psi} < 1$). The second strategy is to keep $\psi$ sufficiently low so as to (just) credibly commit to incentivize the agent to make only good loans. Note, in particular, that it is not optimal to set $\psi \in [\bar{\psi}, 1)$, as the bank would then still realize only the price $p_{GB}$. [Further, we show in the proof of Proposition 2 that it is also not optimal to choose $\psi \in (\bar{\psi}, \bar{\psi})$, which would give rise to a mixed strategy equilibrium.]

We now substitute $\psi = \psi$ from Equation (20) together with $p = p_G$ into the respective profits $V_G$. For $V_{GB}$, we substitute $\psi = 1$ together with $p = p_{GB}$. Comparing the respective profits $V_G$ and $V_{GB}$, the bank wants to limit securitization to $\bar{\psi}$, thereby making it credible to induce the agent to screen loans if

$$\tau \bar{R}_{GB} < \left(-\eta_B - \frac{\Delta_K}{1 - \mu}\right) \left(1 - \mu \frac{\bar{R}_G - \bar{R}_B}{p_G - \bar{R}_B}\right). \tag{22}$$

Proposition 2.
In the auxiliary “commitment game,” where the bank chooses the level of securitization $\psi$ before it determines the agent’s compensation scheme, the equilibrium is characterized as follows. If Equation (22) holds, the bank will securitize loans only up to $\psi = \bar{\psi}$ and induce the agent to make only good loans. If the opposite of Equation (22) holds strictly, then the bank will fully securitize a loan, $\psi = 1$, and induces the agent to make both good and bad loans. When Equation (22) holds with equality, both outcomes can arise.

Before we discuss in detail the characterization in Proposition 2 and derive predictions from it, we show that Proposition 2 also characterizes the
outcome of the original game, where securitization is chosen only after loans have been made.

4.3 EQUILIBRIUM OF THE ORIGINAL GAME

Return to the original game, where the bank chooses $\psi$ only after a loan has been made (Instead, recall that in the auxiliary game $\psi$ was observably chosen before the compensation scheme and thus before a loan was made.). Given that outsiders do not observe the bank’s choice of compensation, this now represents a game of incomplete information. It is well known that by specifying sufficiently “pessimistic” beliefs for any out-of-equilibrium choice of $\psi$, a wide range of equilibria can be supported in such games. Incidentally note that in contrast to a (standard) signaling game, in our model, the “type” of the bank is endogenous (In fact, in a pure-strategy equilibrium, the market’s beliefs about the average quality of loans is degenerate before $\psi$ is observed.). With the freedom to choose out-of-equilibrium at hand, it is straightforward that one can still support the same outcome as in the auxiliary game (cf. Proposition 2).

In what follows, we make use of a refinement criterion: Forward Induction (cf. Govindan and Wilson, 2009). Forward Induction captures the idea that players should, even if they observe something unexpected, assume that other players chose rationally in the past and that they will choose rationally in the future. Consequently, the support of the investors’ updated beliefs is restricted to such strategies that are an optimal continuation in some Perfect Bayesian Equilibrium. Applied to our setting, investors’ beliefs should, thus, put positive probability mass on “GB,” after observing an out-of-equilibrium value $\psi$, only if there exists an equilibrium of the continuation game such that {“GB”, $\psi$} is a profit-maximizing strategy for the bank.

Proposition 3.
Consider the original game, where the level of securitization $\psi$ is observably chosen only after a loan has been made and thus, in particular, after the compensation contract was implemented. Then, if we employ Forward Induction as a refinement, the outcome is the same as in the auxiliary game [Proposition 2.] i.e., if Equation (22) holds, the bank will securitize loans only up to $\psi = \underline{\psi}$ and induce the agent to make only good loans. If the opposite of Equation (22) holds strictly, then the bank induces the agent to make both good and bad loans and fully securitizes a loan, $\psi = 1$. When Equation (22) holds with equality, both outcomes can arise.
4.4 COMPARATIVE ANALYSIS

Proposition 3 reveals that when the bank wants to expand its activities by making both good and bad loans, it optimally steps up securitization ($\psi = 1$). Below, we analyze when, in terms of the model’s primitives, this is more likely to be the case. It is first instructive to relate such a switch toward $\psi = 1$ to all other endogenous variables of our model. The following results are implied by Proposition 3.

**Corollary 1.**

*Compare the outcome when the bank induces the agent to screen loans with the outcome when the bank induces the agent to make loans but not to screen.* With screening, (i) compensation also conditions on loan performance, instead of only loan volume, and it is flatter in the sense that $\tilde{w} > 0$, compared to $\tilde{w} = 0$; (ii) bonus pay is delayed when $\delta \geq \tilde{\delta}$, while without screening, it is never delayed; (iii) the bank only securitizes a fraction $\psi < 1$, instead of fully securitizing all loans; and (iv) the average quality of loans is higher and, thus, the likelihood of default lower, $d_G < d_{GB}$, resulting in a higher price $p$ for its securities.

Agarwal and Wang (2009) analyze data from a field experiment where a piece rate was introduced for a subgroup of a bank’s small-business-loan officers (Note that a piece rate corresponds to the optimal contract without screening.). They find that piece rates result in higher approval rates and a higher rate of default. Assertion (iii) makes the additional prediction that loans should be more likely to be (fully) securitized when the respective agents receive steep, volume-oriented, and short-term incentives. There is evidence on the relation between securitization and subsequent default. Purnanandam (2010) shows that originators that made a larger fraction of their loans with the purpose of reselling them in the secondary market experienced higher charge-offs and more defaults when they subsequently were unable to sell once the secondary market had dried up. Dell’Ariccia, Igan, and Laeven (2012) relate the expansion in subprime lending to a lowering of lending standards and find that effects are stronger, if a larger fraction of the originated loans is sold to outside investors. Mian and Sufi (2009) document how loan denial rates in subprime zip codes decreased when securitization of subprime mortgages went up.

We next ask how securitization, loan quality, and compensation are jointly affected by the model’s primitives. Recall that the key condition for this is given by Condition (22). When this holds, only good loans are made in equilibrium; the fraction $\psi$ of loans is securitized; the agent receives a strictly positive base wage ($\tilde{w} > 0$); and his bonus is possibly deferred (when $\delta \geq \tilde{\delta}$).
For brevity’s sake, we simply say that this regime becomes more likely when the respective Condition (22) is relaxed. Instead, when a change in primitives has the opposite effect on Condition (22), we say that the alternative regime, in which both good- and bad quality loans are made, becomes more likely.

**Corollary 2.**

*It is more likely that the bank fully securitizes loans and no longer induces the agent to screen, thus providing him with only volume-oriented and short-term incentives, when the benefits from securitization, \( \tau \), are higher or when the internal agency problem is more severe. This is the case when the early performance signal is less precise (lower \( q \)), when the agent’s cost is higher (higher \( c \)), or when the agent’s time preference is higher (lower \( \delta \)).*

The benefits from securitization should increase when different regulation imposes different financing constraints on the buyers and sellers of these securities.\(^{19}\) In this vein, Mian and Sufi (2009) find that loans that are sold to nonbank financial firms experience a higher increase in default rates than those that are sold to other banks. Keys et al. (2009) compare default rates for mortgages with similar observable characteristics, but different likelihood of being subsequently securitized, along Assertions (3) and (4) of the preceding Corollary 1. When the originating institution was likely to have a higher funding requirement, the increase in default rate was larger.\(^{20}\) The second part of the Corollary 2 focuses on the bank’s internal agency problem. If it becomes harder for the bank to control the agent, the bank is more likely to stop inducing the agent to screen loans. Agarwal and Wang (2009) find that the adverse effect of incentives on loan quality is smaller if the originating agent is more likely to be under closer supervisory scrutiny, as he is younger or shorter tenured. Jiang, Nelson, and Vytalical (2011) report that a decrease in control over the agent has a higher impact on default rates when the agent is more likely to have private (“soft”) information, as a mortgage has only partial instead of full documentation. Finally, Agarwal and Wang (2009) find a greater response of loan quality to more high-powered incentives when loans are of longer maturity, which in our model would imply a higher \( \delta \). As we increase the time horizon, \( \tau \) should also increase, which, from assertion (1), works toward strengthening these predictions.

\(^{19}\) Several papers, such as Parlour and Plantin (2008), have also suggested an intertemporal shift in \( \tau \). They argue that stricter capital requirements, “risk-based” deposit insurance, and the removal of interstate banking restrictions in the United States all increased banks’ opportunity costs of holding on to their originated loans.

\(^{20}\) Precisely, as in Keys et al. (2010), this exploits the “rule of thumb” applied by mortgage lenders that a FICO score below 620 makes a borrower “just” unacceptable. The authors argue that loans above the threshold can more easily be securitized.
5. Regulating Compensation

We now analyze the equilibrium outcome in the presence of regulation. In Section 5.1, we consider the policy that a regulator imposes a requirement to defer any bonus from $t = 1$ to $t = 2$ and in Section 5.2, we consider a tax on bonus payments in $t = 1$. In Section 6, we analyze the case where a regulator may also control the extent to which loans are securitized.

5.1 MANDATORY DEFERRED COMPENSATION

Consider the constraint that $w_1 (\cdot) = 0$. Suppose, first, that the bank does not want to induce the agent to screen loans. In this case, we previously found that the bank always wants to pay out a bonus immediately. When it is, instead, forced to defer the bonus, this must increase to $c/\delta$ so as to still induce the agent to exert effort at cost $c$. Denote the respective compensation costs under regulation by $K_{GB}^R := c/\delta$. When only good loans are made, the respective costs of compensation are $K^R := K_2$, which is given in Equation (13).

Recall that we previously characterized the equilibrium without regulation in two steps. We first solved the bank’s incentive problem and, thereby, derived the respective costs of compensation $K_G$ and $K_{GB}$. We then solved jointly for the equilibrium quality of loans and the bank’s securitization strategy. With regulation, the only change is that we must now substitute $K_G$ and $K_{GB}$ with the respective costs of compensation $K_{GB}^R$ and $K_{GB}^R$—or, likewise, $\Delta_K$ by the incremental costs of compensation under regulation $\Delta_K^R := K_{GB}^R - K_{GB}$. In analogy to Equation (20), the bank will incentivize the agent to make only good loans when

$$\psi \leq \psi^R := \left(-\eta_B - \frac{\Delta_K^R}{1 - \mu}\right) \frac{1}{p_G - \bar{R}_B}. \quad (23)$$

Next, in analogy to Condition (22), we obtain that securitizing only $\psi = \psi^R$ is optimal only when

$$\tau \bar{R}_{GB} < \left(-\eta_B - \frac{\Delta_K^R}{1 - \mu}\right) \left(1 - \mu \frac{\bar{R}_G - \bar{R}_B}{p_G - \bar{R}_B}\right). \quad (24)$$

Hence, imposing mandatory deferred bonus pay can lead to an increase in the quality of loans only when regulation makes it “relatively cheaper” for the bank to provide the respective incentives:

$$\Delta_K^R < \Delta_K. \quad (25)$$
More formally, when (25) holds, then Condition (24) is easier to satisfy than the corresponding Condition (22).

Recall that mandatory deferred bonus pay strictly increases the compensation costs when all loans are made indiscriminately: \( K_{\text{GB}}^R > K_{\text{GB}} \). Since for \( \delta \geq \hat{\delta} \), the optimal compensation for agents who should screen loans already entails deferred compensation, \( K_G = K_2 \), regulation does not impose additional costs: \( K_G^R = K_G \). Hence, we can conclude that for \( \delta \geq \hat{\delta} \), Condition (25) holds strictly. Regulation of pay then increases the likelihood that only high-quality loans are made. However, for \( \delta < \hat{\delta} \), the converse of (25) may hold, such that regulation can decrease average loan quality.

**Proposition 4.**
Suppose that deferred bonus compensation is made mandatory. This (weakly) increases average loan quality, thereby reducing the likelihood of default when \( \delta > \hat{\delta} \) holds, where \( 0 < \hat{\delta} < \bar{\delta} \) is given by:

\[
\hat{\delta} := \left[ 1 + \frac{1}{\mu} \left( \frac{1-q}{2q-1} \right) \cdot \frac{1}{\gamma_B} \right]^{-1}.
\]  

(26)

Instead, for \( \delta < \hat{\delta} \), regulation of pay (weakly) decreases average loan quality. When \( \delta = \hat{\delta} \), regulation has no impact.

We now discuss in detail why policy intervention can lead to a deterioration of loan quality when \( \delta < \hat{\delta} \). At first, this seems somewhat counterintuitive since by forcing the bank to defer the bonus, one could conjecture that the bank becomes more inclined to make use of the information in \( t=2 \) and, thereby, to induce the agent to screen loans. This conjecture is, however, not fully true. Recall that the agent must be paid a rent to ensure that he uses his private information to make only good loans. We know that this rent is lower when the bonus is paid in \( t=2 \), where the information on loan performance is more precise. However, deferring pay is costly, as from our previous discussion, the bank must pay a higher expected bonus when it wants to make only good loans so as to compensate for the payment of \( \tilde{w} > 0 \). Crucially, this implies that in this case also the “deadweight loss” of deferred compensation becomes larger. When \( \delta < \hat{\delta} \), this effect becomes sufficiently strong so that mandatory deferred compensation makes it relatively more costly for the bank to ensure that only good loans are made.

Put differently, the possibility that mandatory deferred pay can reduce average loan quality relies on the fact that the thereby engendered incremental compensation costs can be higher in the regime where the agent is induced to make only good loans. This, in turn, relies on three observations: first, when there are such unintended consequences, deferred
pay is not the efficient contracting choice for the bank even when it intends to make only good loans; second, the pay that must be deferred is larger when the agent is supposed to screen out bad loans; third, it is inefficient to defer pay as the agent is more impatient than the bank. Hence, the assumption of different time preferences is essential for this result. With equal time preferences, a bank that would want to incentivize the agent to screen loans would always want to delay payment as far as possible into the future, as then the aggregate signal would become more precise. This would be even more pronounced with a risk-averse agent as more information would allow for better risk-sharing.\(^{21}\)

Figure 1 illustrates the two cases that are possible from Proposition 4. For concreteness, in addition to the varying $\delta$, for this exercise we also vary the benefits from securitization $\tau$. The two hatched areas in Figure 1 capture the regions where regulation strictly affects average loan quality, whereas in all other areas, loan quality is not affected. In the horizontally hatched area to the left of $\hat{\delta}$, average loan quality decreases with a corresponding increase in the likelihood of default from $d_G$ to $d_{GB}$. In the vertically hatched area to the right of $\hat{\delta}$, average loan quality increases and the likelihood of default decreases from $d_{GB}$ to $d_G$, instead.

The following comparative result follows from differentiation of the threshold $\hat{\delta}$ in Equation (26).

**Corollary 3.**

Mandatory deferred bonus pay is more likely to lead to a decrease in the quality of loans when deferring pay imposes high costs (low $\delta$) and generates little additional information on loan performance (high $q$), or when the average quality of the loan pool is low (low $\mu$).

Note that, as observed earlier, $\delta$ may be lower as, ceteris paribus, the agent is more impatient or as the bank must wait longer to obtain better information about the loan’s ultimate performance—e.g., as the maturity of the loan is longer. One could conjecture that the agent’s impatience or liquidity preference depends, in particular, on his age and tenure, given that this may affect his own borrowing constraints. For high $q$ and low $\delta$, mandatory deferred pay risks imposing too high incremental costs of compensation on

\(^{21}\) Note, however, that introducing risk aversion while keeping our assumption of different time preferences should not alter our results qualitatively. However, the model’s main tradeoffs would then interfere with a risk sharing effect, thus making it more difficult to obtain any clear cut results. The analysis would be further complicated by the fact that—given the agent’s utility function is sufficiently steep at low consumption levels—the optimal compensation scheme would consist of five strictly positive wage levels instead of only two with risk neutrality [i.e., $w$ and either $w_1(h)$ or $w_2(R_h)$, respectively].
the bank compared to the derived benefits in terms of the generated information on loan performance. When the average quality of the loan pool deteriorates, the bank must increase its bonus so as to still incentivize the agent. This increase must be higher when the agent is induced to screen loans, as it must also “compensate” the simultaneous increase in \( \tilde{w} \), which is required to ensure that bad loans are rejected. But then, the increase in the “deadweight loss” is also higher under mandatory deferred pay. Thus, regulation may have unintended consequences precisely when the agent’s ability to screen out bad loans is of highest value, as they make up a large fraction of the overall pool.

5.2 DOES THE BANK BENEFIT FROM REGULATION?

Regulating compensation is never in the bank’s interest if it destroys the equilibrium with only good loans. Instead, the bank benefits from mandatory deferred pay when it helps to overcome a commitment problem vis-à-vis the buyers of its securities. Mandatory deferred pay is in the bank’s interest if, without regulation, it would not be credible for the bank to defer pay and, at the same time, relate compensation to loan performance and not only loan volume. We return to this issue below.

Figure 1. The two curves indicate, as a function of \( \delta \), the maximum values for \( \tau \) such that Condition (24) still holds. In the horizontally hatched area, regulation leads to a lower average loan quality and in the vertically hatched area, regulation leads to a higher average loan quality (Figure 1 is calibrated with the following values: \( \mu = 0.7 \), \( \gamma_G = 0.7 \), \( \gamma_B = 0.3 \), \( q = 0.7 \), \( R_h = 7 \), \( R_l = 2 \), \( \kappa = 5 \), \( c = 0.05 \)).
when we discuss other ways how policy could help the bank to achieve commitment vis-à-vis investors in its own securities.

However, the bank’s and the social planner’s (regulator’s) preferences are not always perfectly aligned. The social planner’s objective function is the sum of the expected payoff of the bank, of investors, and of the agent. Thus, the rent that the agent obtains when he is induced to screen loans represents, from the social planner’s perspective, a pure transfer.

**Corollary 4.**

When $\delta < \hat{\delta}$, both the bank and the social planner prefer that mandatory deferred pay is not imposed. When $\delta > \hat{\delta}$, regulating pay may be in the social planner’s interest but not in the bank’s. Precisely, there exist two thresholds, $\delta_b > \delta_r$, such that regulation is in the social planner’s interest if $\delta \geq \delta_r$, while it is in the bank’s interest if $\delta \geq \delta_b$.

Note that the gap between the bank’s and the social planner’s incentives would widen even further when the subsequent default of loans imposed externalities that are taken into account by the social planner, but not by the bank or the investors in its securities. It is straightforward to extend our analysis in this way, though for the brevity’s sake, we refer the reader to the Supplementary appendix for a formal analysis.

Note again that the imposition of mandatory deferred pay can be in the bank’s own interest as it solves a commitment problem vis-à-vis the investors in the bank’s own securities. As long as this is not observable, the bank cannot credibly commit to provide its agents with the respective incentives to make only good loans. As we showed, however, a policy of mandatory deferred compensation can be too intrusive in that it may reduce the average quality of loans, thus being neither in the bank’s nor in the social planner’s interest. This case could be avoided when policy intervention was less intrusive and required only to make agents’ compensation transparent to investors. Left on its own, the bank could not achieve such credible transparency, as it would have an incentive to secretly renegotiate the agent’s compensation. This is where policy intervention could play a role, though a focus on disclosure alone would impose on investors a great deal of information processing.

**5.3 BONUS TAX**

Instead of making it mandatory to defer bonus pay, a regulator may want to affect the bank’s incentives by taxing a short-term bonus. Such a tax has been proposed in several countries and, notably, by the International
Monetary Fund (IMF, 2010). In our model, the imposition of a percentage tax rate \( T < 1 \) would firstly affect the agent’s payoff in Equation (2):

\[
U_\theta := (1 - T)[\rho_\theta w_1(h) + (1 - \rho_\theta)w_1(l)] + \delta[\gamma_\theta w_2(R_h) + (1 - \gamma_\theta)w_2(R_l)].
\]

Clearly, the bank would then have to compensate the agent through raising his pay. When it does not want to induce the agent to screen out bad loans, the bank either has to pay an early bonus of size \( c/(1 - T) \) or, to avoid the tax, a deferred bonus of size \( c/\delta \). When \( T > 1 - \delta \), the bank defers the bonus. Thus, we have for the cost of compensation \( K_{GB}^T = c/(1 - T) \), when \( T \leq 1 - \delta \) and \( K_{GB}^T = c/\delta \), when \( T > 1 - \delta \). When \( \delta \geq \delta \), where \( K_G^T = K_2 \) holds for any \( T \) if the agent is induced to screen, we can conclude that a bonus tax makes the outcome with only good loans more likely. Proposition 5 also analyzes the situation in which a tax has the opposite implication.

**Proposition 5.**

Suppose that early bonus pay is taxed at rate \( T \). This (weakly) increases average loan quality if \( \delta > \hat{\delta}_T \), where \( 0 < \hat{\delta}_T < \delta \) satisfies

\[
\frac{1 - \hat{\delta}_T}{\delta_T} := \frac{1}{\mu} \left( \frac{1 - q}{2q - 1} \right) \frac{1}{\gamma_G - \gamma_B} \left( \frac{T}{1 - T} \right)
\]

when \( T < 1 - \delta \) and \( \hat{\delta}_T = \hat{\delta} \), as in Equation (26), when \( T \geq 1 - \delta \). For \( \delta < \hat{\delta}_T \), a bonus tax (weakly) reduces average loan quality. When \( \delta = \hat{\delta}_T \), regulation has no impact on loan quality.

In our model, when the goal of regulation is to induce banks to incentivize their own agents to screen out bad loans, the optimal tax on short-term bonus pay would be as follows. For \( \delta \leq \hat{\delta} \), a tax can only have the opposite effect, such that, optimally, \( T = 0 \). For \( \delta \geq \hat{\delta} \), a tax always has the intended consequence, as it affects only “bad” banks. Finally, for \( \hat{\delta} < \delta < \tilde{\delta} \), the intended consequences are obtained only when the tax is sufficiently large. Thus, in our model, the optimal regime is to either impose no tax or to impose a tax that makes a short-term bonus prohibitively expensive: \( T \geq 1 - \delta \). This stark characterization is admittedly due to the way we model the agent’s preferences, namely, by endowing him with risk neutrality together with impatience (liquidity preference). This leaves open the question: would the additional flexibility of a tax, as compared to making deferred pay mandatory, not be beneficial in another environment?
6. Regulating Securitization

From Proposition 4, mandatory deferred pay can “backfire” by leading to a deterioration of loan quality. A social planner could, however, always “enforce” the desired outcome by requiring the bank to retain at least the fraction $1 - \psi$, provided that $\psi > 0$. Such a minimum retention requirement was recently imposed in Europe (EC, 2009) and in the USA as part of the Dodd–Frank Act of the US Congress, passed in July 2010. In what follows, we first consider the case where, as previously, when there is no policy intervention, the bank can still commit to retain a fraction $1 - \psi$ of each loan. In contrast, we subsequently analyze the case where such commitment is not possible without policy intervention.

6.1 OBSERVABLE RETENTION

Intuitively, when policy intervention directly addresses the level of securitization, this will monotonically affect the bank’s willingness to make only good loans and to incentivize its agents accordingly. As we show, the imposition of mandatory deferred bonus pay can then still play a positive role, provided that $\delta > \tilde{\delta}$. The reason is that by mitigating the bank’s commitment problem vis-à-vis investors, regulating compensation reduces the minimum stake that the bank needs to retain (Formally, we then have that $\psi^R > \psi$). In this case, the two policy measures are complementary.

Proposition 6.
Suppose that the social planner could impose mandatory deferred pay or a minimum retention requirement when loans are securitized, or both. When the social planner wants to ensure that bad loans are screened out, this is achieved most efficiently as follows:

1. If $\delta \leq \tilde{\delta}$, this can be ensured only through imposing a minimum retention requirement $\psi \leq \psi$, while imposing mandatory deferred pay would be counterproductive.
2. There exists $\hat{\delta} < \tilde{\delta} < 1$ such that for $\delta \in (\hat{\delta}, \tilde{\delta})$, it is efficient to still impose only a minimum retention requirement $\psi \leq \psi$.
3. If $\delta \geq \hat{\delta}$, it is efficient to impose mandatory deferred pay together with a minimum retention requirement $\psi \leq \psi^R$.

While we refer to this case as that with “observable retention,” note that this also implies the (dynamic) commitment not to securitize in the future the remaining fraction of the loan.
Proposition 6 comes with the caveat that, in our model, the regulator has detailed knowledge about the industry—i.e., about the model’s parameters. This allows the regulator to choose a threshold \( \psi \) or \( \psi^R \) precisely, such that the bank is just committed to induce its agent to make only good loans. Note, also, that when the regulator imposes only a requirement on securitization without regulating pay, the bank’s and the regulator’s preferences always diverge if this requirement becomes binding. As we show next, this is no longer the case when the bank faces a commitment problem vis-à-vis investors also with respect to its retention strategy.

6.2 UNOBSERVABLE RETENTION

Without regulation, it may also not be credible for the bank to commit to retaining a given exposure to the loan, in particular, when there is a large, nontransparent market for securitized products or when (single name) credit derivatives are available in the case of commercial loans.\(^{23}\) Suppose thus that the bank can no longer commit to retain a minimum fraction of a loan. To capture this, we suppose that there are \( N \) possible investors. At the securitization stage, the firm can offer each investor a tranche \( \hat{\psi}_n \) with \( \sum_{n=1}^{N} \hat{\psi}_n \leq 1 \). Importantly, now each offer is only observed by the respective investor, but not by the other investors.\(^{24}\) We restrict consideration to symmetric equilibria, where \( \hat{\psi}_n = \hat{\psi} \). Denote thus by \( \psi_{nc} = N\hat{\psi} \), the equilibrium level of securitization under noncommitment. We further focus our discussion in the main text on the case where \( N \to \infty \), as then, given that \( \hat{\psi} \to 0 \), each investor holds, in equilibrium, a negligible fraction of the securitized loan. Intuitively, when the bank then wants to secretly securitize the remaining fraction of a loan, this can be done through targeting a single investor without having a price impact on the securities bought by other investors. Hence, in contrast to a deviation where the total level of securitization is observable to all investors, the bank now gains, in addition, the difference between \( \psi_{nc} p_G \) and \( \psi_{nc} p_{GB} \) (Recall that \( N \to \infty \)).

\(^{23}\) While our present analysis presumes, for simplicity, that the bank retains, if at all, a fraction of a loan, we show in the Supplementary appendix that a credible commitment to make only good loans would be achieved at the lowest cost through making the bank’s remaining exposure as risky as possible. In the recent years, an active market for such equity tranches has developed with often limited or no transparency on the remaining exposure of the originating bank (cf. Franke and Krahnen, 2008; Fender and Mitchell, 2009).

\(^{24}\) Adopting a sequential structure for the model would generate the same commitment problem only if it were “open ended.”
As formally derived in Proposition 7, in analogy to expression (20) for the threshold $\psi$ with observable retention, we now obtain, without observability, the threshold

$$
\psi_{nc} := \left( -\eta_B - \frac{\Delta K}{1 - \mu} - \frac{\tau \tilde{R}_{GB}}{1 - \mu} \right) \frac{1}{p_G - \tilde{R}_B - \tau \frac{\tilde{R}_{GB}}{1 - \mu}}.
$$

As previously, we now ask when it is profitable for the bank to induce the agent to make only good loans and then securitize only the fraction $\psi_{nc}$, instead of making and fully securitizing all loans. Note that, by construction, the choice of $\psi_{nc}$ ensures that, at $\psi_{nc} = \psi_{nc}$, it just does not pay to deviate by no longer inducing the agent to screen and then “secretly” sell the remaining fraction $1 - \psi_{nc}$ at $p_{GB}$, while still selling the fraction $\psi_{nc}$ at $p_G$. When $\psi_{nc} > 0$, it is then a fortiori not more profitable to make all loans and securitize all of them at $p_{GB}$.

**Proposition 7.**

Consider the game where, when a loan is securitized, each investor observes only the size of his tranche, $\psi_n$, but not the share that the bank retains. Let the number of potential investors go to infinity: $N \to \infty$. Then, taking the limit of the symmetric outcome that is supported by Forward Induction, we have the following:

1. If $\psi_{nc} > 0$, as given in Equation (27), the bank sells the fraction $\psi_{nc}$ and induces the agent to make only good loans.
2. If $\psi_{nc} < 0$, all loans are made and then fully securitized ($\psi_{nc} = 1$).
3. If $\psi_{nc} = 0$, both outcomes with $\psi_{nc} = 0$ (no securitization) and $\psi_{nc} = 1$ (full securitization) can be supported.

As is intuitive, we have that $\psi_{nc} < \psi$ whenever $\psi$ is positive. The “commitment” to make only good loans is more difficult to achieve when the bank’s own residual exposure is not observed. As a consequence, without commitment, it is less likely that bad loans will be screened out [Formally, Condition (22) is implied by the new condition $\psi_{nc} \geq 0$.].

### 6.2.1 Regulation with unobservable retention

Consider, first, the impact of mandatory deferred bonus pay. Recall from our previous analysis that this affects the equilibrium outcome only through its effect on the compensation cost increment, $\Delta K$ instead of $\Delta K$. As this does not depend on whether or not retention is observable, our previous results fully extend to the case with unobservable retention. Hence, irrespective of whether or not retention is observable, regulating compensation can lead to
an increase in the quality of loans only when $\delta > \hat{\delta}$. Instead, when $\delta \leq \hat{\delta}$, only a regulation of the bank’s securitization activity is effective.

Interestingly, in stark contrast to the case where the bank’s retained stake was observable (cf. Proposition 6), the bank may now benefit from the imposition of a minimum retention requirement. This allows the bank to “commit,” at lower cost, to inducing the agent to make fewer but better loans. Precisely, the respective cost difference is given by the otherwise foregone benefits from securitization $(\psi - \psi_{\text{nc}})\tau G$. Incidentally, when without regulation, the bank would still want to retain the fraction $1 - \psi_{\text{nc}}$, the imposition of a minimum retention requirement, $1 - \psi$, leads to a higher level of securitization. In this case, regulation generates the efficiency gains $(\psi - \psi_{\text{nc}})\tau G$ even though it does not affect the average quality of loans. As the characterization of the optimal choice between regulating securitization or compensation, or both, is the same as in Proposition 4, we omit a formal proof of the preceding discussion.

7. Conclusion

Our model offers a rationale for why mandatory deferred bonus pay may increase the quality of loans in the presence of securitization, as it helps banks to overcome a commitment problem vis-à-vis the buyers of their securities. At the heart of our argument is the interaction between a bank’s internal agency problem and its external agency problem from securitization. This establishes a link between the compensation structure that the bank provides to its own agents, the quality of its loans, and its securitization strategy.

The ability to securitize creates a commitment problem, which is more severe when the bank cannot commit to retain some exposure. While we show that this may be mitigated through mandatory deferred compensation, this can “backfire” and lead, instead, to a deterioration of loan quality. We also analyze the implications of the requirement for banks to retain a minimum exposure to their originated deals. This is only in the bank’s own interest when, without such a regulation, the unobservability of the bank’s retained exposure creates an additional commitment problem. When deferred compensation is not too inefficient, so that its imposition does not “backfire,” mandatory retention and mandatory deferred compensation can become complementary in reducing a bank’s opportunism vis-à-vis the investors in its securities. This is the case when regulating compensation reduces the minimum retention required to induce the bank
to create the appropriate incentives for its own agents to screen out bad loans.

Banks are more likely to fully securitize a loan, while also making pay more volume-oriented and short-term incentives, when the internal agency problem is more severe, as this implies higher incremental costs of inducing agents to screen out bad loans. Further predictions of our model relate to the benefits from securitization and to average quality of the loan pool. Generally, the model predicts how the quality of loans, the level of securitization, and the structure of pay should move together.

**Supplementary Data**

Supplementary Data are available at *Review of finance* online.

**Appendix A**

**Proof of Proposition 1.** Note first that by optimality and limited liability, it must hold that $w_1(l) = w_2(R_l) = 0$. Once we substitute and transform the binding incentive Constraints (4) and (5)—i.e.,

$$\frac{c}{\mu} = (\rho_G - \rho_B)w_1(h) + \delta(\gamma_G - \gamma_B)w_2(R_h)$$

and

$$w_1(h) = \frac{c}{\mu \rho_G - \rho_B} - \frac{1}{\rho_G - \rho_B} - \delta w_2(R_h) \frac{\gamma_G - \gamma_B}{\rho_G - \rho_B},$$

the expected wage costs $K$ in Equation (6) can be written as:

$$K = c + \frac{c}{\mu \rho_G - \rho_B} + \left(1 - \delta\right)\mu \gamma_G - \delta \left(\frac{1 - q}{2q - 1}\right)w_2(R_h).$$

Then, from differentiation, $w_2(R_h) \geq 0$ is optimal when $\delta \geq \tilde{\delta}$ and $w_1(h) \geq 0$ when $\delta \leq \tilde{\delta}$. The respective values for $w_1(h)$, $w_2(R_h)$, and $\bar{w}$ then follow immediately from the binding incentive Constraints (4) and (5), together with $w_2(R_h) = 0$ in Case (1) and $w_1(h) = 0$ in Case (2).

**Proof of Lemma 1.** It remains to characterize for the continuation game with given $\psi$ the equilibrium in mixed strategies when $\psi \in (\underline{\psi}, \bar{\psi})$. Denote by $\lambda$ the probability that the bank will induce the agent to reject bad loans and
let \( \hat{\lambda} \) be the investors’ expectations about \( \lambda \). Investors, thus, believe that \( \theta = G \) with probability

\[
\mu(\hat{\lambda}) := \frac{\mu}{\lambda \mu + (1 - \hat{\lambda})},
\]

such that their willingness to pay is given by

\[
p = (1 + \tau) \left[ \mu(\hat{\lambda}) \tilde{R}_G + (1 - \mu(\hat{\lambda})) \tilde{R}_B \right]. \tag{A.1}
\]

Further, using \( V_G \) and \( V_{GB} \) from Equations (18) and (19), respectively, we find that the bank is indeed indifferent when

\[
\psi \tilde{R}_B - \eta_B - \frac{\Delta K}{1 - \mu} = \psi p. \tag{A.2}
\]

Once we substitute Equation (A.1) for \( p \) and use that \( \lambda = \hat{\lambda} \) (rational expectations), we obtain

\[
\lambda = \frac{1}{1 - \mu} \left( 1 - \mu \frac{(\tilde{R}_G - \tilde{R}_B)(1 + \tau)}{-\Delta K/(1 - \mu - \eta_B) - \tau \tilde{R}_B} \right). \tag{A.3}
\]

Note that indeed \( \lambda = 1 \) at \( \psi = \frac{\psi}{\psi} \) (provided this is positive), while \( \lambda = 0 \) at \( \psi = \tilde{\psi} \).

**Proof of Proposition 2.** It remains to show that the bank never sets \( \psi \in (\tilde{\psi}, \psi) \). Substituting from Equation (A.3) for the resulting equilibrium mixing strategy, the bank’s profits are then given by

\[
\mu \left[ \eta_G - \eta_B - \psi(\tilde{R}_G - \tilde{R}_B) \right] - \frac{K_G - \mu K_{GB}}{1 - \mu},
\]

which is strictly decreasing in \( \psi \), implying that \( \psi \) dominates any \( \psi \) that induces \( \lambda < 1 \).

**Proof of Proposition 3.** The original game with ex post securitization can be represented more formally as follows. At Stage 1, the bank decides on the “quality” \( Q \in \{G, GB\} \), where the strategy \( \lambda \) is the probability that \( Q = G \) is implemented at cost \( K_G \) instead of \( Q = GB \) at cost \( K_{GB} \). At Stage 2, a securitization strategy \( \sigma(\psi|Q) \) specifies the probability that offer \( \psi \) is made, given the actually chosen compensation strategy and the thereby achieved quality of loans \( Q \). At Stage 3, investors then buy at the fair
price, given their updated beliefs. Investors’ beliefs are given by a probability distribution \( \mu(G|\psi) \) over \{G, GB\}, which is formed according to Bayes’ rule when possible—i.e., given the observed \( \psi \) and the equilibrium strategies \( \lambda^* \) and \( \sigma^*(\cdot) \), it holds that

\[
\mu^*(G|\psi) = \frac{\mu\lambda^*\sigma^*(\psi|G)}{\mu\lambda^*\sigma^*(\psi|G) + (1 - \lambda^*)\sigma^*(\psi|GB)}.
\]

We first support a perfect Bayesian equilibrium that generates the outcome from the auxiliary game of Proposition 2. If Condition (24) holds, we specify \( \lambda^* = 1 \) and \( \sigma^*(G|\psi) = 1 \). If the converse holds strictly, we specify \( \lambda^* = 0 \) and \( \sigma^*(G|\psi) = 1 \). If the condition holds with equality, we specify \( \lambda^* \in [0,1] \) and \( \sigma^*(G|\psi) = \sigma^*(1|GB) = 1 \). For investors, we specify the beliefs

\[
\mu^*(G|\psi) = \begin{cases} 1 & \text{if } \psi \leq \bar{\psi}, \\ 0 & \text{if } \psi > \bar{\psi}, \end{cases}
\]

implying the price function

\[
p^*(\psi) = \begin{cases} p_G & \text{if } \psi \leq \bar{\psi}, \\ p_{GB} & \text{if } \psi > \bar{\psi}. \end{cases}
\]

We show next that this is also the unique outcome that is consistent with Forward Induction. Take any candidate equilibrium where the bank would, after implementing \( Q = G \), choose some \( \psi = \tilde{\psi} < \bar{\psi} \). To support this, after observing \( \hat{\psi} \in (\tilde{\psi}, \bar{\psi}) \), investors must put positive probability on \( Q = GB \). However, for \( \tilde{\psi} < \bar{\psi} \), the bank would be strictly better off if it had chosen \( Q = G \), such that this strategy profile is ruled out by Forward Induction. An analogous argument holds for any “pooling strategy,” where \( \lambda^* \in (0,1) \) and, subsequently, \( \sigma^*(\psi|G) = \sigma^*(\psi|GB) = 1 \).

**Proof of Corollary 2.** Note, first, that Condition (22) can be rewritten in the following way:

\[
\mu \psi \tau \tilde{R}_G - \Delta_K > \tau \tilde{R}_{GB} + (1 - \mu)\eta_B.
\]  

(A.4)

Differentiating the LHS of Equation (A.4) w.r.t. \( \tau \) yields

\[
\mu \tilde{R}_G \psi + \mu \tau \tilde{R}_G \left( \frac{d\psi}{d\tau} \right) < \mu \tilde{R}_G,
\]

where we use that

\[
\frac{d}{d\tau} \psi = \left[ \frac{\Delta_K}{1 - \mu} + \eta_B \right] \frac{\tilde{R}_G}{\left[ \tilde{R}_G(1 + \tau) - \tilde{R}_B \right]^2} < 0,
\]
while differentiating the RHS w.r.t. $\tau$ yields $\mu \tilde{R}_G + (1 - \mu) \tilde{R}_B > \mu \tilde{R}_G$. Next, differentiating the RHS of (22) w.r.t. $q$, we have for $\delta \leq \tilde{\delta}$

$$
\left( \frac{c}{1 - \mu} \right) \left( \frac{1}{\gamma_G - \gamma_B} \right) \left( \frac{1}{2q - 1} \right)^2 \left( 1 - \mu - \frac{\tilde{R}_G - \tilde{R}_B}{\tilde{R}_G(1 + \tau) - \tilde{R}_B} \right) > 0,
$$

while the condition is not affected when $\delta > \tilde{\delta}$. We differentiate the RHS of (22) w.r.t. $c$ to obtain

$$
- \frac{d \Delta_K}{dc} \frac{1}{1 - \mu} \left( 1 - \mu \frac{\tilde{R}_G - \tilde{R}_B}{p_G - \tilde{R}_B} \right) < 0,
$$

where we use that $d \Delta_K/dc > 0$ follows from inspection of $K_1$ and $K_2$ in Equations (12) and (13), respectively. Finally, differentiating the RHS of Equation (22) w.r.t. $\delta$ yields for $\delta \geq \tilde{\delta}$

$$
\frac{1}{\delta^2} \left( \frac{c}{1 - \mu} \right) \left( \frac{\gamma_G}{\gamma_G - \gamma_B} \right) \left( 1 - \mu \frac{\tilde{R}_G - \tilde{R}_B}{\tilde{R}_G(1 + \tau) - \tilde{R}_B} \right) > 0,
$$

while the condition is not affected when $\delta < \tilde{\delta}$. 

\textit{Proof of Proposition 4.} Suppose that deferred bonus compensation is made mandatory, such that $w_1(\cdot) = 0$. As discussed in the main text, we can fully apply the arguments leading to Proposition 2 for the unregulated case, as well as the respective expressions, once we replace $\Delta_K$ by $\Delta_K^R$. This yields expression (23) for $\psi^R$ and Condition (24) for the characterization of the equilibrium with regulation.

Comparing the outcomes with and without regulation, given the argument in the main text, we can restrict consideration to the case where $\delta < \tilde{\delta}$. The incremental costs $K_G^R - K_G$ are then strictly positive and equal to

$$
c \left( \frac{1 - \delta}{\delta} \right) \left( \frac{\gamma_G}{\gamma_G - \gamma_B} \right) - \left( \frac{c}{\mu} \right) \left( \frac{1}{\gamma_G - \gamma_B} \right) \left( \frac{1 - q}{2q - 1} \right).
$$

Comparing this to

$$
K_G^R - K_{GB} = c \left( \frac{1 - \delta}{\delta} \right),
$$

we have that Equation (25) holds only if $\delta > \hat{\delta}$, where $\hat{\delta}$ is given by Equation (26). Finally, $\hat{\delta} < \tilde{\delta}$ follows from inspecting the respective definitions in (26) and (7), while noting that $\gamma_G > \gamma_B$. 

\hfill \blacksquare
Proof of Corollary 4. From the discussion in the main text, we can restrict consideration to $\delta > \hat{\delta}$. Regulation then (weakly) increases the bank’s profits when

$$\mu \tau \psi^R_R - K^R_G \geq \tau \tilde{R}_{GB} + (1 - \mu)\eta_B - K_{GB},$$

which after substitution and rearranging yields the condition

$$\delta \geq \delta_b := \left(1 + \frac{B - C}{A}\right)^{-1}, \quad (A.5)$$

where

$$A = c\left[\left(\frac{\gamma_B}{\gamma_G - \gamma_B}\right) + \left(\frac{1}{1 - \mu}\right)\left(\frac{\gamma_B}{\gamma_G - \gamma_B}\right)\frac{\mu \tau \tilde{R}_G}{\tilde{R}_G(1 + \tau) - \tilde{R}_B}\right],$$

$$B = -\tau \tilde{R}_{GB} - \eta_B \left(1 - \frac{\tilde{R}_G - \tilde{R}_B}{\tilde{R}_G(1 + \tau) - \tilde{R}_B}\right) - \left(\frac{c}{\mu}\right)\left(\frac{1}{1 - \mu}\right)\left(\frac{\gamma_B}{\gamma_G - \gamma_B}\right)\frac{\mu \tau \tilde{R}_G}{\tilde{R}_G(1 + \tau) - \tilde{R}_B},$$

$$C = \left(\frac{c}{\mu}\right)\left(\frac{\gamma_B}{\gamma_G - \gamma_B}\right).$$

Likewise, social surplus (weakly) increases when

$$\mu \tau \psi^R_R - K^R_G + \frac{c}{\mu \gamma_G - \gamma_B} \geq \tau \tilde{R}_{GB} + (1 - \mu)\eta_B - K_{GB},$$

which transforms to

$$\delta \geq \delta_r := \left(1 + \frac{B}{A}\right)^{-1}. \quad (A.6)$$

Finally, $\delta_r < \delta_b$ follows from inspecting the respective definitions in Equations (A.5) and (A.6). 

Proof of Proposition 5. Suppose, first, that the bank wants to induce the agent to screen out bad loans. The derivation of the optimal compensation is then analogous to Proposition 1, with the only difference that the bank’s cost from paying a given after tax early bonus is now $(1 + T)w_1(h)$. This obtains a threshold $T_G$, such that deferred pay is now optimal when $T \geq T_G$, where

$$\frac{T_G}{1 - T_G} := \frac{1}{\rho_G}\left[\frac{1 - \delta}{\delta}(2q - 1)\gamma_G - \frac{1}{\mu}(1 - q)\right].$$
Note that $T_G > 0$ holds only when $\delta < \hat{\delta}$. With a bonus tax, we thus have for $T \geq T_G$ that $K^T_G := K_2$, while for $T < T_G$, we have

$$K^T_G := c + \frac{c}{\mu} \frac{\rho_B}{\rho_G - \rho_B} + c - \frac{\rho_G}{\rho_G - \rho_B} \frac{T}{1 - T}. \quad (A.7)$$

Now recall that $K^T_{GB} := \min \{ \frac{c}{1 - T}, \frac{c}{\delta} \}$. Further, to determine the impact of a bonus tax, we have again to determine only the sign of the change in incremental compensation costs, which changes from $\Delta^K$ to $\Delta^K_T := K^T_G - K^T_{GB}$. When $T \leq T_G$ and $\delta < \hat{\delta}$, we have that

$$\Delta^K_T - \Delta^K = c \frac{\rho_B}{\rho_G - \rho_B} \frac{T}{1 - T}. \quad (A.7)$$

When $T_G < T \leq 1 - \delta$ and $\delta < \hat{\delta}$, we have that $\Delta^K_T = K_2 - c/(1 - T)$, such that $\Delta^K_T - \Delta^K < 0$ only if $\delta > \delta_T$. Finally, when $T \geq 1 - \delta$, we have that $\Delta^K_T = K_2 - c/\delta$, which from Proposition 4 is smaller than $\Delta^K$ iff $\delta \geq \delta$.

**Proof of Proposition 6.** Consider first $\delta \leq \hat{\delta}$. When only a minimum retention requirement is introduced, total surplus is given by

$$\Omega_r := \mu \tau \psi \tilde{R}_G + \mu \eta_G - c, \quad (A.8)$$

and if also a mandatory deferred pay rule is introduced, it equals

$$\Omega_c := \mu \tau \psi^R \tilde{R}_G + \mu \eta_G - c - \left(\frac{1 - \delta}{\delta}\right) \left(\frac{\gamma_G}{\gamma_G - \gamma_B}\right). \quad (A.9)$$

Now, for $\delta \leq \hat{\delta}$, we know from our prior analysis that $\psi^R \leq \psi$ and, thus, as then $\Omega_r > \Omega_c$, bonus pay should not be regulated. For $\delta \in (\hat{\delta}, \hat{\delta})$, in contrast, we have that $\psi^R > \psi$. Comparing Equation (A.8) to (A.9) yields that $\Omega_r \geq \Omega_c$ only if $\tilde{\delta} \geq \tilde{\delta}$, which is given by

$$\tilde{\delta} = \frac{\hat{\delta}}{1 - \delta} + \frac{\tilde{R}_G(1 + \tau) - \tilde{R}_B}{\tau \tilde{R}_G} \left(1 - \mu\right) \gamma_G \left(\frac{2q - 1}{1 - q}\right).$$

If $\delta \in (\hat{\delta}, \hat{\delta})$, therefore, also pay should be regulated. The same is true if $\delta \geq \tilde{\delta}$. To see this, note that total surplus under only minimum retention then equals

$$\Omega_r := \mu \tau \psi \tilde{R}_G + \mu \eta_G - c - \left(\frac{1 - \delta}{\delta}\right) \left(\frac{\gamma_G}{\gamma_G - \gamma_B}\right),$$

while if also bonus pay is regulated, total surplus is given by Equation (A.9). The result follows as, for $\delta \geq \tilde{\delta} > \hat{\delta}$, we have that $\psi^R > \psi$ holds strictly.
Proof of Proposition 7. Recall that we restrict attention to the symmetric case. As in Proposition 3, beliefs are a function of the observed offered tranche $\hat{\psi}_n$. We stipulate again that, conditional on the beliefs, $\mu(\cdot|\psi_n)$, the security is fairly priced. When the bank makes only good loans, then its payoff is

$$V_G := \mu(p - \bar{R}_G)N\hat{\psi} + \mu\eta_G - K_G,$$

where in equilibrium $p = p_G$. Suppose that the bank deviates in the following way. It does not induce the agent to screen and securitizes the full loan by selling to $N - 1$ investors, a total share of $(N - 1)\hat{\psi}$ at $p = p_G$; while selling to one investor, the whole residual $1 - (N - 1)\hat{\psi}$ at price $p = p_{GB}$. The respective payoff is then

$$V_{dev} := (p_G - (1 + \tau)\bar{R}_{GB})(N - 1)\hat{\psi} + \tau\bar{R}_{GB} + \mu\eta_G + (1 - \mu)\eta_B - K_{GB},$$

(A.10)

such that $V_G \geq V_{GB}$ holds only when

$$N\hat{\psi} \leq \psi_{\underline{nc}}(N):$$

$$= \frac{-(1 - \mu)\eta_B - \Delta_K - \tau\bar{R}_{GB}}{(1 - \mu)[(1 + \tau)\bar{R}_G - \bar{R}_B] - \tau\bar{R}_{GB} - \frac{(1+\tau)(1-\mu)(\bar{R}_G - \bar{R}_B)}{N}},$$

where $\psi_{\underline{nc}}(N)$ is (when positive) strictly increasing in $N$ with $\psi_{\underline{nc}}(N) \rightarrow \psi_{\underline{nc}}^*$, as given in Equation (27).

We now first support the following (Perfect Bayesian Equilibrium) outcome: (i) When $\psi_{\underline{nc}}(N) \geq 0$, the bank induces the agent to make only good loans and then sells to each investor the fraction $\psi^*_n = \psi_{\underline{nc}}(N)/N$; (ii) when $\psi_{\underline{nc}}(N) < 0$, the bank induces the agent to make both good and bad loans and then sells to each investor the fraction $\psi^*_n = 1/N$. We stipulate the following beliefs: $\mu(G|\psi_n) = 1$ when $\psi_n \leq \psi_{\underline{nc}}(N)/N$ and $\mu(GB|\psi_n) = 1$ when $\psi_n > \psi_{\underline{nc}}(N)/N$. To see that this choice supports the equilibrium characterization, note from the discussion in the main text that when $\psi_{\underline{nc}}(N) > 0$, then the bank is strictly worse off by making all loans and then securitizing all of it in a more “transparent” way—i.e., by offering to more than one investor a higher fraction than $\psi_{\underline{nc}}(N)/N$.

It now remains to show that the characterized outcome is uniquely supported by Forward Induction. For brevity, we conduct the argument for the case where beliefs specify either $\mu(G|\psi_n) = 1$ or $\mu(GB|\psi_n) = 1$, such that in any symmetric equilibrium where $\psi^*_n < 1$ is chosen it must
hold, from \( \tau > 0 \) and from optimality for the bank, that \( \mu(GB|\psi_n) = 1 \) for all \( \psi_n > \psi_n^* \), while \( \mu(G|\psi_n^*) = 1 \) when \( 0 < \psi_n^* < 1 \) (The case where \( \psi_n^* = 0 \) is degenerate, as then there is no sale to investors.). Note also that from the previous discussion, it must hold that \( \psi_n^* \leq \psi_{nc}(N)/N \) when \( Q^* = G \). It remains to show that when \( \psi_{nc}(N)/N > 0 \), the unique outcome specifies \( Q^* = G \) and \( \psi_n^* = \psi_{nc}(N)/N \).

Recall that under Forward Induction, when an investor \( n \) observes (unexpectedly) \( \psi_n \neq \psi_n^* \), he must assume that the bank has chosen its unobserved strategies rationally. In contrast to Proposition 3, this includes now also believes over the vector \( \psi_{-n} \). Take, thus, a deviation \( \psi_n^* < \psi_n < \psi_{nc}(N)/N \). We argue that in anticipation of this move, the bank is strictly better off with \( Q = G \) than with \( Q = GB \). For this note, the maximum payoff that the bank could realize with \( Q = GB \) is obtained as follows. We know that in the candidate equilibrium, it must hold that \( \mu(GB|\psi_n) = 1 \) for all \( \psi_n > \psi_n^* \). Hence, the bank would then optimally either choose \( \psi_{n'} = \psi_n^* \) (and earn \( p_G \)) for all \( n' \neq n \) or, instead, \( \psi_{n'} = 1 - (N - 2)\psi_n^* - \psi_n \) for only one \( n' \) (and earn \( p_{GB} \) on this fraction). However, by construction of \( \psi_{nc}(N)/N \), the bank’s payoff from either choice is strictly inferior to that of choosing \( \psi_n^* = \psi_{nc}(N)/N \) and \( Q = G \).

References


25 See Govindan and Wilson (2009) for a representation. With respect to simultaneous moves, this is then similar in spirit to the use of “wary beliefs” in the Industrial Organization literature (e.g., McAfee and Schwartz, 1994).


