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Résumé

Cet article analyse l'impact de la titrisation sur la concurrence dans le marché primaire du crédit. Nous développons un modèle de concurrence par les prix sur plusieurs périodes, avec décision stratégique par les banques concernant leur intensité de contrôle (*monitoring*) des emprunteurs, et coûts de changements de banque pour les emprunteurs. Dans cet environnement, nous montrons que la titrisation peut avoir un effet d'adoucissement de la concurrence. Cet effet induit une augmentation des profits bancaires via l'extraction de rente dans le marché primaire, et dans le même temps une baisse de l'efficience du marché du crédit. Sur un plan empirique, les résultats suggèrent que le développement de la titrisation peut-être dû en partie à une intensification de la concurrence sur les marchés de crédit. L'analyse suggère également que les réformes ne devraient pas se limiter aux problèmes d'information sur les marchés de produits titrisés, mais aussi prendre en compte les conditions de concurrence sur les marchés primaires.

Mots-clés: titrisation, concurrence bancaire, contrôle des emprunteurs
Code JEL: G21, L12, L13

Abstract

We analyze the impact of loan securitization on competition in the loan market. Using a dynamic loan market competition model where borrowers face both exogenous and endogenous costs to switch between banks, we uncover a competition softening effect of securitization that allows banks to extract rents in the primary loan market. By reducing monitoring incentives, securitization mitigates winner's curse effects in future stages of competition thereby decreasing *ex ante* competition for initial market share. Due to this competition softening effect, securitization can adversely affect loan market efficiency while leading to higher equilibrium profits for banks. This effect is driven by primary loan market competition, not by the exploitation of informational asymmetries in the secondary market for loans. We also argue that banks can use securitization as a strategic response to an increase in competition, as a tool to signal a reduction in monitoring intensity for the sole purpose of softening *ex ante* competition. Our result suggests that securitization reforms focusing exclusively on informational asymmetries in markets for securitized products may overlook competitive conditions in the primary market.

Keywords: securitization, loan sales, banking competition, monitoring, rent extraction
JEL: G21, L12, L13

1 Introduction

The financial crisis triggered by the US subprime mortgage sector has had an unprecedented negative impact on the real economy and on the banking sector. There is widespread consensus that losses related to securitized products such as MBS or CDOs were at the heart of the financial crisis, and a number of discussions have followed among practitioners, academics and regulators concerning how to reform securitization activities.[1]

Indeed, several recent empirical studies suggest that higher securitization activity is associated with a reduction in loan quality. Evidence along this line has been documented for subprime mortgages (Dell'Ariccia, Igan and Laeven, 2008, Mian and Sufi, 2009, Keys, Mukherjee, Seru and Vig, 2010, Purnanandam, 2011) as well as for corporate loans (Berndt and Gupta, 2009, Gaul and Stebunovs, 2009). This literature argues that the originate-to-distribute (OTD) model of lending based on securitization was a main cause of the crisis. When lenders and securitizers retain insufficient skin in the game, incentives get distorted along the securitization chain, leading to lax monitoring and screening, as well as intentional sales of low quality loans. Theoretical contributions with opaque secondary markets have analyzed these incentive dilution effects (Morrison, 2005, Parlour and Winton, 2008).

This negative view of securitization raises a fundamental question. According to contemporary banking theory, screening and monitoring are at the core of banks' expertise (Bhattacharya and Thakor, 1993). Reduction in those core activities should therefore lead to an erosion in value creation by, and ultimately profits of banks. One may thus ask why, unless there are huge direct benefits, banks' increasing participation in the OTD model before the crisis was not penalized by decreasing profits or share prices.

In this paper, we argue that higher securitization can allow banks to make more profits by extracting rents from their borrowers in the primary loan market. An alternative explanation, consistent with the above cited papers, is that originating banks exploit investors' inability to understand and price securitized products. In other words, banks' profits are simply the counterpart of (future) losses by unsuspecting final investors in the secondary market. However, this reasoning hinges on the notion that buyers of securitized products are unsophisticated investors, contradicting the fact that many buyers were themselves banking institutions. We find it more natural to explore potential rent extraction from other agents that are much less sophisticated than banks: clients in the primary loan market.

Our paper analyzes the interaction between securitization and loan market competition and points to a softening competition effect of securitization. Specifically, we consider a simple duopoly model of the loan market where banks compete for borrowers over two periods. The framework has two main ingredients: borrowers

[1] See for example American Securitization Forum, Securities Industry and Financial Markets Association, Australian Securitisation Forum and European Securitisation Forum (2008), ECB (2008), Franke and Krahnen (2008).

face exogenous costs when switching from one bank to its competitor, and banks strategically choose the intensity of monitoring of their borrowers during the first period. As monitoring entails private information, the initial lending bank (which will be referred to as the relationship bank) has an informational advantage in the second period, when competing with the outside bank that tries to poach its first-period clients. A key aspect of the framework is that, due to the presence of switching costs, banks earn profits from poaching their competitors clients. In equilibrium, banks make positive profits equal to these poaching profits.

In this setup, we show that securitization has a competition softening effect. Selling to outsiders the cash flow that will be generated by (a fraction of) the loan portfolio reduces banks' monitoring incentives, in line with the papers on the dark side of securitization. As a side effect, banks have less private information about their own clients, which in equilibrium makes poaching more profitable, because of the less acute informational asymmetry that exists between the relationship bank and the outside bank. In turn, the *ex ante* (first period) market share becomes less important, as banks can more profits from poaching in the second period. Eventually, this softens *ex ante* competition, leading to higher overall banking profits in equilibrium.

Those results have two broad implications. First, we highlight an additional effect—a rent extraction, or surplus distribution effect—of securitization, thereby contributing to the literature on the *consequences* of securitization. As we discuss in section 3.5, due to the competition competition effect, under certain conditions securitization can increase banks' profits but worsens overall loan quality and loan market efficiency. As mentioned above, this increase in profits is not driven by the exploitation of informational asymmetries in the secondary market for loans, but by rent extraction in the primary market. Secondly, our results suggest that banks can strategically use loan securitization to soften the effect of loan market competition, thereby contributing to the literature on the *motivation* for securitization. We show that, because of the competition softening effect, securitization can be used as a response to an (exogenous) increase in competition. In our model, securitization is used as a tool to signal a reduction in the intensity of monitoring, which in turn mitigates *ex ante* competition as competitor banks know that they can poach their rival's borrowers in a future round of competition. As we argue in section 4.3, this may explain the concomitant increase in competition, massive securitization, and reduction in credit standard that took place before the crisis.

Regarding policy implications, our results suggest that new regulations that only target securitization markets may not be sufficient. In the US, the main recommendations (on securitization) of the Dodd-Frank Wall Street Reform and Consumer Protection Act enacted on July 2010 require better information disclosure on securitized products, and more skin in the game for securitizers through a 5% minimum retention of the securitized portfolio. The European Union has also adopted a similar proposal requiring originators to hold at least 5% of the securitized portfolio.[2]

[2]For more details, see IX.D. of the Dodd-Frank Act "Improvements to the Asset-Backed Securi-

As such, these reforms focus exclusively on the problems related to informational asymmetries between sellers and buyers in the secondary market. However, this line of prescription may overlook the other side of securitization activity: the market for the underlying asset (in particular the loan market).

The rest of the article is as follows. In the reminder of this section we discuss related literature. Section 2 presents the general environment of the model. Section 3 proceeds with the equilibrium analysis and shows how securitization affects competition, monitoring and loan market efficiency. Section 4 discusses some broad implication of the competition softening effect, and in particular how the increase in securitization can be related to an increase in competition. Most proofs are relegated to an appendix.

1.1 Related literature

Our paper is related to several strands of the literature. First of all, it is related to the literature on the relationship between securitization/loan sales and bank monitoring. Morrison (2005) and Parlour and Plantin (2008) showed that such credit risk transfer instruments reduce banks incentives to monitor their borrowers when there is informational asymmetry between loan-selling banks and buyers, a situation that is harmful in terms of social welfare. In our article, we demonstrate similar results regarding monitoring incentives and social welfare. However, the reduction in monitoring is neither an unintended consequence of securitization nor motivated by the exploitation of informational asymmetries in the secondary loan market, as suggested in their models, but by the intention to soften competition in the future. Our analysis thus sheds light on the current discussion on regulations in the securitization market, and suggests a new dimension that policy makers must consider.

On the other hand, our study is also obviously related to the literature on the motivation of loan securitization. One commonly held idea concerning the rationale for securitization is banks' perspective on risk management, according to which banks use securitization to transfer or diversify credit risks (Allen and Carletti, 2006, Wagner and Marsh, 2006, etc.). Another well-known argument is that of the regulatory arbitrage associated with capital requirements (Acharya, Schnabl and Suarez, 2013, Calomiris and Mason, 2004, Carlstrom and Samolyk, 1995, Duffee and Zhou, 2001, Nicolo and Pelizzon, 2008). Given that capital is more costly than debt, the retention of a proportion of capital for loans in a balance sheet creates additional cost for banks. By taking this loan off their balance sheet, they can save their capital. A third argument is related to the more efficient recycling of bank funds (Gorton and Pennacchi, 1995, Parlour and Plantin, 2008). With a constraint on funds, retaining a loan until maturity involves an opportunity cost if banks have other more profitable lending opportunities. By using securitization, banks can recuperate their funds earlier, and redeploy them in another investment project. We offer a novel explanation of

tization Process" and Article 122a, European Parliament, 2009.

why banks securitize their loans: banks can strategically use securitization to soften competition in the primary loan market.

Thirdly, this article is related to the literature concerning the link between relationship banking and loan market competition. Peterson and Rajan (1995) show that banks have a greater incentive to develop their relationship with new borrowers when loan markets are less competitive and more concentrated. Boot and Thakor (2000) show that banks may refocus on relationship lending in order to survive in the face of interbank competition, because this allows banks to shield their rent better. However, we show that a relationship banking orientation can increase *ex ante* competition in order to capture more new clientele so as to extract rent in the future, which in turn reduces overall profit. We hence add a dynamic perspective to the link between relationship banking and loan market competition.

Our analysis also contributes to the literature on the strategic use of information in imperfectly competitive credit markets. Hauswald and Marquez (2006) analyze banks' strategic use of information acquisition as a barrier to entry. In our environment with competition over multiple periods, banks strategically reduce information acquisition to mitigate the consequences of entry. In a framework related to ours, Gehrig and Stenbacka (2007) and Bouckaert and Degryse (2004) show that, when the initial lender automatically obtains proprietary information about former clients, banks can use information sharing to soften *ex ante* competition. We show that securitization has a similar softening competition effect, in a setup with endogenous monitoring.

It can also be interesting to relate our analysis to some recent studies on the interaction between lending capacity and imperfect banking competition. Schliephake and Kirstein (2013) show that in the presence of regulatory minimum capital requirements, banks can choose their capital structure as an imperfect commitment to a loan capacity. When raising additional capital is sufficiently costly, this precommitment allows banks to reduce the fierceness of (Bertrand) loan rate competition and obtain the profits that would prevail under Cournot competition. We show that securitization can be used strategically to soften price competition, even when banks are not constrained in their lending capacity. Hakenes and Schnabel (2010) and more recently Huang, Li and Sun (2013) analyze the link between limited lending capacity and securitization. In those papers an increase in lending competition reduces banks capacity to provide on-the-balance-sheet funding to risky borrowers, inducing banks to securitize to expand their lending capacity. This lending capacity channel suggests an indirect link between competition and securitization. We provide a different mechanism linking competition and securitization, by modeling a direct anticompetitive effect of securitization.

2 Environment

We consider a two-period duopoly model with two banks, A and B. They compete in two subsequent periods over loan rates (Bertrand price competition) by offering short-term loan contracts to a unit mass of borrowers. Banks have access to unlimited funds at the market rate r, which we normalize to zero for simplicity.

2.1 Borrowers and banks

Borrowers can be of two types, $\theta \in \{H, L\}$. H borrowers (a fraction λ) have access to one positive NPV project in each period that yields output Y with probability $p_H > 0$ (and 0 otherwise) for a fixed outlay of I. Type H are good borrowers that never shirk when managing a project.[3]

In contrast, type L borrowers (a fraction $1 - \lambda$) have access to two different *negative* NPV projects in the first period. His "best" project yields output Y with probability $p_L > 0$ and no private benefits; however, he can also choose a project that delivers private benefits $B > 0$ but always fail. Private benefits B are large enough so that unmonitored (L-) borrowers always choose their worst alternative ("shirking"). As in (Holmstrom and Tirole, 1997), banks can prevent shirking by monitoring. Monitoring has two important effects. First, it raises the success probability of loans for L-types; in addition, by monitoring the borrower's behavior, the bank learns its type. This information is relationship specific and cannot be transferred to outsiders ("soft information"). To sum up, we posit

$$p_H Y > I > B > 0$$

$$I > p_L Y$$

We note by $\sigma^A, \sigma^B \in [0, 1]$, the intensity of monitoring that banks choose strategically. It is unobservable by third parties and monitoring is costly. Higher intensity of monitoring gives more precise signal on the type of the borrowers but incurs higher cost. In other words, the intensity σ requires a monitoring cost σc with $c > 0$. The bank i with σ^i receives a perfect signal on the type of the borrowers (H or L) with probability σ^i and does not receive any signal ($\varnothing$) with probability $1 - \sigma^i$. As two extreme cases, $\sigma^i = 1$ denotes the case in which bank i can distinguish perfectly H-type from L among its clientele, and $\sigma^i = 0$ corresponds to the case in which bank i does not monitor at all its clientele, implying that it has no additional information other than publicly observable one.

As we focus on how bank's monitoring incentives are shaped by the prospect of *future* competition, we abstract from monitoring in the second period, and simply assume that in the second period type L borrowers have access to one project that delivers private benefits B and fails surely.

[3] Or borrowers who never engage in excessive side consumption when they borrow to finance a home/car.

Projects' outcomes are observable (*e.g.* due to a credit bureau or a credit registry, in which the default record of borrowers are registered). Banks can use this information to update their beliefs about a borrower's type. The information content of the first period result depends on the monitoring behavior. Specifically, for a borrower financed by a bank that is expected to monitor its clients with intensity σ_e:

$$\begin{aligned}\Pr\left[H\left|Y,\sigma_e\right.\right] &= \frac{\lambda p_H}{\lambda p_H+(1-\lambda)\,\sigma_e p_L},\\ \Pr\left[H\left|0,\sigma_e\right.\right] &= \frac{\lambda(1-p_H)}{\lambda(1-p_H)+(1-\lambda)(1-\sigma_e p_L)}.\end{aligned}$$

For tractability, we assume that without additional pieces of information, it is always unprofitable to lend to a borrower who defaulted in the first period whereas the period 2-project of a borrower who succeeded in the first period has a *ex ante* positive NPV , that is,

$$\Pr\left[H\left|0,\sigma_e=1\right.\right]p_H Y-I < 0 \tag{1}$$

$$\Pr\left[H\left|Y,\sigma_e=1\right.\right]p_H Y-I > 0 \tag{2}$$

Finally, we also assume that making a loan in the first period is ex ante efficient, that is $\lambda p_H Y - I > 0$, and that

$$\lambda(1-p_H)(p_H Y-I)+(1-\lambda)\,p_L Y > c \tag{3}$$

Condition 3 simply states that the net *social* value of monitoring is positive.

2.2 Switching Costs

Borrowers can switch their banks in the second period but this incurs a switching cost. This cost is heterogeneous among borrowers, with the idiosyncratic switching cost (s) distributed uniformly on $[0,\bar{s}]$ for tractability. Borrowers learn their individual switching cost only at the end of the first period, and it is not observable by other parties, including banks. As a consequence, banks cannot make a contract conditional on individual switching costs. As will be clear, this will allow banks to make a positive profit under Bertrand price competition. The heterogeneity and private character of switching costs renders poaching a rival's borrowers profitable, as high quality borrowers with low switching costs will have an incentive to switch if the loan rate offer made by the outside bank is more attractive.

This assumption about the switching cost is quite natural, to the extent that borrowers' satisfaction or dissatisfaction with a bank may differ depending on the individual preference for the bank's services, and borrowers can only measure them exactly once they have had a relationship. Switching costs may capture the direct cost of closing an account with one bank and opening it elsewhere, the cost associated with a different application procedure with other banks, and also the loss of the relationship benefit between the borrower and his former bank.[4]

[4]The assumption on switching cost is supported by empirical evidence in the banking and credit

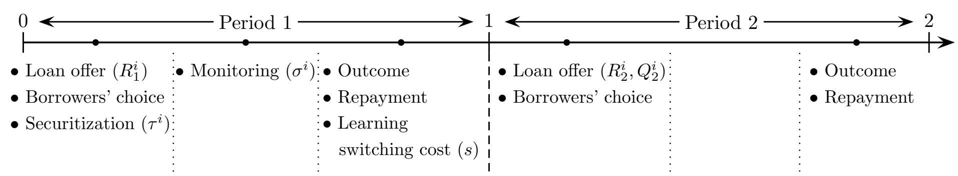

Figure 1: Timing

2.3 Securitization

We analyze two polar cases with respect to securitization: a benchmark economy where banks cannot securitize (section 3.3), and a case where securitized markets are open and banks choose the fraction of their loan portfolio to securitize (section 3.4).

Securitization occurs in period 1 after loan granting for period 1 projects. For simplicity, we assume that each bank issues pass-through securities on its whole loan portfolio, and sell a homogenous fraction $\tau^i \in [0,1]$ of loan repayment cash flows to outside investors. The residual fraction $1-\tau^i$ is retained on the balance sheet.[5]

The securitization market is perfectly competitive and populated by infinitely many rational investors with sufficient funds. This implies that the securities backed by the fraction τ^i of the loan portfolio of bank i will be priced at the expected present value of their future cash flow, given investors' available information and expectations. Revenues from securitizing for bank i are thus equal to $\mu^i \tau l^i \left(\sigma_e^i\right) R_1^i$, where

$$l^i\left(\sigma_e^i\right) \equiv \frac{1}{1+r}\left(\lambda p_H + \sigma_e^i\left(1-\lambda\right)p_L\right) = \lambda p_H + \sigma_e^i\left(1-\lambda\right)p_L \tag{4}$$

is the market price for a unit of loan repayment sold by bank i, which depends on investors' expectations regarding bank i's monitoring intensity. Monitoring intensities are correctly anticipated in equilibrium $\left(\sigma^i = \sigma_e^i\right)$, implying that investors pay a fair price for securitized products. In particular, there is no mispricing of securitized products.

2.4 Timing

The timeline of the game is illustrated in Figure 1. In the first period, banks compete by offering loan rates R_1^A, R_1^B for first period loans. Given these rates, borrowers choose one of the banks and invest in their first period project. In the case with securitization, the fraction τ^i of future cash flows from the loan portfolio is securitized. Banks monitor their own borrowers ("clients") with intensity σ^i. The monitoring

card sector. See, for example, Barone, Felici and Pagnini (2011), Kim, Kliger and Vale (2003) and Stango (2002).

[5] One interpretation is that banks securitize before monitoring borrowers (if they do so), which makes sense in that we consider interim monitoring. Homogenous securitization across the whole portfolio could also be rationalized as a way to ensure that banks do not "cherry-pick" which loans to securitize.

intensity, as well as the information generated by monitoring, is unobservable to outsiders. Returns from projects are realized (publicly observed) and borrowers repay their loan in the case of success. Banks transfer the fraction τ^i of repayment cash-flows to investors. Borrowers learn their switching cost (s). In the second period, banks compete over two groups of borrowers: their own clients and the clients of their rival. Banks' loan offers depend on public information (period 1-default record) and, when relevant, on inside information on a monitored client. As described in more details below, the pricing strategy of bank i in the second stage competition can be summarized by $\left(R_2^i, Q_2^i\right)$, where R_2^i is the loan rate offered to clients with a good credit record, and Q_2^i is the "poaching rate" set to attract rival's clients with a good credit record. If borrowers receive an offer from both banks, they decide whether to continue their relationship with the first-period bank, or to change their bank. The rest is similar to the first period.

3 Analysis

3.1 Second-period competition

We first characterize the outcome of second-period competition, taking as given first-period market shares (μ^A,μ^B). Consider competition over the clients of bank i, and let $\iota \in \{H, L, \varnothing\}$ denotes the insider bank (i) information about the type of its borrowers. Note that, given (1) and (2), the rival bank (j) makes an offer, denoted by Q_2^j, to borrowers who succeeded and no offer to borrowers who defaulted.

Clearly, bank i makes an offer Y, which is accepted, to H that defaulted since they do not receive any offer from the rival bank (captive clientele). By contrast, bank i does not make any offer when $\iota = L$. Hence, L that succeeded always change their bank as they receive only one offer from the external bank.

H that succeeded receive an offer from each bank and thus face a tradeoff between interest rate and switching cost. A type H receiving two offers, R_2^i from its initial bank and Q_2^i from the rival would switch to the rival bank whenever

$$p_H\left(Y - R_2^i\right) < p_H\left(Y - Q_2^j\right) - s,$$

This yields a switching threshold

$$s < p_H\left(R_2^i - Q_2^j\right)$$

The following result characterizes the second-period profits earned by both banks on the first-period clients of a given bank, under an additional condition ensuring that the period 2-competition subgame has a unique (pure strategy) Nash equilibrium.

The condition to obtain a pure strategy equilibrium is[6]

$$\lambda p_H \frac{1}{9}\bar{s} > (1-\lambda)\, p_L I. \tag{5}$$

Proposition 1 *(Under condition (5)) The period-2 competition subgame over the clients of bank i admits a unique equilibrium in pure strategies, with*

$$R_2^i = \frac{1}{p_H}\left(I + \frac{2}{3}\bar{s}\right), \qquad Q_2^i = \frac{1}{p_H}\left(I + \frac{1}{3}\bar{s}\right).$$

The associated (per-borrower) profits of bank i and rival j on i's first period clients are given by

$$\tilde{\pi}^{i/i}\left(\sigma^i\right) = \sigma^i \bar{\pi}^{i/i} + \left(1-\sigma^i\right)\pi^{i/i} \tag{6}$$

$$\tilde{\pi}^{j/i}\left(\sigma_e^i\right) = \sigma_e^i \bar{\pi}^{j/i} + \left(1-\sigma_e^i\right)\pi^{j/i} \tag{7}$$

where

$$\begin{aligned}
\pi^{i/i} &= \lambda p_H \frac{4}{9}\bar{s} \\
\bar{\pi}^{i/i} &= \lambda\left(1-p_H\right)\left(p_H Y - I\right) + \lambda p_H \frac{4}{9}\bar{s} \\
\pi^{j/i} &= \lambda p_H \frac{1}{9}\bar{s} \\
\bar{\pi}^{j/i} &= \lambda p_H \frac{1}{9}\bar{s} - (1-\lambda)\, p_L I
\end{aligned}$$

Proof. See Appendix. □

The profits described in proposition 1 exhibit two important properties. First, due to the presence of switching costs, profits are strictly positive. Second, the profits made on the clients of bank i by respectively the relationship bank (i) and the rival bank (j) are affected differently by the monitoring intensity of i. The profit of the relationship lender (i) increases with σ^i, from $\pi^{i/i}$ with no monitoring to $\bar{\pi}^{i/i} > \pi^{i/i}$ with full monitoring. By contrast, the rival bank (j) makes a profit from poaching the clients of i which decreases with the (expected) monitoring intensity of i, ranging from $\pi^{j/i}$ with no monitoring to $\bar{\pi}^{j/i} < \pi^{j/i}$ with full monitoring. The reason is that monitoring induces a winner's curse problem for the rival in the second period competition stage. When monitoring, the initial bank has private information on the type of its clients, and thus reject a type L in period 2. An offer from the rival will thus attract all (monitored) type L clients that succeeded in period 1. This winner's curse effect is reflected in the difference $\bar{\pi}^{j/i} - \pi^{j/i} < 0$.

[6] A condition like (5) is standard in this type of setup. See e.g. Bouckaert and Degryse (2004) and Gehrig and Stenbacka (2007).

Given these contrasting impacts of the monitoring intensity we introduce the following notations, which capture the (absolute value of the) impact of monitoring on second period profits:

$$\Delta\pi^{i/i} \equiv \bar{\pi}^{i/i} - \pi^{i/i} > 0, \tag{8}$$

$$\Delta\pi^{i/j} \equiv \pi^{j/i} - \bar{\pi}^{j/i} > 0. \tag{9}$$

3.2 First-period choices

At the beginning of the first period, banks have no private information on borrowers and compete by offering first period loan rates.[7] First period market shares obey

$$\mu^i = 1 - \mu^j = \begin{cases} 0 & \text{if } R_1^i > R_1^j, \\ 1/2 & \text{if } R_1^i = R_1^j, \\ 1 & \text{if } R_1^i < R_1^j. \end{cases}$$

We assume that banks do not discount future profits. The overall (expected) profits of bank i can thus be expressed as

$$\Pi^i = \mu^i \tilde{\rho}^i \left(\tau^i, R_1^i, \sigma^i, \sigma_e^i\right) + \mu^j \tilde{\pi}^{i/j}\left(\sigma_e^j\right), \tag{10}$$

where $\tilde{\rho}^i$ denotes the expected profits on i's initial clients, and $\tilde{\pi}^{i/j}$ defined in proposition 1 the expected profits from poaching the competitor's clients. Profits on the initial clients can be decomposed as the sum of first-period profits, net of monitoring costs, and second-period profits:

$$\tilde{\rho}^i\left(\tau^i, R_1^i, \sigma^i, \sigma_e^i\right) = \overbrace{-\,I - \sigma^i c}^{\text{costs}} + \overbrace{\left(1-\tau^i\right)\left(\lambda p_H + \sigma^i (1-\lambda) p_L\right) R_1^i}^{\text{retained cash flows}} + \underbrace{\tau^i l\left(\sigma_e^i\right) R_1^i}_{\text{revenues from securitization}} + \underbrace{\tilde{\pi}^{i/i}\left(\sigma^i\right)}_{\text{future profits}}$$

Given its choice of securitization τ^i and first period rate R_1^i, as well as market expectations σ_e^i, bank i chooses an unobservable monitoring intensity that maximizes the profits earned on its clients. This monitoring decision can be easily characterized if one uses (6) to obtain

$$\begin{aligned} \tilde{\rho}^i\left(\tau^i, R_1^i, \sigma^i, \sigma_e^i\right) &= -I + \left(1-\tau^i\right)\lambda p_H R_1^i + \tau^i l\left(\sigma_e^i\right) R_1^i + \pi^{i/i} \\ &\quad + \sigma^i\left(\left(1-\tau^i\right)(1-\lambda) p_L R_1^i + \Delta\pi^{i/i} - c\right), \end{aligned} \tag{11}$$

[7] In what follows, we restrict ourselves to equilibria in which banks do not randomized over the first period rate. We show in the appendix that this is without loss of generality, as any equilibria is "essentially" in pure strategy.

from which it follows that the bank monitoring intensity must satisfy:

$$\sigma^i = \begin{cases} 0 & \text{if } c > \left(1-\tau^i\right)(1-\lambda)\, p_L R_1^i + \Delta\pi^{i/i}, \\ (0,1) & \text{if } c = \left(1-\tau^i\right)(1-\lambda)\, p_L R_1^i + \Delta\pi^{i/i}, \\ 1 & \text{if } c < \left(1-\tau^i\right)(1-\lambda)\, p_L R_1^i + \Delta\pi^{i/i}. \end{cases} \tag{12}$$

The right hand side of the (in)equality in (12) displays the additional profits earned on a client when monitoring increases. This marginal gain from monitoring spreads over the two periods. The first term is the gain from preventing shirking by (L-type) borrowers in the first period. It is important to note that while the bank incurs the full cost of monitoring, only the *retained* cash flows matter for incentives. Hence, a higher fraction τ^i of securitized cash flows reduces the incentive to monitor, everything else being equal. The second term, $\Delta\pi^{i/i} > 0$, is the future rent on clients retained in period two.

3.3 Benchmark: Outcome without securitization

As a benchmark, we first characterize the outcome of competition under the assumption that banks *cannot* securitize. The comparison with this case will be useful to understand the impact of securitization in our setup. Formally, we solve the model under the assumption that τ^A and τ^B are exogenously fixed to 0.

We focus on equilibria in which both banks are active in the first period. In the initial competition stage, each bank seeks to maximize its overall profits,

$$\max_{R_1^i, \sigma^i} \Pi^i = \mu^i \tilde{\rho}^i \left(0, R_1^i, \sigma^i, \sigma_e^i\right) + \mu^j \tilde{\pi}^{i/j} \left(\sigma_e^j\right), \tag{13}$$

given its expectations as to the monitoring intensity of its rival, and outsider's expectations as to its own monitoring intensity.

An equilibrium must satisfy the following conditions. First, monitoring intensities are correctly anticipated, that is $\sigma^i = \sigma_e^i$ for $i = A, B$. Second, banks choose their monitoring intensity optimally, that is (12) holds for both banks. Finally, as one can conjecture from expression (13), price competition implies that profits on clients and profits from poaching must be equalized. To see this, consider for instance a candidate equilibrium where both banks play $\sigma^* = 0$, and let $R(0)$ denote the rate at which $\tilde{\rho}^i (0, R(0), 0, 0) = \tilde{\pi}^{i/j} (0)$. Clearly, no bank will offer an interest rate below $R(0)$, since it can always secure profits $\tilde{\pi}^{i/j} (0)$ by not lending initially and poaching in period 2. On the other hand, if bank i were to set a rate $R_1^i > R(0)$, bank j would undercut to attract the full market and make profits strictly above $\tilde{\pi}^{i/j} (0)$. Hence, the equilibrium rate must be $R^* = R(0)$, that is $\tilde{\rho}^i (0, R^*, \sigma^*, \sigma^*) = \tilde{\pi}^{i/j} (\sigma^*)$ must hold.

The following result characterizes the outcome of competition for the benchmark economy.

Proposition 2 *(Under assumption* (5)*) There exists a unique Nash equilibrium in which both banks are active in the first period. This equilibrium is symmetric, and characterized by a first-period loan rate*

$$R_{ns}^{*}=\begin{cases}\frac{\pi^{i/j}-\pi^{i/i}+I}{\lambda p_H} \quad (\equiv R(0)) & \text{if } c_{ns}\leq c,\\ \frac{c-\Delta\pi^{i/i}}{(1-\lambda)p_L} & \text{if } \bar{c}_{ns}<c<c_{ns},\\ \frac{c+\bar{\pi}^{i/j}-\bar{\pi}^{i/i}+I}{\lambda p_H+(1-\lambda)p_L} \quad (\equiv R(1)) & \text{if } \quad c\leq\bar{c}_{ns}.\end{cases}$$

and a monitoring intensity

$$\sigma_{ns}^{*}=\begin{cases}0 & \text{if } c_{ns}\leq c,\\ \frac{c_{ns}-c}{c_{ns}-\bar{c}_{ns}} & \text{if } \bar{c}_{ns}<c<c_{ns},\\ 1 & \text{if } \quad c\leq\bar{c}_{ns}.\end{cases}$$

where

$$\begin{aligned} c_{ns} &\equiv \Delta\pi^{i/i}+\frac{(1-\lambda)\,p_L}{\lambda p_H}\left(I-\pi^{i/i}+\pi^{i/j}\right),\\ \bar{c}_{ns} &\equiv \Delta\pi^{i/i}+\frac{(1-\lambda)\,p_L}{\lambda p_H}\left(I-\pi^{i/i}+\bar{\pi}^{i/j}\right). \end{aligned}$$

Equilibrium profits are given by $\Pi_{ns}^{*}=\sigma_{ns}^{*}\bar{\pi}^{j/i}+(1-\sigma_{ns}^{*})\,\pi^{j/i}$.

Proof. See Appendix. □

One important feature of proposition 2 is that banks make strictly positive profits in equilibrium. The intuition for this is as follows. As shown in proposition 1, the presence of switching costs allows each bank to make positive profits in the second stage not only on its own clients but also on its rival's clients. In contrast to future rents on one's clients, future profits on the competitor's clients cannot be passed on to borrowers through lower rates in the first period. Future profits from poaching thus act as a form of "opportunity return" on funds, and price competition in the first stage drives down interest rates to the point where banks' profits on their clients are equal to future profits on their competitor's clients. Formally, $\tilde{\rho}^{i}\left(0,R_{ns}^{*},\sigma_{ns}^{*},\sigma_{ns}^{*}\right)=\tilde{\pi}^{i/j}\left(\sigma_{ns}^{*}\right)>0$ holds in equilibrium.

3.4 Outcome with securitization

We now analyze the outcome of competition when banks can choose to securitize a fraction of their loan portfolio. At the beginning of the first period, each bank independently decides on its securitization level τ^{i}. Banks then enter the first period competition stage, knowing the securitization choice of its competitor.[8] The rest of

[8] The assumption that τ^{i} is chosen before setting R_1^{i} captures the idea that banks can adjust their credit condition policy more easily than their securitization policy, since the latter involves structural changes that are slow to implement (e.g., setting up of SPV vehicles,...). The assumption that banks observe the securitization strategy of their competitor is consistent with the fact that commercial banks have a predominant role in most functions performed along the securitization chain, notably as servicers and lead underwriters (Cetorelli and Peristiani, 2012).

the game unfolds as before.

To simplify, we focus on symmetric equilibria where both banks choose the same securitization level τ^*.[9] The following proposition characterizes the equilibrium outcome when securitization level (τ), interest rate (R), and monitoring intensity (σ) are endogenously determined.

Proposition 3 *There exist $\Delta\pi^{i/i} \leq \bar{c}_s \leq c_s$ with $\bar{c}_s < \bar{c}_{ns}$ and $c_s < c_{ns}$ such that:*

1. *For $c \geq c_s$, any equilibrium features $\sigma_s^* = 0$ and $R_s^* = R(0)$. Further, banks choose any level of securitization $\tau^* \geq \tau_0$, where*

$$\tau_0 = \frac{(1-\lambda)\, p_L \left(I - \pi^{i/i} + \pi^{i/j}\right) - \lambda p_H \left(c - \Delta\pi^{i/i}\right)}{(1-\lambda)\, p_L \left(I - \pi^{i/i} + \pi^{i/j}\right)}.$$

2. *For $\bar{c}_s < c < c_s$, we have a unique equilibrium with $\sigma_s^* \in (0,1)$ where the level of securitization, the first period interest rate and monitoring level are respectively given by:*

$$\begin{aligned} R_s^* &= \frac{c + \Delta\pi^{i/j} - \Delta\pi^{i/i}}{(1-\lambda)\, p_L} \\ \tau_s^* &= \frac{\Delta\pi^{i/j}}{c + \Delta\pi^{i/j} - \Delta\pi^{i/i}} \\ \sigma_s^* &= \frac{(1-\lambda)\, p_L \left(I - \pi^{i/i} + \pi^{i/j}\right) - \lambda p_H \left(c + \Delta\pi^{i/j} - \Delta\pi^{i/i}\right)}{2\,(1-\lambda)\, p_L \Delta\pi^{i/j}} \end{aligned}$$

3. *For $c \leq \bar{c}_s$, any equilibrium features $\sigma_s^* = 1$ and $R_s^* = R(1)$. Banks choose any level $\tau^* \leq \bar{\tau}_0$, where*

$$\bar{\tau}_0 = \frac{(1-\lambda)\, p_L \left(I - \pi^{i/i} + \bar{\pi}^{i/j}\right) - \lambda p_H \left(c - \Delta\pi^{i/i}\right)}{(1-\lambda)\, p_L \left(I - \bar{\pi}^{i/i} + \bar{\pi}^{i/j} + c\right)}$$

The equilibrium profit is given by $\Pi_s^* = \sigma_s^* \bar{\pi}^{i/j} + (1-\sigma_s^*)\, \pi^{i/j}$. c_s and $\bar{c}_s$ are given by

$$\begin{aligned} c_s &= \max\left\{\Delta\pi^{i/i}, c_{ns} - \Delta\pi^{i/j}\right\}, \\ \bar{c}_s &= \max\left\{\Delta\pi^{i/i}, \bar{c}_{ns} - \frac{\lambda p_H + (1-\lambda)\, p_L}{\lambda p_H} \Delta\pi^{i/j}\right\}. \end{aligned}$$

Proof. See Appendix. □

The equilibria are represented in figure 2.[10] To see how securitization matters

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[9] As the characterization in proposition 3 suggests, configurations where banks choose different securitization levels that satisfy the relevant condition on τ^* are also consistent with equilibrium, with the same monitoring intensity and first period rate. For instance, in the case $c \geq c_s$, any choice τ^A, τ^B such that $\tau^A \geq \tau_0, \tau^B \geq \tau_0$, along with $\sigma^* = 0$, $R_1^* = R(0)$, is an equilibrium.

[10] Figures 2 to 5 are drawn with the parameter specification used in the proof of proposition 5. For this specification, $\Delta\pi^{i/i} < \bar{c}_s < c_s$.

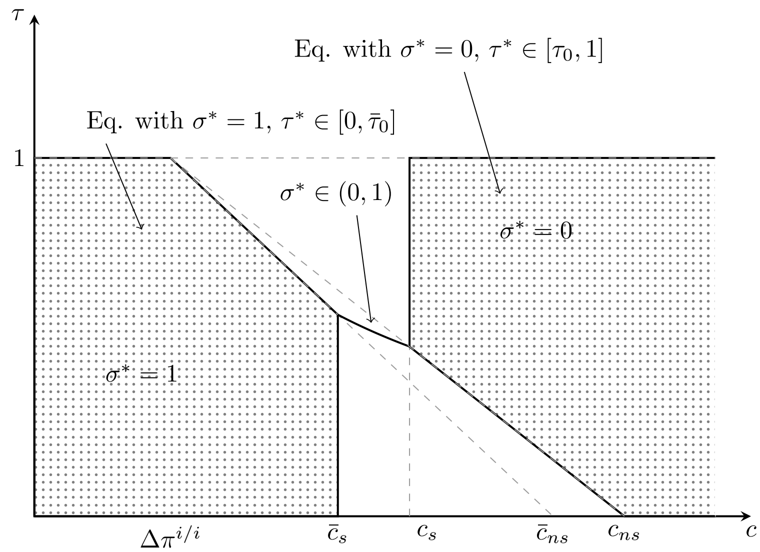

Figure 2: Equilibrium with securitization.

for the fierceness of competition and monitoring intensity, it is useful to compare with the benchmark economy. This is presented in the following result, which follows directly from comparing propositions 2 and 3 :

Proposition 4 *The introduction of securitization has the following impact on equilibrium outcomes:*

1. *When $c \leq \bar{c}_s$ or $c \geq c_{ns}$, securitization is irrelevant.*
2. *When $\bar{c}_s < c < c_{ns}$, securitization is used in equilibrium and leads to*
   - lower *monitoring intensity than in the benchmark, $\sigma_s^* < \sigma_{ns}^*$;*
   - higher *(first period) loan rates, $R_s^* > R_{ns}^*$;*
   - higher *profits for banks, $\Pi_s^* - \Pi_{ns}^* = (\sigma_{ns}^* - \sigma_s^*)\, \Delta\pi^{i/j} > 0$.*

Proof. See Appendix. $\square$

Proposition 4, which is our main result, highlights the "competition softening" effect of securitization. This effect can be seen formally in the fact that when it operates (case 2), competition under securitization leads to higher equilibrium profits and higher interest rate in the first period. Figures 3 to 5 illustrate the results in proposition 4.

The intuition for this competition softening effect is as follows. Since securitizing more tends to reduce monitoring incentives, the level of securitization of a given bank

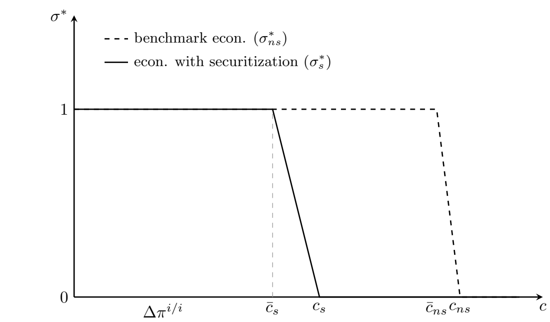

Figure 3: Equilibrium monitoring intensity

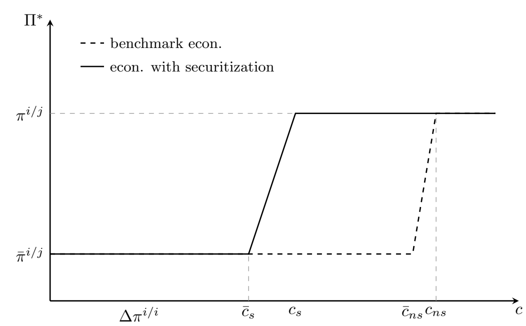

Figure 4: Equilibrium profits

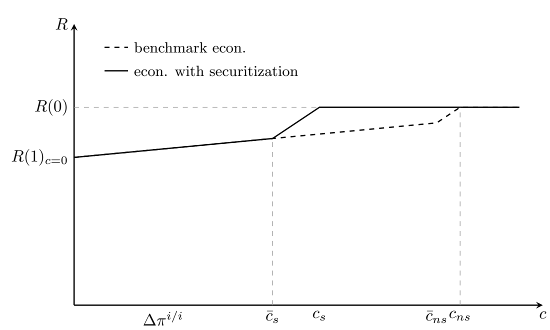

Figure 5: Equilibrium first period loan rates

provides some guidance to the competitor on its (unobserved) monitoring intensity. The perceived reduction in monitoring intensity associated with securitization raises the competitor opportunity return on funds through an increase in the second-period profits from poaching. In turn, this reduces banks' incentives to undercut each other in the first-stage loan rate competition, leading to higher equilibrium rates. In a way, banks use securitization to signal a low monitoring intensity to competitors in order to reduce the fierceness of competition for market share. This strategic, "anti-competitive" use of securitization allows banks to enjoy higher equilibrium profits than in the benchmark economy without securitization.

As stated in proposition 4, this mechanism matters for intermediate values of monitoring costs. When monitoring costs are very high ($c \geq c_{ns}$), securitization cannot reduce banks monitoring since banks cannot recover monitoring costs even when retaining all cash flows on their balance sheet. Therefore, equilibrium monitoring intensity is zero irrespective of the level of securitization. On the other hand, when monitoring costs are very low ($c \leq \bar{c}_s$), securitization cannot be used as a credible signaling tool because private incentives to monitor—as embedded in eq. (12)—are too strong. In that case, banks monitor with full intensity in equilibrium even if they can choose to engage in securitization. By contrast, for intermediate value of the cost of monitoring ($\bar{c}_s < c < c_{ns}$), securitization can have an impact on the monitoring intensity, and ultimately on equilibrium loan rates and profits.

3.5 Welfare

Proposition 4 shows that banks can strategically use securitization to obtain higher equilibrium profits even though securitizing leads to a reduction in monitoring. In doing so, they are not motivated by the efficiency of monitoring, but instead by how monitoring intensity affects winner's curse effects and profits from poaching in future round of competition. In other words, the private and social value of monitoring are not aligned.

In view of this, it is interesting to discuss the effect of securitization on welfare in our setup. We define welfare as the sum of investors' and borrowers' utility and banks' profits, $\mathcal{W} \equiv U^{inv.} + U^{bor.} + 2\Pi^*$, and are interested in the sign of $\Delta\mathcal{W} \equiv \mathcal{W}_s - \mathcal{W}_{ns}$. Since investors buy securitized loans at a fair price, their utility is unaffected and simply given by their outside option, $U_s^{inv.} = U_{ns}^{inv.}$. To study the impact on welfare, it is thus sufficient to look at the total value created through investments financed in the credit market, net of monitoring and switching costs. For a given monitoring intensity σ, this can be expressed as

$$S(\sigma) = \overbrace{\lambda\left[p_H Y - I\right]}^{\text{type } H\text{, period 1}} + \overbrace{\lambda\left[p_H\left(p_H Y - I - \frac{1}{18}\bar{s}\right) + (1-p_H)\,\sigma\,(p_H Y - I)\right]}^{\text{type } H\text{, period 2}}$$
$$+ \underbrace{(1-\lambda)\left[\sigma p_L Y - I\right]}_{\text{type } L\text{, period 1}} + \underbrace{(1-\lambda)\left[\sigma p_L\left(-\frac{1}{2}\bar{s} - I\right)\right]}_{\text{type } L\text{, period 2}} - \sigma c,$$

where the terms in the first line stand from the value created by projects of H-borrowers, and the first two terms in the second line from the value created by projects of L-borrowers.[11] Using $S(\sigma)$, the impact on welfare can be expressed as

$$\Delta\mathcal{W} \equiv \mathcal{W}_s - \mathcal{W}_{ns} = \left(\sigma_s^* - \sigma_{ns}^*\right)\cdot\Theta \tag{14}$$

with

$$\Theta = \lambda(1-p_H)(p_H Y - I) + (1-\lambda)\,p_L Y - (1-\lambda)\,p_L\left(I + \frac{1}{2}\bar{s}\right) - c. \tag{15}$$

Θ measures the marginal impact of an increase in monitoring on welfare. The first two terms in (15) correspond to the social value of monitoring, which breaks down into two components: the refinancing of unlucky H-borrowers that would have been rejected without the information generated by monitoring, captured in $\lambda(1-p_H)(p_H Y - I))$, and the increase in the success probability for L-borrowers, captured in $(1-\lambda)\,p_L Y$. However, because the information generated by monitoring is soft and cannot be shared between banks, an increase in monitoring also allows lucky L-borrowers to obtain a loan from the competing bank in period 2. The refinancing of these negative NPV projects leads to an expected loss of $-(1-\lambda)\,p_L\left(I + \frac{1}{2}\bar{s}\right)$.

As can be seen from (14), the competition softening effect will be associated with a decrease in welfare whenever monitoring is good for welfare, that is $\Theta > 0$. Formally, we can state:

Proposition 5 *One can find configurations such that banks profits are higher ($\Pi_s^* > \Pi_{ns}^*$), and welfare lower ($\mathcal{W}_s < \mathcal{W}_{ns}$), in the economy with securitization. Furthermore, a mild and sufficient condition for the softening competition to be detrimental for borrowers $\left(U_s^{bor.} < U_{ns}^{bor.}\right)$ is $2Y > I + \frac{1}{2}\bar{s}$.*

[11] The explanation for the terms with switching costs is the following. In equilibrium (given the second period loan rates in proposition (1) switching occurs for successful H type borrowers with switching costs below $s^* \equiv \frac{1}{3}\bar{s}$ and lucky type L. Overall switching costs for the former is given by $\int_0^{\frac{1}{3}\bar{s}} s ds = \frac{1}{18}\bar{s}$, and for the latter $\int_0^{\bar{s}} s ds = \frac{1}{2}\bar{s}$. Consistent with usual practice, we do not include private benefits in the definition of social welfare. Formulae are slightly different but results are qualitatively similar if one includes such benefits.

Proof. See Appendix. □

This negative impact on welfare is consistent with the literature on the dark side of securitization. Parlour and Plantin (2008) showed that securitization (loan sales) reduces banks' monitoring incentives, and can be harmful in terms of social welfare. Morrison (2005) demonstrated a similar result in the context of the use of CDS. Our analysis adds to this line of research by showing that securitization can increase banks' profits even though it harms welfare. Proposition 5 highlights that the increase in banks' profits is the result of pure extraction of rent from borrowers.

4 Discussion

Our analysis so far has derived the competition softening effect of securitization: securitization has the potential to reduce the fierceness of loan rate competition and allow banks to enjoy higher profits by extracting rent from borrowers. We discuss in this section some implications of this effect.

4.1 Monitoring cost and securitization

Our formal results suggest an interesting link between the equilibrium level of securitization and the magnitude of monitoring costs.

Proposition 6 *The competition softening effect arises when $\bar{c}_s < c < c_{ns}$. Furthermore, higher equilibrium levels of securitization are required to sustain this effect when monitoring costs are lower.*

Proof. Follows from the fact that the equilibrium τ^* in the region $[\bar{c}_s, c_s]$ as well as the minimum τ_0 in $[c_s, c_{ns}]$ are decreasing functions of c. □

The intuition is quite straightforward. With lower monitoring costs, banks have *ceteris paribus* higher private incentives to monitor. Hence, they must securitize more to credibly signal a low level of monitoring—with a view to soften competition. This insight may shed some light on the heterogeneity of securitization levels across loan sectors or across economies.[12] Available evidence indicates that securitization expanded strongly in advanced economies (mostly US and Europe) but remained relatively underdeveloped, or non existent in developing countries (Gyntelberg and Remolona, 2006). Consistent with this observation, our theoretical model would predict that banks need to resort to relatively high levels of securitization to soften competition in advanced countries where monitoring costs are relatively low. By contrast, securitization does not matter in developing countries where monitoring costs are high.

This theoretical insight also has cross-sectional implications across loan sectors. Monitoring for mortgage loans or consumer loans are basically based on hard information such as credit scores from external credit bureau, implying lower monitoring

[12]We thank an anonymous referee for suggesting this interpretation of our results.

costs than in the corporate loan sector, where monitoring is largely based on soft information more difficult to collect and to process. Banks using securitization to reduce the intensity of competition would thus need to securitize more in the former loan sectors than in the latter for this purpose. This prediction is consistent with the empirical findings in Loutskina (2011), who documents high securitization levels for mortgage or consumer (auto or credit card) loans and relatively low securitization levels for corporate loans (see figure 6).

4.2 Insights from an incumbent/entrant setup

We now use a variant of the model with an alternative competitive structure to illustrate how the competition softening effect can be used by banks in reaction to an increase in competitive pressure.

Specifically, we consider a setup with an incumbent bank (A) facing entry by a competitor (E) on its loan market, and show that A can use its securitization choice to mitigate the consequence of entry. To focus on A's strategic securitization decision, we assume that E has no monitoring ability and that switching from E to A in the second period entails no switching costs.[13] Apart from this, assumptions are the same as in section 3.4.

Consider first the monopoly case. A clearly sets rate $R = Y$ on each loan he grants, and maximizes his profit by fully monitoring all borrowers ($\sigma = 1$).[14] Given that securitization can only reduce monitoring, it follows that securitization is never be used, and A earns monopoly profits

$$\Pi^{monopoly} \equiv \lambda\left(p_H Y - I\right) + \left(1-\lambda\right)\left(p_L Y - I\right) - c + \lambda\left(p_H Y - I\right) \tag{16}$$

Consider now the entry of E. The assumptions regarding the entrant imply that period two competition will result in zero profits for both banks on E's initial clients. Given this, the incumbent and entrant profits write, respectively

$$\Pi^A \;=\; \mu^A \left[\begin{array}{l} -I + \left(\lambda p_H + \sigma_e^A \tau^A \left(1-\lambda\right) p_L\right) R_1^A \\ \quad +\sigma^A\left(-c + \bar{\pi}^{i/i} + \left(1-\tau^A\right)\left(1-\lambda\right) p_L R_1^A\right) + \left(1-\sigma^A\right)\pi^{i/i} \end{array}\right]$$

$$\Pi^E = \mu^E\left[\lambda p_H R_1^E - I\right] + \mu^A \tilde{\pi}^{i/j}\left(\sigma_e^A\right).$$

The latter expression shows that the entrant will drive down its initial rate until its first period profit on a borrower equals the profit it can make by poaching in the

[13] One can thus interpret E as a *de novo* bank entering a market segment in which it has no previous expertise. Note that this implies that securitization by E is irrelevant for the equilibrium, and thus can be ignored.

[14] To see this, note that the monopoly profit with no monitoring ($\sigma = 0$) is given by

$$\Pi^{monopoly} \equiv \lambda\left(p_H Y - I\right) - \left(1-\lambda\right) I + \lambda p_H \left(p_H Y - I\right).$$

Comparing with (16), the value of monitoring is given by $\left(1-\lambda\right) p_L Y + \lambda\left(1-p_H\right)\left(p_H Y - I\right)$, which is always higher than c by assumption (3).

second period. In turn, the incumbent will engage in "limit pricing" by setting a rate just below to maximize its market share. We thus have, in equilibrium,

$$R_1^A = \frac{1}{\lambda p_H}\left(I + \tilde{\pi}^{i/j}\left(\sigma_e^A\right)\right) = \frac{1}{\lambda p_H}\left(I + \pi^{i/j} - \sigma_e^A \Delta\pi^{i/j}\right). \tag{17}$$

As in section 3.4, the monitoring decision of the incumbent satisfies the decision rule (12). It is straightforward to check that for a given τ^A, equations (17) and (12) pin down a unique solution $\left(\sigma^A, R_1^*\right)$, with the property that the equilibrium monitoring intensity σ^A is decreasing in the level of securitization τ^A.[15] The competition softening effect of securitization is apparent in the property that the (first-period) equilibrium rate is increasing in τ^A. This softening competition effect opens the possibility for the incumbent to use securitization as a response to entry, as stated in the following formal result.

Proposition 7 *1. In the monopoly case, securitization is either irrelevant, or leads to a decrease in monitoring and profits. Hence, securitization is never used.*

2. When faced with entry, there are cases where the incumbent bank can strictly increase its equilibrium profits by engaging in securitization. A sufficient condition for this is $\bar{\chi}_0 < c < \chi_0$, where

$$\begin{aligned}\bar{\chi}_0 &= \Delta\pi^{i/i} + \frac{(1-\lambda)\,p_L}{\lambda p_H}\left(I + \bar{\pi}^{i/j}\right),\\ \chi_0 &= \Delta\pi^{i/i} + \frac{(1-\lambda)\,p_L}{\lambda p_H}\left(I + \pi^{i/j}\right).\end{aligned}$$

Proof. See Appendix. □

The intuition for proposition 7 is as follows. Involvement in securitization being observed by the entrant, the incumbent can use its securitization decision to signal a low(er) level of monitoring on its clients, and thus an increase in the (future) profit from poaching. This in turn reduces the competitive pressure from the entrant in the first period. This result provides a link between an exogenous increase in competition and the development of securitization as a strategic tool to mitigate the consequences of higher competition.[16] Indeed, a straightforward implication of 7 is that if E faces an entry cost $f \geq 0$, there is a threshold $\hat{f} > 0$ such that when $f \geq \hat{f}$, E does not enter and A never securitizes, while when $f < \hat{f}$, there is entry and A may securitize. This analysis would thus predict a positive correlation between intensified competition and securitization.

[15] See appendix: proof of proposition 7.

[16] Proposition 7 should not be interpreted as implying that empirically banks that securitize more should be more profitable. The result states that securitization can be used to attenuate the (negative) impact of higher competition on banks' profits.

4.3 Competition and the rise of the OTD model

Our theoretical analysis suggests that the intensification of competition in credit markets can be one factor behind the significant development of securitization witnessed since the 90s.

Over the last two decades, the landscape of the banking sector has changed dramatically, following the liberalization and deregulation of the financial sector. In the United States, the Riegle-Neal Act of 1994 abolished the geographical barrier to entry between states, and the Gramm-Leach-Bliley Act of 1999 terminated the separation between commercial banking and investment banking business. The EU area introduced the single banking license in 1993, thus enabling a bank that obtained a banking license in one member country to open branches in another member country without further permission. Interbank competition has thus dramatically increased, as several studies have noted. (See, for example, Boot and Schmeits, 2006.) During the same period, secondary markets for loans have increased remarkably in terms of securitization as well as in terms of single name loan sales (see figures 6-7 and BIS (2003; 2008)). This development has been radical enough to be interpreted as a shift in banks business model, from the "originate-to-hold" to the "originate-to-distribute" model (Buiter, 2007, Hellwig, 2008). The competition softening effect that we model, and in particular the formal result in proposition 7, suggests that these concomitant developments both in competition and in securitization are not unrelated events. Instead, the increase in securitization could be interpreted as an adaptation by banks to fiercer competition in loan markets.

Finally, it could also be interesting to discuss the development of subprime securitization through the lenses of our analysis. As documented by many empirical studies, the US subprime mortgage market expanded massively during the decade prior to the crisis. The rise in volume was also accompanied by an increasing use of securitization, with the fraction of new mortgages being securitized increasing from below 50% in 2000 to about 80% in 2006.[17] As mentioned in the introduction, several studies show that securitization in this market segment was associated with a deterioration in the quality of loans.[18] At the same time, available evidence suggests that the expansion of this loan sector was associated with fierce competition and entry of new lenders—possibly as a result of saturation of traditional mortgage segments and of excess capacity in the lending industry (Bernanke, 2007, Dell'Ariccia et al., 2008).[19] While our setup is not motivated by the economics of subprime mortgages—

[17] See table 4 in Chomsisengphet and Pennington-Cross (2006) and table 4 in Gorton (2009) for securitization rates.

[18] Relevant studies include, inter alia, Keys et al. (2010), Mian and Sufi (2009), Purnanandam (2011) and Dell'Ariccia et al. (2008).

[19] Dell'Ariccia et al. (2008) analyze the evolution of denial rates (as a proxy for lending standards) in the subprime mortgage market. Regarding competition, they find that "[a]s the industry expanded and more subprime lenders entered specific metropolitan areas, denial rates by incumbents went down."

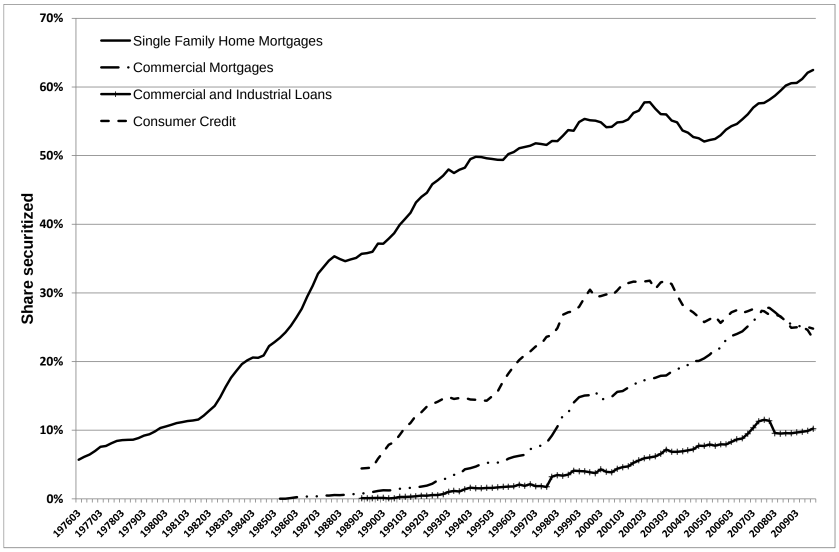

Figure 6: Securitization levels by sector. (Source: Loutskina (2011))

in particular we have no role for house price appreciation[20]—market practice seems to be consistent with a role for dynamic competition in shaping market outcomes. Even though total loan maturities are very long (usually 30 years), most subprime mortgages embed a refinancing option after a short initial period of fixed "teaser" rate, and borrowers themselves consider that they can switch lenders after this initial period if they find a competitor offering more attractive conditions. Our model would thus predict that in this environment lenders securitize massively to soften competition for initial mortgages. Our analysis therefore offers an alternative explanation of three seemingly related empirical observations in this subprime loan market: intense competition, massive securitization, and a low level of monitoring. Interestingly, the rent extraction effect embedded in this mechanism resonates with the view that subprime lending could be interpreted as a form of predatory lending (Ashcraft and Schuermann, 2008).

5 Conclusion

We have analyzed the effect of the originate-to-hold model on strategic competition between banks. Using a dynamic loan market competition model where borrow-

[20]See Bhardwaj and Sengupta (2012) for an empirical analysis of the role of house prices appreciation in the design of mortgage contracts.

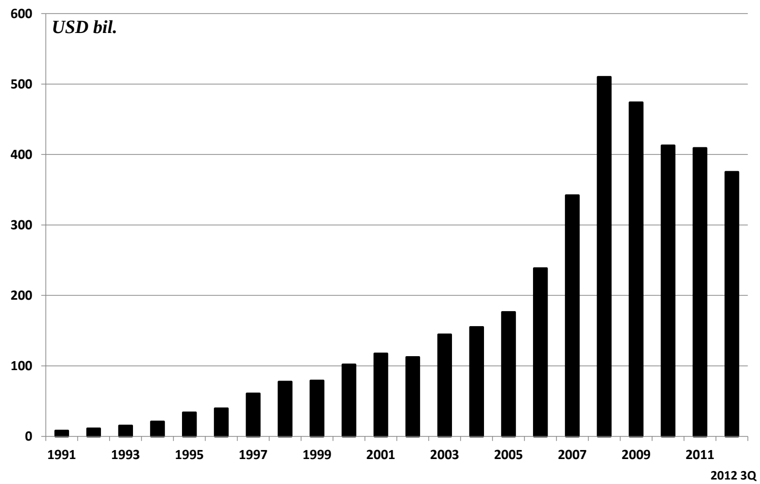

Figure 7: Single name loan sales in the US *(Data: Reuters LPC Traders Survey)*

ers face both exogenous and endogenous costs to switch between banks, we have shown that securitization can lead to a decrease in the intensity of competition. This "competition softening" effect can explain how securitization can be associated with a decrease in loan market efficiency through reduced monitoring while leading to higher equilibrium profits for banks. This effect is driven by rent extraction in the primary loan market. not by the exploitation of informational asymmetries in the secondary market for loans. The analysis also implies that securitization can be used as a response to an increase in competition, suggesting that the intensification of competition in credit markets can be one factor behind the significant development of securitization witnessed since the 90s.

Appendix A. Omitted proofs.

Proof of proposition 1 Let $n_{\iota,\kappa}$ denote the proportion of bank i's clientele with the first-period result $\kappa \in \{0, Y\}$ and i's information on the type $\iota \in \{H, L, \varnothing\}$. Let also R_H, $R_\varnothing$ denote the loan offer to clients that succeeded, contingent on i's private information. (By (1), i makes no offer when $\iota = L$. We show later that $R_H = R_\varnothing$. The respective proportions in the bank i's clientele with i's monitoring intensity σ_i

write

$$\begin{aligned} n_{\varnothing,Y} &= (1-\sigma_i)\,\lambda p_H, \\ n_{L,Y} &= \sigma_i\,(1-\lambda)\,p_L, \\ n_{H,Y} &= \sigma_i \lambda p_H, \\ n_{H,0} &= \sigma_i \lambda\,(1-p_H)\,. \end{aligned}$$

The bank i's profit on its clientele in the second period then writes

$$\begin{aligned} \Pi^{i/i} \quad = n_{H,0}\,(p_H Y - I) + \quad & n_{H,Y}\Pr\left[p_H\left(R_H - Q\right) < s\right]\left(p_H R_H - I\right) \\ & + n_{\varnothing,Y}\Pr\left[p_H\left(R_\varnothing - Q\right) < s\right]\left(p_H R_\varnothing - I\right) \end{aligned} \tag{18}$$

which yields the first order condition w.r.t. R_H

$$\left(p_H R_H - I\right)\frac{\partial}{\partial R_H}\Pr\left[p_H\left(R_H - Q\right) \leq s\right] + p_H \Pr\left[p_H\left(R_H - Q\right) \leq s\right] = 0$$

where

$$\Pr\left[p_H\left(R_H - Q\right) \leq s\right] = \begin{cases} 1 & \text{if} \qquad R_H \leq Q, \\ 1 - \frac{p_H(R_H - Q)}{\bar{s}} & \text{if} \quad Q < R_H < Q + \frac{\bar{s}}{p_H}, \\ 0 & \text{if } Q + \frac{\bar{s}}{p_H} \leq R_H. \end{cases}$$

The FOC thus gives

$$-\frac{p_H}{\bar{s}}\left(p_H R_H - I\right) + p_H\left(1 - \frac{p_H\left(R_H - Q\right)}{\bar{s}}\right) = 0. \tag{19}$$

Similarly, given (18) the FOC w.r.t. $R_\varnothing$ gives

$$-\frac{p_H}{\bar{s}}\left(p_H R_\varnothing - I\right) + p_H\left(1 - \frac{p_H\left(R_\varnothing - Q\right)}{\bar{s}}\right) = 0. \tag{20}$$

From (19) and (20) The best response of bank i is thus

$$R_\varnothing = R_H = \frac{1}{2p_H}\left(I + \bar{s} + p_H Q\right) \tag{21}$$

The competitor j's profit writes

$$\begin{aligned} \Pi^{j/i} \quad = \quad & n_{H,Y}\Pr\left[p_H\left(R_H - Q\right) > s\right]\left(p_H Q - I\right) \\ & + n_{\varnothing,Y}\Pr\left[p_H\left(R_\varnothing - Q\right) > s\right]\left(p_H Q - I\right) - n_{L,Y} I, \end{aligned}$$

which using $R_H = R_\varnothing$ reduces to

$$\Pi^{j/i} \quad = \quad \left[n_{H,Y} + n_{\varnothing,Y}\right]\Pr\left[p_H\left(R - Q\right) > s\right]\left(p_H Q - I\right) - n_{L,Y} I.$$

Deriving w.r.t. Q yields the FOC

$$
\begin{aligned}
0=\frac{\partial\Pi^{j/i}}{\partial Q} &= \left(p_H Q-I\right)\frac{\partial}{\partial Q}\frac{p_H\left(R-Q\right)}{\bar{s}}+p_H\frac{p_H\left(R-Q\right)}{\bar{s}},\\
&= \frac{p_H}{\bar{s}}\left(I+p_H R-2p_H Q\right),
\end{aligned}
$$

which implies that j's best response to i that offers R to i's clients,

$$
Q=\frac{1}{2p_H}\left(p_H R+I\right) \tag{22}
$$

Using (21) and (22), equilibrium rates are given by

$$
\begin{aligned}
p_H R_2^* &= I+\frac{2}{3}\bar{s},\\
p_H Q_2^* &= I+\frac{1}{3}\bar{s}.
\end{aligned}
$$

And equilibrium profits are given by

$$
\begin{aligned}
\tilde{\pi}^{i/i}\left(\sigma_i\right) &= n_{H,0}\left(p_H Y-I\right)+\left[n_{H,Y}+n_{\varnothing,Y}\right]\Pr\left[p_H\left(R_2^*-Q_2^*\right)<s\right]\left(p_H R_2^*-I\right)\\
&= n_{H,0}\left(p_H Y-I\right)+\left[n_{H,Y}+n_{\varnothing,Y}\right]\frac{4}{9}\bar{s}\\
&= \sigma_i\lambda\left(1-p_H\right)\left(p_H Y-I\right)+\lambda p_H\frac{4}{9}\bar{s}
\end{aligned}
$$

$$
\begin{aligned}
\tilde{\pi}^{j/i}\left(\sigma_i^e\right) &= \left[n_{H,Y}+n_{\varnothing,Y}\right]\Pr\left[p_H\left(R_H-Q\right)>s\right]\left(p_H Q-I\right)-n_{L,Y}I\\
&= \left[\sigma_i\lambda p_H+\left(1-\sigma_i\right)\lambda p_H\right]\frac{1}{9}\bar{s}-\sigma_i\left(1-\lambda\right)p_L I\\
&= \lambda p_H\frac{1}{9}\bar{s}-\sigma_i\left(1-\lambda\right)\bar{p}_L I
\end{aligned}
$$

Proof of proposition 2 The proof for the benchmark economy is derived as a special case of proposition 3, when $\tau^A=\tau^B$ is imposed. Consider first the case $\sigma^*=0$. From the proof of proposition 3, $R^*=R\left(0\right)$. Further, $\sigma^*=0$ is individually optimal whenever $\tau^*\leq\tau_0$, it is optimal under $\tau=0$ iff $\tau_0\geq 0$ that is $c\geq c_{ns}$. Consider next the case $\sigma^*=1$. From the proof of proposition 3, $R^*=R\left(1\right)$, and $\sigma^*=1$ is individually optimal whenever $\tau^*\geq\bar{\tau}_0$; hence $\sigma^*=1$ iff $\bar{\tau}_0\geq 0$ that is $c\leq\bar{c}_{ns}$. To conclude, a mixed strategy equilibrium must satisfy (33) and (34) with $\tau^*=0$. The latter yields $R^*=\frac{c-\Delta\pi^{i/i}}{(1-\lambda)p_L}$. Inserting this expression into (34) and rearranging

$$
\begin{aligned}
\sigma^* &= \frac{\pi^{i/j}-\left[-I+\lambda p_H R^*+\pi^{i/i}\right]}{\left(1-\lambda\right)p_L R^*+\Delta\pi^{i/i}-c+\Delta\pi^{i/j}}=\frac{\pi^{i/j}+I-\lambda p_H\frac{c-\Delta\pi^{i/i}}{(1-\lambda)p_L}-\pi^{i/i}}{\Delta\pi^{i/j}}\\
&= \frac{\frac{\lambda p_H}{(1-\lambda)p_L}\left(\pi^{i/j}+I-\pi^{i/i}\right)+\Delta\pi^{i/i}-\lambda p_H\frac{c-\Delta\pi^{i/i}}{(1-\lambda)p_L}-\pi^{i/i}}{\frac{\lambda p_H}{(1-\lambda)p_L}\Delta\pi^{i/j}}=\frac{c_{ns}-c}{c_{ns}-\bar{c}_{ns}},
\end{aligned}
$$

where the last step follows from the definition of c_{ns} and $\bar{c}_{ns}$.

Proof of proposition 3 To characterize equilibria for the game where banks choose τ^A, τ^B, we first state two intermediate results for the subgame associated with a given combination $\left(\tau^A, \tau^B\right)$. The proofs for those intermediate results are presented in a separate section of this appendix. The first result shows that we can focus on equilibria in pure strategy in terms of R_1^i in which profits from clients and profits from poaching are equalized:

Lemma 1 *Equilibria of the $\left(\tau^A, \tau^B\right)$-subgame are "essentially" in pure strategies in the sense that both banks play at most one R that is accepted with strictly positive probability by borrowers on-the-equilibrium path. They may also play in addition rates that are refused w.p. 1, but those rates are irrelevant for equilibrium profits. Furthermore, to characterize equilibria, it is sufficient to consider the solutions to the two equations*

$$\tilde{\rho}_A\left(\tau^A, R, \sigma^A(R), \sigma^A(R)\right) = \tilde{\pi}^{i/j}\left(\sigma^B(R)\right), \tag{23}$$

$$\tilde{\rho}_B\left(\tau^B, R, \sigma^B(R), \sigma^B(R)\right) = \tilde{\pi}^{i/j}\left(\sigma^A(R)\right), \tag{24}$$

where $\sigma^i(R)$ is the correspondence defined by (12). Precisely, both (23) and (24) must hold if both banks are active. Otherwise, the corresponding equation must hold for the inactive bank (e.g. (23) if A is inactive).

Using (11) and (4), the l.h.s. of (23) or (24) can be written as

$$-I + \lambda p_H R + \pi^{i/i} + \sigma^i\left((1-\lambda)p_L R + \Delta\pi^{i/i} - c\right) \equiv \tilde{\rho}\left(R, \sigma^i\right), \tag{25}$$

or, equivalently, as

$$\tilde{\rho}\left(R, \sigma^i\right) = \tilde{\rho}(R, 0) + \sigma^i \phi(R), \tag{26}$$

where $\phi(R) \equiv (1-\lambda)p_L R + \Delta\pi^{i/i} - c$. Using (9), to rearrange the r.h.s. of (23) and (24), the equations in lemma 1 can thus be expressed equivalently as

$$\tilde{\rho}(R, 0) + \sigma^i \phi(R) = \pi^{i/j} - \sigma^j \Delta\pi^{i/j}. \tag{27}$$

The next result restricts the equilibria we need to consider when analyzing deviation by one bank:

Lemma 2 *Assume $\tau^A \neq \tau^B$. Then each equation (23)-(24) yields a unique solution, which we denote respectively by $S^a \equiv \left(R^a, \sigma^{Aa}, \sigma^{Ba}\right)$ and $S^b \equiv \left(R^b, \sigma^{Ab}, \sigma^{Bb}\right)$. The subgame has a unique equilibrium with either (i) both banks are active if $S^a = S^b$, with equilibrium variables given by this common solution, or (ii) only one active bank if the $S^a \neq S^b$, with equilibrium variables given by S^j when bank i is inactive.*

We can now use lemma 1 and 2 to characterize symmetric equilibria. For a given τ, define R_τ as the threshold where $\sigma(R_\tau) \in (0,1)$. Formally,

$$R_\tau \equiv \frac{c - \Delta\pi^{i/i}}{(1-\tau)(1-\lambda)p_L}. \tag{28}$$

Finally, define $R(0), R(1), \tilde{R}_0, \tilde{R}_1$ as the solutions to

$$\begin{aligned}\tilde{\rho}(R(0),0) &= \tilde{\pi}^{i/j}(0), \qquad \tilde{\rho}(R(1),1) = \tilde{\pi}^{i/j}(1), \\ \tilde{\rho}\left(\tilde{R}_0,0\right) &= \tilde{\pi}^{i/j}(1), \qquad \tilde{\rho}\left(\tilde{R}_1,1\right) = \tilde{\pi}^{i/j}(0).\end{aligned}$$

Consider first a candidate equilibrium with $\sigma^* = 0$. Given lemma 1, the first period rate is pinned down by $\tilde{\rho}(R,0) = \tilde{\pi}^{i/j}(0)$, which using (25) and (27) gives

$$R^* = R(0) \equiv \frac{I - \pi^{i/i} + \pi^{i/j}}{\lambda p_H}. \tag{29}$$

Given $R(0)$, the condition $\sigma(R(0)) = 0$ implies $R(0) \leq R_{\tau^*}$. Using expressions (29) and (28) and rearranging, this yields

$$\tau^* \geq \tau_0 \equiv \frac{(1-\lambda)p_L\left(I - \pi^{i/i} + \pi^{i/j}\right) - \lambda p_H\left(c - \Delta\pi^{i/i}\right)}{(1-\lambda)p_L\left(I - \pi^{i/i} + \pi^{i/j}\right)}.$$

Note that $\tau_0 \geq 1$ iff $c \leq \Delta\pi^{i/i}$, so that one condition for this to be an equilibrium is $c \geq \Delta\pi^{i/i}$. Also, $\tau_0 < 0$ iff

$$c < \Delta\pi^{i/i} + \frac{(1-\lambda)p_L}{\lambda p_H}\left(I - \pi^{i/i} + \pi^{i/j}\right) \equiv c_{ns}.$$

To conclude that $(R^*, \sigma^*, \tau^*) = (R(0), 0, \tau^*)$ is an equilibrium, we need to check that no bank has a profitable deviation. Consider a deviation by A from τ^* to $\hat{\tau}$.[21] We proceed in a series of steps. Denote by $\hat{R}$ the rate associated with the new equilibrium (unique by lemma 2).

1. A profitable deviation requires $R_{\hat{\tau}} < R(0)$. If $R_{\hat{\tau}} \geq R(0)$, One can check that $S^a = (R(0), 0, 0)$ and $S^b = (R(0), 0, 0)$ still solve (23) and (24). Hence, from lemma 2, $\left(\hat{R}, \hat{\sigma}^A, \hat{\sigma}^B\right) = (R(0), 0, 0)$, and $\hat{\Pi}^A = \Pi^*$. The deviation is not profitable.

2. $R_{\hat{\tau}} \leq \hat{R} < R(0)\,(\leq R_{\tau^*})$. Recall that $\hat{R} \in \left\{R^a, R^b\right\}$. Consider first $R_{\hat{\tau}} \leq \hat{R}$. Assume the contrary, i.e. $\hat{R} < R_{\hat{\tau}}$. Then, $\hat{\sigma}^A = 0$ and $\hat{\sigma}^B = 0$. Plugging into (23) or (24) yields $\tilde{\rho}\left(\hat{R}, 0\right) = \tilde{\pi}^{i/j}(0)$, that is $\hat{R} = R(0)$, and $\hat{\Pi}^A = \Pi^*$; a contradiction. The second inequality, $R_{\hat{\tau}} < \hat{R}$, follows from $R_{\hat{\tau}} < R^a$ and $R_{\hat{\tau}} < R^b$. For R^a, a move to $\hat{\tau} < \tau^*$ shifts the l.h.s. upwards for all $R \geq R_{\hat{\tau}}$ (including for $R(0)$), and does not affect the r.h.s. Since the l.h.s. is an increasing function, R^a must go down. For R^b, a move to $\hat{\tau} < \tau^*$ does not affect the l.h.s., and shifts the r.h.s. downwards for all $R \geq R_{\hat{\tau}}$. Since the r.h.s. is a decreasing function, R^b must go down.

[21] We use "$\hat{x}$" to denote the value of variable x following the deviation.

3. Since $R_{\hat{\tau}} \leq \hat{R} < R(0) \leq R_{\tau^*}$, one must have $\hat{\sigma}^B = 0 = \sigma^*$. Hence, a profitable deviation exists iff A can deviate to an equilibrium where A is the only active bank, with $\tilde{\rho}\left(\hat{R}, \hat{\sigma}^A\right) > \tilde{\pi}^{i/j}(0) = \pi^{i/j}$, and $\hat{R}, \hat{\sigma}^A$ are pinned down by (24), that is $\tilde{\rho}\left(\hat{R}, 0\right) = \pi^{i/j} - \hat{\sigma}^A \Delta\pi^{i/j}$. In such an equilibrium, we have

$$\tilde{\rho}\left(\hat{R}, \hat{\sigma}^A\right) = \tilde{\rho}\left(\hat{R}, 0\right) + \hat{\sigma}^A \phi\left(\hat{R}\right) = \pi^{i/j} + \hat{\sigma}^A\left(\phi\left(\hat{R}\right) - \Delta\pi^{i/j}\right), \quad (30)$$

where the first step follows from (26) and the second from $\tilde{\rho}\left(\hat{R}, 0\right) = \pi^{i/j} - \hat{\sigma}^A \Delta\pi^{i/j}$.

4. From step 3, existence of a profitable deviation requires that $\hat{\sigma}^A\left(\phi\left(\hat{R}\right) - \Delta\pi^{i/j}\right) > 0$, where $\tilde{\rho}\left(\hat{R}, 0\right) = \pi^{i/j} - \hat{\sigma}^A \Delta\pi^{i/j}$. We distinguish two cases.

   - Deviation to $\hat{\sigma}^A = 1$. The rate is given by $\tilde{\rho}\left(\hat{R}, 0\right) = \tilde{\pi}^{i/j}(1) = \bar{\pi}^{i/j}$, which gives $\hat{R} = \tilde{R}_0 \equiv \frac{I - \pi^{i/i} + \bar{\pi}^{i/j}}{\lambda p_H} \quad (< R(0))$. Two conditions should be met:
     (a) There must exist a deviation $\hat{\tau}$ s.t. $R_{\hat{\tau}} \leq \tilde{R}_0$ (since $\hat{\sigma}^A = 1$). Such a $\hat{\tau}$ exists iff this is true for $\tau = 0$, that is $\frac{\bar{\pi}^{i/i} - \pi^{i/i} - c}{(1-\lambda)p_L} \leq \tilde{R}_0$. Rearranging, one gets $c \leq \bar{c}_{ns}$.
     (b) The deviation is profitable, that is $\phi\left(\tilde{R}_0\right) - \Delta\pi^{i/j} > 0$, that is

     $$(1-\lambda)\, p_L \frac{I - \pi^{i/i} + \bar{\pi}^{i/j}}{\lambda p_H} + \Delta\pi^{i/i} - c - \Delta\pi^{i/j} > 0.$$

     Rearranging, one gets $c < \bar{c}_{ns} - \Delta\pi^{i/j}$.
   - Deviation to $0 < \hat{\sigma}^A < 1$. Again, two conditions should be met:
     (a) There must exist $\hat{\tau}$ such that $R_{\hat{\tau}} < R(0)$. This is equivalent to the existence of $\hat{\tau} < \tau_0$, which is equivalent to $\tau_0 > 0$, that is $c < c_{ns}$.
     (b) The deviation must be profitable, that is $\hat{\sigma}^A\left(\phi\left(\hat{R}\right) - \Delta\pi^{i/j}\right) > 0$, implying $\hat{\sigma}^A > 0$ and $\phi\left(\hat{R}\right) - \Delta\pi^{i/j} > 0$. Now, since $\hat{R} < R(0)$ (step 1 above) and since $\phi(.)$ is increasing, a necessary condition is $\phi(R(0)) - \Delta\pi^{i/j} > 0$, that is

     $$(1-\lambda)\, p_L R(0) + \Delta\bar{\pi}^{i/i} - c - \Delta\pi^{i/j} > 0,$$

     which using (29) and rearranging gives $c < c_{ns} - \Delta\pi^{i/j} \equiv c'_s$.

(c) We now argue that $c < c'_s$ is also sufficient. When this holds, A can play a $\hat{\tau}$ s.t. $\tilde{R}_0 < R_{\hat{\tau}} < R(0)$, and $R_{\hat{\tau}}$ is arbitrarily close to $R(0)$. Now, by step 2, $R_{\hat{\tau}} \leq \hat{R} < R(0)$. Hence, the solution to $\tilde{\rho}\left(\hat{R}, 0\right) = \pi^{i/j} - \hat{\sigma}^A \Delta\pi^{i/j}$ is such that $\hat{\sigma}^A > 0$ (since $\tilde{R}_0 < \hat{R} < R(0)$), and $\hat{R}$ can be arbitrarily close to $R(0)$. Hence, this solution gives an equilibrium in which A is active, and where $\hat{\Pi}^A = \tilde{\rho}\left(\hat{R}, \hat{\sigma}^A\right) > \tilde{\pi}^{i/j}(0) = \Pi^*$ (since $c < c'_s$). In addition, given lemma 2, this is the unique equilibrium following the deviation.

To sum up, a profitable deviation with $0 < \hat{\sigma}^A < 1$ exists iff $c < c'_s = c_{ns} - \Delta\pi^{i/j}$, while a profitable deviation with $\hat{\sigma}^A = 1$ requires $c < \bar{c}_{ns} - \Delta\pi^{i/j}$. Since $\bar{c}_{ns} < c_{ns}$, one can conclude that a profitable deviation exists iff $c < c'_s$. Since the condition $\tau_0 \geq 1$ also requires $c \geq \Delta\pi^{i/i}$, we conclude that$(R^*, \sigma^*, \tau^*) = (R(0), 0, \tau^*)$ is an equilibrium iff $c \geq c_s \equiv \max\left\{\bar{c}'_{ns}, \Delta\pi^{i/i}\right\}$.

Consider next a candidate equilibrium with $\sigma^* = 1$. Given lemma 1, the first period rate is pinned down by $\tilde{\rho}(R, 1) = \tilde{\pi}^{i/j}(1)$, which using (25) and (27) gives

$$R^* = R(1) \equiv \frac{c + \bar{\pi}^{i/j} - \bar{\pi}^{i/i} + I}{\lambda p_H + (1-\lambda) p_L}. \tag{31}$$

Given $R(1)$, the condition $\sigma(R(1)) = 0$ implies $R_{\tau^*} \leq R(1)$. Using expressions (31) and (28) and rearranging, this yields

$$\tau^* \leq \bar{\tau}_0 \equiv \frac{(1-\lambda) p_L \left(I - \pi^{i/i} + \bar{\pi}^{i/j}\right) - \lambda p_H \left(c - \Delta\pi^{i/i}\right)}{(1-\lambda) p_L \left(I - \bar{\pi}^{i/i} + \bar{\pi}^{i/j} + c\right)}$$

Note that $\bar{\tau}_0 \geq 1$ iff $c \leq \Delta\pi^{i/i}$, while $\bar{\tau}_0 < 0$ iff

$$c > \Delta\pi^{i/i} + \frac{(1-\lambda) p_L}{\lambda p_H}\left(I - \pi^{i/i} + \bar{\pi}^{i/j}\right) \equiv \bar{c}_{ns}.$$

As for the previous case, $(R^*, \sigma^*, \tau^*) = (R(0), 0, \tau^*)$ is an equilibrium iff no bank has a profitable deviation. We consider a deviation by A to $\hat{\tau} \neq \tau^*$. The reasoning closely follows that for the case $\sigma^* = 1$.

1. By a reasoning symmetric to step 1 for the case with $\sigma^* = 0$, one can check that the equilibrium is unchanged if $R_{\hat{\tau}} \leq R(1)$, so a profitable deviation requires $R(1) < R_{\hat{\tau}}$. In addition, by a reasoning symmetric to that in step 2, the new equilibrium rate after this deviation must satisfy $(R_{\tau^*} \leq) R(1) < \hat{R} \leq R_{\hat{\tau}}$.

2. Since $R_{\tau^*} < \hat{R}$, one must have $\hat{\sigma}^B = 1 = \sigma^*$ in the equilibrium following the deviation. Hence, A can only obtain $\hat{\Pi}^A > \Pi^* = \bar{\pi}^{i/j}$ if it is the only active bank after the deviation. In such an equilibrium, $\tilde{\rho}\left(\hat{R}, 1\right) = \pi^{i/j} - \hat{\sigma}^A \Delta\pi^{i/j}$.

Furthermore, A is active iff $\tilde{\rho}\left(\hat{R},\hat{\sigma}^A\right) > \tilde{\pi}^{i/j}\left(\hat{\sigma}^B\right) = \bar{\pi}^{i/j}$. Using (26) and rearranging,

$$\tilde{\rho}\left(\hat{R},\hat{\sigma}^A\right) = \tilde{\rho}\left(\hat{R},1\right) - \left(1-\hat{\sigma}^A\right)\phi\left(\hat{R}\right) = \pi^{i/j} - \hat{\sigma}^A\Delta\pi^{i/j} - \left(1-\hat{\sigma}^A\right)\phi\left(\hat{R}\right),$$

and, using the definition of $\Delta\pi^{i/j}$,

$$\tilde{\rho}\left(\hat{R},\hat{\sigma}^A\right) - \bar{\pi}^{i/j} = \left(1-\hat{\sigma}^A\right)\left(\Delta\pi^{i/j} - \phi\left(\hat{R}\right)\right).$$

3. By an argument similar to that in step 4 for the case $\sigma^* = 0$, existence of a profitable deviation is equivalent to existence of a solution to $\tilde{\rho}\left(\hat{R},1\right) = \pi^{i/j} - \hat{\sigma}^A\Delta\pi^{i/j}$ satisfying $\left(1-\hat{\sigma}^A\right)\left(\Delta\pi^{i/j} - \phi\left(\hat{R}\right)\right) > 0$. Again, one can consider two types of deviations:

   - Deviation such that $0 < \hat{\sigma}^A < 1$. Since $\hat{\sigma}^A$ solves $\tilde{\rho}\left(\hat{R},1\right) = \pi^{i/j} - \hat{\sigma}^A\Delta\pi^{i/j}$, $\left\{0 < \hat{\sigma}^A < 1\right\} \Leftrightarrow \left\{R(1) < \hat{R} < \tilde{R}_1\right\}$. Hence, this condition is satisfied for any $\hat{\tau}$ s.t. $R_{\hat{\tau}}$ such that $R(1) < R_{\hat{\tau}} < \tilde{R}_1$. Such a deviation exists and is profitable if the two following condition hold:
     (a) There exists $\hat{\tau} \leq 1$ s.t. $R(1) < R_{\hat{\tau}}$. This is equivalent to the existence of $\hat{\tau} > \bar{\tau}_0$, which is equivalent to $\bar{\tau}_0 < 1$, that is $c > \Delta\pi^{i/i}$.
     (b) $\Delta\pi^{i/j} - \phi\left(\hat{R}\right) > 0$. But since $R_{\hat{\tau}}$ can be arbitrarily close to $R(1)$, and $R(1) < \hat{R} \leq R_{\hat{\tau}}$, this condition can be satisfied whenever $\Delta\pi^{i/j} - \phi\left(R(1)\right) > 0$, that is

     $$\Delta\pi^{i/j} > (1-\lambda)\,p_L\frac{c + \bar{\pi}^{i/j} - \bar{\pi}^{i/i} + I}{\lambda p_H + (1-\lambda)\,p_L} + \Delta\pi^{i/i} - c.$$

     Rearranging,

     $$c > \bar{c}_{ns} - \frac{\lambda p_H + (1-\lambda)\,p_L}{\lambda p_H}\Delta\pi^{i/j} \equiv \bar{c}'_s. \tag{32}$$

     Hence, such a profitable deviation exists if and only f $c > \max\left\{\bar{c}'_s, \Delta\pi^{i/i}\right\} \equiv \bar{c}_s$.

   - Deviation such that $\hat{\sigma}^A = 0$. In that case, $\tilde{\rho}\left(\hat{R},1\right) = \pi^{i/j} - \hat{\sigma}^A\Delta\pi^{i/j}$ yields $\hat{R} = \tilde{R}_1$, and a necessary condition for profitable deviation is $\Delta\pi^{i/j} - \phi\left(\tilde{R}_1\right) > 0$. But since $\tilde{R}_1 > R(1)$, when this holds one has also a profitable deviation with $0 < \hat{\sigma}^A < 1$; hence the relevant condition is $c > \max\left\{\bar{c}'_s, \Delta\pi^{i/i}\right\}$.

To sum up, $(R^*, \sigma^*, \tau^*) = (R(1), 1, \tau^*)$ is an equilibrium iff $c \leq \bar{c}_s \equiv \max\left\{\bar{c}'_s, \Delta\pi^{i/i}\right\}$.

Finally, consider a mixed equilibrium $0 < \sigma^* < 1$**.** Note that (since $\bar{c}_s < \bar{c}_{ns}$) there is no equilibrium in pure strategy when $\bar{c}_s < c < \bar{c}_{ns}$. In this region, there should be a mixed strategy equilibrium. From lemma 1, a symmetric mixed strategy equilibrium must solve

$$\tilde{\rho}(R^*, 0) + \sigma^* \phi(R^*) = \pi^{i/i} - \sigma^* \Delta\pi^{i/j}. \tag{33}$$

Note that (33) implies that $0 < \sigma^* < 1$ iff $R(1) < R^* < R(0)$. In addition, $0 < \sigma^* < 1$ requires $R^* = R_{\tau^*}$, that is

$$(1 - \tau^*)(1 - \lambda) p_L R^* + \Delta\pi^{i/i} = c. \tag{34}$$

A third condition on the three equilibrium variables (R^*, σ^*, τ^*) follows from the analysis of deviations. If $\phi(R^*) > \Delta\pi^{i/j}$, one bank (say A) can strictly increase its payoff by playing $\hat{\tau}$ just below τ^*. In that case, A is the only active bank after the deviation iff $\tilde{\rho}\left(\hat{R}, \hat{\sigma}^A\right) > \tilde{\pi}\left(\hat{\sigma}^B\right)$, where $\tilde{\rho}\left(R^*, \hat{\sigma}^B\right) = \tilde{\pi}\left(\hat{\sigma}^A\right)$. Using the same manipulations as for previous cases, this is equivalent to

$$\left(\hat{\sigma}^A - \hat{\sigma}^B\right) \phi(R^*) > \left(\hat{\sigma}^A - \hat{\sigma}^B\right) \Delta\pi^{i/:j}. \tag{35}$$

Now, by a reasoning similar to that in previous cases, one can show that $R_{\hat{\tau}} \leq \hat{R} \leq R^* = R_{\tau^*}$. Hence, either $\hat{R} = R_{\tau^*}$ or $R_{\hat{\tau}} \leq \hat{R} < R_{\tau^*}$. In the former case, $\hat{\sigma}^A = 1$ while $\hat{\sigma}^B < 1$ (since it solves $\tilde{\rho}\left(R^*, \hat{\sigma}^B\right) = \tilde{\pi}(1)$ with $R^* > R(1)$); hence, (35) holds and $\tilde{\rho}\left(R^*, \hat{\sigma}^A\right) > \tilde{\rho}(R^*, \sigma^*) = \Pi^*$. In the latter, $\hat{\sigma}^B = 0$ while $\hat{\sigma}^A > 0$ (since it solves $\tilde{\rho}(R^*, 0) = \tilde{\pi}\left(\hat{\sigma}^A\right)$ with $R^* < R(0)$; hence, (35) holds and $\tilde{\rho}\left(R^*, \hat{\sigma}^A\right) > \tilde{\pi}(0) > \Pi^*$. Hence, A has a profitable deviation. By a symmetric argument, we can show that A has a profitable deviation when $\phi(R^*) < \Delta\pi^{i/j}$. The only case in which there is no profitable deviation is given by

$$\phi(R^*) = \Delta\pi^{i/j}. \tag{36}$$

(33), (34) and (36) uniquely pin down (R^*, σ^*, τ^*), and yield a mixed equilibrium provided the solution satisfies $0 < \sigma^* < 1$ (which is equivalent to $R(1) < R^* < R(0)$) and $0 \leq \tau^* \leq 1$. Using the definition of ϕ and (34),

$$\phi(R^*) = \tau^*(1 - \lambda) p_L R^* + (1 - \tau^*)(1 - \lambda) p_L R^* + \Delta\pi^{i/i} - c = \tau^*(1 - \lambda) p_L R^*,$$

so that (36) can be rewritten as

$$\tau^*(1 - \lambda) p_L R^* = \Delta\pi^{i/j}. \tag{37}$$

Plugging (37) into (34) and solving one gets

$$R^* = \frac{c + \Delta\pi^{i/j} - \Delta\pi^{i/i}}{(1 - \lambda) p_L}, \tag{38}$$

and, from (34),

$$\tau^* = \frac{\Delta\pi^{i/j}}{c - \Delta\pi^{i/i} + \Delta\pi^{i/j}}. \tag{39}$$

Finally, plugging (38) into (33) and solving delivers the expression for σ^* in proposition 3. One can check that for the values c_s' and $\bar{c}_s'$, the mixed equilibrium (σ^*, R^*, τ^*) converges to $(0, R(0), \tau_0(c_s'))$ and $(0, R(0), \bar{\tau}_0(\bar{c}_s'))$, respectively.

Proof of proposition 4 Follows from a direct comparison of prop. 2 and 3, given $\bar{c}_s < \bar{c}_{ns}$ and $c_s < c_{ns}$. The first case ($c \le \bar{c}_s$ and $c_{ns} \le c$) is straightforward. For the second case, we distinguish two subcases. Consider first the case $\bar{c}_s < c \le \bar{c}_{ns}$: $\sigma_s^* < 1 = \sigma_{ns}^*$, and one can check that $R_s^* > R(1)$ is equivalent to $c > \bar{c}_s$. Consider now the case $\bar{c}_{ns} < c < c_{ns}$. Then, if $\bar{c}_{ns} < c < c_s$, both $\sigma_s^*$and σ_{ns}^* belong to $(0,1)$. Direct comparison of the formulae for R_s^* and R_{ns}^* shows that $R_s^* > R_{ns}^*$. In addition in both cases σ^* and R^* are connected through eq. (33), which yields $\sigma^* = \frac{\pi^{i/j} - \tilde{\rho}(R^*,0)}{\phi(R^*) + \Delta\pi^{i/j}}$. Since this function is strictly decreasing, $R_s^* > R_{ns}^*$ implies $\sigma_s^* < \sigma_{ns}^*$. If $c_s \le c_{ns}$, $\sigma_s^* = 0 < \sigma_{ns}^*$, and one can check that $R_{ns}^* < R(0)$ is equivalent to $c < c_{ns}$. Hence, we have shown that $R_s^* > R_{ns}^*$ and $\sigma_s^* < \sigma_{ns}^*$ for $\bar{c}_s < c < c_{ns}$. To complete the proof, $\Pi_s^* - \Pi_{ns}^* = (\sigma_{ns}^* - \sigma_s^*)\,\Delta\pi^{i/j}$ from propositions 2 and 3. Given that $\sigma_s^* < \sigma_{ns}^*$ for $\bar{c}_s < c < c_{ns}$, $\Pi_s^* - \Pi_{ns}^* > 0$.

Proof of proposition 5 We first prove the second part. By $U_s^{inv.} = U_{ns}^{inv.}$ and the definition of $\mathcal{W}$, we have $U_s^{bor.} - U_{ns}^{bor.} = \Delta\mathcal{W} - 2\Pi^*$. Using (14) and $\Pi_s^* - \Pi_{ns}^* = (\sigma_{ns}^* - \sigma_s^*)\,\Delta\pi^{i/j}$, this implies $U_s^{bor.} - U_{ns}^{bor.} = (\sigma_s^* - \sigma_{ns}^*)\left(\Theta + 2\Delta\pi^{i/j}\right)$. The competition softening effect is thus detrimental for borrowers whenever $\Theta + 2\Delta\pi^{i/j} > 0$. Given (3), a sufficient condition is thus $2\Delta\pi^{i/j} > (1-\lambda)\,p_L\left(I + \frac{1}{2}\bar{s}\right)$, that is $2Y > I + \frac{1}{2}\bar{s}$.

To prove the first part, we use the following parameter constellation: $\lambda = 0.4, p_H = 0.9, p_L = 0.1, I = 1, Y = 3, \bar{s} = 2$. One can check that this example satisfies all relevant parameter restrictions, with condition (3) on the social value of monitoring satisfied whenever $c < 0.248$. For this parameter specification, the values of the thresholds are

$$\bar{c}_s = 0.1147, c_s = 0.1347, \bar{c}_{ns} = 0.1847, c_{ns} = 0.1947,$$

so that securitization matters whenever $\bar{c}_s = 0.1147 < c < c_{ns} = 0.1947$. Condition $\Theta > 0$ then writes $c < 0.1280$. Hence, for $0.1147 < c < 0.1280$, one has $\Pi_s^* > \Pi_{ns}^*$ and $\mathcal{W}_s < \mathcal{W}_{ns}$. Note that in this example, securitization is detrimental to borrowers even when $\mathcal{W}_s \ge \mathcal{W}_{ns}$, since $2Y > I + \frac{1}{2}\bar{s}$.

Proof of proposition 7 We first discuss the property of the solution $\left(\sigma^A, R_1^*\right)$ to the system (17) and (12). Plugging the expression (17) for R into (12) shows that there is a unique equilibrium, which is characterized by:

- $\sigma^* = 0$ if $c > \Delta\pi^{i/i} + (1-\tau)(1-\lambda)p_L \frac{1}{\lambda p_H}\left(I + \pi^{i/j}\right) \equiv \chi_\tau$,
- $\sigma^* = 1$ if $c < \Delta\pi^{i/i} + (1-\tau)(1-\lambda)p_L \frac{1}{\lambda p_H}\left(I + \bar{\pi}^{i/j}\right) \equiv \bar{\chi}_\tau$,
- and, for intermediate values of c, σ^* is the unique solution to

$$c = \Delta\pi^{i/i} + (1-\tau)(1-\lambda)p_L \frac{1}{\lambda p_H}\left(I + \pi^{i/j} - \sigma\Delta\pi^{i/j}\right).$$

It is straightforward to see from this that σ^* is non increasing in τ, and decreasing in the intermediate case.

To prove proposition 7, it is sufficient to show that A can obtain with some $\tau > 0$ a profit which is strictly higher than what with $\tau = 0$. From (12), under the condition $\bar{\chi}_0 < c < \chi_0$, the equilibrium monitoring in the absence of securitization ($\tau = 0$) is characterized by $0 < \sigma_{\tau=0} < 1$. Now, for the intermediate case, the incumbent profit writes

$$\Pi^A = \; -I + \left(\lambda p_H + \sigma_A \tau (1-\lambda) p_L\right) R_1^A + \pi^{i/i} \; .$$

The incumbent's profits for $\tau = 0$ is thus simply

$$\Pi^A_{\tau=0} = \; -I + \lambda p_H R_1\left(\sigma_{\tau=0}\right) + \pi^{i/i} \; .$$

Consider now a strictly positive securitization level, $\bar{\tau} > 0$. The associated equilibrium monitoring is such that $\sigma_{\bar{\tau}} < \sigma_{\tau=0}$. Using the expression for the incumbent's profit and the optimal monitoring choice (12), one can find a lower bound for

$$\begin{aligned}
\Pi^A_{\bar{\tau}} \;&\geq\; -I + \left(\lambda p_H + \sigma_{\bar{\tau}}\bar{\tau}(1-\lambda)p_L\right) R_1^A\left(\sigma_{\bar{\tau}}\right) + \pi^{i/i} \; , \\
&\geq\; \sigma_{\bar{\tau}}\bar{\tau}(1-\lambda)p_L R_1^A\left(\sigma_{\bar{\tau}}\right) + \lambda p_H \left(R_1^A\left(\sigma_{\bar{\tau}}\right) - R_1\left(\sigma_{\tau=0}\right)\right) + \Pi^A_{\tau=0}.
\end{aligned}$$

But, using $\sigma_{\bar{\tau}} < \sigma_{\tau=0}$ and the fact that $R_1(\sigma)$ is a strictly decreasing function of σ, this implies that $\Pi^A_{\bar{\tau}} > \Pi^A_{\tau=0}$.

$$\begin{aligned}
\bar{\chi}_0 \; &= \Delta\pi^{i/i} + \tfrac{(1-\lambda)p_L}{\lambda p_H}\left(I + \bar{\pi}^{i/j}\right) \quad , \\
\chi_0 \; &= \Delta\pi^{i/i} + \tfrac{(1-\lambda)p_L}{\lambda p_H}\left(I + \pi^{i/j}\right) \quad .
\end{aligned}$$

Appendix B. Proofs for intermediate results.

Proof of lemma 1 Fix an arbitrary $\left(\tau^A, \tau^B\right)$, and consider an equilibrium of the continuation game. We need some additional notations to allow for the possibility of mixed strategies w.r.t. R. Define

$$\tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right) \equiv \mathbb{E}\left[\tilde{\pi}^{j/i}\left(\sigma^B\right)\right] = \mathbb{E}\left[\sigma^B\right]\bar{\pi}^{j/i} + \left(1 - \mathbb{E}\left[\sigma^B\right]\right)\pi^{j/i}$$

This represents the unconditional profit that bank A would make by not partipating in the first period and poaching B's client in period 2. It is thus the outside option of funds for A given the equilibrium strategy of B. Let $\tilde{\rho}_A(R)$ be the profit that bank A would make on borrowers accepting A' offer, and $p_A(R)$ denote the probability that this offer is accepted on-the-equilibrium (that is, given B's price strategy). Also, let $\tilde{\pi}_A\left(R^A\right)$ denote the profit that A would make on its competitor's client conditional on A's offer being rejected. Formally,

$$\begin{aligned}
\tilde{\rho}_A\left(R^A\right) &\equiv \tilde{\rho}^i\left(\tau^A, R^A, \sigma_{\tau^A}\left(R^A\right), \sigma_e^A\right), \\
p_A\left(R^A\right) &\equiv \Pr\left[A\, wins \left| R^A\right.\right], \\
\tilde{\pi}_A\left(R^A\right) &\equiv \tilde{\pi}\left(\mathbb{E}\left[\sigma^B \left| A\, loses, R^A\right.\right]\right).
\end{aligned}$$

Given these notations, the profit associated with a given interest rate can be expressed as

$$\pi^A\left(R^A\right) \equiv p_A\left(R^A\right)\tilde{\rho}_A\left(R^A\right) + \left(1 - p_A\left(R^A\right)\right)\tilde{\pi}\left(\mathbb{E}\left[\sigma^B \left| A\, loses, R^A\right.\right]\right) \tag{40}$$

Note that $\tilde{\rho}_A(.)$ is strictly increasing and continuous, with a kink at R_{τ^A}, the value at which A's monitoring strategy switches; $\tilde{\pi}_A(.)$ is strictly decreasing, and bounded below by $\tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right)$.

The support of A's strategy will be denoted by $\mathcal{S}^A$. Optimality of A's pricing strategy implies

$$\pi^A\left(R^A\right) = \Pi^A \quad \forall R^A \in \mathcal{S}^A,$$

$$\pi^A\left(R^A\right) \leq \Pi^A \quad \forall R^A \notin \mathcal{S}^A,$$

where Π^A is the equilibrium profit of A. Also, we have that

$$\tilde{\rho}_A\left(R^A\right) \geq \tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right) \quad \forall R^A \in \mathcal{S}^A,$$

since it would never be rational to offer a rate such that, if accepted, would lead to lower profits per borrower than can be earnt by poaching in the second period. Analogous notations and conditions hold for bank B.

The proof requires a number of steps. First, we eliminate equilibria where $\Pi^A > \tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right)$ and $\Pi^B > \tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)$. Then, we consider equilibria in which both banks are active. To conclude, we consider equilibria with only one active bank.

Step 1. We consider candidate equilibria where $\Pi^A > \tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right)$ and $\Pi^B > \tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)$ and rule them out.

- Clearly, $R^A_{max} = R^B_{max} \equiv R_{max}$, and there must be a mass point at R_{max} by both banks. The former follows from the fact that for any $R \geq R^A_{max}$, B would make a profit $\pi_B(R) = \tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right) < \Pi^B$, contradicting the fact that $R \in \mathcal{S}^B$. Consider next the latter. Assume that B does not put any mass point at R_{max}. Then, $p_A(R_{max}) = 0$, and $\pi_A(R_{max}) = \tilde{\pi}\left(\mathbb{E}\left[\sigma^B \left| loses, R_{max}\right.\right]\right) = \tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right) < \pi^A$. Again, a contradiction. For future use, denote by $\delta_B > 0$

(resp., $\delta_A > 0$) the probability that B (resp., A) plays R_{max}. By an application of Bayes' rule, and the definition of $\tilde{\pi}_B(R_{max})$, we have

$$\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right) = \left(1 - \delta_A + \frac{1}{2}\delta_A\right)\tilde{\pi}_B(R_{max}) + \frac{1}{2}\delta_A\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A = R_{max}\right.\right]\right) \quad (41)$$

(and an analogous formulae with the permutation of B/A).

- We now show that since both banks put a mass point at R_{max}, one bank has an incentive to undercut by playing slightly below R_{max}. With a slight abuse of notation, let R_{max}^- denote an interest rate "arbitrarily below R_{max}". Using Bayes' rule, one can compute

$$\begin{aligned}\tilde{\pi}_B(R_{max}) &= \frac{\Pr\left[R^A < R_{max}\right]}{\Pr\left[R^A < R_{max}\right] + \frac{1}{2}\Pr\left[R^A = R_{max}\right]}\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A < R_{max}\right.\right]\right) \\ &\quad + \frac{\Pr\left[R^A < R_{max}\right]}{\Pr\left[R^A < R_{max}\right] + \frac{1}{2}\Pr\left[R^A = R_{max}\right]}\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A = R_{max}\right.\right]\right)\end{aligned}$$

with $\Pr\left[R^A < R_{max}\right] = 1 - \Pr\left[R^A = R_{max}\right] = 1 - \delta_A$.[22] Hence, we have

$$\begin{aligned}\tilde{\pi}_B(R_{max}) &= \frac{1 - \delta_A}{1 - \delta_A + \frac{1}{2}\delta_A}\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A < R_{max}\right.\right]\right) \\ &\quad + \frac{\frac{1}{2}\delta_A}{1 - \delta_A + \frac{1}{2}\delta_A}\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A = R_{max}\right.\right]\right)\end{aligned}$$

and, eventually,

$$\left(1 - \delta_A + \frac{1}{2}\delta_A\right)\tilde{\pi}_B(R_{max}) = (1 - \delta_A)\tilde{\pi}_B\left(R_{max}^-\right) + \frac{1}{2}\delta_A\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A = R_{max}\right.\right]\right) \quad (42)$$

Now, the profit associated with R_{max}^- for, say, bank B is

$$\pi_B\left(R_{max}^-\right) = \delta_A\tilde{\rho}_B\left(R_{max}^-\right) + (1 - \delta_A)\tilde{\pi}_B\left(R_{max}^-\right)$$

while profit at R_{max} are

$$\pi_B(R_{max}) = \frac{1}{2}\delta_A\tilde{\rho}_B(R_{max}) + \left(1 - \delta_A + \frac{1}{2}\delta_A\right)\tilde{\pi}_B(R_{max})$$

using (42), one can rewrite

$$\pi_B(R_{max}) = \frac{1}{2}\delta_A\tilde{\rho}_B(R_{max}) + (1 - \delta_A)\tilde{\pi}_B\left(R_{max}^-\right) + \frac{1}{2}\delta_A\tilde{\pi}\left(\mathbb{E}\left[\sigma^A \left| R^A = R_{max}\right.\right]\right)$$

[22] We use the fact that there is no mass point "at R_{max}^-" since there is a mass point at R_{max}.

and obtain

$$\begin{aligned}\pi_B\left(R_{max}^{-}\right)-\pi_B\left(R_{max}\right) &= \frac{1}{2}\delta_A\left(\tilde{\rho}_B\left(R_{max}^{-}\right)-\tilde{\rho}_B\left(R_{max}\right)\right) \\ &\quad +\frac{1}{2}\delta_A\left(\tilde{\rho}_B\left(R_{max}^{-}\right)-\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\left|R^A=R_{max}\right.\right]\right)\right).\end{aligned}$$

Since $\tilde{\rho}_B$ is continuous, $\tilde{\rho}_B\left(R_{max}^{-}\right)-\tilde{\rho}_B\left(R_{max}\right)\longrightarrow 0$, and one condition for equilibrium is that $\tilde{\rho}_B\left(R_{max}\right)\leq\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\left|R^A=R_{max}\right.\right]\right)$ (otherwise, $\pi_B\left(R_{max}^{-}\right)>\pi_B\left(R_{max}\right)=\Pi^B$). But this implies further that

$$\begin{aligned}\pi_B\left(R_{max}\right) &= \frac{1}{2}\delta_A\tilde{\rho}_B\left(R_{max}\right)+\left(1-\delta_A+\frac{1}{2}\delta_A\right)\tilde{\pi}_B\left(R_{max}\right) \\ &\leq \frac{1}{2}\delta_A\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\left|R^A=R_{max}\right.\right]\right)+\left(1-\delta_A+\frac{1}{2}\delta_A\right)\tilde{\pi}_B\left(R_{max}\right) \\ &\leq \tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right),\end{aligned}$$

where the last equality follows from (41). But this contradicts the assumption that $\pi_B\left(R_{max}\right)=\Pi^B>\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)$.

Step 2. We show that if both banks are active, both (23) and (24) hold. Given step 1, it must be the case that $\Pi^i=\tilde{\pi}\left(\mathbb{E}\left[\sigma^j\right]\right)$ for at least one bank. Assume that$\Pi^A=\tilde{\pi}\left(\mathbb{E}\left[\sigma^B\right]\right)$. We first show that A plays at most one R such that $p_A\left(R\right)>0$. Assume the contrary, i.e. $\exists R<R'$ such that $p_A\left(R\right)\geq p_A\left(R'\right)>0$. Then, using the strict monotonicity of $\tilde{\rho}$

$$\begin{aligned}\pi^A\left(R'\right) &= p_A\left(R'\right)\tilde{\rho}_A\left(R'\right)+\left(1-p_A\left(R'\right)\right)\tilde{\pi}_A\left(R'\right) \\ &\geq p_A\left(R'\right)\tilde{\rho}_A\left(R'\right)+\left(1-p_A\left(R'\right)\right)\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right) \\ &> p_A\left(R'\right)\tilde{\rho}_A\left(R\right)+\left(1-p_A\left(R'\right)\right)\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)\end{aligned}$$

which, since $\tilde{\rho}_A\left(R\right)\geq\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)$ implies $\pi^A\left(R'\right)>\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right)=\pi^A\left(R\right)=\Pi^A$, contradicting the fact that $R\in\mathcal{S}^A$.

This further implies that $R=\min\mathcal{S}^A$, and that B does not play $\leq R$. Also, one must have $R=\min\mathcal{S}^B$, otherwise A would not play R (but above). In addition, B must play R w.p. >0 (mass point). Now, A must also play a mass point at R. (Otherwise, it would not be active, since it would have zero market share with probability one).

Hence, both banks must put a mass point at $R=R_{min}$. This implies in particular that for each bank, $\tilde{\rho}_i\left(R_{min}\right)\leq\tilde{\pi}_i\left(R_{min}\right)=\tilde{\pi}\left(\sigma^j\left(R_{min}\right)\right)$ (where the latter step follows from the fact that $R=R_{min}$). Now, assume that $\tilde{\rho}_i\left(R_{min}\right)<\tilde{\pi}\left(\sigma^j\left(R_{min}\right)\right)$ for one bank, say B. Then, since there is a mass point at R_{min} by A, there cannot be a distinct mass point in the neighborhood to the right of R_{min} (by a reasoning similar to that in step 1), implying that B would obtain a strictly higher profit py playing just above R_{min} rather than by playing R_{min}. A contradiction. Hence,

$\tilde{\rho}_i(R_{min}) = \tilde{\pi}\left(\sigma^j(R_{min})\right)$ must hold for both banks. That is, the equilibrium must simultaneously solve (23) and (24).

Step 3. To conclude, we consider equilibria with only one active bank. Assume A active, B inactive. Since B is inactive, it must be the case that A plays a unique R w.p. 1, with the property that $F_B(R) = 0$ and $F'_B(R) > 0$, where F_B is the cumulative function of B's strategy (in particular, $R = \min \mathcal{S}^B$). This implies in particular that $\tilde{\pi}\left(\mathbb{E}\left[\sigma^A\right]\right) = \tilde{\pi}\left(\sigma^A(R)\right)$.

Now, $\tilde{\rho}_B(R) \leq \tilde{\pi}\left(\sigma^A(R)\right)$ must hold, otherwise B would be strictly better off by being active (undercutting). However, since $R = \min \mathcal{S}^{\mathcal{A}}$, $\tilde{\rho}_B(R) \geq \tilde{\pi}\left(\sigma^A(R)\right)$ must also hold. Hence, $\tilde{\rho}_B(R) = \tilde{\pi}\left(\sigma^A(R)\right)$, that is (24) holds when B is inactive. Note that on A's side, the condition for equilibrium is that A cannot increase his payoff by playing above R, or equivalently being inactive. This is true when $\tilde{\rho}_A(R) > \tilde{\pi}\left(\sigma^B(R)\right)$. (To support the equilibrium, one can consider w.l.o.g. that B plays "just to the right" of R, for instance by playing uniformly over $(R, R+\varepsilon]$. One can check that for εsufficiently small, this strategy supports the equilibrium.)

Proof of lemma 2 Let $\tau^A \neq \tau^B$. We first by show the unicity of a solution to $\tilde{\rho}\left(R, \sigma^i\right) = \tilde{\pi}^{i/j}\left(\sigma^j\right)$, or equivalently,

$$\rho(R, 0) + \sigma^i \phi(R) = \pi^{i/j} - \sigma^j \Delta\pi^{i/j}. \tag{43}$$

Assume there exists two different solutions $S = \left(R, \sigma^i, \sigma^j\right)$ and $S' = \left(R', \sigma'^i, \sigma'^i\right)$. Consider first the case where $R \neq R'$, for instance $R > R'$. Given the monitoring condition (12), this implies that $\sigma^i \geq \sigma'^i$ and $\sigma^j \geq \sigma'^j$. Since the l.h.s. is strictly increasing in R and σ, this implies $\rho(R, 0) + \sigma^i \phi(R) > \rho(R', 0) + \sigma'^i \phi(R')$. On the other hand, since the r.h.s. is strictly decreasing in σ, $\pi^{i/j} - \sigma^j \Delta\pi^{i/j} \leq \pi^{i/j} - \sigma'^j \Delta\pi^{i/j}$. But since S solves (43), we have $\rho(R', 0) + \sigma^{i'} \phi(R') < \pi^{i/j} - \sigma'^j \Delta\pi^{i/j}$, contradicting the assumption that S' is a solution. Consider next the case where $R = R'$. Using (43), we have

$$\left(\sigma^i - \sigma'^i\right) \phi(R) = \left(\sigma'^j - \sigma^j\right) \Delta\pi^{i/j},$$

implying that both $\sigma^i \neq \sigma'^i$ and $\sigma^j \neq \sigma'^j$ must hold. From (12), the former implies $R = R_{\tau^A}$, and the latter $R = R_{\tau^B}$. But $R_{\tau^A} \neq R_{\tau^B}$ since $\tau^A \neq \tau^B$. Hence, $S = S'$.

We now show uniqueness of the equilibrium. From lemma 1, (23) or (24) must hold in equilibrium. From the unicity of S^a and S^b, there is a unique equilibrium with both banks active when $S^a = S^b$. When $S^a \neq S^b$, we distinguish three cases. Consider first the case where $R^a > R^b$. Then S^a is an equilibrium in which B is active, and A inactive. From the monotonicity of $\sigma^i(R)$, $R^a > R^b$ implies $\sigma^{Aa} \geq \sigma^{Ab}$, and $\sigma^{Ba} \geq \sigma^{Bb}$. Hence, we have

$$\tilde{\rho}\left(R^a, \sigma^{Ba}\right) > \tilde{\rho}\left(R^b, \sigma^{Bb}\right) = \tilde{\pi}\left(\sigma^{Ab}\right) \geq \tilde{\pi}\left(\sigma^{Aa}\right)$$

where the first step follows from the monotonicity of $\tilde{\rho}$, the second from the definition of S^b, and the last step from the monotonicity of $\tilde{\pi}$. Since $\tilde{\rho}\left(R^a, \sigma^{Ba}\right) > \tilde{\pi}\left(\sigma^{Aa}\right)$

and $\tilde{\rho}\left(R^a, \sigma^{Aa}\right) = \tilde{\pi}\left(\sigma^{Ba}\right)$, we have an equilibrium in which B is active. By a symmetric argument, the situation in which A is active and B inactive cannot be an equilibrium, since S^b would lead to $\tilde{\rho}\left(R^a, \sigma^{Aa}\right) < \tilde{\pi}\left(\sigma^{Ba}\right)$. Consider next the case where $R^a < R^b$. By a similar reasoning, A is active while B is inactive, with the equilibrium strategies given by $\left(R^b, \sigma^{Ab}, \sigma^{Bb}\right)$. Consider finally the case where $R^a = R^b$. Denote R this common value. If B is active, equilibrium variables are thus given by $\tilde{\rho}\left(R, \sigma^{Aa}\right) = \tilde{\pi}\left(\sigma^{Ba}\right)$, and this is an equilibrium if $\tilde{\rho}\left(R, \sigma^{Ba}\right) > \tilde{\pi}\left(\sigma^{Aa}\right)$. Using the expressions for $\tilde{\rho}$, $\tilde{\pi}^{i/j}$ and some manipulations, this condition writes

$$\tilde{\rho}\left(R, \sigma^{Ba}\right) - \tilde{\pi}\left(\sigma^{Aa}\right) = \left(\sigma^{Ba} - \sigma^{Aa}\right)\left(\phi\left(R\right) - \Delta\pi^{i/j}\right) > 0. \tag{44}$$

Similarly, if A is active, equilibrium quantities are given by $\tilde{\rho}\left(R, \sigma^{Bb}\right) = \tilde{\pi}\left(\sigma^{Ab}\right)$, and the condition for equilibrium is we have

$$\tilde{\rho}\left(R, \sigma^{Ab}\right) - \tilde{\pi}\left(\sigma^{Bb}\right) = \left(\sigma^{Ab} - \sigma^{Bb}\right)\left(\phi\left(R\right) - \Delta\pi^{i/j}\right) > 0. \tag{45}$$

Note that $\phi\left(R\right) \neq \Delta\pi^{i/j}$ must hold, otherwise (44) implies that S^a solves (24), that is $S^a = S^b$ (by unicity). By the same argument, $\sigma^{Ba} \neq \sigma^{Aa}$ and $\sigma^{Ab} \neq \sigma^{Bb}$.To conclude that the equilibrium is unique, we need to show that only (44) or (45) can hold. For this, it suffices to show that $\left(\sigma^{Ab} - \sigma^{Bb}\right)\left(\sigma^{Ba} - \sigma^{Aa}\right) < 0$. Now, since $R_{\tau^A} \neq R_{\tau^B}$, from (12) the monitoring choice of either A or B must be the same in both cases, and equal to 0 or 1. For instance, $\sigma^{Ab} = \sigma^{Aa} = 0$ if $R < R_{\tau^A}$, while $\sigma^{Ab} = \sigma^{Aa} = 1$ if $R > R_{\tau^A}$. In both cases, $\sigma^{Ab} - \sigma^{Bb}$ and $\sigma^{Ba} - \sigma^{Aa}$ have opposite signs. When $R = R_{\tau^a}$, the same reasoning holds for σ^{Ba} and σ^{Bb}. To conclude, when $S^a \neq S^b$, one and only one of (44) or (45), and there cannot be two equilibria.

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