SELLING DREAMS: ENDOGENOUS OVEROPTIMISM AND COLLATERAL USE IN FINANCIAL CONTRACTS

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Abstract. We explore whether overoptimism on behalf of borrowers may arise endogenously in financial markets or whether the financial sector prefers to and is able to induce realism. In our model, borrowers may optimally bias their expectations of future outcomes in pursuit of the anticipatory utility benefits of overoptimism and under due consideration of the potential costs of optimism that arise from agreeing to contractual terms that are detrimental to borrowers' material payoffs. By setting the contractual terms, lenders exert some control over borrowers' incentive to delude themselves into thinking that their project has a lower risk of failure than it actually has. We show that lenders may sometimes want to induce delusion on behalf of borrowers because they can profit from an overly optimistic borrower's willingness to accept inflated levels of collateral requirements. The downside of contracting with a deluded borrower, however, is that she is able to credibly demand better contractual terms, since she believes her outside option to be more valuable and that, in an adverse selection context, allowing high risk borrowers to delude themselves entails that the lender can no longer screen risk types. As a result, lenders sometimes prefer to induce realism. We characterize equilibrium allocations in both monopolistic and competitive lending markets with adverse selection. We find that the presence of optimal expectations may give rise to pooling equilibria with positive collateral, which helps explain the prevalence of collateral across all risk classes found in empirical studies. Also in line with empirical evidence, competitive markets are more likely to give rise to overoptimism and the collateralization of loans to high-risk borrowers when the opportunity cost of funds is low and entrepreneurial profits are high. A financial crisis may thus yield an especially high prevalence of foreclosures and disillusionment, if it comes on the heels of a period of cheap credit.

Keywords: adverse selection, common values, screening, financial contracting, collateral, wishful thinking, delusion, overoptimism.
JEL: D86, D82, G33.

1. Introduction

Evidence for unrealistic optimism abounds (see Kahneman (2011) for a recent review) and the phenomenon has been documented among experimental subjects (e.g. Camerer and Lovallo (1999)), entrepreneurs and businessmen (Arabsheibani et al. (2000)), as well as CEOs, who overestimate their future performance and hold stock options until the expiration date (Malmendier and Tate (2005)). At the same time, intuition tells us that people are often fairly realistic about the likelihood of their future success and may even suffer from anxiety in anticipation of potentially adverse outcomes. We seek to make a contribution to the endeavour of better understanding when optimism is likely to arise and when countervailing forces are likely to hold it in check.

We focus on the context of financial markets and ask how the prevalence of overly optimistic beliefs is impacted upon by factors such as the banking industry's level of competition, the opportunity cost of funds, information asymmetries between lenders and borrowers, and the outside options of borrowers. Borrowers in our model derive anticipatory utility from their expectation of future payoffs and are able to bias their beliefs to inflate this anticipatory utility, as in the optimal expectations framework due to Brunnermeier and

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Parker (2005). A borrower thus receives higher current utility if she is free from worrying about the future because she deludes herself into thinking that her project has only a low probability of failure. Overoptimism regarding her type may, however, come at the cost of agreeing to contractual terms that are detrimental to the borrower's material payoffs in light of her actual risk.

Because lenders set contractual terms, they exert some control over the costs and benefits the borrower associates with being overly optimistic and may therefore affect whether or not the borrower has an incentive to delude herself. In particular, lenders in our model use collateral as a means to benefit from borrower optimism and as a disciplining device that may discourage unrealistic optimism. Instead of being assumed at the outset, we consider borrower overoptimism as an endogenous outcome, to be determined in equilibrium. This sets our paper apart from previous work that studies optimal contract design with optimists (Landier and Thesmar (2009), de la Rosa (2011)), or regulation and consumer protection in insurance settings (Sandroni and Squintani (2007)), while assuming that the level of overoptimism and overconfidence is fixed and exogenous to the model.

Yet the idea that individuals may bias their beliefs in the service of psychological needs is by no means new. While Brunnermeier and Parker (2005) and Bénabou (2013), like us, emphasize an anticipatory utility motive for biased beliefs, Akerlof and Dickens (1982) stress cognitive dissonance reduction and Carrillo and Mariotti (2000) as well as Bénabou and Tirole (2002) point to the motivational benefits of optimism or strategic ignorance. Recent empirical work supports the realism of our modelling assumption of the optimal expectations process. Mayraz (2011); Mobius et al. (2011) uncover self-serving overoptimism or biased information processing in the economic decision making of experimental subjects, while (Oster et al. (2011)) study the health beliefs and economic behaviour of people at risk of Huntington disease, and find evidence for mental processes best described by the optimal expectations paradigm.

Other papers have stressed the importance of motivated cognition in delegation settings. Menichini et al. (2010) and Immordino et al. (2011), for example, study the interplay between contract design and motivated cognition in a moral hazard framework. Their focus on managerial incentives and moral hazard leads them to emphasise the selection of managers on the basis of cognitive traits such as emotional stability, which is a different concern from ours.

In the case of a monopoly lender who knows the borrower's type, we decompose the demand for delusion on behalf of the borrower as arising both from its direct anticipatory utility benefit, and from a strategic benefit: since overoptimism affects the perceived payoff from outside options, adopting overoptimistic beliefs can be an effective bargaining device that allows the borrower to commit to reject offers that are deemed inferior to an inflated subjective outside option. A similar strategic motive for self-deception shows up in the the experimental evidence of Charness, Rustichini and van der Ven (2013) that suggests that subjects become overconfident in order to compel potential competitors to opt out of a tournament.

Under *ex-ante* symmetric information, a lender may costlessly enforce realism through the use of a high-collateral "threat contract" which would be chosen off the equilibrium path by an overoptimistic borrower. Such a contract threatens the borrower with large expected losses if she were to become deluded, and would destroy a large amount of joint surplus if selected. Under *ex-ante* asymmetric information, the use of threat contracts is precluded by the presence of borrowers who truly have a low risk of failure. The lender can no longer tailor his offer to the borrower's type, and therefore any contract taken up by a deluded borrower is also offered, and accepted, by a realistic low-risk borrower. In addition to being a support for side bets, collateral is then used to screen risk types, because pledging costly collateral is cheaper for low-risk types, as in Bester (1985) and Besanko and Thakor (1987)).

We show that when borrowers with private information are prone to delusion, a monopoly lender offers a menu of contracts that is markedly different from the standard second-best menu of contracts that prevails when delusion is not possible. When the weight of anticipatory utility is limited, the potential for delusion does not lead to equilibrium overoptimism, but instead has the effect of eroding the lender's bargaining power. Contrary to what may be expected, enforcing realism on the part of high-risk borrowers is not achieved most efficiently by introducing extra collateral requirements on low-risk borrowers, but instead by giving up repayment in case of success.

The monopolist's contract design changes drastically once the weight of anticipatory concerns becomes large. Then, the lender renounces screening altogether and instead induces delusion on behalf of high-risk borrowers. Collateral no longer serves a separation purpose, since all borrowers choose the same contract, but is instead used to make deluded borrowers pay for their optimism. The amount of collateral effectively chosen reflects a trade-off between taking advantage of the unfair odds presented to optimistic borrowers and the efficiency cost of demanding collateral from low-risk and high-risk borrowers alike.

In the case of a competitive lending market under asymmetric information, borrowers are also screened if the weight on anticipatory utility is sufficiently small. However, for a large weight on anticipatory feelings, the competitive lending market also gives rise to a pooling equilibrium with positive collateral requirements and delusion on behalf of high-risk borrowers. Pooling of risk types with positive collateral is in line with empirical evidence that collateral use is prevalent across risk classes and not necessarily correlated with ex-ante measures of risk (Berger and Udell (1990)), even though the use of collateral does react to changes in ex-ante information asymmetry (Berger et al. (2011)).

We are able to do comparative statics in the case of a competitive lending market and find that the likelihood of observing an equilibrium with collateralisation and overoptimism on behalf of high-risk borrowers is more likely when the opportunity cost of funds is low and the return to projects is high. The inverse relationship between the risk free rate and the likelihood of collateralisation of borrowers is supported by findings in **?**. In addition to a model small firm borrowing, our model may also be viewed as a stylized description of loan financed home purchases, in which a house serves as collateral and future earnings from employment and hence, the a households ability to repay the loan is uncertain. The inverse relationship between the cost of credit and the collateralisation and overoptimism of borrowers, may then help explain how cheap credit in the wake of the 2008 financial crisis could lead to a staggering prevalence of foreclosures and disillusionment following the correlated bad realisation of credit risk during the crisis.

2. Setup

2.1. **Technology, contracts and material payoffs.**

Risk-neutral borrowers seek a fixed-size investment G for a project that may succeed and yield a positive return y or fail and yield no return. A borrower's risk of failure θ is initially known to her and may either be high (θ_H) or low (θ_L), with $1 > \theta_H > \theta_L > 0$. The relative proportions of high and low risks is summarised by the parameter $\nu := \mathbb{P}[\theta = \theta_H] \in (0,1)$. Lenders are also risk-neutral.

When a borrower does not select any of the contracts offered by the lender, she receives a type-dependent reservation utility $U_{Res_\theta} \geq 0$. A contract is a pair (R, C) and defines a repayment R from the borrower to the lender that is due if the project is successful, and a non-negative amount of collateral C that is transferred from the borrower to the lender if the project fails. The borrower's expected material payoff if she accepts contract (R, C) is thus given by

$$U_B(\theta, R, C) = (1-\theta)(y-R) - \theta C \tag{1}$$

We do not impose any wealth constraints on the ability to pledge collateral, but we rule out fully secured loans by assuming that collateral is not perfectly transferable, so that if the project fails, the borrower loses C, but the lender only obtains $\delta(C)C$ with $\delta(C) \leq 1$. While most models of costly collateral assume a constant haircut ($\delta(C) = \bar{\delta} < 1$), we assume that the borrower's assets are heterogeneous in their transferability and that the borrower pledges the most transferable asset first. For example, her stock of treasury bills will be pledged before she considers pledging her car, for which the wedge between private and market value is presumably larger.

Assumption 1. *The rate of value recovery is linearly decreasing in collateral C and liquidation is free at the margin for $C = 0$:*

$$\delta(C) = 1 - \chi C, \ \chi > 0$$

Linearity of $\delta(C)$ is only a technical simplification, while the assumption that $\delta(0) = 1$ is more restrictive, as it implies that using collateral is free at the margin when $C = 0$[1]; and that enforcing contracts with large collateral values is never optimal, as any amount over $(2\chi)^{-1}(1)$ is not worth recovering. On a formal level, using a strictly decreasing recovery rate makes the lender's preferences in the (R, C) space strictly convex. The lender's expected payoffs from contracting with type θ is given by

$$U_I(\theta, R, C) = (1-\theta)R + \theta(1-\chi C)C - G \tag{2}$$

2.2. **Anticipatory utility.**

A crucial building block of our model is that the borrower does not only care about the material payoffs she receives, but also derives utility from anticipating future outcomes. Since this psychological payoff does not depend on her actual type but on what she believes her type to be, denying her true type can yield a direct utility benefit to the borrower. Furthermore, this utility benefit from overoptimism depends on contractual terms available to the borrower, and is therefore determined endogenously by the offers tendered by lenders.

While there is no shortage of plausible theories on motivated cognition and beliefs, we adopt the optimal expectations hypothesis, introduced by Brunnermeier and Parker (2005), which asserts that beliefs are adjusted to reflect an optimal tradeoff of psychological and material benefits. More formally, upon observing the contracts that are offered to her, the borrower chooses whether to believe that she belongs to another class of risk. We assume that there is no direct cost to delusion and that beliefs are an element of the set

[1] Note that in insurance models based on expected utility, the risk premium associated with a small deviation around full insurance is also of second order, which means that the screening technology comes at no cost at the margin.

types $\{\theta_L, \theta_H\}$. A borrower does not have the option to believe that she belongs to a class of risk that has zero probability, and in particular, low risks have no scope for optimism.[2] In a sense we therefore assume that anyone can believe they have the athletic ability of Usain Bolt, but Usain Bolt may not believe he is superman. This assumption entails that the subject of our investigation will be the high-risk borrower, because it is only the high-risk borrower that stands to gain anticipatory utility from deluding herself.

We now write the total expected payoff of a borrower of type θ and belief $\tilde{\theta}$ who accepts contract offer (R, C) as the weighted sum of a material part and an anticipatory part: $U_B(\theta, R, C) + sU_B\left(\tilde{\theta}, R, C\right)$. The material payoffs component depends on the borrower's actual type, while the second term captures the anticipatory utility and depends on the borrower's belief. The parameter $s > 0$ measures the weight the borrower places on anticipatory feelings relative to material outcomes. When a high-risk borrower chooses to believe that she is of low risk, she will do so in an effort to inflate the anticipatory utility component. The cost of her delusion is reflected in the material payoffs component, if her distorted beliefs cause her to agree to contractual terms that are detrimental to her material payoffs. The core *optimal expectations* assumption states that the borrower optimally biases her beliefs in light of this trade-off.

2.3. **Timing of the contracting game.**

- $t = 0$: In the case of a monopoly, the lender offers a menu of contracts $\mathcal{C} = \{(R_i, C_i)\}_i$. In the case of competition, two lenders offer menus of contracts.
- $t = 1$: $Self1$ of the borrower observes her type $\theta \in \{\theta_L, \theta_H\}$ and the menus of contracts available. She chooses her belief $\tilde{\theta} \in \{\theta_L, \theta_H\}$ so as to maximise the undiscounted sum of $U_B(\theta, \tilde{R}, \tilde{C})$, her material payoffs at $t = 3$; and $sU_B(\tilde{\theta}, \tilde{R}, \tilde{C})$, her anticipation payoff at $t = 2$.
- $t = 2$: $Self2$ of the borrower chooses her favoured contract $(\tilde{R}, \tilde{C}) \in \mathcal{C} \cup \{(R_{Res}, C_{Res})\}$ given her belief $\tilde{\theta}$. She receives anticipatory utility from her expectation of material payoffs evaluated with belief $\tilde{\theta}$: $sU_B(\tilde{\theta}, \tilde{R}, \tilde{C})$
- $t = 3$: Material payoffs $U_B(\theta, \tilde{R}, \tilde{C})$ and $U_I(\theta, \tilde{R}, \tilde{C})$ are realised.

The structure of the game contains a crucial assumption regarding when and how a borrower is able to delude herself. In particular, we assume that a borrower may only delude herself before she picks a contract and as a result, delusion comes with the potential cost of choosing a contract that is detrimental to her material payoffs. We may, however, imagine that a borrower would like to remain realistic throughout the contract selection stage and only delude herself once the ink on the contract has dried and there is no more cost of delusion (except perhaps from renegotiation). While this is an interesting pursuit for future research, the structure of our game rules this scenario out. We think that our game structure possesses realism because delusion is perhaps most likely to occur when a borrower is first confronted with the task of evaluating her probability of failure, which happens at $t = 1$ in our model.

Another reason for thinking that an agent is unlikely to be realistic only to delude herself after a contract has been signed, is that the contract she has signed will serve as hard evidence for the borrower's actual risk type. Oster et al. (2011) show that a model based on optimal expectations matches the beliefs and and economic decision making of people at risk of Huntington disease. The power of hard evidence in counteracting delusion is reflected in their finding that those who take a genetic test that diagnoses them as having Huntington disease behave and believe markedly differently from people who do not have the disease,

[2] Such choice of beliefs can be seen as the limit of a "censorship of adverse evidence" process, as in Bénabou and Tirole (2002), but with an absolutely unwitting agent.

while those who only receive a more noisy signal in the form of symptoms or the genetic predisposition because of parent's death of the disease, behave as if they had no risk of having the disease.

2.4. **Equilibrium concept and constraints.**

We study subgame-perfect equilibria of the game described above. We typically characterise offers that induce realism and delusion separately, and then determine which contracts are featured in equilibrium. In any equilibrium, we can without loss of generality denote by (R_L, C_L) the contract picked at time 2 by a borrower with belief $\tilde{\theta} = \theta_L$ and by (R_H, C_H) the contract picked at time 2 by a borrower with belief $\tilde{\theta} = \theta_H$. Crucially, actual types are irrelevant at stage 2, so for example, overoptimistic high-risk borrowers and realistic low-risk borrowers face the same problem and therefore must make the same choices at stage 2. For that reason, contract offers by a monopoly lender can be limited to two contracts. Furthermore, as is standard in screening frameworks, we assume that lender-preferred outcomes are selected in cases of indifference, which allows us to represent monopoly outcomes as the solutions of optimisation programs, taking the beliefs and contract choices of borrowers as control variables.

Where we derive contract offers from maximisation problems, we are lead to consider the following constraints :

Incentive Compatibility constraints express the requirement that the agent not choose to mimic the other agent's type at $t = 2$. Multipliers attached to such constraints are denoted λ.

$$U_B(\theta_L, R_L, C_L) - U_B(\theta_L, R_H, C_H) \geq 0 \tag{3a}$$

$$U_B(\theta_H, R_H, C_H) - U_B(\theta_H, R_L, C_L) \geq 0 \tag{3b}$$

Individual rationality constraints express the requirement that the agent prefer the contract being offered to the outside option, at $t = 2$. These need only apply if there is no exclusion, or if we allow collateral to be negative in latent contracts. Multipliers attached to such constraints are denoted μ. Individual rationality constraints are given by

$$U_B(\theta_L, R_L, C_L) - U_{ResL} \geq 0 \tag{4a}$$

$$U_B(\theta_H, R_H, C_H) - U_{ResH} \geq 0 \tag{4b}$$

where U_{Res} is a borrower's reservation utility and we will generally assume that $U_{Res_L} \geq U_{Res_H}$. As will be explained in more detail below, a pair of type-dependent reservation utilities can equivalently be restated as a single reservation contract (R_{Res}, C_{Res}) which is not bound to satisfy $C_{Res} \geq 0$.

Optimal expectations constraints. We represent the optimal expectation requirement as an additional constraint, guaranteeing sequential optimality in the choice of beliefs. For instance, if the monopolist induces realism on the part of high-risk borrowers, then it must hold that

$$((1+s)\, U_B(\theta_H, R_H, C_H) \geq U_B(\theta_H, R_L, C_L) + sU_B(\theta_L, R_L, C_L)) \tag{5}$$

We use the notation $OE_{H,H}$ in such a case, where the first index denotes type H and the second index indicates the choice of belief $\tilde{\theta} = \theta_H$. Multipliers attached to such constraints are denoted κ. When necessary, profitability constraints are denoted by τ.

3. Efficiency and welfare

In this section, we analyse the total ex ante surplus available to a lender contracting with a high-risk borrower and ask what impact the potential for delusion has on this surplus. A low-risk borrower, by assumption, cannot delude herself and efficiency therefore merely requires that zero costly collateral be used in the contract. For the sake of welfare analysis, and in order not to artificially inflate one agent's utility relative to another's, we assume that the claimants of lender's profits weigh their anticipation of expected profits by the same factor s that is applied by borrowers.[3]

The net present value (NPV) of a high-risk borrower's project can be written as follows:

$$\begin{aligned} NPV =&(1-\theta_H)y - \theta_H \chi C^2 - G \\ &+ s\left[(1-\theta_H)y - \theta_H \chi C^2 - G\right] \\ &+ s\left[(\tilde{\theta} - \theta_H)(y - R - C)\right] \end{aligned} \tag{6}$$

The first part of the above expression is the expected material surplus under allocation (R, C). When $s = 0$, the NPV is reduced to this material part and efficiency requires that no collateral be used in the contract. The second and third part of the NPV derive from the lender's and borrower's anticipatory payoffs. If we impose that a borrower cannot delude herself so that $\tilde{\theta} = \theta_H$, or that $s = 0$, the third part of the NPV disappears and the NPV reduces to $(1+s)\left[(1-\theta_H)y - \theta_H \chi C^2 - G)\right]$, again implying that a benevolent social planner would like to impose $C = 0$. The third part of (6) entails that in the case of a deluded borrower, the NPV is no longer independent of the way in which the surplus is shared. Instead, delusion generates a psychological rent of size $s\left[(\tilde{\theta} - \theta_H)(y - R - C)\right]$ and therefore efficiency requires that the repayment be as small as possible. However, there is a limit to how far the repayment may be reduced, given by the survivability of lenders. If we assume that only the lender is able to secure funds G and needs to secure a minimum repayment, we find a well-defined frontier of repayment-collateral pairs defined by $U_I(\theta, R, C) = \bar{V}_I$ and we can obtain the optimal amount of collateral by maximising the NPV with respect to C:

$$C^* = \frac{1}{2} \frac{s(\theta_H - \theta_L)}{((1-\theta_H) + s(1-\theta_L))\,\theta_H \chi} \tag{7}$$

An efficient contract therefore stipulates a positive collateral requirement. The logic behind this is as follows. For low levels of collateral, when collateral is still very transferable, a one unit increase in collateral carries an expected benefit of approximately $(1+s)\theta_H$ to the lender and an expected subjective cost of only approximately $\theta_H + s\theta_L$ to the deluded borrower. It is therefore efficient to slightly raise collateral in return for a lower repayment. In dealing with a borrower who values her dream of future income streams and who believes the good state of the world to be more likely to occur than it actually is, it is welfare enhancing to increase the spoils of a good realisation at the expense of a harsher experience in case of a bad realisation. This "high reward - high cost of failure" contract that is favoured in the presence of optimal expectations is rather reminicient of entrepreneurship. On the the other end of the spectrum, a realist favors the low stakes payoff structure associated with zero collateral that may be viewed as an analogy for steady employment.

Broadly speaking, efficiency in our model requires that an equilibrium allocation induce delusion, use the unique optimal level of collateral and minimise the repayment in order to leave as high as possible a rent to the borrower. The last requirement derives from the borrower's ability to delude herself, which puts her in the unique position to grow the pie that is to be divided.

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[3] Since we assume that lenders cannot delude themselves, lenders' behaviour is not impacted upon by whether or not they have anticipatory utility concerns. To lighten notation we therefore assume that lenders do not have anticipatory utility in the rest of the paper.

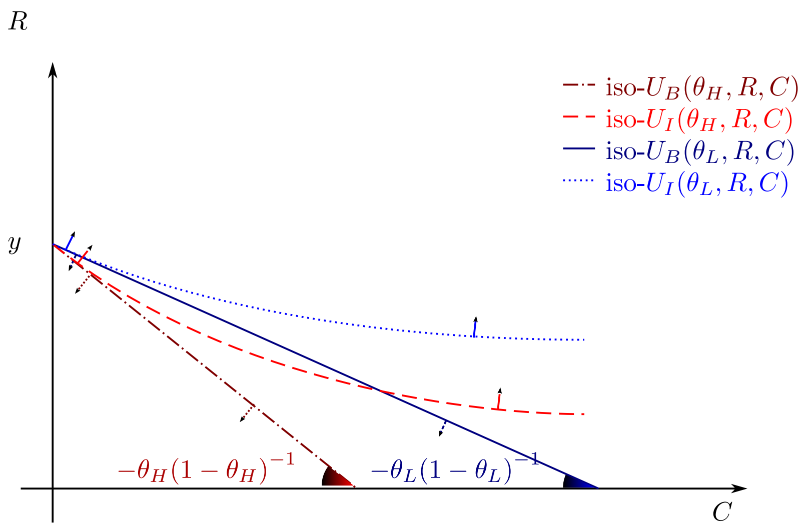

FIGURE 1. Preferences in the (C, R) space.

4. Monopoly lending under symmetric information

4.1. **The case of type-independent reservation utilities.**

We consider a monopoly lender who faces a borrower of commonly known risk θ_H and with the ability to delude herself into thinking that she is a low-risk type $\tilde{\theta} = \theta_L$. We assume that the reservation utilities of both high-risk and low-risk borrowers are equal and we further simplify the problem by setting their common value to zero. From a theoretical viewpoint, equality of reservation utilities removes any bargaining effect of delusion. From a more positive viewpoint, assuming identical outside options can be an acceptable approximation if the project under consideration for financing provides the economy's only outlet for both types' entrepreneurial talent, and entrepreneurial talent is uncorrelated to outside prospects. In contrast with the case of privately informed borrowers, the assumption of symmetric information implies that the monopoly lender has a lot of leeway in their contract design, because she need not worry about adverse selection, specifically whether a contract that is aimed at a deluded borrower with type θ_H has an effect on a borrower of actual type θ_L.

The lender's potential benefit from inducing delusion is illustrated in figure 1. Indifference curves reflecting reservation utilities of both types pass through the point $(0, y)$, but low-risk borrowers are more willing to accept collateral in exchange for a given lowering of repayment. If a borrower adopts belief $\tilde{\theta} = \theta_L$ at stage 1, her subjective indifference curve becomes that of a low risk borrower, and she is therefore willing to accept increases in collateral provided that repayment decreases by at least $-\theta_L(1-\theta_L)^{-1}$. The domain of acceptable offers is thus strictly enlarged, so the lender can exploit the difference in beliefs and make additional profit beyond what can be extracted from a realistic borrower, by offering a contract which is above the iso-$U_I(\theta_H, R, C)$ curve and below the iso-$U_B(\theta_L, R, C)$ line.

The lender can induce delusion by offering a single contract (R_L, C_L) that satisfies the following properties:

$$U_B(\theta_H, R_L, C_L) + sU_B(\theta_L, R_L, C_L) \geq (1+s)U_{Res} = 0 \tag{8a}$$

$$U_B(\theta_H, R_L, C_L) + sU_B(\theta_L, R_L, C_L) \geq (1+s)U_B(\theta_H, R_L, C_L) \tag{8b}$$

$$U_B(\theta_L, R_L, C_L) \geq U_{Res} = 0 \tag{8c}$$

The first inequality states that at $t = 1$, the borrower prefers deluding herself rather than remaining realistic and obtaining her reservation utility. The second inequality stipulates that the borrower's utility from deluding herself and picking the contract (R, C), exceeds the utility of remaining realistic and choosing contract (R, C). The third inequality assures that once a borrower has decided to delude herself at $t = 1$ and evaluates the contract (R, C) at $t = 2$ in light of her belief $\tilde{\theta} = \theta_L$, she finds (R, C) preferable to her perceived outside option.

Proposition 1 describes optimal lending by the monopoly lender [4]. The lender prefers to induce delusion rather than contracting with a realistic borrower and arrives at the equilibrium allocation by maximising her profits subject to (8a). The solution of the lender's maximisation problem always satisfies inequalities (8b) and (8c).

$$\begin{aligned} \underset{\{R_L, C_L \geq 0\}}{Max} \quad & \theta_H (1 - \chi C_L) C_L + (1 - \theta_H) R_L - G \\ s.t. \quad & \left\{ (1 - \theta_H)(y - R_L) - C_L \theta_H + s((1 - \theta_L)(y - R_L) - C_L \theta_L) \geq (1 + s) U_{Res} = 0 \quad (\kappa_{H,L}) \right. \end{aligned} \tag{9}$$

Proposition 1. (Symmetric information monopoly lender's optimum)
In equilibrium, the lender offers a contract $(R_{L,\langle 9 \rangle}, C_{L,\langle 9 \rangle})$ that induces delusion: $\tilde{\theta}_H = \theta_L$.

$$\kappa_{H,L,\langle 9 \rangle} = \frac{(1 - \theta_H)}{(1 - \theta_H) + s(1 - \theta_L)} \tag{10a}$$

$$C_{L,\langle 9 \rangle} = \frac{1}{2} \frac{s(\theta_H - \theta_L)}{\theta_H \chi (1 - \theta_H) + s(1 - \theta_L)} \tag{10b}$$

$$[(1 - \theta_H) + s(1 - \theta_L)] \left(y - R_{L,\langle 9 \rangle}\right) - (\theta_H + \theta_L s) C_{L,\langle 9 \rangle} = 0 \tag{10c}$$

Proof. We first check that constraints (8b) and (8c) are satisfied. This is readily verified by computing material utilities:

$$U_B\left(\theta_H, R_{L,\langle 9 \rangle}, C_{L,\langle 9 \rangle}\right) = -\frac{1}{2} \frac{(\theta_H - \theta_L)^2 s^2}{((1 - \theta_H) + s(1 - \theta_L))^2 \theta_H \chi} < 0 \tag{11a}$$

$$U_B\left(\theta_L, R_{L,\langle 9 \rangle}, C_{L,\langle 9 \rangle}\right) = \frac{1}{2} \frac{(\theta_H - \theta_L)^2 s}{((1 - \theta_H) + s(1 - \theta_L))^2 \theta_H \chi} > 0 \tag{11b}$$

Furthermore, a general argument (see section 4.2) establishes that the lender-preferred realism-inducing offer has the borrower select $(R_H, C_H) = (y, 0)$. $(R_L, C_L) = (y, 0)$ is feasible in program (9), and therefore yields weekly less profit than the optimal solution. This establishes that the monopolist prefers inducing delusion, strictly so if $s > 0$. □

When borrowers are only interested in material payoffs ($s = 0$), any incentive to engage in denial is removed and the lender does not gain from the malleability of beliefs, since the solution is $(y, 0)$, as with standard preferences. The use of positive collateral in our simple model of symmetric information lending thus derives from the joint presence of anticipatory utility and the possibility to bias beliefs. To gain intuition for the

[4]The lender may obviously make an arbitrary amount of offers that satisfy (8) and are not taken up along the equilibrium path. Only equilibrium *outcomes* are uniquely determined.

use of positive collateral in equilibrium, we may rewrite (8a) by expressing the maximal repayment R_L that induces delusion for a given collateral requirement C_L.

$$R_L \leq y - \frac{(\theta_H + \theta_L s)\, C_L}{(1-\theta_H) + s\,(1-\theta_L)} \tag{12}$$

At $t = 1$, when she decides whether or not to delude herself, the borrower is therefore willing to accept a unit increase in collateral as long as it is accompanied by a $[(1-\theta_H) + s\,(1-\theta_L)]^{-1}\,(\theta_H + \theta_L s)$ decrease in repayment. The reduction in repayment that a borrower who intends to delude herself requires to be compensated for a unit increase in collateral is thus lower[5] than $(1-\theta_H)^{-1}\theta_H$, the repayment reduction which corresponds to fair odds. Since the lender evaluates her profits at realistic success and failure probabilities and we assume that the first unit of collateral is perfectly transferable, the lender thus always stipulates positive collateral in her contract offer in order to benefit from the disagreement in beliefs at $t = 2$.

At the margin, the amount of collateral is determined by the following first-order condition

$$\theta_H\,(1 - \chi\, C_L - \chi\, C_L) = \frac{(1-\theta_H)\,(\theta_H + \theta_L s)}{((1-\theta_H) + s\,(1-\theta_L))} \tag{13}$$

The left-hand side is the marginal benefit of increasing collateral: with probability θ_H, the borrower transfers an increased amount, which is valued at $(1 - \chi\, C_L)$ and decreases the value of inframarginal collateral by χC_L. On the right-hand side is the marginal cost of increasing collateral: with probability $(1-\theta_H)$, the lender pockets a repayment that is reduced by a factor of $((1-\theta_H) + s\,(1-\theta_L))^{-1}\,((\theta_H + \theta_L s))$. This reflects the fact that even though the borrower believes her risk is low, and would therefore agree to a unit increase in collateral in exchange for a reduction in repayment of $-(1-\theta_L)^{-1}\theta_L$, further trades along her stage 2 - indifference curve would, when anticipated in stage 1, push the expected cost of delusion past the acceptable threshold. Therefore, the lender commits to put a limit on how much he leverages the difference in beliefs.

To summarise, we have stripped down the model to incorporate only the elements of psychological rent and gains from speculative trade, and we conclude that the monopolist's optimal offer:

- exactly induces overoptimism by the borrower: the borrower is indifferent between being realistic or deluded and therefore earns no rent at stage 1. The amount of collateral is constrained efficient.
- features a strictly positive stage 2 rent: the borrower would still agree to an offer with a higher repayment at stage 2, assuming it had not been anticipated.
- features leftover gains from trade at stage 2: given their respective beliefs on the probability of failure, both agents would agree to alter the contract to comprise more collateral and less repayment
- features a negative material payoff, i.e. the borrower is worse off in material terms than by choosing her outside option.

As we shall see, when elements such as competition, type-dependent outside options and private information are integrated into the model, although psychological rent and speculative trade remain fundamental mechanisms, some of these properties can be overturned.

The point that a high-risk borrower that is induced to delude herself is left with a negative expected material payoff if she contracts with a monopoly is of some interest to the debate surrounding predatory lending. Our model highlights the importance of considering psychological payoffs when evaluating outcomes in financial markets, since what may look like a borrower has been tricked or mislead may in fact constitute a contract that is tailored to a borrower's psychological desires. We note that a social planner may care more about material than psychological outcomes, because, for example, overcollateralisation and negative material payoffs exert negative externalities on dependents of borrowers or even the macroeconomy. Our model then

[5] For $s > 0$, we have $(1-\theta_L)^{-1}\theta_L < [(1-\theta_H) + s\,(1-\theta_L)]^{-1}\,(\theta_H + \theta_L s) < (1-\theta_H)^{-1}\theta_H$, with equality on the right and left as s tends to 0 and ∞ respectively.

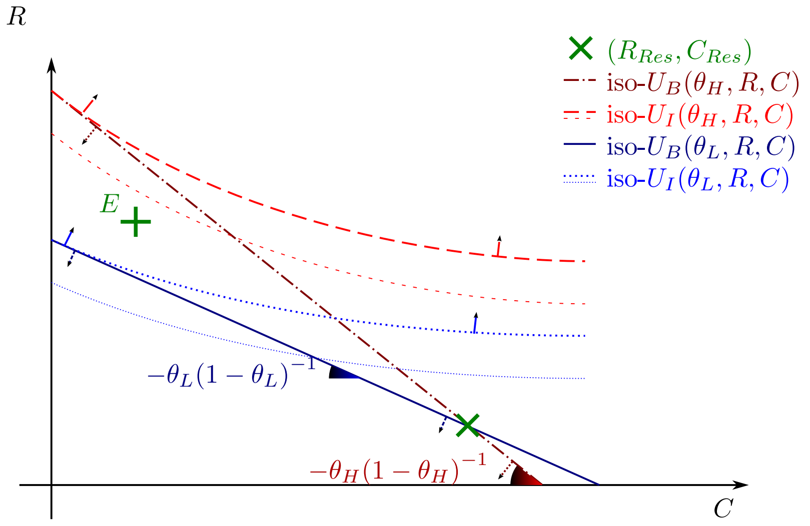

FIGURE 2. Large bargaining effect. (R_{Res}, C_{Res}) is the type-independent outside option contract.

suggests that public policy that is targeted at avoiding negative material payoffs on behalf of borrowers should take psychological motives seriously, since this might well be the domain in which the policy lever is most fruitfully applied.

4.2. **The case of type-dependent reservation utilities.**
We now turn to the general case, in which the monopolist still has perfect information ex ante about the borrower's type, but delusion has an independent *bargaining effect*: distorted beliefs enable the borrower to commit to reject any offer deemed less favourable than her –possibly inflated– outside option.

When considering delusion-inducing and realism-inducing contracts, the lender must now consider the potential for delusion to raise the borrower's self-assessed outside option. Since low-risk borrowers are endowed with an unambiguously better project, this phenomenon is not just a theoretical curiosity but a very likely occurrence. For instance, if outside options are derived from a type-independent, positive collateral contract offered by a competitive fringe of lenders, then there is a discrete gap between the reservation utilities, in favour of the low-risk borrower: $U_{Res_H}/(1-\theta_H) < U_{Res_L}/(1-\theta_L)$ holds. Figure 2 exemplifies this case: adopting belief $\tilde{\theta} = \theta_L$ implies that the borrower prefers her outside option over a contract such as E at stage 2, even though the material payoff delivered by E is smaller than the material payoff delivered by the outside option. Since asymmetric information is both more realistic and more in line with our modelling assumptions, this section is mostly treated in appendix. However, we summarise the main insights from the analysis.

The appropriate measure of bargaining effect is the distance between weighted reservation utilities

$$((1-\theta_L))^{-1}(U_{Res_L}) - ((1-\theta_H))^{-1}(U_{Res_H})$$

which we refer to as the magnitude of the bargaining effect. When this difference is sufficiently low, as is the case when reservation utilities are type-independent, the monopolist induces delusion and offers the optimal amount of collateral. When the bargaining effect is intermediate, the lender always induces delusion, but may not choose the optimal amount of collateral. Finally, when the difference between reservation utilities is positive and large, while it is still efficient to induce delusion, the monopolist may not be able to capture these efficiency gains because borrowers effectively commit to reject offers that are too low. So the lender may choose to induce realism[6], even if this entails that he prevents a psychological rent from being generated, because inducing denial would force him to leave too large a rent to the borrower.

If the monopolist chooses to induce realism, we show that the incentive for the agent not to delude himself is provided costlessly by offering a menu of two contracts, one destined for realistic borrowers, which is taken up in equilibrium, and one "threat contract" that a deluded high-risk borrower would prefer to her equilibrium contract. At stage 1, the borrower chooses to remain realistic because if she were to become overoptimistic, she could not refrain from agreeing to take on a large amount of collateral, effectively accepting a large side-bet at unfair odds against her success probability, and this would ultimately be detrimental to her welfare. The threat contract is never taken up in equilibrium, so it comes at no cost to the lender. This is no longer true when the type of the agent is not known with certainty: if the lender faces a population of low-risk as well as high-risk borrowers, the contract that a deluded high-risk borrower would select off the equilibrium path is the contract selected by true low-risk borrowers, and is therefore not freely chosen.

[6]This is the case if χ is sufficiently high or if s is sufficiently low, in a sense made precise in figure 6.

5. Monopoly lending under asymmetric information

We now turn to contracting with a monopoly lender under asymmetric information and we restrict attention to the case where the monopolist at least sometimes has an incentive to separate types and therefore to induce realism, because the bargaining effect of delusion is sufficiently strong in the following sense:

Assumption 2. (Interior screening)
The reservation utility of low-risk types exceeds that of high-risk types by a positive amount:

$$\frac{U_{Res_L}}{1-\theta_L} - \frac{U_{Res_H}}{1-\theta_H} \geq \frac{\nu(\theta_H-\theta_L)^2}{2(1-\theta_L)^2\,(1-\nu)\,(\theta_L)\,\chi\,(1-\theta_H)} > 0 \tag{14}$$

This assumption is more likely to be satisfied when the proportion of type-H borrowers is small, when the difference between the two types is large, and when the inefficiencies associated with collateral are significant (χ is large). It guarantees that the monopolist's screening program has an interior solution and does not feature exclusion of low-risk borrowers.

5.1. Second best contracts when borrowers do not have anticipatory utility concerns ($s = 0$).

This section provides the non-behavioral benchmark for the case with anticipatory utility concerns and may be skipped by the reader familiar with the standard contracting setting in which collateral is employed as a screening device.

Under assumption 2, the lender cannot offer a contract without collateral in which no rent is given up to either borrower type because there is no way to make the high-risk reveal his type if there exists another contract with less repayment. However, collateral can be used to make agents self-select and reveal their private information.

For instance, offering the reservation contract (destined for low risks) and the high risks' first-best contract is incentive-compatible, because of the single-crossing condition, and it is individually rational by construction. However, the investor is only able to extract low repayment from low-risk agents, who pledge a high amount of collateral. The investor may choose to lower the collateral of the low risks' contract in exchange for a higher repayment, but this effort comes at the cost of awarding a rent to the high risks.

We define formally the lender's optimisation program as in any standard screening problem, with the caveat that reservation utilities are still given by a reservation contract. The monopolist maximises total profit, subject to participation constraints and incentive compatibility constraints.

$$\begin{aligned}
&\underset{\{C_H,C_L,R_H,R_L\}}{Max} \quad \nu\,(\theta_H\,(1-\chi\,C_H)\,C_H + (1-\theta_H)\,R_H) + (1-\nu)\,(\theta_L\,(1-\chi\,C_L)\,C_L + (1-\theta_L)\,R_L) - G \\
&s.t. \quad \begin{cases}
(1-\theta_H)\,(y-R_H) - C_H\theta_H - U_{Res_H} \geq 0 & (\mu_H) \\
(1-\theta_L)\,(y-R_L) - C_L\theta_L - U_{Res_L} \geq 0 & (\mu_L) \\
(1-\theta_H)\,(y-R_H) - C_H\theta_H - (1-\theta_H)\,(y-R_L) + C_L\theta_H \geq 0 & (\lambda_H) \\
(1-\theta_L)\,(y-R_L) - C_L\theta_L - (1-\theta_L)\,(y-R_H) + C_H\theta_L \geq 0 & (\lambda_L) \\
C_H \geq 0 & (\zeta_H) \\
C_L \geq 0 & (\zeta_L)
\end{cases}
\end{aligned} \tag{15}$$

As is standard in screening problems, we look for candidate solutions as the solutions to a relaxed "interior screening" program: low risks get their reservation utility, and their provision of collateral is positive (hence

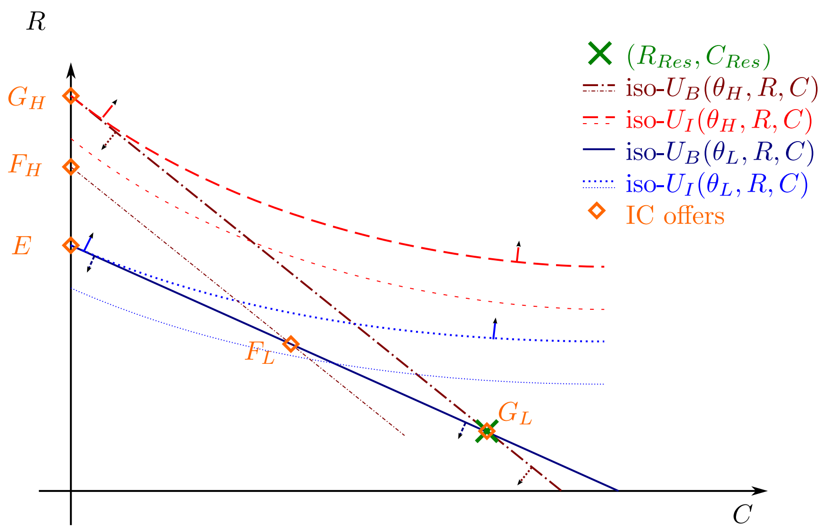

FIGURE 3. Incentive-compatible offers.

distorted). High risks are indifferent between mimicking and not mimicking low risks, and they earn a rent.

$$\underset{\{C_H, C_L, R_H, R_L\}}{Max} \quad \nu \left(\theta_H \left(1 - \chi C_H\right) C_H + \left(1 - \theta_H\right) R_H - G\right) + \left(1 - \nu\right) \left(\theta_L \left(1 - \chi C_L\right) C_L + \left(1 - \theta_L\right) R_L - G\right)$$
$$s.t. \quad \begin{cases} \left(1 - \theta_L\right)\left(y - R_L\right) - C_L \theta_L - U_{Res_L} \geq 0 \quad (\mu_L) \\ \left(1 - \theta_H\right)\left(y - R_H\right) - C_H \theta_H - \left(1 - \theta_H\right)\left(y - R_L\right) + C_L \theta_H \geq 0 \quad (\lambda_H) \\ C_H \geq 0 \quad (\zeta_H) \end{cases} \tag{16}$$

We have therefore relaxed the (ζ_L), and (λ_L) constraints[7] The low-risk agent is the one trying to separate, so she is not interested in mimicking. Because of the information rent, the participation constraint (μ_H) is also relaxed, so this program is an instance of the standard trade-off between rent extraction and efficiency in screening problems. Starting from the incentive-compatible efficient lending offer ($C_H = C_L = 0$, and $R_H = R_L, U_B(\theta_L, R_L, C_L) = U_{ResL}$, or point E in figure 3), the lender distorts the allocation of mimicked types ($C_L > 0$) and accepts a second-order efficiency loss in return for a first-order gain (relaxing the high-risk borrower's incentive constraint). This process continues until the marginal costs and benefits of the distortion are equal, with a pair of offers such as (F_H, F_L). The assumption of perfect transferability of the first infinitesimal unit of collateral guarantees that offer E is always dominated, but we need to impose an additional restriction to guarantee that offer G is dominated also, as discussed formally in assumption 2.

[7] We can plug the optimum values $R_{H,\langle 16\rangle}, R_{L,\langle 16\rangle}, C_{H,\langle 16\rangle}, C_{L,\langle 16\rangle}$ in the omitted constraints to confirm that the solution to the relaxed program solves the initial program. The (μ_L) constraint requires the interiority assumption 2 to be satisfied, but the incentive-compatibility constraint (λ_L) is necessarily satisfied, because the single-crossing holds. Indeed, evaluated at the optimum, we have:

$$\left(1 - \theta_L\right)\left(R_{H,\langle 16\rangle} - R_{L,\langle 16\rangle}\right) - \theta_L\left(C_{L,\langle 16\rangle} - C_{H,\langle 16\rangle}\right) = \frac{\nu(\theta_H - \theta_L)^2}{2\left(1 - \theta_L\right)\left(1 - \nu\right)\chi\left(\theta_L\right)\left(1 - \theta_H\right)} \geq 0$$

The solution to program (16) is given by:

$$C_{H,\langle 16\rangle} = 0, \quad C_{L,\langle 16\rangle} = \frac{1}{2}\frac{(\theta_H - \theta_L)\,\nu}{(1-\theta_L)\,(1-\nu)\,\theta_L \chi} \tag{17a}$$

$$\mu_{L,\langle 16\rangle} = \frac{1-\theta_L - \nu\,(\theta_H - \theta_L)}{(1-\theta_L)}, \quad \lambda_{H,\langle 16\rangle} = \nu, \quad \zeta_{H,\langle 16\rangle} = 0 \tag{17b}$$

$$y - R_{L,\langle 16\rangle} - \theta_L y + \theta_L R_{L,\langle 16\rangle} - C_{L,\langle 16\rangle}\theta_L - U_{Res_L} = 0 \tag{17c}$$

$$-R_{H,\langle 16\rangle} + \theta_H R_{H,\langle 16\rangle} - C_{H,\langle 16\rangle}\theta_H + R_{L,\langle 16\rangle} - \theta_H R_{L,\langle 16\rangle} + C_{L,\langle 16\rangle}\theta_H = 0 \tag{17d}$$

We analyse particularly the determination of the optimal amount of low-risk collateral C_L.

$$(1-\nu)\,\theta_L\,(1-\,\chi C_L -\,\chi C_L) + \lambda_H\theta_H = \mu_L\theta_L \tag{18a}$$

$$(1-\nu)\,\theta_L\,(1-\,\chi C_L -\,\chi C_L) + \nu\,\theta_H = (1-\nu)\,\theta_L + \frac{\nu\,\theta_L\,(1-\theta_H)}{(1-\theta_L)} \tag{18b}$$

The amount of collateral applied to low-risk borrowers is determined by the first-order condition (18a), where the left-hand side is the marginal benefit of increasing collateral: with probability θ_L, low-risk borrowers transfer an increased amount, which is valued at $(1-\chi C_L)$ and decreases the value of inframarginal collateral by χC_L. In addition, raising collateral requirements on low-risk borrowers relaxes the incentive constraint on high-risk borrowers. The marginal cost of increasing collateral corresponds to the decrease in repayment necessary to maintain the participation of low risks. Substituting in the values of the relevant multipliers, we obtain that $\lambda_{H,\langle 16\rangle}\theta_H = \nu\theta_H$: increasing C_L implies that a mimicking hig-risk borrower would pay an additional θ_H in expectation, so her repayment can be increased without altering incentives. This increase in repayment (times their proportion, ν) is fully captured by the monopolist, since repayment transfers value efficiently. Furthermore, we have $\mu_{L,\langle 16\rangle}\theta_L = (1-\nu)\,\theta_L + ((1-\theta_L))^{-1}\,(\nu\,\theta_L\,(1-\theta_H))$: low-risks' expected repayment must drop by θ_L to maintain their participation, and high risks in turn must also have their repayment in case they are successful drop by $\theta_L\,(1-\theta_L)^{-1}$, to maintain incentives. Fortunately for the lender, this lowering in repayment is only felt with probability $(1-\theta_H)$ per borrower, or $(1-\nu)\,(1-\theta_H)$ for the population.

What may go wrong with our approach is that the values of $R_{H,\langle 16\rangle}, R_{L,\langle 16\rangle}, C_{H,\langle 16\rangle}, C_{L,\langle 16\rangle}$ that solve the relaxed program may not ensure the high type's participation. Then the lender resorts to "corner screening": the low-risk agent is given the reservation contract, while the high-risk agent receives his first-best contract. This pair of contracts is obviously incentive-compatible and individually rational, and they perform best, not only for $\nu = 1$ (there are only high risks in the population), but also in a neighbourhood of $\nu = 1$. We imposed assumption 2 to guarantee that the parameters are such that interior screening prevails.

Lemma 1. (Conditions for interior and corner screening)
The solution to program (16) satisfies type H's participation constraint if and only if assumption 2 holds. Then it also solves the original program (15). If not, either the solution is given by (19):

$$R_L = R_{Res},\, C_L = C_{Res}, \quad R_H = -\frac{(R_{Res} - C_{Res})\,\theta_H - R_{Res}}{(1-\theta_H)},\, C_H = 0 \tag{19}$$

or excluding low-risk borrowers is optimal.

We now state formally the benchmark result.

Proposition 2. (Optimal screening without anticipatory utility concerns)
Under assumption 2, the optimal screening menu is given by (17). It features positive collateral requirements on low-risk borrowers and a rent for high-risk borrowers.

5.2. **Second best contracts when borrowers have anticipatory utility concerns ($s \geq 0$).**

We now turn to the case of privately informed borrowers who are endowed with non-zero anticipatory utility concerns. Now high-risk borrowers may choose to deny their actual risk for the sake of a rosy view of the future and in contrast with the analysis of symmetric information, the use of threat contracts is limited by the fact that deluded high-risk borrowers and realistic low-risk borrowers must be offered, and agree to, the same contract, since they hold identical beliefs. The threat of highly collateralised loans in a delusion path is therefore no longer costless to a lender who attracts both types.

We seek to characterise how optimal screening is affected by the presence of anticipatory utility concerns and we proceed by deriving the monopoly's optimal realism inducing set of contracts and comparing these to the most profitable contracts that yield delusion on behalf of borrowers.

5.2.1. *Realism-inducing offers.*
Consider first the situation of a lender trying to induce realism on the part of the borrower: $\tilde{\theta}_H = \theta_H$, $\tilde{\theta}_L = \theta_L$. The general program writes as follows:

$$\underset{\{C_H \geq 0, C_L \geq 0, R_H, R_L\}}{Max} \quad \nu U_I(\theta_H, R_H, C_H) + (1-\nu) U_I(\theta_L, R_L, C_L)$$
$$s.t. \begin{cases} U_B(\theta_H, R_H, C_H) - U_{Res_H} \geq 0 & \langle IR_H \rangle \\ U_B(\theta_L, R_L, C_L) - U_{Res_L} \geq 0 & \langle IR_L \rangle \\ U_B(\theta_H, R_H, C_H) - U_B(\theta_H, R_L, C_L) \geq 0 & \langle IC_H \rangle \\ U_B(\theta_L, R_L, C_L) - U_B(\theta_L, R_H, C_H) \geq 0 & \langle IC_L \rangle \\ (1+s) U_B(\theta_H, R_H, C_H) - U_B(\theta_H, R_L, C_L) - sU_B(\theta_L, R_L, C_L) \geq 0 & \langle OE_{H,H} \rangle \\ (1+s) U_B(\theta_L, R_L, C_L) - U_B(\theta_L, R_H, C_H) - sU_B(\theta_H, R_H, C_H) \geq 0 & \langle OE_{L,L} \rangle \end{cases} \tag{20}$$

The optimal expectations constraint on high-risk agents $\langle OE_{H,H} \rangle$ collapses into the incentive constraint $\langle IC_H \rangle$ as $s = 0$. This is not particularly surprising, because mimicking and delusion share obvious similarities. Furthermore, we can show that $\langle OE_{H,H} \rangle$ is uniformly tighter than $\langle IC_H \rangle$, as made precise in lemma 2.

Lemma 2. (Redundancy of the incentive constraint)
Any offer $\{C_H \geq 0, C_L \geq 0, R_H, R_L\}$ that satisfies $\langle OE_{H,H} \rangle$, $\langle IR_H \rangle$ and $\langle IC_L \rangle$ also satisfies $\langle IC_H \rangle$, strictly so for $s > 0$.

Proof. For a given (R_H, C_H), we characterise the set of (R_L, C_L) offers that satisfy $\langle OE_{H,H} \rangle$ as follows:

$$-\frac{(\theta_H + \theta_L s)(C_L - C_H)}{((1-\theta_H) + s(1-\theta_L))} + \frac{s(\theta_H - \theta_L)((y - R_H) + C_H)}{((1-\theta_H) + s(1-\theta_L))} \leq R_L - R_H \tag{21}$$

In the (C, R) space, and in figure 4, this defines a line with slope $-(1-\theta_H + s(1-\theta_L))^{-1}((\theta_H + s\theta_L))$, which lies in $\left[(1-\theta_L)^{-1}\theta_L, (1-\theta_H)^{-1}\theta_H\right]$. Furthermore this line lies above the point (C_H, R_H) as long as $\langle IR_H \rangle$ holds[8]. □

If an offer just satisfies incentive-compatibility, then the borrower receives an identical material payoff following realism or delusion, absent anticipatory utility concerns. Since the material payoff is the same either way, there is no downside to enjoying the higher emotional payoff that optimism provides.

Corrolary 1. (The standard screening menu induces delusion for $s > 0$)
Assume $s > 0$. The set of contracts that solves (16) violates condition $\langle OE_{H,H} \rangle$. If the high-risk borrower receives that offer, she chooses optimally to delude herself ($\tilde{\theta}_H = \theta_L$) at stage 1.

[8]Collateral is non-negative and $U_{Res_H} \geq 0$. Therefore, $(y - R_H) + C_H$ can never be negative for an individually rational contract.

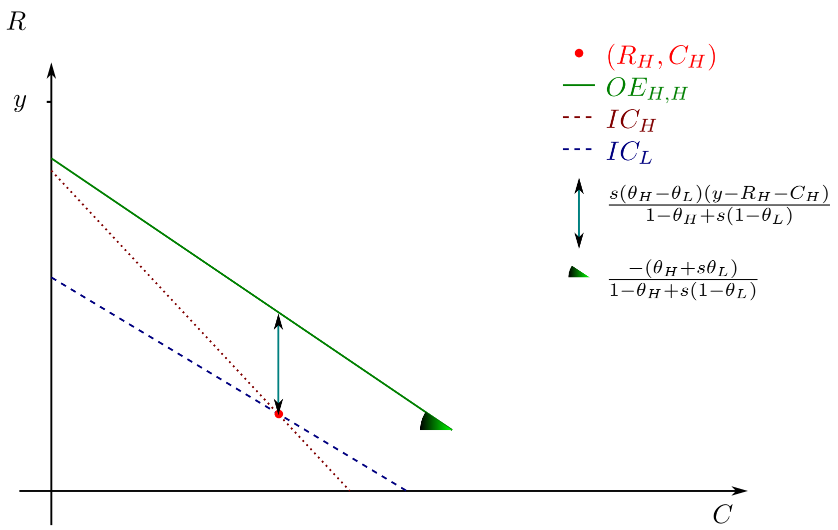

FIGURE 4. Geometrically, the locus of (R_L, C_L) contracts that make (R_H, C_H) —or any point on the same indifference curve IC_H— realism-inducing is the set of points above the $OE_{H,H}$ line.

Therefore, a lender trying to get the borrower to adopt realistic beliefs must provide additional incentives beyond those of standard screening. One could imagine doing so with either additional collateral for the low-risk contract or with a lower repayment for the high-risk contract. As we now show, cognitive incentives are delivered, not by increasing the punishment in a delusion path (an increase in C_L), but by increasing the rewards for realists, while decreasing the power of the incentive scheme (at the optimal offer, C_L, and therefore the distance between the two contracts, decrease with s)

As before, we look for the solution to (20) as the solution of a relaxed program that relaxes the constraints $\langle IR_H\rangle, \langle IC_H\rangle, \langle IC_L\rangle, \langle OE_{L,L}\rangle$.

$$\begin{aligned} &\underset{\{C_H\geq 0, C_L\geq 0, R_H, R_L\}}{Max} \quad \nu\, U_I\left(\theta_H, R_H, C_H\right) + (1-\nu)\, U_I\left(\theta_L, R_L, C_L\right) \\ &s.t. \quad \begin{cases} (1-\theta_L)\,(y-R_L) - C_L\theta_L - U_{Res_L} & \geq 0 \quad (\mu_L) \\ (1+s)\,((1-\theta_H)\,(y-R_H) - C_H\theta_H) & \geq \\ \quad (1-\theta_H)\,(y-R_L) + C_L\theta_H - s\,((1-\theta_L)\,(y-R_L) - C_L\theta_L) & \quad (\kappa_{H,H}) \end{cases} \end{aligned} \tag{22}$$

We obtain the solution to program (22). Both constraints are binding, so we can solve analytically for the repayment values R_L and R_H, but their expressions are not simple. However, we can obtain a simple expression for the derivative of R_H with respect to s, which we comment below.

$$C_{H,\langle 22\rangle} = 0 \tag{23a}$$

$$C_{L,\langle 22\rangle} = \frac{1}{2}\,\frac{(\theta_H-\theta_L)\,\nu}{\theta_L\chi\,(1-\theta_L)\,(1+s)\,(1-\nu)} \tag{23b}$$

$$\frac{dR_{H,\langle 22\rangle}}{ds} = -\frac{\nu\,(\theta_H-\theta_L)^2}{\theta_L\chi\,(1-\theta_L)^2\,(1+s)^3\,(1-\nu)\,(1-\theta_H)} - \frac{U_{Res_L}\,(\theta_H-\theta_L)}{(1-\theta_L)\,(1+s)^2\,(1-\theta_H)} < 0 \tag{23c}$$

At the margin, the amount of collateral is determined by the following equation:

$$(1-\nu)\,\theta_L\,(1-2\chi\,C_L) + \kappa_{H,H}\,(\theta_H+\theta_L s) = \mu_L\theta_L \tag{24a}$$

$$(1-\nu)\,\theta_L\,(1-2\chi\,C_L) + \nu\,\theta_H - \frac{\nu\,s\,(\theta_H-\theta_L)}{1+s} = (1-\nu)\,\theta_L + \frac{\nu\,\theta_L\,(1-\theta_H)}{1-\theta_L} + \frac{\nu\,\theta_L s\,(\theta_H-\theta_L)}{(1-\theta_L)\,(1+s)} \tag{24b}$$

When $s = 0$, equation (24b) collapses into (18b), but when $s > 0$, two corrective terms appear and lower the benefit of marginal increases in collateral. The optimal tradeoff is therefore reached for value that decreases with s, giving rise to solution (23). The intuition for this result can be grasped from a comparison of delusion incentives and mimicking incentives of high-risk borrowers. As we have encountered previously, increases in collateral are only weighted by the biased probability assessment θ_L in a delusion path, from the viewpoint of a stage 1 high-risk borrower. It follows that the deterrent effect of increased collateral is lower when applied to a (potentially) deluded borrower, than when applied to a realist tempted by mimicking.

It is readily observed from (23) that the indirect utility of high risk agents $U_B(\theta_H, R_H, C_H)$ increases with s, even though delusion happens entirely off the equilibrium path, and is precluded by the lender's contract offer. This highlights the strategic effects of delusion, viewed as a commitment device[9]: the high-risk borrower effectively demands a lower repayment than in standard screening, which in a normal situation would not be credible, but the credible threat of delusion and of the borrower's choosing an inefficient contract with high collateral forces the lender to offer a better deal, and erodes the lender's bargaining power. This result is somewhat surprising, as one may instead expect that the separation incentives would be made stronger at the margin, not weaker, when the borrower has a higher potential for delusion.

It remains to be checked that the solution to the relaxed program (22) indeed solves program (20). We show that restricting attention to the relaxed program is valid provided that s is smaller than a certain threshold. Furthermore, at that threshold, it is the incentive compatibility constraint of low-risk borrowers that first binds among omitted constraints, and it is easily established that inducing delusion rather than realism is optimal in such a case. The relaxed program therefore characterises all relevant realism-inducing offers.

Lemma 3. (Validity of the "relaxed program" approach)
The solution to program (23) also solves the more general program (20) provided that

$$\leq \bar{s} = \frac{1}{2}\left(\sqrt{1 + 2\frac{\nu\left(\theta_H - \theta_L\right)}{U_{Res_L}\chi\theta_L\left(1-\theta_L\right)\left(1-\nu\right)}} - 1\right).$$

Proof. In appendix A.1. □

Just as the optimal expectation constraint is tighter than the incentive constraint for high-risk borrowers, it is reasonable to expect the opposite to be true for low-risk borrowers: if material payoffs leave the borrower indifferent between to options, anticipatory considerations ought to push the borrower towards optimistic beliefs. We confirm this intuition in the present case.

As previously noted, as s becomes larger, the lender optimally chooses to reduce the repayment required of high-risk borrowers, so as to maintain incentives for realism. Lending becomes more efficient (C_L is lowered) but the distortion was precisely introduced to achieve efficient screening: considering $s_0 < s_1$, any offer that induces realism for $s = s_1$ also induces realism for $s = s_0$, and is therefore revealed to be less profitable. As s becomes large, inducing realism becomes costlier, and eventually the optimal expectations constraint of high-risk borrowers becomes binding.

5.2.2. *Delusion-inducing offers.*
Consider now a lender wanting to induce delusion as a stage-1 optimal expectation for high-risk borrowers. Since the choice of contract in the menu is made at time $t = 2$, both deluded type-H borrowers and realistic type-L borrowers, who hold the same beliefs, must effectively pick the same contract, which can therefore

[9]This type of strategic use of distorted beliefs is commonly encountered in evolutionary biology and sociobiology, see for instance Trivers (2011).

be characterised as a pooling offer. We assume that high-risks pick the same pooling offer if they remain realistic. This is without loss of generality under assumption 2, since the pooling offer is preferred to the outside option, even by realistic borrowers. As we prove later, it is sufficient to impose only individual rationality, as evaluated using belief θ_L.

$$\begin{aligned}
&\underset{\{C_L,R_L\}}{Max} && \nu\left(\theta_H\left(1-\chi C_L\right)C_L+\left(1-\theta_H\right)R_L-G\right)+\left(1-\nu\right)\left(\theta_L\left(1-\chi C_L\right)C_L+\left(1-\theta_L\right)R_L-G\right)\\
&s.t. && \left\{\left(1-\theta_L\right)\left(y-R_L\right)-C_L\theta_L-U_{Res_L}\geq 0 \quad (\mu_L)\right.
\end{aligned} \tag{25}$$

Intuitively, at a pooling offer, there is no material cost to optimism since the borrower pick the same contract regardless of her beliefs. Therefore, it is not surprising that both borrower types are induced to adopt belief θ_L. Formally, faced with a single pooling offer (R_P, C_P) that is individually rational with either belief, a either borrower adopts belief θ_L provided that $s\left(\theta_H-\theta_L\right)\left(C_P+y-R_P\right)\geq 0$, which is implied by individual rationality.

$$\mathbb{E}\left[\theta\right]\left[\left(1-\chi C_L\right)-\chi C_L\right]=-\frac{\theta_L}{\left(1-\theta_L\right)}\left(1-\mathbb{E}\left[\theta\right]\right) \tag{26a}$$

$$C_{L,\langle 25\rangle}=\frac{\nu\left(\theta_H-\theta_L\right)}{2\left(1-\theta_L\right)\chi\mathbb{E}\left[\theta\right]} \tag{26b}$$

$$R_{L,\langle 25\rangle}=y-\frac{\theta_L\nu\left(\theta_H-\theta_L\right)}{2\left(1-\theta_L\right)^2\chi\mathbb{E}\left[\theta\right]}-\frac{U_{Res_L}}{\left(1-\theta_L\right)} \tag{26c}$$

When delusion is induced, all borrowers, not only the low-risk types, are willing to exchange collateral for repayment at a constant rate of $-\theta_L/(1-\theta_L)$, which represents unfair odds for the risky borrowers, and can be leveraged by the lender. The optimum amount of collateral $C_{L,\langle 25\rangle}$ is positive and characterised by the first-order condition (26a), which equates the marginal benefit of increasing collateral − a marginal revenue $(1-2\chi C)$ with probability $\mathbb{E}\left[\theta\right]$− to the marginal cost: the repayment must be lowered by $-\frac{\theta_L}{(1-\theta_L)}$ to maintain participation. This lowering of repayment is weighted by the average probability of repayment $(1-\mathbb{E}\left[\theta\right])$.

5.2.3. *Optimal contract design.*

We now bring together the two previous sections and establish that a monopolist constrained by hidden information should use a separating, realism-inducing offer for s close to zero, but should switch to a pooling, delusion-inducing offer after s passes a certain threshold.

Proposition 3. (Optimal contract design)
There exists a threshold value $s^* > 0$ such that:

- *For $0 \leq s < s^*$, , the optimal offer induces realism and is characterised by* (23)
- *For $s > s^*$, the optimal offer induces delusion by the high-risk agent and is characterised by* (26).

Proof. In appendix A.2. □

Figure 5 illustrates proposition 3.

5.2.4. *Interpretation and the extent of distortions.*

As established in (23), the indirect utility of high risk agents $U_B(\theta_H, R_H, C_H)$ increases with s in the $0 < s < s^*$ range, even though delusion happens entirely off the equilibrium path, and is precluded by the lender's contract offer. This highlights the strategic effects of delusion, viewed as a commitment device[10]: the high-risk borrower effectively demands a lower repayment than in standard screening, which in a normal situation would not be credible, but the credible threat of delusion and of the borrower's choosing an inefficient

[10]This type of strategic effect of beliefs is common in evolutionary biology and sociobiology, see for instance Trivers (2011).

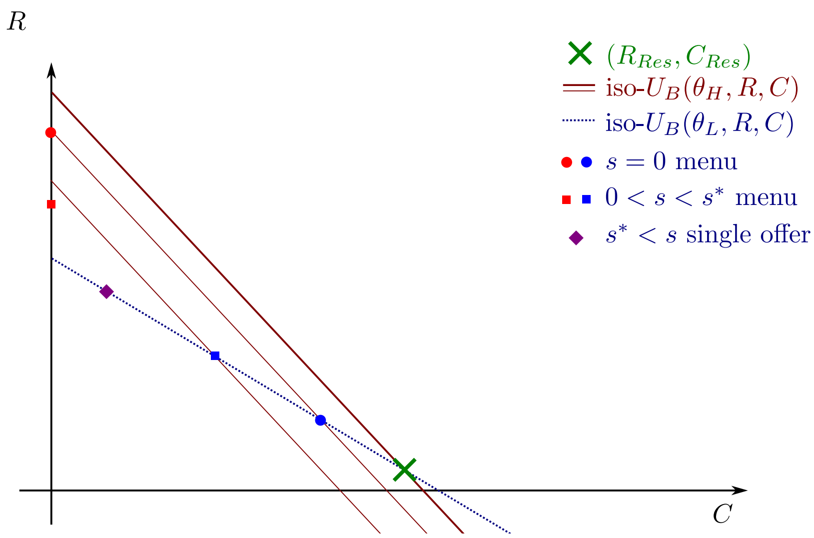

FIGURE 5. Changes in optimal contract design as s increases

contract with high collateral erodes the lender's bargaining power. This result is somewhat surprising, as one may instead expect that the separation incentives would be made stronger, not weaker, when the borrower has a higher potential for delusion. In evolutionary terms, the mechanism we uncover makes the potential for delusion adaptive: high-risk borrowers benefit from the presence of actual low-risk borrowers and from their own implicit commitment to delude themselves and demand similar lending terms to theirs.

A second outcome of our model that warrants explanation is the persistence of positive collateral lending in the pooling offer, even absent screening motives. To gain intuition for why collateral requirements are positive, recall that the first unit of collateral is perfectly transferable and that the lender expects to seize collateral with probability $\mathbb{E}[\theta] = \nu\theta_H + (1-\nu)\theta_L$. A self-assessed low risk borrower, on the other hand, knows that she will only have to give up collateral with probability θ_L and therefore accepts a positive level of collateral in return for a correspondingly lower repayment at the expense of the high risk type, whose collateral is seized more often.Therefore, positive collateral arises because of a disagreement between the deluded borrowers and the lender about the true probability of failure of high risk types, as a way for the lender to make lenders and deluded borrowers take a mutually profitable bet on the probability of failure.

Finally, we can quantify the amount of distortion in the optimal offer and assess the efficiency of lending.

Corrolary 2. (Use of collateral)
The prevalence of collateral (unconditional probability of accepting a contract with positive collateral) jumps from $1-\nu$ *to* 1 *as* s *becomes larger than* s^**. The expected amount of collateral transferred equals* $(1+s)^{-1}\left(\mathbb{E}[\theta]\, C_{L,\langle 25\rangle}\right)$ *for* $s < s^*$ *and* $\mathbb{E}[\theta]\, C_{L,\langle 25\rangle}$ *for* $s > s^*$*.*

In terms of observables, the expected amount of collateral seized decreases, then jumps upwards as s becomes larger than s^*, and therefore moves in the same way as the prevalence. Due to the linearity of the transferability rate (assumption 1), the amount of collateral *transferred*[11] in the pooling, delusion-inducing offer exactly equals the amount transferred in the separating, realism-inducing offer when $s = 0$. However, the extent of collateral-induced distortions is magnified in the separating case, as can be seen by applying Jensen's inequality to the mapping $C -> \chi C^2$. Therefore, if we have a strict prediction regarding the amount of collateral transferred, it does not follow that separating optima occasion less destruction of value than pooling optima.

[11]The amount of collateral *pledged* may or may not increase with s.

6. Competitive lending market with asymmetric information

We model competition by allowing two lenders to post menus of contract offers in period $t = 1$. In line with Wilson (1977) and the recent literature on strategic foundations for Wilson outcomes in insurance and other competitive screening settings (Netzer and Scheuer (2012), Mimra and Wambach (2011)), we impose the removal of unprofitable menus following a deviation. This modification of the extensive form delivers equilibrium existence and allows for cross-subsidisation from low-risk to high-risk borrowers. Period $t = 1$ of our contracting game may be broken up into two subperiods as follows:

- $t = 1.1$: Firm i and firm j simultaneously offer menus of contracts
- $t = 1.2$: Upon observing the other firm's offer, firms withdraw offers that are not profitable.

6.1. **Preliminary analysis.** Let us define the borrower-optimal pooling contract, $(R_{L,\langle 27\rangle}, C_{L,\langle 27\rangle})$, which maximises the utility of low-risk borrowers subject to a zero-profit constraint when high-risk borrowers also accept the contract.

$$\begin{aligned} &\underset{\{C_L,R_L\}}{Max} && (1-\theta_L)(y-R_L) - C_L\theta_L \\ &s.t. && \Big\{ \mathbb{E}[\theta](1-\chi C_L)C_L + (1-\mathbb{E}[\theta])R_L - G \geq 0 \quad (\tau) \end{aligned} \tag{27}$$

This program gives rise to the following level of collateral

$$C_{L,\langle 27\rangle} = \frac{1}{2}\frac{(\theta_H-\theta_L)\,\nu}{\chi\,(1-\theta_L)\,\mathbb{E}[\theta]} \tag{28}$$

In a pooling equilibrium, high risk borrowers choose delusion since they would choose the single offer regardless of whether they are deluded or realistic and biased expectations thus do not entail the potential cost of picking an unfavourable contract.

Similarly, we denote by $((R_{L,\langle 29\rangle}, C_{L,\langle 29\rangle}), (R_{H,\langle 29\rangle}, C_{H,\langle 29\rangle}))$ the solution to the following programme, which maximises the utility of low-risk borrowers subject to a realism-inducement constraint, a zero-profit constraint, absence of cross-subsidisation from high to low risks, and incentive compatibility for *low risks*. That last requirement is typically ignored in environment where a single-crossing condition holds, but we account for it in our definition, for completeness. Fortunately, if s is high enough that this constraint is binding, types are not separated in equilibrium.

$$\begin{aligned} &\underset{\{C_H\geq 0, C_L\geq 0, R_H, R_L\}}{Max} && U_B(\theta_L,R_L,C_L) \\ &s.t. && \begin{cases} \nu\,U_I(\theta_H,R_H,C_H) + (1-\nu)\,U_I(\theta_L,R_L,C_L) \geq 0 & (\tau) \\ -U_I(\theta_H,R_H,C_H) \geq 0 & (\tau_H) \\ U_B(\theta_L,R_L,C_L) - U_B(\theta_L,R_H,C_H) \geq 0 & (\lambda_L) \\ (1+s)\,U_B(\theta_H,R_H,C_H) - U_B(\theta_H,R_L,C_L) - sU_B(\theta_L,R_L,C_L) \geq 0 & (\kappa_{H,H}) \end{cases} \end{aligned} \tag{29}$$

If high-risk to low-risk cross-subsidisation is not an issue, and neither is downward incentive compatibility, so $\tau_H = \lambda_L = 0$, the program again mirrors that of a screening monopolist, and the determination of collateral at the margin obeys an identical tradeoff:

$$\begin{aligned} &\underset{\{C_H\geq 0, C_L\geq 0, R_H, R_L\}}{Max} && U_B(\theta_L,R_L,C_L) \\ &s.t. && \begin{cases} \nu\,U_I(\theta_H,R_H,C_H) + (1-\nu)\,U_I(\theta_L,R_L,C_L) \geq 0 & (\tau) \\ (1+s)\,U_B(\theta_H,R_H,C_H) - U_B(\theta_H,R_L,C_L) - sU_B(\theta_L,R_L,C_L) \geq 0 & (\kappa_{H,H}) \end{cases} \end{aligned} \tag{30}$$

$$C_{L,\langle 30\rangle} = \frac{1}{2(1+s)}\frac{(\theta_H-\theta_L)\,\nu}{\theta_L\chi\,(1-\theta_L)\,(1-\nu)}, \qquad C_{H,\langle 30\rangle} = 0 \tag{31}$$

If the high-risk to low-risk cross-subsidisation constraint binds, then the solution is akin to the standard Rotschild-Stiglitz outcome in competitive screening: contracts makes zero-profit type-by-type, high risks pay no collateral, and their optimal expectation constraint is binding. Imposing zero profit type-by-type, we find a quadratic in C with a positive real root, denoted as $\bar{C}(s)$.

$$Q(C) := (\theta_H - \theta_L)\left[y\,(1-\theta_L)\; s + G\right] - (\theta_H - \theta_L)\; C - \left[\chi\,\theta_L\left((1-\theta_H) + s\,(1-\theta_L)\right)\right] C^2 \tag{32}$$

As long as the solution $C_{L,\langle 30\rangle}$ is lower than $\bar{C}(s)$, the constraint associated to τ_H is slack. This is the case if the proportion of high risks is low enough. More precisely, we can provide a sufficient condition that guarantees that $C_{L,\langle 30\rangle}$ is the solution to the general programme (29) for all s.

Lemma 4. (Solution to (29))
A sufficient condition for (31) and the associated repayment to solve programme (29) is that

$$\frac{1}{2}\,\frac{(\theta_H - \theta_L)\;\nu}{\theta_L \chi\,(1-\theta_L)\;(1-\nu)} \leq \bar{C}(0), \tag{33}$$

where $\bar{C}(0)$ is the positive root of the polynomial:

$$(\theta_H - \theta_L)\,G - (\theta_H - \theta_L)\;C - \left[\chi\,\theta_L\left((1-\theta_H)\right)\right] C^2$$

Proof. Observe that $C_{L,\langle 30\rangle}$ decreases with s. A sufficient condition that enables us to ignore high-to-low subsidisation is therefore that for $s = 0$, $C_{L,\langle 30\rangle} < \bar{C}(0)$ and that $\bar{C}(s)$ be increasing in s (the value at zero increases with s, but the negative C^2 term also does). To prove the second claim, write the implicit derivative as follows :

$$\frac{d}{ds}\bar{C}\,(s) = \frac{(1-\theta_L)\;(\theta_H - \theta_L)\left((1-\theta_H)\;y - G + \bar{C}\,(s)\right)}{(s\,(1-\theta_L) + 1 - \theta_H)\left[(2\,\theta_L\left((1-\theta_H) + s\,(1-\theta_L)\right))\,\chi\,\bar{C}\,(s) + (\theta_H - \theta_L)\right]} > 0 \tag{34}$$

The sign follows from nonnegativity of $\bar{C}$ and from the assumption that the high-risk project is profitable in material terms: $(1-\theta_H)\;y - G \geq 0$. Therefore, the second claim follows. $\square$

6.2. **Competitive equilibria.** The search for equilibria boils down to comparing the value of the two programmes. We can characterize the unique equilibrium outcome in a threshold s^{**}.

Proposition 4. (Asymmetric information, competitive lending: equilibrium)
We construct an equilibrium in which both lenders offer both the contracts solving (29) and the contract solving (27). There exists a unique threshold s^{**} such that

- *for $s < s^{**}$ the equilibrium features realism ($\tilde{\theta}_H = \theta_H$) and borrowers select the type-dependent contracts which solve (29).*
- *for $s > s^{**}$ the equilibrium features delusion ($\tilde{\theta}_H = \theta_L$) and borrowers select the type-independent contract which solves (27).*
- *s^{**} is the unique s that solves $U_B(\theta_L, R_{L,\langle 30\rangle}, C_{L,\langle 30\rangle}) = U_B(\theta_L, R_{L,\langle 27\rangle}, C_{L,\langle 27\rangle})$*

We furthermore claim that the equilibrium outcome is unique for all $s \neq s^{**}$.

If one firm offers the best pooling contract, no other single contract offer can attract the profitable low risk type. If a pooling equilibrium exists, the best pooling contract will therefore be its equilibrium outcome. The equilibrium allocation is given by the best pooling contract when the best pooling contract yields a higher utility for the low risk type than the best separating contracts and it is given by the best separating contracts otherwise. The best separating contracts are offered for low values of s, when screening is relatively cheap. But as s rises, an increasingly high rent needs to be given up to the high risk type to keep her realistic, because she would receives greater and greater anticipatory utility benefits from believing she has a low risk of failure. Eventually, for a high enough s, it makes sense for lenders to renounce screening and offer a contract that will be taken up by both types. The fact that the best pooling contract makes use of positive collateral requirements to transfer some rent from high to low risk borrowers then makes the renouncement of screening even more desirable.

To gain intuition for the equilibrium allocation suppose that one firm offers the best pooling contract and ask whether there is a profitable deviation that the other firm may pursue. We know that such a deviation would have to lead to different risk types taking up different contracts, because no pooling contract can beat the best pooling contract. If the deviating firm constructed a contract that attracts only low risk types while leaving the high risk borrowers to pick up the best pooling offer, the other firm would withdraw the best pooling contract that has now been rendered unprofitable. This would leave the high risk borrowers picking up the deviating contract and making it unprofitable. A deviation from best pooling therefore requires that both risk types are offered a contract and that the two contracts incentivise the high risk borrower to remain realistic and self-select.

Since any deviating contract offer that attracts the low risk borrowers leads to the withdrawal of the best pooling contract, it is possible to imagine a separating deviation that assures self-selection while making positive profits on the high risk borrowers and negative profits on the low risk type. Such a deviation, however, can be blocked by the firm with the best pooling contract offering a latent contract that if taken up only by the high risk borrowers makes zero profits. This accounts for the presence of the condition that $U_I(\theta_H, R_H, C_H) \leq 0$ in (**??**), the program that yields what turns out to be the only profitable deviation to the best pooling contract, if such a deviation exists.

We are now in a position to explore the comparative statics of our model, by asking how shifts in the parameters impact on the threshold s^{**}. Note that a shift in parameters that decreases s^{**} makes it more likely that we observe the best pooling equilibrium allocation with delusion on behalf of high risk borrowers, while the likelihood of observing the separating equilibrium allocation and realism on behalf of borrowers is decreasing in parameter shifts that increase the s^{**}.

Proposition 5. *The threshold s^{**} is*

- *increasing in the investment cost, or the opportunity cost of funds G*
- *decreasing in the return of the project y.*

Proof. Assume that the solution to (29) features cross-subsidisation. We differentiate the value of (27) and (29) with respect to the relevant parameter and study their difference. If it is positive, the threshold s^{**} goes down with the relevant parameter, so delusion is more likely. For an increase in y, we obtain:

$$\frac{(1-\theta_L)\,\nu\, s\,(\theta_H-\theta_L)}{s\,(1-\theta_L)+(1-\mathbb{E}[\theta])} \tag{35}$$

For a decrease in G, we obtain:

$$\frac{(1-\theta_L)\,\nu\, s\,(\theta_H-\theta_L)}{(1-\mathbb{E}[\theta])\,(s\,(1-\theta_L)+(1-\mathbb{E}[\theta]))} \tag{36}$$

□

We thus find that the incidence of delusion and the collateralization of high risk borrowers is decreasing in the cost of funds G. This entails that we would expect more delusion in an economy in which lenders or banks are able to borrow at a low risk-free rate. The intuition for this is as follows. The lower G, the higher are the returns that accrue to the borrower when the project is a success because less needs to be repaid to the lender for her to break even. This provides a cognitive incentive for the high risk borrower to delude herself into thinking that the state in which these larger returns are realized occurs relatively more often.

Note that in our equilibrium, high risk types only pledge collateral when $s > s^{**}$, which means that our model predicts that an economy with a competitive lending market should see an increase in the use of collateral if interest rates are low. This is precisely what Jiménez et al. (2006) find in their investigation of the likelihood of collateral use in a large sample of Spanish business loans. They also note that they "know of no theory or any previous evidence on the relation between the use of collateral and macroeconomic conditions".

Other things equal, an increase in y, has a similar effect on the borrower's returns in the good state of the world as a decrease in G and hence, also increases the incentive to believe that the success probability of the project is high. The comparative statics of our model suggest that we expect overoptimism during economic booms and when interests are low.

7. Conclusion

We study the interaction between lenders and privately informed borrowers whose beliefs are malleable and motivated by anticipatory utility, and we consider that collateral acts simultaneously as a screening instrument and as the support of mutually agreeable bets on the probability of success of borrowers' projects. We show that borrowers may be realistic or deluded under both monopoly lending and competitive equilibrium, and we show that delusion is more likely when borrowers place more weight on anticipatory utility, but also, in competitive settings, when the opportunity cost of funds is low or when projects are more valuable.

We try to ground our modelling assumptions in empirical realism, but many facets of our model are open to discussion. One may for example wish to allow borrowers to deceive themselves at a time of their choosing rather than imposing that delusion happens before a contract is signed. Our chief interest is in understanding how profit maximising firms such as banks shape their customer's environment in an effort to profitably influence their beliefs. This framework may well be fruitfully applied to firm's quality and pricing decisions, especially for products that impact on consumer's heath, a domain that is associated with a high prevalence of wishful thinking. While we assume that borrowers receive anticipatory utility, some of our results may translate to the case of borrowers who are motivated by cognitive dissonance reduction and lenders that seek to gainfully influence the cognitive dissonance a borrower needs to confront.

The bulk of empirical work on unrealistic optimism has focussed on the effect of optimism on behaviour. In our model, however, optimism is an outcome, which points to an interesting empirical endeavour that treats unrealistic optimism as a dependent variable. For example, we may explore whether the presence of unrealistic optimism is impacted upon by exogenous variation in interest rates or entrepreneurial profits. Here a good measure of overoptimism may be found in the correlation between expectations and ex post realisations across different scenarios.

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Appendix A. Proofs omitted in the main text

A.1. **Proof of lemma 3.** The solution to program (23) also solves the more general program (20) provided that

$$\leq \bar{s} = \frac{1}{2}\left(\sqrt{1 + 2\frac{\nu\left(\theta_H - \theta_L\right)}{U_{Res_L}\chi\theta_L\left(1-\theta_L\right)\left(1-\nu\right)}} - 1\right).$$

Proof. We simply examine the omitted constraints from program (20) and check that the solution to (23)satisfies them. Recall that given assumption 2, we have $U_{Res_L} > U_{Res_H} \geq 0$.

- $\langle IC_L, OE_{L,L}\rangle$: Evaluated at the optimum, constraints IC_L and $OE_{L,L}$ rewrite into, respectively:

$$0 \leq D_1\left(-2\chi s\theta_L U_{Res_L}\left(1-\theta_L\right)\left(1+s\right)\left(1-\nu\right) + \nu(\theta_H - \theta_L)\right) \tag{37a}$$

$$0 \leq D_2\left(-2\chi s\theta_L U_{Res_L}\left(1-\theta_L\right)\left(1+s\right)\left(1-\nu\right) + \nu\left(1-\theta_H\right)s + \nu\left(1-\theta_L\right)\right), \tag{37b}$$

  withD_1, D_2 positive. Since $\nu\left(1-\theta_H\right)s + \nu\left(1-\theta_L\right) - \nu\left(\theta_H-\theta_L\right) = \nu\left(1-\theta_H\right)\left(1+s\right) > 0$, the relevant bound on s is given by (37a). Isolating s, we obtain the condition given in lemma 3.
- $\langle IC_H\rangle$: We already established that optimal expectation constraint is tighter for the high-risk borrower. We confirm that at the solution, constraint $\langle IC_H\rangle$ rewrites into

$$0 \leq \left[2\theta_L\left(1+s\right)^2\left(1-\theta_L\right)^2\left(1-\nu\right)\chi\right]^{-1}\left(s(\theta_H-\theta_L)^2\nu + 2\chi s\theta_L U_{Res_L}\left(1-\theta_L\right)\left(1+s\right)\left(1-\nu\right)\left(\theta_H-\theta_L\right)\right)$$

  which is satisfied, given our assumptions on reservation utilities.
- $\langle IR_H\rangle$: Participation of high-risk borrowers is ensured by incentive-compatibility, which is satisfied.

□

A.2. **Proof of proposition 3.** There exists a threshold value $s^* > 0$ such that:

- For $0 \leq s < s^*$, , the optimal offer induces realism and is characterised by (23)
- For $s > s^*$, the optimal offer induces delusion by the high-risk agent and is characterised by (26).

Proof. First of all, we note that the payoff associated with (22) decreases with s, while the payoff associated with (25) does not depend on s. The second claim is obvious upon inspection of (26), while the first claim is established by simple differentiation with respect to s. Second, we can express the difference between the value of the two programs as proportional to a polynomial of degree 2 in s, and show that there exists a unique a threshold s^* such that the polynomial is positive for small values of s up to a positive threshold s^* and negative for values of s above s^*.

$$V_{I,\langle 22\rangle} - V_{I,\langle 25\rangle} = K\left(\alpha_0 + \alpha_1 s + \alpha_2 s^2\right) \text{ with } K>0, \alpha_0>0, \alpha_1<0, \alpha_2<0 \tag{38a}$$

$$K = \frac{1}{4}\frac{\nu\ \left(\theta_H-\theta_L\right)}{\theta_L(1-\theta_L)^2\left(1-\nu\right)\left(1+s\right)^2\left(\nu\ \left(\theta_H-\theta_L\right)+\theta_L\right)\chi} \tag{38b}$$

$$\alpha_0 = \nu^2\left(\theta_H-\theta_L\right)\theta_H \tag{38c}$$

$$\alpha_1 = -2\left(1-\nu\right)\theta_L\left[2\,\chi\ \left(1-\theta_L\right)\left(\nu\ \left(\theta_H-\theta_L\right)+\theta_L\right)U_{Res_L} + \nu\ \left(\theta_H-\theta_L\right)\right] \tag{38d}$$

$$\alpha_2 = -\left(1-\nu\right)\theta_L\left[4\,\chi\ \left(1-\theta_L\right)\left(\nu\ \left(\theta_H-\theta_L\right)+\theta_L\right)U_{Res_L} + \nu\ \left(\theta_H-\theta_L\right)\right] \tag{38e}$$

Appendix B. Monopoly lending under symmetric information with type-dependent reservation utilities

In section 5, we assume that the indifference curves associated to the reservation utilities cross in the positive quadrant of the (C,R) space, which means that U_{Res_L} exceeds U_{Res_H} by a sufficient amount (a formal statement is given as assumption 2). One interpretation of this assumption is that reservation utilities are delivered by a competitive fringe of usury lenders who offer a single pooling contract with high collateral and interest, and upon which the lenders can easily improve, but nothing hinges on that particular understanding. In general, we can still define a virtual "reservation contract" (R_{Res}, C_{Res}) that has the property that it yields either type their reservation utilities.

$$U_{Res_H} = (1-\theta_H)\, y - C_{Res}\theta_H - (1-\theta_H)\ R_{Res} \tag{39a}$$

$$U_{Res_L} = (1-\theta_L)\, y - C_{Res}\theta_L - (1-\theta_L)\ R_{Res} \tag{39b}$$

$$C_{Res} = \frac{1}{\theta_H - \theta_L}\left((1-\theta_H)\, U_{Res_L} - (1-\theta_L)\ U_{Res_H}\right) \tag{39c}$$

$$R_{Res} = y - \frac{1}{\theta_H - \theta_L}\left(\theta_H U_{Res_L} - \theta_L U_{Res_H}\right) \tag{39d}$$

Definition 1. (Characterising the amplitude of the bargaining effect)
We can partition the parameter space according to the difference between outside options.
Negative or mild bargaining effect:

$$\frac{U_{Res_L}}{(1-\theta_L)} - \frac{U_{Res_H}}{(1-\theta_H)} \leq -\frac{s\,(\theta_H - \theta_L)\ U_{Res_L}}{(1+s)\,(1-\theta_H)\ (1-\theta_L)} \tag{40}$$

Intermediate bargaining effect:

$$-\frac{s\,(\theta_H - \theta_L)\ U_{Res_L}}{(1+s)\,(1-\theta_H)\ (1-\theta_L)} < \frac{U_{Res_L}}{(1-\theta_L)} - \frac{U_{Res_H}}{(1-\theta_H)} \leq 0 \tag{41}$$

Large bargaining effect:

$$\frac{U_{Res_L}}{(1-\theta_L)} - \frac{U_{Res_H}}{(1-\theta_H)} > 0 \tag{42}$$

Our assumption in section 4.1 satisfies condition (40). In cases (40) and (41), the lender always finds it optimal to induce delusion on the part of the borrower: $\tilde{\theta}_H = \theta_L$. If condition (42) holds, then the monopolist faces a non-trivial choice between enforcing delusion and realism.

B.0.1. *Delusion-inducing offers.*
A monopolist inducing delusion solves problem (43). Note that offers can be limited to a single contract, with the borrower selecting the high-risk's outside option in the off-equilibrium path subgame following $\tilde{\theta} = \theta_H$.

$$\begin{aligned} \underset{\{C_L \geq 0, R_L\}}{Max} \quad & \theta_H\,(1-\chi C_L)\, C_L + (1-\theta_H)\, R_L - G\,(1+r) \\ s.t. \quad & \begin{cases} U_B\,(\theta_L, R_L, C_L) \geq U_{Res_L} & (\mu_L) \\ U_B\,(\theta_H, R_L, C_L) + sU_B\,(\theta_L, R_L, C_L) \geq (1+s)\, U_{Res_H} & (\kappa_{H,L}) \end{cases} \end{aligned} \tag{43}$$

When the optimal expectations constraint (associated with $\kappa_{H,L}$) is active, the monopolist is providing incentives for delusion at the margin. There is no rent at stage 1, in the sense that the borrower is indifferent between delusion and realism. When the constraint is slack, the borrower strictly prefers to be deluded and earns a rent at stage 1: the monopolist fails to capture some of the psychological rent that is created, even beyond the loss associated with the use of collateral. The participation constraint, on the other hand, is enforced at stage 2 and relates to the agents' preference for the offered contract over her outside option. A slack constraint is associated with a positive rent, as was the case in our benchmark example. The following lemma characterises possible solutions to program (43), and the associated timing of rents.

Lemma 5. (Delusion-inducing monopolist: candidate solutions)
There are three possible candidate solutions to program (43). Along with the slackness conditions (44), they can be used to recover the optimal offer (R_L, C_L).

$$[U_B(\theta_L, R_L, C_L) - U_{Res_L}](\mu_L) = 0 \tag{44a}$$

$$[U_B(\theta_H, R_L, C_L) + sU_B(\theta_L, R_L, C_L) - (1+s)U_{Res_H}](\kappa_{H,L}) = 0 \tag{44b}$$

Slack participation constraint (stage 2 rent):

$$C_L = \frac{1}{2}\frac{s(\theta_H - \theta_L)}{((1-\theta_H) + s(1-\theta_L))\theta_H\chi}, \qquad \mu_L = 0,\ \kappa_{H,L} = \frac{(1-\theta_H)}{((1-\theta_H) + s(1-\theta_L))} \tag{45}$$

Active participation constraint, slack delusion-inducing constraint (stage 1 rent):

$$C_L = \frac{1}{2}\frac{(\theta_H - \theta_L)}{\theta_H\chi(1-\theta_L)}, \qquad \mu_L = \frac{(1-\theta_H)}{(1-\theta_L)},\ \kappa_{H,L} = 0 \tag{46}$$

Both constraints active (no rents):

$$\begin{aligned} C_L =& (1 + (1-\theta_L)s)\left(\frac{(1-\theta_H)U_{Res_L}}{(\theta_H - \theta_L)} - \frac{(1-\theta_L)U_{Res_H}}{(\theta_H - \theta_L)}\right) \\ &+ (1-\theta_L)s\left(\frac{\theta_H U_{Res_L}}{(\theta_H - \theta_L)} - \frac{U_{Res_H}\theta_L}{(\theta_H - \theta_L)}\right),\ 0 \le \mu_L,\ 0 \le \kappa_{H,L} \end{aligned} \tag{47}$$

Lemma 5, while mostly technical, does emphasise that the provision of incentives for delusion need not result in a positive stage 2 rent, as computed relative to a low-risk's reservation utility. Indeed, the stage 2 rent must be nonnegative in order for the contract to be taken up, but the outside option of low-risk borrowers does not enter in the determination of delusion incentives. However, if the bargaining effect is mild, then the participation constraint is slack, resulting in a positive rent. The marginal tradeoff which determines the amount of collateral taken up is then identical to the tradeoff exhibited in equation (13):

$$\theta_H(1 - 2\chi C_L) = \frac{(1-\theta_H)(\theta_H + \theta_L s)}{((1-\theta_H) + s(1-\theta_L))} \tag{48}$$

By contrast, if the lender needs not worry about incentivising delusion at the margin, then the benefits of speculative trade are reaped to their full extent, and the marginal trade-off is captured by the following first-order condition:

$$\theta_H(1 - 2\chi C_L) = \frac{(1-\theta_H)\theta_L}{(1-\theta_L)} \tag{49}$$

The marginal cost of additional collateral (right-hand side) is a reduction of repayment reflecting low-risk odds, which is lower than $(((1-\theta_H) + s(1-\theta_L)))^{-1}((1-\theta_H)(\theta_H + \theta_L s))$ the marginal cost of providing delusion incentives.

The reason why participation constraints enter into consideration is related to the bargaining effect. As in the type-independent reservation utility case, the psychological benefit of overoptimism implies that the monopolist can extract a higher repayment than a realistic borrower would accept to pay, and can further make use of collateral as a speculative trade, leveraging the difference in beliefs. However, as the outside prospects of low-risk borrowers improve, the higher repayment may be unacceptable to overoptimistic borrowers at stage 2. In that case, the monopolist's program is solved by (46), in which delusion is warranted without additional cost at the margin, while the monopolist exploits the entirety of gains from trade stemming from the difference in beliefs, or by (47), in which the borrower is indifferent between realism and denial at stage 1, and earns no rent at stage 2.

When the bargaining effect is large, low-risk borrowers have a high outside option and their repayment has to be lowered in accordance. Therefore, inducing realism on the part of borrowers becomes attractive to the lender, even while foregoing the benefits of speculative trade entirely, because a higher repayment can be demanded from realistic borrowers.

B.0.2. *Realism-inducing offers.*
When designing an incentive scheme which induces a borrower to be realistic, a lender has to compensate for the psychological rent associated with overoptimism, either by sweetening the terms offered to realists or by increasing the material cost of delusion. At face value, borrowers' predisposition towards overoptimism ought to make the enforcement of realism costly. However, since the material penalty for delusion only has to be dealt off the equilibrium path, enforcing realism comes at virtually no cost to the lender, as we prove in lemma 6.

The monopolist can induce realism on the part of the borrower by offering a menu of two offers, one destined for realistic borrowers, which is taken up in equilibrium, and one "threat contract" that a deluded high-risk borrower would prefer to her equilibrium contract. At stage 1, the borrower chooses to remain realistic because if she were to become overoptimistic, she could not refrain from agreeing to take on a large amount of collateral, effectively accepting a large side-bet at unfair odds against her success probability, and this would ultimately be detrimental to her welfare.

A suitable realism-inducing menu must satisfy:

$$(1+s)\,U_B\left(\theta_H, R_H, C_H\right) \geq U_B\left(\theta_H, R_L, C_L\right) + sU_B\left(\theta_L, R_L, C_L\right) \tag{50a}$$

$$U_B\left(\theta_L, R_L, C_L\right) \geq \text{Max}\left\{U_B\left(\theta_L, R_H, C_H\right), U_{Res_L}\right\} \tag{50b}$$

$$U_B\left(\theta_H, R_H, C_H\right) \geq U_{Res_H} \tag{50c}$$

Lemma 6. (Realism-inducing menus)
Any H-individually rational (R_H, C_H) contract can be supplemented with a "threat" offer (R_L, C_L) in a manner that induces realism. The offer (R_L, C_L) satisfies incentive compatibility

$$U_B(\theta_L, R_L, C_L) \geq U_B(\theta_L, R_H, C_H), \quad U_B(\theta_H, R_L, C_L) \leq U_B(\theta_H, R_H, C_H)$$

and induces realism:

$$(1+s)U_B(\theta_H, R_H, C_H) \geq U_B(\theta_H, R_L, C_L) + sU_B(\theta_L, R_L, C_L)$$

Among realism-inducing offers, the monopolist's most profitable offer is the zero-collateral offer that leaves no rent to the borrower:

$$C_H = 0, \quad y - R_H = \frac{U_{Res}}{(1-\theta_H)} \tag{51}$$

Proof. The last claim follows directly from the cost of collateral. For the purpose of supplementing an arbitrary offer (R_H, C_H), one suitable threat contract in general is

$$R_L = R_H - \theta_L\left(y - R_H + C_H\right)s \tag{52a}$$

$$C_L = C_H + s\left(\left(1-\theta_L\right)\left(y - R_H\right) + \left(1-\theta_L\right)C_H\right) \tag{52b}$$

The offer actually leaves a deluded borrower indifferent between the two contracts, and leaves the borrower indifferent between realism and delusion at stage 1. However, both indifference conditions may be broken. □

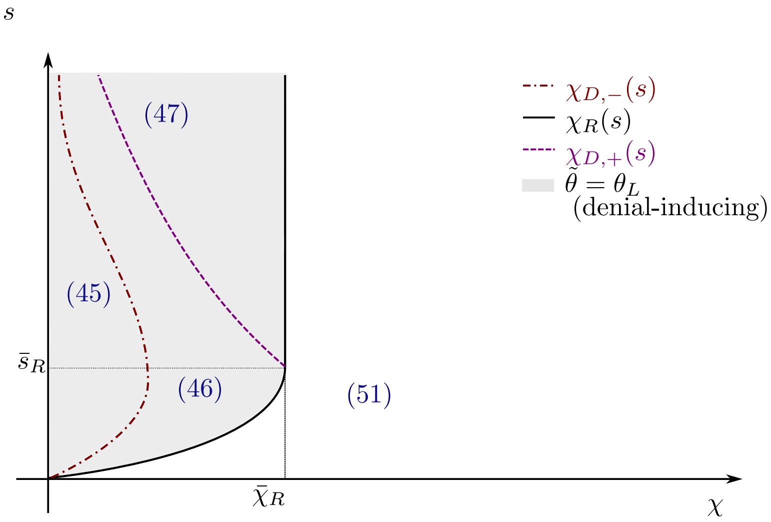

FIGURE 6. Optimal solutions when the bargaining effect is large

B.0.3. *Optimal lending.*

We now characterise the lender's optimal lending as a function of the weight of anticipatory utility concerns, the difference in reservation utilities and the transferability of collateral.

Proposition 6. (Optimal lending to high-risk borrowers with type-dependent utilities)

Negative or mild bargaining effect (condition (40) holds):

- *The monopolist induces delusion:* $\tilde{\theta} = \theta_L$
- *The borrower is exactly induced to delude herself, with no additional stage 1 rent*
- *The offer is characterised by (45)*

Intermediate bargaining effect (condition (41) holds):

- *The monopolist induces delusion:* $\tilde{\theta} = \theta_L$
- *There exist thresholds* $0 \leq \chi_{I,-} \leq \chi_{I,+}$ *such that*
  - *if* $\chi \leq \chi_{I,-}$*, solution (45) applies: the borrower is induced to delude herself, but with no stage 1 rent. The rent at stage 2 is positive.*
  - *if* $\chi_{I,-} \leq \chi \leq \chi_{I,-}$*, solution (47) applies. There are no rents at stage 1 or 2.*
  - *if* $\chi_{I,+} \leq \chi$*, solution (46) applies and there is a positive rent at stage 1 and no rent at stage 2.*

Large bargaining effect(condition (42) holds): the monopolist may either induce realism or induce delusion, depending on the values of χ *and s space. There exists a threshold* $\bar{\chi}_R$ *such that:*

- *for* $\chi \geq \bar{\chi}_R$*, inducing realism is optimal*
- *for* $\chi \leq \bar{\chi}_R$*, there exists a critical value* $s_R(\chi)$ *such that the monopolist induces realism for* $s \leq s_R(\chi)$ *and denial for* $s \geq s_R(\chi)$

Geometrically, the solution is given in figure 6.

If the bargaining effect is large, outside option considerations imply that the monopolist wants to induce realism. On the other hand, delusion generates a psychological rent which can partly be extracted throught the use of collateral. For $s \geq \bar{s}_R$, $\bar{\chi}_R$ is the threshold above which collateral is not sufficiently transferable (side bets are too costly) to justify the inducement of delusion: even though a higher surplus would be generated, it cannot be extracted cheaply enough, and the monopolist induces realism. When $s \leq \bar{s}_R$, the monopolist must give incentives for delusion *at the margin*. This comes at a direct cost and diminish the value of inducing delusion.

To summarise, when the monopolist chooses to induce realism, this is achieved costlessly through the use of threat contracts. However, the monopolist chooses to induces delusion when the bargaining effect is not too strong, and even when a strong bargaining effect seems to make the inducement of realism preferable, the monopolist may still induce delusion if there is a strong potential for psychological rent and if the cost of collateral is not too high. On the other hand, it is perhaps reassuring to note that as s converges to zero,

Corrolary 3. (Convergence $s \to 0$, Large bargaining effect)
Assume that the bargaining effect is large and write

$$\Delta_U := \left[\frac{\theta_H - \theta_L}{(1-\theta_L)\,(1-\theta_H)}\right]^{-1} \left(\frac{U_{Res_L}}{(1-\theta_L)} - \frac{U_{Res_H}}{(1-\theta_H)}\right) > 0 \tag{53}$$

The thresholds involved in the determination of the optimal solution have the following analytical expressions:

$$\chi_R(s) = \frac{(\theta_H - \theta_L)\,(\Delta_U + U_{Res_L})\,s}{\left((\Delta_U + U_{Res_L})\,s + \Delta_U\right)^2 \theta_H\,(1-\theta_L)} \tag{54a}$$

$$\bar{\chi}_R = \frac{1}{4}\,\frac{(\theta_H - \theta_L)}{\theta_H\,(1-\theta_L)\,\Delta_U} \tag{54b}$$

For s close to 0, $\chi_R(s)$ is also close to 0 and therefore $\chi \geq \chi_R(s)$: the monopolist enforces realism because the bargaining effect is dominant.

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