

Article

Strategic Information Suppression in Borrowing and Pre-Lending Cognition: Theory and Evidence [†]

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Abstract: This paper theoretically studies the interaction between an informed borrower and an uninformed lender facing possible default of a loan application. The lender is motivated to invest cognitive resources before making a lending decision. If the regulatory fine is weak, it is impossible for a bad-debt borrower to fully disclose his situation in the application. In this case, when the likelihood of a bad debt is low, the borrower always claims that nothing in the application is wrong. Otherwise, the borrower randomizes between full disclosure and information suppression. The transaction cost of the lender’s pre-lending cognition increases with the default probability, as the default probability is small and decreases thereafter. Evidence from a peer-to-peer lending platform with 816,274 observations between 2012 and 2015 in the United States is largely consistent with our model implications.

Keywords: information suppression; cognition; motivated belief; awareness; P2P platforms

JEL Classification: D82; D83; D86; L14; L15; G51



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“Good morning, Jordan Belfort with Investors’ Center in New York City. The reason I’m calling is that an extremely exciting investment opportunity crossed my desk today. Typically our firm recommends no more than five stocks per year: this is one of them. Aerotype International is a cutting-edge tech firm out of the Midwest, awaiting imminent patent approval on a new generation of radar equipment . . .”

Jordan Belfort in “The Wolf of Wall Street” (2013)

1. Introduction

Selling inappropriate products, which does not deliver the right customer expectation, is of practical importance in many industries. The problem is especially serious in the financial industry where investors cannot be certain if their investment will be properly returned, unless they incur sufficient cognitive costs before making investment decisions.

As a result of information disadvantages, investors may be unaware of some features of the financial products relevant for risk and return. For example, the contractual implications of financial services are extremely complex. Confronted with the “Wall Street Wolves”, such as Jordan Belfort in reality, investors in financial services are increasingly exposed

to the mis-selling of financial products, such as endowment mortgages, private pensions, investment funds and insurance products. The Financial Services Authority¹ noted as early as 2000 that one in eight investors in the United Kingdom who had financial investments in the past five years later regretted their choice.² In Asia, in 2008, thousands of people in Hong Kong, Singapore and Taiwan took to the streets to protest and demand a refund of the money they lost from the financial products backed by failed Lehman Brothers in the financial crisis.³ In China, Fanya Metals Exchange investors lost their money of about 36 billion RMB in 2015 as a result of Fanya's mis-selling,⁴ followed by the Ezubao fraud defaulting on 50 billion RMB in 2016.⁵ In the peer-to-peer (P2P) context, a large number of the borrowers suppress relevant information associated with repayment or even mis-report the actual purpose in their loan applications, which includes engaging in Ponzi schemes (using new funds to pay back earlier investors). Lenders cannot be fully informed about borrowers' repayment capacity at the contracting stage and may end up with an adverse situation such as default as a result.⁶

The literature in economics and finance has noted the importance of the information suppression problem in relation to consumer and investor protection. Gabaix and Laibson [1] analyzed consumers' unawareness of shrouded attributes of products and firms' incentives of information suppression in the competitive markets. Inderst and Ottaviani [2] studied the mis-selling problem in the principal-agent framework. Following that, Inderst and Ottaviani [3] investigated cases where investors were unaware of financial advisors' biased advice. Gui, Huang and Zhao [4] examined the financial fraud issue faced by unaware investors. However, the existing literature typically emphasizes only one particular downside, namely that consumers or investors are hurt at the post-purchase stage. The overall significance of the issue is largely underestimated when one only looks at consumer or investor protection, these being the "tip of the iceberg". As "the economic institutions of capitalism have the main purpose and effect of economizing on transaction costs" Williamson [5], in this paper, we shed light on a different aspect: the transaction cost of pre-contractual cognition by consumers or investors, which is the "submerged part of the iceberg".

Hayek [6] argues that not only does the price mechanism help to utilize knowledge dispersed among individuals, but it also promotes the efficient division of knowledge. When consumers or investors encounter unforeseen contingencies, however, the price mechanism may fail. If the regulator does not have perfect instruments (and therefore cannot promote the awareness of consumers or investors), the division and sharing of knowledge among individuals may be weakened. Although consumers or investors may be unaware, they are aware that they may be unaware of something. Consumers or investors may spend too much cognitive resources in order to avoid them from being potentially hurt. To return to the financial examples mentioned above, in order to prevent from being exploited, investors have to Google the information or consult experts specialized in finance, which results in socially wasteful duplication of cognitive efforts.

In this paper, we address this issue along the lines of economics of motivated beliefs by Benabou and Tirole [7] with respect to the borrower's strategic information suppression (signal jamming) and, particularly, cognition and the incomplete contracting approach by Tirole [8] with respect to the lender's pre-lending cognition (information acquisition).⁷

We study the interaction between a borrower (he) and a lender (she) who is aware that the lending application may not be appropriate, meaning that at the post-contractual stage, she may be adversely surprised by the suppressed information in the application. However, the lender can actively think about it before contracting, leading to our model being qualitatively different from Benabou and Tirole [7] where the "lender" can only passively update his belief according to Bayes' rule.

We deviate from Tirole [8] in two main aspects. First, we assume that the borrower knows whether the loan application is appropriate for the lender or the application involves a temporary expedient that could result in a bad debt, which may be unforeseen by the lender, whereas in Tirole's model, both parties are uninformed *ex ante*. The borrower can

strategically suppress information to the lender. If the loan application is not appropriate, the borrower either suppresses or reveals the temporary expedient followed by accepting a high interest rate of the loan. After introducing asymmetric awareness between the borrower and the lender, in this paper, we focus on the problem of strategic information suppression in borrowing. Second, in Tirole's model, the borrower is uninformed *ex ante*, such that applying for an inappropriate loan is not an intentional act of the borrower. In contrast, in our model, we allow for a regulatory fine for the borrower in the case of information suppression. Since it is commonly known that the borrower knows if the application is appropriate, this penalty is meant to deter the borrower's intent of information suppression. Notably, while this assumption is necessary to generate our main results described below, it is not the case when it comes to Tirole [8].

In our model, three key parameters determine the equilibrium. The first is the *a priori* probability that the loan application is not appropriate, which may lead to information suppression. We call this the *extent* of the information suppression problem. The second parameter is the loss of the lender when the borrower successfully suppresses the inappropriate features of the application. We call this the *effect* of the information suppression problem. The last parameter is the magnitude of the fine imposed on the borrower.

We show that there is a *separating* equilibrium in which the borrower always truthfully applies the appropriate loan if the regulatory power is sufficiently strong. Otherwise, there does not exist separating equilibrium. The reason is as follows. In the case where the loan application is inappropriate, if the borrower truthfully reveals all the relevant information or the actual purpose of the loan application, the lender has no incentive to exert cognitive effort. However, it jeopardizes the borrower's incentive to report truthfully, as information suppression can never be found out before contracting.

Suppose the regulatory power is weak. When the extent of information suppression is low, there is a *pooling* equilibrium where the borrower always announces that the application is appropriate, even though it may not be the case. The lender has a low incentive to question the borrower's repayment. Thus, the borrower prefers to suppress some information as the probability of being punished without obtaining any rent is low. When the extent of information suppression is high, we have no pure-strategy equilibrium. If the borrower suppresses with certainty (whenever it is possible), the lender has to stay on her toes so as to avoid the information suppression. The borrower then has no incentive to suppress, since the probability of being caught is high. Conversely, the argument for no separating equilibrium applies. Thus, given that the application is inappropriate, only when the borrower randomizes between truth telling and suppressing appropriately can the lender choose a corresponding cognition level such that the borrower is indifferent between truth telling and suppressing, which generates a *semi-separating* equilibrium.

We define the transaction cost as the expected cognition cost of the lender. Notably, one of the key results in Tirole [8] is that this transaction cost increases with the extent of suppressing, since the borrower would strictly prefer to suppress in his context. We show that in the pooling equilibrium, the transaction cost is increasing in the extent of the information suppression problem.

In a semi-separating equilibrium, however, we have the *opposite* result: the greater the extent of the information suppression, the smaller the transaction cost, because a greater extent of information suppression induces a much higher probability of awareness-inducing information disclosure by the borrower. In other words, as the extent of information suppression increases, the likelihood that the borrower misreports decreases at a higher speed. Hence, the transaction cost is increasing in the extent of the information suppression problem as long as the extent of the information suppression is small, and it is decreasing thereafter.

We employ publicly available data from LendingClub, one of the leading P2P platforms in the United States, to investigate the implications of the model. Unlike the other financial markets, the P2P platform has the specific feature of direct communication with

two parties to make a loan agreement; it facilitates our observing the strategic behaviors in the lending decision of two parties with information asymmetry.

Using the probit model, we estimate a lender's willingness to spend pre-lending cognitive effort in determining the appropriateness of the application. This is proxied by whether the lender has requested additional information about the loan application at the pre-contractual stage, as a borrower may not fully reveal related information in the application process.

We employ the credit level suggested by the platform to proxy the extent of information suppression. Using the P2P platform, the lender obtains a prior belief about the potential loan from the initial assessment report provided by the platform. However, the assessment report contains only limited information regarding the characteristics of the loan, which cannot fully alleviate lenders' concerns. Especially in terms of some riskier loans, which are more likely to yield bad outcomes, lenders tend to request additional information disclosures, which is costly.

We further use the value of the transaction to proxy the effect of information suppression. The lender's funding amount also influences the cognition effort spent by the lender. To be more concrete, the application amount itself can determine the impact of the potential loan becoming a bad debt. When the debt is uncollectible, the out-of-pocket money becomes a loss for the lender and turns into the borrower's gain. To some extent, the impact of the information suppression can be mitigated by investing more cognitive effort from the lender's perspective.

Our data suggest that the lenders invest more cognitive effort when the value of the transaction is higher. In addition, we observe a "hump-shaped" relationship between the expenditure of cognitive effort and the credit level of the loan, largely consistent with our model implications. More details of the data source and our empirical strategy are provided in Section 3.

The remainder of the paper is organized as follows. The subsection below reviews the related literature. Section 2 presents the model. Section 3 discusses the empirical results. We conclude by some policy discussion and possible theory for future work in Section 4.

Literature

This paper is related to two streams of literature.

First, we have several rationales for incomplete contracts thus far: non-verifiability (Williamson [5], Grossman and Hart [9], Hart and Moore [10], Maskin and Tirole [11]), explicit writing costs (Dye [12], Anderlini and Felli [13], Battigalli and Maggi [14]), signaling by one contracting party (Aghion and Bolton [15], Spier [16], Hermalin and Katz [17]), and strategic incompleteness by both contracting parties (Bernheim and Whinston [18] and Dessi [19]). Recent approaches endogenize incompleteness of contracts from bounded rationality introduced by Simon [20]. Bolton and Faure-Grimaud [21], Tirole [8] and Pavan and Tirole [22] endogenize incomplete contracts from the parties' insufficient cognition. In contrast, when one party is fully rational and the other party is boundedly rational, contractual incompleteness can be the result of strategic information suppression by the rational party. In our paper, the incomplete contract, which leads to strategic suppressing of the borrower, stems from both the lender's inadequate cognition and the borrower's strategic information suppression.

Second, there is growing literature on awareness or attention in behavioral economics and finance, which is tantamount to the notion of availability heuristic to judge probabilities by Kahneman and Tversky [23] in cognitive psychology. In the behavioral industrial organization literature, Gabaix and Laibson [1] model consumers' unawareness of some add-ons (actions of one's opponents). Eliaz and Spiegel [24] study screening consumers' awareness of future changing tastes (preferences). Zhou [25] studies advertising that highlights only a few attributes of a complex multi-attribute product to consumers with limited attention. Li, Peitz and Zhao [26] consider a vertically differentiated duopoly model with unaware consumers. Young [27] studies the impact of the consumer's switching

between a naive and sophisticated cognitive state on market outcomes under different types of competition. In parallel, Li, Peitz and Zhao [28] discuss the role of information disclosure rules for consumers possibly unaware of the adverse effect of a product. Gui and Hu [29] theoretically study the case of product customization of a buyer after purchase. In contract theory, von Thadden and Zhao [30] design incentives for agents who are possibly unaware of their own choice possibilities (one's own actions). In a moral hazard setting, Auster [31] examines an agent's unawareness of future contingencies (actions of nature).⁸ In finance, Gui, Huang and Zhao [4] theoretically study how firms in a leader–follower relationship strategically provide normal or fraudulent financial products, facing possibly unaware investors. In relation, Gui, Huang and Zhao [4] experimentally investigate financial literacy together with investors' unawareness of the link between high risk and high return of financial products and the associated effect of a financial education program.

2. Model

We model the interaction between a borrower's information-suppressing behavior and a lender's pre-lending cognitive effort. The lender's potential unawareness of some certain features of the application is the motivation for us to capture his incentive of pre-lending cognition.

2.1. The Setup

There are two risk-neutral contracting parties: a lender (B , she) and a borrower (S , he). The borrower wants to borrow a fixed amount of money from the lender for his claimed purpose. There is a *status quo* application A available. A can be interpreted as an application provided in the platform with a reasonable purpose such as a car loan, home loan, small business loan or even travel loan. The lender wants to invest the loan application, and if A is appropriate, A delivers return $v > 0$ to the lender, which is the profit obtained from the return on investment. If A is not appropriate, however, the loan is riskier than what the lender expected. The lender's expected return from A deducts to $v - h$ with $h > 0$, as the return on investment is reduced by those uncollected funds.

In the latter case, we assume that there always exists an eye-opening application A' , which is appropriate (meaning it delivers return on investment v to the lender), but is unforeseen by the lender at the contracting stage. Moreover, A' exists if and only if A is inappropriate, as in Tirole [8]. If A is not appropriate, before contracting, the lender may be unaware of some relevant features of the application in relation to the repayment. For example, a borrower, who is under a financial difficulty but without any bad credit history, may have a higher incentive to mis-report the borrowing purpose (e.g., temporary expedient). In this case, an uninformed lender will face an unexpectedly high probability of default on the application.

Hence, the *effect* of the information suppression is modeled by a constant h . If A is not appropriate, and the lender funds the application A , the magnitude h is not only the lender's loss of return on investment from information suppression but also the rent for the borrower who suppresses. By suppressing, there is a redistribution of profit from the lender to the borrower. In general, the gain of the borrower in the case of information suppression h' may be different from the loss of the lender h . Particularly, it is quite plausible to assume a dead-weight loss of information suppression ($h' < h$). This extension is straightforward without changing the qualitative results. Our motivation of this simplification compared with Tirole [8] is that since the borrower has already been informed about the application-appropriateness, the lender's pre-lending cognition is purely rent seeking. Therefore, to complement the existing literature on mis-selling or suppressing in our context (see, e.g., Inderst and Ottaviani [2,3]), we focus only on this particular transaction cost in the information suppression context and rule out the possibility of insufficient cognition of the lender as a free-riding problem in Tirole [8].

Figure 1 shows the timing with details as follows:

- Stage 1: Nature moves.

Nature chooses A to be *not* appropriate with probability ρ . In other words, with probability ρ , some features of the application hurt the lender. We call ρ the *extent* of the information suppression, since, with probability ρ , the loan application is inappropriate, which leads to the potential misconduct.

In contrast to Tirole [8], we assume that the borrower knows nature's move, while the lender does not.⁹ Facing the known application A , the lender is aware that A might be not appropriate for her. In other words, the lender is aware that something may go wrong with A . Here, we assume common knowledge of the game and rationality. Since the two parties have a common prior ρ , the problem is a classical one of asymmetric information between the lender and the borrower. If A is appropriate, we call the borrower type- A ; otherwise, we call him type- A' .

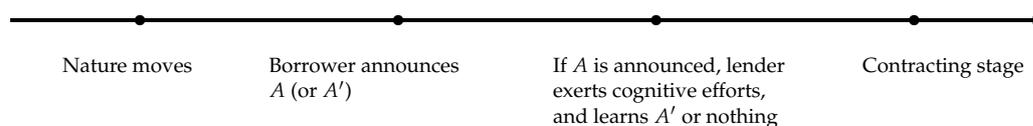


Figure 1. Timeline.

- Stage 2: Borrower's announcing stage.

At this stage, the borrower can say something to the lender. He may announce that the application A is appropriate or point out that A does not deliver the expected return v to the lender and offers an eye-opener application A' .

If the borrower is type- A , then he can only announce that A is appropriate, since A is appropriate, and the lender cannot be harmfully surprised *ex post*. However, type- A' borrower contemplates two options: suppressing some features of the application and falsely saying that the application A is appropriate (information-suppressing), on the one hand, and unveiling A' (truth-telling), on the other hand. Let q be the probability that type- A' borrower suppresses, which is endogenous.

In the same way as Benabou and Tirole [7], we have an asymmetry of information transmission in two states of nature (A and A'). Here, announcing A provides only *soft* information. The lender remains uncertain of the appropriateness of A (if the borrower may suppress in equilibrium). However, announcing A' immediately reveals the *hard* evidence that A is not appropriate and is therefore an eye-opener for the lender, because the borrower can report A' to the lender only if A is *de facto* not appropriate. Intuitively, the borrower can announce some surprising message only if the lender is unaware of something. For example, if the lender is unaware of the borrower's actual purpose of the loan application, the borrower may suppress this purpose or explicitly mention it to the lender. In other words, if nothing of the application goes wrong, the borrower cannot prove it just by (cheap) words. However, if something of the application is really wrong, the borrower can provide the awareness-inducing information to the lender. Thus, the asymmetry of information transmission in two states makes the model different from signaling games¹⁰ (see, e.g., Spence [35]) and cheap-talk games (see, e.g., Crawford and Sobel [36]), where information is always soft, and unraveling games (see, e.g., Grossman and Hart [9], Grossman [37], Milgrom [38], and Milgrom and Roberts [39]), where information is always hard.

- Stage 3: Lender's cognition stage.

If $q > 0$ and the borrower says A is appropriate, the lender still does not know whether or not A is appropriate. However, the lender can think, that is, make an effort to contemplate the situation in this case.¹¹ For example, if the A is a loan application for a wedding purpose, the lender may request additional documentation (such as a wedding venue reservation letter) to verify the reliability of the application. Formally, the lender chooses her *cognition* level b , which maps bijectively to the probability that the lender learns that A' is appropriate, given that A' is the appropriate application. In other words, if something of the application

goes wrong, the lender can find it with probability b . However, if nothing goes wrong (A is appropriate), the lender finds nothing after pre-lending cognition.

The lender bears a cognitive cost, or thinking cost, $C(b)$ that is a smooth, strictly increasing and strictly convex function with the properties $C(0) = C'(0) = 0$ and $C(1) = \infty$.

- Stage 4: Contracting stage.

We assume that the outside options of both parties yield zero payoffs. For analytic simplicity, the lender has full bargaining power at the contracting stage and thus makes a take-it-or-leave-it offer to the borrower.¹²

If the borrower reveals A' to the lender, the lender is suddenly aware of A' and proposes a contract that consists of a loan amount p and a full specification of the application A' .¹³ Then, the borrower decides whether to accept the contract.

If the lender is told that A is appropriate, and after the lender has thought about it at stage 3, there are two possibilities.

(i) The lender learns that A is not appropriate by pre-lending cognition; thus, she knows that the borrower has cheated her. The lender then knows the existence of A' and demands A' accordingly. We assume that whenever the lender knows that the borrower suppresses some important features of the application, a third-party regulator can fine the borrower by a monetary penalty t .¹⁴ To shed light on the mere transaction cost of pre-lending cognition, we assume that the regulator will transfer this amount of the fine to the society, namely the lender.¹⁵ Due to the borrower lending the loan for himself, we assume that the borrower can acquire the information with zero cost. Hence, liability of the borrower requires the borrower to take appropriate care to report the loan. As Milgrom [40] argues,

“... what is needed ... is to hold the seller liable for failures to reveal promptly not only the verifiable information that the seller knew, but also the information that it *should have known* under the circumstances.”

Now one might consider increasing the fine t arbitrarily in the covenant so as to deter information suppression. In reality, however, regulation is imperfect. When the borrower suppresses, the regulator will find it with probability z . Because of the borrower's limited liability W , it is very likely that the *expected* fine t has an upper bound.

(ii) The second possibility is that the lender remains uncertain to whether A is appropriate. Then, the lender proposes a contract, including a loan amount p and the specification of A , under uncertainty.

Suppose that A' is appropriate. The lender can only demand A , although it is not appropriate. The imperfect information of the application in the contract leads to an information-suppression contract. If the borrower accepts the contract, then, at the post-contractual stage, the lender receives payoff

$$v - p - h + t - C(b),$$

and the borrower receives

$$p + h - t.$$

Ex post, the lender will find out that A is actually not appropriate, because she is hurt by uncollected funds h . Then, there is a transfer t from the borrower to the lender.

Suppose that A is appropriate. Since there is no information suppression, if the borrower accepts the contract, then, at the post-contractual stage, the lender receives $v - p - C(b)$, and the borrower receives p .¹⁶

2.2. Analysis

We solve the game backward by using the solution concept of perfect Bayesian equilibrium. To focus on the main welfare loss of pre-lending cognition, we abstract from the inefficient contracting result where a mutually beneficial investment may break down,

therefore ruling out the case in which there are only “lemons” in the market (Akerlof, [41]). Thus, we make the following assumption:

Assumption 1. $v - \rho(h - t) > \rho v$.

The interpretation of Assumption 1, given that there is no cognitive effort and that type- A' borrower suppresses with certainty, is that the lender always prefers $p = 0$ and contracting with both types of borrowers to $p = t - h$ and contracting with only type- A' borrower when $h > t$.¹⁷

Separating Equilibrium

It is clear that separating equilibrium appears when $t \geq h$. The fine is sufficiently high enough to deter information suppression. However, when $h > t$, Appendix A.1 shows that $p = 0$ given the lender’s full bargaining power. In this case, separating equilibrium does not exist. The reason is as follows. Suppose, at stage 2, $q = 0$, i.e., type- A' borrower tells the lender A' with certainty. Then, at stage 3, the lender’s optimal cognitive effort level is $b = 0$. Since there is no information suppression anymore, it is not worthwhile for the lender to spend any resource on thinking. However, if $b = 0$, it turns out that type- A' borrower optimally pretends to be type- A , since type- A' borrower will obtain the rent from information suppression with certainty (and $h - t > 0$). Thus, it is impossible to have a *separating equilibrium* in which the lender can tell type- A borrower and type- A' borrower apart for sure without cognition.¹⁸

Pooling Equilibrium

Alternatively, suppose $q = 1$ at stage 2, i.e., type- A' borrower suppresses information with certainty. Then, at stage 3, given that $p = 0$, the lender maximizes her payoff in expectation

$$\max_b (1 - \rho)v + \rho b(v + t) + \rho(1 - b)(v - h + t) - C(b)$$

where $1 - \rho$ is the probability that A is appropriate, ρb is the probability that A is not appropriate and the lender knows it by pre-lending deliberation, and $\rho(1 - b)$ is the probability of information suppression.

The assumptions on $C(\cdot)$ imply that the optimal cognition is b^* such that

$$C'(b^*) = \rho h. \tag{1}$$

The marginal cost of the cognition equals the marginal benefit from avoiding information suppression. Equation (1) reflects that the equilibrium that the cognition is increasing in ρh , namely, the application of the extent and the effect of the information suppression.

When ρ is small, we have that b^* is small. Thus, if t is also not too large, we have that

$$(1 - b^*)(h - t) + b^*(-t) \geq 0, \tag{2}$$

which means that $q = 1$ is optimal for type- A' borrower. Therefore, when ρ and t are small, there is a *pooling equilibrium* in the sense that both type- A and type- A' borrowers announce that A is appropriate. Intuitively, if the extent and the transfer from type- A' borrower are low, the lender therefore does not exert too many cognitive efforts; then, type- A' borrower has an opportunity to suppress information.

Formally, if $\rho h \leq C'(1 - t/h)$ holds, we have such pooling equilibrium.¹⁹ It is straightforward to see that pooling is more likely to occur for smaller ρ and t , yet the role of h is indeterminate, because increasing h raises the benefit of information suppression for the borrower, which enhances the borrower’s incentive to suppress, yet it also raises the lender’s cognition level, which reduces the borrower’s incentive to suppress. Hence, we cannot judge its impact on the validity of condition (2).

Semi-Separating Equilibrium

However, when $\rho h > C'(1 - t/h)$, there is no pure-strategy equilibrium, since in this case we have

$$(1 - b^*)(h - t) + b^*(-t) < 0, \quad (3)$$

i.e., a high level of cognition by the lender in the pooling equilibrium deters type- A' borrower from information suppression.

For large ρ and t , we therefore investigate the mixed-strategy equilibrium. Suppose type- A' borrower chooses a behavioral strategy $q \in (0, 1)$ at stage 2. Then, at stage 3, the lender solves the following problem upon observing A :

$$\max_b \frac{(1 - \rho)v + \rho qb(v + t) + \rho q(1 - b)(v - h + t)}{1 - \rho + \rho q} - C(b),$$

which implies the optimal cognition level b^* such that

$$C'(b^*) = \frac{\rho q h}{1 - \rho + \rho q}. \quad (4)$$

Since type- A' borrower plays a non-degenerate behavioral strategy, at stage 2, he is indifferent between announcing A and A' :

$$(1 - b^*)(h - t) + b^*(-t) = 0.$$

Therefore, equilibrium of the cognition level is

$$b^* = 1 - \frac{t}{h}; \quad (5)$$

thus, the equilibrium of the cognition level is determined by h and t and is independent of ρ . In particular, b^* is increasing in h and decreasing in t . If h is higher, type- A' borrower has a higher incentive to suppress information. To keep the borrower still indifferent between announcing A and A' , the lender has to think more carefully to reduce type- A' borrower's incentive to suppress. We have the opposite and yet analogous intuition for a higher t .

Plugging b^* in (5) into Equation (4), we have

$$q^* = \frac{(1 - \rho)C'(1 - \frac{t}{h})}{\rho(h - C'(1 - \frac{t}{h}))} \quad (6)$$

which is decreasing in ρ and t . In equilibrium, an appropriate q^* induces the lender to choose the optimal deliberation such that type- A' borrower is indifferent between information suppression and truth telling, which we dub *semi-separating equilibrium*.²⁰ This result is in contrast to Tirole (2009). Although the borrower has no bargaining power, in the presence of the transfer t , type- A' borrower here has no strict incentive to suppress information A' . Disclosure of A' by the borrower is possible, although not necessary, in equilibrium.

We summarize the results we have thus far in the following proposition.

Proposition 1. *There exists a separating equilibrium where two types of borrowers are distinguished by the lender with certainty if and only if $t \geq h$. When $t < h$, if $\rho h \leq C'(1 - t/h)$, there is a pooling equilibrium where both types of borrowers announce that A is appropriate, and the lender's deliberation b^* is characterized by Equation (1); otherwise, there is a semi-separating equilibrium where type- A' borrower randomizes between information suppression and truth telling with type- A' borrower's probability of information suppression q^* given by Equation (6), and the lender's deliberation level b^* is given by Equation (5).*

2.3. Robustness

Heterogeneous Lenders: We assume only partially unaware lenders, meaning the lenders are aware of their potential unawareness. In reality, a number of lenders are completely unaware, i.e., they are naive in the sense that they always believe what the borrower says and do not exert any cognitive efforts. If we allow diversely unaware lenders, the main finding is that the pooling equilibrium is more likely to occur, because type- A' borrower has a higher incentive to suppress due to the opportunity to exploit more completely unaware lenders in the population.²¹

Furthermore, if we allow that a fraction of lenders have the same information as the borrower has, that is, some lenders know A' without the need of costly cognition (when A is not appropriate), the pooling equilibrium is less likely to occur. More informed lenders in the population increase the probability of type- A' borrower being punished when he suppresses.

Heterogeneous Borrowers: The model assumes that all borrowers are immoral in the sense that they suppress information whenever it is worthwhile for them. Suppose that a fraction of borrowers are honest, that is, they always truthfully report the purpose of application. It only reduces the lender's incentive to think, which makes the pooling equilibrium more likely to occur.

More than Two States of Nature: Suppose there are not only the appropriate and non-appropriate applications, but an order of appropriate applications. Simplifying a bit, we have three states of nature: A , A' and A'' . After A' is revealed, the lender may think further to look for the more appropriate A'' .

If the borrower only knows A' , then our analysis is not modified before the lender's cognition for A'' , because there is asymmetric information only on A' between them. After A' is revealed, we are back to the model by Tirole (2009), since both parties are uninformed about A'' . However, if the borrower is fully informed, type- A'' borrower can pretend to be A or A' . Nevertheless, our qualitative results still hold. That is, when t is small, we still have a pooling equilibrium. Conversely, we have a semi-separating equilibrium where type- A' borrower or type- A'' borrower (or both) randomizes his choices.

2.4. Welfare Comparative Statics

We view social surplus of the lender and the borrower as our welfare criterion. In any outcome of the game, we have only one source for a welfare loss: the cognitive cost $C(b)$ for the lender. Thus, we define the *transaction cost* as the expected cognitive cost

$$L \equiv (1 - \rho(1 - q))C(b).$$

In the model, we have three free parameters: ρ , h and t . The comparative statics of the transaction cost with respect to these parameters are in the following proposition.

Proposition 2. *If $\rho h \leq C'(1 - t/h)$, we have $dL/d\rho > 0$, $dL/dh > 0$ and $dL/dt = 0$. Otherwise, we have that $dL/d\rho < 0$, the sign of dL/dh is ambiguous, and $dL/dt < 0$.*²²

Proof. See Appendix A.5. \square

When $\rho h \leq C'(1 - t/h)$, there is a pooling equilibrium where type- A' borrower suppresses information with certainty. Thus, the lender exerts her cognitive efforts with certainty. The transaction cost therefore is $L = C(b)$. The higher the ρ , the higher the cognition level b the lender exerts in order to avoid being mis-sold to, and thus the higher L . By the same token, L is increasing in h . In the pooling equilibrium, however, the lender's cognition level b is independent of the penalty t , because changing t does not influence the lender's marginal payoff of cognition, although the lender prefers a higher t .

When $\rho h > C'(1 - t/h)$, there is a semi-separating equilibrium. Since q is endogenous, the welfare comparative statics are not so straightforward as above.

Particularly striking is that we have the opposite result that L is *decreasing* in ρ here. Since, in the semi-separating equilibrium, what determines the cognition of the lender is only type- A' borrower's indifference condition, which is Equation (5), having more type- A' borrowers in the population does not alter the lender's cognition level. However, when ρ is large, to keep the lender employing the same cognition level as before, type- A' borrower has to reduce q . Equation (6) implies that q decreases at a higher rate than ρ . Thus, the overall probability that the lender exerts the cognition is lower. Although ρ is higher, there is much higher probability of information disclosure. Hence, L is reduced for a higher ρ .

Briefly, *there is a cutoff value $\bar{\rho}$ such that L is increasing in ρ as long as $\rho < \bar{\rho}$ and is decreasing thereafter.*

In the semi-separating equilibrium, however, whether or not L increases as h increases is ambiguous. Since raising h has an ambiguous impact on equilibrium q , we cannot judge the welfare consequence of it.

Lastly, a higher t reduces L in the semi-separating equilibrium. For a higher t , to guarantee type- A' borrower's indifference condition, the lender's cognition level b is lower. The only way to maintain the lender's low cognition level is to reduce type- A' borrower's probability of information suppression q . Since both b and q are reduced, L is reduced.

The welfare comparative statics suggest that a benevolent court of law should weakly increase t to the largest extent. However, t is bound above by the limited liabilities of the parties. Therefore, t can be interpreted as the highest possible penalty, depending on the wealth of the parties in the regulatory process.

3. Evidence

The empirical analysis of this paper focuses on the behaviors of borrowers and lenders in the context of private loan lending. We employ observational data of transactions processed on a P2P platform in which lenders do have concerns about whether the loan application from borrowers is appropriate or not.

The P2P platform itself is embedded with an initial risk assessment algorithm to suggest the credit level of a particular loan application. However, the suggested credit level is not fully reliable, and the security of investments cannot be guaranteed by the platform. In addition, borrowers are better informed than lenders about their financial capabilities in repayments. Thus, lenders may request additional information.

Mechanism of P2P transactions: At the first stage, the borrower posts their loan application following the platform's requirements. The application will be evaluated by LendingClub's proprietary scoring model, and it is regarded as valid once it passes the initial screening assessment. The factors in determining whether the application is valid contain: the borrower's credit score (provided by credit bureaus), debt-to-income ratio, related credit history, and recent credit activities in the past six months. The platform will adjust the interest rate accordingly based on the applicant's information before two parties enter the contracting stage.

At the second stage, the P2P platform is embedded with an algorithm that generates a credit level for each application to potential lenders. There are seven grades—level A to G, and each level will be assigned with according interest rate, from 8.46% to 30.99%. The credit level serves as a direct signal, which also forms the lenders' prior belief regarding the appropriateness of this application according to our model. It considers FICO scores, credit attributes, relative credit activity over the past six months, and other application data in addition to the borrower's performance.

At the third stage, after screening different loan applications, the lender makes a lending decision based on the disclosed information in the application. Given the information disadvantage, the lender may request additional information from the borrower for the assessment. At this stage, the borrower is able to proactively disclose additional information and demonstrate the appropriateness of the application to potential lenders to support the application. The credibility of the loan is not necessarily improved by the additional information in the application.

At the final stage, lenders determine the interest rate of the loan investment and make the lending decisions accordingly.

3.1. Data Description

The dataset we use is published on Databrief and was originally sourced from the LendingClub database²³, one of the lending P2P platforms in the US, to support the key implications of our model. The dataset contains 2,703,430 observations from 2012 to 2019.

Verified and Unverified information: Loan-relevant information is provided by the borrower at the application stage or is requested by the lender at the contracting stage. These pieces of information can be classified as verified or unverified. Verified information relates to the official credit report (such as the borrower's credit history, the last public record, previous and existing credit lines, charge-offs, past-due amounts owed in the borrower's credit files, and the current balance of all accounts) that is generated by the credit bureau. As a result, lenders need not be concerned about the credibility of that information. However, that unverified information (such as self-reported income, employment history, and the purpose of the loan application) is not adequate in helping to avoid potential losses, which prompts lenders to invest extra efforts to obtain more information and to identify the authenticity of the loan application. Thus, requesting and interpreting information from the borrower turns out to be a cognitive cost for the lender.

Pre-lending cognitive effort decision: We generate the variable of interest—the loan description—as an indicator variable that we use as a proxy for the cognitive effort expended by the borrower in looking for potential loans. It equals one when the loan description is provided, and zero otherwise. The intuition behind using descriptive information as a proxy is that borrowers can strategically withhold additional information to avoid the inappropriateness of the loan being noticed by the lender. For example, some borrowers who do not have a bad credit history and are currently in financial difficulty would like to cheat lenders by providing a reasonable purpose (i.e., a travel loan), but their real purpose is to abscond with the money and never pay the loan back in full. In this case, the lender will need to request additional information (i.e., flight tickets, hotel booking letters) to verify the purpose of the application.

Summary of statistics: In our estimation, we drop the observations from 2016 to 2019 as missing “loan description” samples in these years in this public dataset. Table 1 describes the statistics of the selected variables used in our estimation.

3.2. Empirical Analysis

We model cognitive effort cost as a function of the loan's credit level, funded amount from the lender, and purpose of loan borrowing. The term “funded amount” is used to refer to the actual amount that is paid by the lender, not the requested amount by the borrower. Table 2 presents the result of probit regression on the probability of investing in additional cognitive effort based on the loan's credit level and funded amount from the lender. We control factors that might influence the prediction including the purpose of the loan and the borrower's region as robustness checks.

Table 1. Descriptive statistics.

Variable	N	Mean	Std.Dev.	Min	Max
<i>Panel A: Selected variables</i>					
<i>c</i> (Loan Description)	816,274	0.098	0.297	0	1
<i>h</i> (Funded Amount)	816,274	14,996.04	8445.824	1000	35,000
ρ (Grade Level)	816,274	2.814	1.304	1	7
Interest Rate	816,274	0.133	0.044	0.0532	0.29
Debt-To-Income Ratio	816,274	18.457	8.314	0.01	39.99

Table 1. Cont.

Variable	N	Mean	Std.Dev.	Min	Max
<i>Panel B: Loan Proportions by Characteristic</i>					
		<i>Frequency</i>		<i>Proportion of Loans</i>	
<i>Credit Grade</i>					
A		131,387		16.10%	
B		232,549		28.49%	
C		231,107		28.31%	
D		129,792		15.9%	
E		65,572		8.03%	
F		21,058		2.58%	
G		4809		0.59%	
<i>Loan Length</i>					
36 months		566,558		69.41%	
60 months		249,716		30.59%	
<i>Purpose of loans</i>					
Car		6650		0.81%	
Credit Card		195,374		23.93%	
Debt Consolidation		488,766		59.88%	
Home Improvement		46,860		5.74%	
House		2996		0.37%	
Major Purchase		14,110		1.73%	
Medical		7446		0.91%	
Moving		4545		0.56%	
Other		36,647		4.49%	
Renewable Energy		432		0.05%	
Small Business		7442		0.91%	
Vacation		4130		0.51%	
Wedding		876		0.11%	

Econometric Specification: The probit regression model we employ is as follows:

$$c_i = \Phi(\alpha_0 + \beta_1\rho_i + \beta_2h + \beta_3X_i + \epsilon) \quad (7)$$

where $c_i = 1$ indicates that the lender expends additional pre-contractual cognitive effort, ρ represents the credit level of the loan chosen by the lender, which is a proxy for the likelihood that the application is inappropriate, and h represents the funded amount (transaction value), that is, the amount that the lender actually invests in this loan. The funded amount has been transformed into logarithmic form in the estimation to simplify the interpretation. ϵ captures the error term of the equation. As mentioned before, the funded amount may not be exactly equal to the requested loan amount, as in the final contracting stage, the lender can use his bargaining power to provide a take-it-or-leave-it offer to the borrower. The term X denotes the characteristics (the purpose of the borrower's loan request and the borrower's region) in the estimation probit model.

The evidence suggests several results. Firstly, lenders are more likely to expend cognitive effort within an acceptable range when the likelihood of a particular loan being a bad loan increases. Secondly, the coefficient of the funded amount is positive and significant, as expected, revealing that lenders are more likely to invest more effort when the loan amount increases. Thirdly, the decision for additional cognitive effort spending relates to the purpose of the loan application.

Probit Estimation: Table 2 shows the marginal effect of the explanatory variables in predicting the decision to pre-lend cognitive effort. The benchmark of our probit model is shown in columns 1 and 2 of Table 2, with only one explanatory variable—the loan's

credit level and funded amount, respectively. From column 1, we can conclude that the probability of the lender's perceived pre-lending effort is highest when the credit level is at level B (12.03%), followed by level G (10.38%) and level A (10.16%). When credit level rises from "A" to "B", the probability of additional cognitive effort spent on loan applications rises by 1.87%. While starting with grade "C", the change in probability decreases gradually compared to the previous grade. The pattern of increasing likelihood of information requests from grade "E" to "G" has statistical significance in our estimation, which is inconsistent with our theoretical model. The possible explanation includes the heterogeneous individual choices being more volatile than in the previous grade level. Given the observational data that we have, the contribution of the heterogeneous individual differences cannot be measured properly. We perform a series of two sample *t* tests to investigate the population difference across credit levels, reported in Table 3.

In addition to columns 1 and 2, columns 4 and 5 were used to control loan applications. The regression results are consistent with the prediction in the benchmark case. When the purpose of the loan application is to support vacation spending and moving expenses, lenders are less likely to ask borrowers for more information about the application because the loan amounts requested for these activities are relatively small. For home purchases, however, lenders are more likely to require borrowers to provide detailed information about the purchase in order to identify the property and to ensure a return on investment. In the case of weddings, lenders may question the credibility of the reasons behind the application.

Column 6 combines all of the explanatory variables and controls from the previous columns. This is conducted mainly to ensure that our main result still holds, and it provides reassurance that differences in the borrower's regional area and loan purpose are not driving our results.

Figure 2 shows the pattern of marginal effects of the change in the probability of spending additional cognitive effort given a platform-assigned credit level. It presents a "hump-shaped" relationship between the expenditure of cognitive effort and the credit level of the loan. The probability of obtaining additional information is 10.16% among loans with grade A, and it jumps to 12.03% among loans with grade B. However, it continuously drops from grade B to grade E with the corresponding values, 8.92%, 8.21%, and 6.77%. There is more volatility in the lender's behavior among those with grade G compared to the other credit levels' loan application, with a relatively larger standard error (0.0044).

Given the limitations of the observational data, we could not find the contributor to the volatility of the standard deviation. However, we do not need to worry about the credibility of the probit estimation, as adding the controls and regional fixed effect in Equation (7) does not alter the magnitude and direction of the predictive result (as shown in Table 2, column 6). We claim that the large range of standard deviations of credit levels F and G could be driven by their limited sizes (2.58% and 0.59% of the total sample, respectively) and the missing variable in capturing the individual differences in terms of the lenders' risk attitudes. Considering the type of risk could help in understanding the wider standard error and the unusually increasing pattern of growth from E to G levels.

Table 2. Probit estimates of willingness to invest pre-lending cognitive effort.

VARIABLES	Pre-Lending Cognitive Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
Grade A	0.1016 *** (0.0008)		0.1015 *** (0.0008)	0.1017 *** (0.0008)		0.1018 *** (0.0008)
Grade B	0.1203 *** (0.0007)		0.1207 *** (0.0007)	0.1203 *** (0.0007)		0.1207 *** (0.0007)
Grade C	0.0892 *** (0.0006)		0.0894 *** (0.0006)	0.0893 *** (0.0006)		0.0894 *** (0.0006)
Grade D	0.0821 *** (0.0008)		0.0821 *** (0.0008)	0.0821 *** (0.0008)		0.0819 *** (0.0008)
Grade E	0.0677 *** (0.0001)		0.067 *** (0.001)	0.0676 *** (0.001)		0.0668 *** (0.001)
Grade F	0.0997 *** (0.0021)		0.0983 *** (0.002)	0.0991 *** (0.0021)		0.0978 *** (0.0021)
Grade G	0.1038 *** (0.0044)		0.1014 *** (0.0043)	0.1023 *** (0.0044)		0.1003 *** (0.0043)
<i>h</i> (Funded Amount)		0.0032 *** (0.0005)	0.0054 *** (0.0005)		0.0012 ** (0.0005)	0.0041 *** (0.0005)
Credit Card				−0.0041 (0.0037)	−0.016 (0.0028)	−0.0065 * (0.0038)
Debt Consolidation				0.0003 (0.0037)	−0.0034 (0.0038)	−0.002 (0.0037)
Home Improvement				−0.0053 (0.0039)	−0.0079 * (0.0039)	−0.0071 * (0.0039)
House				0.0362 *** (0.0073)	0.0255 *** (0.0072)	0.0346 (0.0074)
Medical				−0.0398 *** (0.0046)	−0.0457 *** (0.0046)	−0.0401 *** (0.0047)
Moving				−0.0246 *** (0.0054)	−0.0345 *** (0.0053)	−0.0241 *** (0.0055)
Renewable Energy				−0.0019 (0.0151)	−0.0143 (0.0141)	−0.0016 (0.0154)
Small Business				0.013 *** (0.0053)	−0.0005 (0.0051)	0.0112 ** (0.0053)
Vacation				−0.0295 *** (0.0054)	−0.0361 *** (0.0054)	−0.0284 ** (0.0056)
Wedding				0.2924 *** (0.0169)	0.2719 *** (0.0168)	0.2942 *** (0.017)
Regions Control			YES	YES	YES	YES
Observations	816,274	816,274	816,274	816,274	816,274	816,274

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Entries in the Table 2 represent marginal coefficients. The sample is restricted to the issue year of the loan from year 2012 to 2015.

To support our argument regarding the limited sample of credit levels F and G, we use a two-sample *t* test for identifying the potential differences across individual credit level samples. Table 3 presents a closer inspection of the identification of the underlying differences in the group means of cognitive effort expenditures for the different credits. Regarding the fact that cognitive effort increases again with credit E, we need to identify it to determine if it is naturally different with grades F and G. From panel E to panel G, we can easily identify the difference between two chosen groups, as the insignificant *p* value suggests these two groups have different population means in terms of the cognitive effort expenditure. It can be argued that the unusual pattern of raising from level E to level G with an undetermined standard error range is due to the heterogeneous nature of the loans themselves, although we cannot identify the contributing factors in this case.

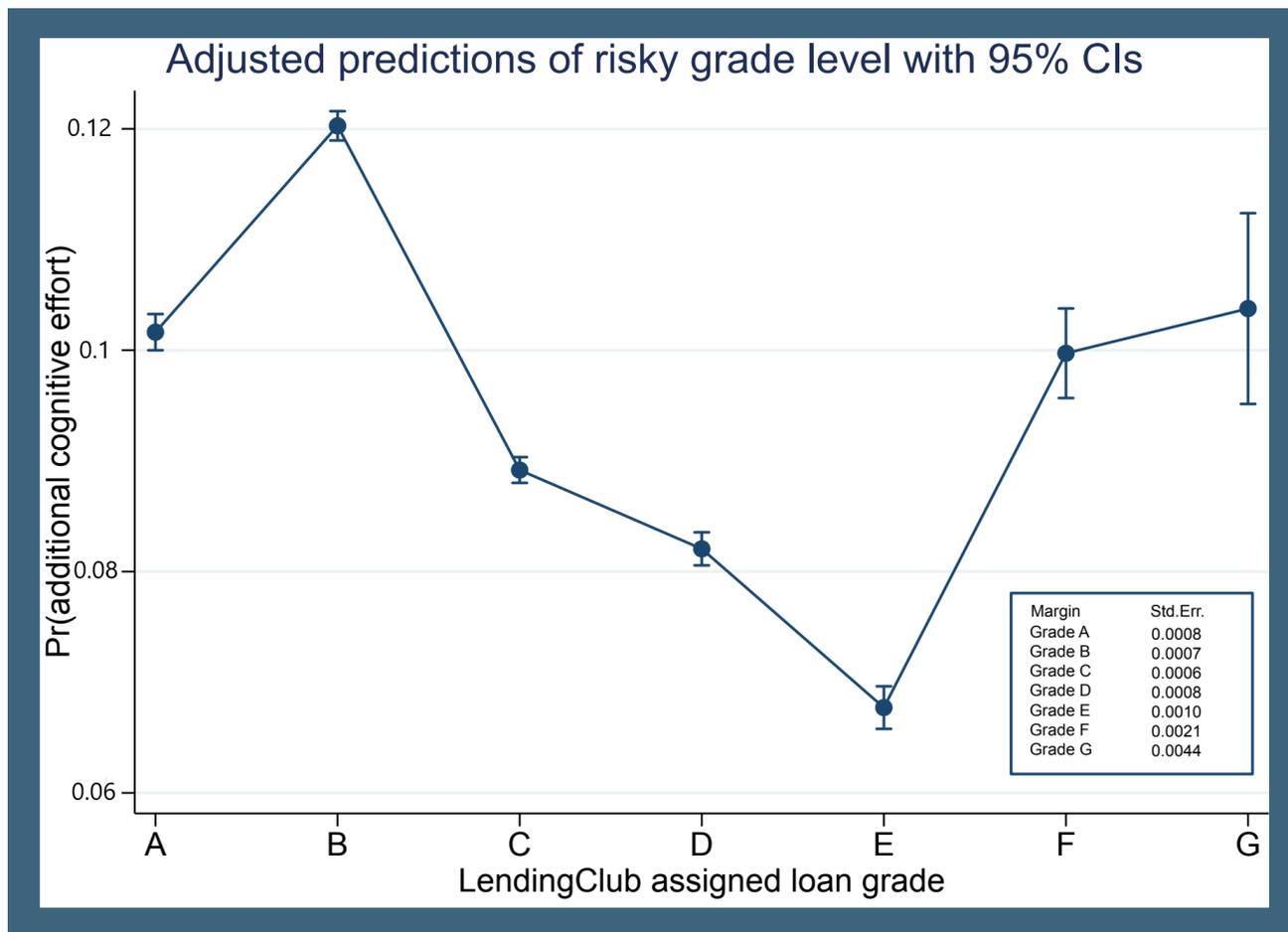


Figure 2. Marginal probability effect of different credit levels on the cognitive effort decision.

Table 3. Two-sample *t* tests for cognitive effort: across grade.

	Cognitive Effort Mean	Std. Err.	Observations	<i>p</i> Values
<i>Panel A: Grade A versus Grade B:</i>				
Grade A	0.1016	(0.0008)	131,387	0.000
Grade B	0.1202	(0.0007)	232,549	
<i>Panel B: Grade A versus Grade C:</i>				
Grade A	0.1016	(0.0008)	131,387	0.000
Grade C	0.0892	(0.0006)	231,107	
<i>Panel C: Grade A versus Grade D:</i>				
Grade A	0.1016	(0.0008)	131,387	0.000
Grade D	0.0821	(0.0008)	129,792	
<i>Panel D: Grade A versus Grade E:</i>				
Grade A	0.1016	(0.0008)	131,387	0.000
Grade E	0.0677	(0.001)	65,572	
<i>Panel E: Grade A versus Grade F:</i>				
Grade A	0.1016	(0.0008)	131,387	0.3948
Grade F	0.0997	(0.0021)	21,058	

Table 3. Cont.

	Cognitive Effort Mean	Std. Err.	Observations	<i>p</i> Values
<i>Panel F: Grade A versus Grade G:</i>				0.6308
Grade A	0.1016	(0.0008)	131,387	
Grade G	0.1038	(0.0044)	4809	
<i>Panel G: Grade F versus Grade G:</i>				0.4006
Grade F	0.0997	(0.0021)	232,549	
Grade G	0.1038	(0.0044)	4809	

4. Concluding Remarks

Policy discussion: Atkinson et al. (2000) [45] suggest ex ante solutions to information suppression mainly via promoting public awareness, i.e., providing independent advice to consumers, and educating consumers through mass media, schools and so on. Korobkin (2003) [46] also recommends ex ante intervention by legislatures, i.e., mandatory information disclosure rule. However, the ex ante mechanism is valid only if the regulator is able to require the loan borrower to disclose all information related to the application, which is very unlikely. One may consider the possibility of using catch-all clauses in the law. For example, the legislator can require the borrower to disclose all his credit history and to identify his current income or ongoing financial sources. However, catch-all clauses are always vague. For example, a borrower's referrer cannot fully guarantee that the information provided by the borrower is trustworthy. After more information is provided with respect to the resale of personal information, some information will be worth more than the loan-lending amount itself from a privacy protection perspective. Furthermore, how the borrower packages his loan-lending purpose is important. If a borrower misreports the actual purpose of the loan application, then in our model, this is purely information suppression. The cost of negotiation for the lender becomes the cost of identifying the authenticity of the application.

Some scholars suggest the ex post judicial mechanism, by using the unconscionability doctrine to interpret contracts, which refuses to enforce those contracts with unconscionable terms.²⁴ However, this doctrine as applied by common law courts is not defined by status and thus is too vague.

The theory in the future: Classical models of information economics such as signaling games and screening games treat the information asymmetry between two players as exogenous. The literature on information disclosure endogenizes information structures via strategic information transmission by the informed player, while the other literature on information acquisition studies how the uninformed party actively gathers information. While our paper combines information disclosure and information acquisition, our setup is still not general enough. In this regard, Pavan and Tirole (2022) [47] provide a unifying framework studying the interaction between players' stage-1 choice of information structure and the equilibrium in a stage-2 game. Both models of information acquisition and signal jamming belong to Pavan and Tirole's (2022) [47] cognitive games. While a player chooses to refine his own information in the former model, a player influences his opponent's information in the latter model. Naturally, this raises the question of how a player's information acquisition and the other player's signal-jamming interact with each other. As also indicated in the conclusion section in Pavan and Tirole (2022) [47] on the alleys for future research, multi-stage cognition deserves the attention for the follow-up investigations. In our context, we study the lender's pre-lending cognition in stage 3 against the borrower's strategic information suppression in stage 2. For future research, one may consider the role of post-lending cognition that may potentially influence two

players' long-term relationship. Thus, a variety of applications in economics and finance with multi-stage cognition leave us a rich agenda for future studies.

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Appendix A

Appendix A.1. Equilibrium Loan Amount p When $t < h$

At stage 4, when type- A' borrower tells the lender A' or the lender finds that A' is appropriate by deliberation, the lender optimally demands A' . Sequential rationality implies that the borrower accepts the contract if and only if $p \geq 0$, and the optimal loan amount proposed by the lender is $p = 0$.

When the borrower says A is appropriate and the lender finds nothing after deliberation, the optimal loan amount remains $p = 0$. To show this point, let

$$\hat{\rho} \equiv \frac{\rho q(1-b)}{1-\rho+\rho q(1-b)}$$

be the posterior probability of information suppression from the lender's view given that the lender finds nothing after deliberation and the lender believes that type- A' borrower's probability of information suppression is q according to Bayesian rule.

Suppose that the lender proposes the loan amount equal to $p \geq 0$. Then, both types of borrowers accept it. The lender therefore receives her expected payoff

$$U_1 \equiv (1-\hat{\rho})(v-p) + \hat{\rho}(v-h+t-p) - C(b).$$

The lender's best proposal is $p = 0$ given that $p \geq 0$.

Suppose that the lender proposes loan amount $p \in [t-h, 0)$. Then, type- A borrower will reject it. The lender receives her expected payoff

$$U_2 \equiv \hat{\rho}(v-h+t-p) - C(b).$$

The lender's best proposal is $p = t-h$ given that $p \geq t-h$.

If $p < t-h$, both types of borrowers reject it. Thus, the lender receives payoff $-C(b)$.

Assumption 1 implies

$$(1-\rho)v - \rho(h-t) > 0$$

that also implies

$$(1-\hat{\rho})v - \hat{\rho}(h-t) > 0, \tag{A1}$$

since $\hat{\rho} < \rho$ holds for all $b > 0$ and q .

Equation (A1) is equivalent to $U_1 > U_2$. Hence, $p = 0$ is better than $p = t-h$ for the lender. Intuitively, after the lender exerts deliberation efforts and finds nothing, type- A' borrower *may* not suppress with probability one, and the lender believes that information suppression is less likely to occur and is more willing to contract with both types of borrowers.

Moreover, Assumption 1 also implies that the loan amount $p < t-h$ is never optimal, as $v > 0$. For the lender, contracting with both types of borrowers is also better than her outside option, since there is a positive gain from investment.

Furthermore, Appendix A.2 shows that if Assumption 1 holds, $p = 0$ without delay is also the equilibrium outcome in a general bargaining game where the lender makes all

the offers in an infinite-horizon setting in which delay can work as a screening device for the lender.

Appendix A.2. An Infinite-Horizon Bargaining Game Where the Lender Makes All the Offers

In this section, we show that $p = 0$ without delay is also the equilibrium outcome in a more general bargaining setting. We consider here a general bargaining protocol where the lender makes all the offers in an infinite-horizon bargaining game. The lender here can use delay as a screening device to separate the borrower's types.

The lender's final equilibrium offer must be $p_0 = 0$ where the subscript 0 denotes the last period, because any lower offer would not be accepted by type-A borrower, whereas any higher offer would be accepted and therefore dominated. We suppose now that there are $n (\geq 0)$ periods that remain before the last period with $p_0 = 0$ in equilibrium. In order to minimize information rent for type-A' borrower, type-A' borrower should be indifferent between accepting the current offer p_n and waiting n more periods to receive p_0 , i.e.,

$$h - t + p_n = \delta^n (h - t + p_0)$$

where δ is the discount factor. Hence, the lender optimally chooses $p_n = (\delta^n - 1)(h - t)$ in the current period. The lender's expected payoff is therefore

$$\begin{aligned} & (1 - \hat{\rho})\delta^n (v - p_0) + \hat{\rho}(v - h + t - p_n) - C(b) \\ & = (1 - \hat{\rho})\delta^n v + \hat{\rho}[v - \delta^n (h - t)] - C(b). \end{aligned}$$

It is left to determine the optimal periods of delay n . Assumption 1 implies

$$(1 - \rho)v > \rho(h - t)$$

that also implies

$$(1 - \hat{\rho})v > \hat{\rho}(h - t),$$

or equivalently

$$(1 - \delta^n)(1 - \hat{\rho})v > (1 - \delta^n)\hat{\rho}(h - t) \text{ for all } n > 0,$$

or, after some manipulations,

$$(1 - \hat{\rho})v + \hat{\rho}(v - (h - t)) - C(b) > (1 - \hat{\rho})\delta^n v + \hat{\rho}[v - \delta^n (h - t)] - C(b) \text{ for all } n > 0.$$

Hence, $n = 0$ is optimal for the lender. That is, the lender optimally chooses $p_0 = 0$ in the first period, which leads to pooling equilibrium.²⁵

Appendix A.3. Multiple Lenders in the Pooling Equilibrium

We assume two lenders (B_1 and B_2). For the expositional purpose, we focus on the pooling equilibrium.

Given lender 2's deliberation level b_2 , lender 1 chooses b_1 to maximize

$$\begin{aligned} & (1 - \rho)v + \rho(b_1 b_2 + b_1(1 - b_2) + (1 - b_1)b_2) \left(v + \frac{t}{2} \right) \\ & + \rho(1 - b_1)(1 - b_2) \left(v - h + \frac{t}{2} \right) - C(b_1). \end{aligned}$$

Here, t is the maximal transfer from the borrower. When information suppression is detected, the monetary punishment for the borrower is returned to the society. Thus, each lender shares half of the transfer.

Since the problem is symmetric for lender 2, the equilibrium deliberation levels of two lenders are $b_1 = b_2 = b^*$ such that

$$(1 - b^*)\rho h = C'(b^*).$$

Thus, the equilibrium deliberation level in the pooling equilibrium is lower compared to the single-lender case, as each lender can free ride the other lender's deliberation. However, because there are two lenders here, it is still ambiguous whether the total transaction cost is lower or not.

Now we consider the possibility of collusion between one lender and the borrower. When one lender finds information suppression and the other does not, the informed lender can be silent on it and can ask the borrower for a secrete transfer up to t . Thus, the unique informed lender has to be rewarded by the total transfer in a collusion-proof equilibrium.

Therefore, lender 1 chooses b_1 to maximize

$$(1 - \rho)v + \rho b_1 b_2 \left(v + \frac{t}{2} \right) + \rho b_1 (1 - b_2)(v + t) + \rho(1 - b_1)b_2 v + \rho(1 - b_1)(1 - b_2) \left(v - h + \frac{t}{2} \right) - C(b_1).$$

The equilibrium deliberation levels of two lenders are $b_1 = b_2 = b^{**}$ such that

$$(1 - b^{**})\rho h + \frac{\rho t}{2} = C'(b^{**}).$$

Each lender is therefore incentivized to choose a higher deliberation level b^{**} compared to the equilibrium deliberation level in the collusion-free case.

Note that it is ambiguous whether each lender's deliberation in the collusion-proof equilibrium is higher or lower than that in the pooling equilibrium in the single-lender case. The lender is more likely to choose a higher deliberation level in the two-lender case if the problem of collusion dominates the free riding problem, i.e., t is relatively high.

Appendix A.4. The Case Where Assumption 1 Fails

When Assumption 1 fails, the lender contemplates three alternatives.

First, the lender exerts b^* and contracts with both types of borrowers. The result is described in Proposition 1.

Second, the lender exerts b' and contracts with only type- A' borrower. Under this plan, the lender proposes $p = h - t$ and therefore solves the following problem upon observing A :

$$\max_b \frac{(1 - \rho)0 + \rho q b(v + t) + \rho q(1 - b)v}{1 - \rho + \rho q} - C(b).$$

Compared to the first plan, the lender loses investment amount v from contracting with type- A borrower, but gains additional rent $h - t$ from type- A' borrower in the case where information suppression is not detected. Since the loan amount $h - t$ is so low that it is common knowledge that the trade occurs only if A is not appropriate, there is no transfer ex post in this case.

The optimal deliberation level b' is characterized by

$$C'(b') = \frac{\rho q t}{1 - \rho + \rho q}. \tag{A2}$$

Suppose that the second plan is strictly better than the first one for the lender, which is possible only for a positive q . Equation (A2) implies that b' is also positive. However, because type- A' borrower's expected net payoff from information suppression is

$$(1 - b')0 + b'(-t) < 0$$

for any $b' > 0$, type- A' borrower's optimal q is zero, a contradiction.

Hence, there is no equilibrium in which the lender strictly prefers the second plan.

Third, the lender may exert some deliberation effort and contracts with no borrowers. Under this plan, the lender proposes any loan amount $p > h - t$ and therefore solves the following problem upon observing A :

$$\max_b \frac{(1 - \rho)0 + \rho qb(v + t) + \rho q(1 - b)0}{1 - \rho + \rho q} - C(b).$$

Along similar lines of the arguments in the second plan, there is no equilibrium in which the lender strictly prefers the third plan.

Appendix A.5. Proof of Proposition 2

When $\rho h \leq C'(1 - t/h)$, there is a pooling equilibrium; thus, $q = 1$. The transaction cost is therefore $L = C(b)$. By (1), we have that

$$\frac{dL}{d\rho} > 0, \quad \frac{dL}{dh} > 0, \quad \text{and} \quad \frac{dL}{dt} = 0.$$

When $\rho h > C'(1 - t/h)$, there is a semi-separating equilibrium. First, we show $dL/d\rho < 0$. To see this, by Equation (5), we have $dC(b)/d\rho = 0$. Thus,

$$\frac{dL}{d\rho} = C(b) \frac{d(1 - \rho(1 - q))}{d\rho}.$$

Equation (6) implies

$$\frac{d\rho q}{d\rho} = \frac{d\left(\frac{(1-\rho)C'(1-\frac{t}{h})}{h-C'(1-\frac{t}{h})}\right)}{d\rho} = -\frac{C'(1-\frac{t}{h})}{h-C'(1-\frac{t}{h})}.$$

Since $h - C'(1 - t/h) > 0$ (otherwise, $q < 0$ by Equation (6)), we have $d(\rho q)/d\rho < 0$. Furthermore, we have

$$\frac{d(1 - \rho(1 - q))}{d\rho} = -1 + \frac{d\rho q}{d\rho} < 0.$$

We therefore obtain $dL/d\rho < 0$. Second, we judge the sign of dL/dh . By definition,

$$\frac{dL}{dh} = (1 - \rho(1 - q))C'(b) \frac{db}{dh} + C(b) \frac{d(1 - \rho(1 - q))}{dh}.$$

Equations (5) and (6) imply

$$\begin{aligned} \frac{dL}{dh} &= (1 - \rho(1 - q^*))C'(b^*) \frac{t}{h^2} + C(b^*)(1 - \rho) \frac{tC''(b^*) - hC'(b^*)}{h(h - C'(b^*))^2} \\ &= \frac{1 - \rho}{h(C'(b^*) - h)^2} [tC'(b^*)(h - C'(b^*)) + C(b^*)(tC''(b^*) - hC'(b^*))] \end{aligned}$$

of which the sign is ambiguous. If $tC''(b^*)$ is sufficiently low compared to $hC'(b^*)$, we have $dL/dh < 0$, although we have $h - C'(b^*) > 0$ here. Otherwise, we have $dL/dh > 0$. Lastly, we show $dL/dt < 0$. To show this, we first have

$$\frac{dL}{dt} = (1 - \rho(1 - q))C'(b) \frac{db}{dt} + C(b) \frac{d(1 - \rho(1 - q))}{dt}.$$

By Equations (5) and (6), we have

$$\frac{dL}{dt} = -\frac{(1 - \rho(1 - q^*))C'(b^*)}{h} - \frac{C(b^*)(1 - \rho)C''(b^*)}{h(h - C'(b^*))^2} < 0.$$

Notes

- 1 Since 2013, the Financial Conduct Authority, taking over the responsibility of the Financial Services Authority, has created an alternative regulatory framework for both retail and wholesale financial services.
- 2 See *Informed decisions? How consumers use Key Features: a synthesis of research on the use of product information at the point of sale*, Financial Services Authority, November 2000.
- 3 See the article “Troubled Securities in Asia” in *The Economist*, 20 November 2008.
- 4 See the full story of Fanya: <http://www.metalbulletin.com/fanya>, accessed on 16 September 2022.
- 5 See <http://letscrowdsmarter.com/ezubao-scam/>, accessed on 16 September 2022.
- 6 See <https://www.scmp.com/economy/china-economy/article/3115580/chinas-p2p-purge-leaves-millions-victims-out-cold-losses>, accessed on 16 September 2022.
- 7 Benabou and Tirole [7] investigate how memory bias in equilibrium depends on the individual’s degree of present bias, while Tirole [8] studies how contractual incompleteness in equilibrium depends on parties’ cognitive capacity, time preference, the extent of hold-up problem, and bargaining power. Although two papers appear to be in different fields, regarding the approach, the former focuses on how one party influences the information structure of the other party, whereas the latter sheds light on how one party refines his own information structure. In our paper, we combine both issues in one model, and study how one party’s signal-jamming interacts with the other party’s information acquisition.
- 8 See also the emerging literature of delegation with unawareness of contingencies and actions (e.g., Auster and Pavoni [32,33] and Lei and Zhao [34]).
- 9 The information advantage for borrowers is common in situations where borrowers understand their financial situation, loan purpose and repayment ability, and thus gain a detailed understanding of the appropriateness of the application.
- 10 Here, type- A borrower as a “good-type” agent has no signaling device at all.
- 11 This feature qualitatively differentiates our paper from Benabou and Tirole [7] in which the uninformed party’s information acquisition is absent.
- 12 If the borrower has the full bargaining power, there is no pure-strategy cognition in equilibrium. In addition, similar to footnote 13 in Tirole [8], since the lender exerts the cognitive efforts before contracting, off the equilibrium path, if the lender exerts less cognitive efforts the lender will reject the contract proposed by the borrower. Thus the payoff function of the lender is not smooth at the optimal cognitive level in the hypothetical equilibrium. Moreover, an arbitrary balance of bargaining power in Tirole still involves bargaining with symmetric information, whereas our model would incorporate both signaling and screening, and bargaining with asymmetric information is thereby beyond the scope of this paper, as a technical reason.
- 13 Of course, after the borrower reveals A' , the cost of understanding A' for the lender is not zero in reality. However, it should be much lower than the cost of learning A' by the lender alone. Thus, without loss of generality, we normalize the cost of understanding A' to zero. Further, the borrower may manipulate the understanding cost for the lender, i.e., by disclosing the eye-opening information only by lender’s request. In this case, we would rather interpret the borrower’s behavior as strategic information suppression (announcing A).
- 14 Besides the fine from the regulator, it is also natural to assume that the lender can sue the borrower and receive an additional transfer of T after the rest of the funded amounts turn out to be an uncollectible debt. Thus, the total penalty from information suppression is $T + t$ if the lender can provide the default notice. However, assuming a difference of the punishment amounts for uncollectible debt does not change our results qualitatively. Thus, for simplicity, we let $T = 0$.
- 15 We consider the case of multiple lenders in Appendix A.3 where an individual lender’s cognition may be reduced as a free-riding result.
- 16 The lender may consider the commitment of a fund-amount depending on the borrower’s announcement. However, since both the lender’s surprise and loss from A' are not contractible, we rule out the possibility of a contingent loan amount.
- 17 In Appendix A.4, we show that if this assumption fails, there is even no equilibrium in which the lender strictly prefers to contracting with only type- A' borrower or proposing nothing.
- 18 The negative result is akin to the Grossman-Stiglitz paradox, which says that there is no pure-strategy equilibrium of loan amount when acquiring quality-information is costly for consumers in the market (see Grossmann and Stiglitz, 1980) [42].
- 19 Pooling equilibrium occurs if and only if

$$(1 - b^*)(h - t) + b^*(-t) \geq 0$$

where b^* is characterized by Equation (1), which is equivalent to

$$b^* \leq 1 - \frac{t}{h}.$$

By strict convexity of $C(\cdot)$, it is also equivalent to

$$C'(b^*) \leq C'(1 - \frac{t}{h}),$$

which is nothing but

$$\rho h \leq C'(1 - \frac{t}{h}).$$

- 20 The feature of semi-separating equilibrium smacks of an inspection game. The lender is the counterpart of an inspector, and the borrower is the counterpart of an inspectee [43]. Nevertheless, they have some substantial differences. First, in our model, there are heterogeneous borrowers, and it is impossible for type-A borrower to suppress information. Hence, when the fraction of type-A borrower, namely $1 - \rho$, is high, there exists a pure-strategy equilibrium that is a pooling one. Second, there are two types of errors for the inspector in the statistical parlance. However, our model excludes the lender's type I error, since describing A' implies that A' is appropriate.
- 21 Alternatively, we can reinterpret diversely unaware lenders as heterogeneous cognitive cost functions. One is $C_1 = C$ as before. The other is C_2 such that $C_2(0) = 0$ and $C_2(b) = \bar{C}$ for $b > 0$ where \bar{C} is a sufficiently large constant. The lender with the later function will never think and always contracts with the borrower as long as Assumption 1 is satisfied. Hence, there is no behavioral difference between these two interpretations, although the beliefs of the lenders in two interpretations are different. Thus, we can model completely unaware lenders "as-if" their cognitive costs are significantly high (see, e.g., Friedman (1953) [44] for the "as-if" justification).
- 22 It is worth mentioning that the results in Proposition 2 are robust to the more general case with a direct dead-weight loss of information suppression Δ . To see it, let the transaction cost be $L = (1 - \rho(1 - q))C(b) + \rho q \Delta$ where $\rho q \Delta$ is the expected welfare loss from information suppression. It is straightforward to see that $dL/d\rho > 0$, $dL/dh > 0$ and $dL/dt = 0$ in the pooling equilibrium. In the semi-separating equilibrium, since ρq is lower for a higher ρ as shown in Appendix A.5, we still have that $dL/d\rho < 0$. Further, the sign of dL/dh is ambiguous as well. Lastly, q is decreasing in t , so $dL/dt < 0$ remains.
- 23 Data Availability Statement: A publicly available dataset was analyzed in this study. This dataset can be found here: <https://doi.org/10.17632/wb3ndt69gf.3> (accessed on 16 September 2022).
- 24 See Korobkin (2003) [46] and Becher (2008).
- 25 Note that the pooling result $p_0 = 0$ is renegotiation-proof.

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