Multidimensional Heterogeneity and the Nature of Advantageous Selection in the Consumer Credit Market

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Abstract

This paper presents a novel mechanism of advantageous selection in the highly concentrated consumer credit market of South Korea. Advantageous selection is explained by combination of two components: consumers' unobserved heterogeneity in consumption smoothing motives and banks' sufficient market power. On the demand side, consumers who have stronger consumption smoothing motives are willing to pay higher interest rates to smooth consumption. At the same time, they exert more effort to prevent default since their opportunity cost of being excluded from the credit market is higher. On the supply side, sufficient market power allows banks to charge higher interest rates to the borrowers who are willing to pay more for consumption smoothing. Using a theoretical model, I prove that advantageous selection may occur only when banks have market power. Then, I show that empirical relationships between a proxy for consumption smoothing motives, loan choices, and default risks appear consistent with the mechanism involving heterogeneous consumption smoothing motives. Furthermore, by exploiting special dynamic features of loan contracts and related panel data on delinquencies, I separately identify moral hazard from adverse selection. I find a strong endogenous relationship between moral hazard and consumption smoothing motives: consumers who have stronger consumption smoothing motives exert more effort to prevent default.

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Keyworkds: Asymmetric Information, Credit Market, Multidimensional Heterogeneity, Consumption Smoothing, Default

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1 Introduction

When consumers choose a loan from a menu where interest rates are paired with collateral requirements in credit markets, existing theories predict that low risk borrowers will be more willing to accept high collateral requirements for a reduction in interest rates, compared to high risk borrowers (Bester (1985), Bester (1987), Besanko and Thakor (1987a), Besanko and Thakor (1987b), Chan and Thakor (1987), Boot, Thakor, and Udell (1991)). Hence when consumers' default risk is private information, these theories predict a positive empirical correlation between a loan interest rate and default probability, conditional on all the observable factors used for pricing the loans.

However, analyzing South Korean consumer credit market data, I find that consumers who choose a loan with a high interest rate paired with a low collateral requirement are less likely to default than those who choose a loan with a low interest rate paired with a high collateral requirement. That is, I find evidence of ***advantageous selection in the consumer credit market***, a negative correlation between a loan interest rate and default probability. On the contrary, looking at the corporate loan data, I do not find any conspicuous evidence of asymmetric information between firms and the bank.

One notable difference between the consumer loan market and the corporate loan market in South Korea is the degree of market concentration. After the 1997 Asian financial crisis, the Korean credit market underwent a huge consolidation initiated by the governmental authority. This resulted in the consumer loan market that is much more highly concentrated than the moderately concentrated corporate loan market. The highly concentrated consumer loan market may serve as an environment in which an additional dimension of unobserved heterogeneity may cause non-classical results, as previously suggested by Chiappori, Jullien, Salanié, and Salanié (2006) in the insurance market setting.

In this paper, I highlight one important source of the advantageous selection in the non-competitive consumer credit market, namely ***unobserved heterogeneity in consumption smoothing motives***, and explore its mechanism. I first argue that consumption smoothing motive is an important dimension of unobserved heterogeneity among consumers. My arguments are motivated by some specific characteristics of the South Korean consumer credit market as well as general theoretical considerations.

Consumers may use credit markets to smooth their inter-temporal consumption by translating their consumption from periods of low marginal utility to periods of high marginal utility. In addition, the consumption smoothing motives may be heterogeneous, as represented by the different curvatures of their utility functions. This heterogeneity may be in general difficult to observe for banks, and is certainly not a part of the factors used for loan pricing in this market.[1]

The unobserved heterogeneity in consumption smoothing motives matters when consumers

[1] Jullien, Salanié, and Salanié (2007) characterize the optimal menu of contracts when the agent's risk-aversion is his private information and point out that it is difficult for principal to precisely observe agent's risk-aversion.

choose their loan terms. After classifying consumers based on their observable risk factors, a bank suggests a menu of contracts composed of pairs of an interest rate and a collateral requirement, where the loan interest rate is decreasing in the value of pledged collateral.[2] Consumers who have stronger consumption smoothing motives will tend to choose a high interest loan with a low collateral requirement. This is because their willingness to pay interest costs to reduce the collateral requirement by one unit is higher than the willingness of those who are less motivated to smooth consumption. Consumers may face some risk of defaulting against their will, in which case they would lose their pledged collateral, potentially resulting in severe changes in their consumption path. Hence those who derive larger disutility from a volatile consumption path will be more willing to bear large interest costs instead of pledging high levels of collateral.

Furthermore, the unobserved heterogeneity in consumption smoothing motives can generate differential incentives to prevent default. Given that consumers rely on the credit market for consumption smoothing, their opportunity cost of being excluded from the credit market increases with their consumption smoothing motives. Hence, if default leads to exclusion from the credit market, consumers who are strongly motivated to smooth consumption will exert more effort to avoid default. In other words, those who enjoy greater utility gain from consumption smoothing suffer more from losing access to the consumer credit market, and thus face a stronger incentive to avoid default by honoring existing debts. These relationships between the unobserved heterogeneity in consumption smoothing motives, loan choices, and default risks can drive advantageous selection in the non-competitive consumer credit market (Figure C.1 in the appendix visualize the intuition.).

Importantly, the non-competitiveness of the credit market is required for the above relationships to generate advantageous selection. In the competitive market, a bank has to charge higher interest rates to the riskier borrowers.[3] Otherwise, it will be profitable for other banks to skim the cream off the lower risk borrows by offering a marginally lower rate. On the other hand, under imperfect competition, hidden information on consumption smoothing motives matters, since a bank is able to charge a higher interest rate to the borrowers who are willing to pay to smooth consumption. I formalize this idea in my model, proving that unobserved heterogeneity in consumption smoothing motives cannot cause a negative correlation between a loan interest rate and default probability if the market is competitive and that it may cause a negative correlation only when a bank has market power.

I use a unique dataset from a major South Korean bank to show that the heterogeneity in consumption smoothing motives is a critical driver of the advantageous selection. The dataset includes information not only on the loans from the bank, but also on savings account balances

[2] It is because the recovery, which is a portion of money recovered by the banks when default occurs, increases with the value of pledged collateral. More details will be provided in chapter 4.

[3] In the competitive market, the value of hidden information on consumption smoothing motives is ***private***, in the sense that it has no impact on banks' profit.

and history of credit card consumption for each consumer. One notable piece of information is the use of installment plans. This special credit card feature that is widely available in South Korea allows consumers to split the price of a good and repay over a number of months with some interest costs. One can freely choose whether to exercise this option or not when making the initial purchase of each good with her credit card. Essentially, it is a short-term loan that provides an additional way to smooth consumption but with a high interest rate. Due to the high interest rate, only the consumers who have strong consumption smoothing motives will use the option.

Using this data, I construct a proxy for consumption smoothing motives. I categorize a group of consumers who have zero or small balance in their savings account, upward savings trend or increasing income path, have borrowing constraints, and have large amounts of debt in installment plans as those who are strongly motivated to smooth consumption. I provide theoretical proofs for the validity of this proxy. Then, I explicitly test that the consumers who have stronger consumption smoothing motives tend to choose a credit loan that does not require any collateral but instead imposes a high interest rate. At the same time, I show that those consumers tend to default less, thereby explaining the negative correlation between a loan interest rate and default probability.

I then explore the mechanisms of this relationship by examining different sub-groups. Advantageous selection appears to be more conspicuous among repeated borrowers than first-time borrowers. One possible explanation is that the bank may have better information on unobserved default risk for the repeated borrowers, allowing it to concentrate on exploiting market power to charge a higher interest rate to those consumers who are more willing to pay to smooth consumption, resulting in stronger patterns of advantageous selection among repeated borrowers.

No clear relationship between an interest rate and default probability for the first-time borrowers does not necessarily imply the lack of asymmetric information between those borrowers and the bank. For the first-time borrowers, there is bi-dimensional private information: one on consumption smoothing motives, and the other on default risks.[4] Under this bi-dimensional private information, two types of consumers choose a credit loan that charges a higher interest rate instead of requiring any collateral: borrowers who have unobservably stronger consumption smoothing motives and those who have unobservably higher default risks. The first type of borrowers is less risky, while the second type of borrowers is, of course, riskier than the bank predicts. Consistent with this idea, I show that consumers who have stronger consumption smoothing motives among the first-time borrowers still tend to choose a credit loan and are less likely to default. This relationship alone would generate a negative correlation between a loan interest rate and default probability. However, I find that the education level, which is also an unpriced characteristic, generates a positive correlation between a loan interest rate and default probability. Hence, private

[4] Finkelstein and McGarry (2006) show that riskier people buy more insurance but people who have strong taste for insurance, who are relatively less risky, also buy insurance, resulting in absence of a positive correlation between insurance coverage and risk occurrence.

information on these factors can lead to the disappearance of significant asymmetric information in the market.[5]

In the last part of the paper, I conduct a deeper investigation into the moral hazard aspect of the relationship between consumption smoothing motives and default risk. My theoretical model predicts that consumers who are strongly motivated to smooth consumption exert more effort to prevent default since their opportunity cost of default is higher. However, in the earlier parts of the paper, I only provide correlational evidence that those consumers are less likely to default by establishing a negative empirical association between consumption smoothing motives and default probability.

There are two possible hypotheses regarding this association. First hypothesis is bi-dimensional self-selection; consumers differ in two characteristics, consumption smoothing motives and default risk, and they exogenously negatively associated. Second hypothesis, which I support, is that there exists moral hazard as well as uni-dimensional self-selection; consumers who have stronger consumption smoothing motives choose loans with higher interest rates, and they also face higher incentives to prevent default due to the same concerns about consumption smoothing. These consumers exert more effort to avoid default, generating an ***endogenous negative association*** between consumption smoothing motives and default risk.

Distinguishing these two possible hypotheses has important policy implications. For example, pure adverse selection problems can be solved by loan guarantees and improved screening processes. On the other hand, if there exists moral hazard, policymakers and the bank should consider legal reforms regarding limited access to effective recourse and should consider improving dynamic contracting schemes to fully account for the incentives to default.

To empirically support the second hypothesis, I separately identify moral hazard from adverse selection by using panel data on delinquencies. Notably, I exploit the dynamic features of the loan contracts under which these delinquencies occur. The loan contracts have a convex penalty scheme in which the penalty increases as the number and/or duration of past delinquencies increases. That is, every increase in either the number or the duration of past delinquent spells contributes to an even higher marginal cost of a future delinquency. This provides additional incentive for a delinquent borrower to prevent future delinquencies. If I find evidence that borrowers react to these changes in incentives, it indicates the existence of moral hazard.

Econometrically, finding such evidence involves identifying the patterns of ***negative occurrence dependence*** and ***negative lagged duration dependence*** in the data. Negative occurrence dependence is defined as having a larger number of previous delinquent spells reduces the probability that a borrower will become or remain delinquent. Similarly, negative lagged duration dependence is defined as having longer duration of previous delinquent spells reduces the prob-

[5]This does not imply that this equilibrium is efficient as the first best allocation. In this equilibrium, both unobservably high risk borrowers and borrowers who are less risky but with stronger consumption smoothing motives pay the same interest rate. It implies that at least one group does not pay a fair price.

ability that a borrower becomes or remain delinquent.[6] Since, under the convex penalty scheme, the marginal cost of future delinquency increases with the number and/or duration of past delinquent spells, the behaviors of a rational borrower would exhibit negative occurrence dependence and negative lagged duration dependence.

I first employ the nonparametric tests developed by Abbring, Chiappori, and Pinquet (2003) to identify negative occurrence dependence. Then, I employ the parametric approach by Doiron and Gørgens (2008) to identify both negative occurrence dependence and negative lagged duration dependence. The results of nonparametric tests show that there is negative occurrence dependence and it is more pronounced among borrowers who have stronger consumption smoothing motives. In addition, the parametric estimation indicates that both negative occurrence dependence and negative lagged duration dependence are more pronounced for the consumers who have stronger consumption smoothing motives, implying that those consumers exert more effort to prevent default.

To the best of my knowledge, this is the first paper that presents and investigates a source of advantageous selection in the consumer credit market.[7] Building on the ideas of Finkelstein and McGarry (2006) and Fang, Keane, and Silverman (2008) who introduce multidimensional heterogeneity to explain advantageous selection in the insurance markets, I propose that unobserved heterogeneity in consumption smoothing motives is a source of advantageous selection in the consumer credit market. Unlike the previous works, by separately identifying moral hazard from adverse selection, I also examine the endogenous link between bi-dimensional unobserved heterogeneity: endogenous association between consumption smoothing motives and default risks.

It is well known that separately identifying moral hazard and adverse selection in the static setting, using cross-sectional data, is difficult. Several papers successfully separate them out based on some large-scale randomized experiments or by exploiting institutional features that move borrowers across contracts without directly affecting their behavior. Ausubel (1999), Karlan and Zinman (2009) and Agarwal, Chomsisengphet, and Liu (2010) use large-scale randomized experiments while Adams, Einav, and Levin (2009) and Dobbie and Skiba (2013) exploit regulatory and institutional features to separately identify moral hazard and adverse selection.

Abbring, Chiappori, and Pinquet (2003) develop nonparametric tests to separately identify moral hazard from asymmetric information in dynamic settings with panel data. They exploit dynamic contract features, accident histories, and shocks to discounted marginal cost of future accidents to identify moral hazard in the French car insurance market. This approach has been

[6] These definitions follow Heckman and Borjas (1980).

[7] Davidoff and Welke (2004) find advantageous selection in the U.S. reverse mortgage market. They argue that this advantageous selection might have come from heterogeneity in risk aversion without presenting empirical evidence that risk aversion is the source of the advantageous selection. Unlike Davidoff and Welke (2004), I introduce unobserved heterogeneity in consumption smoothing motives as a source of advantageous selection and present direct empirical evidence that the unobserved heterogeneity in consumption smoothing motives does cause advantageous selection in the highly concentrated consumer credit market.

extended by Abbring, Chiappori, and Zavadil (2008) and Dionne, Pinquet, Maurice, and Vanasse (2010). Similarly, I exploit the dynamic contract features of the loan delinquency data and employ both parametric and nonparametric test to identify moral hazard.

I also contribute to the growing empirical literature on detecting asymmetric information in insurance markets and credit markets. Several papers empirically test for existence of asymmetric information in insurance markets. The empirical results of the tests are quite mixed. Puelz and Snow (1994), Finkelstein and Poterba (2004), Cohen (2005), and He (2009) find evidence of asymmetric information in their markets, while Cawley and Philipson (1999), Chiappori and Salanié (2000)[8], and Cardon and Hendel (2001) do not find any evidence of asymmetric information.

In terms of asymmetric information in credit markets, in addition to the papers I already cited before (Ausubel (1999), Karlan and Zinman (2009), Agarwal, Chomsisengphet, and Liu (2010), Adams, Einav, and Levin (2009), Dobbie and Skiba (2013)), Davidoff and Welke (2004) find advantageous selection in the U.S. reverse mortgage market. Agarwal, Chomsisengphet, and Liu (2016) find that less credit-worthy applicants are more likely to select credit contracts with a lower collateral requirement and a higher interest rate in the home equity loan market. Edelberg (2004) finds robust evidence of adverse selection when high risk borrowers pledge less collateral and pay higher interest rates, even after controlling for income levels, loan size, and risk aversion, and evidence of moral hazard.

The remainder of the paper is structured as follows. Chapter 2 provides the theoretical foundation showing that advantageous selection cannot occur unless banks have market power. Chapter 3 describes the data. Chapter 4 provides empirical evidence of advantageous selection in the Korean consumer credit market and discuss the relevant features of the market. Chapter 5 shows that moral hazard and consumption smoothing motives have a strong relationship. Chapter 6 concludes. The appendix provides additional details and theoretical proofs.

2 Theoretical Foundation

In this chapter, I lay a theoretical foundation of advantageous selection. From a theoretical point of view, I introduce inter-temporal elasticity of substitution (IES) and use it as a shortcut to represent heterogenous consumption smoothing motives.[9] Consumers with low IES have stronger consumption smoothing motives than consumers with high IES.[10] In turn, it implies that con-

[8]In this paper, they also develop a general "positive correlation test" to check for the presence of asymmetric information in a contractual relationship within a competitive market

[9]I use this shortcut only for theoretical proofs. Consumption smoothing motive is a more general concept than the one as represented by inter-temporal elasticity of substitution.

[10]Several pieces of literature deal with heterogeneous IES. Blundell, Browning, and Meghir (1994) and Attanasio and Browning (1995) suggest that rich households tend to show larger IES. Also Mankiw and Zeldes (1991) and Vissing-Jørgensen (2002) find larger IES for stockholders than for non-stockholders. Bayoumi (1993) and Wirjanto (1995) indicate that liquidity constrained households show smaller IES.

sumers with low IES tend to choose a high interest rate loan paired with a low collateral requirement, and at the same time those consumers are less likely to default.

In the following theoretical work, I show that the opportunity cost of being excluded from the credit market is higher for the consumers with lower IES, i.e. the consumers who have stronger consumption smoothing motives, using a simple two period model. And then, more importantly, I show that unobserved heterogeneity in consumption smoothing motives may generate advantageous selection only when the bank has market power.

2.1 Definition of IES and Heterogeneous Opportunity Cost of Default

Inter-temporal Elasticity of Substitution measures consumers' willingness to substitute consumption between time periods in response to changes in the expected real interest rate. If the real rate rises, current consumption may decrease due to increased return on savings. At the same time, current consumption may also increase as the consumer decides to consume more immediately, as she feels richer. The net effect on current consumption is the inter-temporal elasticity of substitution.[11]

2.1.1 Definition and Implication of IES

Mathematically, inter-temporal elasticity of substitution (IES) equals the minus of the inverse of the elasticity of the marginal utility: IES = $-\frac{d\log(c_t)}{d\log(u'(c_t))}$, where c_t is the consumption in period t. This is general, in that it is unambiguous even if a consumer has a non-homothetic preference.[12]

Under homothetic preferences, the above definition of IES is equivalent to Hall (1988)'s definition of the elasticity of the consumption ratio to the corresponding relative price. That is to say, it is a measure of responsiveness of the growth rate of consumption to the gross real interest rate. In this case, the mathematical definition of IES becomes, IES $= \frac{d\log(c_{t+1}/c_t)}{d\log(R)}$, where c_t is the consumption in period t, and where $R = 1 + r$ is the gross real interest rate.

If the preference is time separable, $U = \sum_{t=0}^{T} \beta^t u(c_t)$, the Euler equation $u'(c_t) = \beta R u'(c_{t+1})$ is derived from the utility optimization of the consumer under certainty. If I take logarithms in the Euler equation, $\log R = -\log \frac{u'(c_{t+1})}{u'(c_t)} - \log \beta$, then the IES can be rewritten as

$$\text{IES} = \frac{d\log(c_{t+1}/c_t)}{d\log(R)} = -\frac{d\log(c_{t+1}/c_t)}{d\log u'(c_{t+1})/u'(c_t)}$$

So, if I additionally assume iso-elastic utility function, $u(c_t) = \frac{c_t^{1-\gamma}-1}{1-\gamma}$, then IES = $1/\gamma$. In sum, the larger value of the parameter γ implies the smaller IES.

[11] Hall (1988)

[12] Under time separable von Neumann-Morgenstern expected utility function, risk aversion and IES have a one-to-one relationship: IES is the inverse of risk aversion. However, two parameters have different meanings. Risk aversion represents preference toward risk under uncertainty, while IES represents preference toward inter-temporal consumption smoothing.

From a theoretical point of view, IES is a useful shortcut for consumption smoothing motives. Consumers with low IES tend to adhere to their original target consumption growth path, even when the price (the interest rate) changes, implying stronger consumption smoothing motives than consumers with high IES.

In turn, it implies that consumers with low IES are more willing to bear higher interest rates to reduce a collateral requirement as opposed to those consumers with high IES.[13] As a result, consumers with low IES, who have stronger consumption smoothing motives, tend to choose a credit loan that charges a higher interest rate instead of requiring any collateral.

2.1.2 Heterogeneous Opportunity Cost of Default

In addition to this tendency of choosing a credit loan, consumers with low IES are less likely to default. Consumers with heterogenous IES, representing differential consumption smoothing motives, have differential incentives to prevent default since their opportunity cost of being excluded from the credit market varies according to their IES. Consumers with low IES exert more costly effort to avoid default since their opportunity cost of being excluded from the credit market is higher. In other words, those who enjoy a bigger utility gain from consumption smoothing suffer more from denial of access to the consumer credit market, and thus face a stronger incentive to avoid default by honoring existing debts.

In Appendix A., I use a simple two-period model to prove the above argument theoretically. The basic steps and ideas are as follows. As a first step, I show that the optimal borrowing amount decreases in the IES. That is to say, a consumer with low IES tends to borrow more from a bank at any given interest rate. As a second step, I show more directly that the ***compensating income variation***, which would be required for the consumer to become indifferent to autarky, is larger for the consumer with lower IES. Please refer to the appendix for the full model.

The theoretical model implies that heterogeneity in IES can be an important dimension that may cause a negative correlation between a loan interest rate and default probability in the consumer credit market. Consumers with low IES tend to choose a high interest rate loan with a low collateral requirement and, at the same time, they are less likely to default, generating advantageous selection in the consumer credit market.

However, this additional dimension matters only when the bank has market power. If the market is competitive, the information value of the unobserved IES is ***private***, i.e. it does not have an impact on the bank's profit. In the next section, I elaborate on this point theoretically in a quite general setting.

2.2 Credit Market Model

Chiappori, Jullien, Salanié, and Salanié (2006) show that even if there is an additional dimen-

[13]Just as, in insurance markets, risk averse people are more willing to pay higher premium to get higher coverage.

sion of unobserved heterogeneity that is positively correlated to insurance demand and negatively correlated to accident risk, the additional dimension cannot generate a negative correlation between coverage and accident risk if the market is competitive. Similarly, here I show that when a menu is composed of pairs of loan interest rates and collateral requirements in the consumer credit market, the unobserved heterogeneity in IES may cause a negative correlation between a loan interest rate and default probability only when the bank has market power.

In the first part of the model, I will verify conditions under which a positive correlation between a loan interest rate and default probability is expected in the credit market. And then, I find conditions under which a negative correlation between a loan interest rate and default probability may be observed.

2.2.1 Competitive Market

Consider a consumer who chooses a contract from a given menu in the credit market. Here the menu is composed of pairs of loan interest rates and collateral requirements. Banks sort consumers based on observables X to predict their default risk, and then suggest the menu of contracts to them based on the classification. Since I focus on the choices of consumers in the credit market, I consider a group of consumers who are indistinguishable with respect to observables over which the bank can price discriminate. I omit X for convenience.

Formally, a contract (C_i) is composed of a gross interest rate $(R_i = 1 + r_i)$ and collateral (D_i), i.e. $C_i = (R_i, D_i)$.[14] Suppose that a consumer, characterized by parameter θ, has the future income w which is distributed $F_\theta(w)$ with the support of $[0, \infty)$. The parameter θ, therefore the income distribution $F_\theta(w)$, is the source of private information. A borrower with parameter θ privately chooses income distribution $F_\theta(w)$ from a set $\mathscr{F}$. If the set $\mathscr{F}$ is a singleton, then it means that this is a pure adverse selection model. Otherwise it allows borrowers to choose the level of effort to prevent default. (moral hazard)

A borrower has wealth D_0, which can be pledged but cannot be liquidized instantly. Generally, with a fixed loan amount (L), when the value of pledged collateral (D_i) increases, applied interest rate (R_i) decreases whenever $D_i < R_i L$.[15] This is because, for the bank, the cost of default decreases as the value of pledged collateral increases, until the value is just equal to the amount of loan.

I make two behavioral assumptions on the borrowers in this model.

Assumption 1. Each consumer's preference is state independent over the distribution of the final wealth and monotonic with respect to first-order stochastic dominance.

[14] I do not consider the credit rationing issue here. Some previous papers include the rationing probability in the contract term. Also this argument assumes that the amount of loan (L) is fixed whatever contract they choose. Refer to the small loan argument.

[15] It is consistent with usual loan contracts.

Assumption 2. Consumers are averse to mean-preserving spreads on future wealth. (a weak preference for inter-temporal smoothing)

These assumptions are so weak that the result covers a large class of models. It not only does not depend on single crossing condition but also allows heterogeneous preferences and even non-expected utility.

Suppose that a borrower prefers contract C_1 to C_2 which requests less collateral than contract C_1; $D_1 > D_2$. This implies that the price of the contract C_1, i.e. interest rate R_1, is lower than that of C_2, enough to compensate for the difference in collateral requirements.

Default occurs if $w < R_i L$.[16] When default occurs, a bank liquidizes the pledged collateral and then allots liquidized collateral and income w for the repayment of debt. After that the bank returns the balance to the borrower, if any.[17] So the final wealth of the borrower becomes $W_i(w) = \max\{D_0 - D_i, w - R_i L + D_0\} = w - R_i L + D_0 + Q_i(w)$ which is a non-decreasing function in w where,

$$\begin{aligned} Q_i(w) &= \begin{cases} -w + R_i L - D_i & \text{if } w < R_i L - D_i \\ 0 & \text{if } w \geq R_i L - D_i \end{cases} \\ &= \max\{-w + R_i L - D_i, 0\} \end{aligned}$$

Note that $Q_i(w)$ is the part of the debt that the borrower cannot repay.

Now let's see how $Q_2(w) - Q_1(w)$ behaves. Let's set $\bar{w}_i \equiv R_i L - D_i$

$$Q_2(w) - Q_1(w) = \begin{cases} (R_2 - R_1)L + (D_1 - D_2) & \text{if } w < \bar{w}_1 \\ -w + R_2 L - D_2 & \text{if } \bar{w}_1 \leq w < \bar{w}_2 \\ 0 & \text{if } w \geq \bar{w}_2 \end{cases}$$

So as w increases, $Q_2(w) - Q_1(w)$ is non-increasing. As a results, $W_2(w) - W_1(w)$ is non-increasing.

Explicitly, $W_2(w) - W_1(w) = (R_1 - R_2)L + Q_2(w) - Q_1(w)$ is,

$$W_2(w) - W_1(w) = \begin{cases} D_1 - D_2 & \text{if } w < \bar{w}_1 \\ -w + R_1 L - D_2 & \text{if } \bar{w}_1 \leq w < \bar{w}_2 \\ (R_1 - R_2)L & \text{if } w \geq \bar{w}_2 \end{cases}$$

[16] Here I consider the case that in both contracts, $D_i < R_i L$. If, in both contracts, $D_i \geq R_i L$ then the final wealth $W_i(w) = \bar{w}_f + D_0 - w - RL, \forall w \in [0, \bar{w}_f]$. Note that, in this case, the final wealth is the same in both contracts. This is because I assumed R_i does not decrease any more after $D_i \geq R_i L$. If I assume that R_i still decrease even after $D_i \geq R_i L$, then contract C_1 dominates contract C_2 in terms of first order stochastic dominance in final wealth. Actually, if $D_2 \geq R_1 L$ then contract C_1 always first order stochastic dominates C_2. As a result, C_2 will never be chosen in the market. So I only consider the case $D_2 < R_1 L$. Of course some steps are different but the results still hold.

[17] Here, I do not consider the collateral disparity issue like in Barro (1976), i.e. I assume that the value of pledged collateral is the same for both banks and borrowers.

Since $W_i(w)$ is non-decreasing function in w, and since $W_2(w) - W_1(w)$ is non-increasing function in w, $W_1(w) - EW_1(w)$ is a mean-preserving spread of $W_2(w) - EW_2(w)$.[18]

Since the borrower prefers C_1 to C_2, and since the borrower is averse to the mean-preserving spread in future wealth by Assumption 2, $E_1W_1(w)$ should not be smaller than $E_1W_2(w)$.[19] Otherwise, it contradicts the Assumption 1. As a result, we can immediately get the following proposition.

Proposition 1.

Suppose a loan contract C_2 requests less collateral than C_1, and suppose both contracts are sold to borrowers who are indistinguishable with respect to observables over which the bank can price discriminate. Then under Assumption 1 and 2, the following inequality holds.

$$(R_2 - R_1)L \geq \int [Q_2(w) - Q_1(w)]dF_1(w) \tag{1}$$

The result in Proposition 1 provides a test that does not rely on the market structure. However, it does not translate into a correlation structure between a loan interest rate and default probability. It is because the non-negative correlation between a loan interest rate and default probability can not be established independently of the competitive context or the information structure. Hence, from now on I consider the competitive market structure to recover the non-negative correlation.

I define the profit function of the firm $\Pi_i(w) = S_i(w) - (1+k)L$ where k is riskless interest rate and $S_i(w)$ is,

$$S_i(w) = \begin{cases} w + D_i & \text{if } w < R_iL - D_i \\ R_iL & \text{if } w \geq R_iL - D_i \end{cases}$$

There is no general consensus on the definition of competitive equilibrium under asymmetric information. Here, I use the non-decreasing profit (NDP) condition as a concept of competitive equilibrium under asymmetric information. It means that profit of the bank does not decrease as the value of pledged collateral increases.

$$\int \Pi_1(w)dF_1(w) \geq \int \Pi_2(w)dF_2(w) \tag{NDP}$$

NDP condition is so weak that it covers almost all existing equilibrium concepts with asymmetric information. It covers the concept of zero profit competitive equilibrium (Rothschild and Stiglitz (1976)), which implies that the profit of every contract to be zero. Also it covers the cross-subsidy model (Miyazaki (1977)) in which the losses made on the less powered contract (credit loan) are subsidized by the profit stemming from the high powered contract (collateralized loan).[20]

[18] This is a well-known result. The proof will be provided upon request.

[19] This expectation is calculated in the aspect of the borrower who choose contract C_1.

[20] In cross-subsidy equilibrium, a bank taxes low risk people to subsidize high risk people. As a result, low risk people pay more interest rate than is fair, while high risk people pay less interest rate than is fair and they still get the loan

Here, note that $Q_i(w) + S_i(w) = R_iL$. Then the NDP condition becomes,

$$R_1L - \int Q_1(w)dF_1(w) \geq R_2L - \int Q_2(w)dF_2(w) \tag{2}$$

So by combining inequalities (1) and (2), I get Proposition 2.

Proposition 2.

Suppose a loan contract C_2 requests less collateral than C_1 and both contracts are sold to borrowers who are indistinguishable with respect to observables over which the bank can price discriminate. Also suppose that Assumptions 1, 2, and NDP condition hold. Then,

$$\int Q_2(w)dF_2(w) \geq \int Q_2(w)dF_1(w) \tag{3}$$

Interpretation of the inequality (3) is as follows. Assume that $w \in \{0, \tilde{w}\}$ and that $\tilde{w} \geq R_2L - D_2$. There are two contracts C_1 and C_2 which requires less collateral than C_1.

$$(R_2L - D_2)p_2 \geq (R_2L - D_2)p_1$$

where, p_i is the probability of default under each contracts.

Since $R_2L - D_2 > 0$, I get $p_2 \geq p_1$. In other words, default probability is higher in the contract that requires less collateral, i.e. a higher interest rate. This gives the positive correlation between a loan interest rate and default probability in the competitive credit market, regardless of the existence of the unobserved IES.

2.2.2 Imperfect Competition

Now, suppose that the bank has market power. I need two conditions for the positive correlation property to hold.[21]

Assumption 3. The borrowers have a von Neumann-Morgenstern utility function.

Assumption 4. Inter-temporal Elasticity of Substitution of all agents is the same or fully observed by the bank if heterogeneous, and the bank can use the information when pricing the contract.

If Assumption 3 and Assumption 4 are satisfied, the utility function is determined up to an affine transformation:

without any collateral requirement. Low risk people accept this tax since they can pledge less collateral by relaxing the incentive compatibility constraint of the high risk people.

[21]These conditions are adopted from Chiappori, Jullien, Salanié, and Salanié (2006)

There exist functions $v(W)$, a^θ, and c^θ such that, for any θ, one can write

$$u^\theta(W,F) = a^\theta(F)v(W) - c^\theta(F)$$

with $a^\theta(F) > 0$.

Now suppose that the contracts C_1 and C_2 are chosen in equilibrium by some borrowers. Since both contracts are chosen in equilibrium, two inequalities below hold.

$$\int v_1(w)dF_1(w) \geq \int v_2(w)dF_1(w) \tag{4}$$

$$\int v_2(w)dF_2(w) \geq \int v_1(w)dF_2(w) \tag{5}$$

where, $v_i(w) = v(W_i(w))$. From the two inequalities above I get

$$\int (v_2(w) - v_1(w))(dF_2(w) - dF_1(w)) \geq 0 \tag{6}$$

Since $W_2(w) - W_1(w)$ is non-increasing in w, $(v_2(w) - v_1(w))$ is non-increasing. So the equation implies F_2 puts more weight on low w (when the default is likely to occur). To interpret the inequality (6) consider the case when $w \in \{0, \tilde{w}\}$, where $\tilde{w} \geq R_2L$. Then, I get $p_2 \geq p_1$, which gives the positive correlation between an interest rate and default rate.

However, if the individual IES is not observed, then the above result does not hold. Consider a simple example. Suppose that there are two types of borrowers: high IES and low IES (whose default risk is the same). And suppose that there are two states in the world: $w = 0$ (default) $w = \bar{w} \geq R_2L$ (non-default). Then in the monopoly contract, the bank will attract the borrower with low IES by suggesting the contract that requires less collateral (high interest rate), while attracting the high IES borrower by suggesting the contract that requires more collateral (low interest rate). Now let me introduce an infinitesimal difference in risk that is perfectly correlated with IES. If IES and the default risk are positively correlated, then I get the negative correlation between loan interest rate and default probability.

In sum, I may find a negative correlation between a loan interest rate and default probability only when the bank has market power and the IES is unobserved by the bank. In the next section, I provide evidence that the bank did indeed have quite strong market power in the data period.

3 The Data

3.1 Market Concentration

After the 1997 Asian financial crisis, the Korean credit market underwent a huge consolidation initiated by the governmental authority. In the consumer loan market, the Herfindahl-Hirschman Index (HHI)[22] rose from 835.6 to 2,262.7 between the year 1995 and the year 2002. During the

[22] HHI $= \sum_{i=1}^{N} s_i^2$, where s_i is the market share of firm i in percent unit, and N is the number of firms. The HHI can range from close to 0 to 10,000.

same period, the HHI increased from 716.4 to 1,334.6 in the corporate loan market.[23] It implies that the consumer loan market are highly concentrated and the corporate loan market are moderately concentrated, according to the standard suggested by the U.S. Department of Justice.[24] Especially for consumer loans, the market share of the bank that provided my dataset is about 42.6% in year 2002.[25] Through the data period, the bank maintained its market power for consumer loans except for small fluctuations,[26] while corporate loan market becomes competitive. The highly concentrated consumer loan market, as I proved in the previous section, provides an environment in which an additional dimension of heterogeneity may cause non-classical results.

3.2 Data Summary

Table 1: Descriptive Statistics (Corporate Loans)

	Mean	S.D.	Q1	Q3
Loan Interest Rate (%)	7.2	1.2	6.5	7.9
Credit Score	481.9	165.9	430	580
Amount of Loan (Million Dollars)	1.2	1.5	0.6	1.3
Asset (Million Dollars)	8.4	38.2	2.2	7.0
Revenue (Million Dollars)	8.5	25.3	1.5	7.8
Debt (Million Dollars)	6.0	29.3	1.7	5.3
Profit (Million Dollars)	0.6	2.3	0.1	0.5
Observations	5,755			

Notes: S.D. means standard deviation, and Q1, Q3 mean the first and the third quantile separately.

Table 1 shows descriptive statistics of the corporate loan data that is provided by a large com-

[23] Lee and Lee (2005)

[24] The U.S. Department of Justice divides the spectrum of market concentration as measured by the Herfindahl-Hirschman Index (HHI) into three regions.
(https://www.justice.gov/atr/15-concentration-and-market-shares)

- HHI $\leq$ 1000: Competitive Market
- $1000 < HHI \leq 1800$: Moderately Concentrated Market
- HHI $>$ 1800: Highly Concentrated Market

[25] In terms of mutual installment deposit market, the market share of this bank comes close to 61.5% in year 2002 and corresponding HHI is 4,040.8.

[26] Please refer to Appendix D. for the table showing the full history of bank merging in Korea.

Table 2: Descriptive Statistics (Consumer Loan)

	Mean	S.D.	Q1	Q3
Loan Interest Rate (%)	6.4	1.9	5.5	7.2
Maturity (Year)	16	8.5	10	20
Credit Score	790	75.5	752	841
Behavior Score	1094	85.4	1052	1145
Introducing Score	970.6	259.8	730	1148
Amount of Loan ($1,000)	46	65	4	60
Credit Loan Dummy	0.18	0.38	0	0
Number of Referring Credit State	0.0007	0.031	0	0
Observations		28,605		

Notes: S.D. means standard deviation, and Q1, Q3 mean the first and the third quantile separately. The number of observations is 26,667 in case of Introducing Score since it is only available for first-time borrowers.

mercial bank in Korea. The data is comprised of firm level corporate loans initiated between January 2005 and December 2008. For each loan, the data contains its history from the initiation date till November 2011. The data includes credit ratings of the firms and firm specific characteristics which are considered when pricing the loans. In case of firm credit ratings, the bank totally depends on credit score and credit class which is rated by a third party credit agency. The credit score is a numerical value ranging from 0 to 999. As the credit score of a firm increases, its default rate decreases in general. The firm level characteristics includes revenue, profit, asset, and debt of each firms.

Table 2 shows descriptive statistics of the consumer loan data that is provided by another large commercial bank in Korea. The data is comprised of individual consumer loans initiated between April 2005 and May 2009. For each loan, the data contains its history from the initiation date till May 2009.

One very unique feature of the consumer loan data is that it is merged with credit card usage data and balance on savings account data by individual identification numbers. I observe that each consumer appearing in the loan data has credit card account and savings account in the same bank, which allows to match individuals across the loan data, the credit card data, and the savings data. This individual level matching allows me to construct an individual level proxy for consumption smoothing motives using credit card consumption pattern and balance of savings account.

As measures of consumer credit risk, I have credit score, credit class, behavior score, and introducing score. As in the corporate credit market, credit score and credit class are rated by a third party agency and are most widely used in the consumer credit market. Behavior score is similar to the credit score but evaluated by the bank itself rather than by a third party agency. The bank observes the behavior of the borrower and updates the behavior score over time. Behavior score is more frequently updated than the credit score. Introducing score is only available for the first-time borrowers. Since banks do not have enough credit information for the first-time borrowers, they additionally build the introducing score. In addition to measuring credit, the introducing score also allows me to identify who are the first-time borrowers.

I mainly analyze the bank loan data to find the evidence of advantageous selection. Considering that the crucial feature of the tests for information asymmetries is to compare observationally same consumers for the bank, it is important to condition on every observables used in pricing the loans. In that sense, this bank loan data is unique. It incorporates not only credit rating variables such as credit score, credit class, behavior score, and first score but also detailed consumer characteristics such as wage, occupation, housing location, age, financial asset, and real estate. These comprehensive set allows me to control all the observables used in pricing the loans.

3.3 Background: Menu of Contracts

After classifying consumers based on their observable risk factors, a bank suggests a menu of contracts[27] composed of pairs of interest rates and collateral requirements. A borrower can choose whether to make a credit loan or a collateralized loan. There are several options for collateralized loans in terms of what will be kept as a pledge, such as real estate, savings, or warranty from a credit guarantee company.

The interest rate charged on a loan can be decomposed into Koribor,[28] education taxes,[29] profit, and credit risk cost.[30] Among them, the ***credit risk cost*** is the source of the negative correlation between a loan interest rate and the value of pledged collateral.

[27]Korean consumer credit market is ***exclusive***: a bank can impose an exclusive relationship with a borrower when they sign a contract. Whether the contract is exclusive or not is crucial in terms of the possible set of contracts (Chiappori and Salanié (2013)). Under an exclusive contract, a convex price scheme - a unit interest rate rises with a decrease in the collateral requirement - is possible. In Korea, when a consumer borrows money from a bank, all of the loan information is registered to the Korea Federation of Banks, which holds all borrower information. The other banks refer the information if the consumer tries to borrow additional money. Usually, it is denied and, even when a loan limit is very low with a higher interest rate is possible.

[28]The Korea Interbank Offered Rate, or KORIBOR, is the average interest rate at which term deposits are offered between prime banks in the Korean wholesale money market or interbank market. Basically, it is a Korean version of Libor.

[29]This education tax is constant along the whole data period.

[30]Loan Interest Rate = Koribor Rate + Tax + Credit Risk Cost + Profit. This is a rough formula. The exact formula for the loan interest rate is kept secret by the banks.

Table 3: Interest Rate Gap between Credit Loans and Collateralized Loans

Consumer Loans	OLS
Dependent Variable	Loan Interest Rate
Credit Loan Dummy	1.88***
	(0.095)
Credit Ratings	Yes
Consumer Characteristics	Yes
Allow Full Interactions	Yes
Adaptive lasso has been used to pick the relevant conditional variables.	
Observations	14,480

Notes: Table reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loans, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The credit risk cost is the expected cost of default for the bank, which is higher for consumers with a higher expected default rate and is lower for loans with high recovery. In turn, it means that a bank charges a higher interest rate to borrowers with lower credit ratings, while it offers a lower interest rate for collateralized loans than for credit loans, thereby generating a negative relationship between a loan interest rate and the value of pledged collateral, given credit ratings.

This negative relationship is a quite general feature. Dey and Dunn (2007) empirically show the negative correlation between the value of the pledged collateral by borrowers and the interest rate charged by bank in the HELOC(Home Equity Line of Credit) market.[31]

Table 3 explicitly shows the negative correlation between a loan interest rate and value of pledged collateral in my dataset: the interest rate of credit loans is, on average, 1.88 percentage points higher than that of collateralized loans after conditioning on observable factors used in pricing the loans.

[31] They support the sorting-by-private-information paradigm (borrowers who pledged higher amounts of collateral signal their superior risk-types and therefore are rewarded with lower interest rates by the bank) against the sorting-by-observed-risk paradigm, which predicts a positive correlation between collateral and borrower risk.

3.4 A proxy for Consumption Smoothing Motives

In Korea, if a consumer purchases a good using her credit card, she needs to pay the full balance of her credit card account at the end of the month (at the credit card payment due). If she pays on time, she only needs to pay the price of the good without any interest cost. Hence, using credit cards allows consumers to delay the payment. However, if she does not pay all the balance at the credit card payment due, a penalty interest rate is imposed to the residual balance and credit ratings become aggravated.[32]

In Korea, however, there is a unique credit card feature known as ***the installment plan***, which allows consumers to split the price of a good and repay through several months with high interest cost. One can choose to participate in the plan or not when purchasing a good by a credit card. Essentially, it is equivalent to making a short-term loan but again with a high interest rate.

Here is an example of the installment plan. Suppose a consumer makes a \$90 purchases using a 3-month installment contract with a monthly installment interest rate r^I. She needs to repay $\$(\frac{90}{3} + 90 \times r^I)$ in the first month, $\$(\frac{90}{3} + 60 \times r^I)$ in the second month, and $\$(\frac{90}{3} + 30 \times r^I)$ in the last month.

The installment contract, if she repays on time for 3 months, does not impact her credit ratings at all. Hence, for consumers who cannot borrow money anymore, the installment contract gives an additional way to smooth consumption.

Except for some special promotions,[33] however, the yearly installment interest rate is quite high: 10% $\sim$ 21.4%.[34] Unless the willingness to pay the interest cost to smooth consumption is high enough, consumers would not use the plan and would give up the consumption smoothing.

From this concept, I can construct a proxy for consumption smoothing motives. All consumers in my dataset received a loan from a bank. In Korea, it is very hard to receive additional loans if someone already has outstanding debt. Even when it is possible, the cost to receive an additional loan to buy some goods is very high. Hence, those consumers who already received a loan from a bank are essentially unable to borrow more. Now, consider a group of consumers who have zero or small balance in their savings account, upward savings trend or increasing income path, and who can no longer borrow money from the bank. If some of them use installment purchases, they can be regarded as a group of consumers who have stronger consumption smoothing motives, and in turn a group of consumers with lower IES from a theoretical point of view. In Appendix B., I use a simple two-period model to theoretically show that the proxy for consumption smoothing motives is valid. Please refer to the appendix for the full proof.

[32]In the United States, on the other hand, if a consumer pays the minimum payment due until the due date, her credit ratings are not affected much. Minimum payment due is the amount which one pays to avoid a late payment fee. Of course, the consumer needs to pay interest on the remaining unpaid amount.

[33]I exclude these special promotions when I make a proxy for consumption smoothing motives.

[34]So the monthly installment interest rate is between 0.83% $\sim$ 1.78%, while the monthly savings interest rate is about 0.25%.

4 Evidence of Advantageous Selection in the Consumer Credit Market

In this section, I empirically show that, conditional on all the observables used for pricing the loans, there indeed is a negative correlation between a loan interest rate and default probability in the *consumer loan market*, while there is an insignificant positive correlation in the *corporate loan market*.

To directly show that the unobserved consumption smoothing motives cause the negative correlation in the consumer credit market, I use my proxy for consumption smoothing motives. Using the proxy, I explicitly show that consumers who have strong consumption smoothing motives tend to choose credit loans which charges a high interest rate instead of requiring a high level of collateral. At the same time, I show that those consumers are less risky, generating a negative correlation between a loan interest rate and default probability.

I then subdivide the data into two groups; first-time borrowers and repeated borrowers. By the subdivision, for the repeated borrowers, I show that the bank collects more information on private default risks during the previous contract periods. It allows the bank to concentrate on exploiting market power to charge a higher interest rate to the consumers who are willing to pay to smooth consumption. On the other hand, for the first-time borrowers, multidimensional unobserved heterogeneity generates opposite direction of correlations between loan interest rates and default rate, annihilating each other. Hence, it results in seemingly no significant asymmetric information between the first-time borrowers and the bank, which is not true.

For the empirical analysis, I use duration analysis. Duration measures the elapsed time from the month of a loan initiation until, if any, its default. Duration is regarded as right-censored if a spell ends without default by the end of either maturity or end of an observation period. Generally, the hazard function is defined as follows.

$$h(t|x) = \lim_{\epsilon \to +0} \frac{P(t \leq T < t + \epsilon | T \geq t, x)}{\epsilon}$$

It can be used to approximate a conditional probability.

Especially, here I estimate a Cox proportional hazard model (PHM) using partial maximum likelihood.

$$h_i(t|x) = h_0(t) \exp(x_i' \beta)$$

where $h_0(t)$ is the baseline hazard which is common to all units in the population.

4.1 Corporate Loans

Table 4 shows the partial maximum likelihood estimates of the Cox proportional hazard model and least squares estimate of the linear probability model using ***corporate loans*** data. For reference, the average default rate in the corporate loan market is about 0.64%.

Table 4: Corporate Loans

Dependent Variables Corporate Loans	Cox PHM Default Hazard Without Observables	 With Observables	Linear Probability Model Default Dummy With Observables
Loan interest rate	0.116** (0.045)	0.095 (0.163)	0.0005 (0.0008)
Credit Ratings	No	Yes	Yes
Firm Characteristics	No	Yes	Yes
Month of Loan Initiation	No	Yes	Yes
Number of observations	5,755	5,755	5,755

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model and reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company. Firm level characteristics includes asset, profit, debt, and revenue.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Without controlling any observables, there is a positive correlation between a loan interest rate and default hazard. A loan with 1 percentage point higher interest rate has a higher default hazard rate by about 12.3% ($\exp(0.116) - 1 \simeq 0.123$). This is quite natural in that the bank charges a higher interest rate to the firms that they believe are riskier, i.e. to the firms with lower credit ratings.

However, once I control the observables used for pricing the loans, including credit ratings and firm characteristics, I could only find a insignificant positive correlation between a loan interest rate and default hazard rate. The estimate shows that a contract with 1 percentage point higher interest rate has a higher default hazard rate by about 9.5%. More direct interpretation through the linear probability model says that the default probability is 0.05 percentage points higher for a loan with 1 percentage point higher interest rate.

The survival estimates from Cox proportional hazard model, Figure F.1 and Figure F.2 in Appendix F.1, show these results graphically. Figure F.1 graphically shows the *unconditional* positive correlation between a loan interest rate and default probability. Figure F.2 shows that, once I control observable factors that are considered when pricing the loans, firms that choose a higher interest rate loan paired with a lower collateral requirement have a lower survival rate, i.e. a higher default rate, at every point in time[35]

Although it is statistically insignificant, there are at least three possible causes of the positive correlation. Firms with private information that they are riskier among the firms that are indistin-

[35] The survival function does not cross each other since I use Cox proportional hazard model.

guishable with respect to observables over which the bank can price discriminate choose a higher interest rate loan paired with a lower collateral requirement to prevent losing much pledged collateral if they default. At the same time, a higher interest rate induces firms to choose riskier projects with higher expected payoffs when successful. On top of that, less collateral provides less incentive to prevent default, resulting in the positive correlation between a loan interest rate and default probability.

To check robustness of the non-existence of asymmetric information, I additionally execute the "positive correlation test" following Chiappori and Salanié (2000). This positive correlation test provides a robust way to test existence of asymmetric information under a competitive market condition.[36]

In the equations below, D_i represents default status for each individual i: $D_i = 1$ means that the borrower i defaults. Also, for each borrower i, r_i is the interest rate of the loan contract and X_i is the observables that are used for pricing the loan.

$$D_i = 1(X_i\alpha + e_i > 0) \tag{7}$$

$$r_i = X_i\beta + \epsilon_i \tag{8}$$

I first estimate probit (7) and least squares (8), weighing each individual by the number of months under the loan contract, w_i. Then, I generate a test statistic, W, using the generalized residual $\hat{e}_i$ and the least squares residual $\hat{\epsilon}_i$ from the equation (7) and (8) separately.

$$W = \frac{(\sum_{i=1}^{n} w_i \hat{e}_i \hat{\epsilon}_i)^2}{\sum_{i=1}^{n} w_i^2 \hat{e}_i^2 \hat{\epsilon}_i^2} \tag{9}$$

Following Gourieroux, Monfort, Renault, and Trognon (1987), under the null of conditional independence $cov(e_i, \epsilon_i | X_i) = 0$, W is distributed asymptotically as a $\chi^2(1)$. The result, $W = 0.310$, shows that I cannot reject the null hypothesis that there is no asymmetric information.[37]

4.2 Consumer Loans

Table 5 shows the partial maximum likelihood estimates of the Cox PHM using ***consumer loans*** data. For reference, the average default probability is 4.2% in the consumer credit market. As in the corporate loan case, there is an *unconditional* positive correlation between a loan interest rate and default hazard. The reason, likewise in the corporate loan case, is that the bank charges a higher interest rate to the consumers whom they think riskier, i.e. consumers with lower credit ratings.

[36] Note that the corporate loan market becomes competitive during the data period, which justifies the validity of the positive correlation test.

[37] 10% critical value of chi square distribution with degree of freedom 1 is $\chi^2_{0.10}(1) = 2.706$, and for 5%, it is $\chi^2_{0.05}(1) = 3.841$. Note that $W = 0.310$ is much less than those critical points.

Table 5: Consumer Loans (Full Sample)

	Cox PHM		Linear Probability Model
Dependent Variables	Default Hazard		Default Dummy
Consumer Loans	Without Observables	With Observables	With Observables
Loan interest rate	0.040***	−0.039***	−0.0044***
	(0.013)	(0.011)	(0.0007)
Credit Ratings	No	Yes	Yes
Consumer Characteristics	No	Yes	Yes
Observations	28,605	28,605	28,605

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model and reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, once I control observables used for pricing the loans, I do indeed find a negative correlation between a loan interest rate and default hazard. That is to say, consumers who choose a higher interest rate loan paired with a lower collateral requirement among available loans are less likely to default, indicating advantageous selection in the market. A loan with 1 percentage point higher interest rate has a lower default hazard rate by 3.9%. Again the linear probability model says that the default probability is 0.44 percentage points lower, i.e. about 10% less default, for a loan with 1 percentage point higher interest rate.

The survival estimates from Cox proportional hazard model, Figure F.3 and Figure F.4 in appendix F.2, show these results graphically. Figure F.3 graphically shows the *unconditional* positive correlation between a loan interest rate and default probability. Figure F.4 shows that, once I control observable factors that are considered when pricing the loans, consumers who choose a higher interest rate loan paired with a lower collateral requirement have higher survival rate, i.e. lower default rate, at every point in time.[38] That is, it shows advantageous selection graphically.

The negative correlation only can be explained, as I already proved in the previous model, when the bank has market power and when there is an unobserved heterogeneity that is correlated to the contract choice and to the default behavior. The unobserved heterogeneity in consumption smoothing motives matters at this point. Consumers who have stronger consumption smoothing motives tend to choose a pair of a higher interest rate and lower collateral requirement. It is because their willingness to pay interest cost to reduce the collateral requirement by one unit

[38] The survival function does not cross each other since I use Cox proportional hazard model.

Table 6: Consumer Loans (Small Loans V.S. Large Loans)

	Cox PHM	
Dependent Variables	Default Hazard	
Consumer Loans	Less than or Equal to $20,000	Larger than $20,000
Loan interest rate	-0.055^{***}	0.064
	(0.013)	(0.047)
Credit Ratings	Yes	Yes
Consumer Characteristics	Yes	Yes
Observations	14,480	14,125

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

is higher than those who are relatively weakly motivated to smooth consumption. At the same time, those consumers exert more effort to reduce default probability, which will be more deeply studied in the second part of the paper, since their opportunity cost of being excluded from the credit market is higher, resulting in advantageous selection in the consumer credit market.

In the following empirical analysis using a proxy for consumption smoothing motives, I explicitly show that consumers who have strong motives to smooth consumption tend to choose a non-collateralized credit loan with a high interest rate and at the same time they tend to default less, which generates the negative correlation between a loan interest rate and default probability.

I subdivide the dataset into small loans (less than or equal to $20,000) and large loans (larger than $20,000) and then focus on the small loans for two reasons.

First, a credit loan availability is limited to small loan sizes. In order to borrow a large amount of money from the bank, consumers need to pledge high value collateral. In that case, the contract choice may be driven not only by the tradeoff between a loan interest rate and the value of pledged collateral but also by how large a loan the borrower is requesting. This confounding factor can be removed if I focus on small loans of amounts that are within the bank's credit loan limit. The $20,000 cutoff is conservative in that choice between a credit loan and a collateralized loan is available for any amount under $20,000.

Second, often during the data period, Korean consumers use mortgage loans to buy a second house as an investment rather than for consumption smoothing behavior. In that case, only investors expecting high returns, which implies riskier investors, tend to choose a credit loan which charges a higher interest rate. In that sense, I expect a positive correlation between a loan interest rate and default probability among large loans. Again, by focusing on the small loans, I try to exclude loans for investment purpose and to concentrate on consumption smoothing behavior where the consumption smoothing motives matter.

As intuition suggests, a negative correlation between a loan interest rate and default probability becomes stronger (1st column of Table 6), while a positive correlation, though statistically insignificant, appears (2nd column of Table 6) in large sized loans.

Before proceeding further, I need to check whether the negative correlation is fictitious or not. According to Chiappori and Salanié (2000), restricted functional forms, forbidden cross effects, or nonlinear functions of the exogenous variables could drive spurious asymmetric information results. Nonparametric estimation could be one solution but I will confront the curse of dimensionality. Instead, from now on, I allow full interactions among covariates and use the ***adaptive Lasso*** to choose the relevant variables for all specifications.

Lasso tends to choose false positives, i.e. too many variables, unless one imposes very strong conditions.[39] Instead, here I use the adaptive Lasso to consistently select the true active set of variables under relatively weak assumptions.[40] Adaptive Lasso identifies the right subset of true variables and reaches the oracle properties, i.e. it performs as well as if the true underlying model were given in advance,[41] assuming compatibility condition (Zou (2006), and Bühlmann and Geer (2011)). Here, with Cox proportional hazard model, the adaptive Lasso solves the below problem, which minimizes a strict convex function (Zhang and Lu (2007)).

$$\min_{\beta}[-\frac{1}{n}l_n(\beta) + \lambda \sum_{j=1}^{d} \frac{|\beta_j|}{|\tilde{\beta}_j|}] \tag{10}$$

where $l_n(\beta) = \sum_{i=1}^{n} \delta_i[\beta^T z_i - \log\{\sum_{j=1}^{n} I(\tilde{T}_j \geq \tilde{T}_i)\exp(\beta^T z_j)\}]$, where λ is the tuning parameter chosen through 10-fold cross validation[42], and where $\tilde{\beta} = (\tilde{\beta}_1, ..., \tilde{\beta}_d)^T$ is the maximizer of the log partial likelihood $l_n(\beta)$.

It is basically a two step procedure that penalizes those with lower absolute value of initial

[39] One of the restrictive condition is so called "irrepresentable condition" which is restrictive but necessary to prevent false positive. Please see Zou (2006) or Zhao and Yu (2006) for the details.

[40] The compatibility condition is sufficient to achieve variable selection consistently through the adaptive Lasso. For details of compatibility condition, please see Bühlmann and Geer (2011). But it is clear that very small coefficients cannot be chosen by any regularization method. To avoid these very small coefficients, here I additionally assume so called "beta-min" conditions. The "beta-min" condition requires some lower non-zero bound on the true coefficients.

[41] A fitting procedure has an oracle property if it identifies the right subset model and has the optimal estimation rate.

[42] In k-fold cross-validation, the original sample is randomly partitioned into k equal sized subsamples. Of the k subsamples, a single subsample is retained as the validation data for testing the model, and the remaining $k-1$ subsamples are used as training data. The cross-validation process is then repeated k times (the folds), with each of the k subsamples used exactly once as the validation data. The k results from the folds can then be averaged to produce a single estimation. 10-fold cross validation is commonly used.

Table 7: Consumer Loans (Using Adaptive Lasso)

	Cox PHM		
Dependent Variable	Default Hazard		
Consumer Loans	Full Sample	$\leq$ \$20,000	$>$ \$20,000
Loan interest rate (%)	-0.027^{**}	-0.039^{***}	0.070
	(0.012)	(0.013)	(0.055)
Credit Ratings	Yes	Yes	Yes
Consumer Characteristics	Yes	Yes	Yes
Allow Full Interactions	Yes	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.			
Observations	28,605	14,480	14,125

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

estimates, $|\tilde{\beta}_j|$, more. In the first step, I maximize log partial maximum likelihood, $l_n(\beta)$, and get the initial estimates $\tilde{\beta}_j$. In the second step, I minimize equation (10) with the initial estimates $\tilde{\beta}_j$. As is well know, because of the L_1-geometry (kinky penalty), the Lasso performs variable selection in that an estimated component can be exactly zero. The number of variables that become exactly zero depends on the magnitude of λ and $|\tilde{\beta}_j|$. As one penalize more, i.e. higher λ, more variables are estimated to be zero. Similarly, the procedure ends up penalizing more those with lower initial estimates, $|\tilde{\beta}_j|$.

Table 7 shows the same contents as in Table 5 and Table 6 using the adaptive lasso. The negative correlation between a loan interest rate and default hazard is little bit weaker but it is still significant.

Now let me introduce consumption smoothing group dummy which captures unobserved heterogeneity in strong consumption smoothing motives. The consumption smoothing group dummy is a proxy for the unobserved consumption smoothing motives. Consumers who have a increasing savings trend or increasing income path, and who use an installment plan offered by their credit card company belong to the consumption smoothing group. Those consumers are

Table 8: Summary Statistics of Consumption Smoothing Group

Consumption Smoothing Group	No	Yes
Observations	25,379	3,226
Proportion of Men (%)	60.1	58.5
House Owner (%)	62.4	71.0
Online Transaction Preferred (%)	4.7	4.2
Avg. of Loan Maturity (Month)	15.9	17.4
Credit Card: Purchase/Limit (%)	7.8	28.4

Table 9: Consumer Loans (Condition on Consumption Smoothing Motives)

Dependent Variable Consumer Loans	Cox PHM Default Hazard Less than or Equal to $20,000
Loan interest rate × (1 - Consumption Smoothing Group) (%)	−0.036***
	(0.013)
Loan interest rate × Consumption Smoothing Group (%)	−0.012
	(0.009)
Consumption Smoothing Group	−0.844***
	(0.368)
Credit Ratings	Yes
Consumer Characteristics	Yes
Allow Full Interactions	Yes
Adaptive lasso has been used to pick the relevant conditional variables.	
Observations	14,480

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

people who have stronger consumption smoothing motives as I prove in the Appendix B. Table 8 compares observable characteristics of the consumers who are in the consumption smoothing group with those of the consumers who are outside of the group.

Table 9 shows the estimates of Cox proportional hazard model including interactions between a loan interest rate and consumption smoothing group dummy. The results show that for the consumers in the consumption smoothing group, a group of consumers who have *relatively homogenous* high consumption smoothing motives, a negative correlation between a loan interest rate and default hazard become much weaker (about 67%) and statistically insignificant, implying that once unobserved heterogeneity in consumption smoothing motives is controlled the negative correlation between a loan interest rate and default hazard disappears. Also note that consumers in the consumption smoothing group are much less likely to default: default hazard decreases by about 57% ($\exp(-0.844) - 1 = -0.57$).

From now on, let me try to provide more direct empirical evidence showing that how unobserved heterogeneity in consumption smoothing motives causes the negative correlation between a loan interest rate and default hazard.

If consumers in the consumption smoothing group, a unpriced characteristic, tend to choose a credit loan and, at the same time, if they are less likely to default, then it signals the unobserved heterogeneity in consumption smoothing motives is the source of advantageous selection. To see this, consider the following model (Finkelstein and McGarry (2006)). For illustration purpose, I use linear specification.

Let X_i be the set of observables used in pricing the loans for the consumer i. Also D_i and r_i are default dummy and a loan interest rate respectively.

$$\begin{aligned} r_i &= X_i\gamma + \eta_i \\ D_i &= X_i\beta + \epsilon_i \end{aligned}$$

Under the null of symmetric information in the competitive market, ϵ_i and η_i should not be correlated: $Cov(r_i, D_i|X_i) = 0$. But what I found from the previous results is that there is a negative correlation in the non-competitive consumer credit market: $Cov(r_i, D_i|X_i) < 0$. It signals that there is an unobserved heterogeneity that affects both contract choice and default behavior. In turn, it implies that both error terms can be decomposed more.

Let Z_i be the dummy of the consumption smoothing group: a group of consumers who have strong consumption smoothing motives.

$$\begin{aligned} \eta_i &= \rho_1 Z_i + \nu_i \\ \epsilon_i &= \pi_1 Z_i + \mu_i \end{aligned}$$

What I expect is that, for the consumers in the consumption smoothing group, $\rho_1 > 0$ (would tend to choose a higher interest rate loan paired with a lower collateral requirement) and at the

Table 10: Loan Choices and Default Tendency of the Consumption Smoothing Group

Dependent Variable	Probit Credit Loan Dummy	OLS Credit Loan Dummy	Probit Default Dummy	OLS Default Dummy
Consumption Smoothing Group	0.317*** (0.053)	0.091*** (0.016)	−0.477*** (0.120)	−0.020*** (0.004)
Credit Ratings	Yes	Yes	Yes	Yes
Consumer Characteristics	Yes	Yes	Yes	Yes
Allow Full Interactions	Yes	Yes	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.				
Observations	14,480	14,480	14,480	14,480

Notes: Table reports the probit and least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

same time $\pi_1 < 0$ (would be less likely to default), which drives the negative correlation between a loan interest rate and default probability.

The first two columns of the Table 10 show that consumers in the consumption smoothing group, compared to those outside of the group, are more likely to choose a credit loan by 9.1 percentage points. Again, noting that a credit loan charges a higher interest rate than a collateralized loan, the consumers in the consumption smoothing group tend to choose a higher interest rate loan as I expected.

At the same time, last two columns of the Table 10 show that the consumers in the consumption smoothing group default 2.0 percentage points less than the consumers outside of the group. Considering that default rate, on average, is about 4.2% in this dataset, those consumers default about 50% less, which is a notable difference.

Further meaningful subdivision is to separate first-time borrowers and repeated borrowers (see Table 11). The bank can collect more precise information on the unobserved default risk during the contract periods. As a result, for the repeated borrowers, the bank has better information on private default risk which facilitates exploiting market power to charge a higher interest rate to the borrowers who are willing to pay to smooth consumption. It results in significant advantageous selection for the repeated borrowers.

However, for the first-time borrowers, there is not only unobserved heterogeneity in consumption smoothing motives but also heterogeneity in default risks, caused by unobserved income volatility and/or unobserved education level. One of the issues of multidimensional unobserved

Table 11: First-time Borrowers V.S. Repeated Borrowers

	Cox PHM	
Dependent Variable	Default Hazard	
Consumer Loans	First-time Borrowers	Repeated Borrowers
Loan interest rate	0.019	-0.184***
	(0.017)	(0.059)
Credit Ratings	Yes	Yes
Consumer Characteristics	Yes	Yes
Allow Full Interactions	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.		
Observations	13,581	899

Notes: Table reports the partial likelihood estimates of the Cox proportional hazard model. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Contract Choices and Default Tendency of First-time and Repeated Borrowers

	OLS			
Consumer Loans	First-time Borrowers		Repeated Borrowers	
Dependent Variable	Credit Loan Dummy	Default Dummy	Credit Loan Dummy	Default Dummy
Consumption Smoothing Group	0.079***	-0.019***	0.206**	-0.025***
	(0.017)	(0.005)	(0.089)	(0.006)
Credit Ratings	Yes	Yes	Yes	Yes
Consumer Characteristics	Yes	Yes	Yes	Yes
Allow Full Interactions	Yes	Yes	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.				
Observations	13,581	13,581	899	899

Notes: Table reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

heterogeneity is that one of the unobserved factors generates a correlation between a loan interest rate and default probability in one direction, while the other factors generate correlations between a loan interest rate and default probability in the opposite direction. Then, those correlations in the opposite direction annihilate each other. The private information on default risks is a source of a positive correlation between a loan interest rate and default probability as classical theories predict. It is because riskier borrowers avoid pledging a high level of collateral for a reduction in an interest rate, while less risk borrowers choose to do so. This positive correlation derived by private information on default risks annihilate the negative correlation derived by private information on consumption smoothing motives as presented in the first column of Table 11. It results in seemingly no significant asymmetric information between the first-time borrowers and the bank. However, it does not imply that there is no asymmetric information between the first-time borrowers and the bank at all.

The first column of Table 12 shows that the consumers who have stronger consumption smoothing motives, among the first-time borrowers, still tend to choose a credit loan which charges a higher interest rate. At the same time, the second column of Table 12 show that those consumers among the first-time borrowers are 1.9 percentage points less likely to default. These two facts

Table 13: Contract Choices of Internet Banking Prefer Group among First-time Borrowers

	OLS	
Consumer Loans	First-time Borrowers	
Dependent Variable	Credit Loan Dummy	Default Dummy
Online Banking Prefer Group	−0.026**	−0.028***
	(0.011)	(0.007)
Credit Ratings	Yes	Yes
Consumer Characteristics	Yes	Yes
Allow Full Interactions	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.		
Observations	13,581	13,581

Notes: Table reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

indicate that the unobserved consumption smoothing motives alone should have generated a negative correlation between a loan interest rate and default probability. However, it has been neutralized by a positive correlation between a loan interest rate and default probability derived by other factors.

Here, I suggest two sources of the positive correlation between a loan interest rate and default probability among the first-time borrowers. First, Table 13 shows that consumers who prefer online banking tend to choose a collateralized loan and at the same time default less, which should have generated a positive correlation between a loan interest rate and default probability, if it were not for unobserved heterogeneity in consumption smoothing motives. Most probable intuition behind this phenomenon is as follows. Usually only highly educated consumers utilize online banking system at that time. Because, it has not been long since the online banking system has been introduced in Korea.[43] Although I control occupation and wage as exogenous variables, the residual variation in education level generates a positive correlation between a loan interest rate and default probability. These highly educated consumers have private information on their default risks, which are relatively less risky. Hence, those consumers choose a collateralized loan

[43]Three bank in Korea introduced the online banking system in July 1999. The system called "Banktown" made by KT Commerce Solution is the first online banking system in Korea. And it is propagated to other banks in early 2000s.

Table 14: Compare Income Volatility: First-time Borrowers V.S Repeated Borrowers

Consumer Loans Dependent Variables	OLS Standard Deviation of Overtime Income
First-time Borrowers	771.29*** (264.63)
Credit Ratings	Yes
Consumer Characteristics	Yes
Allow Full Interactions	Yes
Adaptive lasso has been used to pick the relevant conditional variables.	
Observations	28,605

Notes: Table reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

which charges lower rate.

On top of that, the bank suffers from unobserved heterogeneity in default risk caused by income volatility more with the first-time borrowers. For each individual, I measure the standard deviation of over time income profile. Table 14 shows that the realized income volatility is higher for the first-time borrowers than that of repeated borrowers condition on all the observables used for pricing the loans. A consumer whose income path is more volatile, i.e. riskier, will choose credit loans to avoid losing pledged collateral if she defaults, generating a positive correlation between a loan interest rate and default probability. These two sources of the positive correlation annihilate the negative correlation derived by unobserved heterogeneity in consumption smoothing motives, resulting in seemingly no significant asymmetric information between the bank and the first-time borrowers.

Table 15 shows that, on average, the interest rate gap between credit loans and collateralized loans is much higher for the repeated borrowers. It suggests that the bank exploits the market power more efficiently with repeated borrowers by collecting more information on consumers' hidden types during the loan contract periods.[44] It results in even much stronger negative corre-

[44]Comparing first and third column of Table 12 shows that the tendency of consumption smoothing group to choose

Table 15: Interest Rate Gap between Credit and Collateralized Loans: First-time V.S. Repeated

	OLS	
Dependent Variable	Loan Interest Rate	
Consumer Loans	First-time Borrowers	Repeated Borrowers
Credit Loan Dummy	1.25***	5.03***
	(0.07)	(0.66)
Credit Ratings	Yes	Yes
Consumer Characteristics	Yes	Yes
Allow Full Interactions	Yes	Yes
Adaptive lasso has been used to pick the relevant conditional variables.		
Observations	13,581	899

Notes: Table reports the least squares estimates. Credit ratings includes all the credit rating variables that the bank uses when pricing the loans. It includes credit score and credit class which is provided by a third party credit rating company, and also includes behavior score and first score which are rated by the bank itself. Consumer characteristics includes income, occupation, location, real estate, previous bank loan amount, number of previous loan, and whether she is the owner or the renter of her house. I allow full interaction among the covariates and use adaptive lasso to pick the relevant variables.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

lation between a loan interest rate and default hazard among repeated borrowers.

5 Differential moral hazard on heterogeneous consumption smoothing motives

In the first part of the paper, I provide evidence of advantageous selection in the form of a negative correlation between the interest rate of a loan and the hazard of default in the consumer credit market. Consumers who have strong consumption smoothing motives tend to choose a credit loan, which charges a higher interest rate, and at the same time they default less, generating the negative correlation between a loan interest rate and default risk.

This negative correlation is based on the negative association between consumption smoothing motives and default risk: consumers who have strong consumption smoothing motives are less likely to default.

There are two possible underlying stories that generate the negative association between consumption smoothing motives and default risk.

Hypothesis 1

There is bi-dimensional self-selection: One based on unobserved heterogeneity in consumption smoothing motives and the other based on unobserved heterogeneity in default risk, and they happen to be negatively associated.

Hypothesis 2

There is uni-dimensional adverse selection but there is also moral hazard: there is unobserved heterogeneity in consumption smoothing motives and consumers who are un-observably strongly motivated to smooth consumption exert more costly effort to avoid default since they are more eager to sustain their opportunity to smooth consumption through the credit market, generating the ***endogenous negative association*** between consumption smoothing motives and default risk.

Either hypothesis, combined with the fact that consumers who are strongly motivated to smooth consumption tend to choose a higher interest rate loan, may generate the negative correlation between a loan interest rate and default hazard.

In the second part of the paper, by separately identifying moral hazard from adverse selection, I give empirical evidence in favor of the second hypothesis. I will show that consumers who have stronger consumption smoothing motives indeed exert more costly effort to avoid default. In order to separately identify moral hazard from adverse selection, I exploit dynamic contract features of

credit loans becomes stronger although the interest rate gap between credit loans and collateralized loans becomes higher for the repeated borrowers (Table 15).

this lending contract.

There are at least two broad ways to identify moral hazard from asymmetric information in dynamic setting with panel data (Abbring, Chiappori, and Pinquet (2003), Chiappori and Salanié (2013)). One approach is to compare the features of existing contracts to the theoretical predictions about the form of optimal contracts under adverse selection and moral hazard. This approach exploits the fact that, in a dynamic setting, optimality has different implications in each case. Hence, a careful empirical investigation of the dynamic features of observed contracts may provide useful insights in the type of problem they are designed to address. This approach is very robust if it relies on simple qualitative characteristics of optimal contracts. But except for very specific cases, it is very hard to derive the dynamic optimal contracts under asymmetric information.

Instead, here I follow the second approach, as in Abbring, Chiappori, and Pinquet (2003). This does not assume optimality of the existing contracts. It merely relies on the idea that particular features of existing contracts, whether optimal or not, have different theoretical implications for observed behavior under adverse selection and moral hazard.

More concretely, Abbring, Chiappori, and Pinquet (2003) show that, under the "bonus-malus" mechanism in car insurance markets, moral hazard leads to negative occurrence dependence: the occurrence of an accident increases incentives to prevent an accident in the future and reduces the probability of the future accident. On the other hand, under pure adverse selection, accident probabilities should not respond to the history of accidents.

Regarding the credit market, here I deal with the history of delinquencies, which are the previous steps of the default, and dynamic contract features, especially penalty schemes, related to the history of delinquency. Note that, unlike car accident in which duration of the accident does not make sense, duration of past delinquencies, i.e. time spent in past delinquency states, in addition to the number of past delinquencies, is also included in the history of delinquency.

In Korean credit market, the cost of future delinquency increases in a convex way as both the number and duration of past delinquencies increase. Under such a convex penalty scheme, an occurrence and/or longer duration of delinquency increases the marginal cost of future delinquency, which in turn changes the incentives to prevent future delinquency. As a result, if I find negative occurrence dependence and/or negative lagged duration dependence, it indicates that the Hypothesis 2 is true.

The most important part to exactly figure out negative occurrence dependence and negative lagged duration dependence is to disentangle the unobserved heterogeneity in risk type. If someone simply examines the inter-temporal correlation of delinquency, it is likely to find the positive occurrence and/or positive lagged duration dependence caused by the unobserved heterogeneity in delinquency risk: bad type consumers made more and longer delinquencies in the past and are also more likely to be delinquent in the future, indicating that both negative occurrence and lagged duration dependence are revealed only if successfully conditioning on borrowers' observed and unobserved heterogeneity.

I show that there is indeed negative occurrence and negative lagged duration dependence and it is more conspicuous among consumers who are strongly motivated to smooth consumption. Those consumers are more careful to avoid default so they do not lose their opportunity to smooth consumption through the credit market.

5.1 Dynamic Contract Features in Korean Credit Market

5.1.1 Occurrence Dependence and Lagged Duration Dependece

At an individual level, that is to say conditional on all observables and unobservables, ***occurrence dependence*** means that the number of previous delinquent spells affects the probability that a consumer will become or remain delinquent. Similarly, ***lagged duration dependence*** means that the probabilities of remaining delinquent or becoming delinquent depend on the lengths of previous delinquent spells.

Note that both of them are ***causal relations***: occurrence and/or longer duration of past delinquencies changes the incentives of a borrower, resulting in change in the probability of remaining or becoming delinquent.

Let me set D_t to be a dummy variable which shows the status of delinquency in period t. If delinquency occurs at period t, then $D_t = 1$, otherwise $D_t = 0$.

The mathematical definition of occurrence dependence follows, for each individual i, and $\forall j = 0, 1, 2, ...,$

$$P_i(D_{t+j} = 1 | D_{t-1} = 1) \begin{cases} > P_i(D_{t+j} = 1 | D_{t-1} = 0) : \text{ Positive Occurrence Dependence} \\ = P_i(D_{t+j} = 1 | D_{t-1} = 0) : \text{ No Occurrence Dependence} \\ < P_i(D_{t+j} = 1 | D_{t-1} = 0) : \text{ Negative Occurrence Dependence} \end{cases}$$

In Appendix C., I show that the experience rating scheme used in the Korean consumer credit market causes the negative occurrence dependence and the negative lagged duration dependence by a dynamic optimizing model, which signals the existence of moral hazard. Please see Appendix C. to find the theoretical background of the negative occurrence dependence and negative lagged duration dependence under convex penalty scheme.

5.1.2 Experience Rating in Korean Credit Market

I use the common definition of short term delinquency and long term delinquency. Short term delinquency is defined as being delinquent less than 90 days, while long term delinquency is defined as being delinquent more than 90 days. Long term delinquency is regarded as a default without any special reasons. In this part, I focus on short term delinquency and its negative occurrence and lagged duration dependence in the consumer credit market.

In Korea, when a borrower is delinquent more than 5 business days on a payment of more than about $100, banks report the delinquency to the credit bureau. This information is propagated to all financial institutions in Korea. On top of that, once delinquency is reported to the credit bureau, all payment by credit cards is denied and also the borrower cannot make any additional loans until she repays the delinquent amount.

The exact formula to evaluate the credit score is strictly confidential. Instead, here I list several qualitative features of credit scoring provided by the credit bureau.

1. When delinquency occurs the credit score decreases. How much it decreases depends on the personal characteristics and past history of delinquency. If the borrower was in good standing (high credit score) the amount of decrease is small while the amount of decrease is large if he was in bad standing.

2. If the consumer repays the delinquent amount quickly, only for the first time delinquency, credit score can be recovered to almost same as the original level. How much the credit score is recovered depends on the length of delinquency and amount of delinquency.

3. If the consumer makes the second delinquency in the future, her credit score decreases larger than the first time delinquency even the length of delinquency and the delinquent amount is the same, since there is additional penalty called "cumulative delinquency penalty". As a result, the penalty scheme for credit score is convex.

4. Cumulative delinquency penalty is also applied to the duration of delinquency. For any fixed number of delinquency, if the duration of delinquency increases, then the penalty increases, which means the cost of future delinquency increases.

5. If the cumulative number of days being delinquent reaches 90 days (even if it is reached by several times of separate delinquency), the penalty is huge. It is hard to get any kind of credit (including credit cards) from any financial institution.

A lower credit score affects all kinds of financial contracts. When a consumer borrows money, not only the limit of the loan decreases but also the interest rate increases highly. Furthermore, if a borrower makes several delinquencies, any kind of loan is denied and at the same time, the payment by credit cards is also denied. So she loses ways to smooth consumption.

On top of that, the bank penalizes the borrower by applying an additional penalty interest rate when delinquency occurs. For the short term delinquency, especially less than a month, the bank applies an additional 6% annual interest rate to the delinquent amount. If the borrower has been delinquent more than a month, "acceleration" starts, which means, from that point, the increased annual interest rate is applied not to delinquent amount but to the outstanding debts itself. As a result, monthly due amount increases in a very convex way. If the borrower is delinquent for 3 consecutive months (90 days), an annual interest rate is increased by 7 percentage points and it is applied to the outstanding debts. Furthermore, the bank regards the loan as being default and becomes to have a right to sell collateral at auction to withdraw the bad loan.

Here is an example. Suppose a consumer borrows 100 thousand dollars at 6% annual interest rate. The principal is due at the end of the contract and the borrower only needs to pay monthly interest. According to the contract, monthly interest is $500. If the borrower is delinquent for a month, 6% annual interest rate is added to the original interest rate, leading to 12% annual interest rate to the delinquent amount. So, in the next month she needs to pay $\$1005(= \$505 + \$500)$ to the bank. If the borrower, however, is delinquent for two months, "acceleration" starts: Not to the delinquent amount but to the outstanding debts, 12% interest rate is applied in the second month. So, she needs to pay $\$2005 = [\$505(\text{1st month}) + \$500(\text{2nd month}) + \$1000(\text{"by acceleration"})]$. If the borrower is delinquent again, the bank regards the loan as being default.

5.1.3 Why Delinquency Occurs: ex-ante and ex-post moral hazard

A consumer exerts costly effort to prepare sufficient liquidity to pay her monthly due amount. And then, once the monthly income is realized, the consumer optimally chooses whether to be delinquent or not. If the realized income does not meet the monthly due amount, of course, she will be delinquent. However, even when the consumer can repay the debt, she still may optimally choose not to repay.

If the level of effort to stay liquid is affected by the contract terms, we speak of ***ex-ante moral hazard***. On the other hand, after monthly income is realized, if the optimal decision to being delinquent or not is affected by the contract terms, we speak of ***ex-post moral hazard***.

In the theoretical model in Appendix C., I consider both ex-ante and ex-post moral hazard. The model shows that, under convex penalty scheme, a consumer exerts more effort to prepare liquidity and decreases the threshold income level whether to being delinquent or not.

In the empirical model, however, it is difficult to separate ex-ante moral hazard from ex-post moral hazard in the credit market. In the automobile insurance market, Chiappori and Salanié (2000) discard all accidents in which only one automobile was involved in order to exclude ex-post moral hazard. Whenever, at least, two automobiles are involved, it is hard to optimally choose not to declare. When it comes to the credit market, as far as I know, there is no previous work to separate ex-ante moral hazard from ex-post moral hazard. This will be left for the future work.

5.2 Econometric Model

Here I try two different approaches. I first identify occurrence dependence non-parametrically following Abbring, Chiappori, and Pinquet (2003). Then, I also identify both occurrence dependence and duration dependence parametrically by adopting Doiron and Gørgens (2008).

5.2.1 Non-parametrically Identify Occurrence Dependence

The intuition behind the non-parametric identification under convex penalty scheme, in which an occurrence of delinquency increases the marginal cost of future delinquencies, follows.

Let me start with the restrictive assumption that the contract-time effects is constant: for example, there is no time-variant effect on delinquency hazard. In that case, the distribution, H_1, of the first claim time, T_1, in the subpopulation with exactly one delinquency over the contract period should be uniformly distributed under the null of no moral hazard. However, if there is moral hazard, a consumer responds to the change in incentives. So a delinquency is more likely to occur sooner than later. As a result, if the cumulative distribution function of T_1, is larger in every point than that of the uniform distribution, then we can conclude that there is moral hazard. However, note that null hypothesis becomes there is no moral hazard and stationarity under the assumption of no contract-time effect.

Then, I will relax the restrictive stationarity assumption, the distribution of the first claim time, T_1, does not have to be uniformly distributed anymore. Instead, if we think of the distribution, H_2, of the second claim time, T_2, in the subpopulation with exactly two delinquencies over the contract period,

$$H_1(t)^2 = H_2(t)$$

under the null of no moral hazard.

For delinquency intensity, I use a form which is similar to mixed proportional hazard model. Note that this is not a standard form of a proportional hazard model since it does not have proportional observed part, which is included in individual specific effect λ, and since it includes a term capturing occurrence dependence.

$$\theta(t|\lambda, N[0,t)) = \lambda\beta(\lambda)^{N(t-)}\psi(t)$$

where $\beta(\lambda) : [0, \infty) \to (0, \infty)$ represents a measurable function captures occurrence dependence, where $\psi(t)$ captures contract-time effects, and where $N[0,t) := N(u); 0 \leq u < t$ represents the full history of delinquencies. Note that $N(t)$ is the number of occurrences until time t. The model is quite general except assuming separability.

Here I use data of consumer loans with 24 months maturity, which are observed without censoring. Table 16 shows the number of observations by the number of delinquencies.

Let me define $\Psi(t) = \int_0^t \psi(u)du$. Under stationarity assumption, $\Psi(t) = t/T$, one can show that

$$H_1(t) \equiv \Pr(T_1 \leq t|N(T) = 1) = \Psi(t)$$

under the Null, $\beta(\lambda) = 1$. Also $\Pr(T_1 \leq t|N(T) = 1) \lesseqgtr \Psi(t)$ if $\beta(\lambda) \gtreqless 1$. Figure 1 shows the result.

In Figure 1, the blue line shows the cdf of uniform distribution and the red line shows the empirical cdf of $\Pr(T_1 \leq t|N(T) = 1)$. Under stationarity assumption, the null hypothesis of the test is joint hypothesis of stationarity and no moral hazard. Kolmogorov-Smirnov test result

Table 16: Number of Observations by the Number of Delinquencies

Number of Delinquencies	Observations
M_0 (no delinquency)	2902
M_1 (1 delinquency)	508
M_2 (2 delinquencies)	218
M_3 (3 delinquencies)	110
M_4 (4 delinquencies)	82
M_5 (5 delinquencies)	38
M_6 (6 delinquencies)	17

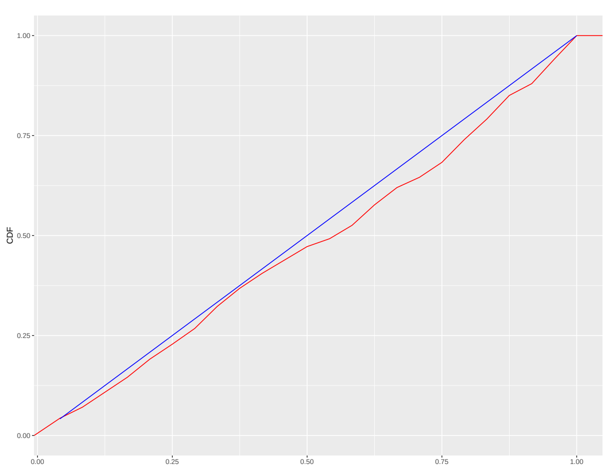

Figure 1: Under Stationarity Assumption

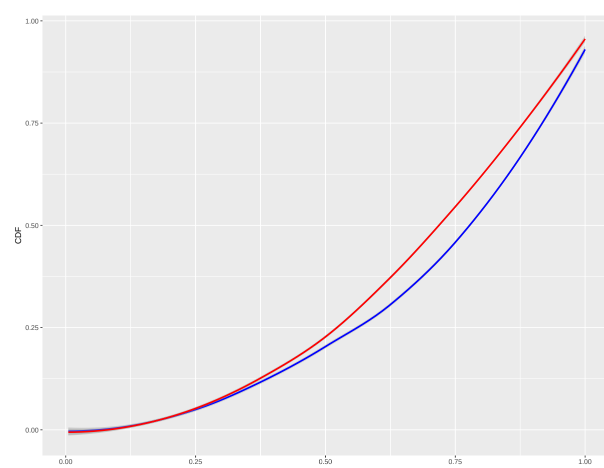

Figure 2: Allow Nonstationarity

shows that $\sup_{t\in[0,T]} |\widehat{H_1(t)} - t/T| = 0.107$, p-value = 0.121, implying that there is insignificant positive occurrence dependence or there is non-stationarity. As I will show later, this comes from non-stationarity rather than positive occurrence dependence.

Stationarity assumption is quite strong, so Abbring, Chiappori, and Pinquet (2003) also introduce test procedure under general non-stationarity.[45] Note that, under non-stationarity, $\Psi(t) \neq t/T$ in general. Under the null, $\beta(\lambda) = 1$, one can show that

$$H_2(t) \equiv Pr(T_2 \leq t|N(T) = 2) = \Psi(t)^2$$

It implies that $[Pr(T_1 \leq t|N(T) = 1)]^2 = Pr(T_2 \leq t|N(T) = 2)$ since $H_1(t) \equiv Pr(T_1 \leq t|N(T) = 1) = \Psi(t)$ under the null. Also $[Pr(T_1 \leq t|N(T) = 1)]^2 \lesseqgtr Pr(T_2 \leq t|N(T) = 2)$ is the evidence of $\beta \lesseqgtr 1$. Again, Kolmogorov-Smirnov (KS) statistic can be applied.

In Figure 2, the red line is the distribution, $H_2 = Pr(T_2 \leq t|N(T) = 2)$, of the second claim time, T_2, in the subpopulation with exactly two delinquencies over the contract period, while the blue line represents $[Pr(T_1 \leq t|N(T) = 1)]^2$. KS test result shows that $\sup_{t\in[0,T]} |\widehat{H_1(t)}^2 - \widehat{H_2(t)}| = 0.125$, p-value = 0.087, which means that there is weak negative occurrence dependence once I allow non-stationarity.

For both subgroups of consumers who have strong consumption smoothing motives or consumers who are relatively weakly motivated to smooth consumption (Figure 3 and Figure 4), KS test results show that there is negative occurrence dependence and the negative occurrence dependence is more conspicuous in the subgroup of consumers who are strongly motivated to smooth consumption. Corresponding KS test results are following. For consumers who are relatively weakly motivated to smooth consumption, $\sup_{t\in[0,T]} |\widehat{H_1(t)}^2 - \widehat{H_2(t)}| = 0.125$, p-value =

[45] For robustness check, more direct comparison of the first and second claim times of each contract with two claims are executed. And the results show that the negative occurrence dependence is very robust.

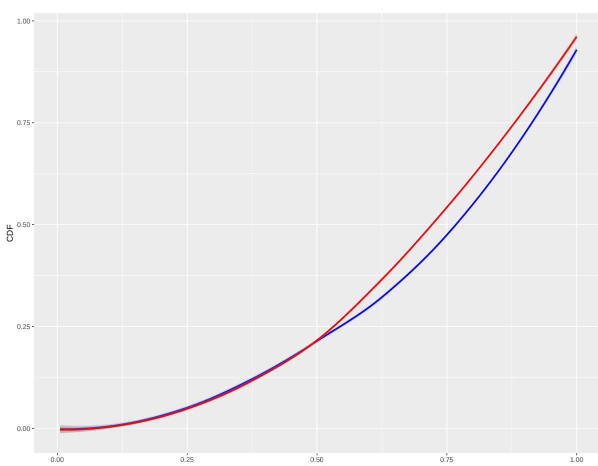

Figure 3: Weakly Motivated Group

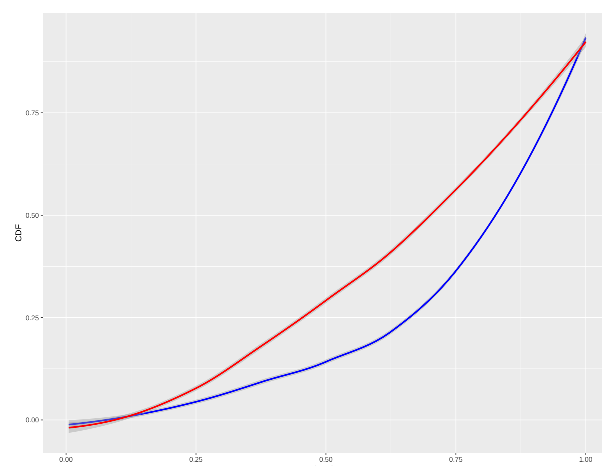

Figure 4: Strongly Motivated Group

0.087. And for consumers who have strong consumption smoothing motives, $\sup_{t\in[0,T]}|\widehat{H_1(t)}^2 - \widehat{H_2(t)}| = 0.25$, p-value = 7.453×10^{-6}. It means that the negative occurrence dependence is more conspicuous among consumers who are strongly motivated to smooth consumption. The test result corresponds to the previous argument that consumers who are strongly motivated to smooth consumption have stronger incentive to prevent default since their opportunity cost of being excluded from the market is higher.

5.2.2 Parametrically Identify Occurrence Dependence and Lagged Duration Dependence

In the Korean consumer credit market, unlike the insurance market described in Abbring, Chiappori, and Pinquet (2003), not only the number of past delinquencies but also the duration of past delinquencies matters. As the duration of past delinquencies becomes longer, the convex penalty scheme increases the marginal cost of future delinquency, resulting in lower probability of future delinquency under moral hazard.

Here, referring to Doiron and Gørgens (2008), I try to estimate both occurrence dependence and lagged duration dependence to find the evidence of moral hazard in the market.

A borrower can be in 3 states (S): Good (G), Delinquency (D), and Default (F). $Y_i(t,s) = \{T_{i,j}, S_{i,j}\}_{j=0}^{J_i(t)}$ represents the delinquency history of person i until period t. Here, j is the transition times and $J_i(t)$ is the maximal number of transitions until period t. Note that $T_{i,j-1} < T_{i,j}$ and $S_{i,j-1} \neq S_{i,j}$.

Let $h(t,s|y(\bar{t},\bar{s}),x(t),v)$ denotes the conditional transition intensity to state s at time t given that the current spell in state $\bar{s}$ began at time $\bar{t}$, where $x(t)$ represents the observed characteristics and v captures unobserved heterogeneity.

The likelihood function becomes,

$$\begin{aligned} L(y_i(t_{i,n_i},s_{i,n_i}),c_i|x_i(c_i),v_i) &= L(c_i|y_i(t_{i,n_i},s_{i,n_i}),x_i(c_i),v_i) \\ &\times (\Pi_{j=1}^{n_i} L(t_{i,j},s_{i,j}|y_i(t_{i,j-1},s_{i,j-1}),x_i(t_{i.j}),v_i)) \\ &\times L(s_{i,0}|t_{i,0},x_i(t_{i,0}),v_i)L(t_{i,0}|x_i(t_{i,0}),v_i) \end{aligned}$$

Here, for $s_{i,j-1} \neq F$

$$\begin{aligned} &L(t_{i,j},s_{i,j}|y_i(t_{i,j-1},s_{i,j-1}),x_i(t_{i,j}),v_i) \\ &= h(t_{i,j},s_{i,j}|y_i(t_{i,j-1},s_{i,j-1}),x(t_{i,j}),v_i) \\ &\times \exp[-\sum_{k\neq s_{i,j-1}} \int_{t_{i,j-1}}^{t_{i,j}} h(u,k|y_i(t_{i,j-1},s_{i,j-1}),x_i(u),v_i)du] \end{aligned}$$

And

$$\begin{aligned} &L(c_i|y_i(t_{i,n_i},s_{i,n_i}),x_i(c_i),v_i) \\ &= \exp[-\sum_{k\neq s_{i,j-1}} \int_{t_{i,n_i}}^{c_i} h(u,k|y_i(t_{i,n_i},s_{i,n_i}),x_i(u),v_i)du] \end{aligned}$$

Table 17: Occurrence Dependence & Lagged Duration Dependence

Consumption Smoothing Group	Number of Past Delinquencies	Duration of Past Delinquencies
Yes	-0.118^{***}	-0.074^{***}
	(0.011)	(0.007)
No	0.005	-0.020^{***}
	(0.004)	(0.003)

Notes: Table reports the maximum likelihood estimates for each separate group. First row shows the estimates for consumers belong to the consumption smoothing group (consumers who have strong consumption smoothing motives) and the second row shows the estimates for consumers not belong to the group.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

And then, integrating out unobserved heterogeneity term.

$$L_i = \int_{-\infty}^{\infty} L(y_i(t_{i,n_i}, s_{i,n_i}), c_i | x_i(c_i), v_i) dF(v_i)$$

The hazard function I use,

$$h(t, s | y(\bar{t}, \bar{s}), x(t), v) = \lambda_{\bar{s},s}(t - \bar{t}; \alpha_{\bar{s},s}) \exp(x(t)'\beta_{\bar{s},s} + y(\bar{t})'\delta_{\bar{s},s} + z(v)'v_{\bar{s},s})$$

where, $\lambda_{\bar{s},s}(t - \bar{t}; \alpha_{\bar{s},s}) = \alpha_{\bar{s},s}(t - \bar{t})^{\alpha_{\bar{s},s}-1}$.

$\delta_{\bar{s},s}$ are the main parameters, which capture negative occurrence dependence and negative lagged duration dependence.

In order to capture the decrease in the penalty for a new delinquency if the latest delinquency occurred a long time ago, I use the following specification.

- Cumulative number : $\sum_{j=1}^{J_i(t)} 1(S_{i,j-1} = s) e^{-\rho_s(t - T_{i,j})}$
- Cumulative duration : $\sum_{j=1}^{J_i(t)} 1(S_{i,j-1} = s) \int_{T_{i,j-1}}^{T_{i,j}} e^{-\rho_s(t - T_{i,j})}$

The parameter ρ_s acts as a "discount" or "depreciation" factor that reduces the impact of a past delinquency as time goes by.

Table 17 shows the maximum likelihood estimates of $\delta_{\bar{s},s}$ when the state changes from good "G" to delinquency "D" separately for the consumers who belong to the consumption smoothing group and who do not belong to the group. Especially, the first column shows the result of the negative occurrence dependence and the second column provides evidence of negative lagged duration dependence.

The results show that not only negative occurrence dependence exists but also negative lagged duration dependence exists. Both negative occurrence dependence and negative lagged duration dependence are stronger for the consumers who have strong consumption smoothing motives. For those consumers, future delinquency hazard decreases by about 11% ($\exp(-0.118) - 1 =$

-0.111) as the consumer had been delinquent one more time, while it decreases by about 7.4% if the consumer had been delinquent 1 more week. On the other hand, for the consumers who do not belong to the consumption smoothing group, future delinquency hazard does not change as the consumer had been delinquent one more time, while there is significant negative lagged duration dependence: future delinquency hazard decreases by about 2% if the consumer had been delinquent 1 more week.

These results show that consumers who have strong consumption smoothing motives exert more costly effort to avoid default, generating ***endogenous negative correlation*** between consumption smoothing motives and default risk. As such, they again show the Hypothesis 2 is better explanation of the data than Hypothesis 1.

6 Concluding Remarks

Classical adverse selection models of the credit market consider heterogeneity in risk type as the sole source of adverse selection. It is reasonable since, in a competitive setting, true risk matters to the uninformed party, even conditional on observables considered when pricing the contracts, while other dimensions of heterogeneity does not. Recent empirical findings in diverse insurance markets emphasize the role of risk aversion as an additional source of heterogeneity. My empirical findings in the *non-competitive* consumer credit market are closely related with those recent findings in the insurance markets based on either alternative source of heterogeneity or multi-dimensional heterogeneity.

By analyzing micro level data from the Korean corporate credit markets, I find weak evidence or no evidence of positive relationship between a loan interest rate and the default hazard once I control for all the observables considered when pricing the loans. It might be because the Korean bank rather precisely prices the corporate loans based on observable risk factors without leaving room for unobserved heterogeneity.

In the case of consumer loans, to the contrary, I find opposite results to what the classical theories predicts. Consumers who borrow money at a higher interest rate are not more but less likely to declare default once all the observables considered when pricing the loans are controlled for, resulting in favorable selection rather than adverse one. Finding favorable selection is unusual in the credit market, but it is not uncommon in insurance markets. In insurance markets, although high risk consumers purchase high coverage, highly risk averse consumers also purchase high coverage. Thus, in so far as those who are more risk-averse are less risky, advantageous selection arises in the insurance market as well as the classical adverse selection. In the insurance market, due to these two opposite selection effects, the claim rates of those who purchase high insurance coverage are not necessarily higher than the claim rates of those who purchase low coverage. But again, it is important to emphasize that this advantageous selection may occur only when the market is non-competitive.

Borrowing this kind of reasoning into the consumer credit market, I provide evidence that unobserved heterogeneity in consumption smoothing motives causes advantageous selection in the consumer credit market. Since consumption smoothing is one of the main reasons why consumers apply for consumer loans, consumers who are more eager to smooth consumption borrow money even at a higher interest rate with a lower collateral requirement. Those consumers are also more likely to pay back the debt for fear of losing access to the future credit market and thus for fear of losing consumption smoothing opportunities in the future.

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Appendix

A Heterogeneous Opportunity Cost of Default

I use a simple two-period model to show that a consumer with lower IES, implying stronger consumption smoothing motives, has a higher opportunity cost of being excluded from the credit market. In other words, I will show that a consumer with low IES is more willing to pay to join the credit market.

The basic steps and ideas are following. In the first step, I will show that the optimal borrowing amount is decreasing in the IES. That is to say, a consumer with low IES tends to borrow more from a bank at any given loan interest rate. And in the second step, more directly, I will show that the ***compensating income variation*** for which the consumer is indifferent to remain in autarky is larger for the consumer with lower IES.

Suppose the income of a consumer in period 1 is y_1 and $y_2 > y_1$ in period 2. Unless the interest rate, $R = 1 + r$, is too high, the consumer will borrow money and try to smooth consumption between period 1 and 2. In the following program, b represents the borrowing amount.

$$
\begin{aligned}
\max_{c_1, c_2, s} \quad & u(c_1) + u(c_2) \\
s.t. \quad & c_1 = y_1 + b \\
& c_2 = y_2 - Rb
\end{aligned}
$$

The first order condition is,

$$
\frac{\partial V}{\partial b} = u'(y_1 + b^*) - Ru'(y_2 - Rb^*) = 0 \tag{11}
$$

Suppose the consumer has iso-elastic utility function: $u(c_t) = \dfrac{c_t^{1-\gamma} - 1}{1-\gamma}$. One can easily show that if the cross partial derivative of the objective function with respect to b and γ is positive, then the optimal borrowing amount $b^*(\gamma)$ is an increasing function in γ.

$$
\begin{aligned}
\frac{\partial^2 V}{\partial b \partial \gamma} &= -(y_1 + b)^{-\gamma} \log(y_1 + b) + R(y_2 - Rb)^{-\gamma} \log(y_2 - Rb) \\
&= (y_1 + b)^{-\gamma} \log(\frac{y_2 - Rb}{y_1 + b}) \\
&= \frac{1}{\gamma}(y_1 + b)^{-\gamma} \log R > 0
\end{aligned}
$$

The last equality follows from the first order condition. Solving the first order condition gives the optimal borrowing amount $b = \dfrac{y_2 - R^{1/\gamma} y_1}{R + R^{1/\gamma}}$. Here, let's define a threshold interest rate R^* which induces $b = 0$, no borrowing point. Then, $R^* = (\frac{y_2}{y_1})^{\gamma}$ increases as γ increases. It means that a consumer with lower IES is willing to pay higher interest cost to join the credit market.

Now, I will show that the amount of compensating income variation, d, for which the consumer is indifferent to remain in autarky is larger for the consumer with lower IES. The steps are following.

1. find the utility V, of a consumer who is allowed to smooth consumption through the credit market
2. find the compensating income variation, d for the consumer to be indifferent whether to remain in autarky or to join the credit market without any compensation.
3. show that d is increasing in γ: $\frac{\partial d}{\partial \gamma} > 0$

From the equation (11), I can get the optimal borrowing amount b^* and the maximized value becomes,

$$V = u(y_1 + b^*) + u(y_2 - Rb^*)$$

Now let's consider the same consumer who is not allowed to join the credit market (Autarky). And let's set the compensation income d that makes the consumer to be indifferent whether to remain in autarky or to join the credit market without any compensation.

$$u(y_1 + d) + u(y_2 + d) = u(y_1 + b^*) + u(y_2 - Rb^*) = V$$

Using the first order Taylor approximation,

$$u(y_1) + u'(y_1)d + u(y_2) + u'(y_2)d = u(y_1) + u'(y_1)b^* + u(y_2) - u'(y_2)Rb^*$$

Then,

$$d = \frac{u'(y_1) - Ru'(y_2)}{u'(y_1) + u'(y_2)} b^*$$

For further illustration, let's assume the consumer has iso-elastic preferences. Then, $b^* = \frac{R^{-\frac{1}{\gamma}} y_2 - y_1}{1 + R^{1-\frac{1}{\gamma}}}$ and d becomes,

$$d = (\frac{y_1^{-\gamma} - Ry_2^{-\gamma}}{y_1^{-\gamma} + y_2^{-\gamma}})(\frac{R^{-\frac{1}{\gamma}} y_2 - y_1}{1 + R^{1-\frac{1}{\gamma}}}) \equiv Qb^*$$

where, $Q = \frac{y_1^{-\gamma} - Ry_2^{-\gamma}}{y_1^{-\gamma} + y_2^{-\gamma}}$. First note that $b^* \geq 0$, when $\gamma \geq \frac{\log R}{\log(y_2/y_1)} \equiv \gamma^*$. Consumers with high enough IES do not join the loan market since they prefer to consume more in the second period rather than to smooth consumption. Also it is easy to check that whenever $b^* \geq 0$, then $Q \geq 0$.

Now since $\frac{\partial Q}{\partial \gamma} = \frac{y_1^{-\gamma} y_2^{-\gamma} \log(y_2/y_1)}{(y_1^{-\gamma} + y_2^{-\gamma})^2} \geq 0$ and since $\frac{\partial b^*}{\partial \gamma} = \frac{\log R}{\gamma^2} \frac{R^{-\frac{1}{\gamma}}}{(1+R^{1-\frac{1}{\gamma}})^2} \geq 0$, the partial derivative of d with respect to γ is positive: $\frac{\partial d}{\partial \gamma} = \frac{\partial L}{\partial \gamma} b^* + L \frac{\partial b^*}{\partial \gamma} \geq 0$.

The result implies that a consumer with low IES needs higher income compensation d to be indifferent whether to remain in autarky or to join the credit market without any compensation. In sum, consumers with low IES have higher opportunity cost of being excluded from the credit market.

B Validity of the proxy for Consumption Smoothing Motives

To directly show that unobserved heterogeneity in consumption smoothing motives, of which IES is used as a shortcut in a theoretical point of view, is the source of advantageous selection, I construct a proxy for IES using the credit card consumption pattern and balance in the savings account.

A set of consumers who

1. have outstanding debt, therefore cannot borrow anymore
2. have zero or small balance in their savings account
3. have upward savings trend or increasing income path
4. use the installment plan

is regarded as a group of consumers who have strong consumption smoothing motives, and I call them "consumption smoothing group". Just to clarify, consumers in the consumption smoothing group should satisfy all three conditions.

Here I prove the validity of the proxy for consumption smoothing motives through a simple two period model. Again, IES is used as a shortcut representing heterogenous consumption smoothing motives in a theoretical perspective.

Suppose a consumer with borrowing constraint ($b \leq 0$ in the model). The only way she can smooth consumption is to save or to join the installment plan by purchasing goods using a credit card. Suppose her income in period 1 is y_1 and $y_2 > y_1$ in period 2. Let $R = 1 + r$ denotes the monthly gross interest from borrowing, and r^I denotes an interest rate imposed to the monthly installment. Note that the installment interest rate is higher than the borrowing rate, $r^I > r$.

A consumer's optimization program is as follows.

$$\begin{aligned}
\max_{c_1, c_1^I, c_2, s} \quad & u(c_1 + c_1^I) + u(c_2) \\
s.t. \quad & \frac{c_1^I}{2} + c_1^I r^I + c_1 = y_1 + b \\
& c_2 = -Rb + y_2 - \frac{c_1^I}{2} - \frac{c_1^I}{2} r^I \\
& b \leq 0 \\
& c_1 \geq 0\ ,\ c_1^I \geq 0\ ,\ c_2 \geq 0
\end{aligned}$$

Here c_t is regular consumption in period t which includes purchasing by cash and by credit cards without the installment plan. And c_1^I is consumption by the installment plan in period 1. From now on, for convenience, let's assume the consumer has iso-elastic utility function.

Then, the Lagrangian equation and the Karush-Kuhn-Tucker problem are as follows.

$$\begin{aligned} L &= \frac{(y_1 + b + \frac{c_1^I(1-2r^I)}{2})^{1-\gamma} - 1}{1-\gamma} + \frac{(-Rb + y_2 - \frac{c_1^I(1+r^I)}{2})^{1-\gamma} - 1}{1-\gamma} \\ &- \lambda_1 b + \lambda_2 (y_1 + b - \frac{(1+2r^I)}{2} c_1^I) + \lambda_3 c_1^I + \lambda_4(-Rb + y_2 - \frac{(1+r^I)}{2} c_1^I) \end{aligned}$$

with,

$$\begin{aligned} c_1 &= y_1 + b - \frac{1+2r^I}{2} c_1^I \\ c_2 &= -Rb + y_2 - \frac{c_1^I}{2} - \frac{c_1^I}{2} r^I \end{aligned}$$

The first order conditions become,

$$\begin{aligned} L_{c_1^I} &= (y_1 + b + \frac{c_1^I(1-2r^I)}{2})^{-\gamma} (\frac{1-2r^I}{2}) - (-Rb + y_2 - \frac{c_1^I(1+r^I)}{2})^{-\gamma} (\frac{1+r^I}{2}) \\ &- \frac{(1+2r^I)}{2} \lambda_2 + \lambda_3 - \frac{(1+r^I)}{2} \lambda_4 = 0 \\ L_b &= -(y_1 + b + \frac{c_1^I(1-2r^I)}{2})^{-\gamma} + R(-Rb + y_2 - \frac{c_1^I(1+r^I)}{2})^{-\gamma} \\ &+ \lambda_1 - \lambda_2 + R\lambda_4 = 0 \end{aligned}$$

Also complementary slackness conditions are

1. $\lambda_1 \geq 0$ and $\lambda_1 b = 0$
2. $\lambda_2 \geq 0$ and $\lambda_2 (y_1 + b - \frac{(1+2r^I)}{2} c_1^I) = 0$
3. $\lambda_3 \geq 0$ and $\lambda_3 c_1^I = 0$
4. $\lambda_4 \geq 0$ and $\lambda_4(-Rb + y_2 - \frac{(1+r^I)}{2} c_1^I) = 0$

Note that the objective function is concave and the constraint set is compact, so the maximization program has a unique maximum. The maximum point depends on the parameter values. Under some parameter values, the maximum point may be characterized by $c_1 = 0$ or $c_2 = 0$. However, here I exclude those candidates since no one indeed does in my dataset. In other words, I only consider parameter values within a reasonable set which excludes no regular consumption, $c_1 = 0$ or $c_2 = 0$, in each period.

Consumption by installment plan c^I can be either 0 or positive. Here I try to show two points.

- Given $\frac{y_2}{y_1}$, and R, there exists a threshold point γ^* such that if $\gamma > \gamma^*$, then $c_1^I > 0$ at the maximum point.
- $\frac{\partial c_1^I}{\partial \gamma} > 0$, when $c_1^I > 0$ at the maximum point.

Now let's solve the program.

1. Suppose $b < 0$ and $c_1^I > 0$, then $\lambda_i = 0 \; \forall i = 1, 2, 3, 4$.[46]

   The first order conditions imply $R = \frac{1+r^I}{1-2r^I}$. It means that only when $R = 1 + r = \frac{1+r^I}{1-2r^I}$, all choice variables are positive at the maximum. Noting that $r < r^I$, $R = 1 + r$ is always less than $1 + r^I$. So this cannot be the maximum point.

2. Suppose $b = 0$ and $c_1^I > 0$, then $\lambda_i = 0 \; \forall i = 2, 3, 4$.

   In this case, the first order conditions give

$$\frac{c_1^I}{2y_2} = \frac{K - \frac{y_1}{y_2}}{(1-2r^I) + (1+r^I)K} \tag{12}$$

   where, $K = [\frac{1-2r^I}{(1+r^I)}]^{1/\gamma}$. Note that $c_1^I > 0$, only when $K > \frac{y_1}{y_2}$. This condition gives the threshold γ^* in which if $\gamma > \gamma^*$, then $c_1^I > 0$, otherwise $c_1^I = 0$. From the condition $K = [\frac{1-2r^I}{(1+r^I)}]^{1/\gamma} > \frac{y_1}{y_2}$, $\gamma^* = \frac{\log(\frac{1+r^I}{1-2r^I})}{\log(\frac{y_2}{y_1})}$

   Now from the equation (12), taking derivative with respect to γ gives,

$$\begin{aligned} \frac{1}{2y_2}\frac{\partial c_1^I}{\partial \gamma} &= \frac{\frac{\partial K}{\partial \gamma}[(1-2r^I) + (1+r^I)K] - (K - \frac{y_1}{y_2})(1+r^I)\frac{\partial K}{\partial \gamma}}{[(1-2r^I) + (1+r^I)K]^2} \\ &= \frac{\frac{\partial K}{\partial \gamma}[(1-2r^I) + \frac{y_1}{y_2}(1+r^I)]}{[(1-2r^I) + (1+r^I)K]^2} \end{aligned}$$

   Since monthly installment interest rate (r^I) is in between $0.83\% \sim 1.78\%$, $(1-2r^I) > 0$. So if $\frac{\partial K}{\partial \gamma} > 0$, then $\frac{\partial c_1^I}{\partial \gamma} > 0$.

   Here, $\frac{\partial K}{\partial \gamma} = \frac{K}{\gamma^2}\ln(\frac{1+r^I}{1-2r^I})$. Note that $\frac{1+r^I}{1-2r^I} > 1$.

   The result implies that a consumer with low IES tends to use installment plan more than a consumer with high IES given $\frac{y_2}{y_1}$.

3. Suppose $b = 0$ and $c_1^I = 0$, which implies Autarky economy. In this case, $c_1 = y_1$ and $c_2 = y_2$.

4. Suppose $b < 0$ and $c_1^I = 0$, then $\lambda_i = 0 \; \forall i = 1, 3, 4$. In this case, from the first order conditions

$$b = -\frac{y_1 - Ny_2}{NR + 1}$$

   where, $N = [\frac{2}{\{1 + r^I + R(1+2r^I)\}}]^{1/\gamma} < 1$.

[46] Again, note that I only consider the case $c_1 > 0$ and $c_2 > 0$.

Note that, $b < 0$ only when $\frac{y_1}{y_2} > N$. Let $\gamma^{**} = \frac{\log(\frac{\{1+r^I+R(1+2r^I)\}}{2})}{\log(\frac{y_2}{y_1})}$, then $b < 0$ only when $\gamma < \gamma^{**}$.

It is not difficult to verify that $\gamma^* > \gamma^{**}$.

In conclusion,

- when $\gamma > \gamma^*$, $c_1^I = \dfrac{2(y_2)K - 2y_1}{(1-2r^I) + (1+r^I)K} > 0$ and at the same time $\dfrac{\partial c_1^I}{\partial \gamma} > 0$.
- when $\gamma \leq \gamma^*$, $c_1^I = 0$, Especially when $\gamma^{**} \leq \gamma \leq \gamma^*$, $c_1^I = 0$ and also $b = 0$, i.e. autarky economy.
- when $\gamma < \gamma^{**}$, then still $c_1^I = 0$ and $b = -\dfrac{y_1 - Ny_2}{NR+1} < 0$, save for the future.

The intuition behind the savings behavior of a consumer with very high IES, i.e. a consumer with very low γ, is simple. Let's consider an extreme case. Consider a consumer with $\gamma = 0$, i.e. the infinite IES. At the optimum, the consumer chooses to save all the income in period 1, $b = -y_1$, unless β is too small. It is because she has a linear utility function, therefore, she saves all the income in the first period to gain interest from the saving, and will spend all in the second period.

In sum, the result implies that a consumer with low IES tends to use installment plan more than a consumer with high IES if their income paths are the same.

C The Model for Negative Occurrence Dependence and Negative Lagged Duration Dependence

Occurrence dependence is a causal relationship in that occurrence of delinquency changes the incentives of a borrower, in turn, changes the probability of future delinquency. Here I try to show that, under convex penalty scheme, if a consumer can change the probability of delinquency by exerting effort, then there should be negative occurrence dependence.

Let me consider a borrower who contracts a loan and receives stochastic flow of income. The borrower may choose to postpone repayment for which I am going to call delinquency. Several model primitives are following.

Model Primitives and Assumptions

1. The contract is composed of (L, T, r_t, m_t), where L is loan amount, T is maturity, r_t is an yearly interest rate, m_t is monthly due amount. Of course, the monthly due amount m_t is determined by L, T, r_t, and the delinquency status of a borrower.

2. Consumer's instantaneous utility is $u(v_t, c_t)$. Utility comes from two arguments, the value of durables, v_t, which can also be used as collateral (like house or car) and non-durable consumption, c_t. Here I assume $u(v_t, c_t)$ is strictly concave, increasing, and twice continuously differentiable in the 2nd argument. Also I assume $\lim_{c_t \to 0} u(v_t, c_t) = -\infty$ and Inada type condition on the second argument.

   (a) $u_2(v_t, c_t) > 0$
   (b) $u_{22}(v_t, c_t) < 0$
   (c) $\lim\limits_{c_t \to 0} u(v_t, c_t) = -\infty$
   (d) $\lim\limits_{c_t \to +\infty} u_2(v_t, c_t) = 0$

3. The income follows a process $y_t = y_0 + e_t + \eta_t$, where y_0 is determined from personal own characteristics, e_t is costly effort, and η_t is stochastic part which is identically and independently distributed across time with $E\eta_t = 0$.

4. $\Gamma(e_t)$ is the cost of effort e_t. Assume that Γ is strictly convex, increasing, and twice continuously differentiable.

   (a) $\Gamma'(e_t) > 0$
   (b) $\Gamma''(e_t) > 0$

5. The value of durables at period 0, v_0, is given; v_t depreciates at a constant rate δ so that $v_t = (1 - \delta)v_{t-1}$.

6. Consumers cannot contract an additional loan during the contract period. I also abstract from savings, which is arguably restrictive.[47]

Time Line

1. At date t, a consumer chooses a level of effort e_t^* which depends on d^{t-1}, the whole history of delinquency until time period $t-1$.

2. η_t is drawn from the distribution, i.e. the monthly income y_t realizes.

3. After the income realizes a consumer chooses whether to be delinquent or not.

Moral Hazard

To define the case without moral hazard, let's think of a specific costly effort function:

$$\Gamma(e_t) = \begin{cases} 0, & \text{if } e_t \leq e_0 \\ \infty, & \text{if } e_t > e_0 \end{cases}$$

Then, a consumer always chooses his effort level $e_t^* = e_0$.

Without moral hazard, the consumer repays whenever he can. So without moral hazard, y_t^* is irrelevant. As a result, given $e_t^* = e_0$, a consumer repays monthly due amount whenever his monthly income realizes not less than the due amount (m_t).

With moral hazard, however, consumer optimizes his own value function and determines the optimal effort level e_t^*. And then the consumer optimally chooses whether to be delinquent or not. In this context it is easy to see that there is negative occurrence dependence if $(y_t^* - e_t^*)$ decreases as the number of past delinquencies increases. Likewise, there is negative lagged duration dependence if $(y_t^* - e_t^*)$ decreases as the duration of past delinquencies increases.

Bellman Equation

A consumer optimally chooses the effort level by solving,

$$e_t^*(v_t, m_t(d^{t-1})) = \underset{e_t}{\text{argmax}} \int V_t(v_t, y_t(d^{t-1}), m_t(d^{t-1}), e_t(d^{t-1})) f(y_t|e_t) dy_t \tag{13}$$

Here, $V_t(v_t, y_t, m_t, e_t, d^{t-1})$, which is explicitly defined below, is the value function by optimally choose delinquency status at period t after the realization of η_t, i.e. the realization of current income y_t. Note that once we condition on $e_t(d^{t-1})$, y_t does not depend on d^{t-1} since the only source

[47] Actually, consumers in my dataset do not save much.

of dependence of y_t on past delinquency is through $e_t(d^{t-1})$.

$$V_t(v_t, y_t(d^{t-1}), m_t(d^{t-1}), e_t(d^{t-1})) = \max_{d_t}\{u(v_t, y_t(d^{t-1}) - m_t(d^{t-1})) - \Gamma(e_t(d^{t-1}))$$
$$+ \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0))$$
$$, u(v_t, y_t(d^{t-1})) - \Gamma(e_t(d^{t-1})) + \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))\} \quad (14)$$

If the cumulative number of days being delinquent reached to 90 days at the decision period t, the consumer loses collateral and at the same time loses all kinds of credits from any financial institutions. (Autarky)

$$V_t(v_t, y_t(d^{t-1}), m_t(d^{t-1}), e_t(d^{t-1})) = \max_{d_t}\{u(v_t, y_t(d^{t-1}) - m_t(d^{t-1})) - \Gamma(e_t(d^{t-1}))$$
$$+ \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) \quad (15)$$
$$, u(v_t, y_t(d^{t-1})) - \Gamma(e_t(d^{t-1})) + \beta E_t V^{Au}_{t+1}(v^D_{t+1}, y_{t+1}(d^{t-1}, d_t = 1))\}$$

where,

$$V^{Au}_t(v^D_t, y_t) = E_t[\sum_{\tau=0}^{\infty} \beta^\tau u(v^D_{t+\tau}, y_{t+\tau})]$$

$v^D_{t+\tau} = 0$ for securitized loans, and $v^D_{t+\tau} = v_{t+\tau}$ for credit loans.

If a consumer repays in the final period.[48]

$$V_{T+1}(v_{T+1}, y_{T+1}(d^T), m_{T+1}(d^T), e_{T+1}(d^T)) = \sum_{\tau=1}^{\infty} \beta^{\tau-1} u(v_{T+\tau}, c_{T+\tau})$$

Here, $c_{T+\tau}$ is the consumption path when the consumer can still participate the financial market.

After the income, y_t, realizes a consumer chooses whether to be delinquent or not. Let us set y^*_t as a threshold level of income that the consumer is indifferent whether to be delinquent or not. The threshold income y^*_t is determined by the equation below.[49]

$$u(v_t, y^*_t - m_t(d^{t-1})) + \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0))$$
$$= u(v_t, y^*_t) + \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1)) \quad (16)$$

[48] If a borrower is delinquent in the last period T, he needs to repay the debt in the next period.

[49] I omit the dependence of y^*_t on d^{t-1}.

Proposition C.1.

There exists a threshold income y_t^*, such that a consumer optimizes to be delinquent if $y_t < y_t^*$, otherwise repays the monthly due amount. Furthermore, $y_t^*(\beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))])$ is decreasing in the argument.

Proof.

y_t^* satisfies the below equation which comes from the equation (16)

$$\begin{aligned} & u(v_t, y_t^*) - u(v_t, y_t^* - m_t(d^{t-1})) \\ = \; & \beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - \\ & V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))] \end{aligned} \tag{17}$$

- Existence

  First, by the strict increasing concavity in the 2nd argument of $u(v_t, c_t)$ and the optimality of $e_{t+1}^*(d^{t-1}, d_t = 0)$, it is easy to see that

  $$\begin{aligned} & E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) \\ > \; & E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 1)) \\ > \; & E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1)) \end{aligned}$$

  And note that $u(v_t, y_t) - u(v_t, y_t - m_t)$ is continuous in y_t. Since $u(v_t, y_t)$ is twice continuously differentiable in the 2nd argument, $u(v_t, y_t) - u(v_t, y_t - m_t) = u(v_t, y_t) - u(v_t, y_t) - u_2(v_t, c_t^*)(-m_t) = m_t u_2(v_t, c_t^*)$, where $c_t^* \in (y_t - m_t, y_t)$. As a result, $\lim_{y_t \to +\infty}[u(v_t, y_t) - u(v_t, y_t - m_t)] = 0$. Also since $\lim_{c_t \to 0} u(v_t, c_t) = -\infty$, it is easy to show that $\lim_{y_t \to m_t}[u(v_t, y_t) - u(v_t, y_t - m_t)] = +\infty$. In sum,

  1. $u(v_t, y_t) - u(v_t, y_t - m_t)$ is continuous in y_t.
  2. $\lim_{y_t \to +\infty}[u(v_t, y_t) - u(v_t, y_t - m_t)] = 0$.
  3. $\lim_{y_t \to m_t}[u(v_t, y_t) - u(v_t, y_t - m_t)] = +\infty$.
  4. $E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)$
     $> E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))$

  These four facts give the existence of $y_t^* \in (m_t, +\infty)$.

- Uniqueness

  Uniqueness directly comes from the strict concavity of $u(v_t, c_t)$ in the 2nd argument. Suppose there exists $y_t^* \neq y_t^{**}$ such that

$$\begin{aligned} & u(v_t, y_t^*) - u(v_t, y_t^* - m_t) \\ = \;& \beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - \\ & V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))] \end{aligned}$$

$$\begin{aligned} & u(v_t, y_t^{**}) - u(v_t, y_t^{**} - m_t) \\ = \;& \beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - \\ & V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))] \end{aligned}$$

Since $u_{22}(v_t, c_t) < 0$

$$\begin{aligned} \partial/\partial y_t[u(v_t, y_t) - u(v_t, y_t - m_t)] &= u_2(v_t, y_t) - u_2(v_t, y_t - m_t) \\ &= u_2(v_t, y_t) - [u_2(v_t, y_t) + u_{22}(v_t, c_t^{**})(-m_t)] = u_{22}(v_t, c_t^{**})m_t < 0 \end{aligned}$$

where, $c_t^{**} \in (y_t - m_t, y_t)$

So, if $y_t^* \neq y_t^{**}$, $u(v_t, y_t^*) - u(v_t, y_t^* - m_t) \neq u(v_t, y_t^{**}) - u(v_t, y_t^{**} - m_t)$. Contradiction.

- Property

  Now let's focus on proving $y_t^*(\beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))])$ is increasing in the argument.

  Since, $\partial/\partial y_t[u(v_t, y_t) - u(v_t, y_t - m_t)] < 0$, if RHS of equation (17), which is the argument itself, increases then y_t^* decreases.

As I showed in Proposition C.1, if $E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))]$ increases as the number of past delinquencies and/or duration of past delinquencies increases. In turn, it means y_t^* decreases as the past number of delinquencies increases. I insist, under the convex penalty scheme and if marginal cost of increasing effort level is high enough then $E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))]$ increases as the number of past delinquencies and/or duration of past delinquencies increases.[50] As a result, optimal income threshold $y_t^*(d^{t-1})$ is decreasing in the number of past delinquencies and/or duration of past delinquencies.

[50] Note that as the number of past delinquencies changes, all future optimal level of effort also changes. If this change is large, $E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 0), m_{t+1}(d^{t-1}, d_t = 0), e_{t+1}(d^{t-1}, d_t = 0)) - V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t = 1), m_{t+1}(d^{t-1}, d_t = 1), e_{t+1}(d^{t-1}, d_t = 1))]$ may not increase in d even under convex penalty scheme. To prevent those result, here I assume the marginal cost of increasing effort level is high.

Now, let's focusing on the optimal effort problem of the consumer.

Proposition C.2.

The optimal effort level, $e_t^*(d^{t-1})$, increases as the past number of delinquencies and/or the past duration of delinquencies increases when m_t is relatively small.

proof.

From equation (13),

$$\begin{aligned}
e_t^* &= \underset{e_t}{\operatorname{argmax}} \int V_t(v_t, y_t, m_t, e_t, d^{t-1}) f(y_t|e_t) dy_t \\
&= \underset{e_t}{\operatorname{argmax}} \int_{y_t^*-y_0-e_t}^{\infty} [u(v_t, y_t(d^{t-1}) - m_t(d^{t-1})) + \\
&\quad \beta E_t V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=0), m_{t+1}(d^{t-1}, d_t=0), e_{t+1}(d^{t-1}, d_t=0), (d^{t-1}, d_t=0))] f(\eta_t) d\eta_t \\
&\quad + \int_{-\infty}^{y_t^*-y_0-e_t} [u(v_t, y_t(d^{t-1}) - m_t(d^{t-1})) + \\
&\quad \beta V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=1), m_{t+1}(d^{t-1}, d_t=1), e_{t+1}(d^{t-1}, d_t=1), (d^{t-1}, d_t=1))] f(\eta_t) d\eta_t \\
&\quad - \Gamma(e_t)
\end{aligned} \tag{18}$$

Using the Leibniz rule, first order condition of equation (18) becomes,

$$\begin{aligned}
\Gamma'(e_t^*) &= f(y_t^* - y_0 - e_t^*)[\{u(v_t, y_t^* - m_t(d^{t-1})) - u(v_t, y_t^*)\} \\
&+ \beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=0), m_{t+1}(d^{t-1}, d_t=0), e_{t+1}(d^{t-1}, d_t=0), (d^{t-1}, d_t=0)) \\
&- V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=1), m_{t+1}(d^{t-1}, d_t=1), e_{t+1}(d^{t-1}, d_t=1), (d^{t-1}, d_t=1))]] \\
&\quad + \int_{y_t^*-y_0-e_t^*}^{\infty} u_2(v_t, y_0 + e_t^* + \eta_t - m_t) f(\eta_t) d\eta_t \\
&\quad + \int_{-\infty}^{y_t^*-y_0-e_t^*} u_2(v_t, y_0 + e_t^* + \eta_t) f(\eta_t) d\eta_t
\end{aligned}$$

From equation (16), we know that

$$\begin{aligned}
&u(v_t, y_t^* - m_t(d^{t-1})) - u(v_t, y_t^*) \\
+ \ &\beta E_t[V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=0), m_{t+1}(d^{t-1}, d_t=0), e_{t+1}(d^{t-1}, d_t=0), (d^{t-1}, d_t=0)) \\
- \ &V_{t+1}(v_{t+1}, y_{t+1}(d^{t-1}, d_t=1), m_{t+1}(d^{t-1}, d_t=1), e_{t+1}(d^{t-1}, d_t=1), (d^{t-1}, d_t=1))] = 0
\end{aligned}$$

So the F.O.C becomes,

$$\Gamma'(e_t^*) = \int_{y_t^*-y_0-e_t^*}^{\infty} u_2(v_t, y_0 + e_t^* + \eta_t - m_t) f(\eta_t) d\eta_t + \int_{-\infty}^{y_t^*-y_0-e_t^*} u_2(v_t, y_0 + e_t^* + \eta_t) f(\eta_t) d\eta_t \tag{19}$$

Now using the implicit function theorem,

$$
\begin{aligned}
&[\Gamma''(e_t^*) - \{u_2(v_t, y_t^* - m_t) - u_2(v_t, y_t^*)\} f(y_t^* - y_0 - e_t^*) \\
&- \int_{y_t^* - y_0 - e_t^*}^{\infty} u_{22}(v_t, y_0 + e_t^* + \eta_t - m_t) f(\eta_t) d\eta_t - \int_{-\infty}^{y_t^* - y_0 - e_t^*} u_{22}(v_t, y_0 + e_t^* + \eta_t) f(\eta_t) d\eta_t] \frac{\partial e_t^*}{\partial y_t^*} \\
&= -\{u_2(v_t, y_t^* - m_t) - u_2(v_t, y_t^*)\} f(y_t^* - y_0 - e_t^*)
\end{aligned}
$$

Note that $\Gamma''(e_t^*) > 0$, $\{u_2(v_t, y_t^* - m_t) - u_2(v_t, y_t^*)\} f(y_t^* - y_0 - e_t^*) > 0$, and $u_{22}() < 0$.

So if

$$
\begin{aligned}
&\Gamma''(e_t^*) - \int_{y_t^* - y_0 - e_t^*}^{\infty} u_{22}(v_t, y_0 + e_t^* + \eta_t - m_t) f(\eta_t) d\eta_t - \int_{-\infty}^{y_t^* - y_0 - e_t^*} u_{22}(v_t, y_0 + e_t^* + \eta_t) f(\eta_t) d\eta_t \\
&> \{u_2(v_t, y_t^* - m_t) - u_2(v_t, y_t^*)\} f(y_t^* - y_0 - e_t^*) \qquad (20)
\end{aligned}
$$

then, $\frac{\partial e_t^*}{\partial y_t^*} < 0$.

If m_t is relatively small, inequality (20) is satisfied. q.e.d

The intuition behind the need of relatively small m_t is that effort reduces the utility not only in case of well-repayed but also in case of delinquency, so that a risk averse consumers facing high m_t may opt for increasing his worst-case income instead of reducing the probability of delinquency.

In sum, as the number and/or duration of past delinquencies increases, y_t^* decreases by Proposition C.1, and e_t^* increases by Proposition C.2. As a result, $(\max\{y_t^*, m_t\} - e_t^*)$ decreases, i.e. there are negative occurrence dependence and negative lagged duration dependence.

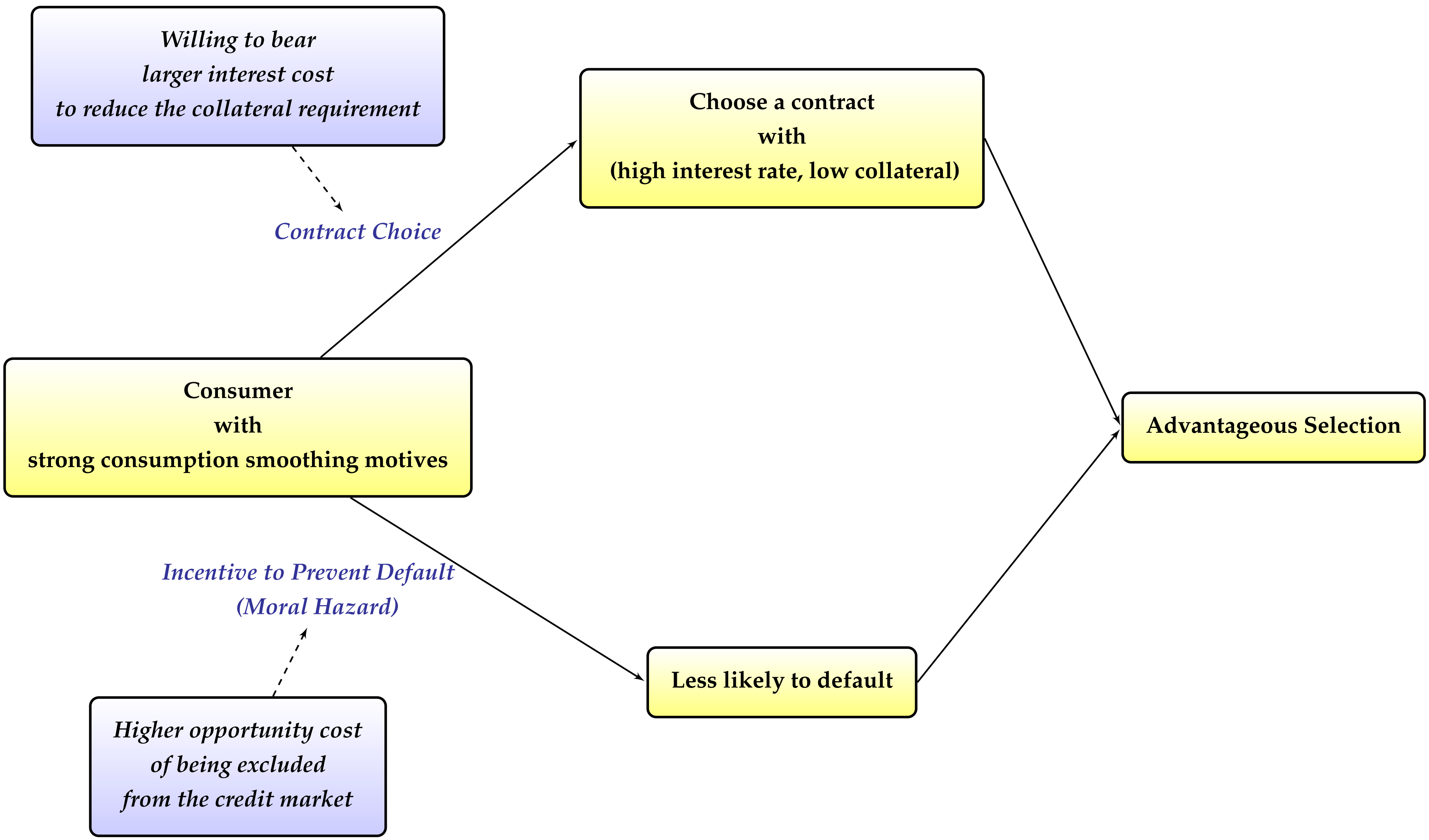

Figure C.1: **The Source and The Mechanism of Advantageous Selection**

D History of Bank Merging in Korea

<table>
<tr><td>91</td><td>92</td><td>93</td><td>94</td><td>95</td><td>96</td><td>97</td><td>98</td><td>99</td><td>00</td><td>01</td><td>02</td><td>03</td><td>04</td><td>05</td><td>06</td><td>07</td><td>08</td><td>09</td><td>10</td><td>11</td><td>12</td><td>13</td></tr>
<tr><td colspan="7">KB Kookmin Bank (A)</td><td colspan="3" rowspan="3">KB Kookmin Bank (B)</td><td colspan="13" rowspan="6">KB Kookmin Bank (C)</td></tr>
<tr><td colspan="7">Daedong Bank</td></tr>
<tr><td colspan="7">Korea Long-Term Credit Bank</td></tr>
<tr><td colspan="7">Housing & Commercial Bank (A)</td><td colspan="3" rowspan="3">Housing & Commercial Bank (B)</td></tr>
<tr><td colspan="7" rowspan="2">Dongnam Bank</td></tr>
<tr></tr>
<tr><td colspan="7">KEB Hana Bank (A)</td><td rowspan="4">KEB Hana Bank (B)</td><td colspan="3" rowspan="5">KEB Hana Bank (C)</td><td colspan="12" rowspan="6">KEB Hana Bank (D)</td></tr>
<tr><td colspan="7" rowspan="3">The Chungchong Bank</td></tr>
<tr></tr>
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<tr><td colspan="8">Boram Bank</td></tr>
<tr><td colspan="11">Seoul Bank</td></tr>
<tr><td colspan="7">Shinhan Bank (A)</td><td colspan="8" rowspan="2">Shinhan Bank (B)</td><td colspan="8" rowspan="5">Shinhan Bank (C)</td></tr>
<tr><td colspan="7">Dong Hwa Bank</td></tr>
<tr><td colspan="8">Chohung Bank (A)</td><td colspan="7" rowspan="3">Chohung Bank (B)</td></tr>
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<tr><td colspan="8">Kangwon Bank</td></tr>
<tr><td colspan="8">The Commercial Bank of Korea</td><td colspan="3" rowspan="2">Hanvit Bank</td><td colspan="12" rowspan="3">Woori Bank</td></tr>
<tr><td colspan="8">The Hanil Bank</td></tr>
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<tr><td colspan="14">Jeil Bank</td><td colspan="9">Standard Chartered Bank Korea</td></tr>
<tr><td colspan="23">Korea Exchange Bank</td></tr>
<tr><td colspan="23">Industrial Bank of Korea</td></tr>
<tr><td colspan="23">Local Banks</td></tr>
</table>

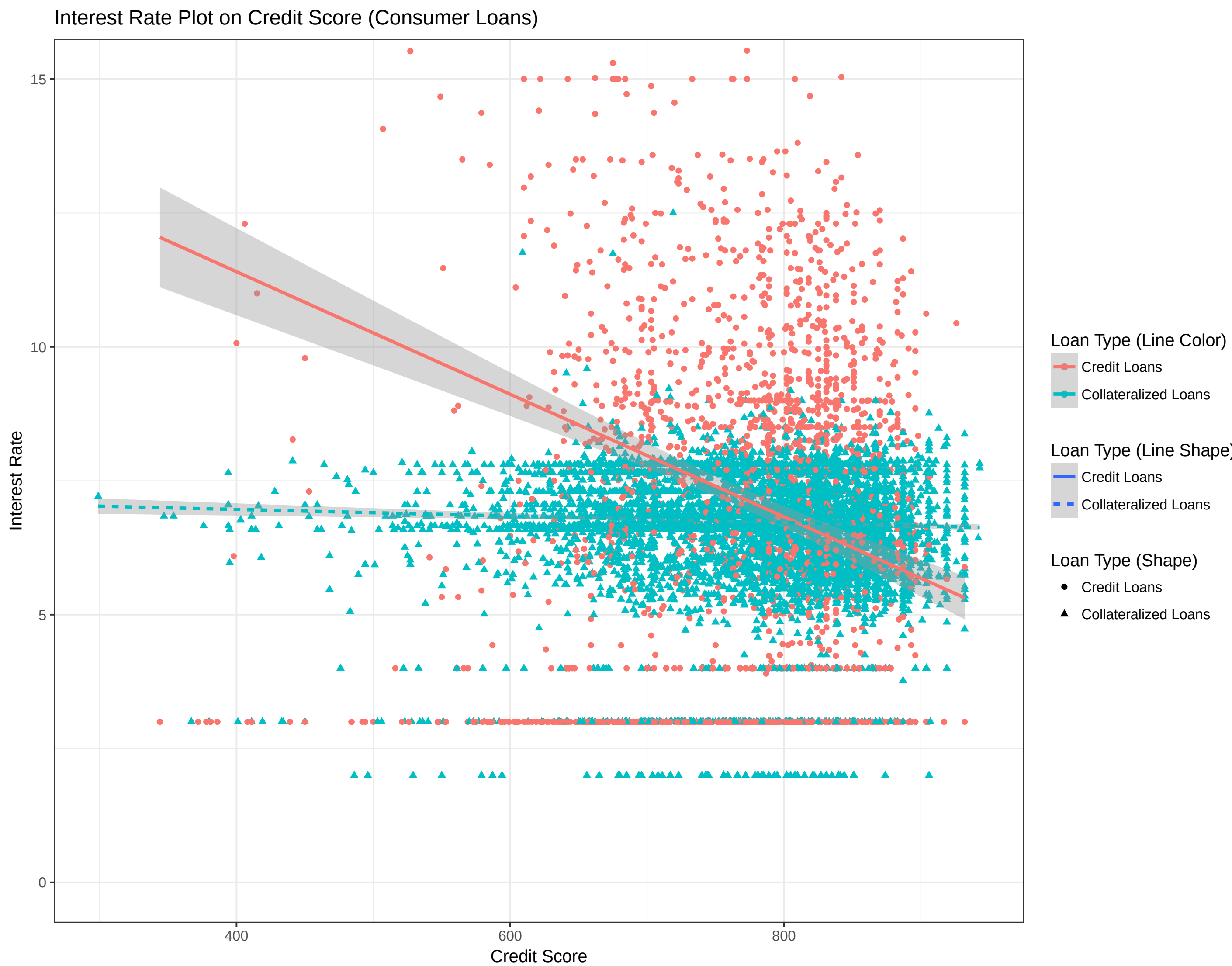
History of Bank Merging in Korea (Source: Bank of Korea)

E Interest Rate Plot on Credit Score

E.1 Corporate Loans

The above plot is the interest rate plot on credit score for corporate loans. The interest rates of both credit loans and collateralized loans decrease as the credit score increases since bank charges higher rate to the firms with lower credit score.

E.2 Consumer Loans



The above plot is the interest rate plot on credit score for consumer loans. Note that the interest rates of credit loans significantly decrease as the credit score increases while those of collateralized loans almost stay the same. It is because, for consumer loans, approved amounts of collateralized loans are usually less than the value of collateral, indicating full recovery even when a consumer defaults. With full recovery, credit score does not affect to the interest rate much. Also note that there are several loans with a very low interest rate which are only offered to specific group of borrowers, e.g. employees by government or by major companies etc., implying that it is important to condition on individual occupations while empirically detecting asymmetric information.

F Survival Plots

F.1 Corporate Loans

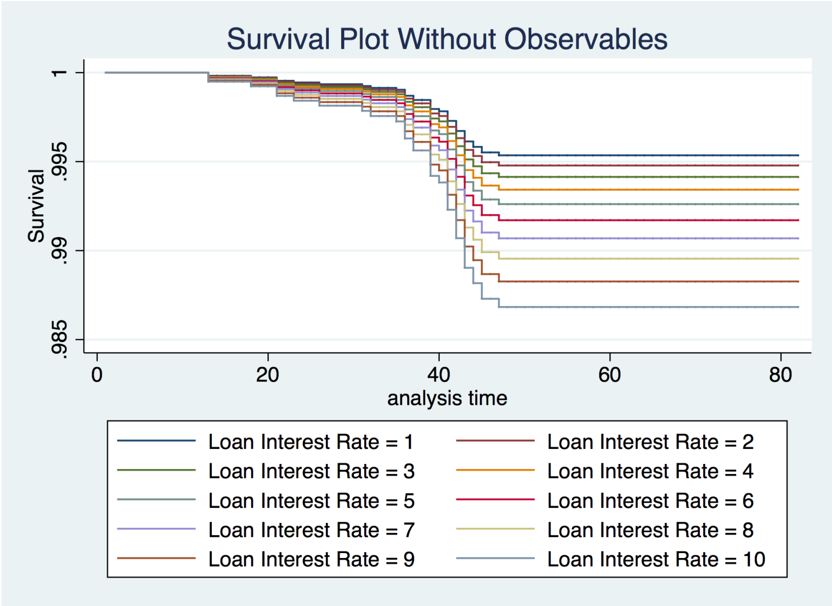


Figure F.1

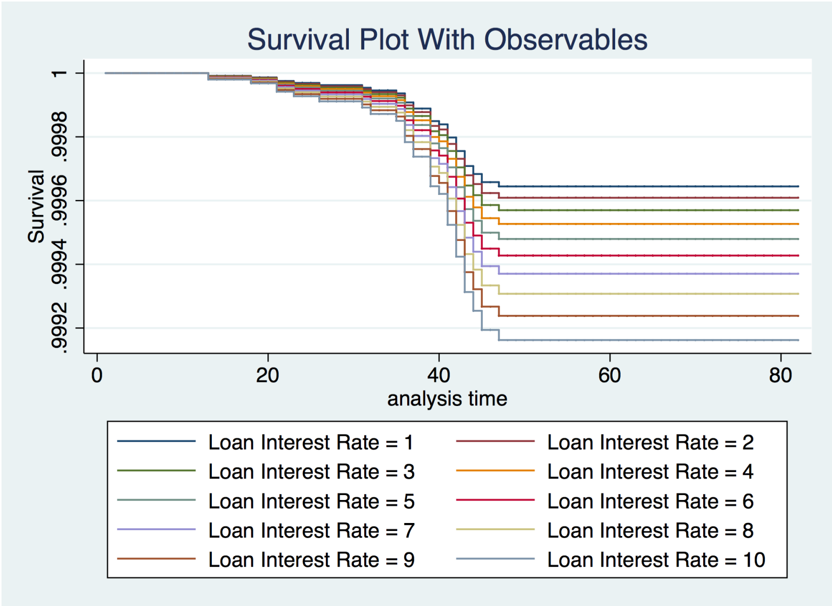


Figure F.2

F.2 Consumer Loans

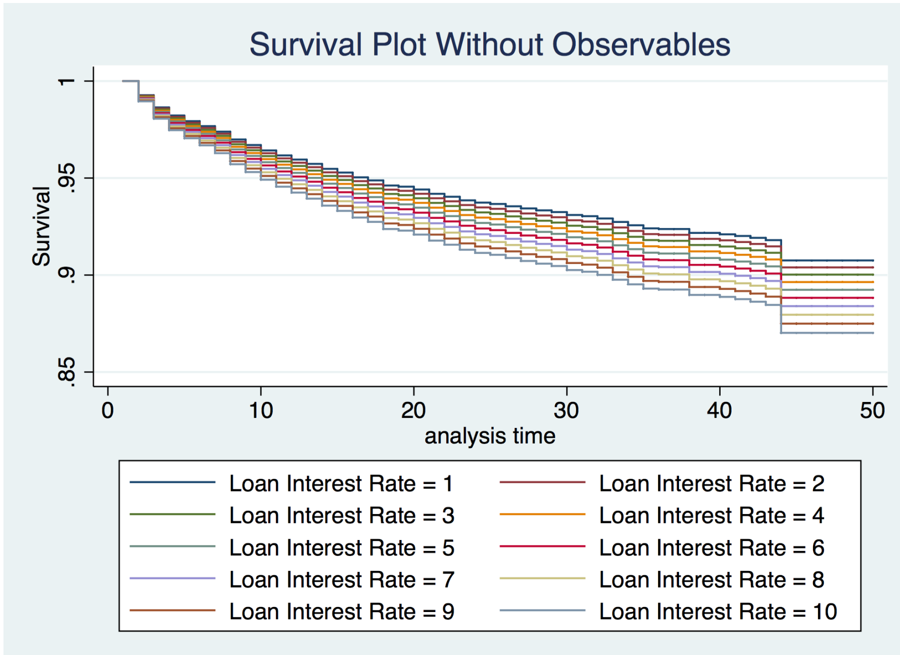


Figure F.3

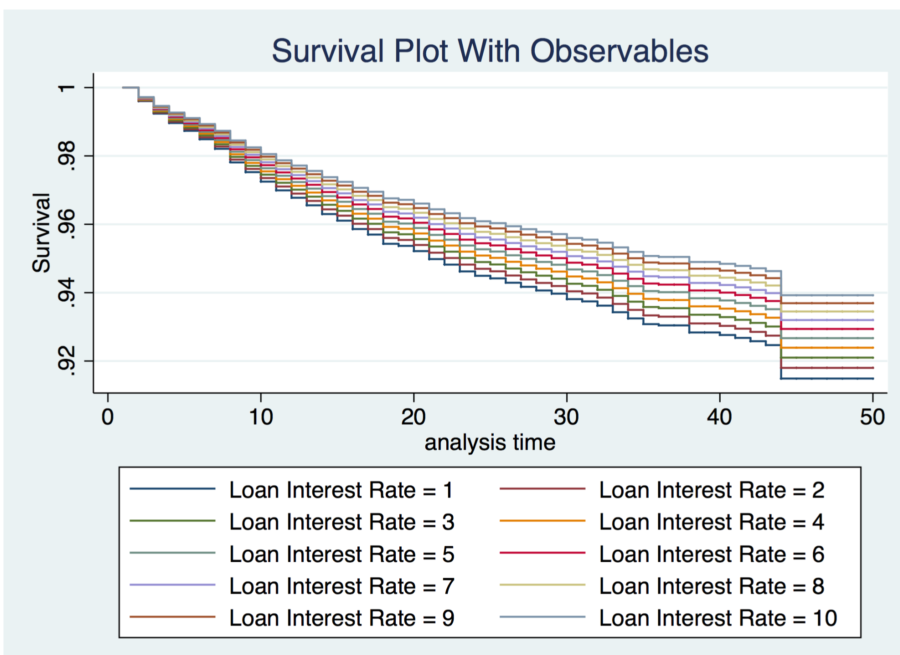


Figure F.4