Multidimensional heterogeneity and nature of selection in consumer credit market

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Abstract

Consumers in the credit market are heterogeneous not only in their risk type but also in their inter-temporal elasticity of substitution (IES). Like for firms, unmeasured heterogeneity in risk type causes a positive relation between interest rate and default. Unlike for firms, though, unmeasured heterogeneity in IES causes a negative relation between interest rate and default. It is because consumers with a lower degree of IES enjoy a bigger utility gain from inter-temporal 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. By estimating proportional hazard models with varying sets of control variables, we have found that once observable risk factors are controlled for those consumers who borrow money at a higher interest rate are not more but less likely to default, an evidence counter to Stiglitz and Weiss (1981)'s theoretical prediction on borrowing firms. Consumers are not like firms in the credit market.

Keywords: asymmetric information, credit market, default, heterogeneity, inter-temporal elasticity of substitution, risk aversion
JEL Classification: D14, D82, D91, D92

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1 Introduction

In the credit market, are the borrowing consumers different from the borrowing firms? According to Stiglitz and Weiss (1981), under information asymmetry in the corporate credit market, interest rate functions as a screening device such that a higher interest rate attracts those firms that are worse on average in terms of default risk. We have found that, in the Korean consumer credit market, among the observationally equivalent consumers in terms of risk type, those who borrow money at a higher interest rate are less likely to default, an evidence counter to Stiglitz and Weiss (1981)'s theoretical prediction on firms.

In this paper, we develop a model that suggests a negative relationship between the loan interest rate and the default probability for the consumer loans and empirically test the negative relationship in the consumer credit market. As a safety check, we also test Stiglitz and Weiss (1981)'s theoretical prediction on the borrowing firms using firm level data.

According to Chiappori, Jullien, Salanié, and Salanié (2006), risk aversion becomes a key parameter when it comes to imperfect competition. In consumer credit market, we believe that inter-temporal elasticity of substitution[3] becomes a key parameter when it comes to consumer loans.

After the 1997 Asian financial crisis, the Korean credit market had gone through a huge reconstruction initiated by governmental authority. Many banks abruptly disappeared from the market, resulting in increasing market power for small number of large surviving banks. According to Lee and Lee (2004), Herfindhal-Hirschman Index (HHI)[4], which is a measure of the degree of market concentration, had risen from 835 in year 1995 to 2,262 in year 2002 for the consumer loan market. During the same period, HHI had increased from 716 to 1,334 for the corporate loan market. The U.S. Department of Justice considers a market with HHI of less than 1,000 to

[3]If we assume that preference can be represented by time separable von Neumann-Morgenstern utility function, risk aversion and inter-temporal elasticity of substitution are two opposite representations of the same information. If per-period utility function is of CRRA type, then inter-temporal elasticity of substitution is just inverse of risk aversion.

[4]$HHI = \sum s_i^2$, where s_i is the percentage(%) market share of the i^{th} firm. HHI takes a value in the range $(0, 10, 000)$.

be a competitive market, $1,000 \sim 1,800$ to be a moderately concentrated market, and 1,800 or greater to be a highly concentrated market. In year 2002, the Korean consumer loan market was highly concentrated and the Korean corporate loan market moderately concentrated. Our sample covers reconstruction period in Korea.

If heterogeneity among the borrowing consumers lies in their degrees of intertemporal elasticity of substitution (IES), a financial contract with a higher interest rate is more likely to attract those consumers with a lower degree of IES among a group of consumers who are observationally equivalent in terms of risk type. These consumers 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.

Heterogeneity among potential market participants and the resulting adverse selection is an essential element of credit market, insurance market, marriage market, used car market, and many other markets. In this paper, we argue that, while firm level heterogeneity is well characterized in terms of risk type, consumer level heterogeneity has additional dimension in terms of IES. Let us briefly sketch our model. After classifying the consumers based on their observable risk factors, banks randomly suggest contracts of high or low interest rates.[5] Consumers with a lower degree of IES always accept contracts whether offered interest rate is high or low. It is because their willingness to pay is higher than even the higher interest rate charged by the bank. Consumers with a higher degree of IES, on the other hand, selectively accept contracts only when the offered interest rate is low. It is because their willingness to pay lies in-between the two offered interest rates. Those consumers with a lower degree of IES are rationally less likely to choose personal bankruptcy as they suffer more from denial of access to the consumer credit market in the future and the resulting denial of consumption smoothing opportunity, generating a negative relationship

[5] Interest rate, in general, is negatively correlated with the value of pledged collateral since the recovery rate, which is a portion of money recovered when there is default, increases as pledged collateral increases. This feature is quite general. Dey and Dunn (2006) empirically shows negative relation between the value of the collateral pledged by borrowers and the interest rate charged by bank in the HELOC (Home Equity Line of Credit) market. With this result, they support 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.

between the loan interest rate and the default risk in the consumer credit market.

The rest of the paper is organized as follows. Section 2 briefly touches on classical and recent issues in the insurance and the credit markets. Section 3 presents a theoretical model suggesting a negative relationship between the loan interest rate and the default rate in the consumer credit market. Heterogeneity in degree of IES among the borrowing consumers plays an important role in deriving the negative relationship. Using firm and individual level data on the Korean credit markets, section 4 empirically tests a positive relationship between the interest rate and the default probability for the corporate loans, and a negative relationship between the interest rate and the default probability for the consumer loans. Section 5 concludes the paper.

2 Insurance Market vs. Credit Market

Before analyzing the credit market, it is useful to review classical and recent issues in the insurance market in terms of asymmetric information. The insurance market is similar to the credit market in that market participants are heterogeneous and thus cause selection issues. Of course, the source of heterogeneity and the resulting nature of selection are different across the two markets.

Existing theories on the insurance market identify two important aspects of asymmetric information, moral hazard (incentive effect) and adverse selection (selection effect). Moral hazard states that purchasers of insurance with a high coverage become less cautious and more risk prone. Adverse selection predicts that high risk individuals tend to buy high coverage insurance (see Rothschild and Stiglitz 1976). As a combined effect of moral hazard and adverse selection, higher claim rates are predicted to be associated with a higher coverage in the insurance market.

There has been much empirical research to test whether moral hazard and adverse selection actually exist in various insurance markets. The basic idea is to compare claim rates across those who purchase different insurance packages in terms of (coverage, premium) combination. A finding that those who purchase (higher coverage, higher premium) package exhibit a higher claim rate, conditional on information available to insurance companies, suggests existence of asymmetric information. Existing literature documents mixed empirical results.

Puelz and Snow (1994) show that, within each observable risk category, consumers of a higher risk type choose a contract with a lower deductible, and that contracts with a lower deductible are associated with higher average premium per coverage, which suggests presence of adverse selection. Cawley and Philipson (1999), to the contrary, observe that asymmetric information does not exist in the insurance market. They find that mortality rate of the U.S. males who purchase life insurance is below that of the uninsured even after controlling for many observable factors, that low risk consumers hold more coverage, and that the marginal price of insurance does not rise with insurance coverage.

Chiappori and Salanié (2000) emphasize that selection issue in the insurance market applies only to those who belong to the same risk class sharing the same observable risk factors. According to their empirical study in the auto insurance market, a positive correlation between coverage and accident probability is not observed anymore once several observable risk factors are controlled for, especially those observables that are taken into account when setting insurance premium. They introduce a so called positive correlation test to test presence of asymmetric information in contractual relationship.

By estimating a model that integrates both health insurance and health care, Cardon and Hendel (2001) find no evidence of asymmetric information, and thus no reason to expect any gap in health care expenditures between the insured and the uninsured. They claim that it is not the asymmetric information but the combined effect of price, income, and demographic differences that explains expenditure gap between the insured and the uninsured. Finkelstein and Poterba (2004) also find no evidence of substantive differences in mortality rates by annuity size, even though they find a systematic relationship between mortality and other annuity characteristics such as timing of payments and possibility of payments to annuitant's estate. Using Israeli auto insurance data, Cohen (2005), on the other hand, finds that those auto insurance purchasers who choose a lower deductible tend to have more accidents, leading to higher total losses for the insurance company. Such coverage-accident correlation exists only for policyholders with enough years of driving experience.

These papers show that evidences on asymmetric information and adverse selection are mixed. Cohen and Siegelman (2010) warn that one should not jump to the conclusion that these studies are mutually contradictory. They argue that the mixed results rather imply that existence of adverse selection varies across markets, and across segments even within a market.

Also, other sources of heterogeneity than the personal risk types are important in understanding selection issues in the insurance market. Across various insurance markets, depending on sources of heterogeneity, one could find not only evidences of adverse selection but also those of advantageous selection. Finkelstein and McGarry (2006) introduce the concept of multi-dimensional heterogeneity into empirical analyses of insurance markets. They test existence of information asymmetry in the long term care insurance market based on two-dimensional heterogeneity: heterogeneity in risk type and heterogeneity in risk aversion. These two sources of heterogeneity counteract each other in terms of adverse vs. advantageous selection. Those who believe they are more likely to use a nursing home than the insurance industry predicts, buy long term care insurance, generating adverse selection. Those who have above-average preferences for insurance (more risk-averse) conditional on what the insurance industry observes, also buy long term care insurance, which generates advantageous selection so far as more risk-averse consumers are less risky. Using a proxy for risk aversion, based on information whether respondents undertake various types of preventive health care, they find evidence of advantageous selection in that people who are more risk averse are both more likely to own insurance and less likely to enter a nursing home.

Fang, Keane, and Silverman (2008) argue that any private information could function as a source of advantageous selection if it is positively correlated with insurance coverage and at the same time negatively correlated with risk. They find that conditional on observable controls for the price of Medigap, medical expenditures for senior citizens with Medigap coverage are, on average, about $4,000 less over the lifetime than for those without, an evidence of advantageous selection. As a determinant of advantageous selection, they put more emphasis on heterogeneity in cognitive ability than heterogeneity in risk preference.

So far, we have briefly reviewed classical and recent issues in the insurance market. Now let us move on to asymmetric information issues in the credit market. According to the seminal work of Stiglitz and Weiss (1981), those firms that borrow money at a high interest rate are risky ones. Firms that borrow money at a high interest rate, would take riskier projects characterized by (low success probability, high return upon success), resulting in a positive correlation between loan interest rate and default rate.

Davidoff and Welke (2004), using data from Home Equity Conversion Mortgage (HECM) and American Housing Survey (AHS), find that selection in the US reverse mortgage market is advantageous rather than adverse in that benefit from reverse mortgage take-up is negatively correlated with time till move out. Consumers expecting short life or high mobility enter into reverse mortgage at a higher rate than their proportionate share in the population. They argue that this advantageous selection might have come from heterogeneity in risk aversion without empirically exploring the sources of advantageous selection. One cannot rule out other channel of advantageous selection that certain individual characteristics, such as health status, access to unreported assets, bequest motives, house prices in local markets or attachments to home equity, are commonly influencing mortgage take-up and early move out.

Agarwal et al. (2006), using a proprietary panel data set of over 108,000 home equity loans and lines of credit, indicate that less credit-worthy applicants are more likely to select credit contracts with a lower collateral requirement and a higher interest rate. They also find that borrowers who are relatively less risky are more likely to reject the bank's counter offer, and that lender's ex-ante efforts successfully reduce ex-post default risks.

Karlan and Zinman (2009) try to distinguish hidden information effects from hidden action effects by running three sets of randomized field experiments. First, upon contracting those respondent consumers who have received the same offer rate, the lender randomizes the contract rate between the offered rate and a lowered rate. From this random variation in which all of them positively respond to the same offer rate but a random subset of them contracts at a lower rate, the authors identify hidden action effect. Second, the lender randomly selects a subset of those who have already struck a financial contract with the lender at a low interest rate, and offers them dynamic incentive in the form of favorable future borrowing rate contingent on borrower's action. Through this random variation, they identify additional hidden action effect. Third, by comparing default rates across those who have responded to a higher offer rate but in fact contracted at a lower rate and those who have both responded to and contracted at the lower rate, they identify hidden information effect. They find that approximately $13 \sim 21(\%)$ of default is due to hidden action effect, that is, moral hazard. They conclude that asymmetric information in the form of hidden action helps explain the prevalent credit constraints even in a rather homogeneous market for financing high-risk borrowers. They expect positive correlation between loan interest rate and default rate by the hidden action effect. It is based on two assumptions that the project success probability is increasing but concave in effort and that a borrower with a project of a lower success probability gains higher return upon success, which is similar to the assumptions in Stiglitz and Weiss (1981).

Using mortgages and automobile loans from Survey of Consumer Finances, Edelberg (2004) finds robust evidence of adverse selection that high risk borrowers pledge less collateral and pay higher interest rates even after controlling for income levels, loan size, and risk aversion, evidence of moral hazard such that collateral is used to induce borrower's effort to avoid repayment problems, and some evidence of advantageous selection that a higher interest rate sometimes attracts borrowers of a lower risk. As a source of the negative relationship between loan interest rate and default risk, she simply argues that effort is more difficult to induce among higher risk borrowers.

Unlike Edelberg (2004), our model in next section explicitly derives the negative relationship by introducing heterogeneity in IES in addition to heterogeneity in risk type. If we suppose time separable utility function and von Neumann-Morgenstein expected utility function, then risk aversion parameter and IES parameter have one to one relationship. However, under general condition, two parameters have different meaning. Risk aversion parameter represents preference toward risk under uncertainty, while IES parameter represents preference toward inter-temporal consumption smoothing when there is uneven income stream over time.

Let us briefly sketch our model. After classifying consumers based on their observable risk factors, banks randomly offer either a high or a low interest rate. Since a borrower with a lower IES is more willing to pay higher interest rate, and since a borrower with a lower IES faces a higher opportunity cost of default, there can be advantageous selection in consumer credit market. We also consider the interaction between advantageous selection and moral hazard. Banks advantageously select consumers since consumers with a lower degree of IES, who are less likely to default, optimize to join the market even at a high interest rate. Consumers with a lower degree of IES exert a bigger amount of effort to prevent default.

3 Model

In this section, we would like to show that, under certain conditions, there arises negative correlation between interest rate and default rate. The basic intuition is as follows. Consumers with a lower degree of inter-temporal elasticity of substitution (IES), are in stronger demand for inter-temporal consumption smoothing and thus are more willing to take a given financial offer from the bank. These consumers would honor the existing debt and by renewing the contract would like to stay in the financial market (maintaining access to the credit market). Consumers with a higher degree of IES, are less likely to take a given financial offer by selectively accepting only those financial contracts with a lower interest rate and then intentionally declaring default after the contract.

Suppose that there are two types of consumers differing in their degrees of IES, consumers with low degree of IES (γ_h)[6] and consumers with high degree of IES (γ_l)[7], that the bank does not observe IES type of consumers, and that consumer's income stream is exogeneously given as (y_l, y_h) for each pair of (odd, even) periods where $y_l < y_h$. There is neither heterogeneity nor uncertainty in the income streams.

The bank offers a financial contract for a single pair of (odd, even) periods.

[6]Lower degree of IES corresponds to higher degree of risk aversion if we assume von Neumann-Morgenstein expected utility function with time separability.

[7]Likewise, higher degree of IES corresponds to lower degree of risk aversion.

That is, the bank offers a contract for a pair of periods at a time. After sorting the consumers based on their observable risk types, the bank randomly offers either a higher or a lower interest rate to each individual consumer without knowing his/her IES type. Over time, interest rates are assumed to be reset randomly, independently of the path of the previous interest rates. Financial contracts take the form of offering a constant, perfectly smooth consumption flow for each pair of (odd, even) periods in exchange for uneven income stream. More specifically, the bank offers either $(c_l; c_l)$ or $(c_h; c_h)$ in exchange for $(y_l; y_h)$ where $c_l < c_h$. Of course, the implied interest rate is higher in the case of $(c_l; c_l)$ than in the case of $(c_h; c_h)$.

Note that $(c_l; c_l) \leftrightarrow (y_l; y_h)$ exchange corresponds to a financial contract according to which the consumer borrows $c_l - y_l$ for consumption in the odd period and pays back $y_h - c_l$ in the even period where $y_l < c_l < c_h < y_h$, and that $(c_h; c_h) \leftrightarrow (y_l; y_h)$ exchange corresponds to a financial contract according to which the consumer borrows $c_h - y_l$ for consumption in the odd period and pays back to the bank $y_h - c_h$ in the even period.

Timing of the contract is as follows. First, the bank offers a financial contract. Second, the consumer decides whether to accept or to turn down the offer. Third, once the offer is taken, the consumer chooses whether to declare default or not. Then, the whole contract sequence starts afresh between the bank and the surviving consumers who have not yet declared default.

If the bank offers a financial contract $(c_l; c_l)$ to the consumer, he/she chooses among the following three options.

(i) To turn down the offer and wait (the corresponding choice specific value function is denoted V_l^1)

(ii) To take the offer and then declare default (denoted V_l^2)

(iii) To take the offer and honor the contract (denoted V_l^3)

The choice specific value functions can be derived using Bellman's principle of optimality.

$$
\begin{aligned}
V_l^1 &= v(y_l, y_h) + \beta^2[\frac{1}{2}V_l + \frac{1}{2}V_h] \\
V_l^2 &= v(c_l, y_h) + \frac{\beta^2}{1-\beta^2}v(y_l, y_h) - \eta(\gamma) \\
V_l^3 &= v(c_l, c_l) + \beta^2[\frac{1}{2}V_l + \frac{1}{2}V_h]
\end{aligned}
$$

where $v(x, y) = u(x) + \beta u(y)$ with β being the discount factor and $u(x)$ being the per-period utility function, V_l and V_h are to be defined shortly, and $\eta(\gamma)$ denotes disutility arising from default for a consumer with IES parameter γ.

The consumer's value is defined as the maximum among the three choice specific value functions.

$$V_l = max\{V_l^1, V_l^2, V_l^3\}$$

Similarly, if the bank offers a contract $(c_h; c_h)$ to the consumer, he/she chooses among the following three options.

(i) To turn down the offer and stay out of the financial market thereafter (the corresponding choice specific value function is denoted V_h^1)

(ii) To take the offer and then declare default (denoted V_h^2)

(iii) To take the offer and honor the contract (denoted V_h^3)

Again, the choice specific value functions can be derived using Bellman's principle of optimality.

$$
\begin{aligned}
V_h^1 &= \frac{1}{1-\beta^2}v(y_l, y_h) \\
V_h^2 &= v(c_h, y_h) + \frac{\beta^2}{1-\beta^2}v(y_l, y_h) - \eta(\gamma) \\
V_h^3 &= v(c_h, c_h) + \beta^2[\frac{1}{2}V_l + \frac{1}{2}V_h]
\end{aligned}
$$

The consumer's value is defined as the maximum among the three choice specific value functions.

$$V_h = max\{V_h^1, V_h^2, V_h^3\}$$

We can easily show that there exists parameter combinations such that

(i) Consumers with a higher degree of IES will not take an offer of $(c_l; c_l)$, and will wait for arrival of next offer with a lower interest rate

(ii) Consumers with a higher degree of IES will take an offer of $(c_h; c_h)$, declare default, and then permanently stays in autarky (losing access to the credit market) thereafter

(iii) Consumers with a lower degree of IES will always take an offer, whether $(c_l; c_l) \leftrightarrow (y_l; y_h)$ exchange or $(c_h; c_h) \leftrightarrow (y_l; y_h)$, honor the contract, and maintain access to the credit market forever.

To sum, consumers with a lower IES is eager to smooth consumption even when he/she is offered an unfavorable financial contract with a higher interest rate whereas consumers with a higher IES faces much weaker incentive to smooth consumption and bigger incentive to declare default.

The theoretical results derived above imply that, in the consumer credit market, among a group of consumers who are observationally equivalent in terms of risk type, those who borrow money at a higher interest rate are less likely to declare default compared with those who borrow money at a lower interest rate (favorable selection in terms of IES type), that as the interest rate goes up the default rate is likely to increase (moral hazard of those with a higher degree of IES), and that adverse selection and moral hazard interact in that only those consumers with high IES create moral hazard problem in the consumer credit market.

4 Empirical Results

According to our two-dimensional heterogeneity arguments, one source of heterogeneity in risk type and the other in IES, relation between the interest rate and the default rate tends to be positive as unmeasured/uncontrolled heterogeneity in risk type plays a bigger role whereas the relation tends to be negative as unmeasured/uncontrolled heterogeneity in IES plays a bigger role. As more observables are controlled, unmeasured/uncontrolled heterogeneity plays a smaller role. We thus expect that in the corporate credit market as we control more of observable risk factors the positive relation would become weaker, that in the consumer credit market as we control more of observable risk factors the positive relation would switch its sign to negative since it is not easy to control for IES while it is relatively easier to control for risk type, and that as we try to control for IES in the consumer credit market the negative relation would become weaker.

In this section, we conduct two sets of empirical works using two different data sources. First, using firm level data from the Korean corporate credit market, we test the positive relationship between the loan interest rate and the default probability, and also test whether the positive relationship becomes weaker as more of risk types are controlled for. Second, using the consumer loan data, we test the negative relationship between the loan interest rate and the default probability, and also test whether the negative relationship becomes any weaker as IES type is controlled for. Of course, we need to control for observable risk factors before testing the direction of each relationship.

4.1 Data Description

The corporate loan data is provided by a large commercial bank in Korea.[8] 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. Out of a total of 32,452 observations, we select 5,755 ones according to the following criteria. First, we only use those corporate loans with amortized repayment every 3 months, resulting in 8,221 observations. Second, we eliminate those data with either missing information or apparent errors, ending up with 5,755 observations.

[8]By contract with the bank, we are allowed neither to reveal the name of the bank nor the data.

Table 1: Descriptive Statistics (Corporate Loan)

	mean	sd	min	max
Initial Loan Interest Rate (%)	7.2	1.3	.76	49
Credit Score	482	166	0	958
Amount of Loan (Billion Won[a])	1.2	1.5	0.5	70
Asset (Billion Won)	8.4	38.2	0.02	2504.1
Revenue (Billion Won)	8.5	25.3	0.0	1492
Debt (Billion Won)	6.0	29.3	0.0	1964.5
Profit (Billion Won)	0.6	2.3	0.0	127.6

[a] Billion Korean won is approximately equal to Million US dollars.

The credit score is a numerical value ranging from 0 to 999. It is assigned by a third party credit agency. As the credit score of a firm increases, its default rate decreases in general. By partitioning the credit score, we create 10 different credit classes from class 1 of highest credit to class 10 of the lowest.

The consumer loan data is provided by another large commercial bank in Korea.[9] 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. We only use those consumer loans with amortized repayment every 1 month. In the end, we use 30,314 accounts belonging to 21,608 consumers.[10]

One very unique feature of our consumer loan data is that it is merged with credit card usage data through matching on individual identification numbers between individual loan account and the credit card account. We observe that each individual consumer appearing in our loan data has credit card account in the same

[9] Again, by contract with the bank, we are allowed neither to reveal the name of the bank nor the data.

[10] We analyze the consumer loan data using loan accounts, not consumers, as unit of analysis. Some consumers have more than a single loan account. The unobserved characteristics affecting the default rate would be correlated across those accounts belonging to the same consumer. To account for the correlation across the accounts belonging to the same individual, we use clustered standard errors for our inference later on.

bank, which allows us to match individuals across the loan data and the credit card data. Thanks to successful merging of the two data sources, we are able to construct a proxy variable for individual IES using credit card usage patterns and then to try to control for IES in studying the relation between interest rate and default rate in the loan data. We use monthly average number of card loan as a proxy for IES. In Korea, people can easily borrow money at ATM with their credit cards. The interest rate for this card loan is much higher than usual bank loans while the card loan amount is lower.[11] So we regard an individual who use card loans more frequently as a person who is willing to pay a higher interest rate to smooth consumption, a characteristic of individuals with a lower degree of IES.

Table 2: Descriptive Statistics (Consumer Loan)

	mean	sd	min	max
Initial Loan Interest Rate (%)	6.4	2.0	0	26
Maturity (Year)	16.0	8.5	0.9	35
Credit Score	789.2	76.2	214	943
Amount of Loan (Million Won[a])	46	65	0.3	1600
Number of Card Loan	0.06	.27	0	4
Card Loan Amount (Million Won)	0.3	2.3	0	140.7

[a]Million Korean won is approximately equal to 1,000 US dollars.

As measures of consumer credit risk, we have credit score, behavior score, and first score. As in the corporate credit market, credit score is assigned by a third party agency and is most widely used in the consumer credit market. Behavior score is similar to the credit score but evaluated by the bank herself 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. The so called first score is only available for the first time borrowers. Since banks do not have enough credit information for the first time borrowers, they

[11]The average loan interest rate is 19.02% for the card loan while it is 6.40% for the bank loan.

additionally introduce the first score. In addition to measuring credit, the first score also allows us to identify who are the first time borrowers.

4.2 Estimation Results

The default hazard rate at time t since initiation for a loan with characteristic x is modeled as

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

where $h_0(t)$ is the so called baseline hazard rate and $\exp(x'\beta)$ is the so called proportionality factor. The model is called Cox proportional hazard model (PHM). In this paper, we estimate β semi-parametrically without specifying the baseline hazard function by using the Cox partial maximum likelihood. Duration measures are regarded as right-censored if a spell ends without default by the end of either maturity or end of the observation period. We do not use information after the first episode, resulting in single-spell duration.

Definition of default for consumer loans is two weeks arrear (14 business days). So duration measures elapsed time in month from initiation of a loan until the borrowing consumer is two business weeks behind in his/her dues. The default rate according to this definition is 4.07% which is quite similar to the average default rate in Korea.[12] To check robustness, we also use two alternative definitions of default (See tables A.1 through A.3 in the appendix. Also refer to online appendix).

Since we are dealing with asymmetric information issue at time of loan initiation, we only use information which is available at the time of striking contracts in both corporate loans and consumer loans.

Table 3 shows the estimation results of the Cox PHM using the corporate loan data. Model 1 uses loan interest rate as a sole covariate. The result shows that as the loan interest rate rises by 1 percent point, the default hazard rate increases by about 13.1%. This result looks reasonable since banks charge a higher loan interest rate if they consider a firm as riskier in type. Once we control for observables in

[12]The average default rate for the consumer loans in Korea was 4.26% in year 2004.

Table 3: Corporate Loan (Cox PHM)

Observables Controlled	Model 1	Model 2	Model 3
Loan Interest Rate (%)	0.131***	0.187	0.085
	(0.040)	(0.143)	(0.168)
Credit Risk Cost[a]		0.515	0.899**
		(0.357)	(0.362)
Credit Score/100		-0.854***	-1.070***
		(0.086)	(0.117)
Amount of Loan (Billion Won[b])		-0.518	-0.701*
		(0.353)	(0.408)
Asset (Billion Won)		-0.054	-0.014
		(0.146)	(0.160)
Revenue (Billion Won)		-0.012	-0.034
		(0.025)	(0.030)
Debt (Billion Won)		0.047	-0.007
		(0.163)	(0.175)
Profit (Billion Won)		0.206	0.307
		(0.335)	(0.372)
Maturity (Year)		0.254*	0.297**
		(0.131)	(0.134)
Observations	5755	5755	5755

Model 3 includes time dummies for the months of loan initiation.
Within parentheses are standard errors.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a](Credit Risk Cost) = (Expected Default Rate)×(1- Recovery Rate). Where, Recovery Rate = (Value of Collateral)/(Amount of Loan)

[b]Billion Korean won is approximately equal to Million US dollars.

models 2 and 3, however, we could not find any significantly positive effect of loan interest rate on the default hazard rate.[13] Comparing the estimated effects of the loan interest rate on the default hazard rate across these three models, we observe that as we control more of observable risk factors the positive relationship between the loan interest rate and the default hazard rate becomes weaker and weaker. The coefficient on credit score is notable, which shows that as the credit score increases by 1 point the default hazard rate decreases by about $0.85 \sim 1.07\%$. To sum, once we control for observable firm/loan characteristics, there does not seem to be remaining any further unobserved heterogeneity among the borrowing firms in the corporate credit market.

So far, we have just made sure that the Korean corporate loan data is not an exception in that the relation between the loan interest rate and the corporate default rate is positive and that the positive relation becomes weaker as more risk factors are controlled for, which is consistent with what we expect. Now let us move on to the analyses of consumer loan data to see whether consumers are like firms in the credit market.

Table 4 shows the estimation results for the consumer loans. Two main quantities of interest from Table 4 are the estimate of the effect of initial loan interest rate on the default hazard rate, and the estimated effect of number of card loan usage on the default hazard rate. The estimate in the "interest rate only" model shows that as the loan interest rate rises by 1 percent point, the default hazard rate increases by about 3.1%. Again, this result looks reasonable since banks charge a higher loan interest rate if they consider a consumer as risky in type. As we control for observable risk factors in the model, the estimates show that as the initial loan interest rate increases by one percent point the default hazard rate decreases by about 4.0%, establishing a negative relationship between the loan interest rate and the default hazard rate in the consumer credit market, and that as the monthly average number of card loan usage increases by one per month, the default hazard rate decreases by about 53.4%.[14]

[13] Note that model 3 additionally includes time dummies to control for macro-economic situations at the time of loan initiation.

[14] Here 53.4% is obtained from the equation $1-\exp(-0.763) = 0.534$, where -0.763 is the coefficient estimate of the "average number of card loan usage."

Table 4: Consumer Loan (Cox PHM)

Observables Controlled	Interest Rate only	Observables Only	IES Added
Initial Loan Interest Rate (%)	0.031**	-0.041***	-0.039***
	(0.014)	(0.012)	(0.012)
Maturity (Year)		-0.006	-0.007
		(0.004)	(0.004)
Amount of Loan (Billion Won[a])		-2.464***	-2.553***
		(0.870)	(0.856)
Behavior Score/100		-0.179***	-0.189***
		(0.024)	(0.024)
Credit Inquiry Dummy		1.334***	1.324***
		(0.327)	(0.325)
Fixed Interest Rate Dummy		-0.456***	-0.478***
		(0.139)	(0.140)
Total Loan Amount (Billion Won)		-0.980	-0.735
		(0.598)	(0.543)
Avg. Number of Card Loan			-0.763***
			(0.188)
Avg. Card Loan Amount (Million Won[b])			-0.001
			(0.014)
Observations	30314	30314	30314

All models include credit class dummies except for the model termed "interest rate only".
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Billion Korean won is approximately equal to Million US dollars.
[b] Million Korean won is approximately equal to 1,000 US dollars.

Note that the average number of card loan usage is used as a proxy for strength of demand for inter-temporal consumption smoothing. We establish that those who are more willing to smooth consumption (as captured by the proxy variable) are less likely to default in the consumer credit market, and that, as IES is controlled for to a certain extent by using number of card loan usage as a proxy variable, the negative relationship between the loan interest rate and the default probability becomes somewhat weaker.

If the sole source of consumer heterogeneity had been risk type, this negative relation between the loan interest rate and the default hazard rate would have not been observed. If that had been the case, as we had added more observable risk factors into the model the positive coefficient of the initial loan interest rate would have shrunken to zero. Noting that consumers with a lower degree of IES are both more willing to pay a higher interest rate to borrow money and less willing to declare default, as we have suggested through the theoretical model, we expect a negative relation between the loan interest rate and the default hazard rate when there is an additional source of heterogeneity in terms of IES. As we include a proxy variable measuring degree of IES (avg. number of card loan) the negative effect becomes weaker, consistent with theoretical prediction.

For each credit class, Tables A.8 and A.9 in Appendix A.3 show the results of regressing the default dummy on several listed covariates. The results show that those who have used card loan at least once are less likely to default, which is consistent with the Cox regression results shown above. This negative relation is not statistically significant for higher credit classes of 1 through 4 while being statistically significant for lower credit classes of 5 through 9. We think this differential pattern makes senses considering that consumers of lower credit face a stronger incentive to borrow money for inter-temporal consumption smoothing, and to stay in the credit market by paying back existing debts.

From a banker's perspective, risk types are better measured for returning clients than for the first time borrowers. In Tables 5 and 6, we report the Cox regression results separately by returning status of the clients. Table 5 shows the results for the returning clients. As we are better able to control for returning clients' risk types,

Table 5: Consumer Loan (Repeated Borrowers)

Observables Controlled	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	-0.173***	-0.165***
	(0.056)	(0.054)
Maturity (Year)	0.015	0.013
	(0.021)	(0.021)
Amount of Loan (Billion Won[a])	-9.842***	-10.092***
	(3.103)	(3.159)
Behavior Score/100	-0.111	-0.116
	(0.085)	(0.087)
Fixed Interest Rate Dummy	-1.188***	-1.256***
	(0.410)	(0.412)
Total Loan Amount (Billion Won)	-3.297**	-3.188**
	(1.600)	(1.536)
Avg. Number of Card Loan		-1.673*
		(1.008)
Avg. Card Loan Amount (Million Won[b])		0.093*
		(0.055)
Observations	2239	2239

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Billion Korean won is approximately equal to Million US dollars.
[b] Million Korean won is approximately equal to 1,000 US dollars.

Table 6: Consumer Loan (First Time Borrowers)

Observables Controlled	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	0.008	0.009
	(0.021)	(0.021)
Maturity (Year)	0.001	0.000
	(0.005)	(0.005)
Amount of Loan (Billion Won[a])	-2.368***	-2.444***
	(0.881)	(0.856)
Behavior Score/100	-0.163***	-0.172***
	(0.024)	(0.025)
First Score/100	-0.156***	-0.158***
	(0.015)	(0.016)
Credit Inquiry Dummy	1.140***	1.111***
	(0.309)	(0.313)
Fixed Interest Rate Dummy	-0.364**	-0.381**
	(0.177)	(0.181)
Total Loan Amount (Billion Won)	-0.297	-0.103
	(0.412)	(0.325)
Avg. Number of Card Loan		-0.690***
		(0.203)
Avg. Card Loan Amount (Million Won[b])		-0.016
		(0.020)
Observations	28075	28075

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Billion Korean won is approximately equal to Million US dollars.
[b] Million Korean won is approximately equal to 1,000 US dollars.

the negative relationship between the loan interest rate and the default hazard rate becomes more visible. It is because banks are now better informed about their risk types while banks still do not well know their IES types. The coefficient estimate of behavior score is now smaller in size and statistically insignificant. It is because, for repeated borrowers, credit scores have been updated from their previous loan history and thus the credit class dummies well capture individual credit risks, so the role of behavior score in signaling the default risk is now relatively limited.

Table 6 shows the results when we limit data to the first time borrowers. The results show that there is no significant relation between loan interest rate and default probability. It suggests that two opposing effects cancel out each other regarding the relation between interest rate and default, positive correlation arising from heterogeneity in risk types and negative correlation arising from heterogeneity in IES types.

Now we would like to limit our sample to consumer loans of relatively smaller size. We believe that small consumer loans are more likely to be used for inter-temporal consumption smoothing whereas large ones mainly for housing purchase. To study how the relation between the loan interest rate and the default rate changes by loan size, Tables 7 and 8 report the Cox regression results separately by loan size.

Table 7 shows the results when we limit data to loans with loan amount under 20 million won.[15] The results show that the negative relationship between initial loan interest rate and default rate becomes stronger. Table 8 shows the results for loans over 20 million won. As you can see from Table 8, the negative relationship between initial loan interest rate and default rate goes away for large sized loans. If one uses a large amount of loan to buy a house for residential purpose, it might be associated with consumption smoothing behavior. Often, though, the Korean consumers use mortgage loan to buy a second house for investment purpose, in which case it is rather like a corporate investment than a smoothed consumption. For such loans, the relation between the loan interest rate and default rate would be positive as in the corporate credit market.

[15] Here, we use a threshold value of 20 million won since it is the median loan amount in our data. In the online appendix, you can see the results using 50 million as an alternative threshold.

Table 7: Loans sized under 20 million won

	Interest Rate only	Observables Only	IES Added
Initial Loan Interest Rate (%)	0.000	-0.066***	-0.065***
	(0.015)	(0.018)	(0.018)
Maturity (Year)		0.020***	0.019***
		(0.007)	(0.007)
Amount of Loan (Billion Won[a])		-47.427***	-46.643***
		(9.378)	(9.385)
Behavior Score/100		-0.198***	-0.203***
		(0.036)	(0.036)
Credit Inquiry Dummy		1.640***	1.676***
		(0.549)	(0.527)
Fixed Interest Rate Dummy		-0.631***	-0.643***
		(0.174)	(0.175)
Total Loan Amount (Billion Won)		-9.533***	-8.897***
		(2.147)	(2.146)
Avg. Number of Card Loan			-0.341
			(0.239)
Avg. Card Loan Amount (Million Won[b])			-0.007
			(0.017)
Observations	15503	15503	15503

All models include credit class dummies except the model "interest rate only".
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

Table 8: Loans sized over 20 million won

	Interest Rate only	Observables Only	IES Added
Initial Loan Interest Rate (%)	0.233***	0.127*	0.131*
	(0.068)	(0.075)	(0.073)
Maturity (Year)		0.001	0.001
		(0.007)	(0.007)
Amount of Loan (Billion Won[a])		-0.617	-0.605
		(0.712)	(0.702)
Behavior Score/100		-0.158***	-0.171***
		(0.032)	(0.031)
Credit Inquiry Dummy		0.712	0.769*
		(0.552)	(0.467)
Fixed Interest Rate Dummy		-0.192	-0.187
		(0.427)	(0.426)
Total Loan Amount (Billion Won)		0.099	0.097
		(0.262)	(0.258)
Avg. Number of Card Loan			-0.992***
			(0.260)
Avg. Card Loan Amount (Million Won[b])			0.019
			(0.020)
Observations	14811	14811	14811

All models include credit class dummies except the model "interest rate only".
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

As you can see from Tables A.4 through A.7, the differential relationship by loan size continues to prevail whether we limit our data to repeated borrowers or to the first time borrowers. The negative relationship is observed for loans under 20 million won whereas the positive relationship is observed for loans over 20 million won.

Table 9: Consumer Loan (Counter-Factual Analysis)

Observables Controlled	Repeated Borrowers	First time borrowers
Initial Loan Interest Rate (%)	-0.265**	-0.057**
	(0.132)	(0.022)
Maturity (Year)	0.037	0.002
	(0.025)	(0.005)
Amount of Loan (Billion Won[a])	-9.738*	2.121*
	(5.580)	(1.115)
Behavior Score/100	-0.052	-0.121***
	(0.063)	(0.014)
Credit Inquiry Dummy	-42.658***	-0.675
	(1.320)	(0.607)
Fixed Interest Rate Dummy	-2.477***	-0.596***
	(0.723)	(0.174)
Total Loan Amount (Billion Won)	-6.648**	-4.123***
	(3.275)	(1.119)
First Score/100		-0.061***
		(0.014)
Observations	2241	28076

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.

Table 9 shows counter-factual results which we obtain by using risk measures as updated in the last period rather than using them as available at the time of loan

Table 10: Consumer Loan (Time Varying Interest Rate Added)

	Interest Rate only	Observables Only	IES Added
Initial Loan Interest Rate (%)	0.222***	-0.109***	-0.115***
	(0.017)	(0.032)	(0.032)
Time Varying Interest Rate (%)	0.053**	0.104***	0.117***
	(0.026)	(0.032)	(0.034)
Maturity (Year)		-0.013**	-0.016***
		(0.006)	(0.006)
Amount of Loan (Billion Won[a])		1.982	1.478
		(1.513)	(1.502)
Behavior Score/100		-0.245***	-0.250***
		(0.016)	(0.017)
Credit Inquiry Dummy		-0.231	-0.132
		(0.411)	(0.395)
Total Loan Amount (Billion Won)		-5.740***	-5.032***
		(1.630)	(1.569)
Avg. Number of Card Loan			-1.621***
			(0.234)
Avg. Card Loan Amount (Million Won[b])			0.008
			(0.010)
Observations	20240	20240	20240

All models include credit class dummies except the model "interest rate only".
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

initiation. Every measure of risk type is updated to reflect more closely the true risk type of borrowers. The estimates of loan interest rate become larger in negative direction. Even for the first time borrowers, there is negative relation between loan interest rate and the default risk. Table 9 shows that once we successfully control for the risk type of borrowers, the negative correlation prevails between interest rate and default rate, which is mainly driven by heterogeneity in IES types as heterogeneity in risk types are now better controlled.

Table 10 shows the estimation results when we additionally control for time varying interest rate which is defined as a gap between the current interest rate and the initial interest rate.[16] While we maintain negative relation between initial interest rate and default rate, the relation between floating interest rate and the default rate turns out positive, which is consistent with our model prediction: As the floating interest rate goes up, incentive to declare default (moral hazard) increases for those who have a higher IES.

5 Concluding Remarks

The classical adverse selection models consider heterogeneity in risk type as the main cause of adverse selection. Recent empirical findings in diverse insurance markets emphasize role of risk appetite as an additional source of heterogeneity. Our empirical findings in the 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 panel data from the Korean corporate credit markets, we find weak evidence or no evidence of positive relationship between interest rate and the default hazard rate once we control for observables on risk types, which is consistent with findings in Chiappori and Salanie (2000). It might be because the Korean bank rather precisely prices the corporate loans based on observable risk factors without leaving room for unobserved heterogeneity. After classifying the

[16]Here, to define time varying interest rates meaningfully, we only use those financial contracts with floating interest rates.

firms using their observable risk factors, the bank suggests contracts of high or low interest rate. If the firms still have private information about their risk type, riskier firms are willing to take an offer with a higher interest rate. On the other hand, if the bank successfully classifies the firms and suggests proper menus, then there does not necessarily arise any stronger incentive for riskier firms to take offers with a higher interest rate.

In the case of consumer loans, to the contrary, we find the exact opposite results to what the classical theory on corporate loans predicts. Consumers who borrow money at a higher interest rate are not more but less likely to declare default once observable risk factors are controlled for, resulting in favorable selection rather than adverse one. Such selection results look quite unusual in the credit market, but not quite so in the insurance markets. In the insurance markets, although high risk consumers purchase high coverage insurances, highly risk averse consumers also purchase high coverage insurances. Thus, 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.

Mitigation of the adverse selection in the insurance market is explained by introducing different source of heterogeneity, say heterogeneity in risk preference on top of heterogeneity in traditional risk types. Borrowing this kind of reasoning into the consumer credit market, we suggest a model with heterogeneity in degree of intertemporal elasticity of substitution. Since consumption smoothing is one of the main reasons why consumers apply for consumer loans, consumers with a lower degree of IES (who face a stronger incentive to smooth consumption) borrow money even at a higher interest rate. Consumers with a lower degree of IES are also more likely to pay back the consumer debt for fear of losing access to the future credit market and thus for fear of losing consumption smoothing opportunities in the future. According to this reasoning, we expect a negative relationship between the loan interest rate and the default rate in the consumer credit market.

To test model implications, after controlling for observable risk factors, we first study the relation between loan interest rate and the default hazard rate, second the relation between degree of IES and the default hazard rate, and third whether the relation between loan interest rate and the default hazard rate becomes any weaker as the degree of IES is controlled for. We use "frequency of card loan usage" as a proxy for degree of IES. According to this proxy variable, those who use card loan more frequently are regarded as those with a lower degree of IES. Our empirical results seem to support our theoretical predictions that among a group of observationally equal-risk borrowers those who borrow money at a higher interest rate are less likely to default, that those consumers who face a lower degree of IES are less likely to default, and that the negative relation between the loan interest rate and the default hazard rate becomes slightly weaker as a proxy for the degree of IES is controlled for.

References

Agarwal, S., B. W. Ambrose, S. Chomsisengphet, and C. Liu, 2006, "Asymmetric Information in Dynamic Contract Settings: Evidence from the Home Equity Credit Market," Available at SSRN 1017883.

Cardon, J. H., and I. Hendel, 2001, "Asymmetric information in health insurance: evidence from the National Medical Expenditure Survey," RAND Journal of Economics, 408-427.

Cawley, J., and T. Philipson, 1999, "An Empirical Examination of Information Barriers to Trade in Insurance," The American Economic Review, 827-846.

Chiappori, P. A., and B. Salanie, 2000, "Testing for asymmetric information in insurance markets," Journal of political Economy, 56-78.

Chiappori, P. A., B. Jullien, B. Salanie, and F. Salanie, 2006, "Asymmetric information in insurance: General testable implications," The RAND Journal of Economics, 783-798.

Chiappori, P. A., and B. Salanie, 2013, "Asymmetric information in insurance markets: predictions and tests," Handbook of Insurance. Springer New York, 397-422.

Cohen, A., 2005, "Asymmetric information and learning: Evidence from the automobile insurance market," Review of Economics and Statistics, 197-207.

Cohen, A., and P. Siegelman, 2010, "Testing for adverse selection in insurance markets," Journal of Risk and Insurance, 39-84.

Cox, D. R., 1975, "Partial likelihood," Biometrika, 269-276.

Davidoff, T., and G. Welke, 2004, “Selection and Moral Hazard in the Reverse Mortgage Market,” Available at SSRN 608666.

Edelberg, W., 2004, “Testing for Adverse Selection and Moral Hazard in Consumer Loan Markets,” Federal Reserve Working Paper.

Fang, H., M. P. Keane, and D. Silverman, 2008, “Sources of Advantageous Selection: Evidence from the Medigap Insurance Market,” Journal of Political Economy, 303-350.

Finkelstein, A., and J. Poterba, 2004, “Adverse selection in insurance markets: Policyholder evidence from the UK annuity market,” Journal of Political Economy, 183-208.

Finkelstein, A., and K. McGarry, 2006, “Multiple dimensions of private information: Evidence from the long term care insurance market,” The American economic review, 938-958.

Karlan, D., and Zinman, J., 2009, “Observing unobservables: Identifying information asymmetries with a consumer credit field experiment,” Econometrica, 1993-2008.

Lee, S., and Lee, J., 2004, “Bank Consolidation and Bank Competition: An Empirical Analysis of the Korean Banking Industry,” The Bank of Korea, 1-55.

Puelz, R., and A. Snow, 1994, “Evidence on adverse selection: Equilibrium signaling and cross-subsidization in the insurance market,” Journal of Political Economy, 236-257.

Rothschild, M., and J. E. Stiglitz, 1976, “Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information,” The Quarterly

Journal of Economics, 629-649.

Stiglitz, J. E., and A. Weiss, 1981, "Credit rationing in markets with imperfect information," The American economic review, 393-410.

A Appendix

A.1 Alternative definitions of default

A.1.1 30 business days

Table A.1: Consumer Loan

	Interest Rate only	Observables Only	IES Added
Initial Loan Interest Rate (%)	0.074***	-0.003	-0.002
	(0.024)	(0.018)	(0.018)
Maturity (Year)		-0.018**	-0.018**
		(0.008)	(0.008)
Amount of Loan (Billion Won[a])		-1.276	-1.368
		(1.360)	(1.359)
Behavior Score/100		-0.171***	-0.177***
		(0.033)	(0.033)
Credit Inquiry Dummy		1.150	1.194
		(0.897)	(0.842)
Fixed Interest Rate Dummy		-0.406**	-0.427**
		(0.205)	(0.205)
Total Loan Amount (Billion Won)		-2.377*	-2.144*
		(1.248)	(1.218)
Avg. Number of Card Loan			-0.448*
			(0.262)
Avg. Card Loan Amount (Million Won[b])			-0.007
			(0.021)
Observations	30314	30314	30314

All models include credit class dummies except for the model termed "interest rate only".
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a] Billion Korean won is approximately equal to Million US dollars.
[b] Million Korean won is approximately equal to 1,000 US dollars.

Table A.2: Consumer Loan (Repeated Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	-0.116**	-0.105**
	(0.049)	(0.052)
Maturity (Year)	0.020	0.019
	(0.036)	(0.039)
Amount of Loan (Billion Won[a])	-10.751*	-12.138**
	(6.099)	(5.995)
Behavior Score/100	-0.241*	-0.247*
	(0.128)	(0.139)
Fixed Interest Rate Dummy	-1.535**	-1.673**
	(0.651)	(0.715)
Total Loan Amount (Billion Won)	-10.226	-9.639
	(6.816)	(6.574)
Avg. Number of Card Loan		-1.417
		(1.114)
Avg. Card Loan Amount (Million Won[b])		0.103
		(0.064)
Observations	2239	2239

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

Table A.3: Consumer Loan (First Time Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	0.030	0.029
	(0.029)	(0.030)
Maturity (Year)	-0.009	-0.010
	(0.009)	(0.009)
Amount of Loan (Billion Won[a])	-1.482	-1.677
	(1.439)	(1.428)
Behavior Score/100	-0.153***	-0.157***
	(0.036)	(0.036)
First Score/100	-0.158***	-0.162***
	(0.026)	(0.025)
Credit Inquiry Dummy	1.060	1.074
	(0.736)	(0.680)
Fixed Interest Rate Dummy	-0.387	-0.423
	(0.268)	(0.275)
Total Loan Amount (Billion Won)	-1.426	-1.111
	(1.120)	(1.018)
Avg. Number of Card Loan		-0.365
		(0.292)
Avg. Card Loan Amount (Million Won[b])		-0.030
		(0.034)
Observations	28075	28075

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

A.2 Separate analyses by loan size

A.2.1 Loan size under 20 million Korean won

Table A.4: Loans sized under 20 million won (Repeated Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	-0.247***	-0.232***
	(0.060)	(0.058)
Maturity (Year)	0.027	0.023
	(0.038)	(0.042)
Amount of Loan (Billion Won[a])	-112.144	-89.429
	(87.408)	(85.438)
Behavior Score/100	-0.290	-0.311
	(0.211)	(0.220)
Fixed Interest Rate Dummy	-2.084***	-2.243***
	(0.805)	(0.777)
Total Loan Amount (Billion Won)	-45.451	-38.861
	(33.281)	(28.976)
Avg. Number of Card Loan		-3.231**
		(1.554)
Avg. Card Loan Amount (Million Won[b])		0.373
		(0.317)
Observations	995	995

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

Table A.5: Loans sized under 20 million won (First Time Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	-0.031	-0.031
	(0.032)	(0.032)
Maturity (Year)	0.028***	0.026***
	(0.008)	(0.008)
Amount of Loan (Billion Won[a])	-28.952***	-27.797***
	(9.758)	(9.800)
Behavior Score/100	-0.185***	-0.190***
	(0.036)	(0.036)
First Score/100	-0.167***	-0.169***
	(0.023)	(0.023)
Credit Inquiry Dummy	1.527***	1.549***
	(0.488)	(0.473)
Fixed Interest Rate Dummy	-0.517**	-0.538**
	(0.252)	(0.256)
Total Loan Amount (Billion Won)	-7.060***	-6.315***
	(1.910)	(1.894)
Avg. Number of Card Loan		-0.311
		(0.247)
Avg. Card Loan Amount (Million Won[b])		-0.016
		(0.022)
Observations	14508	14508

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

A.2.2 Loan size over 20 million Korean won

Table A.6: Loans sized over 20 million won (Repeated Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	-0.107	-0.114
	(0.212)	(0.232)
Maturity (Year)	0.032	0.033
	(0.030)	(0.031)
Amount of Loan (Billion Won[a])	-10.418***	-10.316***
	(3.886)	(3.877)
Behavior Score/100	-0.057	-0.075
	(0.122)	(0.120)
Fixed Interest Rate Dummy	-39.309***	-37.502***
	(0.685)	(0.660)
Total Loan Amount (Billion Won)	-1.774	-1.906
	(1.535)	(1.534)
Avg. Number of Card Loan		-1.431
		(1.136)
Avg. Card Loan Amount (Million Won[b])		0.103
		(0.069)
Observations	1244	1244

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

Table A.7: Loans sized over 20 million won (First Time Borrowers)

	Initial Observables Only	IES Observables Added
Initial Loan Interest Rate (%)	0.165**	0.167**
	(0.076)	(0.074)
Maturity (Year)	-0.000	-0.000
	(0.007)	(0.007)
Amount of Loan (Billion Won[a])	-0.332	-0.370
	(0.706)	(0.700)
Behavior Score/100	-0.161***	-0.170***
	(0.034)	(0.034)
First Score/100	-0.071***	-0.083***
	(0.026)	(0.026)
Credit Inquiry Dummy	0.650	0.656
	(0.486)	(0.412)
Fixed Interest Rate Dummy	0.101	0.105
	(0.414)	(0.414)
Total Loan Amount (Billion Won)	0.127	0.133
	(0.253)	(0.247)
Avg. Number of Card Loan		-0.925***
		(0.269)
Avg. Card Loan Amount (Million Won[b])		0.001
		(0.025)
Observations	13567	13567

All models include credit class dummies.
All models include dummies for the months of loan initiation.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.
[b]Million Korean won is approximately equal to 1,000 US dollars.

A.3 Linear probability model

Table A.8: Consumer Loan

Observables Controlled	All	Class 1	Class 2	Class 3	Class 4
Positive Avg. Card Loan Dummy	-0.023***	0.030	-0.001	-0.005	-0.007
	(0.004)	(0.020)	(0.007)	(0.006)	(0.006)
Amount of Loan (Billion Won[a])	-0.027	0.017	-0.033	-0.043	0.019
	(0.020)	(0.043)	(0.023)	(0.027)	(0.047)
Maturity (Year)	0.000	-0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fixed Interest Rate Dummy	-0.010*	-0.005	-0.004	-0.010*	-0.007
	(0.005)	(0.004)	(0.007)	(0.006)	(0.007)
Number of observations	30314	1604	3935	4415	4660

These are linear probability models regressing default dummy on listed covariates.
Credit class dummies are included in model "all".
Starting time dummies are included.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[a]Billion Korean won is approximately equal to Million US dollars.

Table A.9: Consumer Loan

Observables Controlled	Class 5	Class 6	Class 7	Class 8	Class 9
Positive Avg. Card Loan Dummy	-0.026***	-0.029***	-0.039***	-0.048**	-0.115**
	(0.006)	(0.009)	(0.014)	(0.023)	(0.047)
Amount of Loan (Billion Won)	-0.014	-0.092	-0.185	0.052	0.595
	(0.054)	(0.058)	(0.121)	(0.137)	(0.496)
Maturity (Year)	0.000	0.000	0.000	-0.002	-0.004
	(0.000)	(0.001)	(0.001)	(0.001)	(0.004)
Fixed Interest Rate Dummy	-0.008	-0.014	0.028	-0.071**	-0.068
	(0.009)	(0.011)	(0.024)	(0.031)	(0.069)
Number of observations	6428	4541	2878	1378	413

These are linear probability models regressing default dummy on listed covariates.
Starting time dummies are included.
Within parentheses are standard errors which are clustered by consumer unit.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$