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Estimating Risk Aversion Using Individual-Level Survey Data*

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Attitude towards risk can be an important factor in explaining various economic decisions, such as the choice of self-employment. As a first step towards understanding the prevalence of self-employment in South Korea, we structurally estimate risk aversion parameters based on the standard expected utility theory. We use hypothetical lottery questions from a large-scale longitudinal survey (the Korean Labor and Income Panel Study) conducted in two waves to a sample of approximately 8,000 individuals. The estimation results show that the constant relative risk aversion parameter ranges from 0.6 to 0.8: male, younger, less educated, unmarried and higher income individuals are less risk averse. Erroneous responses are more likely for male, younger, more educated and poorer respondents. We also find significant impact of responses to the hypothetical questions on self-employment, which suggests that our estimates for risk preferences are likely predictive of actual choice of self-employment.

JEL Classification: C81, C90, D00, D80, D81
Keywords: Risk Aversion, Self-employment, Heterogeneity, CRRA

I. Introduction

Decision under uncertainty is prevalent in many settings of economic decision making. Risk preference measurement is fundamental in many economic models. For example, risk preference is one of the key parameters for calibrating macroeconomic models, forecasting investment in the financial market or estimating demand

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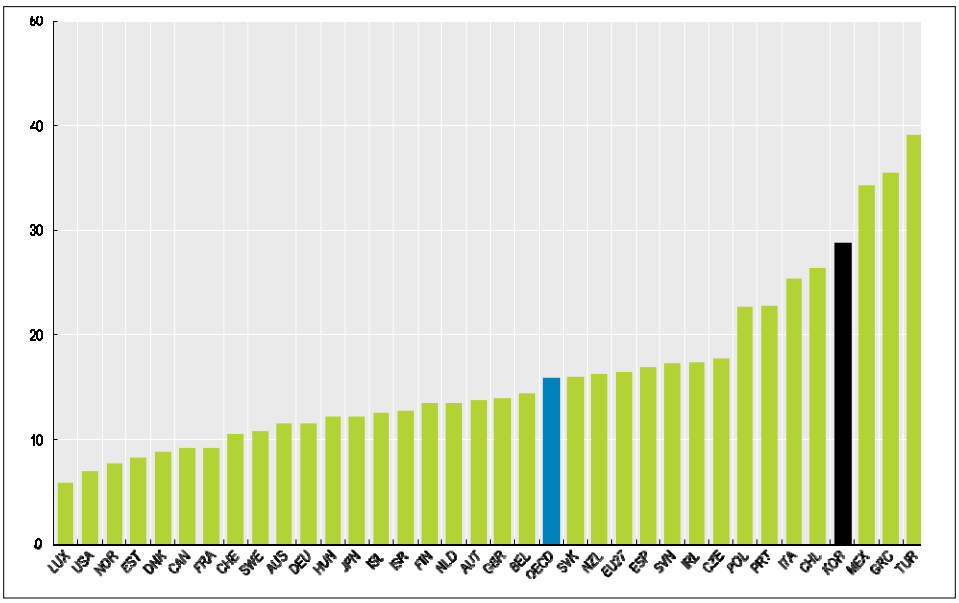
functions for insurance or retirement savings. South Korea (hereafter Korea) has unusually high ratio of self-employment among OECD countries. As of 2010, compared with OECD average ratio of 15.9% and European OECD average of 16.5%, the ratio for South Korea is 28.8%, more than 12 percentage points greater (see Figure 1). South Korea has the fourth highest ratio next to Turkey (39.1%), Greece (35.5%), and Mexico (34.3%). While there are numerous explanations for individuals' choice of self-employment, the link between self-employment and risk attitudes has been established in the literature (Fairlie, 2002; Cramer et al., 2002; Ahn, 2010).[1] Figure 2 plots self-employment ratio against responses to risk related question per country, using the data from the World Value Survey (WVS). Although it is only suggestive, there seem to be positive relationships between self-employment ratio and responses to the risk-related questions. Thus, in this paper, as a first step toward understanding the prevalence of self-employment in Korea, we elicit risk preferences using Korean individual data. To our best knowledge, our paper is the first attempt to structurally estimate microeconomic risk preference parameters at the individual level for the Korean population.

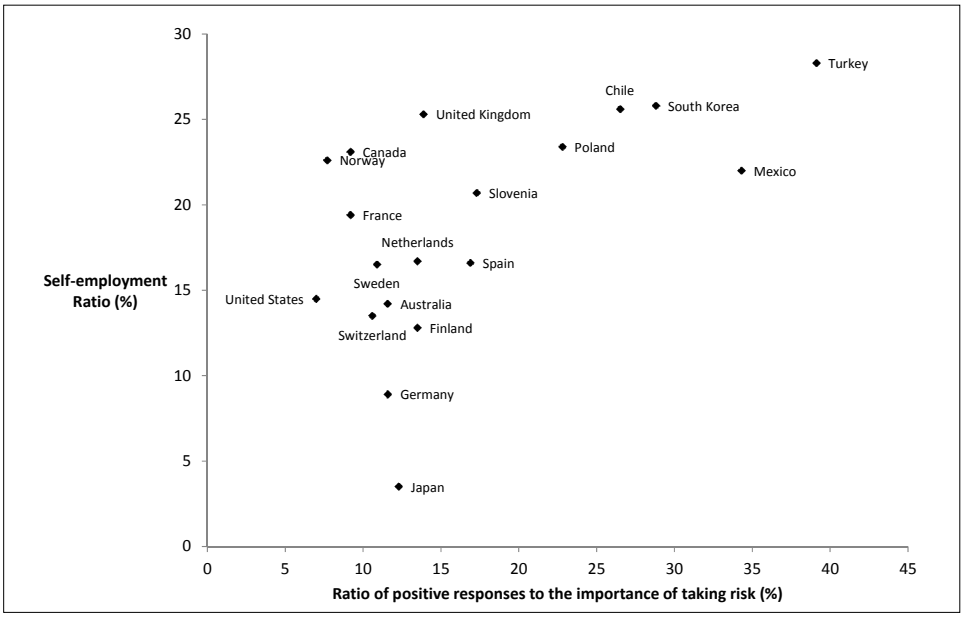
[Figure 1] Self-employment Rates of OECD Countries (as a percentage of total employment)



Source: OECD Factbook 2011-2012 http://dx.doi.org/10.1787/888932505469.

[1] Fairlie uses National Longitudinal Survey of Youth (NLSY) to show that individual attitude toward risk is an important determinant of self-employment decision. Cramer et al. (2002) uses data from a Dutch survey called "Barbant survey" to show correlation between risk attitudes and the choice of self-employment. Ahn (2010) showed that self-employment and risk attitudes have strong correlation using 1979 National Longitudinal Survey of Youth.

[Figure 2] Ratio of Positive Responses to the Importance of Taking Risk and Self Employment Probability for OECD Countries



Source: Self-employment ratio from OECD Factbook 2011-2012 http://dx.doi.org/10.1787/888932505469. Ratio of positive responses to the importance of taking risk from World Value Survey 2005-2008 http://www.wvsevsdb.com/wvs/WVSIntegratedEVSWVS variables.jsp?Idioma=I. The ratio is the percentage of people who selected two strongest responses out of 6 possible responses, "very much like me" and "like me" to the statement, "It is important to this person: adventure and taking risks".

There have been numerous attempts to elicit risk preferences by using data from laboratory experiments (Holt and Laury, 2002; Eckel and Grossman, 2008; Harrison and Rutström, 2008). Recently non-experimental survey data have also been used in eliciting risk preferences, most notably in Hryshko et al. (2011) and Dohmen et al. (2005). Despite the limitation of relying on non-incentivized hypothetical questions, using data from household surveys is advantageous since the surveys are conducted for individuals and households from a nationally-representative sample, whereas in most lab experiments, the subjects are college students. Surveys provide rich background information about individuals, which is not usually available in short surveys conducted along lab experiments.

Along the line of the recent literature, in this paper, we also use a set of hypothetical lottery questions in the Korean Labor and Income Panel Study (KLIPS) and estimate risk aversion parameter under the assumption of the standard expected utility model. We use a structural estimation method, which allows for not only heterogeneity in risk aversion across demographic groups, but also potential noise in survey responses. Lastly, given that the identical set of questions were asked

in two waves, we can examine how risk aversion or survey quality changes over time within individuals.

Few attempts have been made to estimate risk aversion parameters for the Korean population but, to our best knowledge, structural estimation using individual-level data is still absent. A majority of papers have used time-series data from financial markets. Most of these papers have estimated macro-finance models (Lee, 1992; Byun and Kang, 2007; Kang, 2008; Yi et al. 2011). Others have estimated risk aversion of farmers using agricultural production data due to high-level of inherent variability in agricultural production and prices (Ahn and Kim, 2002; Kwon, 2002). Thus our micro-econometric estimates for risk preferences in this paper will be complementary to the results from these existing papers.

To summarize our main findings, we find that when we assume a constant relative risk aversion (CRRA) utility function, the risk aversion parameter is about 0.7. We find evidence that survey responses to hypothetical questions, although they are not incentivized, are predictive of real economic decisions with large stakes, such as stock market participation. Thus our estimates for risk preference parameters based on those survey responses should help us better understand choice of self-employment in Korea.

We also find that there exists substantial heterogeneity across demographic groups. Female, older, more educated, married and poorer respondents tend to be more risk averse. Our results also indicate that erroneous results are more likely for male, younger, more educated and poorer respondents. Lastly, we find that repeat participants to the identical survey questions are less risk averse and make more random choices.

II. Data

2.1 Sample

The KLIPS is an annual representative longitudinal survey of individuals from about 5,000 households in Korea. The KLIPS consists of household survey and individual level survey for the members of the household aged 15 or older. The first wave of the survey started in 1998 for 13,321 individuals in 5,000 households. Survey respondents have face-to-face interviews with respondents when possible for a wide range of personal and household information. The 7^{th} and the 10^{th} waves of the KLIPS, each conducted on 11,661 individuals from 4,762 households and 11,855 individuals from 5,069 households, respectively, include hypothetical lottery questions.

Respondents who did not personally participate in the interviews are eliminated

as risk attributes for an individual cannot be accurately answered by others. We only kept the adult population aged between 20 and 85 for our analysis. Overall, 7,553 and 8,235 individuals were included in our analysis from the 7th and the 10th waves of the KLIPS, respectively. Personal characteristics including age, gender, education level, marital status were gathered from the KLIPS personal survey and household income was taken from the household survey and was matched to each individual based on household identification numbers.

[Table 1] Hypothetical Lottery Questions

Question Number	Option A (Safe Choice)	Option B (Risky Choice)	Gap in Expected Payoff (Option A - Option B)
1	100,000	1/2 of 150,000, 1/2 of 50,000	0
2	100,000	1/2 of 200,000, 1/2 of 0	0
3	100,000	2/5 of 200,000, 3/5 of 0	20,000
4	100,000	3/5 of 200,000, 2/5 of 0	-20,000
5	100,000	1/5 of 500,000, 4/5 of 0	0

Notes: All units are in Korean Won. The questions were asked in the order of the question number. Each question was asked for the payment option for a day's work.

2.2. Lottery Questions

There is a set of five hypothetical lottery choice questions, exactly identical in the 7th and the 10th waves of the KLIPS. Each question offers three payment options for a day's work. Respondents are asked to select if they would take a risk-free certain payment, lottery option or if they are indifferent between the two choices. The five different lottery treatments are presented in Table 1. The certainty option commonly offers 100,000 Korean won (KRW), and the five lottery options offer different lotteries (different payoffs and probabilities). For example, the first lottery option gives 50,000 KRW with probability 0.5 and 150,000 KRW with probability 0.5. The five questions were asked in the same order as presented in Table 1.

We reshaped the data so that each respondent would have five observations, each observation corresponding to each respondent's response to one of five lottery questions. To get a sense of the distribution of risk preferences among the Korean population, in Table 2 we present the proportion of respondents who selected the risk-free cash option for *all* the five options from the 7th wave. The proportion increases for older age group, lower education group and lower income group, while it decreases for male and single group. The patterns in risk attitudes across demographic groups are consistent with those reported for other countries (Harrison and Rutström, 2008; Dave et al., 2010; Hryshko et al., 2011).

[Table 2] Probability of Safe Choices by Individual Characteristics

	Probability of Safe Choices	Observations
Age groups:		
Age between 20-29	0.734 (0.442)	1,103
Age between 30-39	0.752 (0.432)	2,083
Age between 40-49	0.815 (0.388)	1,899
Age between 50-59	0.883 (0.321)	1,327
Age between 60-69	0.937 (0.243)	810
Age 70 and over	0.942 (0.233)	331
Gender		
Male	0.742 (0.437)	3,452
Female	0.879 (0.326)	4,101
Education		
Less than High School	0.905 (0.293)	2,308
High School Graduates	0.793 (0.405)	3,000
College Graduates	0.757 (0.429)	2,245
Marital status		
Married	0.834 (0.372)	5,755
Not Married	0.760 (0.428)	1,798
Household income		
Annual Household Income less than 10,000,000	0.881 (0.324)	933
Annual Household Income between 10,000,000 and 25,000,000	0.814 (0.389)	2,564
Annual Household Income between 25,000,000 and 50,000,000	0.804 (0.397)	2,802
Annual Household Income greater than 50,000,000	0.800 (0.400)	1,133
All respondents	0.816 (0.388)	7,553

Notes: Safe choice refers to the selection of certainty over lottery for all five questions. All monetary units are in Korean Won. Standard deviations are reported in parentheses.

III. Structural Estimation Using Individual Choices

We assume that the choices over risky alternatives follow the expected utility theory. We use the following hybrid power-expo utility function (Saha, 1993):

$$U(x) = (1 - \exp(-\alpha x^{1-\gamma})) / \alpha \tag{1}$$

Note that the utility function embeds the CRRA and constant absolute risk aversion (CARA) specifications. It reduces to CARA when $\gamma = 0,$ and the function reduces to CRRA when $\alpha = 0$. If $\alpha > 0$, the Arrow-Pratt index of relative risk

aversion is positive and the utility function exhibits the property of increasing relative risk aversion.

$$\frac{-u''(x)x}{u'(x)} = \gamma + \alpha(1-\gamma)x^{1-\gamma} \tag{2}$$

Following Holt and Laury (2002) and Andersen et al. (2008), we introduce a noise parameter μ from Luce (1959). This parameter captures the insensitivity of choice probabilities to payoffs in the following probabilistic choice index in the form of a cumulative probability distribution function:

$$\nabla \mathrm{EU} = EU_A^{1/\mu} / (EU_A^{1/\mu} + EU_B^{1/\mu}) \tag{3}$$

where EU_j denotes the expected utility of option $j = A$ (risk-free cash) or B (lottery). It is easy to see that, as μ increases, the choice probability approaches 0.5. At the extreme, the choice will be completely random. On the other hand, as μ approaches zero, the probability of the option with greater expected utility will be chosen approaches one, which is consistent with the standard expected utility theory.[2]

Using survey respondents' choice for each of the five lottery questions, we construct the following conditional log-likelihood:

$$\ln L(\alpha, \gamma, \mu; y, \mathbf{X}) = \sum_i^N \sum_j^5 ((\ln(\nabla \mathrm{EU}) | y_i^j = 1) + (\ln(1 - \nabla \mathrm{EU}) | y_i^j = -1)), \tag{4}$$

where $y_i^j = 1$ (or –1) denotes individual i's selection of option A (or B) for lottery question j. $\mathbf{X}$ is a vector of demographic characteristics of individuals including gender, age, education level, marital status, annual household income and the order of the hypothetical question. We allow for heterogeneity in risk aversion parameter γ and noise parameter μ, both of which are specified as linear functions of individual characteristics $\mathbf{X}$. We will estimate γ and μ without or with $\mathbf{X}$. We estimate Huber-White standard errors to correct for heteroskedasticity.

Note that we use expected utility from (hypothetical) income, distinguished from expected utility from wealth, as x is the payoff, not wealth. Studies consistently show that agents do not integrate income from all sources in every decision under experiment settings (Binswanger, 1981; Schechter, 2005). Heinemann (2005) also show that subjects fail to integrate their initial wealth with their decisions at all,

[2] Risk estimates are sensitive to the stochastic model used (Wilcox, 2008). Selection of the most suitable stochastic model is still under heavy debate.

using experiment data of Holt and Laury (2002) and Harrison et al. (2005). In behavioral economics this kind of behavior, which is not fully rational, is called "narrow framing" (DellaVigna, 2009).

There is an alternative method of estimating risk parameters (Coller and Williams, 1999). Given the responses to hypothetical lottery questions, assuming a certain utility function, it is possible to compute the upper and lower bound of the risk aversion parameter, assuming CRRA utility function. Then, using the upper and lower bounds, a conditional likelihood function can be constructed. Compared to the first estimation method using individual choice data, this method is simple but limited at least for the following two reasons; first, it requires assuming a specific distribution of risk aversion parameter. Second, using this approach, we cannot fully utilize the data from those respondents that make "inconsistent" choices, i.e., the computed lower bound is greater than the upper bound.[3]

IV. Estimation Results

4.1 Results for Risk Aversion Parameter

Table 3 presents the estimates of relative risk aversion parameter γ and noise parameter μ as a function of individual characteristics from the 7th wave of the survey, the first time that respondents were exposed to lottery choice questions. In Column 1, we estimate the power-expo utility function. The results support CRRA as α is statistically insignificant. Thus we use CRRA as our main specification.[4]

Column 2 presents the results when both parameters are not allowed to vary across individual characteristics. We find that γ is about 0.7 and μ is 0.3.[5] Both estimates seem to be a little higher than other estimates using data from lab experiments. Holt and Laury (2002) estimate of γ is 0.27 and μ is 0.13; Dave et al. (2010) estimate is 0.41 and 0.06, respectively; and Harrison and Rutström (2008) estimate of γ using data from Harbaugh et al. (2002) is 0.48. The value of risk aversion parameter from our study is greater than estimates from experiments. However, direct comparison of estimated parameters is difficult as demographic background of participants, the set of hypothetical questions used and the data acquisition methods were greatly different among the studies. Greater risk aversion may be driven by demographic variations in populations in survey compared to

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[3] Recall that the first method can still use these observations by allowing for noise.

[4] We can test specifications by using log likelihood. However, as the result provides log pseudo-likelihood, the distribution of likelihood ratio test is not standard and complex.

[5] We used individual interval estimation method using the same data and found that γ is over 4, which seems to be large compared to estimates in other studies using individual data in the literature. It seems that the use of less restrictive method yields much more reasonable estimates.

[Table 3] Maximum Likelihood Estimations of Risk Parameter and Noise Parameter

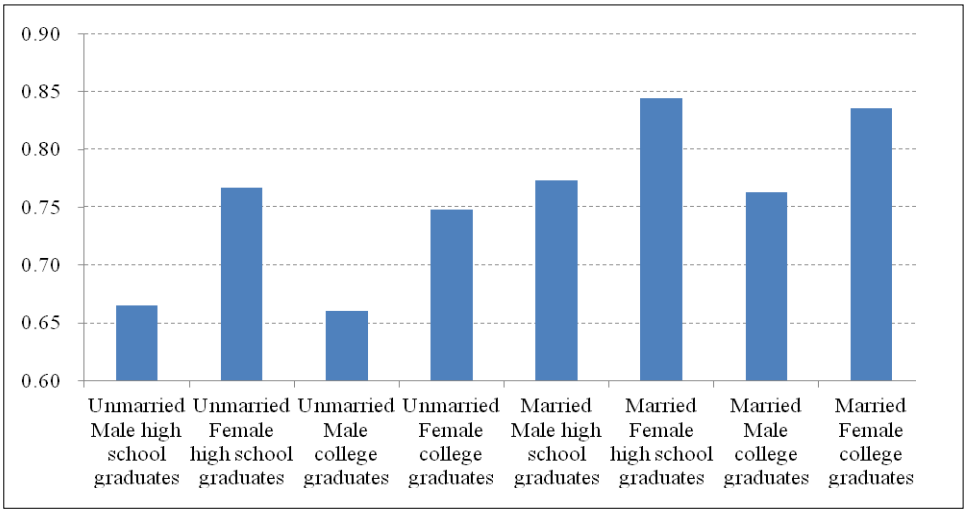
	Sample Mean	(1) *Power-expo*	(2)	(3) *CRRA*	(4)
γ : Constant		0.270**	0.712***	0.392***	0.560***
		(0.137)	(0.009)	(0.051)	(0.050)
Male	0.46			-0.108***	-0.096***
	[0.50]			(0.022)	(0.020)
Age	44.04			0.005***	0.004***
	[13.57]			(0.001)	(0.001)
High School Graduates	0.40			0.090***	0.076***
	[0.49]			(0.026)	(0.024)
College Graduates	0.30			0.105***	0.087***
	[0.46]			(0.032)	(0.028)
Married	0.76			0.074**	0.062**
	[0.43]			(0.030)	(0.028)
Annual Income (in millions KRW)	32.62			-0.0006***	-0.0005***
	[34.24]			(0.0001)	(0.00003)
Question Order					-0.043***
					(0.005)
μ : Constant		0.901***	0.298***	0.246***	0.243***
		(0.049)	(0.005)	(0.027)	(0.024)
Male				0.118***	0.106***
				(0.013)	(0.011)
Age				-0.002***	-0.002***
				(0.0004)	(0.0004)
High School Graduates				0.068***	0.062***
				(0.013)	(0.012)
College Graduates				0.076***	0.067***
				(0.017)	(0.015)
Married				0.011	0.008
				(0.016)	(0.015)
Annual Income (in millions KRW)				-0.0003***	-0.0002***
				(0.0001)	(0.0001)
α		-0.019			
		(0.177)			
Wald Test Statistics				88.32***	187.44***
Log Pseudolikelihood		-12,764	-15,791	-14,980	-14,935
Number of Observations:		37,760	37,760	37,760	37,760

Note: Standard deviations are reported in squared brackets, and standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

subjects of all three experiments who are mostly college students. For example, age may explain the discrepancies because the average age of survey participants is much higher than that of college students and older people are generally more risk averse.

When we allow for heterogeneity in both risk aversion and noise parameters, we find that risk aversion increases for older, more educated and married respondents while it decreases with income and being male. The increase in risk aversion by college graduation compared to non-high school graduates, or the decrease in risk aversion by male compared to female, is comparable to the increase in risk aversion from aging by twenty one years. Magnitude of decrease in risk aversion by income is relatively small as an increase in annual household income by ten million KRW is comparable to the increase in risk aversion from aging by one year. Figure 3 illustrates the risk aversion variation per key demographic groups by gender, education level and marital status. We assume the mean annual income and age level for each respective demographic group. Unmarried males with college education exhibit the lowest risk aversion and married females with high school education exhibit the highest risk aversion. The estimated γ ranges from 0.66 to 0.84 over the selected key demographic groups.

[Figure 3] Predicted Risk Aversion Parameters of Key Demographic Groups



Notes: Predicted CRRA risk aversion parameters based on the estimates in Column (4) in Table 3. Prediction is evaluated at mean age and annual income of each demographic group.

Harrison et al. (2005) point out that the order of questions may affect subjects' responses. Independent of increasing scale of payoffs, the order of hypothetical questions has a statistically significant effect on risk attitudes. We verify this "order effect" in our analysis. Table 1 shows that the scale of payoffs does not increase with

the order of questions; hence we can identify pure psychological order effect, independent from scale effect. Risk aversion decreases with the order of questions, controlling for all other individual heterogeneity.

4.2 Results for Structural Noise Parameter

We find that μ increases for the male, higher education group and decreases with income and age. The magnitude of the male gender's impact on increasing randomness in the survey response is comparable to the magnitude of reduction in the randomness from aging by roughly fifty nine years. Again, impact of income increase in noise reduction is small compared to other characteristics; reduction in randomness by annual household income increase by ten million KRW is comparable to noise reduction from increase in age by one and a half years.

Dave et al. (2010) argued that given different set of lottery questions with varying complexity, there may be a tradeoff between precision of risk preference measurement and comprehensibility, where randomness in responses may increase for respondents with limited math skills. In our analysis, assuming that the higher level of education is correlated with greater cognitive skill, respondents with greater cognitive skills are more likely to give random answers. The difference may stem from the nature of personal survey, where greater cognitive skill enhances a respondent's understanding of privacy protection, lack of reward in earnest responses and lack of punishment for poor quality participation and it may lead to more random or careless answers to survey questions in general to save personal participation time.

A noble characteristic of the survey allows us to study the magnitude of changes in respondents' responses when the respondents were asked the same type of lottery questions repeatedly in a relatively long period of time (3 years). Table 4 summarizes the estimates of γ and μ from both the 7^{th} and 10^{th} wave of the survey data. The results are similar to those in Table 3 using the 7^{th} wave data only. One notable result is that inclusion of the respondents from the 10^{th} wave of the survey vastly decreases incidence of erroneous responses. The noise parameter decreases in the second time the questions are asked while respondents become less risk averse as full specification model (3) indicates.[6]

We examine the stability of risk preferences within individuals over time by comparing the number of inconsistent answers between the 7^{th} wave and the 10^{th} wave. Table 5 summarized the probability of inconsistent answers of 6,117 respondents who participated in both the 2004 survey (7^{th} wave) and 2007 survey (10^{th} wave). Inconsistent answers do not necessarily imply deviations from expected utility theory. Rather it may represent errors due to trembling hands, respondents'

[6] Power-expo utility model would not converge when we included the 10^{th} wave survey data.

[Table 4] Maximum Likelihood Estimations of Risk Parameter and Noise Parameter of the Pooled 7th and 10th Rounds of the KLIPS Survey

	Sample Mean	(1)	(2)	(3)
γ : Constant		0.701***	0.402***	0.699***
		(0.005)	(0.037)	(0.046)
Male	0.46		-0.071***	-0.065***
	[0.50]		(0.015)	(0.014)
Age	44.84		0.005***	0.004***
	[13.77]		(0.001)	(0.001)
High School Graduates	0.39		0.068***	0.062***
	[0.49]		(0.020)	(0.019)
College Graduates	0.32		0.078***	0.068***
	[0.47]		(0.024)	(0.022)
Married	0.76		-0.007	-0.005
	[0.43]		(0.023)	(0.021)
Annual Income (in millions KRW)	35.87		-0.002	-0.002
	[36.45]		(0.002)	(0.002)
Second Time Exposure			0.044***	-0.137***
			(0.017)	(0.024)
Question Order				-0.034***
				(0.003)
μ : Constant		0.252***	0.203***	0.198***
		(0.003)	(0.018)	(0.017)
Male			0.092***	0.085***
			(0.008)	(0.007)
Age			-0.001***	-0.001***
			(0.0003)	(0.0002)
High School Graduates			0.060***	0.057***
			(0.010)	(0.009)
College Graduates			0.063***	0.059***
			(0.012)	(0.011)
Married			-0.010	-0.009
			(0.011)	(0.011)
Annual Income (in millions KRW)			0.00002	0.00002
			(0.0002)	(0.0001)
Second Time Exposure			-0.042***	-0.042***
			(0.008)	(0.008)
Wald Test Statistics			69.15***	180.00***
Log Pseudolikelihood		-29,838	-28,257	-28,191
Number of Observations:		78,940	78,940	78,940

Note: Standard deviations are reported in squared brackets, and standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

[Table 5] Inconsistent Responses in the 2004 and 2007 Surveys

	Probability of Inconsistent Answers		
	2004 Survey	2007 Survey	Number of Observation
Age between 20-29	0.197	0.109	778
Age between 30-39	0.174	0.100	1,652
Age between 40-49	0.128	0.058	1,590
Age between 50-59	0.082	0.043	1,141
Age between 60-69	0.048	0.024	708
Age 70 and over	0.048	0.032	248
Male	0.172	0.095	2,726
Female	0.092	0.047	3,391
Less than High School	0.117	0.066	3,685
High School Graduates	0.144	0.072	2,432
College Graduates	0.174	0.104	1,679
Married	0.116	0.068	4,792
Not Married	0.171	0.070	1,325
Annual Household Income less than 10,000,000	0.076	0.051	764
Annual Household Income between 10,000,000 and 25,000,000	0.132	0.062	2,108
Annual Household Income between 25,000,000 and 50,000,000	0.139	0.076	2,278
Annual Household Income greater than 50,000,000	0.135	0.075	872
Total	0.128	0.068	6,117

Notes: Linear regression of inconsistent answer dummy as the dependent variable showed that male, younger and non-married agent has higher probability of making inconsistent lottery decisions. Education level and income level coefficients were not statistically significant.

learning behavior during the survey or respondents' carelessness in survey responses. They are classified as inconsistent if: 1) different responses to questions 1, 2 or 5, the lotteries with the same expected payoff difference, or 2) selection of lottery in question 3 and selection of non-lottery in question 1, 2 or 5, the lotteries with higher expected value than in question 3, and 3) selection of certainty in question 4 and selection of non-certainty in question 1, 2 or 5, the lotteries with lower expected value than in question 4. Overall inconsistent respondents were 12.8% of the population in 2004 but the number decreased precipitously to 6.8% in 2007. Decrease in random responses is common in all age, gender, education, marital status and income sub-groups. Repeat exposure to the same lottery questions in a three-year window decreased erroneous responses.

[Table 6] Responses to Hypothetical Lottery Questions and Self-Employment

	Sample Mean (1) & (2)	(1)	(2)	Sample Mean (3)	(3)
Number of Safe Choice X Consistent Answers	4.14 [1.87]	-0.016*** (0.004)	-0.008* (0.004)	4.14 [1.87]	-0.010* (0.005)
Inconsistent Answers	0.11 [0.31]	-0.026 (0.025)	0.002 (0.024)	0.13 [0.34]	-0.026 (0.027)
Male	0.46 [0.50]		0.180*** (0.009)	0.44 [0.50]	0.165*** (0.010)
Age	44.29 [13.59]		0.002*** (0.0004)	46.84 [13.80]	0.002*** (0.0004)
High School Graduates	0.40 [0.49]		-0.006 (0.012)	0.38 [0.49]	-0.006 (0.013)
College Graduates	0.29 [0.45]		-0.049*** (0.013)	0.30 [0.46]	-0.044*** (0.015)
Married	0.77 [0.42]		0.061*** (0.010)	0.77 [0.42]	0.042*** (0.011)
R^2		0.004	0.081		0.063
Number of Observations:		7,066	7,066		6,105

Notes: Linear probability models are estimated. The dependent variable is the indicator for self-employment. The unit of observation is individual. Standard deviations are reported in brackets and standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5. Behavioral Relevance of Survey Responses and Hypothetical Bias

Our results are based on non-incentivized responses to hypothetical questions. Although there are advantages of using survey data, survey responses might not be incentive compatible and our results may be limited in that sense. To address this concern at least partially, we examine whether the responses to the lottery questions have any predictive power for risky choices in the real world; actual self-employment and stock ownership. In addition we perform sensitivity analysis where we estimate the impact of lagged risk aversion on risk-related decisions. The number of safe choices and inconsistent answers are measured in the 7th wave of KLIPS and all other variables including the dependent variables are measured in the 10th wave of the survey.

Table 6 present results from linear regression analysis, taking self-employment as dependent dummy variable. For simplicity we use the number of safe choices as a measure of risk aversion. The key coefficient is on the interaction variable between the counts of safe choices, defined as selection of certainty choice with consistent, or

non-random, response. In Table 6, this coefficient is statistically significant and negative in all models. Nearly one percentage point fall in self-employment probability is correlated with one more certainty payment selection by a respondent. The results indicate that the more certain payment selection or "safe" choice a respondent makes, given that the respondent's response was not random, less likely it is for the respondent to be self-employed, clearly a risk taking behavior. The results also indicate that self-employment probability increases for male and married individuals. This is consistent with Korean labor market characteristic where married male are typically the major source of household income that when they failed to be promoted in a company, they either quit or are laid off prematurely to start their own small businesses. College graduates who are likely to have better education and to have more stable job would be less likely to be self-employed, indicating that Korean companies have strong preference for college graduates. The results from sensitivity analysis presented in the third column are similar in magnitude and statistical significance to the results presented in the second column. This shows that the correlation between risk aversion and self-employment between the 7th and the 10th waves of KLIPS are stable over time.

We tested the validity of the influence of the survey responses on another financial risk related behavior, stock ownership. We used identical model as the analysis for Table 6, only replacing the dependent variable with an indicator for stock ownership. We limited the stock ownership analysis to heads of households only because stock market participation was only reported per household. Table 7 summarizes the result and the key coefficient is again negative, indicating that more "safe" choices are related to less stock ownership, another clearly risk taking behavior. In Column 2, a respondent who has one more certainty payment selection is about one percentage point less likely to participate in stock market investment. Stock market participation also increases as respondent graduates from college and it decreases among individuals whose responses to lottery questions were inconsistent. The results from the third column shows, as it was the case for self-employment analysis, that risk aversion measure is stable over time. The number of safe choices measure from the 7th wave of KLIPS seems to have similar correlation with stock-ownership measured in the 10th wave of KLIPS.[7]

Holt and Laury (2002) find that risk aversion increases when hypothetical questions are replaced by corresponding questions with real payoffs. Thus, responses to hypothetical questions may underestimate the degree of risk aversion. This is called as the "hypothetical bias" in the literature (Harrison and Rutström, 2008). As a corroborative analysis, we conducted the identical estimation as in this study, using a set of experiment data conducted on Korean college students with both hypothetical and real payoffs to assess the increase in risk aversion parameter.

[7] Results in Table 6 and Table 7 are robust to probit and logit models.

The experiment was conducted on 188 undergraduate students of Sogang University by Lee (2011), and lottery questions with both hypothetical and real payoffs are asked. The estimated CRRA risk aversion coefficient using the responses to real monetary returns was 0.423 and the coefficient using the responses to hypothetical returns was 0.185. As the dataset used in the study is Korean survey, the difference may be a reasonable guideline for the difference between the risk aversion estimate based on questions with hypothetical returns, as in the KLIPS, and the estimate based on real returns.

[Table 7] Responses to Hypothetical Lottery Questions and Stock Ownership

	Sample Mean (1) & (2)	(1)	(2)	Sample Mean (3)	(3)
Number of Safe Choice X	3.99	-0.019***	-0.017***	3.97	-0.019***
Consistent Answers	[1.99]	(0.003)	(0.003)	[2.00]	(0.004)
Inconsistent Answers	0.13	-0.072***	-0.067***	0.15	-0.088***
	[0.33]	(0.019)	(0.019)	[0.36]	(0.020)
Male	0.85		-0.002	0.81	-0.005
	[0.36]		(0.013)	[0.39]	(0.012)
Age	48.58		0.0003	50.69	0.001*
	[13.14]		(0.0003)	[13.50]	(0.0003)
High School Graduates	0.39		0.019**	0.37	0.019*
	[0.49]		(0.009)	[0.48]	(0.010)
College Graduates	0.28		0.092***	0.29	0.092***
	[0.45]		(0.011)	[0.45]	(0.011)
Married	0.78		0.015	0.74	0.023**
	[0.41]		(0.011)	[0.44]	(0.011)
R^2		0.010	0.042		0.045
Number of Observations:		3,118	3,118		2,830

Notes: Linear probability models are estimated. The dependent variable is the indicator for household stock ownership. The unit of observation is households. Standard deviations are reported in brackets and standard errors are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

VI. Conclusion

In this paper we structurally estimate the CRRA risk aversion parameter under the assumption of expected utility theory among the Korean adult population by utilizing survey responses to hypothetical lottery questions. We find that the parameter γ is about 0.7. However there exists a great deal of heterogeneity; Female, older, more educated, married and poorer respondents tend to be more risk

averse. There are a number of important auxiliary implications from the results of this study regarding risk preference elicitation methods. First, we find that the noise parameter μ is sensitive to individual characteristics. It is important to control heterogeneity when risk aversion parameters are structurally estimated. Second, our study provides useful intuitions on survey design, exploiting longitudinal nature of the survey. Repeat exposure to exactly same survey within three years drastically decreases likelihood of random responses. The implication of the finding on survey design is that asking identical set of questions in a longitudinal survey may not be effective. Rather, new set of questions may have to be developed for more accurate estimation of risk parameter.

Korea has unusually great proportion of people who are self-employed among the OECD countries. Consistent with the previous literature, we find that less risk-averse people are more likely to be self-employed. Impacts of risk aversion on other economic behaviors such as choice of degree program, terminal education level, savings and health level may be studied further as well.

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