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Self-Rated Health as Private Information in Predicting Mortality:
A Logit Analysis Using KLIPS

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Using a ten-year span of the Korean Labor and Income Panel Study and a logit specification, this study aims to analyze whether self-rated health has private information about future mortality controlling for demographic and socioeconomic characteristics, health behaviors, and critical medical factors. In particular, it is explored whether predictive power of self-rated health varies with age. For that purpose, the data is divided into three age groups consisting of 30-44, 45-54, and 55-69 groups. It is shown that predictive power of self-rated health on mortality exhibits an increasing and non-decreasing pattern with age. Recently, one noticeable phenomenon in the Korean pension market has been that the enrolment into a defined contribution plan has increased compared to a defined benefit plan. Unlike the workers in DB plan, workers in DC plan annuitize wealth upon retirement. Thus, if individuals have more private information about their health at retirement phase than at younger phase in their lifetimes, the annuity markets at retirement age are likely to suffer from more informational problem. Given the empirical results, it may become hard to insure longevity risk for workers in DC plans in Korea compared to those who are enrolled into DB plans.

Keywords: Self-Rated Health, Mortality, Private Information, Firm Size

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Ⅰ. Introduction

This study aims to analyze whether self-rated health (SRH) has private information about future mortality controlling for observed characteristics of individuals such as demographic and socioeconomic status, health behaviors, and critical medical factors. The idea is to explore whether SRH contains information beyond that would typically be available to any other market participants.[1] For that purpose, this study uses a ten-year span of the Korean Labor and Income Panel Study (KLIPS). There are some previous research that have analyzed the relation between SRH and mortality (or health) using the same data (Khang et al., 2004), Kim and Williams (2012), Kim et al. (2013), and Moon and Woo (2008)). However, the works mentioned above were rather incomplete in the sense that they used only information on demographic and socioeconomic status of individuals as control variables. As a result, it was hard to determine whether the estimated coefficients of SRH variable contain private information on future mortality because objective health status such as health behaviors and critical medical factors hidden in unobservables may be correlated with SRH and yield biased estimates. In this study, the limitations are tackled using additional survey of 'health and retirement' conducted in the 4th wave of KLIPS. So far, there have been a numerous literature investigating the role of SRH as a mortality predictor.[2] To the extent that SRH does contain a predictive power for future longevity, I am interested in how the predictive power varies with age. Therefore, it is further investigated whether predictive power of SRH varies with age. A few studies previously took the same approaches and presented the contrasting results. That is, Banks et al. (2007) found out the positive relationship between predictive power of SRH and age whereas Burstrom and Fredlund (2001) and Van Doorslaer and Gertdtham (2003) discovered the negative relationship. Under this

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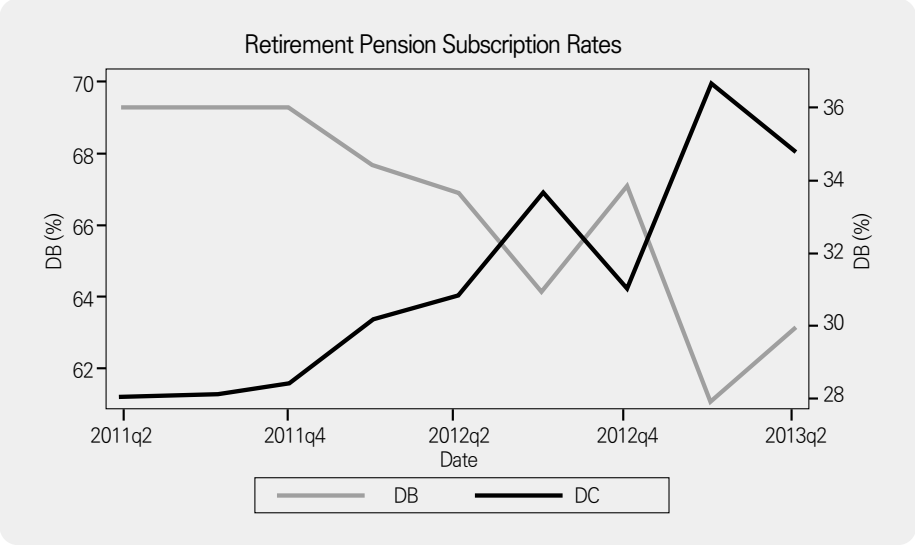
1) Obviously, if this happens, SRH is supposed to possess private information in forming a longevity expectations.

2) For a comprehensive survey on this topic, see Idler and Benyamini (1997).

circumstance, it is difficult to determine whether the contrast reflects a true difference in the underlying populations, or differences in the way SRH is measured across the different surveys. It is expected that this study helps to figure out whether the contrasting results reflect a real difference across the countries. Recently, one noticeable phenomenon in the Korean pension market is that the enrolment into a defined contribution plan has increased gradually compared to a defined benefit plan as shown in figure 1. In fact, traditional DB pension plans have been gradually losing their dominance in the occupational pension systems of many countries. For the details on this trends, see Broadbent, Palumbo, and Woodman (2006).

Figure 1. Retirement Pension Subscription Rates



Source: Financial Supervisory Service

Much has been made of the fact that this trend exposes workers to a greater financial market risk. However, the other aspect of DC pension that it may alter worker's exposure to longevity risk has received little attention so far. Contrary to the fact that workers are effectively committed to an annuity when firms provide

them with DB plans, workers in DC plans should purchase various immediate annuities with wealth at retirement. As well known, annuity markets are susceptible to significant informational problem. Only those who have private information that their health status is good tend to purchase annuities. If individuals have more information about their health (in other words, expected longevity) at retirement phase than at younger phase in their lifetimes, the annuity markets at retirement age are likely to suffer from more adverse selection than the annuity markets that are tied at younger age. Thus, it may become hard to insure longevity risk for workers in DC plans compared to subscribers to DB plans. To investigate this possibility, we classify the data into 30-44, 45-54, and 55-69 age groups and test whether there are differences in predictive power of SRH across age groups. To my best knowledge, Banks et al. (2007) was the only work that investigates whether predictive power of SRH varies with age to have an insight on the current trends in pension market. Conventionally, a typical approach to test for informational problem in an annuity market is to look for correlation between annuity purchases and subsequent ex-post risk experience[3] (see Finkelstein and Poterba (2002), (2004)). In this study, I follow a complementary strategy proposed by Banks et al. (2007) to determine directly whether individuals actually have private information about future longevity.

The next section provides details on the data and empirical strategy. The results are presented and discussed respectively in the subsequent sections. The last section provides concluding remarks.

[3] Mainly, this approach is quite hard to implement unless a researcher can acquire a firm-level data. In Korea, Lee (2012) is the only empirical work that investigated an annuity market using a firm-level data.

Ⅱ. Data and Methodology

1. Data Description

The data used in this report are KLIPS administered by the Korea Labor Institute. KLIPS is an annual longitudinal survey of the labor market and income activities of representative households and individuals residing in urban areas. The first wave of the KLIPS was launched in 1998 and the most recently released data is the 13th wave that was conducted in 2010. The original sample of the KLIPS was comprised 5,000 households that were recruited through two stage stratified clustering sampling. The ten-year data spanning from the 4th wave (year 2001) to the 13th wave (year 2010) are taken for the analysis. The 4th wave of the survey consists of not only information on the standard survey questions such as household characteristics, economic activities, labor movement, and social activities of individuals but also comprehensive health related information of individuals contained in one-shot additional survey of 'health and retirement'. This additional survey includes information on SRH, mental and physical disability, pre-existing diagnosed medical conditions, and health behaviors. To figure out whether SRH contains additional predictive power on mortality, it is adequate to control for health behavior, diagnosed

Table 1. The distribution of mortality across age groups

Age	Male			Female		
	No. of subject	No. of death		No. of subject	No. of death	
		By disease	By other		By disease	By other
15-29	1,487	4	2	1,677	0	1
30-44	1,737	15	11	1,702	7	1
45-54	951	33	9	904	12	3
55-69	832	91	39	933	37	11
70+	263	31	90	458	15	104

medical conditions, and activity restriction as well as demographic and socioeconomic factors. In this respect, the 4th wave is chosen as a starting point for analysis. Table 1 provides the distribution of mortality across age groups.

Mortality employs a variable that flags all deceased individuals in the years between 2002 and 2010. In this study, the bold bracket zone in the table shows the subjects used for analysis. In the analysis, I focus on the individual who are active in the labor market. Therefore, I exclude age group 15-29 because mortality rate is too low and it is difficult to fix socioeconomic indications such as education and job for them in Korea. In addition, age group 70+ is excluded because they are already retired. I further define mortality as 'death by disease' because 'death by other causes' such as accident and natural death due to aging does not seem to be properly related to the private information contained in SRH. The used sample is divided into three groups according to some distinct features. Age 45 is the age when the individuals become eligible for purchasing an immediate annuity. Age 55 is when the average Korean workers start to retire and this process continues up to about age 65. I make this group include age up to 69 because it contains retiree who purchases immediate annuity upon the retirement. All the ages are measured at year 2001. Although some works analyze different gender groups separately, I pool the data because the mortality rate in female group is substantially low. Table 2 presents definitions and summary statistics of the variables used in the analysis.

Table 2. Descriptive statistics of variables

Variable	Mean	Standard Deviation
Independent variables		
Male	0.484	0.500
Age	48.27	12.79
Good health	0.493	0.499
Fair health	0.265	0.441
Single	0.053	0.225

Variable	Mean	Standard Deviation
Divorce/widowed	0.119	0.324
<=Middle school	0.455	0.498
>=College	0.200	0.400
Part-time employee	0.088	0.283
Self-employed/Employer	0.248	0.432
Unemployed/economically inactive	0.387	0.487
Smoker	0.327	0.470
Drinker	0.500	0.500
Activity restriction[a]	0.039	0.193
Critical medical condition[b]	0.019	0.136
$11,620<Annual household income<$19,365	0.274	0.446
$19,365<Annual household income	0.329	0.470
Dependent variable		
mortality	0.032	0.176
number of observations (n) = 6,985		

a Activity restriction flags those who because of a physical or mental condition or a health problem are limited in the kind of activity they can perform.

b Individuals who are subject to heart disease, cancer, and/or stroke are classified into having critical medical conditions. Also, those who have serious aftereffects due to the past critical medical conditions are included in this category.

Regarding SRH, the question “How would you rate your current health?” was provided to interviewees to extract information on their subjective health condition. Interviewees were asked to choose from the following 5 questions: “Very good”, “Good”, “Fair”, “Poor”, and “Very Poor”. I reclassify this subjective health status into the following: “Very good” and “Good” are classified as “Good”, “Fair” is classified as “Fair”, and “Poor” and “Very poor” are classified as “Poor”. Table 3 presents the distribution of SRH by age groups. The rates of those who report good health rapidly decrease with age while the rates of those who report poor health exhibit a rapidly increasing pattern. For those who report fair health, the rates show a slightly increasing pattern up to the retirement phase.

Table 3. Distribution of self-rated health by age groups

	Age			
SAH	All	30 to 44	45 to 54	55 to 69
Good	52.0%	68.1%	46.7%	25.7%
Fair	26.5%	22.5%	29.7%	31.0%
Poor	21.5%	0.94%	23.6%	43.3%
Total	100%(6,985)	100%(3,427)	100%(1,843)	100%(1,715)

Figure 2 shows the relationship between mortality and SRH in a nonparametric way. This is implemented using a locally weighted scatterplot smoothing (lowess) method. In this figure, it is clearly observed that there is a positive relationship between them. The fundamental question is this: "Does SRH contain additional predictive power on mortality once all the relevant factors such as socioeconomic and demographic characteristics, health behavior, and critical medical conditions are adequately controlled for."

Figure 2. Mortality and SRH

2. Methodology

The Logit model is used to identify how predictive power of SRH varies with age. That is, first, I divide the data into age groups as described in the previous section: 30-44, 45-54, and 55-69. Then, within each age group, econometric models of the following form are estimated:

$$\Pr ob(y_{2001+k}=1)=\frac{\exp(\alpha_A SRH_{2001}+X_{2001}\beta_A+Z_{2001}\gamma_A)}{1+\exp(\alpha_A SRH_{2001}+X_{2001}\beta_A+Z_{2001}\gamma_A)},$$

where y_{2001+k} is a measure of mortality at time 2001+k (k=1,⋯,9); SRH_{2001} is SRH at time 2001; X_{2001} includes demographic and socioeconomic variables; and Z_{2001} includes health behaviors, pre-existing diagnosed clinical conditions, and activity restrictions. Thus, I test whether SRH has additional predictive power for future mortality once controlling for the types of information that would be observed by an insurer in an annuity or insurance market. In short, empirical strategy is to model mortality between 4th wave and 13th wave as functions of information in the 4th wave. To determine whether private information about health accumulates with age, it is natural to compare estimates of the effect of SRH in models estimated for different age groups (as indicated by the A subscript on the coefficients of SRH variable). Regarding the parameter estimates, I present a measure of risk effect of SRH on the probability of future mortality with both marginal effect and odds-ratio. The former is the difference between the probability of a future mortality for individuals in one SRH category and the probability of the same health outcome for individuals in another SRH category. The latter is the ratio between the probability of a future mortality for individuals in one SRH category and the probability of the same health outcome for individuals in another SRH category. Finally, following the estimation of the logit model, I perform the test of equality between risk effects in different age groups for marginal effect. When the evidence

of either increasing patter or decreasing pattern of predictive power of SRH on future mortality across age groups is found, it is natural to be concerned with whether this pattern is statistically significant. That is, we need to verify whether parameter estimates are really statistically different from each other once estimated coefficients are significant. For this purpose, I perform the seemingly unrelated estimation (SUR) between the different age groups.

Ⅲ. Empirical Results

Marginal effects are presented in table 4. Marginal effects of good SRH versus a baseline of poor SRH are given in the first row of the table. Marginal effects of fair SRH, again versus the baseline category of poor SRH, are given in the second row. The results for the pooled sample are given in the first column. Table 4 indicates that individuals reporting good health and fair health in the 4th wave are less likely to experience death over the next 10 years compared to respondents reporting poor health, controlling for demographic and socioeconomic factors, pre-existing clinical conditions, and health behaviors. The model fits for logistic of mortality are in general good. Some scalar measures of fit for regression models are presented in the last four rows in table 4. According to log-likelihood ratio (LR) test, the model is statistically significant because the p-value is less than 0. In addition, McKelvey and Zavoina's R2, AIC, and BIC are presented to measure the goodness-of-fit of the model.

Table 4. Marginal Effects of SRH

	All	30-44	45-54	55-69
good	-0.86*** (-3.90)a	0.60 (0.78)	-1.03** (-2.41)	-0.97*** (-3.32)
fair	-0.73*** (-3.50)	0.68 (0.87)	-0.93** (-2.05)	-0.78*** (-3.01)
male	1.28*** (5.59)	0.71 (1.00)	0.89* (1.80)	1.45*** (5.09)
age	0.07*** (7.16)	0.18*** (2.83)	0.02 (0.29)	0.05* (1.90)
Single	-0.47 (-0.85)	1.00 (1.51)	-	-
Divorce/widowed	-0.62** (-2.31)	1.07 (1.31)	-0.30 (-0.57)	-0.86*** (-2.55)
Middle school	0.17 (0.85)	-0.36 (-0.72)	-0.34 (-0.97)	0.65** (2.21)
college	-0.40 (-1.31)	-1.99* (-1.90)	-0.87 (-1.13)	0.37 (0.91)
Part-time employee	0.65* (1.81)	1.66 (1.33)	0.92 (1.58)	-0.11 (-0.21)
Self-employed/employer	0.34 (1.13)	2.42** (2.26)	0.48 (0.92)	-0.55 (-1.29)
Unemployed/economically inactive	1.27*** (4.36)	3.09*** (2.85)	0.88* (1.69)	0.67* (1.80)
Middle income	-0.43** (-2.09)	-0.38 (-0.71)	-0.45 (-1.12)	-0.51* (-1.83)
High income	-0.35* (-1.68)	-0.53 (-0.85)	-0.78* (-1.68)	-0.24 (-0.91)
Smoker	0.46** (2.26)	0.92 (1.36)	-0.002 (-0.01)	0.58** (2.40)
Drinker	-0.07 (-0.38)	-0.15 (-0.27)	0.43 (1.07)	-0.32 (-1.35)
Activity restriction	0.61** (2.49)	-1.23 (1.52)	1.30*** (3.05)	0.28 (0.82)
Clinical disease	0.55* (1.79)	2.42** (1.96)	-0.55 (-0.49)	0.62* (1.80)
LR chi-square test statistic Prob > chi-square	369.83 0.00	51.629 0.00	58.915 0.00	132 0.00
McKelvey and Zavoina's R2	0.375	0.548	0.231	0.272
AIC	0.205	0.073	0.215	0.474
BIC	-60252.88	-27523.87	-13179.74	-11789.82

a Parentheses indicate z-values. *p < 0.1, **p < 0.05, and ***p < 0.01

The corresponding odds-ratio, reported in table 5, indicates that those who report good health and fair health are two thirds and a half less likely to experience death over the following 10-year period, respectively, compared to respondents reporting poor health. Both marginal effects and odds-ratios are statistically significant at conventional levels ($p < 0.05$).

Table 5. Odds-ratios for SRH

	All	30-44	45-54	55-69
good	0.43*** (-3.90)a	1.82 (0.78)	0.36** (-2.41)	0.38*** (-3.32)
fair	0.48*** (-3.50)	1.98 (0.87)	0.39** (-2.05)	0.46*** (-3.01)
male	3.58*** (5.59)	2.04 (1.00)	2.44* (1.80)	4.24*** (5.09)
age	1.07*** (7.16)	1.20*** (2.83)	1.02 (0.29)	1.05* (1.90)
Single	0.63 (-0.85)	2.74 (1.51)	-	-
Divorce/widowed	0.54*** (-2.31)	2.90 (1.31)	0.74 (-0.57)	0.42*** (-2.55)
Middle school	1.18 (0.85)	0.69 (-0.72)	0.71 (-0.97)	1.92** (2.21)
college	0.67 (-1.31)	0.14* (-1.90)	0.42 (-1.13)	1.44 (0.91)
Part-time employee	1.93* (1.81)	5.25 (1.33)	2.51 (1.58)	0.90 (-0.21)
Self-employed/employer	1.41 (1.13)	11.25** (2.26)	1.61 (0.92)	0.58 (-1.29)
Unemployed/economically inactive	3.55*** (4.36)	21.98*** (2.85)	2.45* (1.69)	1.96* (1.80)
Middle income	0.65** (-2.09)	0.68 (-0.71)	0.64 (-1.12)	0.60* (-1.83)
High income	0.70* (-1.68)	0.59 (-0.85)	0.46* (-1.68)	0.79 (-0.91)
Smoker	1.56** (2.26)	2.51 (1.36)	0.99 (-0.01)	1.79** (2.40)
Drinker	0.93 (-0.38)	0.86 (-0.27)	1.54 (1.07)	0.72 (-1.35)
Activity restriction	1.83** (1.79)	3.41 (1.52)	3.67*** (3.05)	1.32 (0.82)
Clinical disease	1.74* (1.79)	11.19** (1.96)	0.58 (-0.49)	1.85* (1.80)

a Parentheses indicate z-values. *p < 0.1, **p < 0.05, and ***p < 0.01

I next examine results of models separately for the 30-44, 45-54, and 55-69 age groups to investigate whether the additional predictive power of SRH varies with age. In tables 4 and 5, results for the 30-44, 45-54, and 55-69 age groups are in the second column, the third column, and the final column respectively. The marginal effects on mortality risk of reporting good health is actually positive for the youngest group[4], turns negative for the second group, negative and decreases (that is, less negative) for the third group. From these results, it seems that the incremental predictive power of SRH decreases with age in accordance with the results from the Swedish data. However, the coefficient in the youngest group is not statistically different from zero. The same qualitative features occur in the odds-ratios model. Under this circumstance, it is necessary to check out whether statistically significant coefficients are statistically different from each other; that is, between 45-54 and 55-69 age groups.[5] Table 6 reports the results from tests of equality between marginal effects in second and third age groups from SUR and confirms that the marginal effects for two groups are not statistically different from each other. Numbers in the table indicate p-values from test. That is, although predictive powers of SRH seem to vary with age in the second and third group, the degree of private information contained in two groups are the same amounts. Therefore, we conclude that predictive power of SRH on mortality shows an increasing and non-decreasing pattern with age.

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4) For this result, Banks et al. (2007) presents an interesting interpretation. According to them, if this positive coefficients results are robust, it might reflect misperception leading to under-investment in health or greater engagement in risky activities.

5) On the other hand, I have implemented the same procedure using 'fair' as a baseline. The empirical results show that the estimated coefficients of 'good' in this case are not significantly different from the coefficients of 'fair'. Judging from this fact, the difference between 'good' and 'fair' may not be large.

Table 6. Tests of Equality of Marginal Effects

	(good) 45-54	(fair) 45-54
(good) 55-69	0.912	-
(fair) 55-69	-	0.768

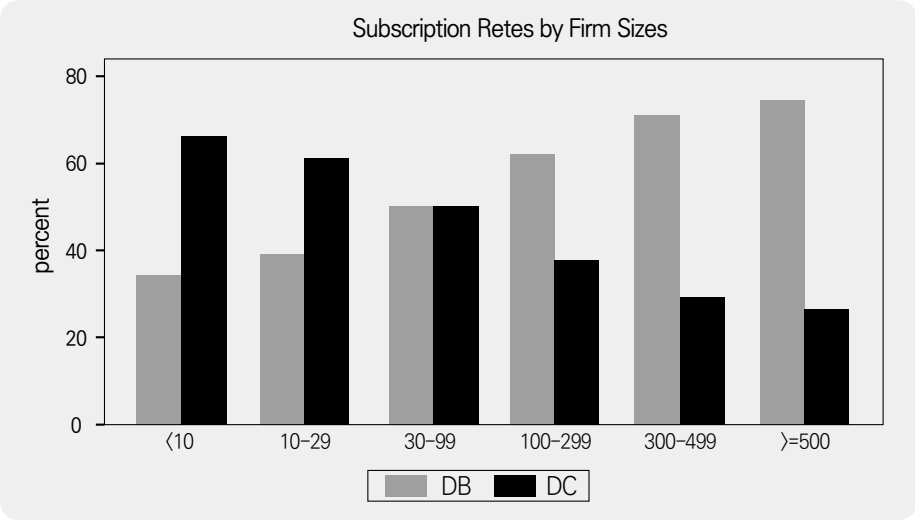
I briefly discuss the estimated coefficients of other variables. First of all, male tends to experience higher mortality rates than female as predicted. Further, this effect becomes significant and stronger as individuals become older. Regarding a marital status, divorcees and widowed people seem to experience a lower mortality rate. In particular, compared to the couples, old individuals without a partner have lower mortality rate. This may contrast with a common sense and need a further scrutinization in the future. Education level does not seem to play a significant role in predicting mortality. Household income level turns out to exert a meaningful effect on mortality. Especially, the richer households appear to experience a lower level of mortality compared to the poorer households. This effect is also present in some age subgroups. Regarding an employment status, both individuals with a part-time job and the unemployed experience a higher mortality rate compared to full-time workers. It is noticeable that this effect is apparent in every age subgroup for the unemployed. With regard to health behaviors, smoking affects mortality positively whereas drinking does not seem to affect mortality. The latter result may be due to the fact that the drinking behavior are measured loosely.[6] As can be predicted, activity restriction and clinical disease affect mortality in a positive way. The effects are present in some age subgroups. Overall, the signs are shown as they are expected, except for a marital status variable.

[6] Here, if an individual drinks any amount of alcoholic drinks during a week, s/he is classified as a drinker. Although data has more detailed classification according to the amount, I adopt a broader definition since there are already many explanatory variables in the model.

Ⅳ. Discussion

In this study, it is investigated whether SRH contains private information on future mortality controlling for commonly observed features of individuals. Using a ten-year span of KLIPS, it is shown that two older age groups including retiring group have private information whereas SRH of younger age group does not contain any private information contents. This result is contrary to the results obtained by Burstrom and Fredlund (2001) and Van Doorslaer and Gerdtham (2003) with the Swedish data and similar to the one by Banks et al. (2007) with Canadian data. Therefore, this study provides valuable additional evidence that age patterns in the predictive power of SRH may reflect a difference in the underlying populations. Empirical results in this report suggest that asymmetric information between the insured and an insurance firm may be present with regard to the insured's future health, resulting in a possible informational problem in annuity markets. Figure 3 shows DB and DC plan subscription rates with respect to firm sizes which are measured by the

Figure 3. Subscription Rates by Firm Sizes.



Source: Financial Supervisory Service

The next step would be twofold. First, with an access to panel data such as KILPS, it is necessary to investigate the co-evolution process of SRH and observed medical conditions of individuals through lifetime. Using the Health and Retirement Survey, Hurd and McGarry (2002) explores the evolution of subjective survival probabilities and their ability to predict actual mortality. I would implement this kind of information updating process by individuals that occurs in response to new information such as the onset of a new disease condition. With the dynamic panel data analysis, it is also possible to appropriately control the plausible problem arising from the potential intra-personal correlation.[7] Second, it would be necessary to analyze an annuity market directly to find out whether there exists the asymmetric information problem in the immediate annuity market in Korea. Through this direction of research, the role of SRH as private information with regard to annuity market may become much clearer.

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[7] See Fujii (2010) for an interesting discussion on intra-personal correlation problem. She used simultaneous estimation methods to solve the problem.

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Health and Social Welfare Review

사망률 추정에 있어서 주관적 건강상태에 담긴 사적 정보:
한국노동패널자료를 이용한 로짓분석

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본 연구논문에서는 개인의 인구학적・사회경제적 특성, 건강관련 위험행위, 주요 질병보유 등을 통제한 후 주관적 건강상태변수가 미래의 사망률에 대한 사적 정보를 담고 있는지를 분석한다. 이를 위해 한국노동패널의 10년 간 자료를 이용하여 로짓모형을 분석한다. 특히, 주관적 건강상태가 보유하는 미래 건강에 대한 예측력이 연령대에 따라 변하는지를 분석하는 것이 주요 목표이다. 이러한 목적을 위하여 자료를 30~44, 45~54, 55~69의 세 개 연령대로 구분하여 고찰한다. 본 연구결과에 의하면 향후 사망에 대한 주관적 건강상태변수는 향후 사망에 대한 예측력을 보유하며 예측력은 개인의 연령이 증가함에 따라 증가한 후 비 감소 양상을 보인다. 최근, 우리나라 퇴직연금시장에서 보이는 특징은 확정기여형연금가입이 상대적으로 증가하고 있다는 것이다. 확정기여형에 가입한 근로자는 은퇴와 함께 퇴직연금으로부터의 자산을 개인연금을 통해 연금화해야 한다. 따라서, 본 연구결과와 같이 근로자들이 젊은 시절보다 퇴직이 가까운 시점에서 그들의 건강에 대해 사적 정보를 보유한다면 비대칭적 정보의 발생으로 인하여 확정기여형 퇴직연금에 가입한 근로자들은 장수위험에 대한 대처에 있어 어려움을 겪을 가능성이 있을 것으로 판단된다.

주요용어: 주관적 건강상태, 사망률, 사적 정보, 기업규모