

## Retirement and Cognitive Ability in Korea\*

Hyejin Kim\*\*

*This study examines the effect of retirement on the cognitive ability of aging Koreans. Using six (2006–2016) waves of the Korean Longitudinal Study of Aging (KLoSA), we find the significant negative effect of retirement on cognitive ability. After retirement, individuals experience a decline in their cognitive ability scores by approximately 1% when compared with the average score. We also investigate the heterogeneity across age, gender, education, and job characteristics. The negative influence of retirement is pronounced and significant for those who are aged 68–80, are females, have lower levels of education, are non-wage-and-salary workers, and are blue-collar workers.*

JEL Classification: I12, J14, J24, J26

Keywords: Cognitive Ability, Retirement

### I. Introduction

Population aging is an important issue in many developed countries, in which an aging problem has been prompted by an increase in life expectancy. In Korea, population aging has progressed faster than that in other developed countries, thereby increasing its impact on society. The proportion of the population aged 65 and older is expected to increase from 13.8% in 2017 to 47.7% in 2045 (Statistics Korea, 2018). The life expectancy of Koreans is also expected to be the highest in the world for both men and women by the year 2030. The life expectancy for men and women born in 2030 is predicted to be 84.1 and 90.8 years, respectively (Kontis

---

*Received: April 24, 2017. Revised: Aug. 31, 2018. Accepted: Nov. 13, 2018.*

\* We would like to thank Chulhee Lee, Jungmin Lee, Sok Chul Hong, Syngjoo Choi, Keunkwan Ryu, Jae-Young Lim, Seonghee Kim, and two anonymous reviewers for their helpful comments on this study. This research was supported by the BK21Plus Program (future-oriented innovative brain raising type, a21B20130000013) funded by the Ministry of Education (Korea) and National Research Foundation of Korea. All remaining errors are our own.

\*\* Department of Economics, Seoul National University, 1 Kwanak-ro, Kwanak-gu, Seoul, Korea.  
Email: hyjnkim@snu.ac.kr.

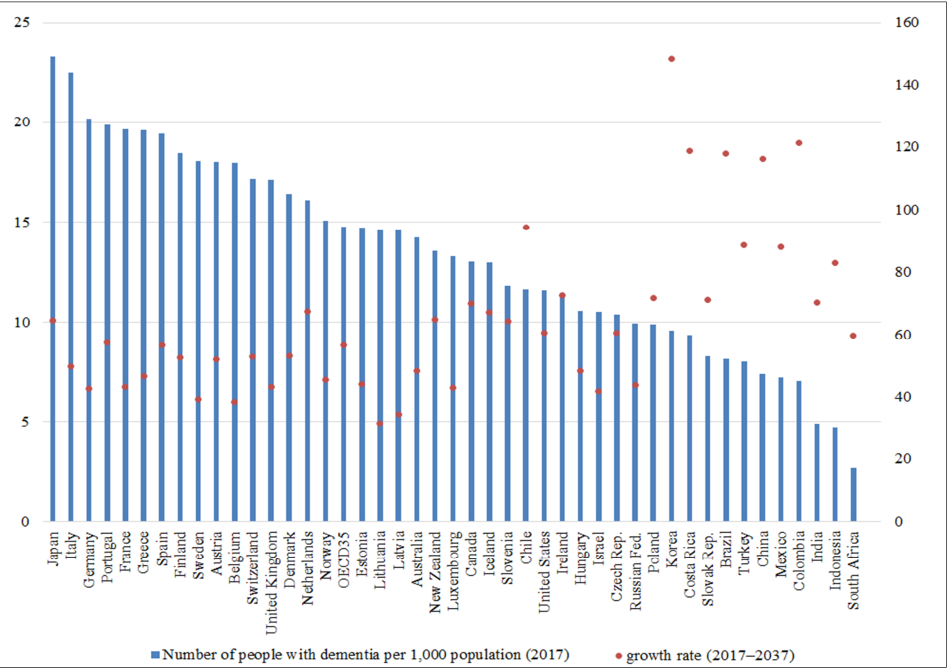
et al., 2017). Among the groups surveyed by Kontis et al. (2017), Korean women are the only group whose life expectancy is over 90 years.

Amid rapid population aging, particular attention has been devoted to the poverty and labor market participation of aging workers in Korea. Approximately half of South Korea's elderly are in poverty and at the highest level among the countries in Organisation for Economic Co-operation and Development (OECD), which defines poverty as having less than 50% of the median income. The job insecurity of aging workers is considered the main cause of poverty in the elderly population. After extensive restructuring in the labor market following the financial crisis in the late 1990s, old workers retire earlier than before because of companies' mandatory retirement practices (Grubb et al., 2007). As the average retirement age decrease and combined with the increase in life expectancy, the period after retirement of aging Koreans has become considerably longer than in the past.

This extended period raises concerns regarding how it may impact one's cognitive functioning later in life. Cognitive ability is fundamental for decision-making because it influences an individual's ability to process information and make appropriate choices (Mazzonna and Peracchi, 2012). Cognitive decline may have a serious negative impact on an individual's financial planning for retirement (Banks and Oldfield, 2007), medical treatment compliance, and planning of sequential activities (Fillenbaum et al., 1988). Moreover, cognitive impairment is emerging as a major driver of disability in old age. In 2017, Korea was estimated to have dementia in approximately 10 out of 1,000 people, which is lower than the OECD average. However, the number of people living with dementia is expected to increase by 148.6% over the next 20 years. This figure is the highest growth rate among OECD countries (Figure 1). Alzheimer's disease and related forms of dementia bring not only emotional hardship in supporting dependents but also come with significant social costs of dementia (Coe et al., 2012). In Korea, the social cost of dementia was 11.7 trillion won (around 1.0% of the national GDP) in 2013, and this cost is estimated to increase to 43.2 trillion won (nearly 1.5% of the national GDP) by 2050 (Kim and Lee, 2014).

Increasing research evidence shows that aging is related to the decline in cognitive ability. However, the rate of age-related cognitive decline is heterogeneous among individuals, and this rate is associated with an individual's socioeconomic status, such as education (Le Carret, 2003), occupation (Adam et al., 2006), and lifestyle activities (Newson and Kemps, 2005). In this study, we focus on the relationship between cognitive functioning and retirement, which is a critical event that occurs later in an individual's life.

[Figure 1] Prevalence of dementia in 2017 and its growth rate from 2017 to 2037



A simple ordinary least squares (OLS) estimation of the cross-sectional data shows the negative relationship between retirement and cognitive ability. However, this result may be biased because of the potential reverse causality (people with lower cognitive abilities may decide to retire earlier) or a correlation between the retirement choice and unobservable factors (Mazzonna and Peracchi, 2012). Therefore, previous studies have used instrumental variables (IV) or exploited the panel dimension of the dataset to control for retirement endogeneity and individual heterogeneity. A number of studies conducted in European countries and the United States use pension eligibility rules as IV. The majority of studies indicate the steep increase in the probability of retirement after reaching the age of eligibility for receiving social security benefits, such that this eligibility rule is a “strong” instrument.

However, aging Koreans do not react strongly to financial incentive inherent in the public pension scheme to retire.<sup>1</sup> Therefore, using pension eligibility ages as instruments is unsuitable. For example, we do not observe an increase in the retirement probability at age 60, the age at which people born before 1953 can receive full benefits from social security (see Figure A1). When we use eligibility

<sup>1</sup> Choi and Lee (2007) find that the effect of expected public pension wealth on early retirement is not substantial. Lee and Lee’s (2015) results show that the expected present value of public pensions is not significantly associated with the retirement hazard.

rules as instrument variables, Cragg–Donald weak identification tests cannot reject the null hypothesis of weak instruments at the 10% level of significance, thereby indicating that the instrument is weakly identified. The Cragg–Donald F statistics is 1.05, whereas the critical value for the 10% level is 16.3.

In this study, instead of using the IV technique, we mitigate the potential endogeneity caused by reverse and simultaneous causation by lagging the endogenous variable. We also use the panel dimension of the Korean Longitudinal Study of Aging (KLoSA), which allows for the time-variant individual effect to be controlled in addressing this endogeneity issue. We acknowledge that the problem of reverse causality is not completely solved without using the IV strategy. However, we analyze whether the lagged or the contemporaneous Mini-Mental State Examination (MMSE) score affects the transition from work to retirement, and the results report that the lagged or contemporaneous score does not have an effect on this transition. Although the reverse causality hypothesis has yet to be tested directly, the reverse causality problem may not be serious in our study.<sup>2</sup>

Our results highlight a small but significant negative effect of retirement on cognitive ability test scores. In the use of six (2006–2016) waves of KLoSA, we find that individuals exhibit a decline in cognitive functioning after retirement by approximately 5% of the standard deviation (SD). This decline corresponds to around 0.9% decrease in test score when compared with the sample average score.

A number of studies also analyze the heterogeneity of the effect of retirement on cognition. Mazzonna and Peracchi (2012) find that education is crucial in explaining heterogeneity in the level of cognitive abilities and argue that large and systematic differences exist in measured cognitive functions across European regions. Coe et al. (2012) distinguish between white- and blue-collar workers in estimating retirement effects. Although they find no effect of retirement length on cognition for white-collar workers, retirement may be beneficial for the late-life cognition of blue-collar workers. We also find evidence of the heterogeneity of retirement effects by age, gender, education, and previous employment status and occupation.

The rest of this paper is organized as follows. Section II reviews the previous literature regarding retirement and cognitive functioning. Section III describes the data we use and presents the empirical strategy. Section IV reports the main results and the results from the robustness analysis. Finally, Section V concludes this study.

---

<sup>2</sup> Additionally, we examine the retirement impact on the subset of samples that are not likely to be affected by this reverse causality problem, that is, people whose retirement decisions are not driven by cognitive decline. As in our main results, we find evidence of a negative effect of retirement on those employed in jobs characterized by a high level of physical burden. Job requirements in terms of physical strength are measured by survey responses to questions on what type of physical ability is needed for the job (physical strength, lifting heavy objects, bending upper body, bending knees, squatting, and good eyesight).

## II. Literature Review

Following the traditional human capital model, Mazzonna and Peracchi (2012) establish a model for the formation and deterioration of cognitive capital. The important insight of this model is that individuals can counterbalance natural age-related cognitive capital deterioration by investing in cognitive repair activities. The amount of repair investment depends on market and nonmarket incentives. After retirement, individuals lose the market incentive to invest in repair activities and lead to the increased rate of cognitive decline. This model can also support the use-it-or-lose-it hypothesis, which refers to the idea that a person can stave off normal cognitive aging by engaging in cognitively demanding activities (Rohwedder and Willis, 2010). On the one hand, we can suppose that workers engage more in mental exercises than retirees because work environments provide more cognitively challenging and stimulating environments than nonwork environments. Thus, retirement may lead to a decline in an individual's cognitive abilities. On the other hand, if retirees maintain an "engaged lifestyle" with active and intellectually stimulating activities, such as reading, playing bridge, or accomplishing crossword puzzles, then cognitive functioning can be preserved and even improved after retirement.

Empirical studies that investigate the causal relationship between retirement and cognitive ability show mixed results. Rohwedder and Willis (2010) estimate the effect of retirement on cognition in cross-country microdata from the English Longitudinal Study of Ageing, the Survey of Health, Ageing and Retirement in Europe (SHARE), and the United States Health and Retirement Study (HRS). They use national pension policies as instruments and find that retirement has a significant negative impact on the cognitive ability of individuals in their early 60s. Coe et al. (2012) use data from HRS and exploit offers of early retirement windows as instruments for retirement because these offers are legally required to be nondiscriminatory and unrelated to cognitive ability. Their IV results report that no clear relationship exists between retirement duration and late-life cognition.

Although these studies mainly use cross-sectional data, Bonsang et al. (2012) utilize the six waves of HRS to create longitudinal datasets that allow for fixed effects (FEs) to be controlled. They also apply the IV method using the early and normal eligibility age for social security as an instrument. The FE-IV estimates show the significant negative effect of retirement. Following Bonsang et al. (2012), Bianchini and Borella (2016) exploit the panel dimension of three waves of the SHARE dataset. They apply the IV technique to FE transformation by using country-specific retirement rules as an instrument. Unlike previous studies, they find that retirement duration has a positive effect on memory. Nishimura and Oikawa (2017) perform cross-sectional cross-country and dynamic analyses of individual countries by using the panel data of eligibility age in the United States,

European countries, China, Japan, and Korea; they show that retirement has only a weak effect on cognitive ability. The mixed results among previous studies can be explained by different identification strategies, data, and sample selection. Furthermore, the differences between Europe and the United States in their cultures, social norms, labor markets, health systems, and public and private pension systems may create these distinctions between the studies.

Within Korea, the literature on retirement focuses on reasons why aging workers are leaving the labor market. Cho and Kim (2005) suggest that many Korean corporations utilize mandatory retirement to deal with exorbitant wage increases that outpace productivity and are generated by the traditional seniority-based wage system. Lee and Lee (2013) show that workers leaving their jobs because of formal mandatory retirement are relatively few and largely males employed in large establishments, whereas informal mandatory retirement places strong pressure on aging female workers. Sung and Ahn (2006) find that non-wage-and-salary workers are more likely to remain in the labor force than wage-and-salary workers, thereby suggesting that previous job characteristics are important. Lee and Lee (2015) find that self-employed individuals are less likely to retire than wage-and-salary workers because of good matching between workers and jobs (i.e., between the required and desired amount of work) for self-employed individuals.

However, empirical literature analyzing the effect of retirement on physical and mental health and cognitive ability is limited. Kim and Choi (2017) reveal that retirement has a negative impact on health and overall life satisfaction among seniors. Seok (2011) shows that retirement has a negative impact on an individual's subjective health status. Ha (2015) uses the difference-in-difference approach with the propensity matching score method and finds no significant effect of retirement on cognition. However, she only uses the second and third waves of KLoSA. In this research, we use six waves of KLoSA and exploit its panel dimension, thereby allowing the control of time-invariant unobserved heterogeneity.

### III. Data and Empirical Strategy

#### 1. Data

Our analysis is based on six waves (2006–2016) of KLoSA, which is a nationally representative sample of approximately 10,000 people that are at least 45 years of age in South Korea. KLoSA has been conducted every 2 years since 2006 with consistent survey categories. To allow for international comparative studies on population aging, the survey categories and topics have been drafted in reference to the United States and European versions of the panel study. This dataset contains a wide range of topics that are grouped into the following seven main categories: demographics,

family, health, employment, income, assets, and subjective expectations and satisfaction.

In our research, we select a sample of individuals aged 55–80. These age restrictions allow us to exclude potential outliers whose low levels of cognition are likely pathological rather than a reflection of normal age-related cognitive decline (Coe et al., 2012). Furthermore, we exclude individuals who have never worked. The total sample corresponds to an unbalanced panel that includes 17,355 observations for 5,909 individuals.<sup>3</sup> We use KLoSA's definition of retirement that indicates a self-reported status where the individual has stopped full-time income-earning activities, is currently not working or working only as a hobby, and barring any major changes, plans to continue working only as a hobby.

KLoSA also provides measurements of cognitive ability that are based on the MMSE score, which is designed to measure aspects of cognitive functioning and is widely used for dementia screening. If the score is less than 24 out of 30 points, then the diagnosis is mild cognitive impairment. Individuals with a score below 19 are diagnosed as having dementia. This test is conducted on a one-to-one basis by the interviewer with no time limit. The total number of points available is 30. The test covers the following areas of cognitive functioning: orientation for time and place (10 points), memory (6 points), attention and calculation (5 points), language (3 points), and visuospatial skill (6 points). The dependent variable in the main results is the MMSE score. We also examine the effect of retirement on five domains of the sub-MMSE score to identify the differential impacts of retirement. All cognitive ability scores are standardized by subtracting their sample average and dividing by their sample SD to conduct the comparison and easily interpret the coefficients.

Columns (1) to (3) of Table 1 present the means of total scores and the five subitem scores by retirement status. Overall, retired individuals have lower test scores than working individuals, and the differences between the two groups are statistically significant. On average, the score of working individuals is 0.4 points higher than the score of retired individuals. These score gaps are most and least pronounced for visuospatial skills and attention and language, respectively. In addition to the simple comparison between nonretirees and retirees, we pair the before- and after-retirement scores for the same individuals and compare the means (columns (4)–(6) of Table 1). The gaps decrease, and the language score gap becomes statistically insignificant.

---

<sup>3</sup> Given that we use six waves of data, attrition starts at the second wave. A systematic relationship between cognitive ability, retirement, and attrition cause bias in our estimates, and we test for this probability by using the method proposed by Verbeek and Nijman (1992). We add a dummy variable indicating whether the individual is observed in the next wave. Evidence shows that sample attrition is related to cognitive ability. However, inclusion of the “next” variable slightly changes the coefficients of retirement, thereby indicating that although attrition is related to cognition, its effect on our main results is likely negligible.

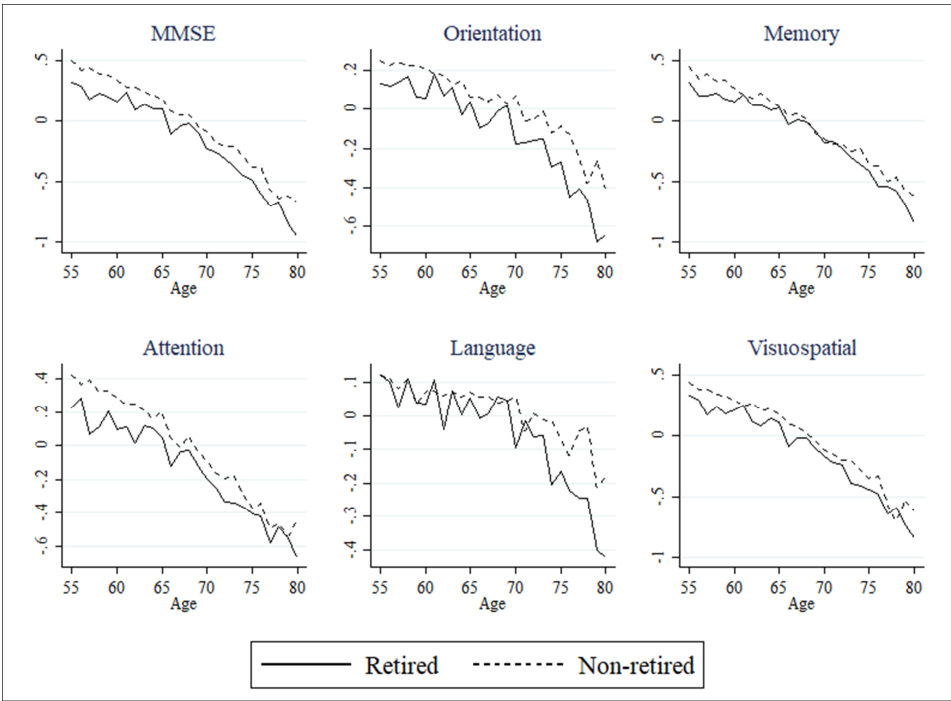
[Table 1] Means of cognitive ability score

	(1) Nonretiree	(2) Retiree	(3) Difference = (1) – (2)	(4) Before	(5) After	(6) Difference = (4) – (5)
MMSE	0.158	−0.237	0.396***	0.050	−0.106	0.156***
Orientation	0.107	−0.161	0.268***	0.037	−0.048	0.085**
Memory	0.121	−0.182	0.303***	0.057	−0.103	0.160***
Attention	0.132	−0.198	0.330***	0.003	−0.102	0.106***
Language	0.051	−0.077	0.128***	−0.024	−0.031	0.008
Visuospatial skills	0.135	−0.202	0.338***	0.074	−0.075	0.149***

Note: \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

Figure 2 shows the age profile of the average cognitive scores based on retirement status. First, the figure shows that the level of cognitive ability generally declines with age, and the slope is steeper for individuals over 65 years of age. Overall, nonretirees have higher levels of cognitive ability than retirees at all ages. However, we cannot assess whether a causal relationship exists between retirement and cognitive ability with this graphical evidence because of the potential endogeneity issue.

[Figure 2] Age profile of average cognitive score based on retirement status





## 2. Empirical Strategy

We investigate the impact of retirement on cognitive functioning within the framework of the FE model, which allows for the control of individual FEs. In the FE model, the identification of retirement coefficients depends on the individual samples who transition from work to retirement. In our sample of 5,909 individuals and 17,355 individual-year observations, 1,976 individuals retired. Our baseline specification is expressed as follows:

$$Y_{it} = \alpha_0 + \alpha_1 age_{it} + \alpha_2 agesq_{it} + \alpha_3 R_{it-1} + \beta' X_{it} + \mu_i + \epsilon_{it},$$

where  $Y_{it}$  represents the standardized MMSE score for  $i$ th individual in period  $t$ . The sample average of the unstandardized MMSE score is 26.01, and the SD is 4.44. We also consider the alternative dependent variable, which is the standardized score for orientation, memory, attention, language, and visuospatial skill, to help in estimating the effect of retirement on different areas of cognition.

The three main explanatory variables are  $age_{it}$ ,  $agesq_{it}$ , and  $R_{it-1}$ , where  $age_{it}$  is the individual's age, and  $agesq_{it}$  is the squared term of age.  $R_{it-1}$  is the dummy variable that is equal to 1 or 0 if the individual is reported to have retired or otherwise, respectively. We mitigate the possibility of the reverse causation and simultaneity by lagging the endogenous variable by one wave (2 years). This method is supported by Bonsang et al. (2012), Celidoni et al. (2017), Coe et al. (2012), and Mazzonna and Peracchi (2012) who suggest that the retirement effect can occur with a lag because environmental changes do not instantaneously affect cognitive functioning. Moreover, Atchley (1982) argues that retirees might experience a so-called "honeymoon phase," in which they can now engage in activities that they have previously put off because of work-related constraints. This factor may attenuate the negative effects of retirement on cognition immediately after retirement.

In the FE model, we control for time-invariant unobserved heterogeneity  $\mu_i$  by demeaning the variables and using the within transformation.  $\epsilon_{it}$  is an idiosyncratic error term. The other control variables in  $X_{it}$  include observed characteristics that influence cognitive ability, such as marital status, household income, and health and activity variables.

## IV. Results

### 1. Baseline Results

Table 2 demonstrates the pooled OLS, random effect (RE), and FE estimates of the effects of retirement on the MMSE score based on the total sample. We find that the coefficient of retirement is statistically negative in the OLS and RE estimates. In columns (3) to (5) of Table 2, the FE estimator is used and the retirement effect is still negative. However, the magnitude of the estimate for the retirement effect decreases after controlling the time-invariant individual effects. After retirement, individuals experience a decrease in their MMSE score by approximately 5.24% of the SD. This decline corresponds to a 0.23 point decrease in the unstandardized MMSE score, which is equal to 0.0524 times 4.44, and an approximately 0.88% decrease compared with the sample average score, which is equal to 0.23 divided by 26.01. Controlling for health and activity variables slightly changes the magnitude of the retirement effect, but we observe a qualitatively similar pattern.<sup>4</sup> We find that the use of the FE estimator can control for time-invariant heterogeneity. Hence, in the subsequent analysis, we only report coefficients that are based on FE regression.<sup>5</sup>

We then use the scores of the five cognitive domains as alternative dependent variables to capture the differential impact of retirement on the areas of cognitive functioning. The coefficients for orientation, language, and visuospatial skills demonstrated in Table 3 are significant and negative. The negative effect of retirement is most pronounced in the orientation domain. Retirement is associated with the reduction in the orientation score of nearly 7.9% of the SD. By contrast, memory and attention are seemingly unaffected by the retirement status. Although the coefficients are negative, the effect is not statistically significant.

---

<sup>4</sup> For baseline results, we include individuals who reported returning to work (i.e., partial retirement). However, including these individuals in the sample will require the assumption that the effect on cognitive functioning of leaving the labor force or going back into the labor force is symmetric. Moreover, individuals going back to work may be more likely to remain active in the labor market (e.g., looking for a job) during their nonworking period (Bonsang et al., 2012). Therefore, we assess the sensitivity of the results by excluding those individuals. When examining the effect of complete retirement on cognitive ability, the retirement effect is still negative but not significant. Moreover, the contemporaneous variable is significant and negative although the lagged retirement variable is not significant.

<sup>5</sup> The Hausman test rejects the null hypothesis of nonsystematic differences between the estimated FE and RE coefficients, thereby indicating that the RE estimates are inconsistent and that the FE model is preferred over the RE model.

**[Table 2]** Effects of retirement status on cognitive ability (baseline results)

Dependent variable	(1)	(2)	(3)	(4)	(5)
VARIABLES	OLS	RE	MMSE score FE	FE	FE
Age	0.1430*** (0.0236)	0.1332*** (0.0230)	0.1360*** (0.0268)	0.1276*** (0.0265)	0.1214*** (0.0264)
Agesq	-0.1284*** (0.0176)	-0.1208*** (0.0173)	-0.1182*** (0.0201)	-0.1087*** (0.0200)	-0.1038*** (0.0200)
Retirement (lagged)	-0.0877*** (0.0156)	-0.0762*** (0.0163)	-0.0551*** (0.0201)	-0.0512** (0.0200)	-0.0524*** (0.0200)
Controls					
Marital status	Y	Y	Y	Y	Y
Household income	Y	Y	Y	Y	Y
Health variables	Y	Y	N	Y	Y
Activity variables	Y	Y	N	N	Y
Observations	17,355	17,355	17,452	17,359	17,355
R-squared	0.2573		0.0201	0.0335	0.0388
Number of pid		5,909	5,926	5,910	5,909

Note: Robust standard errors are presented in parentheses. “Health variables” refer to self-reported health status, chronic disease, and depression; and “activity variables” refer to workout, leisure, and social activities. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

**[Table 3]** Effects of retirement status on cognitive ability (sub-MMSE score)

Dependent variable	(1)	(2)	(3)	(4)	(5)
VARIABLES	Orientation	Memory	Attention	Language	Visuospatial
Age	0.0768** (0.0363)	0.2018*** (0.0430)	0.1194*** (0.0457)	0.0273*** (0.0092)	0.1099*** (0.0389)
Agesq	-0.0670** (0.0275)	-0.1658*** (0.0322)	-0.1013*** (0.0343)	-0.0222*** (0.0070)	-0.1012*** (0.0294)
Retirement (lagged)	-0.0790*** (0.0292)	-0.0313 (0.0324)	-0.0393 (0.0359)	-0.0164** (0.0071)	-0.0650** (0.0293)
Observations	17,355	17,355	17,355	17,355	17,355
R-squared	0.0171	0.0223	0.0138	0.0087	0.0269
Number of pid	5,909	5,909	5,909	5,909	5,909

Note: Robust standard errors in parentheses. All specifications control for marital status, household income, and health (self-reported health status, chronic disease, and depression) and activity (workout, leisure, and social activity) variables. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$ .

We also divide our sample into the age groups of 55–67 and 68–80 years of age. Columns (1) and (2) in Table 4 list the results for each group. This subgroup analysis is helpful in investigating the effect of retirement in different age groups on

cognitive functioning. Individuals in the 55–67 group do not display a decline in their MMSE scores after retirement, and the aging effects are also not significant. However, individuals aged 68–80 experience a decrease in their MMSE scores by 10.63% of the SD, which is approximately twice that of baseline results. We then investigate gender-specific retirement effects (columns (3) and (4)). The size and significance of the effect vary across genders with a transition toward retirement being associated with a decline of 4.55% and 6.15% of the SD for males and females, respectively. In columns (5) and (6), we consider the heterogeneity in the retirement-induced cognitive decline between highly educated individuals (i.e., middle school graduate or higher) and the rest of the sample. The negative impact of retirement is strong for less-educated people. These results are consistent with Mazzonna and Peracchi (2012), who show a large negative retirement effect only for females with low levels of education.

[Table 4] Heterogeneous effects of retirement status on cognitive ability (based on age, gender, and education)

Dependent variable	(1)	(2)	(3)		(4)	(5)
	Age		MMSE score		Education	
	55–67	68–80	Male	Female	High	Low
VARIABLES						
Age	0.0251 (0.0974)	−0.1681 (0.1219)	0.1424*** (0.0335)	0.0937** (0.0431)	0.1490*** (0.0354)	0.0705 (0.0448)
Agesq	−0.0251 (0.0791)	0.0913 (0.0829)	−0.1184*** (0.0253)	−0.0848*** (0.0325)	−0.1228*** (0.0273)	−0.0693** (0.0326)
Retirement (lagged)	0.0024 (0.0263)	−0.1063*** (0.0330)	−0.0455* (0.0267)	−0.0615** (0.0298)	−0.0457* (0.0251)	−0.0581* (0.0320)
Observations	8,894	8,461	10,085	7,270	9,668	7,684
R-squared	0.0223	0.0514	0.0460	0.0319	0.0417	0.0398
Number of pid	3,755	3,522	3,136	2,773	3,339	2,581

Note: Robust standard errors are presented in parentheses. All specifications control for marital status, household income, and health (self-reported health status, chronic disease, and depression) and activity (workout, leisure, and social activity) variables. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

Heterogeneity may also depend on the characteristics of the individual's previous employment. Table 5 indicates that we first distinguish among wage-and-salary, self-employed, and unpaid family workers before retirement to capture the differences in their work environments. Evidence shows the retirement-induced cognitive decline in self-employed and unpaid family workers (columns (2) and (3)). However, the retirement effect for wage-and-salary workers is statistically insignificant (column (1)). Moreover, columns (4) and (5) show the evidence of

heterogeneity in cognitive decline after retirement across previous occupation types. The negative retirement effect on cognition is significant only for blue-collar workers. The transition to retirement has no effect on the cognitive functioning of white-collar workers.

Hence, we find that retirement has a negative effect on cognition. However, not all cognitive domains respond to transition from work to retirement in the same manner. Retirement may ultimately obtain results for deterioration of certain types of cognitive functioning but have a limited impact on others. In addition, the effects are heterogeneous with respect to age, gender, education, and previous employment status and occupation.

[Table 5] Heterogeneous effects of retirement status on cognitive ability (based on employment status and occupation)

Dependent variable	(1)	(2)	(3)	(4)	(5)
	MMSE score			Occupation	
	Employment status		Unpaid family worker	White-collar	Blue-collar
VARIABLES	Wage-and-salary worker	Self-employed			
Age	0.1220** (0.0532)	0.0987** (0.0483)	0.1153*** (0.0442)	0.0671 (0.0662)	0.0906** (0.0379)
Agesq	−0.1065*** (0.0412)	−0.0846** (0.0369)	−0.1000*** (0.0324)	−0.0620 (0.0515)	−0.0813*** (0.0289)
Retirement (lagged)	0.0225 (0.0318)	−0.1235** (0.0506)	−0.0785*** (0.0291)	0.0266 (0.0460)	−0.0720** (0.0311)
Observations	4,652	5,015	7,688	1,785	8,695
R-squared	0.0387	0.0454	0.0432	0.0373	0.0397
Number of pid	1,542	1,524	2,843	598	2,731

Note: Robust standard errors are presented in parentheses. All specifications control for marital status, household income, and health (self-reported health status, chronic disease, and depression) and activity (workout, leisure, and social activity) variables. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

2. Robustness Verification

In this subsection, we present the results of the robustness analysis. We initially test our assumption that the effect of retirement on cognitive functioning may not be immediate but appears with a time lag. Table 6 demonstrates that we include both contemporaneous and lagged endogenous variables. The results in column (2) indicate that the negative effect of retirement on cognitive ability is unlikely instantaneous. The coefficient estimate of the contemporaneous endogenous variable is negative but not statistically significant. However, the coefficient of the

lagged term is significant and close to our main baseline result in column (1). We also use the lead term of the endogenous variable to conduct a placebo test. If the transition from work to retirement indeed affects the outcome, then the lead term should have zero effects. Otherwise, such term will capture the anticipatory effect of retirement. The coefficient of the lead endogenous variable (column (3)) is insignificant, thereby indicating the credibility of our main results. The coefficient of the lagged term is still significant and slightly smaller in magnitude than the estimates in the baseline results.

[Table 6] Dynamic effects of retirement on cognitive ability

	(1)	(2)	(3)
Dependent variable		MMSE score	
VARIABLES			
Age	0.1214*** (0.0264)	0.1221*** (0.0265)	0.1014** (0.0415)
Agesq	−0.1038*** (0.0200)	−0.1040*** (0.0200)	−0.0838*** (0.0316)
Retirement (lagged)	−0.0524*** (0.0200)	−0.0521*** (0.0199)	−0.0445* (0.0261)
Retirement		−0.0203 (0.0203)	−0.0236 (0.0258)
Retirement (lead)			−0.0028 (0.0230)
Observations	17,355	17,355	11,682
R-squared	0.0388	0.0389	0.0285
Number of pid	5,909	5,909	4,538

Note: Robust standard errors are presented in parentheses. All specifications control for marital status, household income, and health (self-reported health status, chronic disease, and depression) and activity (workout, leisure, and social activity) variables. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

Assuming that an immediate shift in the level of cognitive functioning at the time of retirement with no additional effect of retirement duration exists on the age trajectory of cognition, we examine the status effect of retirement on cognitive functioning in the baseline specification (Coe et al., 2012). However, cognitive ability can be affected not only by the change in retirement status but also by the length of exposure to retirement. Hence, retirement may cause the cumulative loss in an individual’s cognitive functioning. One might expect this loss to be zero at the beginning of the retirement period and then build up over the years (Bonsang et al., 2012; Celidoni et al., 2017). We use an alternative specification where the endogenous variable is the retirement duration, which is measured in years with monthly precision elapsed since retirement. The years spent in retirement are set to

0 if individuals are not yet retired. Table 7 lists the OLS, RE, and FE estimates. The estimated coefficients of time spent in retirement are negative but not statistically significant in all three models. These results are partially consistent with the works of Bonsang et al. (2012) and Celidoni et al. (2017), both of which support the hypothesis that retirement duration may also affect the evolution of cognitive decline at old age.

[Table 7] Effects of retirement duration on cognitive ability

	(1)	(2)	(3)	(4)	(5)
Dependent variable			MMSE score		
VARIABLES	OLS	RE	FE	FE	FE
Age	0.0831** (0.0340)	0.0940*** (0.0343)	0.2104*** (0.0364)	0.2084*** (0.0359)	0.1175*** (0.0418)
Agesq	−0.0843*** (0.0254)	−0.0925*** (0.0258)	−0.1785*** (0.0280)	−0.1683*** (0.0277)	−0.1039*** (0.0322)
Retirement duration	−0.0021 (0.0016)	−0.0012 (0.0024)	−0.0041 (0.0080)	−0.0021 (0.0078)	−0.0018 (0.0096)
Controls					
Marital status	Y	Y	Y	Y	Y
Household income	Y	Y	Y	Y	Y
Health variables	Y	Y	N	Y	Y
Activity variables	Y	Y	N	N	Y
Observations	6,609	6,609	8,796	8,747	6,609
R-squared	0.2730		0.0402	0.0644	0.0583
Number of pid		2,208	2,752	2,747	2,208

Note: Robust standard errors are presented in parentheses. “Health variables” refer to self-reported health status, chronic disease, and depression; and “activity variables” refer to workout, leisure, and social activity. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

According to KLoSA’s definition, we use the binary dependent variable that takes the value of 1 if the MMSE score is less than 24, which is the threshold value for mild cognitive impairment. Columns (1) and (2) in Table 8 present the OLS and RE estimates. The coefficients for retirement status are positive and significant. In the FE model specification (columns (3)–(5)), the coefficient turns statistically insignificant, and the magnitude also becomes significantly closer to zero than the OLS and RE estimates. These results suggest that although retirement causes a cognitive decline, such decline is not severe enough to be diagnosed as mild cognitive impairment.

Finally, we examine the reemployment effect on cognitive ability. When individuals return to the labor market, they gain the market incentive to invest in cognitive-challenging activities again, and this incentive might have a positive impact on their cognitive capital. However, reemployment, similar to retirement, is

**[Table 8]** Effects of retirement status on the probability of getting mild cognitive impairment

	(1)	(2)	(3)	(4)	(5)
Dependent variable		Mild cognitive impairment dummy			
VARIABLES	OLS	RE	FE	FE	FE
Age	−0.0524*** (0.0098)	−0.0516*** (0.0099)	−0.0513*** (0.0123)	−0.0487*** (0.0124)	−0.0473*** (0.0124)
Agesq	0.0473*** (0.0073)	0.0469*** (0.0074)	0.0455*** (0.0093)	0.0430*** (0.0094)	0.0413*** (0.0094)
Retirement (lagged)	0.0232*** (0.0068)	0.0175** (0.0072)	0.0124 (0.0097)	0.0092 (0.0097)	0.0094 (0.0097)
Controls					
Marital status	Y	Y	Y	Y	Y
Household income	Y	Y	Y	Y	Y
Health variables	Y	Y	N	Y	Y
Activity variables	Y	Y	N	N	Y
Observations	17,355	17,355	17,452	17,359	17,355
R-squared	0.1853		0.0139	0.0186	0.0212
Number of pid		5,909	5,926	5,910	5,909

Note: Robust standard errors are presented in parentheses. “Health variables” refer to self-reported health status, chronic disease, and depression; and “activity variables” refer to workout, leisure, and social activity. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

**[Table 9]** Effects of reemployment on cognitive ability

	(1)	(2)	(3)	(4)	(5)
Dependent variable			MMSE score		
VARIABLES	OLS	RE	FE	FE	FE
Age	0.0721 (0.0485)	0.0660 (0.0462)	0.0880 (0.0567)	0.0794 (0.0563)	0.0865 (0.0559)
Agesq	−0.0751** (0.0352)	−0.0713** (0.0335)	−0.0882** (0.0407)	−0.0764* (0.0407)	−0.0793** (0.0404)
Reemployment (lagged)	0.2113*** (0.0459)	0.1525*** (0.0388)	0.0399 (0.0413)	0.0415 (0.0415)	0.0368 (0.0414)
Controls					
Marital status	Y	Y	Y	Y	Y
Household income	Y	Y	Y	Y	Y
Health variables	Y	Y	N	Y	Y
Activity variables	Y	Y	N	N	Y
Observations	5,319	5,319	5,363	5,321	5,319
R-squared	0.2582		0.0242	0.0334	0.0444
Number of pid		2,071	2,084	2,072	2,071

Note: Robust standard errors in parentheses. “Health variables” refer to self-reported health status, chronic disease, and depression; and “activity variables” refer to workout, leisure, and social activity. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.



also an endogenous decision. Increasing one's cognitive ability may induce reemployment, and unobservable individual heterogeneity may be correlated with both the reemployment decision and cognition. To account for the issue of endogeneity, albeit imperfect, we lag the endogenous regressor and exploit the panel dimension again. We analyze the reemployment effect after restricting the sample to individuals who retired during the first wave of the survey. Table 9 shows that the estimated coefficients of interest are positive and statistically insignificant. It is difficult to say that the negative effect of retirement is canceled out by reemployment.

### **3. Discussion**

Our main results indicate that the transition to retirement is detrimental to the cognitive ability of aging people. The finding is consistent with previous research conducted in the United States and European countries (Rohwedder and Willis, 2010; Bonsang et al., 2012; Mazzonna and Peracchi, 2012; Celidoni et al., 2017). Our retirement estimates are smaller than those found in previous studies (Fonseca et al., 2017). Rohwedder and Willis (2010) report that retirement induces nearly a 40% decline in the average score. Bonsang et al.'s (2012) results indicate that retirees experience a decrease in their cognitive test scores by approximately 10% compared to the sample average score. Compared with these studies, the coefficients in our main results are very small. However, these studies use eligibility ages for pension benefits as the instruments and focus on the effect of retirement on memory score. Thus, these findings are difficult to compare with our main results directly because of different methodologies and outcomes used. When we compare our main results to the FE estimates from Bonsang et al. (2012), who reports that retirement causes a 1.33% decrease in the sample average cognitive score, the coefficients are quantitatively similar.

Our results also suggest that retirement may affect some cognitive domains more than others. The results of the five different domains of cognition show the significant negative effect of retirement for orientation for time and place, language, and visuospatial skills but not for memory and attention, thereby indicating that retirement is minimally associated with Alzheimer's disease. Age-related neuronal modifications that are at the root of Alzheimer's disease have heterogeneous effects on an individual's cognitive functioning. For example, episodic memory deficits are largely considered a hallmark symptom of Alzheimer's disease (Dubois et al., 2007, as cited in Xue et al., 2017), but this instance is less the case for other cognition domains. Verbal memory may also be a more sensitive measure of cognitive decline than other indicators (Xue et al., 2017). Our results show that cognitive decline induced by retirement is highly unlikely to cause Alzheimer's disease.

Finally, we find evidence that heterogeneity exists in the cognitive decline across

demographic and job characteristics with retirement-induced cognitive deterioration being significantly larger for women, low-educated people, non-wage-and-salary workers, and blue-collar employees. One potential explanation for this heterogeneity is the individual differences in the brain and cognitive reserves. In this study, brain reserve refers to actual differences in the brain itself that allow people to increase their tolerance to brain damage, whereas cognitive reserve denote the individual differences on how tasks are performed that may allow some people to be more resilient than others to decline (Stern, 2012). Across all ages, the total brain size is consistently reported to be approximately 10% larger in males; thus, we can expect that men will be able to withstand more cognitive deterioration than women (Giedd et al., 2012). Stern (2012) also finds that educational and occupational experiences influence the reserve against the expression of Alzheimer's pathology. A reserve is built in a number of different environments, but education and job experiences are the most influential because of the relatively large amount of time spent in each factor. For example, complex occupational tasks require individuals to build daily connections in the brain that may disrupt or delay aging-related processes (Denier et al., 2017). We observe that self-employed and unpaid family workers have jobs with significantly less cognitively demanding jobs than wage-and-salary workers. In addition, jobs for white-collar workers require more cognitive skills than blue-collar occupations.<sup>6</sup> In essence, retirees with varying levels of brain and cognitive reserves may experience different paths of cognitive deterioration.

## V. Conclusions

This study investigates the impact of retirement on cognitive ability, which is measured by using the MMSE score with KLoSA (2006–2016). We rely on the panel dimension of the dataset to control for time-invariant individual unobservable heterogeneity and use the lagged endogenous variable to address the endogeneity issue. Our results show the negative effects of retirement on cognitive functioning. The change in status from employment to retirement causes a decrease in an individuals' MMSE score by 5.24% of the SD, which corresponds to a 0.88% decrease compared with the sample average score. The causal relationship between cognitive functioning and retirement cannot be precisely measured without using

---

<sup>6</sup> We measure the job requirement index in terms of cognitive skills from the survey responses to the questions regarding what kind of cognitive ability is needed for the job (high level of concentration, leadership skills, and computer skills). The value of the total index ranges from 3 to 12, meaning the higher the index, the more cognitively demanding it is. The average for self-employed and unpaid family workers is 6.56 and 5.76, respectively, whereas for wage-and-salary workers, the average is 6.86. Moreover, white-collar's average is 8.46, and blue-collar's average is 6.21.

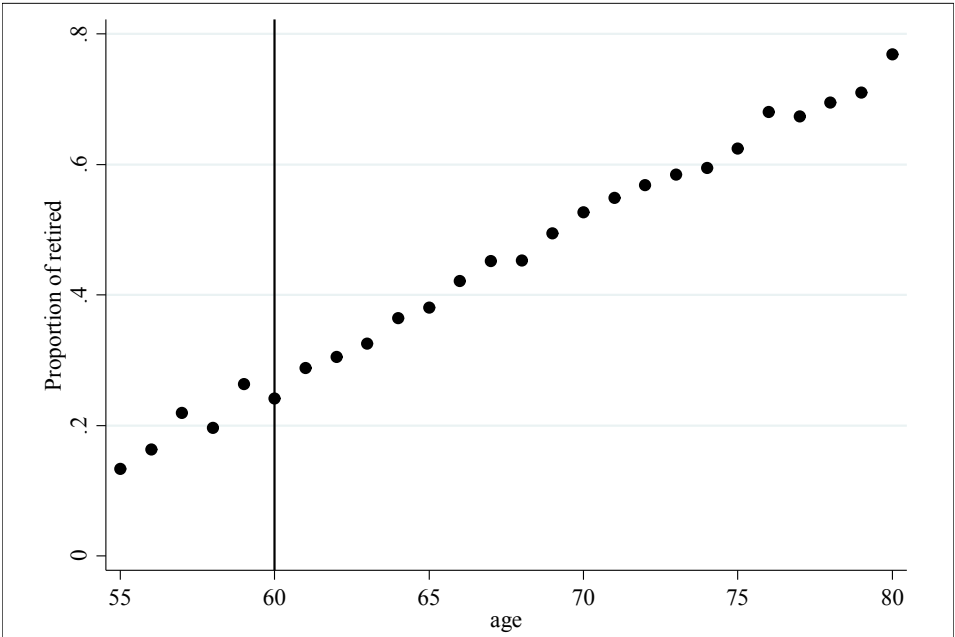
instrumental variables. Therefore, an important issue for further research is to find appropriate instruments for retirement in the context of Korean culture.

Our results indicate that postponing retirement can potentially have a positive effect on cognition. The Korean government revised the law by raising the mandatory retirement to 60 years of age in May 2013. Since 2016, the law has affected all companies and public organizations with more than 300 workers. At present, the Ministry of Employment and Labor intends to extend the retirement age to 65 years old by 2033. In the cognitive capital aspect, letting workers remain in the labor market longer can be beneficial.

We also examine how retirement effects vary among individuals. Although the effects of retirement are not significant for those aged 55–67, individuals aged 68–80 experience a decline in cognitive ability after retirement. The negative influence of retirement on cognitive skills is stronger for females than that of males. The results indicate that the cognitive functioning of low-educated individuals is negatively affected by the transition to retirement, but this result is not the case for highly educated people. Finally, we find evidence of heterogeneity of response regarding previous job types with significant retirement-induced cognitive decline for non-wage-and-salary and blue-collar workers. Continued research is needed to understand the possible mechanisms that exert the heterogeneity of the retirement effect on cognition further.

Appendix

[Figure A1] Proportion of Retired Individuals Born Before 1953



Note: The sample is restricted to persons born before 1953 whose eligibility age for public pension is 60.

## References

- Adam, S., E. Bonsang, S. Germain, C. Bay, and S. Perelman (2006), "Occupational Activities and Cognitive Reserve: A Frontier Approach Applied to the Survey on Health," Ageing, and Retirement in Europe (SHARE) (No. DP 2006-05). CREPP.
- Atchley, R. C. (1982), "Retirement as a Social Institution," *Annual Review of Sociology*, 8(1), 263–287.
- Banks, J., and Z. Oldfield (2007), "Understanding Pensions: Cognitive Function, Numerical Ability and Retirement Saving," *Fiscal Studies*, 143–170.
- Bianchini, L., and M. Borella (2016), "Retirement and Memory in Europe," *Ageing and Society*, 36(7), 1434–1458.
- Bonsang, E., S. Adam, and S. Perelman (2012), "Does Retirement Affect Cognitive Functioning?" *Journal of Health Economics*, 31(3), 490–501.
- Celidoni, M., C. Dal Bianco, and G. Weber (2017) "Retirement and Cognitive Decline. A Longitudinal Analysis using SHARE Data," *Journal of Health Economics*, 56, 113–125.
- Cho, J., and S. Kim (2005), "On using Mandatory Retirement to Reduce Workforce in Korea," *International Economic Journal*, 19(2), 283–303.
- Choi, K., and S. Lee (2007), "The Effect of the National Pension System on the Retirement Behavior of the Older Workers in Korea," *Korean Social Security Studies*, 23(4), 83–103.
- Coe, N. B., H. M. von Gaudecker, M. Lindeboom, and J. Maurer (2012), "The Effect of Retirement on Cognitive Functioning," *Health Economics*, 21(8), 913–927.
- Denier, N., S. A. Clouston, M. Richards, and S. M. Hofer (2017), "Retirement and Cognition: A Life Course View," *Advances in Life Course Research*, 31, 11–21.
- Dubois, B., H. H. Feldman, C. Jacova, S. T. DeKosky, P. Barberger-Gateau, J. Cummings, ... and K. Meguro (2007), "Research Criteria for the Diagnosis of Alzheimer's Disease: Revising the NINCDS–ADRDA Criteria," *The Lancet Neurology*, 6(8), 734–746.
- Fillenbaum, G. G., D. C. Hughes, A. Heyman, L. K. George, and D. G. Blazer (1988), "Relationship of Health and Demographic Characteristics to Mini-Mental State Examination Score among Community Residents," *Psychological Medicine*, 18(03), 719–726.
- Fonseca, R., A. Kapteyn, and G. Zamarro (2017), "Retirement and Cognitive Functioning: International Evidence," *Financial Decision Making and Retirement Security in an Aging World*, 46.
- Giedd, J. N., A. Raznahan, K. L. Mills, and R. K. Lenroot (2012), "Magnetic Resonance Imaging of Male/female Differences in Human Adolescent Brain Anatomy," *Biology of Sex Differences*, 3(1), 19.
- Grubb, D., J. Lee, and P. Tergeist (2007). *Addressing Labour Market Duality in Korea*, Paris: Organisation for Economic Cooperation and Development (OECD).
- Ha, M. (2015). The Effect of Retirement on Cognitive Functioning: Difference-in-Difference Analysis using Propensity Score Matching," *The Journal of Korean*

- Gerontological Society*, 35(2), 337–354.
- Kontis, V., J. E. Bennett, C. D. Mathers, G. Li, K. Foreman, and M. Ezzati (2017), “Future Life Expectancy in 35 Industrialised Countries: Projections with a Bayesian Model Ensemble,” *The Lancet*, 389(10076), 1323–1335.
- Kim, B., and E. Choi (2017), “Effects of Retirement on Health and Life Satisfaction,” *Quarterly Journal of Labor Policy*, 17(1), 85–107.
- Kim, S., and C. Lee (2014), “A Survey Report on Dementia Management Project,” National Assembly Budget Office.
- Le Carret, N., S. Lafont, L. Letenneur, J. F. Dartigues, W. Mayo, and C. Fabrigoule (2003), “The Effect of Education on Cognitive Performances and its Implication for the Constitution of the Cognitive Reserve,” *Developmental Neuropsychology*, 23(3), 317–337.
- Lee, C., and E. Lee (2015), “Retirement of Older Wage Workers in Korea: Hazard Model Analysis by Firm Size,” *Korean Journal of Labour Economics*, 38(3), 31–65.
- Lee, C., and J. Lee (2013), “Employment Status, Quality of Matching, and Retirement in Korea: Evidence from Korean Longitudinal Study of Aging,” *Journal of Population Ageing*, 6(1-2), 59–83.
- Mazzonna, F., and F. Peracchi (2012), “Ageing, Cognitive Abilities and Retirement,” *European Economic Review*, 56(4), 691–710.
- Mielke, M. M., P. Vemuri, and W. A. Rocca (2014), “Clinical Epidemiology of Alzheimer’s Disease: Assessing Sex and Gender Differences,” *Clinical Epidemiology*, 6, 37–48.
- Newson, R. S., and E. B. Kemps (2005), “General Lifestyle Activities as a Predictor of Current Cognition and Cognitive Change in Older Adults: A Cross-sectional and Longitudinal Examination,” *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 60(3), 113–120.
- Nishimura, Y., and M. Oikawa (2017), “Mental Retirement: Evidence from Global Aging Data,” MPRA Paper No. 76431.
- Roberts, J., N. Rice, and A. M. Jones (2010), “Early Retirement among Men in Britain and Germany: How Important is Health?” *The Geneva Papers on Risk and Insurance-Issues and Practice*, 35(4), 644–667.
- Rohwedder, S., and R. J. Willis (2010), “Mental Retirement,” *The Journal of Economic Perspectives*, 24(1), 119–138.
- Seok, S. (2011), “The Effect of Retirement on Health,” *Quarterly Journal of Labor Policy*, 11(1), 81–102.
- Statistics Korea. 2018 Statistics on the Aged. Available at: <http://kostat.go.kr/portal/eng/pressReleases/1/index.board?bmode=read&aSeq=363974>. Accessed 24 April 2018.
- Stern, Y. (2012), “Cognitive Reserve in ageing and Alzheimer’ Disease,” *The Lancet Neurology*, 11(11), 1006–1012.
- Sung, J., and J. Ahn (2006), “What Makes the Older Work for Satisfactory Lives?” *Quarterly Journal of Labor Policy*, 6(1), 39–74.
- Verbeek, M., and T. Nijman (1992), “Testing for Selectivity Bias in Panel Data Models,” *International Economic Review*, 681–703.

- Xue, B., D. Cadar, M. Fleischmann, S. Stansfeld, E. Carr, M. Kivimäki, A. McMunn, and J. Head (2017), “Effect of Retirement on Cognitive Function: The Whitehall II Cohort Study,” *European Journal of Epidemiology*, 1–13.