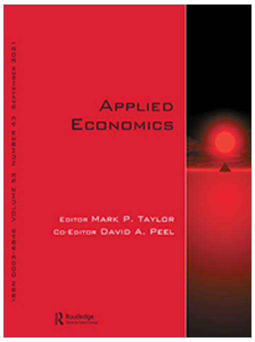

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Effects of wage-peak system on youth employment: Evidence from South Korea

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ABSTRACT
After the increase in the minimum retirement age, South Korea introduced a wage-peak system to mitigate increases in firm costs due to the wage of elderly workers. In this study, we examined how the later retirement age has affected employment opportunities for younger workers. We also investigated the difference in impact of later retirement on employment between firms within and outside of the system. Using the difference-in-differences empirical method, we found that this system has increased employment opportunities for younger workers. Moreover, as the proportion of elderly workers increases, the effect of the wage-peak system on the proportion of young workers is enhanced.

KEYWORDS
wage-peak system; retirement policies; lump of labour fallacy; youth employment
Classification codes: J18; J21; J26

I. Introduction

Employment of the elderly has several implications, depending on various economic players, particularly in low-growth and ageing societies, such as that of South Korea (hereafter, Korea). Sluggish economic growth prompts firms to offer early retirement to elderly workers (Dorn and Sousa-Poza 2010). This phenomenon is highly likely to follow in Korea, due to the seniority-based pay system, which rewards senior workers in spite of any decline in their productivity. Early retirement leads to two main problems. First, it may aggravate poverty among elderly workers due to a widespread negative income shock.[1] Second, it may raise the number of those receiving pensions welfare support, reducing the sustainability of public finances.

To deal with issues related to early retirement, the Korean government introduced its wage-peak system in 2003 in which, while it delayed the retirement age, allowed wages decline to as senior workers neared retirement. However, the adoption of this system was not mandatory; moreover, to introduce the system, a firm's management would need consent from the employee union, likely because as employees near their retirement age, they would need to agree to wage cuts during their last few years of work in exchange for the extension of the retirement age. In this setup, the government subsidizes the wages of the elderly workers, which offsets part of their income reduction, facilitating the agreement between labour and management. Furthermore, we also expect that this will help retain senior workers by mitigating the burden of labour costs resulting from the extension of retirement age.

Previous studies have hypothesized that the increased numbers of elderly workers in the labour force resulting from the extension of the retirement age are crowding out younger workers. This supposition is based on the assumption that the number of jobs available in the economy is fixed, in the idea often referred to as the *lump of labour* (Mayhew 1864; Rae 1894; Schloss 1891; Walker 2007). Gruber and Wise (2010) showed that in at least 12 countries, increased elderly workers' labour force participation was not associated with the participation of younger workers. This unexpected outcome was observed likely because the productivity and spillover effects of elderly workers are ignored.[2] Zhang and Zhao (2012) recorded similar

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.
This article is based on part of a research report by Choe (2017) that studies the employment impact of introducing wage-peak system.
[1]In 2017, Korea had the highest poverty rate among the elderly in OECD countries, at 43.8% (OECD 2020a).
[2]For a theoretical discussion, please see Bertoni and Brunello (2017).

empirical findings and argued that, given the difference in skill levels, older and younger workers are more likely to be complements than substitutes for each other, as per the framework of Freeman (1998).[3] Similarly, Munnell and Wu (2012) provided evidence of a positive association between the number of senior workers and that of their younger counterparts, indicating positive net benefit to an increase in the number of older workers.

However, negative impacts on youth employment from extending the retirement age have also been observed. Boeri, Garibaldi, and Moen (2017) and Bertoni and Brunello (2017) showed that older workers crowded out younger workers in Italy; Martins, Novo, and Portugal (2009) found that delaying female workers' retirement age negatively affected employment opportunities, especially among young female workers. In particular, Boeri, Garibaldi, and Moen (2017), among others, reported that two opposite effects of increasing the number of elderly workers could offset each other: 1) due to the complementary relationship between the youth and older workers in production, locking-in elderly workers could raise the demand for youth labour; 2) in the short run, however, that positive effect could be offset by the scale effect, driven by decreasing returns to scale. Therefore, the effect of raising the retirement age on youth employment remains an empirical question.

In Korea, like many other countries, it is still a subject of debate whether an increase in elderly employment would materially increase unemployment among young workers. This question is investigated in this study, using panel data, to determine whether an increase in elderly workers would be associated with a decrease in younger workers by exploiting an exogenous change in the Korea's wage-peak system. In 2013, the Korean government revised the law to allow employees of firms with 300 or more employees to work until the age of 60; this provision went into effect in 2016. To alleviate the burden on firms resulting from this extension to the retirement age, the government has been expanding the scope and size of the wage subsidy under the wage-peak system since 2014. In our study, we exploit these policy changes to identify the effects of elderly employment and the wage-peak system on youth employment with a difference-in-differences framework.

According to our analyses, our outcome of interest is the proportion of youth employment to total employment. To account for the fractional nature of the dependent variable, we applied the fractional probit model suggested by Papke and Wooldridge (1996, 2008). We also adopted the Mundlak-Chamberlain device, adding time averages for all explanatory variables to control unobserved fixed firm effects.

The rest of this paper proceeds as follows. Section 2 presents the Korean retirement age extension and wage-peak system. Section 3 gives the econometric framework for the empirical analysis and the data to be used. Section 4 gives the estimation results. Section 5 discusses the results and concludes the study.

II. Wage-peak system in Korea

The wage-peak system in use in Korea was designed to alleviate the increasing burden of labour costs that resulted from extending the retirement age. However, for this system to apply to a firm, both the management and the union (or other employee representative) must consent to its implementation. In this case, if the retirement age is extended, the employer can reduce the wages of senior workers or their working hours. Then, the senior workers are more likely to accept lower wages in exchange for an extension of the retirement age. Additionally, in this system, the government is expected to provide elderly workers with a wage subsidy to compensate for their reduced income, in the expectation that this will lead to higher rates of consent between the employer and the union.

To illustrate the functioning of the wage-peak system, we considered the example of firm A with a retirement age of 57 that is being extended to 60 under wage-peak system. Firm A is eligible for wage cuts for older workers as they reach the former retirement age. Firm A has two options. The

[3]Freeman (1998) explained the weak aggregate employment effects of work-sharing by imperfect substitutes resulting from the substantial heterogeneity in skills between the unemployed and the employed.

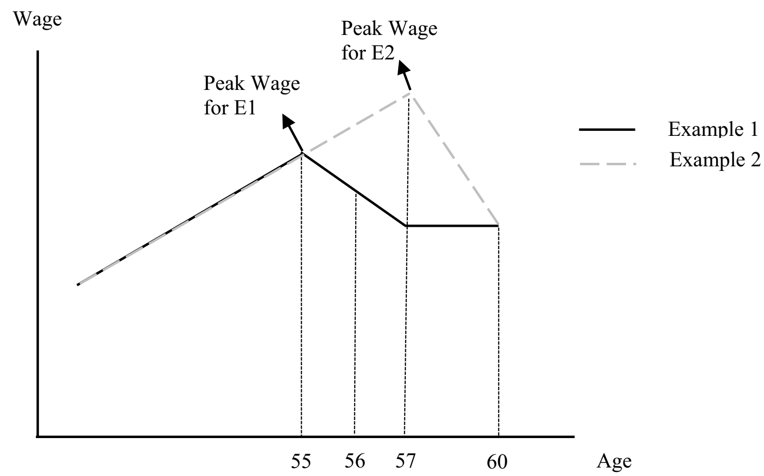

Figure 1. Wage schemes under peak wage system.

first option is to reduce wages at ages younger than 57. The second option is to reduce wages at 57 or older, after the former retirement age. Figure 1 presents these options.[4] Regarding the size of the wage cut, firms should reduce wages by more than 10% and 15% in the first and second wage cut, respectively, compared to the peak wage. In addition, firms should lower wages by 20% or more compared to the peak wage. However, for those with 300 employees or less, each year's wage reduction rate is allowed to remain at 10% regardless of the period.

To promote this system, in 2014, the Korean government expanded the scope and size of the wage subsidy to compensate for senior workers' lower wages. As shown in Table 1, the government subsidizes elderly workers' wage cut as much as it did the gap between the actual wage reductions and each year's proposed amount of wage cut. The subsidies were expected to encourage unions or employee representatives to partner with firm management to adopt the system.

Note that, over the five years after receiving peak wage, an elderly worker with an annual wage of 72.5 million KRW (about 62,205 US dollars) is eligible for the maximum wage subsidy.[5] As shown in Table 2, the maximum amount of subsidy per person is between 7.2 and 10.8 million KRW (about 6,178 and 9,266 USD), depending on the new retirement age.

The following example is given to illustrate the details of the wage-peak system. Elderly worker A working for firm B is receiving their peak wage, that is, 50 million KRW (about 42,900 USD). In the following year, firm B reduces their wage by 10%. Here, no subsidy is provided to compensate for the wage decrease because the government subsidizes the differential between the actual wage reduction and a loss of 10% from the peak wage only when the former is larger than the latter. Thus, 45 million KRW (about 38,610 USD) is the actual annual wage received by worker A. In firm D, which features a greater wage drop than firm B, elderly worker C faces a 20% wage reduction relative to the peak

Table 1. Wage reduction and subsidy over 5 years.

	Wage-Peak System		
Amount	First Year	Second Year	Third–Fifth Years
Wage Reduction	10% × PW	15% × PW	20% × PW
Actual Wage Reduction	W_1% × PW	W_2% × PW	W_3% × PW
Subsidy	(W_1% – 10%) × PW	(W_2% – 15%) × PW	(W_3% – 20%) × PW

Note: PW indicates peak wage.

Table 2. *Subsidy limits*(unit: million KRW).

New Retirement Age	Limits
60 years and older	10.8 million KRW (9,266 USD)
Younger than 60 years	7.2 million KRW (6,178 USD)

[4]A firm also has the option to reduce working hours instead of reducing wages under the wage-peak system.
[5]We use the 2020 average exchange rate for USD to the KRW, which is 1,165.697 (OECD 2020b).

wage. The available subsidy is 10% of the peak wage, or 5 million KRW (about 4,290 USD). In the wage-peak system, the subsidy is intended to reduce the burden of labour costs and to prevent a significant decline in actual wages. Firms with a wage-peak system are more likely to hire new employees. Therefore, despite the delaying of the retirement age, we expect that the wage-peak system will help contribute to job creation for the youth.

III. Data and empirical model

In the empirical analysis, we merged the following novel administrative datasets to form a longitudinal firm-level dataset from 2011 through 2016: Wage Decision Status Survey (WDS) data provided by the Ministry of Employment and Labour and Employment Insurance (EI) administrative data from the Korea Employment Information Service. The WDS survey data includes sufficient information on all Korean firms with 100 or more employees to allow identify whether they adopted the wage-peak system. The EI administrative data allowed us to identify the number of workers in each firm by age group.

We exploited two exogenous policy changes associated with the wage-peak system. First, in 2013, the Korean government announced a new law, which came into effect in 2016, and required firms with more than 300 employees to extend the retirement age to 60 or older. Second, in 2014, the government expanded the coverage and benefit of the wage-peak subsidy. Figure 2 indicates the growth in the number of firms with more than 300 employees adopting the wage-peak system; this value grew dramatically beginning in 2014.

To account for the full impact of the wage-peak system, we considered 2012 to 2014 a transitory period, as it generally takes time for firms to respond to a new administrative system, and the revised wage-peak system was fully operational as of 2014. Therefore, in our study, we defined our treatment group as firms that had implemented the system as of 2014, with the control group being those that had not yet adopted the system from 2011 to 2016.

We restricted our sample to firms with 300 employees or more, as this group had a double incentive to adopt the new system to alleviate the burden of wage costs. First, in the system, these firms were required to lower wages for workers nearing retirement. Second, senior workers with reduced wages received partial compensation for the loss from the government. However, this only applied to firms operating in the system. This implied that wages partially decreased the treatment group. In the control group, on the other hand, senior workers' wages did not necessarily decrease. In the difference-in-differences framework, variations in wage reduction enabled us to identify the effects of elderly employment and the wage-peak system on youth employment.

Figure 4 shows the trend in proportion of youth employment to employment at large for the treatment and control groups, respectively. As indicated in Figures 2 and 3, for both groups, as the

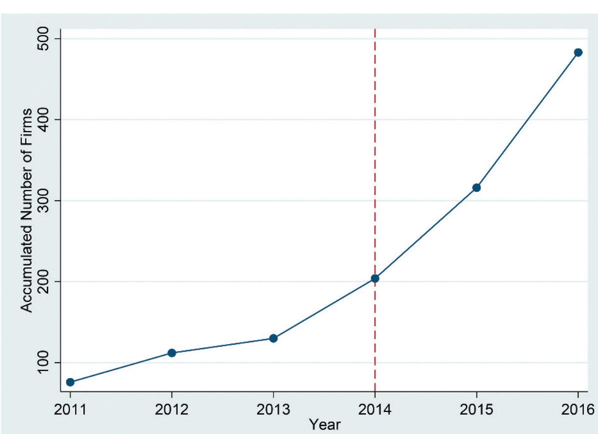

Figure 2. Accumulated number of firms that adopted the wage-peak system.

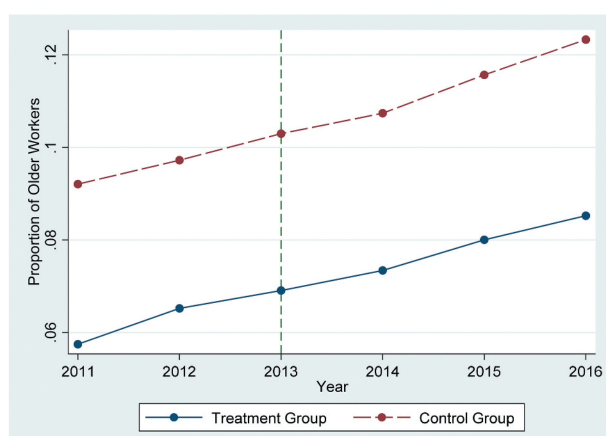

Figure 3. Proportion of older workers to total workers.

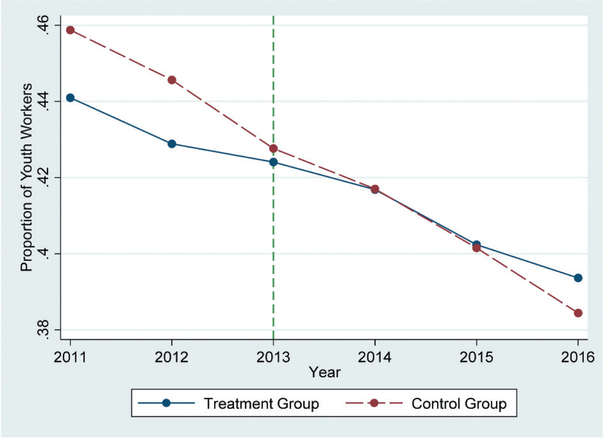

Figure 4. Proportion of younger workers to total workers.

proportion of elderly workers rises, that of younger workers drops over time. Interestingly, after 2014, while both groups registered saw similar trends in the proportion of elderly workers, the proportion of the youth employment sharply decreased in the control group relative to the treatment group. It is, therefore, important to note that there is a negative association between the proportion of youth and elderly employment. Moreover, the magnitude of the correlation in the treatment group is less prominent than in the control group.

To assess this relationship statistically, we used the fractional response model using quasi-maximum likelihood estimation, following Papke and Wooldridge (1996, 2008):

$$E(Workers34_{it}|Workers55-64_{it-1},\ X_{it-1},\ m_i)$$

$$= \phi(\beta_1 TG_i + \beta_2 Year2014_t + \beta_3 [TG \times Year2014]_{it} + \beta_4 Workers55-64_{it-1}$$

$$+ \beta_5 [TG \times Year2014 \times Workers55-64]_{it} + X_{it-1}\gamma + m_i + t_t) \quad (1)$$

where $Workers34_{it}$ represents the proportion of younger workers to the total employees for firm i in year t; TG_i is the binary variable for firmi with a value of 1 if the firm is treated, and 0 otherwise; $Year2014_t$ is an indicator variable with a value of 1 if the year is from 2014 to 2016, and 0 otherwise;[6] $TG \times Year2014$ is the interaction term between TG_i and $Year2014_t$; $Workers55-64_{it-1}$ is the proportion of elderly workers for firm i in year t; $Treat \times Year2014 \times Age55-64$ is the interaction term between TG_i, $Year2014_t$, and $Age55-64_{it-1}$; X_{it-1} is a vector of explanatory variables that could affect youth employment for a firm i in the year t, including 1) the proportion of elderly workers with a B.A. (BA Workers55-64), 2) proportion of elderly workers with a M.A. or Ph.D., 3) firm age, 4) total population, 5) local youth unemployment rate, and 6) gross regional domestic product per capita in region j; m_i and t are vectors of unobserved firm fixed effects and time effects, respectively.

Following the Mundlak and Chamberlain approach, we accounted for the firm's fixed effects by including time averages for all explanatory variables except for time dummies (Mundlak 1978; Chamberlain 1980). We estimate, in our empirical specification, that β_3, β_4, and β_5 have essential policy implications. Positive β_3 implies that the wage-peak system helps create jobs for younger workers. Negative β_4 indicates that the rise in the proportion of older employment is associated with a decrease in the proportion of youth employment. Positive β_5 shows that implementing the wage-peak system mitigates the negative effects of the increase in elderly workers.

In our analyses, the key variables obtained from EI data are based on the number of employees by younger and older employee groups. We defined the younger group as including people aged 19 to 34 and older group as including people aged 55 to 64. In Korea, youth are officially defined as being under of 35, because 1) men are obliged to serve in the military for two years, and 2) young people frequently take leaves of absence from college to prepare for employment before graduating. We defined the older group as 55 years old and older, as the previous retirement age in Korea was 55, so the wage-peak system directly affected workers this age and older. The EI data include all Korean workers eligible for EI in the year t. The EI system enforces enrolment for all workers with more than 60 monthly working hours. Under the current system, the EI premiums of the majority of full-time workers are paid jointly by both employers

[6]The TG_i is equal to 1 for all of 2011–2016 for companies that have adopted the wage peak system. Meanwhile, $Year2014_t$ has a value of 1 for both the treatment and control groups between 2014 and 2016 and 0 earlier than 2014. In a difference-in-differences method, the treatment effect is estimated by the coefficient of the intersection term of TG_i and $Year2014_t$.

and employees. In the data, the total number of employees in the year t is equivalent to the sum of those insured in the t − 1 year and the number of the newly insured people in the t year, net of those who lose their insurance in that particular year. Using this information, we calculated the number of full-time employees, with the employee's information for each year's EI status, using the firms' age groups for each specific year.

Table 3 presents the summary statistics for the key variables in our analysis. On average, the proportion of younger workers in our data is 40.9%, and that of senior workers is 10.6%. As shown in Table 4, the proportion of younger workers decreased by 6% before and after 2013, and that of the senior workers increased by 2%.

IV. Regression results

Table 4 gives the coefficient estimates for the fractional probit models. In column (1), the coefficient estimate (β_3) for [TG × Year2014] is 0.024, which is statistically significant. To interpret the magnitude of the treatment effects, we adjusted the coefficients using the scale factor and gave the average partial effects (APE) estimates in column (2). The APE estimate for β_3 indicates that, holding other factors constant, the adoption of the wage-peak system raises the proportion of youth employees on average by 0.8%p.

We also observed a negative relationship between senior and youth employment: the coefficient estimate (β_4) on [Workers55 − 64] is −1.632, which is statistically significant. The APE estimate of β_4 shows that, ceteris paribus, a 10%p increase in the proportion of older workers is associated with a 5.27%p decrease in the proportion of younger workers. The coefficient of the variable [Workers35 − 54] was estimated to be −1.954, which means that when the proportion of middle-aged workers increases by 10%p, the number of young workers decreases by 6.31%p. By contrast, middle-aged employees have a relatively greater ripple effect on employment in the youth group.

Because the wage-peak system directly affects the employment of elderly workers, we expect that the effect of introducing the wage-peak system may be heterogeneous, depending on the proportion of elderly workers in the company. To confirm this, we conducted an analysis including [TG × Year2014 × Workers55 − 64], which is the interaction term between the proportion of elderly workers and a key variable to capture treatment effects (columns 3 and 4 in Table 4).

It appeared that the effect of introducing the wage-peak system (β_5) on the proportion of elderly workers was not statistically different from 0, and the remaining estimates did not qualitatively differ from the previous results. However, the heterogeneous effects of introducing the wage-peak system in

Table 3. Summary statistics.

Variables	Descriptions	Total Mean (Std. Dev.)	Before 2013 Mean (Std. Dev.)	After 2013 Mean (Std. Dev.)
Workers 29 or less	Ratio of younger workers aged 29 or younger	0.253 (0.179)	0.278 (0.189)	0.237 (0.171)
Workers 34 or less	Ratio of younger workers aged 34 or younger	0.419 (0.229)	0.446 (0.237)	0.402 (0.222)
Workers 35–54	Ratio of workers aged between 35 and 54	0.454 (0.173)	0.443 (0.179)	0.462 (0.168)
Workers 55–64	Ratio of elderly workers aged between 55 and 64	0.100 (0.137)	0.088 (0.131)	0.108 (0.141)
BA Workers 55–64	Ratio of elderly workers with a B.A.	0.304 (0.272)	0.330 (0.293)	0.287 (0.256)
MA Workers 55–64	Ratio of elderly workers with a M.A. or Ph.D.	0.054 (0.117)	0.067 (0.137)	0.045 (0.101)
Firm Age	Firm age	17.350 (4.085)	15.358 (3.512)	18.656 (3.905)
Total Population	Total population (millions)	6.657 (3.299)	6.576 (3.260)	6.711 (3.324)
Youth Unemployment rate	Local youth unemployment rate	0.089 (0.014)	0.078 (0.010)	0.096 (0.011)
GRDP per capita	Gross regional domestic product per capita	34.802 (7.909)	33.492 (7.789)	35.661 (7.872)
Observations		2,379	942	1,437

Table 4. Estimation results of fractional probit model.

	Model 1		Model 2	
	Coefficient	APE	Coefficient	APE
TG_i	−0.005 (0.013)	−0.002 (0.004)	−0.012 (0.017)	−0.004 (0.005)
$TG_i \times Year2014_t$	**0.024**** **(0.010)**	**0.008**** **(0.003)**	**0.020*** **(0.012)**	**0.006*** **(0.004)**
$Year2014_t$	−0.022 (0.025)	−0.007 (0.008)	−0.023 (0.025)	−0.007 (0.008)
$Workers35-54_{it-1}$	−1.954*** (0.085)	−0.631*** (0.028)	−1.947*** (0.086)	−0.629*** (0.028)
$Workers55-64_{it-1}$	−1.632*** (0.185)	−0.527*** (0.060)	−1.641*** (0.189)	−0.530*** (0.061)
$TG_i \times Year2014_t \times Workers55-64_{it-1}$			0.081 (0.112)	0.026 (0.036)
$BAWorkers55-64_{it-1}$	0.020 (0.024)	0.006 (0.008)	0.019 (0.024)	0.006 (0.008)
$MAWorkers55-64_{it-1}$	−0.004 (0.036)	−0.001 (0.012)	−0.004 (0.036)	−0.001 (0.012)
$\ln(F\_Age)_{it-1}$	−0.044 (0.028)	−0.014 (0.009)	−0.044 (0.028)	−0.014 (0.009)
$\ln(POP)_{it-1}$	−0.015 (0.209)	−0.005 (0.067)	−0.009 (0.209)	−0.003 (0.067)
$YouthUnempRate_{it-1}$	−0.866*** (0.333)	−0.280*** (0.107)	−0.857** (0.335)	−0.277** (0.108)
$\ln(GRDPpercapita)_{it-1}$	−0.398* (0.239)	−0.129* (0.077)	−0.396* (0.240)	−0.128* (0.078)
Constant	1.135*** (0.184)		1.130*** (0.184)	
Observations	2,379		2,379	

Note: (1) All models contain year dummies for each year. (2) The fractional probit estimation includes the time averages for all explanatory variables to account for the unobserved fixed effect. (3) Robust standard errors are in parentheses. (4) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

relation to the proportion of elderly workers should be interpreted using the coefficient estimate of [TG × Year2014] ($\hat{\beta}_3$) combined with $\hat{\beta}_5$. The effect of introducing a wage-peak system at the average of the proportion of elderly workers increased the proportion of younger workers to 2.8%p. In Model 2 of Table 4, it can be seen that while $\hat{\beta}_5$ was statistically insignificant, the joint test rejects the null hypothesis, $\hat{\beta}_3 + \hat{\beta}_5 \times \overline{Workers55 - 64_{it-1}} = 0$, at a 5% significance level.[7] We interpret this to mean that as the proportion of elderly workers increases, the effect of the wage-peak system on the proportion of young workers is enhanced.

We found that the employment of elderly workers was inversely related to youth employment, shedding new light on the ongoing debates indicating that the conception of *a lump of labour* may be accurate. We consider that this evidence may reflect the cost of retaining elderly workers, likely due to the seniority-based pay system. Our findings revealed that the wage-peak system mitigates the harmful effects of increasing elderly workers on youth employment; its impact becomes more pronounced as the proportion of elderly workers grows. Interestingly, retaining elderly workers with an advanced degree has a positive effect on youth employment.

V. Robustness checks

We conducted several additional tests to confirm the robustness of our main findings in relation to the effect of introducing the wage-peak system. First, we partially limited the study period to 2012–2016 (Model 1 in Table 5). Because the wage-peak system was introduced in 2014, even if the analysis period is limited to 2012 or later, we should still observe its effects of the system. It seems that the introduction of the wage-peak system increases the share of youth employment by 1.0%p, which is qualitatively similar to the estimation results indicated in Table 4.

Second, we redefined the youth group, using a more general definition. In this study, due to the unique Korean environment, youth employment was defined as those under 35 years old, although a widely accepted definition is restricted

[7]The results of the joint test are available from the authors upon request.

Table 5. Sensitivity analysis.

	Model 1		Model 2		Model 3	
Dependent Variable	Aged 34 or younger		Aged 29 or younger		Aged 34 or younger	
Treatment Year	2014		2014		2012 (placebo treatment)	
Study period	2012–2016		2011–2016		2011-2016	
	Coefficient	APE	Coefficient	APE	Coefficient	APE
TG_i	−0.014	−0.005	−0.008	−0.002	0.003	0.001
	(0.014)	(0.005)	(0.013)	(0.004)	(0.014)	(0.004)
$TG_i \times Year_t$	0.030***	0.010***	0.031**	0.008**	0.008	0.003
	(0.011)	(0.003)	(0.013)	(0.004)	(0.012)	(0.004)
$Year_t$	0.013	0.004	−0.016	−0.004	−0.024	−0.008
	(0.034)	(0.011)	(0.031)	(0.008)	(0.031)	(0.010)
$Workers35-54_{it-1}(Workers30-54_{it-1})$	−2.256***	−0.729***	−1.911***	−0.523***	−1.964***	−0.634***
	(0.115)	(0.037)	(0.099)	(0.027)	(0.084)	(0.028)
$Workers55-64_{it-1}$	−1.449***	−0.468***	−1.858***	−0.509***	−1.639***	−0.529***
	(0.289)	(0.094)	(0.223)	(0.061)	(0.185)	(0.060)
$BAWorkers55-64_{it-1}$	0.002	0.001	0.018	0.005	0.022	0.007
	(0.026)	(0.008)	(0.026)	(0.007)	(0.024)	(0.008)
$MAWorkers55-64_{it-1}$	0.047	0.015	−0.089**	−0.024**	−0.002	−0.001
	(0.044)	(0.014)	(0.038)	(0.010)	(0.036)	(0.012)
$\ln(F\_Age)_{it-1}$	−0.061**	−0.020**	−0.030	−0.008	−0.045	−0.014
	(0.029)	(0.009)	(0.028)	(0.008)	(0.028)	(0.009)
$\ln(POP)_{it-1}$	−0.741**	−0.239**	0.221	0.061	0.002	0.001
	(0.367)	(0.118)	(0.253)	(0.069)	(0.209)	(0.068)
$YouthUnempRate_{it-1}$	−0.722*	−0.233*	−1.003**	−0.274**	−0.867***	−0.280***
	(0.409)	(0.132)	(0.438)	(0.120)	(0.330)	(0.106)
$\ln(GRDPpercapita)_{it-1}$	−0.495	−0.160	−0.241	−0.066	−0.427*	−0.138*
	(0.350)	(0.113)	(0.311)	(0.085)	(0.242)	(0.078)
Constant	1.173***		1.248 ***		1.140***	
	(0.187)		(0.196)		(0.185)	
Observations	2,379		2,379		2,379	

Note: (1) All models contain year dummies for each year. (2) The fractional probit estimation includes the time averages for all explanatory variables to account for the unobserved fixed effect. (3) Robust standard errors are in parentheses. (4) *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

to those under 30 years old. In an analysis using the usual definition (Model 2 in Table 5), we observe that the introduction of the wage-peak system increased the proportion of young workers by 0.8%p, in the same line with our initial results.

Finally, we performed a placebo test, reported in Model 3 in Table 5. The treatment effect is re-estimated for placebo treatment, assuming the introduction of the wage-peak system in 2012. We presume that the treatment effect does not hold statistical significance because the wage-peak system was not implemented in 2012. The results in Model 3 in Table 5 show that the estimated treatment effect was not statistically significant. In fact, this indirectly tests the common trend assumption; in the absence of treatment, the difference between control and treatment groups would be constant, or fixed over time, which is a crucial assumption for the difference-in-differences method. We confirm that the common trend assumption is valid in our study.

VI. Discussion and conclusion

The Korean central government extended the retirement age, improving job security for senior workers. The main concern that arose in extending the retirement age is whether elderly workers would replace younger workers, following a conception called *the lump of labour*. However, our findings do support *the lump of labour*, at least in the case of Korea.

One plausible reason for this evidence could relate to a drop in the economic growth rate; during the course of the recent recession, evidence was found for a crowding-out effect from senior workers (Boeri, Garibaldi, and Moen 2017). The last ten years have seen the highest rate of youth unemployment in the history of Korea, combined with a 2.3% growth rate in the gross domestic product in 2019, as part of it's a downward trend. Increased labour costs following the extension of the retirement age are likely to negatively affect youth employment. Second, wage rigidity is relevant because, regardless of productivity, wages tend to increase with tenure. Therefore, the gap between productivity and wages is more likely to be widened upon nearing the retirement age (OECD 2018). As such, if the minimum mandatory retirement age increases, additional labour costs could be substantial due to the existence of seniority-based pay. In this employment environment, a negative impact on youth employment can be expected to ensue from raising the retirement age. In conclusion, as mentioned in Boeri, Garibaldi, and Moen (2017), firms may suffer decreasing returns to scale, leading to a lowering of the youth employment rate when the minimum mandatory retirement age is delayed.

Our findings suggest that the wage-peak system could be a win-win policy tool in assisting firms to reduce the burden of labour costs and protect older workers' jobs. As the proportion of older workers is expected to increase, the effect of the wage-peak system on youth employment will likely grow. In Korea in particular, raising the retirement age is likely to increase the economic burden of firms, thereby increasing unemployment among younger workers. In this case, the wage-peak system may be an important policy tool for mitigating the negative effects of extending the retirement age on youth employment.

However, following the trade-off between extending careers and wage reductions among senior workers, the wage-peak system is not common. Nonetheless, the compensating wage-reduction subsidy is crucial for encouraging firms to adopt the system. These findings imply that it is imperative to alter seniority-based wage systems and increase wage flexibility to avert the negative effect on youth employment upon the extension of the retirement age. Firms that do so are incentivized to hire younger workers without forcing older ones to leave their positions.

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