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Abstract

The Elderly Employment Stabilization Law revised in 2006 helped the government to increase elderly employment. Although there has been a discussion of whether the re-employment of elderly workers substitutes or complements the employment of young workers, there are few studies that examine potential peer effects of the former group on the latter's productivity or motivation in the workplace. Note that there might be knowledge spillovers from elderly workers to peers, especially younger ones (positive peer effects) but the presence of unmotivated elderly workers might demoralize peers (negative peer effects). This paper investigates such peer effects from the exposure to elderly workers using the employee satisfaction survey of a Japanese firm. We show that elderly workers do not have significant peer effects on coworkers' satisfaction on average. However, the effects are heterogeneous depending on the ability of the elderly workers, reflected in their wages, and the age and job levels of their peers. Namely, regular workers are more satisfied when they work with elderly workers who receive higher wages. Coworkers in their 30s and 40s receive more training and those in their 50s are more satisfied when they work with elderly workers. In contrast, first line managers are less satisfied by the allocation of elderly workers, especially those with high levels of ability. This paper contributes to the discussion on the efficient assignment of elderly workers.

Keywords: peer effect, productivity, job satisfaction, aging, training, knowledge spillovers
JEL classification: J24, J26, J28, M54

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1 Introduction

The 2006 revision of the Elderly Employment Stabilization Law (EESL), making it obligatory for firms to secure the employment of workers aged between 60 and 65 years, significantly increased the employment of elderly workers in Japan. Yamamoto (2008) estimates the EESL revision effect using the Keio Household Panel Survey. From the difference-in-difference estimation results of the study, the treatment group, consisting of workers aged 60-62 years as of January 2007, showed a 12-14 percentage point higher employment rate than the control group. Kondo and Shigeoka (2017), too, examine the effect, using the Labour Force Survey. In this study, workers born in 1946, that is, the first cohort affected by the EESL revision, are the treatment group, and those born in 1945 are the control group. The study shows the likelihood of the treatment group to be employed at the age of 60 and 61 increases by 2.4 and 3.2 percentage points, respectively (Kondo and Shigeoka, 2017, p.1024). Even if many more elderly workers secure employment, the overall impact on total employment would be smaller if the elderly workers substituted the young or female workers. In fact, several studies have examined the substitutability between elderly workers and other workers in the labor market. Using industry-level data, Ota (2012) examines how a higher share of elderly workers affects the hiring rate of young workers. Since 2006, when the EESL revision came into effect, increased elderly worker employment has had a negative impact on the hiring rate of young workers, especially female workers, indicating their substitutability. Kondo (2016) evaluates how the employment of elderly workers affects the employment share of young workers, considering the ratio of full-time male employees aged 55-59 years to the total full-time male employees at the establishment level as the key independent variable. However, the study finds no significantly negative correlation or evidence supporting their substitutability. While the issue of substitutability in employment can have important policy implications, firm managements need to have better understanding of the roles that can be assigned to the elderly and how they should be deployed in workplaces to maximize overall organizational productivity. Elderly workers are likely to have broad experience and human capital skills, both general and firm-specific, that can be shared with and used to train younger workers. At the same time, elderly workers with obsolete skills and low motivation in the workplace can have negative influence on their peers. Thus, we need to understand the significance and heterogeneity of elderly workers' peer effects to evaluate the potential productivity gain from retraining and assigning them efficiently.

Previous studies have examined the peer effects of students and adolescents. Using the 10th graders in each school taken from the National Education Longitudinal Survey as peer groups, Gaviria and Raphael (2001) find peer effects in the students' propensity to engage in activities such as drug use and going to church, although they also show significant endogeneity bias due to self-selection to schools. The National Longitudinal Study of Adolescent to Adult Health has an advantage in that researchers can identify the adolescents' peer groups because the questionnaire asks them to report the names of their friends. Several researchers use the survey to show evidence of peer effects in eating habits (Fortin and Yazbeck, 2015) and academic achievement (Lin, 2010). In contrast, only a few studies target peer effects of workers. Falk and Ichino (2006) exogenously assign tasks to workers in "pairs" in experiments to measure peer effects and find such effects raising productivity.

A small but growing number of studies examining peer effects in workplaces have found

both positive and negative effects. Chan et al. (2014) focus on the learning aspects of peer effects. They use the records of a cashier working at a Chinese department store to analyze the relationship between interactions among cosmetic sales workers and their sales. The study finds a knowledge spillover in the workplace-the effect is crucial when a new worker interacted with productive peers. In particular, when the new worker worked constantly with a within-counter peer of twice her ability, her sales productivity increased by an additional 5% to 6% the following week (Chan et al., 2014, p.464). The study also identifies the process of knowledge spillover as active teaching and observing.

Mas and Moretti (2009) study the peer effect as social pressure. They use data collated from supermarket registrars in the United States, where workers have incentives to free ride on the efforts of others because managers cannot monitor their contribution continuously. This is especially the case when their coworker's capabilities are higher. However, these negative externalities are apparently offset by positive productivity spillovers through peer pressure. The study finds that workers step up their effort and productivity level when they work with productive peers, especially those with whom they frequently interact in the same shift. Murphy (2019) shows an adverse workplace peer effect exploiting the natural experiment in the US Army. In response to pressure to meet their recruitment goals, in 2005, the US Army relaxed their policy of granting enlistment waivers for health, aptitude, and criminal background (Murphy, 2019, p.441). Using their personnel data, the study finds that interactions with those granted "morality waiver" had a significantly bad influence on soldiers' behavior. One standard deviation increase in exposure to "bad apples"-the ratio of company peers with criminal background to the total number of company peers-raised the likelihood of misconduct by 0.5 percentage points (Murphy, 2019, p.441).

In this study, we analyze how elderly workers affect their peers in the same workplace. That is, we examine whether elderly workers have positive or negative peer effects on other workers. Here, peer effects should capture elderly workers' roles in the internal labor market and their abilities and characteristics. Elderly workers would have substantial positive peer effect if they share their broad skills and knowledge, both general and firm-specific as well as technical or contextual, with other workers. However, elderly workers can also have obsolete skills and low motivation as they near their retirement age and thus exhibit negative peer effect in the workplace. The knowledge of which effect is greater can help us derive implications for efficient allocation of elderly workers.

For our analysis, we use personnel data from a Japanese manufacturing firm's human capital program, called Productivity Effect of HRM Policies and Changing Employment System, conducted by the Research Institute of Economy, Trade and Industry (RIETI). We examine how worker responses to questions in the employee satisfaction survey change when elderly workers are deployed. The survey asks the employees their subjective opinions about their work, satisfaction, and workplace. The combined panel dataset allows controlling for the unobservable worker characteristics and rich time-varying factors.

Our main findings are threefold. First, we find that the coworkers' exposure to elderly workers when they are assigned to the workplace does not generally affect job satisfaction, workplace communication, and training on average. Second, we find that the effects are heterogeneous and depend on the elderly workers' wages, which we interpret as reflecting their abilities. Third, the effects vary depending on the characteristics of the coworkers working with elderly workers. Especially, the results differ significantly by age group and between

non-managerial and managerial workers.

The rest of this paper is organized as follows. Section 2 presents the background of elderly employment in Japan. We describe the data source and define the key variables in Section 3, and then explain our assumptions and regression models in Section 4. Section 5 presents the study results. Finally, we discuss our interpretations and conclude the paper in Section 6.

2 Institutional background

2.1 Elderly employment in Japan

Population aging affects the fiscal balance of social security systems, with the growing number of seniors making it difficult for the working generations to shoulder the national pension burden. Thus, in order to mitigate this burden, the pension system was reformed in 2001, raising the eligibility age of pension benefit gradually to 65. While the revision reduced the burden on the working generations, it created a new problem of a gap between the eligibility age for pension benefit and the retirement age. As many firms set their retirement age at 60 years, a large number of the elderly did not have an income until they reached 65.

In an attempt to address this discrepancy, the EESL was revised in 2006, making it obligatory for firms to offer stable employment to the elderly until the age of 65 by adopting at least one of the following three measures: (1) raising their mandatory retirement age, (2) adopting a re-employment or employment extension policy allowing the elderly to continue working, without changing their official retirement age, and (3) abolishing mandatory retirement (Ministry of Health, Labor and Welfare, 2020).

Simply raising the mandatory retirement age would hurt firm profitability, because most large Japanese firms have maintained an upward-sloping wage profile that pays their old workers more than their productivity; this deferred payment practice has been justified by Lazear (1979)as an incentive scheme to increase worker efforts when outputs are not easily monitored. Therefore, raising or abolishing the mandatory retirement age without changing the entire wage structure is generally perceived as suboptimal. As overhauling the entire compensation policy could be a costly proposition, the majority of firms adopted the re-employment policy, under which the re-employed workers are rehired as non-regular workers (contract workers) despite the fact that all of them were regular workers (called *seishain*) before retirement. In a questionnaire survey conducted by Japan Institute for Labour Policy and Training (2016) covering 6,187 firms employing 50 or more people as of 2015, the employers were asked about their pay policy changes after the EESL revision. From the survey results, 60.2% of the firms did not change their young and middle-aged workers' wage levels or policies in order to extend the employment of the elderly beyond 60 years. Only 5.2% of the firms reported that they had to change their young and middle-aged workers' wage levels or policies to continue employing those aged over 60 years.

While regular workers have an indefinite period of employment, the re-employed workers have a fixed employment term. Since re-employed workers have less employment security and bargaining power, firms can reduce their wages substantially, typically 40% (or even more) below the pre-retirement wage level[1].

[1] Continuous employment benefits that insure the elderly from a big income loss, pay up to 15% of their pre-

A survey of firms with 30 or more employees conducted by the Ministry of Health, Labor, and Welfare in 2017 shows that 93.4% of the firms set their retirement age uniformly. The survey also shows that 78.5% of the firms set their retirement age at 60, implying that around 20% set their retirement age above 60. In firms having more than 1000 employees, the ratio of workers with retirement age set at 60 rises abruptly to 83.2% (Ministry of Health, Labor and Welfare, 2017). The survey further shows that 78.5% of the firms follow a re-employment policy. Thus, we can conclude that the majority of firms have decided to a re-employ their elderly workers, rather than raise or abolish the mandatory retirement age of 60 years.

For a large share of the elderly workers, most of who are re-employed, the wages drop sharply at age 60. Figure 1 illustrates a wage curve using wage census data[2] from Ministry of Health, Labor and Welfare (2018). The figure shows that elderly workers' wages drop by about one-third on average after age 60 to the wage level of workers in their early 30s, indicating a sharp decline in wages for the re-employed.

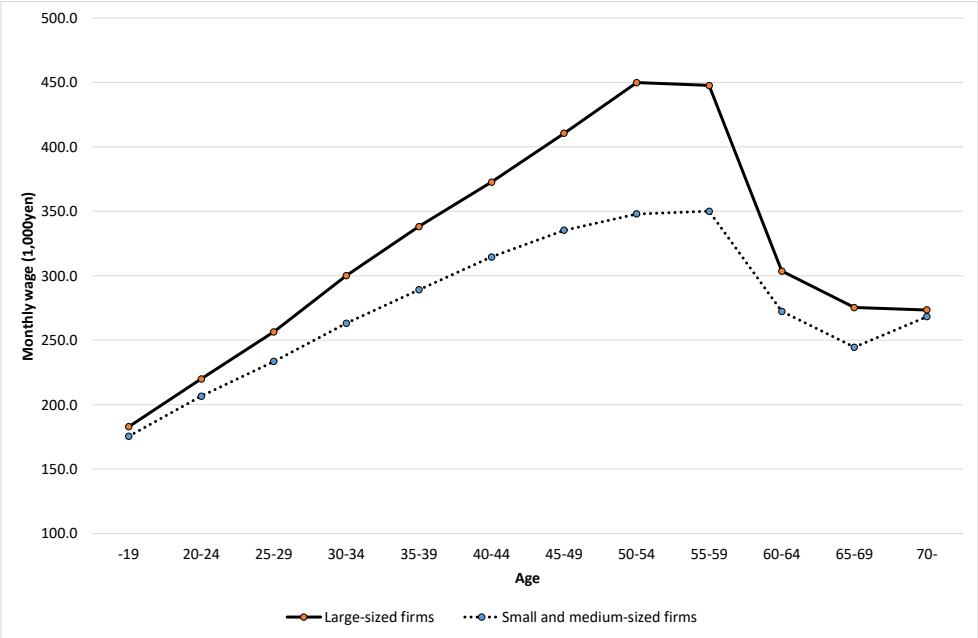

Figure 1: Wage curve of Japanese firms (2018)

retirement wage income in order to help them maintain an income level not below 75% of their pre-retirement income for five years after retirement at the age of 60. Thus, workers are guaranteed 75% of their pre-retirement wage income as long as their employers pay at least 60% of the wage level. This could prompt employers to pay only 60% of the pre-retirement level even if it is less than the workers' productivity or the market wage.

[2]We download the data from Statistics Bureau, Ministry of Internal Affairs and Communications (2019). Because the data exclude part-time workers, the curve can be biased upward.

2.2 Elderly employment policy of Japan C3P Company

Japan C3P Company (not the firm's real name, here after C3P) provided us with their personnel records in the strictest confidence. After the EESL was enacted, the firm introduced their re-employment policy, keeping the retirement age at 60 years. In 2012, the firm raised their retirement age to 63, with an option for workers to be rehired until age 65 under the re-employment policy. Thus, beginning 2012, the firm classifies their elderly workers under two employment types: senior regular workers (hereafter SRWs), and re-employed workers.

Re-employed workers are contract workers re-employed at their retirement age of 60 or 63; they can continue to work up to age 65. However, since re-employed workers are contract workers, their collective bargaining power is weaker than that of regular workers. The average annual wage of re-employed workers is about 2.4 million yen.

SRWs are regular workers aged between 60 and 63. However, starting 2012, all non-managerial workers and first-line managers (*ka-cho*) in C3P move to the new employment status called SRW when they reach age 60. The personnel department and heads of each department interview each of the workers just prior to their transition to SRM to determine the tasks and roles to be assigned to them, and which of the four job grades to be allotted-the wages vary with the job grades. Although they continue to be regular workers, their wages decrease sharply when they become SRW. For example, a worker in S1, the lowest grade, performs his daily tasks under the supervision of his boss and draws an annual wage of about 2.8 million yen. At the highest end, a worker in S4 performs advanced tasks such as project management, planning, and negotiations, and draws an annual wage of about 4.8 million yen.

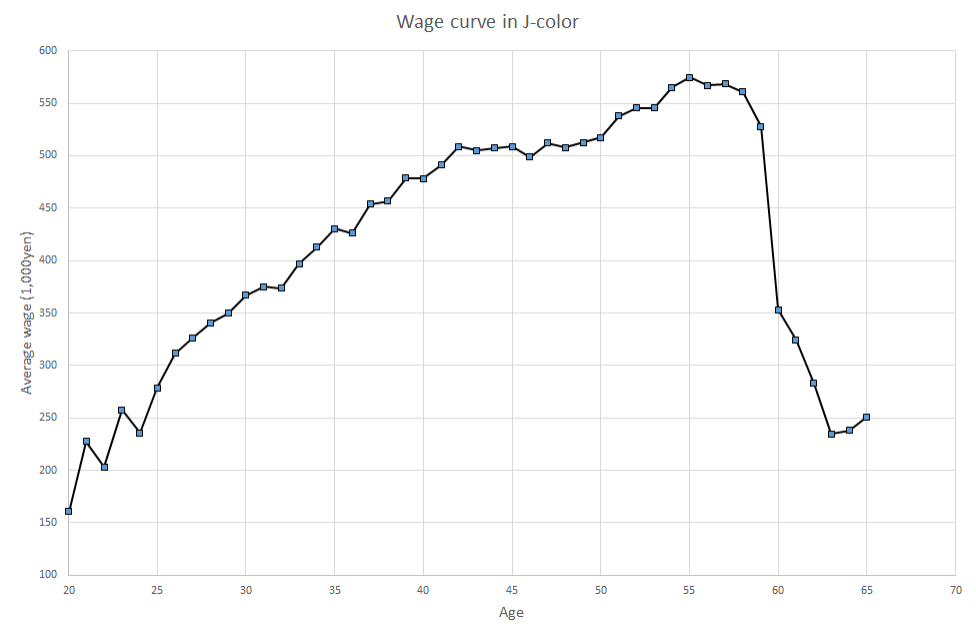

Figure 2: Wage curve in C3P (2018)

The decline in wage curve of the elderly workers in C3P is consistent with overall elderly

employment in Japan as mentioned. We created our wage curve based on C3P data for the fiscal year 2018 (Figure 2). The vertical axis gives the average monthly salary. Figure 2 shows that elderly workers' wages decreased by about onethird at age 60. Their wage levels have fallen to the level that workers receive in their late 20s. The observed pattern is consistent with the national average in Japan.

3 Data

We use the personnel records of Japanese manufacturing firm C3P (a pseudonym) collected by the human capital program "Productivity Effect of HRM Policies and Changing Employment System" of RIETI. Although the firm's website shows more than 8,000 employees on a consolidated basis, our sample includes only the domestic employees engaged in their core businesses: 3,199 workers and 26,044 observations over a 13-year period. Non-managerial workers, elderly workers, and first-line managers make up about 82.03%, 6.47%, and 11.5% of the total sample, respectively.

We examine the elderly workers' peer effects on other workers. Peers are defined as co-workers that include regular workers and first-line managers in the same section, which is a typical workplace unit in Japanese firms. We exclude senior managers, who do not belong to sections, and contract workers younger than 60 years in the sample. Elderly workers can be either regular or contract workers, as explained in the previous subsection. We exclude those in the workplace units that have only one member.

Our outcome variables are from the employee satisfaction survey conducted since 2006. This online survey asks 21 questions about workers' jobs, workplaces, and firms. The management explains that the survey is mainly used for organizational analysis, and individual responses are not disclosed to the middle management. In fact, only a limited number of designated workers in the personnel department can access the data. Table 1 presents the descriptive statistics.

The dependent variables are the responses to one of the following four questions in the employee satisfaction survey : (1) *Job-Satisfaction*: "Overall, how satisfied are you with your current job?" (2) *Workplace-Communication*: "Does your workplace have an atmosphere where you feel safe to express your opinions among each other?" (3) *Workplace-Training*: "Does your boss give you the opportunity to develop according to your own abilities and personality?" (4) *Workplace-Cooperation*: "Do people in your workplace get enough cooperation and collaboration among each other to carry out jobs?" Workers provide their answers using a 3- or 4-point Likert scale. The exact survey response format varies from year to year. The survey used a 3-point Likert scale before 2015, when it switched to a 4-point Likert scale. In the survey, lower numbers indicate higher satisfaction level, and higher numbers indicate lower satisfaction level[3]. We standardized the scores to make them comparable across years. We present the summary statistics in Table 1.

To determine the peer effects, we examine the relationship between the aforementioned outcome variables and the elderly workers' assignment to workplaces. *Anyelderly* indicates

[3]When the 3-point Likert scale was used, 1, 2, and 3 indicate "satisfied," "neither," and "dissatisfied," respectively, and in the survey with the 4-point Likert scale, 1, 2, 3, and 4 indicate "satisfied," "relatively satisfied," "relatively dissatisfied," and "dissatisfied," respectively.

whether the elderly workers are assigned to the same workplace. Note that elderly workers include both SRW and re-employed workers. In addition, following the approach of Murphy (2019), we measure the intensive margin of exposure to elderly workers to capture the frequency of a worker's interaction with elderly workers. That is, we use $Exposure$, which is derived by dividing the number of elderly workers at each workplace by the number of peers excluding the focal worker. If all peers of the worker in the workplace are elderly workers, the variable takes the value 1.

Table 1: Descriptive statistics

	Regular workers			First line managers			Elderly workers		
	Observation	Mean	SD	Observation	Mean	SD	Observation	Mean	SD
Outcome variables									
Job-Satisfaction	21,087	0.002	0.999	2,697	-0.002	0.997			
Workplace-Communication	21,314	0.003	0.998	2,991	0.000	0.998			
Workplace-Training	21,244	0.004	0.999						
Workplace-Cooperation				2,989	0.000	0.998			
Treatment variable									
Anyelderly	21,314	0.284	0.451	2,991	0.248	0.432			
Exposure	21,314	0.056	0.117	2,991	0.071	0.169			
Control variables									
Male	21,314	0.868	0.339	2,991	0.976	0.154	1,686	0.968	0.176
Age	21,314	39.030	10.188	2,991	49.052	5.616	1,686	61.179	1.444
Performance evaluation	21,314	-0.010	0.941						
Overtime hour	21,314	6.828	7.417						
Wage	20,885	5.026	1.276	3,716	7.383	1.093	1,614	3.168	1.084
Education dummies									
Doctor	21,314	0.004	0.062	2,991	0.006	0.075	1,686	0.005	0.073
Master	21,314	0.207	0.405	2,991	0.277	0.448	1,686	0.042	0.201
University	21,314	0.301	0.459	2,991	0.590	0.492	1,686	0.209	0.407
Junior college	21,314	0.022	0.146	2,991	0.008	0.091	1,686	0.020	0.141
College of technology	21,314	0.088	0.283	2,991	0.060	0.237	1,686	0.072	0.258
Vocational school	21,314	0.072	0.259	2,991	0.014	0.116	1,686	0.020	0.141
High school	21,314	0.300	0.458	2,991	0.046	0.209	1,686	0.512	0.500
Junior high school	21,314	0.006	0.078	2,991	0.000	0.000	1,686	0.050	0.218
Missing	21,314	0.000	0.014	2,991	0.000	0.000	1,686	0.070	0.255
Grade dummies									
Grade 1	21,314	0.127	0.333						
Grade 2	21,314	0.200	0.400						
Grade 3	21,314	0.319	0.466						
Grade 4	21,314	0.284	0.451						
Grade 5	21,314	0.070	0.255						
First line managers (2006-2011)									
Grade 1				2,991	0.133	0.339			
Grade 2				2,991	0.289	0.453			
Grade 3				2,991	0.076	0.265			
Grade 4				2,991	0.013	0.115			
Grade 5				2,991	0.000	0.000			
First line managers (2012-2018)									
Grade 1				2,991	0.086	0.280			
Grade 2				2,991	0.322	0.467			
Grade 3				2,991	0.078	0.268			
Grade 4				2,991	0.004	0.063			
Occupational group dummies									
Administration	21,314	0.137	0.344	2,991	0.288	0.453			
Sales	21,314	0.194	0.395	2,991	0.231	0.421			
R&D	21,314	0.267	0.442	2,991	0.303	0.460			
Production	21,314	0.403	0.490	2,991	0.179	0.383			
Section size	21,314	7.913	5.552	2,991	6.133	4.737			

Notes: The first column refers to non-managerial workers of C3P for the fiscal years 2006 to 2018. The second and third columns give the first-line managers and elderly workers for the same period, respectively. The unit of wage is one million yen.

We use the above outcome and treatment variables combined with the information on employee characteristics obtained from personnel records, such as sex, age, grade, education, occupational group, position, and establishment, as our control variables. Regular workers

are classified into five grades. First-line managers have been categorized into five grades prior to 2012 and four grades since 2012. Workers belong to one of the four occupational groups: administration (e.g., finance, HR, legal, etc.), sales, R&D, and production. In addition, there are over 20 positions and 50 establishments. The other data used from personnel records include: (1) performance evaluation ratings[4], which have five or seven ordered levels; (2) overtime hours, which is the annual average overtime hours worked in each month; and (3) annual wage in yen. We also use section codes. These identify the worker's workplace, allowing us to determine where and with whom they worked in a given year. Section size is a variable obtained by counting the number of members in a section each year.

4 Empirical strategy

4.1 Models

We run a linear model as baseline regression.

$$Y_{ijt} = \beta_0 + \beta_1 \times Anyelderly_{ijt} + \beta_2 \times X_{ijt} + \beta_3 \times d_t + \alpha_i + \alpha_j + \epsilon_{ijt} \tag{1}$$

In equation (1), Y_{ijt} is a variable indicating the satisfaction and workplace atmosphere of worker i in workplace j in year t. $Anyelderly_{ijt}$ is a treatment variable indicating whether elderly workers are assigned to the same workplace. X_{ijt} includes the worker's characteristics such as age, performance evaluation rating, and overtime hours. In addition, X_{ijt} includes a workplace variable such as number of workers in the workplace. d_t is a year dummy. α_i and α_j are worker and workplace fixed effects that capture the time-invariant characteristics of worker i and workplace j of the worker in year t. ϵ_{ijt} is an error term. The employees in our sample worked in 3.15 workplaces on average during the observation period, thus resulting in sufficient turnover in workplace assignment to identify α_i and α_j.

Next, following Murphy (2019), we build a model with the treatment variable $Exposure$, which gives the treatment effect continuously.

$$Y_{ijt} = \beta_0 + \beta_1 \times Exposure_{ijt} + \beta_2 \times X_{ijt} + \beta_3 \times d_t + \alpha_i + \alpha_j + \epsilon_{ijt} \tag{2}$$

Equation (2) uses the same sample used in equation (1). Equation (1) examines the extensive margin, identifying how the elderly workers' assignment in the same workplace affects the outcome. In contrast, equation (2) studies the intensive margin, evaluating how the elderly workers' share in the same workplace affects the outcome.

However, exposure to elderly workers can have heterogeneous effects on peers depending on their age, wage, and ability. To evaluate such heterogeneous effects, we include interactive terms between our treatment variable and elderly workers' characteristics in the regression as follows:

$$\begin{aligned} Y_{ijt} = \beta_0 + \beta_1 \times Anyelderly_{ijt} + \beta_2 \times Anyelderly_{ijt} \times \frac{1}{N_{e_{jt}}} \times \sum_{e=1}^{N_{e_{jt}}} X_{e_{jt}} \\ + \beta_3 \times X_{ijt} + \beta_4 \times d_t + \alpha_i + \alpha_j + \epsilon_{ijt}, \end{aligned} \tag{3}$$

[4]The elderly workers' assignment can affect the satisfaction level as well as performance evaluation of peers. However, our analysis results are consistent both with and without the inclusion of performance evaluation in the model.

where $N_{e_{jt}}$ is the number of elderly workers in the workplace and $\frac{1}{N_{e_{jt}}} \times \sum_{e=1}^{N_{e_{jt}}} X_{e_{jt}}$ is the average elderly worker characteristics in the workplace. We use the wage and years of education as elderly worker characteristics, $X_{e_{jt}}$. By including these variables, we can examine the heterogeneous exposure effect on the outcome.

4.2 Exogeneity of assignment

Our treatment variables indicate whether or how many elderly workers are assigned to the focal worker's workplace. However, if the variables are not random (e.g., elderly workers are assigned optimally from the perspective of management), the estimates could be biased.

One concern is that an elderly worker's assignment can depend on the workplace characteristics. For example, if the assignment is correlated with some unobservable workplace characteristics, we cannot identify how the elderly worker's assignment would affect their satisfaction because their satisfaction might be correlated with the unobservables.

To address this concern, we first run a simple regression based on Murphy (2019) to ensure that no correlation exists between coworker characteristics and their assignments. Columns 1 and 2 correspond to the regular workers' sample, while columns 3 and 4 show the results of the same analysis for first-line managers. Column 1 in Table 2 presents a regression of the treatment variable on the control variables indicating workplace characteristics such as number of workers in the workplace, establishment , occupational group, and position. In column 2, we add a worker characteristics vector in the regression. The column 2 result has an explanatory power nearly identical to that in column 1, and none of the characteristics added in column 2 are significant. Thus, we can conclude that elderly workers' assignment is independent of the non-managerial workers' characteristics. In columns 3 and 4, we run the same regression using the first-line managers sample. The variables added in column 4 do not significantly affect the elderly workers' assignments, and so we can conclude that the elderly workers' assignment is independent of the first-line managers' characteristics as well.

Table 2: Test for assignment exogeneity

Dependent variables	Regular workers Anyelderly		First line managers Anyelderly	
	(1)	(2)	(3)	(4)
Age		-0.039		-3.221
		(0.094)		(5.349)
Age2		-0.001		0.094
		(0.004)		(0.168)
Age3		0.000		-0.001
		(0.000)		(0.002)
Age4		0.000		0.000
		(0.000)		(0.000)
Performance evaluation		-0.001		
		(0.003)		
Overtime hour		-0.001		
		(0.001)		
Grade 2 dummy		-0.007		
		(0.015)		
Grade 3 dummy		-0.012		
		(0.021)		
Grade 4 dummy		-0.020		
		(0.027)		
Grade 5 dummy		-0.018		
		(0.035)		
Grade 2 dummy (-2011)				0.051
				(0.046)
Grade 3 dummy (-2011)				-0.059
				(0.081)
Grade 4 dummy (-2011)				0.062
				(0.124)
Grade 1 dummy (2012-)				0.538
				(0.498)
Grade 2 dummy (2012-)				0.438
				(0.505)
Grade 3 dummy (2012-)				0.477
				(0.518)
Grade 4 dummy (2012-)				0.306
				(0.564)
Sales dummy	-0.015	-0.014	0.024	0.024
	(0.026)	(0.026)	(0.073)	(0.071)
R&D dummy	-0.020	-0.017	-0.098	-0.113
	(0.031)	(0.031)	(0.093)	(0.094)
Production dummy	-0.011	-0.009	-0.178*	-0.178*
	(0.028)	(0.028)	(0.095)	(0.093)
Section size	0.046***	0.046***	0.038***	0.038***
	(0.002)	(0.002)	(0.006)	(0.006)
Constant	-0.550***	0.964	-0.501	40.99
	(0.159)	(0.937)	(0.338)	(63.56)
Observations	21,314	21,314	2,991	2,991
R-squared	0.475	0.476	0.573	0.578
Other characteristics	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES
Section FE	YES	YES	YES	YES

The sample includes the regular workers and first-line managers of C3P for the fiscal years 2006 to 2018. The position and establishment are controlled for in each model. Because we assume a non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.

Although the elderly workers' assignment is independent of the coworkers' characteristics, we confirm that some workplace characteristics are correlated with our treatment variable *Anyelderly* in columns 1 and 3. Therefore, we can conclude that the elderly workers' assignment can depend on the workplace characteristics. In this study, we assume the provision of unbiased estimator

$$E(\epsilon_{ijt}|A_{ijt}) = 0, \tag{4}$$

where A_{ijt} is a workplace characteristics matrix with both observable and unobservable variables and ϵ_{ijt} is the disturbance term. Under this assumption, we can consider the elderly workers assigned randomly by controlling for the workplace characteristics. To condition the observable workplace characteristics, we can continue to use control variables such as section size. We can also add workplace fixed effects to control for the unobservable workplace characteristics.

5 Result

5.1 Results from baseline regression

Table 3 shows the estimation results using columns 1, 3, and 5 for equation (1) and columns 2, 4, and 6 for equation (2). The models include three dependent variables, *Job-Satisfaction*, *Workplace-Communication*, and *Workplace-Training*. Neither the extensive margin treatment variable nor the intensive margin treatment variable has a significant coefficient at the 5% level, implying no significant elderly worker assignment peer effect in the workplace on average.

Although the coefficients in the baseline regressions are insignificant, we cannot conclude that the elderly workers' assignment has no effect because these models give only the aggregated effects. We might still observe heterogenous effects–some have positive effects and others have negative effects. For example, it is possible that elderly workers help provide training opportunities only to young workers especially given that the coefficient of the intensive margin treatment variable, *Exposure*, for the effect on *Workplace-Training* is weakly significant.

Table 3: Baseline regression

Dependent variables	Job-Satisfaction		Workplace-Communication		Workplace-Training	
	(1)	(2)	(3)	(4)	(5)	(6)
Anyelderly	-0.021		-0.034		0.032	
	(0.022)		(0.023)		(0.022)	
Exposure		-0.059		0.007		0.130*
		(0.078)		(0.086)		(0.079)
Performance evaluation	0.043***	0.043***	0.034***	0.034***	0.008	0.008
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Overtime hour	0.000	0.000	0.000	0.000	-0.004**	-0.004**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Sales dummy	-0.033	-0.033	-0.067	-0.067	-0.043	-0.044
	(0.082)	(0.082)	(0.077)	(0.077)	(0.077)	(0.077)
R&D dummy	0.080	0.081	-0.043	-0.042	-0.083	-0.083
	(0.079)	(0.079)	(0.076)	(0.076)	(0.077)	(0.077)
Production dummy	0.013	0.013	-0.120	-0.120	0.026	0.027
	(0.088)	(0.088)	(0.076)	(0.076)	(0.078)	(0.078)
Section size	0.003	0.002	0.002	0.000	-0.005	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	6.536***	6.527***	0.936	0.957	1.189	1.219
	(2.225)	(2.226)	(2.210)	(2.210)	(2.061)	(2.059)
Observations	21,204	21,204	21,314	21,314	21,244	21,244
R-squared	0.108	0.108	0.114	0.113	0.103	0.103
Control variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 to 2018. The control variables include age, grade, position, and establishment. Because we assume a non-linear relationship between the dependent variable and age, we also include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.2 Results of heterogeneous peer effects

Table 4: Controlling heterogeneity of elderly workers

Dependent variables	Job-Satisfaction		Workplace-Communication		Workplace-Training	
	(1)	(2)	(3)	(4)	(5)	(6)
Anyelderly	-0.023	-0.021	-0.037	-0.036	0.030	0.029
	(0.022)	(0.022)	(0.023)	(0.024)	(0.023)	(0.023)
Anyelderly × Elderly wages	0.040**	0.035*	0.040**	0.038**	-0.005	-0.005
	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)
Anyelderly × Elderly education		0.028		0.011		-0.002
		(0.021)		(0.020)		(0.022)
Performance evaluation	0.044***	0.044***	0.032***	0.032***	0.008	0.008
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Overtime hour	-0.001	0.000	0.000	0.000	-0.004**	-0.004**
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Sales dummy	-0.039	-0.038	-0.073	-0.072	-0.035	-0.035
	(0.083)	(0.083)	(0.077)	(0.077)	(0.077)	(0.077)
R&D dummy	0.077	0.078	-0.046	-0.046	-0.074	-0.074
	(0.079)	(0.079)	(0.075)	(0.075)	(0.077)	(0.077)
Production dummy	0.015	0.017	-0.122	-0.121	0.017	0.017
	(0.087)	(0.087)	(0.076)	(0.076)	(0.079)	(0.079)
Section size	0.002	0.002	0.002	0.002	-0.006	-0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	6.882***	6.887***	1.002	1.003	1.541	1.541
	(2.249)	(2.250)	(2.252)	(2.252)	(2.042)	(2.042)
Observations	20,912	20,912	21,021	21,021	20,956	20,956
R-squared	0.108	0.108	0.115	0.115	0.104	0.104
Control variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 to 2018. We use the standardized wage and years of education for the cross term. The control variables include age, grade, position, and establishment. Because we assume non-linear relationship between the dependent variable and age, we also include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4 examines how the potential effect of elderly workers' assignment varies with their wage, which is averaged in the workplace in case of multiple elderly workers. Wages can reflect their abilities. Table 4 also includes a model using years of education as proxy for workers' abilities. These models use the standardized value of wage and years of education.

Column 1 shows that a worker is more likely to be satisfied if the elderly workers assigned to the same workplace receive higher wages, although the effect is only weakly significant. The cross term has a positive coefficient significant at the 5% level, suggesting good peer workplace communication when the elderly workers assigned to the workplace receive higher wages. In contrast, the coefficients of these cross terms in column 5 are not significant, suggesting that treatment has no significant effect on training despite the elderly workers' abilities. These

effects show little change even after controlling for the interaction with the elderly workers' years of education in columns 2, 4, and 6. We conclude that workers generally indicate positive effects in terms of job satisfaction and quality of workplace communication with the elderly peers when the latter receives higher wages.

5.3 Causes of heterogeneous effects

In the previous subsection, we showed that the elderly workers' wage levels have a positive effect on their peers' job satisfaction and workplace communication. However, how this mechanism works is still not clear. It is possible that more capable workers take more initiatives to mentor their younger peers, or better-paid workers have higher motivation to work harder and help their fellow workers.

Although the elderly workers' wage levels should reflect their abilities or contribution before their retirement age, some workers receive higher or lower wages than what their past performance would predict. We assume that wages deviating from what the past performance justifies might affect worker motivation. Note that SRW wages are determined by worker grades such as S1 to S4. These grades are determined by the personnel department and department heads considering the workers' expected productivity based on past performance. Thus, those who held managerial positions before retirement age tend to be graded higher than those who have not. Nonetheless, the discrete nature of grading and potentially biased judgments of department heads and the personnel department could result in some workers receiving more or less than the wages they consider appropriate. Furthermore, although the wages of all re-employed workers should be the same based on grade, we still observe some variation, presumably reflecting individual workers' bargaining powers.

We decompose the wages paid into predicted wage ($\widehat{Wage}$), which is based on past performance, and $Wageresidual$, which is the difference between the actual wage and predicted wage in equation (5):

$$Wage = \widehat{Wage} + Wageresidual \tag{5}$$

The predicted wage is obtained by running a regression of the elderly workers' wages on their pre-60 wages, with dummy variables indicating whether they were first-line managers before retirement age, and whether they are SRW or re-employed workers.

Table 5: Identify the effect of wages

Dependent variables	Job-Satisfaction (1)	Workplace-Communication (2)	Workplace-Training (3)
Anyelderly	-0.023	-0.031	0.037
	(0.024)	(0.025)	(0.024)
Anyelderly × $\widehat{Wage}$	0.041**	0.035*	-0.015
	(0.018)	(0.019)	(0.019)
Anyelderly × $Wageresidual$	0.000	-0.005	-0.031
	(0.022)	(0.022)	(0.024)
Performance evaluation	0.043***	0.032***	0.008
	(0.008)	(0.009)	(0.008)
Overtime hour	-0.001	0.000	-0.003**
	(0.002)	(0.001)	(0.002)
Sales dummy	-0.039	-0.080	-0.028
	(0.083)	(0.078)	(0.078)
R&A dummy	0.058	-0.067	-0.083
	(0.079)	(0.076)	(0.078)
Production dummy	0.013	-0.127*	0.005
	(0.088)	(0.076)	(0.079)
Section size	0.001	0.002	-0.006
	(0.004)	(0.004)	(0.004)
Constant	7.153***	1.133	1.737
	(2.244)	(2.271)	(2.041)
Observations	20,406	20,514	20,454
R-squared	0.110	0.116	0.105
Control variables	YES	YES	YES
Year dummies	YES	YES	YES
Worker FE	YES	YES	YES
Section FE	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 to 2018. The control variables include age, grade, position, and establishment. Because we assume a non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

We repeat the analyses in Table 4 by decomposing the heterogeneity due to difference in wage level into the part due to difference in predicted wage and that due to difference in $Wageresidual$. The former captures the effect due to ability difference, while the latter reflects the effect due to motivation difference. Table 5 presents the results. The cross term of predicted value in column 1 has a significantly positive coefficient, while that of $Wageresidual$ has a much less and insignificant coefficient, implying that elderly workers receiving a high wage have a positive impact on their peers' satisfaction mainly because they are more capable. Consistent with the result in column 1, the cross term of predicted value in column 2 has a significantly positive coefficient at the 10% level, suggesting that the heterogeneous effects on quality of workplace communication is caused by the elderly workers' abilities. However, we could find no significant cross-term effect with either the predicted or residual part on

Workplace-training.

5.4 Subsample analysis

In the previous subsection, we examined the possibility of varying peer effects depending on the elderly workers' characteristics. In this subsection, we examine whether the elderly workers' peer effects on workers vary depending on the focal workers' characteristics such as age and occupation. Thus, we repeat the same analysis using a subsample of workers under different age and occupational groups.

Tables 6 and 7 examine the peer effects of elderly workers' assignments on both extensive and intensive margins in the subsample of workers of different age groups from 20s to 50s. Columns 11 and 12 in Table 6 and columns 5 and 6 in Table 7 show significantly positive elderly worker assignment effects on the chances of workers in their 30s and 40s being trained in the same workplace. However, we find no significant effect on the workers in their 20s for any outcome variable. Thus, we can conclude that elderly workers may be sharing their knowledge with the middle-aged rather than the young workers in the firm.

We further find positive effects on the job satisfaction of those in their 50s in columns 13 and 14 of Table 7, and negative effects, although only weakly significant, on that of those in their 20s in columns 7 and 8 of Table 6. One possible explanation for this is that the workers in their 50s and elderly workers are close in age, with the former able to learn how to work in their 60s from the latter. However, age differences may hamper knowledge spillovers from the elderly to workers in their 20s because either the latter may not have developed sufficient business domain knowledge to absorb firm-specific knowledge from the former, or the former may not win the trust of the latter due to lack of latest technical knowledge.

Table 6: Heterogenous effect among ages

Age group	20s						30s					
Dependent variable	Job-Satisfaction		Workplace-Communication		Workplace-Training		Job-Satisfaction		Workplace-Communication		Workplace-Training	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Anyelderly	-0.107*		-0.044		0.039		-0.004		0.020		0.079*	
	(0.062)		(0.064)		(0.057)		(0.044)		(0.041)		(0.046)	
Exposure		-0.263		0.019		0.118		-0.068		0.050		0.393**
		(0.258)		(0.303)		(0.260)		(0.178)		(0.158)		(0.168)
Performance evaluation	0.046**	0.046**	-0.004	-0.004	0.010	0.010	0.014	0.014	0.012	0.013	0.007	0.007
	(0.019)	(0.019)	(0.020)	(0.020)	(0.021)	(0.021)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)
Overtime hour	-0.002	-0.002	-0.004	-0.004	-0.004	-0.004	-0.001	-0.001	0.005*	0.005*	-0.004	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sales dummy	-0.241	-0.240	0.182	0.182	-0.216	-0.216	-0.211	-0.211	-0.062	-0.062	0.254	0.254
	(0.256)	(0.256)	(0.247)	(0.248)	(0.213)	(0.214)	(0.166)	(0.166)	(0.154)	(0.154)	(0.161)	(0.161)
R&D dummy	0.003	0.003	0.301*	0.300*	-0.391*	-0.391*	-0.047	-0.047	0.142	0.142	0.234	0.232
	(0.209)	(0.209)	(0.154)	(0.154)	(0.230)	(0.230)	(0.196)	(0.196)	(0.161)	(0.161)	(0.234)	(0.234)
Production dummy	-0.032	-0.035	0.123	0.123	-0.105	-0.104	-0.191	-0.191	0.000	0.001	0.133	0.138
	(0.200)	(0.200)	(0.155)	(0.155)	(0.190)	(0.189)	(0.239)	(0.239)	(0.166)	(0.167)	(0.217)	(0.217)
Section size	0.008	0.005	-0.002	-0.004	-0.007	-0.006	-0.002	-0.001	0.000	0.000	0.003	0.004
	(0.010)	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Constant	147.7	151.9	-94.48	-91.30	-108.4	-109.6	150.9	149.7	84.75	84.00	-73.32	-72.98
	(140.1)	(140.1)	(158.2)	(158.4)	(155.6)	(155.7)	(372.4)	(372.5)	(369.5)	(369.7)	(419.2)	(419.1)
Observations	4,705	4,705	4,731	4,731	4,719	4,719	6,293	6,293	6,310	6,310	6,298	6,298
R-squared	0.265	0.264	0.222	0.222	0.214	0.214	0.240	0.240	0.247	0.247	0.203	0.203
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 and 2018. The control variables include age, grade, position, and establishment. Because we assume non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 7: Heterogenous effect among ages

Age group	40s						50s					
Dependent variable	Job-Satisfaction		Workplace-Communication		Workplace-Training		Job-Satisfaction		Workplace-Communication		Workplace-Training	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Anyelderly	-0.052		-0.036		0.086*		0.097**		0.019		0.004	
	(0.042)		(0.046)		(0.045)		(0.045)		(0.052)		(0.052)	
Exposure		-0.162		-0.051		0.345**		0.308*		0.240		-0.010
		(0.141)		(0.156)		(0.162)		(0.159)		(0.199)		(0.174)
Performance evaluation	0.046***	0.046***	0.069***	0.069***	0.009	0.009	0.034	0.034	0.044	0.044	0.024	0.024
	(0.016)	(0.016)	(0.017)	(0.017)	(0.015)	(0.015)	(0.024)	(0.024)	(0.028)	(0.028)	(0.024)	(0.024)
Overtime hour	0.004	0.004	0.002	0.002	0.001	0.001	-0.003	-0.003	-0.006	-0.006	-0.005	-0.006
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Sales dummy	-0.003	-0.003	-0.440***	-0.440***	-0.153	-0.151	0.407*	0.406	0.151	0.161	-0.086	-0.088
	(0.215)	(0.214)	(0.152)	(0.152)	(0.184)	(0.184)	(0.246)	(0.248)	(0.383)	(0.385)	(0.229)	(0.229)
R&D dummy	0.473***	0.471***	-0.053	-0.053	0.015	0.019	0.142	0.136	-0.140	-0.140	-0.374	-0.374
	(0.162)	(0.162)	(0.142)	(0.142)	(0.168)	(0.169)	(0.185)	(0.184)	(0.476)	(0.476)	(0.323)	(0.322)
Production dummy	0.059	0.058	-0.115	-0.113	0.003	0.008	-0.417*	-0.416*	-0.313	-0.309	-0.532	-0.533
	(0.185)	(0.185)	(0.170)	(0.169)	(0.200)	(0.201)	(0.218)	(0.218)	(0.322)	(0.323)	(0.351)	(0.351)
Section size	0.002	0.000	0.006	0.004	-0.001	0.002	0.007	0.011	-0.010	-0.010	-0.006	-0.006
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.009)	(0.009)	(0.011)	(0.010)	(0.009)	(0.009)
Constant	17.09	17.14	-81.78	-82.21	-65.89	-66.66	135.0	132.3	66.04	67.81	-124.3	-124.7
	(57.90)	(57.93)	(58.61)	(58.62)	(62.59)	(62.44)	(155.2)	(155.5)	(190.7)	(191.0)	(180.7)	(180.6)
Observations	6,239	6,239	6,278	6,278	6,256	6,256	3,920	3,920	3,948	3,948	3,924	3,924
R-squared	0.248	0.248	0.236	0.235	0.215	0.216	0.246	0.246	0.252	0.252	0.220	0.220
Control variables	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 and 2018. The control variables include age, grade, position, and establishment. Because we assume non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Subsample analyses by occupational type showed no notable peer effects, except in administrative jobs, where interactions with elderly coworkers have a negative effect on workplace communication (Table 8).

Table 8: Effects on administration workers

Dependent variable	Job-Satisfaction		Workplace-Communication		Workplace-Training	
	(1)	(2)	(3)	(4)	(5)	(6)
Anyelderly	-0.016		-0.162**		0.007	
	(0.071)		(0.074)		(0.070)	
Exposure		-0.014		-0.264		0.257
		(0.219)		(0.275)		(0.275)
Performance evaluation	0.018	0.018	0.008	0.009	-0.013	-0.013
	(0.023)	(0.023)	(0.022)	(0.022)	(0.021)	(0.022)
Overtime hour	0.001	0.001	-0.001	-0.001	0.006	0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Section size	0.016	0.015	0.021	0.015	0.019	0.018
	(0.012)	(0.011)	(0.013)	(0.013)	(0.013)	(0.012)
Constant	6.810	6.828	8.737	8.948	11.51	11.42
	(7.975)	(7.969)	(9.336)	(9.378)	(8.373)	(8.364)
Observations	2,906	2,906	2,916	2,916	2,910	2,910
R-squared	0.192	0.192	0.163	0.161	0.176	0.176
Control variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES

Notes: The sample includes the regular workers of C3P for the fiscal years 2006 and 2018. The control variables include age, grade, position, and establishment. Because we assume non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.5 Effects on first line managers

Finally, we conduct a similar analysis using a sample of first-line managers. Because the job satisfaction questionnaire for managers is different, we replaced *Workplace-Training* with the outcome variable *Workplace-Cooperation*.

Table 9: Effects on first line managers

Dependent variables	Job-Satisfaction		Workplace-Communication		Workplace-Cooperation	
	(1)	(2)	(3)	(4)	(5)	(6)
Anyelderly	0.001	-0.005	-0.170**	-0.173**	-0.131*	-0.153**
	(0.064)	(0.065)	(0.073)	(0.074)	(0.071)	(0.070)
Anyelderly × Elderly wages	-0.107**	-0.118**	0.064	0.058	0.052	0.014
	(0.053)	(0.055)	(0.059)	(0.060)	(0.056)	(0.058)
Anyelderly × Elderly education		0.032		0.017		0.112**
		(0.051)		(0.050)		(0.044)
Section size	0.000	0.000	0.026	0.026	-0.020	-0.022*
	(0.011)	(0.011)	(0.017)	(0.017)	(0.013)	(0.013)
Sales dummy	-0.380**	-0.379**	-0.511**	-0.510**	0.146	0.147
	(0.167)	(0.167)	(0.208)	(0.208)	(0.207)	(0.204)
R&D dummy	-0.144	-0.145	-0.006	-0.006	0.241	0.237
	(0.151)	(0.151)	(0.202)	(0.202)	(0.242)	(0.243)
Production dummy	0.046	0.047	0.106	0.106	0.380	0.384
	(0.268)	(0.267)	(0.319)	(0.319)	(0.330)	(0.327)
Constant	-360.8**	-357.9**	29.43	30.85	11.11	20.37
	(151.0)	(151.3)	(156.0)	(156.4)	(149.4)	(149.5)
Observations	2,924	2,924	2,967	2,967	2,966	2,966
R-squared	0.406	0.406	0.353	0.353	0.356	0.359
Control variables	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Worker FE	YES	YES	YES	YES	YES	YES
Section FE	YES	YES	YES	YES	YES	YES

Notes: The sample includes first-line managers of C3P for the fiscal years 2006 and 2018. We use the standardized wage and years of education for cross terms. The control variables include age, grade, position, and establishment. Because we assume non-linear relationship between the dependent variable and age, we include Age^2, Age^3, and Age^4 in each model. Robust standard errors are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9 illustrates the results. In columns 1 and 2, the coefficients of cross term between the workers' assignment in the workplace and their wages are negative, implying that working with elderly workers who earn higher wages has a negative effect on the managers' satisfaction. They might feel that their authority as manager is threatened by the presence of capable elderly workers. In columns 3 and 4, the presence of elderly workers in the same workplace is associated with the managers' perception of poor workplace communication. The treatment variable coefficients are negative in columns 5 and 6, suggesting that managers find it difficult to induce cooperation in the workplace in the presence of elderly workers. However, the cross term between the treatment and elderly workers' education years given in column 6 has significantly positive coefficients, implying that the above negative effects might be canceled out or mitigated when the elderly coworkers have higher education.

6 Discussion and conclusion

In this study, we examine the peer effects of elderly workers to determine how they affect their workplaces and coworkers. For this, we used a dataset combining the personnel records

of a Japanese firm and its employee satisfaction survey results. Although we could find no significant peer effects in general, the peer effects seemed to be heterogeneous depending on the elderly workers' abilities as reflected in their wages. When the elderly workers assigned to a workplace earn higher wages than the average, regular workers in the same workplace are more likely to be satisfied with their job and find better workplace communication. The flip side of this phenomenon is that elderly workers receiving lower wages are more likely to have adverse peer effects. In addition, a subsample analysis showed that coworkers are affected differently by age group. A regression run using a sample of first-line managers found that the assignments of elderly workers, especially the capable ones, might cause their managers to feel less satisfied. This result suggest that managers feel their authority is threatened by the presence of talented elderly workers.

Although the effects in general are mostly insignificant, we have confirmed that capable elderly workers can have positive effects on their coworkers, consistent with the peer learning literature, such as Chan et al. (2014). What is interesting in C3P is that the middle-aged regular workers are the ones most affected, not the young workers or first-line managers. According to Japan Organization for Employment of the Elderly, Persons with Disabilities and Job Seekers (2019), the key roles that many firms expect their elderly workers to play include training of young workers, producing manuals, and supporting first-line managers. Such benefits are not observed in C3P.

This study surely has several limitations. First, it does not have enough external validity because our sample contains only one firm. Additional firms and industries need to be added to this study to strengthen its validity. Second, we could not examine how elderly workers' assignment to a role or job affected that of workers in other age groups, such as young workers. Examining these effects can reveal the substitutability/complementarity of elderly workers in the internal labor market. We will address these issues in a future work.

Nonetheless, our finding that elderly workers can affect their coworkers differently depending on their peers' characteristics has rich managerial implication. Namely, determining carefully the workplaces or peers that elderly workers can be assigned to can improve workplace productivity. In addition, determining what kind of jobs to assign to them can be crucial. Even if the elderly workers are capable enough, there would be no peer effect if only individual jobs are assigned to them. Kume et al. (2019) shows that the "sense of job suitability" of elderly workers who "work under the continuous employment policy" and do different jobs is likely to decrease. Hence, flexibility in deciding which workplaces and jobs to assign to elderly workers based on their abilities may be needed to optimally induce positive peer effect.

References

Chan, Tat Y, Jia Li, and Lamar Pierce, "Learning from peers: Knowledge transfer and sales force productivity growth," *Marketing Science*, 2014, *33* (4), 463–484.

Falk, Armin and Andrea Ichino, "Clean evidence on peer effects," *Journal of labor economics*, 2006, *24* (1), 39–57.

Fortin, Bernard and Myra Yazbeck, "Peer effects, fast food consumption and adolescent weight gain," *Journal of health economics*, 2015, *42*, 125–138.

Gaviria, Alejandro and Steven Raphael, "School-based peer effects and juvenile behavior," *Review of Economics and Statistics*, 2001, *83* (2), 257–268.

Japan Institute for Labour Policy and Training, "*Konenreisha no koyo ni kansuru chousa(kigyo chosa)*[The survey for elderly employment(Company survey)]," *JILPT Chosa Series*, 2016, *156.*

Japan Organization for Employment of the Elderly, Persons with Disabilities and Job Seekers, "*Koreishain Senryakuka no tameno hintoshu* [Best Practices for Empowering Elderly Workers]," 2019. JEED.

Kondo, Ayako, "Effects of increased elderly employment on other workers' employment and elderly's earnings in Japan," *IZA Journal of Labor Policy*, 2016, *5* (1), 2.

_ **and Hitoshi Shigeoka**, "The effectiveness of demand-side government intervention to promote elderly employment: Evidence from Japan," *ILR Review*, 2017, *70* (4), 1008–1036.

Kume, K., K. Tsuru, S. Sano, and K. Yasui, "*Teinengo no koyo patan to sono hyoka: Keizokukoyosha ni chakumokushite*[Post-retirement employment patterns and their assessment: With a focus on those in continuous employment]," *RIETI Discussion Paper Series*, 2019, *19-J-002.*

Lazear, Edward P, "Why is there mandatory retirement?," *Journal of political economy*, 1979, *87* (6), 1261–1284.

Lin, Xu, "Identifying peer effects in student academic achievement by spatial autoregressive models with group unobservables," *Journal of Labor Economics*, 2010, *28* (4), 825–860.

Mas, Alexandre and Enrico Moretti, "Peers at work," *American Economic Review*, 2009, *99* (1), 112–45.

Ministry of Health, Labor and Welfare, "*Heisei 29 nen Shurojoken Sogochosa Kekka no Gaikyo* (The summarized result of the General survey on working condition)," 2017. `https://www.mhlw.go.jp/toukei/itiran/roudou/jikan/syurou/17/`(January 8, 2020).

_ , "*Heisei 30 Nen Chingin Kozo Kihonchosa Kekka no Gaikyo* (The summarized result of the Basic Survey on Wage Structure)," 2018. `https://www.mhlw.go.jp/toukei/itiran/roudou/chingin/kouzou/z2018/index.html`(January 8, 2020).

_ , "*Koreisha no Koyo*(The employment of the elderlys)," 2020. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/koyou_roudou/koyou/jigyounushi/page09.html(January 8, 2020).

Murphy, Francis X, "Does Increased Exposure to Peers with Adverse Characteristics Reduce Workplace Performance? Evidence from a Natural Experiment in the US Army," *Journal of Labor Economics*, 2019, *37* (2), 435–466.

Ota, S., "Young and Old in the Labor Market : Are They Competing for Jobs? (In Japanese)," *The Japanese Journal of Labour Studies*, 2012, *626*, 60–74.

Statistics Bureau, Ministry of Internal Affairs and Communications, "*Chingin kozo kihonchosa Heisei 30 nen chingin kozo kihonchosa*, (Full time workers, Large industrial classification)," 2019. https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00450091&tstat=000001011429&cycle=0&tclass1=000001113395&tclass2=000001113397&tclass3=000001113412&stat_infid=000031683038(January 8, 2020).

Yamamoto, I., "*Konenreisha Koyo Anteiho Kaisei no Kokabunseki* (Analyses of the effects of the EESL revision)," in Y. Higuchi, M. Seko, and *Keiogijukudaigaku keisho renkei 21seiki COE* , eds., *Seido Seisaku no Henko to Shugyo Kodo [Dynamism of Household Behaviors in Japan IV]*, Tokyo: Keio University Press, 2008, pp. 161–173.