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# Mechanisms to improve labor productivity by performing telework

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ABSTRACT

This study investigates mechanisms underlying the influence of telework on labor productivity in Japan. First, this study finds that appropriate telework hours increase labor productivity, but when telework hours are too long, telework decreases labor productivity. Second, telework increases life satisfaction, and life satisfaction improves labor productivity. However, telework increases the stress of balancing work and domestic chores, contrary to Japanese governmental expectations, and the stress decreases life satisfaction. The stress, fortunately, does not directly reduce labor productivity. Although telework increases happiness and work satisfaction, these factors do not influence labor productivity. Third, this study clarifies that telework is more efficient for improving labor productivity if workers commute more than 1 h or commute by trains or buses that are usually very crowded during rush hours in Japan. Finally, the effect of telework for workers who have a greater number of potential trivial duties is insignificantly larger. Supervisors and colleagues often ask others to perform trivial, extra tasks without regard for schedules. Telework may help workers avoid such trivial duties and increase labor productivity. However, the importance of trivial duties is also demonstrated in this study.

## 1. Introduction

Japanese society promotes telework[1] because this practice encourages women and elderly individuals to work, which helps compensate for the nation's labor shortage caused by its declining population. Telework allows parents to balance work and childcare or elder care for a family member and revitalizes rural areas far from the job opportunities of urban areas. According to the 2016 Japanese *Communication Usage Survey*, only 13.2% of firms have introduced telework, despite the survey reporting that average productivity in Japanese firms with telework is high; furthermore, 43.4% of them reported that less than 5% of employees perform telework. Teleworking has been less popular even in Europe (less than 6% in France and approximately 6% in Australia) and the United States (15%–24%), since its first appearance in the 1970s (Aguilera, Lethiais, Rallet, & Proulhac, 2016, pp. 1–11). One reason is that managers doubt whether telework increases labor productivity (Aguilera et al., 2016, pp. 1–11).

The mechanisms that determine an increase in productivity by performing telework are unclear so far. Moreover, a few studies have analyzed telework in Japan, but quantitative analyses are scarce. Therefore, this study investigates the mechanisms of improving labor productivity by performing telework. To remove the influence of unobserved individual characteristics, this study uses the fixed effect model.

Bailey and Kurland (2002) summarize the extant literature: The purposes of introducing telework are to enable a balance between

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[1] Baker et al. (2007, p. 38) argue that “remote working has been studied under various names (e.g. teleworking, telecommuting, working from home), with no generally accepted definitions.” Bailey and Kurland's (2002: 384) survey study defines teleworking as “working outside the conventional workplace and communicating with it by way of telecommunications or computer-based technology (Nilles, 1994; Olson & Primps 1984).”

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work and childcare and decrease commuting. However, they demonstrate that the frequency of telework is 1 day per week, which does not satisfy these purposes in most cases. They argue that the actual motivation to introduce telework is to prevent interruptions at work. Therefore, this study investigates whether reducing commuting and avoiding interruptions at works while teleworking improve labor productivity and examines the relationship between teleworking and balancing work and domestic chores.

Many researchers have enumerated commuting time and cost as the benefit of introducing telework. Hambly and Lee (2018) calculate the opportunity cost estimated by average hourly wage rate saved by telework as the benefit when they evaluate the direct benefit from the process of developing an ultrahigh-speed broadband network across Southwestern Ontario in Canada. Similarly, Mitomo and Jitsuzumi (1999) predict the number of employees who will telecommute by 2010, calculate the reduction in congestion in Tokyo, and evaluate the opportunity cost from the relief of congestion. Wee, Verbrugge, Sadowski, Driesse, and Pickavet (2015) evaluate the indirect benefits of broadband networks for e-business by using a bottom-up approach and argue that telework would decrease commuting time, operational expenditures of firms (e.g., rent for office space), and the necessity for business travel because videoconference would suffice.

Prieger (2013) investigates fixed and mobile broadband penetration in urban and rural areas in the United States, and quotes Stenberg et al. (2009), and argues that broadband penetration helps to expand income through telework and to develop human capital through distance learning. Referring to Stenberg et al. (2009), Prieger asserts the possibility that some global outsourced positions could return to the United States if rural employees and retirees perform telework and could fill the role. The extant studies calculate the cost savings of avoiding a commute; by contrast, this study investigates labor productivity when teleworkers reduce their commuting time on and commuting stress from very crowded trains and buses.

The *discretion to work* is the other factor that increases labor productivity and job satisfaction regardless of teleworking. Morgeson, Delaney-Klinger, and Hemingway (2005) focus on job autonomy in a broad sense that includes discretion to work. Morgeson et al. (2005) collect data at large internationally headquartered firm in the United States and demonstrate that job autonomy is positively related to role breadth, and that have higher supervisory ratings of job performance; they assert that greater discretion engages in the extra role behavior, and that results in higher job satisfaction introducing the extant studies. By contrast, Baker, Gayle, and John (2007) demonstrated individual work-style (planning the day, difficulty deciding to stop working, diverse activities, and compartmentalization) does not correlate with job satisfaction and productivity for employees who work from home. However, Baker et al. (2007) observe that job and agent feedback are associated with positive job satisfaction and productivity.

Regarding the relationship between discretion to work and telework, the 2017 Works report (Recruit Works Institute, 2017) asserts that discretion to work affects the introduction of telework. Thus, it is possible that workers who hold discretionary power have higher productivity regardless of telework. In fact, Kazekami (2018) finds that discretion to work is partially included in the effect of telework. Therefore, this study adds discretion to work to the independent variables.

Psychological factors also affect labor productivity. Luthans, Avolio, Avey, and Norman (2007) collect data from employees in the insurance industry and high-tech manufacturing and find that four factors, namely, efficacy, optimism, hope, and resilience, have significantly positive effects on both performance and satisfaction. A combination of these four factors is would be more effective for performance and satisfaction than the individual components. Thus, this study considers whether telework changes life satisfaction, job satisfaction, and happiness and whether those factors improve labor productivity. The reviewed literature has not examined the effect of satisfaction on job performance; by contrast, this study proposes a hypothesis that satisfaction and happiness increase labor productivity, and investigates this hypothesis.

Thus far, we have considered time saving (by avoiding commutes and interruption at work), discretion to work, and psychological factors (e.g., satisfaction and happiness) as factors that improve labor productivity by performing telework. However, a more fundamental topic is innovation as a factor that improves labor productivity. Innovation, including new products, new services, and new work processes increase labor productivity and, subsequently, economic growth. Researchers have argued that the agglomeration, face-to-face communication, entrepreneurship, and in-house know-how are critical for innovativeness.

Moretti and Wilson (2014) demonstrate that face-to-face communication plays a critical role in creative activities of scientists and in obtaining patents. Coenen and Kok (2014) find that telework has a positive effect on team performance in product development projects if face-to-face communication is sufficient. Amoroso, Audretsch, and Link (2018) examine notable sources of knowledge for exploring new business by asking 420 firms in high-tech manufacturing sectors established from 2001 to 2007 in 10 European countries. They observe that the most important sources are vertical sources (clients, customers, or suppliers) and in-house know-how. Furthermore, according to their results, vertical sources are positively correlated with in-house know-how. Thus, we investigate whether performing tasks for work in solitude or telework hinders the accumulation of knowledge and decreases opportunities for innovation.

In terms of accumulation of knowledge, Vivas and Barge-Gil (2015) examine which firms use and benefit from external knowledge (universities, research institutes, and knowledge-intensive business firms). Vivas and Barge-Gil (2015) analyze 100 examples in the literature from tens of thousands of examples by using a selection method. Next, they observe that large firms, firms actively engaging internal R&D, and firms with a high level of technological use external knowledge. They argue that external knowledge has a positive impact on product innovation and investment, but even chances about sales. They also assert that firms that are large and engage actively R&D derive a benefit from the external knowledge. Therefore, if working with many colleagues in a firm is critical to benefit from external knowledge,[2] telework would be disadvantageous in that regard.

[2] Of course, the importance of firm size for in benefitting from the external knowledge may indicate other factors such as accessibility of external knowledge and broadness of business.

Acs, Audretsch, and Lehmann (2013) argue that the importance of entrepreneurship, compared with universities and research institutes, is greater for innovation. They summarize the literature and point out that the geographically close location can result in the accumulation of knowledge. They also remark that the spillover of knowledge depends on entrepreneurial absorptive capacity, that is, the ability of an entrepreneur to understand new knowledge, recognize its value, and subsequently commercialize it by creating a firm. When we consider telework, we consider who has such capacity and which environments improve such capacity to be crucial points. They also introduced expanding study that innovations are positively correlated with the prevalence of entrepreneur employee activities within established organizations but are not or negatively correlated to the prevalence of independent entrepreneurial activities. Based on the aforementioned studies, we must consider the evil effects of telework such as the negative effect on innovation from a solitary working environment.

Regarding individual skills, Hendarman and Cantner (2018) analyze employees' data from firms of various sizes and industries in Indonesia and find that individual soft skills and hard skills separately increase innovativeness (improving a work process, product, or service; developing cooperation with other institutions; and improving marketing systems). Innovativeness must increase labor productivity. However, Laker and Powell (2011) summarize the extant studies from various points of view and argue that the manager plays a more important role in the transfer soft skills compared with hard skills and that trainees have difficulty exactly recognizing what they must know and in what contexts they must learn that. Telework could create a situation where the worker has difficulty in finding a role model or a coach and in recognizing the appropriate training necessary to reinforce soft skills, and the worker might also find it could be difficult to accumulate soft skills. Moreover, Zhang (2012) notes that the IT industry requires students to obtain soft skills, and peer assessment is more effective than instructor assessment in teamwork projects for soft skill training in her study that proposes the assessment scale of peer assessment for soft skill training.

Moreover, compared with the effect from the environment, individual innovativeness influence organizational citizenship behavior. Ishak (2005) collects data from 385 non-managerial employees of Malaysian commercial banks. She observes that individual innovativeness predicts organizational citizenship behavior such as altruism, civic virtue, and conscientiousness, but is not related to courtesy and sportsmanship.

Thus, telework seems to have positive and negative effects on labor productivity. Therefore, we must first examine the effect of telework on labor productivity and then investigate its mechanisms in terms of (1) the stress of balancing work and domestic chores, (2) the effects of reducing commuting time and avoiding commuter rush, and (3) the effect of avoiding interruption at work by performing telework. As for innovations and soft skill level, this study does not obtain appropriate data to investigate this issue; the estimation period is not sufficiently long for analysis because telework has never been popular in Japan, and such an analysis is beyond the range of one paper. Therefore, this study does not directly analyze the innovation and soft skills of telework.

The remainder of the paper is organized as follows. Section 2 presents the data for examination and observes "teleworkers in Japan." Section 3 investigates the effect of telework hours on labor productivity by using a fixed effect model. Next, this study emphasizes the change in status of telework, such as starting telework, stopping telework, and continuing telework, and examines the effect of those statuses on labor productivity. This study uses the difference in difference method. Section 4 and section 5 investigate the mechanisms of improving labor productivity by performing telework. Section 4 clarifies the relationship among the stress of balancing work and domestic chores, happiness, life satisfaction, work satisfaction, and labor productivity. Section 5, first, this study investigates the effect of reducing commuting time and avoiding crowded trains or buses during rush hours on labor productivity. Second, this study examines whether avoiding interruption at work by performing telework improves labor productivity. Finally, section 6 presents the conclusions and discussion.

## 2. Data and the description of teleworkers in Japan

### 2.1. Data

This study obtained individual data from the Japanese Panel Study of Employment Dynamics. The data were collected in January 2017 and 2018 by the Recruit Works Institute. The questionnaire was completed online by participants who were aged 15 years and older. The distribution of gender, age class, type of employment, and region was determined on the basis of the Labor Force Survey. This study selects regular employees aged younger than 60 years from this data set. Aging teleworkers may have different impacts on productivity because they have—in many cases—retired. This study focused on the employee because the impacts of telework on teamwork and colleagues, such as reducing face-to-face communication, have been emphasized in other studies (Moretti & Wilson, 2014; Coenen and Kok, 2014) and are largely related to the employee.

Regarding employees, 61% of formal teleworkers (see the definition of formal telework in the *Volume* section) are regular workers, and the others are non-regular workers, such as part-time employees, dispatched workers, and contract workers. Regular employees have less flexibility in working style than non-regular employees. Therefore, this study emphasized regular employees. Approximately 9200 regular employees aged 60 years and younger answered the questionnaire in each year. Table 1 shows the descriptive statistics.

In Table 1, the productivity of workers who do not telework in 2016 but start telework in 2017 is slightly higher than for other workers. We must pay attention to whether workers with higher productivity tend to telework when we examine the effect of telework on labor productivity. If we conduct a logit model between workers who start telework in 2016 and non-teleworkers, labor

**Table 1**
The descriptive statistics.

| | Non-teleworkers | Start telework | Continued telework | Stop telework |
|---|---|---|---|---|
| | Mean | | | |
| Productivity#1 | 0.232 | 0.321 | 0.300 | 0.282 |
| Teleworking hours per week | 0.000 | 5.260 | 12.660 | 6.696 |
| Age | 42.064 | 43.416 | 41.366 | 39.920 |
| Job-change dummy #2 | 0.556 | 0.483 | 0.607 | 0.491 |
| Education #3 | 3.880 | 4.757 | 4.742 | 4.175 |
| Gender (female = 1) | 0.314 | 0.257 | 0.176 | 0.230 |
| Firms size | | | | |
| very small (1–9 people) | 0.110 | 0.072 | 0.127 | 0.104 |
| small (10–99) | 0.308 | 0.097 | 0.171 | 0.199 |
| middle (100–299) | 0.145 | 0.089 | 0.101 | 0.086 |
| large (300–999) | 0.135 | 0.126 | 0.161 | 0.158 |
| very large (1000 ~ ) | 0.200 | 0.583 | 0.404 | 0.396 |
| public | 0.102 | 0.033 | 0.037 | 0.058 |
| Industry | | | | |
| Agricultural forestry industries and fisheries | 0.002 | 0.000 | 0.000 | 0.000 |
| Mining industry | 0.001 | 0.000 | 0.000 | 0.000 |
| Construction | 0.071 | 0.028 | 0.048 | 0.065 |
| Manufacturing | 0.213 | 0.264 | 0.226 | 0.203 |
| Electricity, gas and heat supply | 0.016 | 0.013 | 0.019 | 0.031 |
| Telecommunication industry | 0.060 | 0.263 | 0.182 | 0.152 |
| Transportation | 0.069 | 0.038 | 0.024 | 0.075 |
| Retail trade and wholesale | 0.089 | 0.090 | 0.124 | 0.029 |
| Finance | 0.035 | 0.071 | 0.056 | 0.076 |
| Real estate | 0.018 | 0.019 | 0.033 | 0.011 |
| Eating and drinking places, accommodations | 0.023 | 0.017 | 0.012 | 0.041 |
| Medical, health care and welfare | 0.117 | 0.046 | 0.058 | 0.081 |
| Education and learning support | 0.045 | 0.004 | 0.048 | 0.014 |
| Postal service | 0.004 | 0.004 | 0.000 | 0.000 |
| Service industry | 0.095 | 0.083 | 0.082 | 0.134 |
| Public service | 0.092 | 0.033 | 0.037 | 0.048 |
| Other industries | 0.048 | 0.026 | 0.051 | 0.042 |
| Occupation | | | | |
| Services | 0.058 | 0.032 | 0.036 | 0.052 |
| Security guard | 0.023 | 0.008 | 0.013 | 0.021 |
| Agricultural forestry and fisheries | 0.001 | 0.000 | 0.000 | 0.000 |
| Transportation and communication | 0.040 | 0.000 | 0.000 | 0.043 |
| Production processes and labour services | 0.097 | 0.024 | 0.018 | 0.032 |
| Manager | 0.089 | 0.130 | 0.170 | 0.096 |
| Clerical | 0.316 | 0.268 | 0.205 | 0.240 |
| Sales job | 0.075 | 0.152 | 0.222 | 0.169 |
| Professional | 0.260 | 0.363 | 0.300 | 0.292 |
| Other occupations | 0.041 | 0.024 | 0.035 | 0.056 |
| The discretion to work (well-suited and suited = 1, otherwise zero) | 0.486 | 0.626 | 0.671 | 0.518 |
| Having children = 1 | 0.504 | 0.668 | 0.531 | 0.446 |
| Happiness (very happy = 1, unhappy = 5) | 2.776 | 2.564 | 2.515 | 2.517 |
| Stress (stressful = 1, stress-free = 5)#4 | 2.863 | 2.855 | 2.745 | 2.810 |
| Life satisfaction (very satisfied = 1, unsatisfied = 5) | 2.762 | 2.520 | 2.483 | 2.460 |
| Work Satisfaction (very satisfied = 1, unsatisfied = 5) | 2.987 | 2.704 | 2.549 | 2.691 |
| Observation | 17,676 | 219 | 291 | 171 |

#1 Productivity:Annual income/(working hours per week × 48).
#2 Job-change dummy equals one if employee has changed her/his job more than once.
#3 Elementary or junior-high school = 1, Ph.D > degree = 8.
#4 Stress to balance between work and domestic chores.

productivity significantly increases the possibility to start telework in 2016.[3]

The productivity and educational level of non-teleworkers are the lowest in Table 1. Age of workers who telework in 2016 but stop telework in 2017 is slightly younger. However, we do not find evidence that younger individuals tend to stop telework when we conduct a logit and panel-logit model between workers who stop telework and workers who continue telework.[4] Regarding the job-change dummy in Table 1, starting and stopping telework are not caused by changing jobs.

Regarding firm size, in Table 1, a very large firm had recently introduced telework. Workers in the telecommunication industry,

[3] Results available upon request.
[4] Results available upon request.

**Table 2**
Percentage of teleworkers.

| | Regular employees aged younger than 60 years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Male % | | | | Female % | | | |
| | Regulation, applied | Regulation, not applied | No regulation | Total | Regulation, applied | Regulation, not applied | No regulation | Total |
| telework hours = 0 | 0.93 | 0.46 | 95.57 | 96.97 | 0.75 | 0.38 | 97.04 | 98.17 |
| telework hours > 0 | 2.40 | 0.24 | 0.39 | 3.03 | 1.64 | 0.02 | 0.17 | 1.83 |
| Total | 3.34 | 0.70 | 95.96 | 100.00 | 2.39 | 0.40 | 97.21 | 100.00 |

finance, and real estate tend to telework. Workers who start telework and continue telework tend to have discretion to work, but we do not observe this trend in the workers who stop telework. More than half of the female and male teleworkers have children. Female teleworkers with children are aged in their thirties and fifties, although this study does not show this information in Table 1. They may need to engage in childcare or elder care.

The means of happiness for non-teleworkers is 2.776, and that for workers who start telework, continue telework, and stop telework is 2.564, 2.515, and 2.517, respectively. Notably, 1 is *very happy*, and 5 is *unhappy* (details in section 4). Hence, non-teleworkers are unhappier than other workers. This is confirmed by a *t*-test. Satisfaction with life and work for non-teleworkers are lower than for other workers too (1 is *very satisfied*, 5 is *unsatisfied*). Workers who continue telework feel slightly more stress regarding the balance between work and domestic chores (1 is *stressful*, 5 is *stress-free*). However, the difference in workers who continue telework and other workers (non-teleworkers, workers who start telework, and workers who stop telework) is not statistically clear. According to the *t*-test, workers who continue telework feel statistically more stress than non-teleworkers. However, the stress is an insignificant difference between workers who continue telework and workers who start or stop telework, and stress is insignificantly different between non-teleworkers and workers who start or stop telework.

#### 2.1.1. *Volume*

Approximately 2.40% of regular male employees and 1.64% of regular female employees aged younger than 60 years are formal teleworkers (Table 2). "Formal teleworker" indicates the regulations at work and when workers perform telework (telework hours are minutes greater than zero per week) in this study. By contrast, 0.24% of male and 0.02% of female workers telework for minutes greater than zero per week, but the regulations do not apply to them, and 0.39% and 0.17% of male and female workers telework for minutes greater than zero per week, but their firms do not have telework regulations. Most of these teleworkers may be simply working overtime from home when they are unable to finish their tasks at the office. As aforementioned, the 2016 Japanese Communication Usage Survey reports that less than 5% of employees perform telework in half of the firms that have introduced telework. The volume of telework in the data set of this study is similar to that survey.[5]

#### 2.1.2. *Working places and duration of telework*

Approximately 60% of formal teleworkers work at home (56.93% and 59.60% of male regular employees and female regular employees, respectively), although this study does not tabulate those numbers. Fewer formal teleworkers work from satellite offices: 14.98% of male regular employees and 12.58% of female regular employees.

Regarding duration of telework, most workers telework for 8 or fewer hours per week (8 h is equivalent to 1 day per week). Seventy-five percent of formal teleworkers who are regular employees telework for fewer than 16 h. The proportion of telework hours to work hours is less than 10% for half of teleworkers. However, 5% of teleworkers have a 100% proportion (full-time telework is possible).

## 3. Effect of telework hours

### 3.1. *Effect of telework hours on labor productivity*

This study analyzes the effect of telework hours than performing telework in this section. To consider the individual characteristics, this study uses the weighted fixed effect model using two-year panel data. According to Kazekami (2018), the effect of performing telework for fewer than 18 h is larger, and full-time telework decreases labor productivity.[6] Therefore, this study includes telework hours (teleH) and its square ($teleH^2$) as independent variables.

$$y_{it} = \alpha_1 teleH_{it} + \alpha_2 teleH_{it}^2 + \beta x_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

[5] The ratio of teleworking is slightly lower than 5%. The reasons are that this study excludes (1) teleworkers who are not applied the regulation, (2) the teleworkers who are applied the regulation, but teleworking hour is zero minutes, and (3) teleworkers who answer that their firms have the regulation for teleworking in 1 year, but they answer the opposite in the other year.

[6] Kazekami (2018) examines the effect of doing telework instead of teleworking hours and use only one year's data.

i indicates the individual, and t indicates the time. $x$ is the controlled variables. $x$ uses the industry dummy, occupation dummy, firm-size dummy, age, job-change dummy (if employee has changed her/his job more than once it equals one, zero otherwise),[7] educational level, discretion to work, and year dummy as controlled variables.

As for industry dummy and occupation dummy, this study estimates two cases. The first case is that this study uses the specific industry and occupation dummy. The specific industries are workers that intensively telework. Kazekami (2018) conducted a logit model in which industries introduce telework using firm-level data. Based on this previous result, the present study selects manufacturing, information and communications, retail and wholesale, and the finance and insurance industry as the specific industry dummy. Occupation dummies are selected too: managers, clerical workers, sales jobs, and professionals.

The second case is that this study uses all industry dummies that the industries already mentioned plus mining, construction, electricity, gas, heat supply and water, transport, real estate, accommodations, eating and drinking services, medical, health care and welfare, education and learning support, postal services, services (N.E.C.), government, and other industries. In addition, all occupation dummies are used. All occupation dummies are the aforementioned occupations plus service workers; protective services and security guards; agricultural, forestry, and fishery workers; transport and communications; production process and labor services; and other occupations.

As aforementioned, of all the participants who said they telework at firms with no regulations or where the regulations did not apply to them, some likely work overtime from home. This study thus compares teleworkers who properly telework at firms with regulations and non-teleworkers who do not telework at firms with no regulations. This study excludes workers unaware of any firm regulations for telework. Additionally, few workers indicate the existence of regulations at work in 2017 or 2018 but respond that their firms do not have any telework regulations in the other year. This study excludes those workers from the data set.

To measure productivity, we calculate labor productivity as follows because the questionnaire includes the number of working days per week and the number of working hours per week. This study multiplies the working hours per week by 48 (4 weeks × 12 months) and divides the annual income by this result.[8] Some individuals report very high productivity. Therefore, this paper drops the top 1% from the analysis. Similarly, this study drops the top 1% of teleworkers who telework very long hours.

Equation (1) mainly captures the effect of a teleworker. This study emphasizes the impact of a teleworker; thus, this study investigates the factors that relate to an employee in the subsequent sections. However, telework might affect colleagues (e.g., if many workers telework, amounts of work may increase for the few workers at the office) or teamwork (e.g., the efficiency of teamwork may decrease or face-to-face communications decrease). Equation (1) includes those effects as the individual effects and does not directly take out such a spillover effect.

Column (1) and (2) in Table 3 indicate the estimation result for workers who do not telework in 2016 but start telework in 2017 (data in 2017 and 2018 ask workers about questionnaires in 2016 and 2017). In Table 3, column (3) and (4) present the results of workers who continue to telework; column (5) and (6) present the results of workers who telework in 2016 but stop telework in 2017; and column (7) and (8) present the results of all teleworkers who telework in 2016 or 2017, or in both years. Column (2), (4), (6), and (8) are controlled by the specific industries where workers intensively telework and specific occupation dummies. Column (1), (3), (5), and (7) are controlled by all industry dummies and all occupation dummies.

When workers continue telework, telework hours increase labor productivity until a certain point (first row of column (3) and (4) in Table 3). However, performing telework for too many hours decreases productivity. The estimation coefficient of $teleH_{it}^2$ (square of telework hours) in column (3) and (4) are significantly negative. These results are consistent with another study. Kazekami (2018) finds that the performing telework (not telework hours) improves labor productivity, but the full-time telework decreases productivity. Furthermore, the aforementioned results in this study are consistent with Moretti and Wilson (2014) and Coenen and Kok (2014), who have argued that face-to-face communications are important. In terms of teleworkers who start or stop telework, we do not observe clear results. This study further investigates in the following section.

According to the result of teleworkers who continue telework in 2016 and 2017, the increase in 1 h of telework per week improves productivity at approximately ¥160 ($1.48[9]; column [3]) per hour. When annualized, this study takes the following equations based on the productivity measures, ¥160 × (the average number of working hours per week) × 48, where the author obtains approximately ¥340,378 (US$3152).

Age significantly increases labor productivity for workers who start telework. This finding may reflect that large (or conservative) firms, those firms generally have a training system and accumulate human capital, tend to have started telework recently compared with IT firms or bencher firms who started a short time ago because Japanese society promotes telework and because of the policy that prevents workers from leaving firms to care for an elderly family member.

The job-change dummy negatively affects workers who continue telework. This finding is consistent with the seniority wage system in Japan. However, the job-change dummy positively affects workers who start or stop telework. Job hoppers seem tend to have started or stopped telework recently, but Table 1 shows that the rate of the experience of job-change in the life of workers who continue telework is higher (62.20%) than that for workers who start telework (47.9%), stop telework (49.7%), and non-teleworkers

[7] This study uses age and job-change dummy because seniority data is not available.

[8] This study additionally calculates labor productivity as follows. This study multiplies the number of working days by 48 and divides annual income by this result to obtain daily income. Next, this study multiplies daily income by 7 and divides this result by the working hours per week. However, the results using this method are similar to the results using the calculation method in the main text of this study. Therefore, this study does not indicate these results. The results are available upon request.

[9] ¥108 per US$1.

**Table 3**
The estimation result of the weighted fixed-effect model using panel data.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Start telework | | Continued telework | | Stop telework | | All | |
| Dependent variable = | Productivity | | | | | | | |
| teleH (telework hours) | −0.00373 | −0.00366 | 0.0160** | 0.0146** | 0.0113 | 0.0121 | 0.00293 | 0.00277 |
| | (0.00774) | (0.00697) | (0.00622) | (0.00604) | (0.0103) | (0.00742) | (0.00491) | (0.00442) |
| teleH2 (square of telework hours) | 5.20e-05 | 4.90e-05 | −0.000392** | −0.000368** | −0.000232 | −0.000249* | −0.000115 | −0.000118 |
| | (0.000153) | (0.000137) | (0.000162) | (0.000156) | (0.000219) | (0.000144) | (0.000132) | (0.000117) |
| age | 0.455*** | 0.448*** | 0.0778 | 0.0549 | 0.0535 | 0.0918 | 0.0277 | 0.0281 |
| | (0.148) | (0.146) | (0.0955) | (0.0870) | (0.0872) | (0.0883) | (0.0476) | (0.0473) |
| job-change dummy | 0.0969** | 0.0945** | −0.136** | −0.124** | 0.109** | 0.0939* | 0.00217 | 0.00716 |
| | (0.0487) | (0.0470) | (0.0563) | (0.0543) | (0.0519) | (0.0487) | (0.0335) | (0.0320) |
| educational level | 0.0299 | 0.0325 | 0.0315*** | 0.0386* | 0.0205 | 0.00190 | 0.0193 | 0.0160 |
| | (0.0280) | (0.0240) | (0.0116) | (0.0205) | (0.0274) | (0.0322) | (0.0195) | (0.0190) |
| discretion to work | −0.0723 | −0.0738 | 0.00895 | 0.0112 | 0.0190 | 0.0116 | 0.000308 | −0.000832 |
| | (0.0726) | (0.0627) | (0.0308) | (0.0315) | (0.0380) | (0.0321) | (0.0254) | (0.0257) |
| year dummy (2018 = 1) | −0.460*** | −0.453*** | −0.0296 | −0.0121 | 0.0651 | 0.0401 | −0.00120 | 0.000538 |
| | (0.157) | (0.152) | (0.0809) | (0.0721) | (0.0466) | (0.0603) | (0.0422) | (0.0437) |
| Constant | −19.55*** | −19.25*** | −3.047 | −2.143 | −2.258 | −3.627 | −1.008 | −1.024 |
| | (6.261) | (6.240) | (3.904) | (3.578) | (3.528) | (3.561) | (1.966) | (1.957) |
| All industries and occupation dummy | Yes | | Yes | | Yes | | Yes | |
| Specific industries and occupation dummy | | Yes | | Yes | | Yes | | Yes |
| Observations | 219 | 219 | 291 | 291 | 171 | 171 | 681 | 681 |
| R-squared | 0.223 | 0.213 | 0.358 | 0.326 | 0.186 | 0.129 | 0.092 | 0.080 |
| Number of pkey | 113 | 113 | 151 | 151 | 87 | 87 | 351 | 351 |

Robust standard errors in parentheses.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.
Productivity:Annual income/(working hours per week × 48).
Controlled by industry, occupation, and firm size.
Specific industries and occupation dummy is explained in the text.
The discretion to work: well-suited and suited = 1, otherwise zero.
Job-change dummy equals one if employee has changed her/his job more than once.
All is all teleworkers who start, stop or continue teleworking during the estimation periods.

(56.3%).

The discretion to work is insignificant in Table 3. The discretion to work does not matter for labor productivity among teleworkers. When Kazekami (2018) estimates the effect of performing telework (not telework hours) between teleworkers and non-teleworkers, the discretion to work partially increases labor productivity.

### 3.2. *Effect of starting telework and stopping telework*

Next, this study emphasizes changing status of telework, that is, starting telework and stopping telework. This study uses the difference in difference method with weight by following equation (2) and using the data of teleworkers and non-teleworkers in this section:

$$y_{it} = \gamma_0 + \gamma_1 D_i + \gamma_2 year_t + \gamma_3 (D_i \times year_t) + \delta x_{it} + u_{it} \tag{2}$$

D equals one if workers start telework in the second year, and zero otherwise (teleworkers who stopped telework in the second year or continue telework and non-teleworkers are zero); if workers stopped telework in the second year, and zero otherwise; or if workers increase telework hours in the second year than first year, and zero otherwise. To confirm the cross-term is insignificant, D equals one if workers are non-teleworkers, and zero otherwise. *year* equals one if the data is in 2018[10]. $x$ is a controlled variable: all industry dummies, all occupation dummies, the firm-size dummy, age, the job-change dummy, gender, educational level, discretion to work, and the year dummy. In the aforementioned section, the volume of effect in column (3) of Table 3 is slightly larger when all industries and all occupations are controlled than the effect of column (4) when the specific industries and occupations are controlled. Thus, this study uses all industry and occupation dummies hereafter.

Table 4 indicates that productivity of workers who start telework in the second year of estimation periods are significantly higher than other workers in column (1). However, the cross-term between starting telework and the year dummy for 2018 (the second year of estimation periods) is insignificant. The effect that workers who start telework actually do telework in the second year is not clearly

[10] When this study estimates whether workers with lower productivity tend to stop telework for stopping teleworkers, year equals one if the year is in 2017.

**Table 4**
The estimation result of the difference in difference model.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| D= | Start telework | Stop telework | Increasing teleworking hours | Non-teleworkers |
| Dependent variable= | Productivity | | | |
| D | 0.0584*** | 0.0665 | 0.0266 | −0.0327*** |
| | (0.0208) | (0.0408) | (0.0228) | (0.0104) |
| year (2018 = 1) | 0.00405* | | 0.00345 | 0.0252 |
| | (0.00229) | | (0.00229) | (0.0183) |
| year (2017 = 1) | | −0.00324 | | |
| | | (0.00227) | | |
| D × year | −0.0263 | −0.0573 | 0.0328 | −0.0223 |
| | (0.0272) | (0.0450) | (0.0324) | (0.0184) |
| female | −0.0415*** | −0.0413*** | −0.0411*** | −0.0410*** |
| | (0.00260) | (0.00260) | (0.00259) | (0.00259) |
| age | 0.00359*** | 0.00361*** | 0.00361*** | 0.00361*** |
| | (0.000124) | (0.000124) | (0.000125) | (0.000124) |
| job-change dummy | −0.0244*** | −0.0243*** | −0.0246*** | −0.0248*** |
| | (0.00240) | (0.00240) | (0.00241) | (0.00241) |
| educational level | 0.00479*** | 0.00487*** | 0.00481*** | 0.00467*** |
| | (0.000703) | (0.000703) | (0.000705) | (0.000697) |
| discretion to work | 0.0145*** | 0.0146*** | 0.0145*** | 0.0140*** |
| | (0.00229) | (0.00229) | (0.00229) | (0.00228) |
| Constant | −0.0373* | −0.0348 | −0.0378* | −0.00425 |
| | (0.0223) | (0.0225) | (0.0224) | (0.0246) |
| Observations | 18,357 | 18,357 | 18,357 | 18,357 |
| R-squared | 0.183 | 0.183 | 0.183 | 0.185 |

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.
Productivity:Annual income/(working hours per week × 48).
Controlled by industry, occupation, and firm size.
The discretion to work: well-suited and suited = 1, otherwise zero.

shown. Regarding the controlled variables, getting older, higher educational level, and discretion to work increases labor productivity. Being female and the experience of job-change reduce labor productivity.

Column (2) in Table 4 indicates that the estimation result of workers who stopped telework in the second year is insignificant, and the cross-term between stopping telework and the year dummy for 2017 is insignificantly negative. The result is not clear, but workers whose productivity is low when they do telework stop telework in the second year, and they may increase their productivity after stopping telework.

Next, this study investigates whether productivity increases if teleworkers increase telework hours in the second year. Column (3) in Table 4 indicates that the cross-term is insignificantly positive. The difference in difference model shows the same result, that is, increases in telework hours increase labor productivity, presented in section 3.1. As a robustness check, this study conducts the same estimation for non-teleworkers. As a result, non-teleworkers have lower productivity than other workers in the first row in column (4). The productivity of workers who do not take action is lower than workers who start, continue, or stop telework. The cross-term is insignificant, as expected.

## 4. Stress, happiness, life satisfaction, and work satisfaction

As aforementioned, Kazekami (2018) finds that telework increases labor productivity, but male teleworkers suffer the stress of balancing work and domestic chores. Therefore, this study investigates the effect of telework on the stress of balancing work and domestic chores, and the effect of telework on labor productivity in more detail.

First, this study investigates the effect of telework on the stress of balancing work and domestic chores, happiness, life satisfaction, and work satisfaction using the order logit model. The dependent variable is stress, happiness, life satisfaction, or work satisfaction. The participants who completed the questionnaire answered on a scale of 1 (*very strong stress*; *very happy*; *very satisfied with own life*; *very satisfied with own work*) to 5 (*no stress*; *unhappy*; *unsatisfied with own life*; *unsatisfied with own work*). Therefore, the significant negative results mean that teleworkers tend to feel stress, happy, satisfied with life, or satisfied with work. The *parental status* dummy (if an employee has a child, equals one, and zero otherwise) is the independent variable in this section addition to the same independent variables in the aforementioned estimations: parental status dummy, all industry dummies, all occupation dummies, firm-size dummy, age, job-change dummy, educational level, discretion to work, year dummy, and performing telework (performing

**Table 5**
The effect of telework on stress, happiness, and satisfaction by order logit model using panel data.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent variable = | Stress | Happiness | Life satisfaction | Work satisfaction |
| telework | −0.539** | −0.839*** | −0.897*** | −1.240*** |
| | (0.235) | (0.277) | (0.281) | (0.257) |
| female | −0.522*** | −0.726*** | −0.710*** | −0.340*** |
| | (0.0665) | (0.0777) | (0.0784) | (0.0717) |
| telework × female | 0.0679 | 0.122 | 0.0240 | 0.0988 |
| | (0.524) | (0.622) | (0.630) | (0.572) |
| age | 0.0340*** | 0.0250*** | 0.0223*** | 0.00613* |
| | (0.00308) | (0.00359) | (0.00362) | (0.00331) |
| job-change dummy | −0.230*** | 0.230*** | 0.285*** | 0.215*** |
| | (0.0531) | (0.0607) | (0.0611) | (0.0568) |
| educational level | 0.0322** | −0.0571*** | −0.0745*** | −0.0276* |
| | (0.0155) | (0.0180) | (0.0182) | (0.0167) |
| discretion to work | 0.268*** | −0.838*** | −0.820*** | −1.566*** |
| | (0.0423) | (0.0472) | (0.0475) | (0.0463) |
| parental status | −0.359*** | −1.099*** | −0.897*** | −0.233*** |
| | (0.0567) | (0.0670) | (0.0673) | (0.0611) |
| year dummy (2018 = 1) | −0.0624** | −0.112*** | −0.0211 | −0.0170 |
| | (0.0296) | (0.0315) | (0.0316) | (0.0307) |
| Observations | 17,967 | 17,967 | 17,967 | 17,967 |
| Number of pkey | 9109 | 9109 | 9109 | 9109 |

Standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.
Telework = performing telework equals one, zero otherwise.
Stress (stressful = 1, stress-free = 5).
Happiness (very happy = 1, unhappy = 5).
Life satisfaction (very satisfied = 1, unsatisfied = 5).
Work Satisfaction (very satisfied = 1, unsatisfied = 5).
The discretion to work: well-suited and suited = 1, otherwise zero.
Job-change dummy equals one if an employee has changed her/his job more than once.
Parental status equals one if an employee has a child, otherwise zero.
Controlled by industry, occupation, and firm size.

telework equals one, zero otherwise). This study uses workers who continue telework as teleworkers in this section[11] and in section 5 because we observe the clear effect of telework among continuing teleworkers in section 3.1.

Column (1) in Table 5 indicates that the estimation coefficient of telework is significantly negative; thus, teleworkers feel more the stress of balancing work and domestic chores. Teleworkers feel more happiness, life satisfaction, and work satisfaction in column (2), (3), and (4), respectively. Notably, the magnitude of work satisfaction is larger than that of happiness and life satisfaction. Furthermore, females feel more stress from balancing work and domestic chores than males regardless of performing telework. However, females feel happier, more satisfied with their life and somewhat work than males.

Second, this study estimates the effect of those factors (stress, happiness, life satisfaction, and work satisfaction) on labor productivity. This study uses the weighted fixed effect model. The dependent variable is labor productivity. The independent variables are age, job-change dummy, educational level, firm-size dummy, all industry dummies, all occupation dummies, parental status, and discretion to work as well as stress, happiness, life satisfaction, or work satisfaction.

Column (1) in Table 6 indicates that the effect of the stress of balancing work and domestic chores is insignificant. Telework increases stress, as aforementioned, but the stress, fortunately, does not reduce labor productivity. Happiness and work satisfaction do not significantly increase labor productivity. However, life satisfaction significantly increases labor productivity in column (3) in Table 6. The significant negative sign means that if workers feel more satisfaction, that is, the workers answer small number as a scale of 1 is *very satisfied with own life*, and 5 is *unsatisfied with own life*, labor productivity is high.

Although the result is not shown in the tables,[12] being stress-free increases life satisfaction when we estimate the fixed effect model. Therefore, we interpret the effect of telework as follows. Telework increases life satisfaction, and life satisfaction improves labor productivity. However, telework increases the stress of balancing work and domestic chores. Stress does not directly decrease labor productivity but affects life satisfaction. Avoiding the stress of balancing work and domestic chores such as caring for children or an elderly family member is an impetus for Japanese society's promotion of telework. If society regards households with teleworkers as households who have sufficient manpower to care for children and elderly family members because teleworkers stay at

[11] The sign of the estimation result including teleworkers who start or stop telework during the estimation periods is the same as the result demonstrated in the main text. The results are available upon request.

[12] The result is available upon request.

**Table 6**
The effect of stress, happiness, life satisfaction and work satisfaction on the labor productivity.

| The weighted fixed effect model | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Dependent variable = | Productivity | | | |
| stress | 0.000187 | | | |
| | (0.00212) | | | |
| happiness | | −0.00150 | | |
| | | (0.00258) | | |
| life satisfaction | | | −0.00464* | |
| | | | (0.00255) | |
| work satisfaction | | | | −0.00260 |
| | | | | (0.00235) |
| age | −0.0320* | −0.0318 | −0.0318 | −0.0322* |
| | (0.0194) | (0.0193) | (0.0194) | (0.0194) |
| job-change dummy | −0.0123* | −0.0123* | −0.0122* | −0.0122* |
| | (0.00677) | (0.00676) | (0.00677) | (0.00676) |
| educational level | −0.00259 | −0.00255 | −0.00243 | −0.00249 |
| | (0.00215) | (0.00214) | (0.00213) | (0.00214) |
| discretion to work | 0.00164 | 0.00146 | 0.00115 | 0.000811 |
| | (0.00386) | (0.00391) | (0.00385) | (0.00392) |
| parental status | 0.0332** | 0.0327** | 0.0314** | 0.0327** |
| | (0.0161) | (0.0160) | (0.0160) | (0.0160) |
| year dummy (2018 = 1) | 0.0401** | 0.0399** | 0.0399** | 0.0402** |
| | (0.0194) | (0.0193) | (0.0194) | (0.0194) |
| Constant | 1.597** | 1.593** | 1.601** | 1.613** |
| | (0.805) | (0.805) | (0.806) | (0.806) |
| Observations | 17,967 | 17,967 | 17,967 | 17,967 |
| R-squared | 0.006 | 0.006 | 0.007 | 0.007 |
| Number of pkey | 9109 | 9109 | 9109 | 9109 |

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.
Stress (stressful = 1, stress-free = 5).
Happiness (very happy = 1, unhappy = 5).
Life satisfaction (very satisfied = 1, unsatisfied = 5).
Work Satisfaction (very satisfied = 1, unsatisfied = 5).
The discretion to work: well-suited and suited = 1, otherwise zero.
Job-change dummy equals one if an employee has changed her/his job more than once.
Parental status equals one if an employee has a child, otherwise zero.
Controlled by industry, occupation, and firm size.

home, labor productivity may decrease.

## 5. Commuting time and interruption at work

### 5.1. Commuting time

This study examines two mechanisms that improve labor productivity according to telework hours per week in this section. First, this study investigates whether telework reduces commuting time and prevents exposure to the commuter rush, therefore increasing labor productivity. This study divides the data of continuing teleworkers into two groups: continuing teleworkers whose commuting time is less than 60 min, and continuing teleworkers whose commuting time is more than 60, 60 min, and less than 480 min. This study conducts the same estimation as equation (1) in section 3.1. Most continuing teleworkers do telework for 1 or 2 days per week and must go to an office, as explained in section 2. We analyze whether telework is more efficient if commuting time is long because workers can save time when they telework.

This study creates a *commuter rush dummy* that equals one if workers commute to work by bus or train and equals zero if workers commute to work by car, bicycle, or foot in this section. Trains and buses are very crowded during rush hours in Japan. This type of commute may be stressful for workers and may decrease labor productivity. However, the rush dummy may capture some effect of urban life. Workers using the train or bus generally commute to firms in urban areas in Japan, and high-productivity firms agglomerate in urban areas. Therefore, this study creates urban dummy too. *Urban dummy* equals one if workers live in Tokyo metropolitan areas or Osaka metropolitan areas.[13]

[13] In more detail, urban dummy equals one if workers live in Tokyo, Chiba, Kanagawa, Saitama, Osaka, Kyoto, Hyogo and Nara prefectures.

**Table 7**
Effect of reducing commuting time and avoiding commuter rush.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Continued telework | | | | | | | |
| | Commuting time < 60 min. | | 480 min > commuting time ≥ 60 min. | | No rush (commuting by foot, car, bicycle, motorcycle, and other) | | Rush (commuting by train or bus) | |
| Dependent variable = | Productivity | | | | | | | |
| teleH (telework hours) | −0.00169<br>(0.00628) | −0.00216<br>(0.00677) | 0.0201***<br>(0.00552) | 0.0184***<br>(0.00556) | 0.00332<br>(0.00339) | 0.00347<br>(0.00344) | 0.0252***<br>(0.00587) | 0.0249***<br>(0.00614) |
| teleH2 (square of telework hours) | 8.50e-05<br>(0.000161) | 9.02e-05<br>(0.000160) | −0.000524***<br>(0.000129) | −0.000497***<br>(0.000132) | −8.37e-05<br>(6.18e-05) | −8.94e-05<br>(6.16e-05) | −0.000641***<br>(0.000109) | −0.000633***<br>(0.000118) |
| commuter rush dummy | | −0.0590<br>(0.0980) | | −0.106<br>(0.0914) | | | | |
| commuting time | | | | | | 0.000120<br>(7.48e-05) | | −0.000151<br>(0.000336) |
| urban dummy | 0.0283<br>(0.0461) | 0.0606<br>(0.0914) | 0.00810<br>(0.288) | −0.109<br>(0.364) | – | – | 0.381<br>(0.318) | 0.388<br>(0.317) |
| Constant | 2.122<br>(2.398) | 4.361*<br>(2.399) | −3.558<br>(2.168) | −3.267<br>(2.226) | 0.396<br>(1.800) | 0.405<br>(1.746) | −2.638<br>(3.040) | −2.697<br>(2.841) |
| Observations | 107 | 107 | 175 | 175 | 143 | 143 | 148 | 148 |
| R-squared | 0.299 | 0.304 | 0.607 | 0.614 | 0.490 | 0.499 | 0.648 | 0.649 |
| Number of pkey | 70 | 70 | 104 | 104 | 80 | 80 | 82 | 82 |

Robust standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Productivity:Annual income/(working hours per week × 48).
Controlled by age, job-change dummy, educational level, discretion to work, year dummy (2018 = 1), industry, occupation, and firm size.

The other estimation is that this study divides the data of continuing teleworkers by commuting methods. One is the continuing teleworkers who commute by train or bus, and the other is the continuing teleworkers who commute to work by car, bicycle, or foot. In this estimation, this study adds the commuting time in the estimation equation. This study conducts equation (1) in section 3.1 and compares the magnitude of the telework effect by commuting methods. We analyze whether avoiding the commuter rush by performing telework affect labor productivity even if commuting time is controlled.

Column (1) to (4) in Table 7 indicate the results when this study divides the data by commuting time. Whether telework hours increase labor productivity for workers who commute more than 60 and 60 min and less than 480 min is shown in column (3) and (4). By contrast, telework hours do not affect workers who commute less than 60 min, as shown in column (1) and (2). Thus, commuting time is saved by performing telework for long-time commuters and improves labor productivity. The magnitude of the effect is slightly larger, 1 h of telework per week improves productivity at approximately ¥201 ($1.86) per hour, compared with the effect of telework hours on all continuing teleworkers, ¥160 ($1.48), as shown in column (3) in Table 3. Telework is more efficient for workers who commute for a long duration. Urban dummy is insignificant. Commuting rush dummy has a negative effect on labor productivity as predicted, although it is insignificant. Commuter rush decreases labor productivity regardless of telework. The effect of telework includes avoiding the commuter rush by performing telework and economizing commuting time in column (1) to (4).[14]

Therefore, next, we divide the sample by commuting methods. Column (5) to (8) in Table 7 are the estimation results. Column (7) and (8) indicate that the telework hours significantly improve labor productivity for workers who commute by train or bus even if commuting time is controlled, but it is insignificant when employees commute by car, bicycle, or foot. Therefore, telework may reduce stress caused by very crowded trains or buses during rush hours and increase labor productivity. This study controlled urban dummy. Workers who commute by train or bus generally live in urban areas, and workers in urban areas most likely have high productivity. However, urban dummy is insignificant.

## 5.2. Interruption at work

Second, this study examines whether telework avoids interruption at work and then improves productivity. Bailey and Kurland (2002) argue that the actual motivation for telework is to avoid interruption at work. When workers work at an office, their

[14] Controlling the commuter rush dummy means, for example, comparing among teleworkers who commute long duration by train or bus. Telework hours are different among these workers; thus, the effect of telework captures the effect of one telework hour per week that economizes commuting time and avoids stress due to crowded train or bus.

supervisor may ask them to perform another task regardless of their task in process, their colleagues may visit and have a chat with them, or their juniors may ask for their advice although they are busy. If those phenomena often occur, workers might feel that they have more duties that are trivial. Therefore, this study assumes that workers at an office have more duties that are trivial, and this interrupts their tasks in process compared with performing telework.

This study uses (1) the ratio of trivial duties to daily work and (2) trivial duties dummy for more than the average proportion of trivial duties to daily work for all workers equals 1, but 0 otherwise.[15] This study estimates whether trivial duties decrease labor productivity, and for the who workers have more trivial duties, telework hours more increase labor productivity than workers who have less trivial duties because the effect of avoiding interruption at work is larger for the former workers. Thus, this study includes the cross-term between telework hours and the ratio of trivial duties (or trivial duties dummy) in the estimation model.

The estimation model is similar to the aforementioned estimation models. The dependent variable is labor productivity, and the independent variables are the ratio of trivial duties or trivial duties dummy, the cross-term between telework hours and the ratio of trivial duties (or trivial duties dummy), and the square of the ratio of trivial duties. This study controls by the same variables in the aforementioned estimations such as age, educational level, job-change dummy, firm size, industrial and occupational dummies, discretion to work, urban dummy, and year dummy. This study investigates the continuing teleworkers during the estimation periods, just as performed in section 5.1.

Table 8 indicates the results of using the fixed effect model. Column (1) indicates that the trivial duties significantly increase labor productivity contrary to expectations. Likewise, column (5) indicates that the more than the average proportion of trivial duties increases labor productivity. According to these results, opposite of what was expected, and the insignificant results of the cross-term between the trivial duties and telework hours (column [2], [4] and [6]), this study does not find that telework is more efficient for workers who have more trivial duties. Trivial duties may indicate the volume of face-to-face communications that the extant study demonstrates its importance. Additionally, the square of the ratio of trivial duties is insignificantly positive (column [3] and [4]). We do not observe that a large amount of trivial duties decreases labor productivity. Trivial duties continue to increase labor productivity.

However, we do observe trivial duties when teleworkers actually telework. The observed trivial duties are possibly from reduced interruptions at work because of telework. Therefore, this study predicts potential trivial duties in the case that teleworkers do not telework by using Heckman's two-step consistent estimation model. The first estimation step uses the binary variable that non-teleworkers equal one, and if workers are continuing teleworkers equals zero, as the dependent variable, and the explanatory variables are discretion to work and parental status. The second estimation step uses data on trivial duties from only non-teleworkers as the dependent variable, and age, gender, educational level, industry, and occupation dummies, overworking, existence of discrimination, existence of power and sexual harassment, existence of a trade union at the firm, possibility of injury, and possibility of mental illness are controlled.[16]

Column (7) to column (10) in Table 8 are results using the predicted trivial duties. Column (7) and (8) indicate that the estimation coefficient of the rate of predicted trivial duties to daily work is negative but insignificant. Similarly, column (9) and (10) indicate that the effect of the predicted trivial duties dummy for more than the average proportion of trivial duties to daily work for all workers equals 1, but 0 otherwise, is insignificantly negative. As expected, the large amount of trivial duties decreases labor productivity. The predicted trivial duties are potential trivial duties if teleworkers do not telework and work at an office. Thus, if teleworkers do not telework and have potential predicted trivial duties, those trivial duties interrupt their work, and labor productivity decreases.

Column (8) and (10) indicate that the cross-term between telework and predicted trivial duties (ratio of predicted trivial duties or predicted trivial duties dummy) is insignificantly negative. However, the aggregate effects that the effect of telework hours plus the effect of the cross-term are 0.199 and 0.188 for column (8) and (10), respectively, and significant, although this study does not show this information in tables. As expected, telework hours more increase labor productivity of workers who have more potential trivial duties. Finally, for all the aforementioned estimations, the telework hours and their squares have a significantly positive effect and significantly negative effect on labor productivity, as shown in the first and second rows in Table 8, which is similar to the previous sections.

## 6. Conclusion and discussion

This study investigates mechanisms underlying the influence of telework on labor productivity in Japan. Specifically, this study examines (1) the effect of telework on the stress of balancing work and domestic chores, happiness, life satisfaction, and work satisfaction and then the influence from those factors on labor productivity; (2) the effect of reducing commuting time and stress from the commuter rush; and (3) the effect of avoiding interruption at work by performing telework. Additionally, this study first examines whether telework hours increase labor productivity by using a fixed effect model to remove the influence of the unobserved individual characteristics.

As a result, appropriate telework hours increase labor productivity, but when telework hours are too long, telework decreases labor productivity. Behind this, telework increases life satisfaction, and life satisfaction improves labor productivity. Furthermore,

[15] This study drops the top 1% of teleworkers who have too many trivial duties such as 100%.

[16] If this study does not include the variables overworking, existence of discrimination, existence of power and sexual harassment, existence of a trade union at the firm, possibility of injury, and possibility of mental illness, the estimation does not converge.

**Table 8**
Effect of avoiding interruption at work.

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Actual data | | | | | | Predicted trivial duties | | | |
| | rate of trivial duties | | | | trivial duties dummy | | rate of trivial duties | | trivial duties dummy | |
| Dependent variable = | Productivity | | | | | | | | | |
| teleH (telework hours) | 0.0154** | 0.0114* | 0.0155** | 0.0116** | 0.0149** | 0.0159** | 0.0158** | 0.0164** | 0.0152*** | 0.0166*** |
| | (0.00642) | (0.00587) | (0.00636) | (0.00585) | (0.00632) | (0.00625) | (0.00619) | (0.00730) | (0.00572) | (0.00614) |
| teleH2 (square of telework hours) | −0.000386** | −0.000352** | −0.000383** | −0.000351** | −0.000377** | −0.000386** | −0.000389** | −0.000389** | −0.000373** | −0.000364** |
| | (0.000169) | (0.000152) | (0.000165) | (0.000150) | (0.000165) | (0.000163) | (0.000161) | (0.000161) | (0.000147) | (0.000141) |
| rate of trivial duties | 0.00310* | 0.00140 | 0.000382 | −0.00105 | | | | | | |
| | (0.00169) | (0.00154) | (0.00348) | (0.00420) | | | | | | |
| rate of trivial duties × teleH | | 0.000125 | | 0.000121 | | | | | | |
| | | (0.000134) | | (0.000130) | | | | | | |
| square of trivial duties | | | 4.79e-05 | 4.41e-05 | | | | | | |
| | | | (7.21e-05) | (6.49e-05) | | | | | | |
| trivial duties dummy | | | | | 0.0552** | 0.0660 | | | | |
| | | | | | (0.0256) | (0.0452) | | | | |
| trivial duties dummy × teleH | | | | | | −0.00109 | | | | |
| | | | | | | (0.00284) | | | | |
| rate of predicted trivial duties | | | | | | | −0.00657 | −0.00637 | | |
| | | | | | | | (0.0116) | (0.0122) | | |
| rate of predicted trivial duties × teleH | | | | | | | | −3.13e-05 | | |
| | | | | | | | | (0.000288) | | |
| predicted trivial duties dummy | | | | | | | | | −0.0834 | −0.0632 |
| | | | | | | | | | (0.0688) | (0.0695) |
| predicted trivial duties dummy × teleH | | | | | | | | | | −0.00236 |
| | | | | | | | | | | (0.00300) |
| Observations | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 |
| R-squared | 0.390 | 0.400 | 0.394 | 0.403 | 0.377 | 0.378 | 0.367 | 0.367 | 0.373 | 0.376 |
| Number of pkey | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 | 151 |

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.
Productivity:Annual income/(working hours per week × 48).
Controlled by industry, occupation, firm size, urban dummy, age, job-change dummy, educational level, discretion to work, and year dummy. Including constant term.
The discretion to work: well-suited and suited = 1, otherwise zero.
Job-change dummy equals one if employee has changed her/his job more than once.
Trivial duties dummy for more than the average proportion of trivial duties to daily work for all workers equals 1, but 0 otherwise.

telework increases the stress of balancing work and domestic chores, but stress does not directly reduce labor productivity. However, the stress decreases life satisfaction. Additionally, telework increases happiness and work satisfaction, but work satisfaction and happiness do not influence labor productivity. Telework increases work satisfaction, but teleworkers may suffer to balance between work and domestic chores. This result is the opposite of why Japanese society promotes telework, namely, to balance work and childcare, nursing, or leisure. Creating telework that does not decrease life satisfaction by avoiding the increase in the stress of balancing work and domestic chores is essential.

Most teleworkers work at home. While working at home, difficulties may occur, for example, securing time for work or concentrating on work while caring for children or another family member. It may be caused by the teleworker or by her/his family and neighbors. Individuals who work from home are often not recognized as a worker and are asked things to do other things. For example, neighbors ask teleworkers to perform community association activities.

Furthermore, regarding focusing on balancing work and childcare, the large number of children on waiting lists to be admitted to nursery schools is a political issue in Japan. Municipalities create priority levels for nursery school entry based on actual working hours of parents. According to an official survey in 2016, mothers complain that a minus point is given to work from home (teleworkers) in some municipalities' priority systems. Furthermore, many mothers complain that selection criteria are unclear. The latest official documents in 2018 stipulate the same points for priority levels for children to enter nursery schools between working outside the home or at home, but the documents still continue to classify workers by working place. Telework that does not decrease life satisfaction must increase labor productivity efficiently.

Furthermore, this study observes that the effect of telework is larger for workers who commute more than 1 h. The reductions in commuting time increase labor productivity. Additionally, the effect of telework is larger for workers who commute by crowded trains or buses that during rush hours in Japan even if the commuting time is controlled. Avoiding the commuter rush increases labor productivity too. Regarding the effect of avoiding interruption at work by performing telework, the volume of trivial duties increases labor productivity, contrary to expectations. This paper assumes that the volume of trivial duties is the level of interruption at work, but it may mean the importance of face-to-face communications. However, the observed trivial duties are the volume that changed by already performing telework. Therefore, this study predicts the potential volume of trivial duties if teleworkers do not telework. As a result, the predicted potential trivial duties decrease labor productivity insignificantly, and the effect of telework for workers who have more predicted trivial duties is insignificantly larger. The reason for this finding may be to avoid interruption at work.

One of limitations is that this study investigates workers who have already entered the labor market. The possibility of telework that non-labor force let encourage enter the labor market is beyond the aim of this study. The other limitation is that the most teleworkers in this study telework for a short duration per week. The effects of telework when workers work out of the office for long hours and at a high frequency are not demonstrated. Furthermore, as mentioned in section 3.1, this study does not emphasize the spillover effect of teleworkers. Those topics are for further research.

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