

Does teleworking improve labor productivity?

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Abstract

This study investigates the type of workers and firms likely to telework, and its mechanisms of increasing productivity. Workers with higher education, regular employees, and workers with discretion to work usually telework. Firms that rely on information technology or large firms also tend to introduce teleworking. In contrast, female workers, workers in mid-sized firms, workers in production processing, and labor operators are less inclined toward teleworking. Discretion to work partially explains the effect of teleworking. The remaining increase in productivity from teleworking is the result of reduced commuting time, and not the lack of interruption at work. This study finds a larger effect of teleworking for employees whose length of service is long, while shorter length of service is not sufficient to build trust. Furthermore, teleworkers suffer from the stress of balancing work and domestic chores, but this stress disappears when overworking is controlled. Additionally, stress decreases when the teleworker is a female regular employee. Stress from balancing work and domestic chores negatively correlates with life satisfaction and happiness. Teleworking increases productivity in the manufacturing and service industries, but negatively affects productivity in the transportation industry. However, according to individual data, teleworking does not affect manufacturing, but significantly and positively affects productivity in the transportation and telecommunication industries.

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1. Introduction

Japanese society promotes teleworking¹ for several reasons. For example, it encourages women and the elderly to work, which helps compensate the labor shortage from declining populations; it helps parents balance work and childcare; and it improves labor productivity because of better balance between work and domestic chores. Work-style reforms that include teleworking are an important part of Japanese policies. However, extant studies investigate teleworking based on its negative and positive characteristics. A few studies do analyze teleworking or “flexible work” in Japan. Some of these reports are straightforward comparisons between firms that introduced teleworking and those that did not, regardless of firm size, industry, and amount of capital, while other literature involves case studies.

Teleworking has been less popular in Europe (less than 6% in France and around 6% in Australia) and the United States (15–24%) since the seventies when it first appeared (Aguilera et al., 2016). One reason is that managers doubt whether teleworking increases labor productivity (Aguilera et al., 2016).

Before recent teleworking trends in Japan, its introduction was mostly stagnant. Furthermore, few workers telework in firms that introduce teleworking, even though average productivity in Japanese firms with teleworking is high. According to the 2016 Japanese *Communication Usage Survey*, 13.2% of firms have introduced teleworking, and 43.4% of them reported less than 5% of teleworkers for that year. Extant studies do not effectively explain its influence on workers, and quantitative analyses are scarce. Therefore, we investigate the mechanism underlying the influence of teleworking on labor productivity and worker’s satisfactions in Japan. We demonstrate that we do not predict the effect of teleworking based on its recent situation of introduction. For example, the frequency of teleworking is one day per week for many teleworkers, as described in the next section. Therefore, we cannot guess its influence on product development or teleworkers’ colleagues who do not telework, when full-time teleworking is introduced.

The number of teleworkers has decreased, according to the 2014 and 2016 surveys by the Ministry of Land, Infrastructure and Transport, Japan. The share of teleworkers—that is to say, workers who work for more than eight hours outside the office, where they can use information and communication technology (ICT)—in 2012 was at its peak at 21.3%. This number decreased to 16.4% in 2014. The latest Ministry of Land, Infrastructure and Transport survey, conducted in 2016, changes the definition of teleworking. In it, the share of workers who work out of office using ICT is 14.2% (without adjustment in matching with population). This decrease is puzzling if teleworking actually increases labor productivity. The latest survey reports that progress in introducing teleworking depends on each industry. The most common reason for not introducing teleworking is that the content of work is not suitable for teleworking.

The *Communication Usage Survey* queries firms on their introduction of teleworking. According to this survey, introduction of teleworking in manufacturing was the highest in 2006;

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).”

it was the highest in finance in 2016. The reasons for its introduction also differ. In manufacturing, it is to improve productivity, whereas in finance, it is for disadvantaged commuters.

Bailey and Kurland (2002) summarize extant literatures in their study. The authors argue that the purpose of introducing teleworking is to enable a balance between work and childcare, and saving commuting times. However, the frequency of teleworking is one day per week, which does not satisfy these purposes in most cases. They argue that the actual motivation to introduce teleworking is to prevent interruptions at work. Bailey and Kurland also state that the frequency of teleworking affects its influence on outcomes. Therefore, this study examines the relationship between teleworking and the length of commuting time, commuting methods, ratio of trivial duties in an employee's work, and childcare.

According to Bailey and Kurland (2002), teleworkers are mainly male professional workers and female clerical workers. They conclude that extant studies report mixed results on firm size—some studies find that large firms are more likely to introduce teleworking, while others find it more common in small firms. We find that both types of firms introduce teleworking. However, only few mid-sized firms introduce it according to Japanese data, which is our focus.

The mechanisms that determine increased productivity of an individual and a firm are unclear so far. It is possible that high-productivity firms introduce teleworking, or firms that introduce teleworking are willing to reform, and thus their productivity is higher. Bloom et al. (2015) argue that teleworking improves performance, but a part of this improvement is from increased working hours. Moreover, the 2017 Works report (Works Institute, 2017), and Hagihara and Kume (2017), find that teleworking does not increase working hours. The Annual Report on the Japanese Economy and Public Finance 2017 by the Cabinet Office reports that teleworking decreases working hours of male workers.

The 2017 Works report (Works Institute, 2017) states that *discretion to work* affects the introduction of teleworking. Thus, it is possible that workers who hold discretionary power have higher productivity regardless of teleworking. Its positive impact on productivity found by mere comparisons in extant studies may be a spurious effect.

According to Baker et al. (2007), 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. In contrast, the authors find that job and agent feedbacks are associated with positive job satisfaction and productivity.

While teleworking is often recommended, so is the importance of face-to-face communication. Extant studies demonstrate that face-to-face communication plays an important role in creative activities of scientists and in obtaining patents (Moretti and Wilson, 2014). Coenen and Kok (2014) find that teleworking with sufficient face-to-face communication has a positive effect on team performance in product development projects. The authors based their results on face-to-face interviews with two Dutch telecommunication firms.

As for other related studies in Japan, Shu and Naito (2017) demonstrate that work time flexibility represented by the O*net occupational characteristics scores increases wage ratio. Their O*net occupational characteristics scores incorporate time pressure, contact with others, face-to-face discussions, and so on. Yamamoto and Matsuura (2011) find that a simple effort toward work-life balance does not increase total factor productivity, but firms that meet several requirements—such as large size (more than 300 workers), manufacturing industry, large fixed labor cost, and equal opportunity and treatment measure—have a positive impact of effort toward work-life balance on total factor productivity.

The remaining paper is organized as follows. Section 2 presents two sets of data for examination. One is individual data, while the other is firm-level data. This study describes “teleworkers in Japan,” and presents the logistic estimation results to show which type of worker is likely to telework. Section 3 investigates several hypotheses on the mechanisms that improve productivity and satisfaction of teleworkers, and then presents the results. We use individual data in section 3. Section 4 compares similar firms using the propensity matching method and the regression estimation using firm-level data. Then, it demonstrates that firm characteristics that increase the tendency of introducing teleworking, and examines whether teleworking truly improves labor productivity by comparing similar firms. Finally, section 5 presents the conclusions and discussion.

2. Data and the description of teleworkers in Japan

2.1. Data

This study obtains individual data from the Japanese Panel Study of Employment Dynamics. The data were collected in January 2017 by the Works Institute². The questionnaire was filled online by participants who were 15 years of age and above. The distribution of gender, age class, type of employment, and region was determined on the basis of the Labor Force Survey. Approximately 48,000 participants answered the questionnaire. Table 1 shows the descriptive statistics.

This study uses the *Communication Usage Survey* (2006–2016) conducted by the Ministry of Internal Affairs and Communication. This survey covers randomly chosen firms that have more than 100 permanent workers in construction, manufacturing, transportation, wholesale and retail trade, finance and insurance, real estate, and service and other industries. It is conducted every year; since 2006, it also queries firms on teleworking.

This study uses the data from 2006 to the latest survey in 2016. It determines that a firm offers teleworking if its answer indicates that it introduced teleworking regardless of including work at home. If a firm states that it has a plan for teleworking, but has not introduced it, or it neither has introduced teleworking nor has any such plans, this study considers it a firm with no teleworking provisions. Table 2 presents the descriptive statistics.

2.2. Description of teleworkers

This study describes teleworking in terms of (1) regulation, work place, time length, and frequency of telework; (2) characteristics, such as age, gender, employment status, type of

² The data is available for only one year. Teleworking may affect productivity with time lag. This study assumes that teleworkers already telework before 2017. If the data in 2018 is published, this study would like to estimate the effect of teleworking with lag variables, and consider the casual dependence more precisely.

employment, and parental status; and (3) income distribution by industries of teleworkers and non-teleworkers.

Regulation, work place, time length, and frequency of telework

Approximately 2% of regular male employees and 1.5% of regular female employees below 60 years of age are formal³ teleworkers. Their teleworking hours are minutes greater than zero per week, as shown in Table 3. Next, 2.6% and 3% of male and female regular employees, respectively, telework for minutes greater than zero per week, but are unaware of any firm regulations for teleworking. Eight percent of workers telework for minutes greater than zero per week, but their firms do not have any teleworking regulations, or the regulations do not apply to them. Most of these teleworkers may be simply working overtime from home when they are unable to finish their tasks at the office.

Moreover, 1.1% of male non-regular employees and 0.9% female non-regular employees below 60 years of age are formal teleworkers. Their teleworking hours are minutes greater than zero per week, as shown in Table 3. This ratio of teleworkers is slightly lower than that of regular employees. Non-regular employees who telework for minutes greater than zero, but are unaware of any teleworking regulations, form a larger proportion than that of regular employees.

Approximately 60% of formal teleworkers work at home (58%, 61%, 65%, and 58% of male regular employees, female regular employees, male non-regular employees, female non-regular employees, respectively). However, 24% of male regular employees and 26% of female regular employees never work outside the office, even though they telework and their firm has teleworking regulations in place. Formal teleworkers who work from satellite offices are few: 14.5% of male regular employees and 7% of female regular employees. Five percent of formal teleworkers who are female non-regular employees work from satellite offices. However, formal teleworkers who are male non-regular employees are more likely to work from satellite offices. Twenty percent of this same group works from satellite offices.

Regarding the time length of teleworking, Figure 1 illustrates the histogram of hours per week of formal teleworking of male/female regular employees. Most workers telework for eight or fewer hours per week (eight hours is equivalent to one day per week). Women telework for slightly longer hours than men do. The second peak is at 40 hours; this may be because, when employees are unaware of the exact working hours, they normally tend to answer 40 hours, which is the number of legal working hours as prescribed by Japanese law. Seventy-five percent of formal teleworkers who are regular employees telework for fewer than 18 hours, while 75% of non-regular employees telework for fewer than 20 hours. Seventy-five percent of teleworkers who are regular employees, with no awareness of regulations, telework for fewer than 20 hours a week.

Finally, this study considers the working hours per week of teleworkers. Approximately 80% of formal teleworkers—male, female, regular, and non-regular employees—work five days per week. The proportion of teleworking hours to working hours is less than 20% for half the teleworkers. However, 20% of teleworkers have a 100% proportion (it is possible to be a full-

³ “Formal teleworker” indicates the existence of regulations at work, and workers actually do telework.

time teleworker). This study investigates these full-time teleworkers in addition to the majority of teleworkers.

Characteristics

Twenty percent of formal teleworkers are over 60 years of age. Aging teleworkers may have different impact on productivity and satisfaction because they are possibly retired in many cases. Therefore, this study mainly investigates teleworkers who are below 60 years of age. Sixty-four percent of formal teleworkers are male workers in the data. Figure 2 is a histogram of the age of formal teleworkers. Blue, green, red, and pink indicate male teleworkers with children, male teleworkers with no children, female teleworkers with children, and female teleworkers with no children, respectively. Half of the female and male teleworkers have children. However, most female teleworkers with children are in their forties and fifties, indicated by red bars in Figure 2. Figure 2 shows that female teleworkers with no children are young. Therefore, the motivation for teleworking does not lead to a balance between work and childcare in the most cases.

Regarding employment status, half the formal teleworkers are regular workers, while the others are non-regular workers, such as part-time employees, dispatched workers, and contract workers. Seventy-one percent of formal teleworkers are employees. Approximately 10% of formal teleworkers are company officers and 10% are self-employed. The others are family members of the self-employed and piecework at home (e.g., bagging operation, applying stickers, and data entry). This study focuses on the employee because the impact of teleworking on teamwork and colleagues, such as reducing face-to-face communication emphasized in extant studies (Moretti and Wilson, 2014; Coenen and Kok, 2014), is largely related to the employee.

Income distribution by industries

This study considers the annual income in the industry where regular employees tend to telework. It is important that annual income does not reflect productivity because, if employees work longer hours, their annual income may increase, even if their productivity does not change. Figure 3 illustrates the distribution of annual income for industries where regular employees intensively telework. The red and blue lines indicate the distribution of annual income for teleworkers and non-teleworkers, respectively.

The annual income of teleworkers in the Internet-based service industries is more diverse than that of non-teleworkers. Their education level is not different, but the firm size is different. In such industries, teleworkers work at large and small firms.

In the insurance industries, the peak income of teleworkers is lower than that of non-teleworkers. As for other finance industries, the peak income is not relatively lower, but non-teleworkers have twin peaks, where the second peak is higher than the peak for teleworkers.

In the retail estate and construction industries, the income of teleworkers is higher than that of non-teleworkers. Executives and specialists in construction tend to telework, and they work at both small and large firms.

2.3. Results of logit estimation model

To demonstrate the trends in what type of workers telework, this study estimates the waiting logit model. Hagihara and Kume (2017) compare teleworkers from firms with regulations who actually do telework *and* non-teleworkers from firms with regulation who choose not to telework. They find that those with discretion to work tend to choose teleworking. In contrast, having children does not affect the probability of choosing teleworking. Furthermore, the authors find that workers at mid-sized firms (from 100 to 999 employees) do not telework. Hagihara and Kume (2017) also use industry, occupation, marital status, position, and task variety as explained variables.

This study investigates teleworking trends by comparing teleworkers at firms with regulations who do telework *and* non-teleworkers at firms with no regulation who do not telework, rather than ascertaining the probability of choosing teleworking at firms with regulations. This study mainly compares productivity and satisfaction between these groups. Therefore, it is important to know teleworker trends. Additionally, workers decide to telework when regulations exist. However, they also choose firms based on the existence of regulations.

Table 4 presents the odds ratio for when the logit estimation model is estimated. Column (1) shows that workers with higher education, regular employees, and workers with discretion to work tend to telework. In contrast, female employees and employees who work at mid-sized firms (small: 10–99 workers and/or medium: 100–299 workers) are less inclined toward teleworking. The probability of teleworking increases by 0.86% if the employee has discretion to work. Having children is insignificant in our study too.

Column (2) shows that employees in production processing and labor operators are less inclined toward teleworking. Employees who are less exposed to discrimination in gender, age, nationality, disability, and employment status are less inclined toward teleworking. Moreover, the variables for female employees and regular employees become insignificant. Existence of a trade union at the firm and low possibility of injury also decrease the likelihood of teleworking. The probability of teleworking decreases by 0.9% when we increase discrimination by one level (categorized into five levels).

3. Investigating the mechanism using individual data

This study analyzes five hypotheses to investigate the mechanisms behind increased productivity and satisfaction from teleworking using the Japanese Panel Study of Employment Dynamics. First, this study estimates the effect of teleworking on productivity. Then, this study investigates whether discretion to work, rather than teleworking, increases productivity. Second, this study investigates whether saving commuting time and avoiding commuter rush increases productivity. Third, extant studies state that recent motivation to telework is to avoid interruptions in work. Therefore, this study investigates whether productivity increases if employees have more potential trivial duties. Fourth, if teleworking becomes more popular in the future, lack of face-to-face communication could discourage innovation and knowledge-sharing. The data, however, limit the investigation of this issue; yet this study considers the relationship between productivity and length of service. Fifth, teleworking is often recommended to enable a balance between work

and childcare. However, this study investigates whether it decreases the stress from balancing work and domestic chores, rather than childcare, which the questionnaire ignores. Additionally, as shown in the section 2, female teleworkers with children are usually in their forties and fifties, while young teleworkers do not have children. This would mean there are fewer young female workers with young children.

This study uses the waiting regression as the empirical approach. Additionally, this study uses Heckman's two-step consistent estimation model for the third and fifth investigations. As noted earlier, 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 regulations⁴ and non-teleworkers who do not telework at firms with no regulations. It uses the industry dummy, occupation dummy, firm size dummy, age, educational level, and gender dummy as explanatory variables.

To measure productivity, labor productivity is calculated in two ways because the questionnaire includes the number of working days per week and the number of working hours per week. First, this study multiplies the number of working days by 48, and divides annual income by this result. This yields the daily income. Then, this study multiplies the daily income by seven, and divides this result by the working hours per week. Second, this study multiplies the working hours per week by 48, and divides the annual income by this result. Some individuals report very high productivity. Therefore, this paper drops the top 1% from the analysis.

3.1. Effect of teleworking on productivity and the discretion to work

Table 5 shows that formal teleworking increases the annual income (column [1]) and productivity (column [5]) of male regular employees. When overworking is controlled, column (11) shows a significantly positive effect on productivity. However, if discretion to work is controlled as the explanatory variable, the positive effect of formal telework on productivity becomes insignificant, as shown in column (6) against column (5) or column (12) against column (11). Even if the effect of formal teleworking remains significant, the magnitude of the effect decreases, as shown in column (2) against column (1), column (4) against column (3), and column (8) against column (7). Moreover, telework increases the productivity of female regular employees, but discretion to work does not influence the effect of teleworking on productivity.

Seventy-five percent of teleworkers telework for fewer than 18 hours. When this study excludes those who telework over 18 hours, the results are as indicated by the third row to fourth row in Table 5. The effect of teleworking is significantly positive even if discretion to work is controlled for male regular employees. However, the magnitude of the teleworking effect decreases. Discretion to work is partially included in the effect of teleworking.

According to the results on male regular employees and who telework for fewer than 18 hours per week, teleworking increases productivity at approximately ¥332 or ¥185 (\$3 or \$1.68) per hour. When annualized, this study takes the following equations based on the productivity measures: 1) $¥332 \times (\text{the average number of working hours per week}) \div 7 = \text{daily income}$. Then, $\text{daily income} \times (\text{the average number of working days per week}) \times 48$, where the answer is

⁴ In section 3.1., this study also estimates for teleworkers who telework, but do not know whether the firm has regulations in place.

approximately ¥532,892 (\$4,844). 2) If $¥185 \times$ (the average number of working hours per week) $\times 48$, where the author obtains approximately ¥403,800 (\$3,671).

Teleworking does not increase the productivity of female workers, as well as male and female regular employees, who telework for fewer than eight hours, which is equivalent to one day per week. However, the number of observations decreases. Thus, this study estimates the aggregated male and female teleworkers who telework for fewer than eight hours. Columns (9), (11), and (12) in the seventh row of Table 5 show that teleworking increases productivity even if teleworking hours are fewer than eight hours. However, the productivity of the other measurement indicates insignificant results, and discretion to work explains the partial effect of teleworking.

When focusing on the length of teleworking, the magnitude of the effect increases when this study excludes teleworkers who are male regular employees and telework over 18 hours. Moreover, the effect is significant even with discretion to work. Therefore, this study estimates for full-time formal teleworkers. In full-time teleworking, the length of teleworking equals to the length of working hours per week. As shown in the eighth row in Table 5, teleworking significantly decreases annual income and productivity. There are positive effects of teleworking on one hand; on the other hand, lack of face-to-face communication is a negative effect. This result might indicate that partial teleworking is useful, rather than full-time teleworking.

The lower part of Table 5 shows that formal telework increases the productivity of male non-regular employees, but it is insignificant for female employees. Even for male non-regular workers, teleworking does not affect productivity if workers telework for fewer than eight hours.

When this study estimates for regular employees who do telework, but are unaware of regulations, it finds that teleworking does not affect productivity. It significantly decreases the productivity of female regular employees, including teleworkers who telework over 18 hours at one measurement of productivity⁵. From the above, this study analyzes formal teleworkers based on regular employees in the following sections

3.2. Saving commuting time and avoiding commuter rush

The upper part of Table 6 shows that commuting time does not decrease productivity. It is rather significantly positive when the commuting length is less than one hour. Owing to the positive sign of commuting length, the cross term between teleworking and commuting length is not significant. However, this study predicts that it is positive for teleworkers whose commuting length is longer, as they save more time, and thus, their productivity increases.

Next, this study divides the sample into employees whose commuting time is less than one hour and employees whose commuting time is more than one hour and less than two hours. The upper part of Table 7 shows that the magnitude of the effect of teleworking on productivity is larger for workers who commute for longer times than those who commute shorter for times.

This study investigates whether avoiding commuter rush increases productivity. This study first uses a rush dummy that equals 1 if the employee commutes by train or bus, but equals 0 if the employee commutes by foot, car, bicycle, motorcycle, and so on. This study predicts the rush dummy to be significantly negative. However, Table 6 shows that it is significantly positive for any commuting length.

⁵ The results are available upon request.

Next, this study investigates whether the rush dummy captures workers in urban areas, and if productivity is high at urban firms. This study takes the urban dummy and urban2 dummy. The urban dummy equals 1 if the employee lives in prefectures where many people commute by train or bus, but it is 0 otherwise. The urban2 dummy equals 1 if the employee lives in the prefectures of major economic zones; in other words, urban2 dummy is urban dummy plus *Aichi* and *Fukuoka* prefectures. The lower part of Table 6 shows that urban dummy and urban2 dummy have a significant and positive impact on productivity.

If the effect of the rush dummy disappears if we include the urban dummy, the rush dummy is said to capture urban economies. Table 8 shows that the rush dummy and the effect of teleworking are significantly positive even if the urban or urban2 dummies are controlled. Additionally, the urban and urban2 dummies are significantly positive. Finally, this study divides the sample into groups: whether employees commute by train and bus or not. Then, this study compares the magnitude of the effect of teleworking. If this magnitude for commuters traveling by train and bus is larger, then avoiding rush hour by teleworking can explain part of the mechanism that increases productivity by teleworking. The lower part of Table 7 shows that teleworking increases productivity when there is no rush for employees of all commuting length. However, if employees commute for more than one hour, then teleworking affects productivity when there is commuting rush. In conclusion, teleworking is more useful for employees who commute by train or bus for over an hour.

3.3. Interruption of the work

To investigate whether teleworking increases productivity by limiting interruption of work, this study takes an interruption dummy for less than the average proportion of trivial duties to daily work: 15% equals 1, but 0 otherwise. Columns (1), (3), and (5) in Table 9 show that fewer trivial duties increase productivity insignificantly. The cross term between the interruption dummy and teleworking is significantly positive. The aggregated effect—such as the cross term plus the effect of teleworking—is also significantly positive, as shown in the columns (4) and (6) in Table 9. Therefore, this study finds no evidence to suggest that the effect of teleworking for employees who have more duties that are trivial is larger than that for other teleworkers. Although this study does not represent this in the tables, when it uses the ratio of trivial duties or divides the sample by whether or not there are more duties that trivial than average, and then compares the two groups, it finds no evidence to suggest the effect of a reduction in interruptions at work because of teleworking.

However, we do observe trivial duties when teleworkers actually telework. It is possible that the observed trivial duties arise from reduced interruptions at work because of teleworking. Therefore, this study estimates Heckman's two-step consistent estimation model. The first estimation step uses the binary variable of whether or not workers choose teleworking as the independent variable, while the explanatory variables are overworking, discretion to work, parental status, existence of discrimination, and existence of a trade union. The second estimation step uses data on trivial duties from only non-teleworkers as the independent variable, while age, gender, education level, industry, occupation, and existence of power and sexual harassment are controlled.

Figure 4 shows that teleworkers have more predicted trivial duties than do non-teleworkers. Teleworkers would *potentially* have more duties that are trivial if they were not teleworking. However, non-teleworkers cannot choose teleworking because of a lack of teleworking regulations at their firms. This study compares teleworkers with employees who do not telework in spite of regulations. This comparison indicates that the mills ratio is insignificant, and the predicted trivial duties are similar between the teleworkers and non-teleworkers. In addition to the above estimation, it is possible to interpret that the trivial duties represent face-to-face communication with colleagues by proxy.

3.4. The productivity of teleworking and length of service

The positive effect of teleworking contrasts the negative effect of a lack of face-to-face communication. Teleworking is not popularly used to investigate whether lack of face-to-face communication discourages innovation and knowledge-sharing in the data set this study estimates. Instead, this study considers the relationship between teleworking productivity and length of service. A short length of service is not sufficient to build trust. The questionnaire of this data set queries participants about the number of times they have quit their job, but not the length of service. This study thus takes a never-turnover dummy that equals 1 if the employee never leaves the job, but 0 otherwise. Table 10 shows that the never-turnover dummy increases productivity. This is consistent with the seniority wage system in Japan. Teleworking also increases productivity. The cross term between teleworking and the never-turnover dummy is negative. However, the aggregate effect—such as the effect of teleworking plus the cross term—indicates a significantly positive effect on productivity. The effect of teleworking is large for employees who have worked for a long time at the same firm.

3.5. Stress to balance between work and domestic chores, life satisfaction, and happiness

Regarding the relationship between stress to balance between work and domestic charge, life satisfaction, and happiness, the latter two have a strong and positive correlation of 0.82. The correlation between the stress to balance between work and domestic chores and life satisfaction is -0.35. The correlation between the stress to balance between work and domestic chores and happiness is -0.33.

Table 11 shows that the effect of teleworking is significantly negative in column (1) as estimated by the regression model, and in column (4), as estimated by the order logit model for the sample with both genders. As the participants of the questionnaire answer on a scale of 1 (very strong stress) to 5 (no stress), the significant negative results mean that teleworkers tend to feel stress. However, if the extent of overworking is controlled, teleworking does not significantly affect stress, as shown in columns (2) and (5) (in addition to these estimations, when life satisfaction and happiness are dependent variables, teleworking increases these factors even though the extent of overworking is controlled). Moreover, if happiness is controlled, teleworking and overworking increase stress, and happiness decreases the stress from balancing work and domestic chores. Additionally, female workers feel more stress compared with male workers.

The middle part of Table 11 shows the same estimation for male regular employees. The magnitude of teleworking is larger than the estimations for both genders, but the magnitudes of happiness and extent of overworking are almost the same. The lower part of Table 11 shows the same estimation for female regular employees. However, teleworking does not affect stress, as per columns (1) to (6), but the number of observations decreases. Therefore, this study includes the cross term between female employees and teleworking in the estimation. The lowest part of Table 11 shows that, if female regular employees telework, stress decreases, while teleworking itself and overworking increase stress, and happiness decreases stress similar to the previous results on both genders and male regular employees.

However, it is possible that employees who face difficulty maintaining a balancing between work and domestic chores choose teleworking. Therefore, this study estimates Heckman's two-step consistent estimation model. This study uses data on stress from only non-teleworkers. In the first estimation step, this study focuses on whether or not workers choose teleworking. This study does not find any evidence to suggest that employees who feel more stress choose teleworking⁶. However, employees cannot choose teleworking when there is no appropriate regulation. Therefore, this study conducts the same first estimation step using employees who do and do not telework when there is regulation. As a result, employees who feel slightly more stress choose to telework. Additionally, for the same estimation in Table 11 using the predicted stress, this study finds that teleworking does not affect stress in any case.

4. Investigation using firm-level data

This study now uses firm-level data for the analysis. First, this study examines which characteristics of firms encourage teleworking using the logit mode by each year. Some firms report very high labor productivity. Thus, this study drops the top 1% sample. Second, this study matches similar firms using the propensity matching method. This study uses variables that are significant in the former logit estimation separately because using too many variables decreases the matching quality. However, the estimation result in each year indicates the time trend corresponding to economic fluctuation. Hence, this study estimates the pooled regression model with control variables for economic fluctuation. Moreover, this study estimates the data by dividing the sample according to industry because the result of the regression model indicates that the industrial dummies are significant. This study also estimates the data by dividing the quartile of labor productivity level.

4.1. The results of the logit model

Table 12 shows that firms that use the cloud service, ICT, or the social network services (blogs or homepages from 2006 to 2010 because of data limitations) tend to introduce teleworking

⁶ This study predicts the discontinuous stress degrees because the questionnaires queries participants on their stress on a scale of 1 to 5. However, continuous stress degrees are predicted.

in almost all estimated periods. Regarding the magnitudes of odds ratio, the social network service is more important in the early estimated period, ICT tends to be important in the middle estimated period, and cloud service is more important in the recent years. Firms use social services to recruit workers, advertise products, and obtain consumer opinions. Furthermore, firms that have large capital tend to introduce teleworking. As for the number of employments, only the results for the recent years are significant. Large firms, determined by the scale of employment, introduced teleworking in recent years. Additionally, this study simply aggregates the data of each year, and indicates the estimation result as “Pooled estimation” in Table 12. The result is similar to the estimation results by each year. Furthermore, this study merges the data of each year by introduction status of teleworking, using status of the social network service, cloud service and ICT, capital size and industry, and makes pseudo panel data. “Pseudo panel (random)” in Table 12 shows its estimation result. The signs of odds ratios are the same with the other results in Table 12 and significant although the magnitudes for the uses the social network services, cloud services, and the ICT are large.

4.2. Effect of telework by comparing similar firms

This study matches firms using the results from Table 12, and compares the effect of teleworking on labor productivity between similar firms. To conduct the propensity matching method to match similar firms, this study includes the use of cloud service, ICT, and social network services for Figure 5.1, 5.2, and 5.3, respectively, and all three variables for Figure 5.4, in addition to industry and sales per worker. According to these figures, teleworking increases labor productivity by approximately ¥1.4 million to ¥1.9 million (about \$14,000 to \$19,000). All figures indicate that the coefficient falls in 2011 and 2013. It seems that economic fluctuation affects the estimated coefficients.

This study then estimates the regression models by including “operating profit” as a control variable to grasp economic fluctuation. Table 13 shows that teleworking increases labor productivity by approximately ¥1.4 million (\$14,000), as shown in column (1). This effect decreases if this study controls the year dummy, region dummy, capital-class dummy, operating profit, and employment. The magnitude of teleworking decreases by approximately ¥650,000 (\$65,000). Furthermore, this study makes pseudo panel data. This study merges the data of each year by introduction status of teleworking, using status of the social network service, cloud service and ICT, capital size and industry. Columns (3) and (4) indicate the result of pooled model and random model, respectively. The magnitudes of teleworking effect on the labor productivity decreases in the pseudo panel models. Comparing these results with the results that come from the individual data in the section 3, the former results are smaller than the latter. The effects on individual and team productivity are different, and the latter effect maybe smaller. The more detail investigation is needed to analyze the different effects on individual and team productivities.

4.3. Effect of teleworking by industry

Economic activities vary among industries, and their reasons to introduce teleworking differ. This study divides the sample by industry first. Table 14 shows that teleworking positively affects labor productivity in the manufacturing and service industries. Teleworking increases productivity by ¥1.21 million and ¥1.47 million for the manufacturing and service industries, respectively. It negatively affects productivity in the transportation industry, and does not significantly affect productivity in the construction, retail trade and wholesale industries, and finance and retail estate industries.

These results indicate the average effect of teleworking on firms. If this study uses individual data (section 3), the effects of teleworking on individual workers are slightly different, as shown in Table 15. In contrast to firm-level data, teleworking does not affect productivity in manufacturing, but it has a significantly positive effect on productivity in the transportation industry. Teleworking increases productivity in the telecommunication industry, but the results are insignificant for the construction, retail trade and wholesale, drinking and eating services, accommodations, finance, and services industries.

The difference in the results between firm-level and individual data may come from the effect of teleworking on individual and team productivities. Nevertheless, partial differences arise because of different data sources and estimation methods. This is the important issue, but the data sets are limited in this study.

4.4. Effect of teleworking by firm productivity level

This study examines the effect of teleworking on firms on the basis of productivity level. Table 16 shows the estimation results of firms where the productivity levels are under 25%, from 25% to 50%, from 50% to 75%, and over 75%. Table 16 shows that teleworking affects productivity of high-productivity firms. It does not significantly affect productivity of firms with 50% to 75% and under 25% productivity levels. The effect for firms where the productivity level is from 25% to 50% is negative, but insignificant.

Considering discretion to work discussed in section 3.1, it is possible that high-productivity firms tend to introduce teleworking, although the amount of sales per worker is insignificant in the logit estimation model (section 4.1).

5. Conclusion and discussion

This study investigated what types of individual and firms are likely to introduce teleworking, and the mechanisms that determine an increase in productivity and life satisfaction. While straightforward comparisons and case studies are common, quantitative studies are fewer, and therefore the mechanisms have been unclear so far. As a result, workers with higher education, regular employees, and workers with discretion to work tend to telework. In contrast, female employees and employees who work at mid-sized firms, employees in production processing, and labor operators are less inclined toward teleworking.

Teleworking increases productivity by approximately ¥185 or ¥332 (\$3 or \$1.68) per hour; in other words, approximately ¥403,000 or ¥532,000 (\$3,671 or \$4,844) per year.

Teleworking fewer than 18 hours per week has a larger positive impact on productivity than full-time teleworking does. This may result from the lack of face-to-face communication, which is a negative effect of teleworking, though there are other positive effects.

Discretion to work is partially included in the effect of teleworking, and other mechanisms work to increase productivity from teleworking too. For instance, saving commuting time is one such mechanism. The magnitude of the effect of teleworking on productivity is larger for commuters who travel for longer durations than for those who commute for shorter duration. Additionally, teleworking is more useful if employees commute by train or bus for over an hour.

In Europe, one motivation for teleworking is to avoid interruptions at work. However, this study does not find evidence to suggest that the effect of teleworking for the employees who have more duties that are trivial is larger than that for other employees. If this study predicted the potential trivial duties before teleworking, the predicted trivial duties of teleworkers are more than that of non-teleworkers, although firms of non-teleworkers in this study have no regulations. In addition, it is possible to interpret that the trivial duties represent face-to-face communication with colleagues by proxy.

A short length of service is not sufficient to build trust. This study finds that the effect of teleworking for employees who have never left their job is larger than the effect for employees who have experienced turnover.

Stress from balancing work and domestic chores negatively correlates with satisfaction and happiness. Teleworkers tend to feel stress. However, if overworking is controlled, teleworking does not significantly affect stress. Remarkably, stress decreases when female regular employees telework. However, it is possible that employees who find it difficult to balance work and domestic chores choose teleworking.

Firms that use cloud service, ICT, or social network services and large firms tend to introduce teleworking in almost all estimated periods. Teleworking increases the average productivity of firms by approximately ¥1.4 million (\$14,000), but this effect varies by year, region, and capital size.

Estimating by industry, teleworking increases productivity in the manufacturing and service industries, but negatively affects productivity in the transportation industry. However according to the individual data, the telework does not affect the employee's productivity in manufacturing, but it significantly and positively affects the productivity in the transportation and telecommunication industries. This difference may arise from the different effects on individual and team productivities, or efficiency may depend on industry. Furthermore, firms that use IT tend to introduce teleworking. This may indicate that they tackle reform positively and have a pro-teleworking environment. Additionally, using IT in itself may increase productivity. In fact, as shown in the results above, high-productivity firms tend to introduce teleworking.

Regional revitalization is a recent political trend in Japan. Teleworking in rural areas is encouraged, as it connects these places to a large metropolis, like Tokyo. However, the current frequency and share of teleworkers is low in Japan (and in other developed countries). Therefore, the effect of teleworking on team productivity and knowledge-sharing that *may* occur when teleworking is fully introduced cannot be predicted from this data set. This is a topic for future studies.

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Table 1 The descriptive statistics (individual data; the Japanese Panel Study of Employment Dynamics)

	Teleworkers						Non-teleworkers					
	Obs	Weight	Mean	Std. Dev.	Min	Max	Obs	Weight	Mean	Std. Dev.	Min	Max
Productivity1	317	234.87	0.35	0.24	0.002	1.896	12210	8963.42	0.30	0.19	0.00	1.90
Productivity2	317	234.80	0.24	0.14	0.001	0.903	12169	8934.26	0.22	0.12	0.00	0.99
Annual income	317	234.80	506.05	284.27	4	1734	12169	8934.26	446.19	218.46	1	2200
Working hours per week	317	234.80	45.10	11.67	1	110	12169	8934.26	44.56	9.53	1	130
Teleworking hours per week	317	234.80	13.47	16.88	1	100	12169	8934.26	0.00	0.00	0	0
Age	317	234.80	40.13	10.36	18	60	12169	8934.26	41.54	10.38	18	60
Education *1	317	234.80	4.41	1.93	0	8	12169	8934.26	3.79	1.83	0	8
Gender (female=1)	317	234.80	0.26	0.44	0	1	12169	8934.26	0.32	0.47	0	1
Firms size												
very small(1~9 people)	317	234.80	0.14	0.35	0	1	12169	8934.26	0.11	0.32	0	1
small(10~99)	317	234.80	0.21	0.41	0	1	12169	8934.26	0.30	0.46	0	1
middle(100~299)	317	234.80	0.11	0.31	0	1	12169	8934.26	0.14	0.35	0	1
large(300~999)	317	234.80	0.14	0.35	0	1	12169	8934.26	0.13	0.34	0	1
very large(1000~)	317	234.80	0.36	0.48	0	1	12169	8934.26	0.21	0.40	0	1
public	317	234.80	0.05	0.21	0	1	12169	8934.26	0.10	0.30	0	1
Industry												
Agricultural forestry industries and fisheries	317	234.80	0.00	0.05	0	1	12169	8934.26	0.00	0.06	0	1
Mining industry	317	234.80	0.00	0.00	0	0	12169	8934.26	0.00	0.03	0	1
Construction	317	234.80	0.05	0.22	0	1	12169	8934.26	0.07	0.25	0	1
Manufacturing	317	234.80	0.20	0.40	0	1	12169	8934.26	0.22	0.42	0	1
Electricity, gas and heat supply	317	234.80	0.02	0.12	0	1	12169	8934.26	0.02	0.13	0	1
telecommunication industry	317	234.80	0.18	0.38	0	1	12169	8934.26	0.07	0.25	0	1
Transportation	317	234.80	0.05	0.22	0	1	12169	8934.26	0.07	0.26	0	1
Retail trade and wholesale	317	234.80	0.07	0.26	0	1	12169	8934.26	0.09	0.28	0	1
Finance	317	234.80	0.08	0.28	0	1	12169	8934.26	0.03	0.18	0	1
Real estate	317	234.80	0.02	0.15	0	1	12169	8934.26	0.02	0.12	0	1
Eating and drinking places, accommodations	317	234.80	0.02	0.14	0	1	12169	8934.26	0.02	0.15	0	1
Medical, health care and welfare	317	234.80	0.07	0.26	0	1	12169	8934.26	0.11	0.32	0	1
Education and learning support	317	234.80	0.03	0.18	0	1	12169	8934.26	0.04	0.19	0	1
Postal service	317	234.80	0.00	0.00	0	0	12169	8934.26	0.00	0.06	0	1
Service industry	317	234.80	0.11	0.31	0	1	12169	8934.26	0.10	0.29	0	1
Public service	317	234.80	0.04	0.20	0	1	12169	8934.26	0.09	0.29	0	1
Other industries	317	234.80	0.05	0.22	0	1	12169	8934.26	0.05	0.22	0	1
Occupation												
Services	317	234.80	0.05	0.22	0	1	12169	8934.26	0.07	0.25	0	1
Security guard	317	234.80	0.01	0.11	0	1	12169	8934.26	0.02	0.15	0	1
Agricultural forestry and fisheries	317	234.80	0.00	0.05	0	1	12169	8934.26	0.00	0.05	0	1
Transportation and communication	317	234.80	0.02	0.15	0	1	12169	8934.26	0.04	0.21	0	1

Production processes and labour services	317	234.80	0.02	0.16	0	1	12169	8934.26	0.11	0.32	0	1
Manager	317	234.80	0.14	0.35	0	1	12169	8934.26	0.08	0.27	0	1
Clerical	317	234.80	0.23	0.42	0	1	12169	8934.26	0.30	0.46	0	1
Sales job	317	234.80	0.17	0.37	0	1	12169	8934.26	0.07	0.25	0	1
Professional	317	234.80	0.28	0.45	0	1	12169	8934.26	0.26	0.44	0	1
Other occupations	317	234.80	0.07	0.25	0	1	12169	8934.26	0.05	0.21	0	1
Commuting time (minutes per day, weekday)	317	234.80	96.47	122.40	0	600	12169	8934.26	68.85	83.26	0	1440
Sleep (minutes per day, weekday)	317	234.80	404.39	108.16	0	900	12169	8934.26	389.35	91.85	0	1440
Commute method (train or bus=1)	317	234.80	0.47	0.50	0	1	12169	8934.26	0.35	0.48	0	1
Overcapacity job (well-suited=1, unsuited=5)	317	234.80	2.79	1.06	1	5	12169	8934.26	3.23	1.15	1	5
The discrimination *2	317	234.80	3.45	1.21	1	5	12169	8934.26	4.10	1.02	1	5
The sexual harassment or power harassment *3	317	234.80	3.32	1.23	1	5	12169	8934.26	3.76	1.25	1	5
There is a trade union *4	317	234.80	3.13	1.19	1	5	12169	8934.26	3.68	1.30	1	5
Occurrence of injured people at workplace *4	317	234.80	3.61	1.22	1	5	12169	8934.26	4.00	1.23	1	5
Occurrence of mentally illness at workplace *4	317	234.80	3.32	1.25	1	5	12169	8934.26	3.66	1.32	1	5
The discretion right to mode of working*5	317	234.80	0.55	0.50	0	1	12169	8934.26	0.47	0.50	0	1
The ratio of trivial duties	317	234.80	20.59	15.21	0	100	12169	8934.26	18.82	16.58	0	100
Having children=1	317	234.80	0.49	0.50	0	1	12169	8934.26	0.50	0.50	0	1
Urban	317	234.80	0.55	0.50	0	1	12169	8934.26	0.44	0.50	0	1
Urban2	317	234.80	0.64	0.48	0	1	12169	8934.26	0.55	0.50	0	1
Never turnover=1	317	234.80	0.43	0.50	0	1	12169	8934.26	0.45	0.50	0	1
Happiness (very happy=1, unhappy=5)	317	234.80	2.58	0.91	1	5	12169	8934.26	2.80	0.98	1	5
Life satisfaction (very satisfied=1, unsatisfied=5)	317	234.80	2.55	0.96	1	5	12169	8934.26	2.78	1.03	1	5
Stress *6	317	234.80	2.73	0.95	1	5	12169	8934.26	2.87	1.06	1	5

*1 Elementary or junior-high school=1, Ph.D> degree =8

*2 See and hear the discrimination about gender, age, nationality, disability and employment status (well-suited=1, unsuited=5)

*3 See and hear the sexual harassment or power harassment (well-suited=1, unsuited=5)

*4 Well-suited=1, unsuited=5

*5 Well-suited and suited=1

*6 Stress to balance between work and domestic chores (stressful=1, stress-free=5)

Productivity1: Annual income/(working days per week×48)=daily income ; (daily income×7)/working hours per week

Productivity2 : Annual income / (working hours per week×48)

Table 2 The descriptive statistics (firm level data; the Communication Usage Survey)

	Obs	Mean	Std. Dev.	Min	Max
Labor productivity	18934	486.53	625.83	0	4592.93
Telework	18934	0.11	0.31	0	1
Operating profit (million Japanese yen)	18934	2414.82	26867.61	-2400	2283766
Number of employment	18934	706.15	3180.78	0	165612
Using the cloud service	18934	0.28	0.45	0	1
Using ICT	18934	0.39	0.49	0	1
Using the social network services	18934	0.44	0.50	0	1
Industry					
Construction	18934	0.15	0.36	0	1
Manufacturing	18934	0.18	0.39	0	1
Transportation	18934	0.16	0.37	0	1
Retail trade and wholesale	18934	0.17	0.37	0	1
Finance and insurance	18934	0.09	0.28	0	1
Real estate	18934	0.07	0.26	0	1
Services	18934	0.17	0.38	0	1
Capital					
less than ten million Japanese yen	18934	0.03	0.17	0	1
Ten million~ less than thirty million	18934	0.21	0.41	0	1
Thirty million~less than fifty million	18934	0.13	0.34	0	1
Fifty million~less than one hundred million	18934	0.22	0.41	0	1
One hundred million~less than five hundred million	18934	0.21	0.41	0	1
Five hundred million~ten hundred million	18934	0.03	0.18	0	1
Ten hundred million~fifty hundred million	18934	0.07	0.26	0	1
Fifty hundred million~	18934	0.09	0.28	0	1
Region					
Hokkaido	18934	0.05	0.22	0	1
Tohoku	18934	0.07	0.25	0	1
North Kanto	18934	0.05	0.21	0	1
South Kanto	18934	0.30	0.46	0	1
Hokuriku	18934	0.04	0.19	0	1
Koshinetsu	18934	0.05	0.22	0	1
Tokai	18934	0.11	0.32	0	1
Kinki	18934	0.14	0.35	0	1
Chugoku	18934	0.06	0.24	0	1
Shikoku	18934	0.04	0.19	0	1
Kyushu · Okinawa	18934	0.09	0.29	0	1

Table 3 Percentage of teleworkers

	Regular employee below 60 years of age									
	Male					Female				
	Regulation, applied	Regulation, not applied	No regulation	Unaware	Total	Regulation, applied	Regulation, not applied	No regulation	Unaware	Total
tele=0	1.2	3.0	67.0	15.5	86.63	1.2	1.9	70.4	14.4	87.9
tele>0	2.0	0.6	8.2	2.6	13.37	1.5	0.2	7.4	3.0	12.1
Total	3.2	3.5	75.2	18.1	100	2.7	2.1	77.8	17.4	100.0
	Non-regular employee below 60 years of age									
	Male					Female				
	Regulation, applied	Regulation, not applied	No regulation	Unaware	Total	Regulation, applied	Regulation, not applied	No regulation	Unaware	Total
tele=0	0.5	1.5	58.6	30.7	91.3	0.5	1.3	62.3	28.0	92.19
tele>0	1.1	0.3	4.2	3.1	8.7	0.9	0.2	3.8	3.0	7.81
Total	1.6	1.8	62.8	33.8	100.0	1.4	1.5	66.1	31.0	100

Table 4 The results of logit model

	(1)		(2)	
	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.
Education *1	1.067071 **	0.034854	1.056905 *	0.035018
Employment status (regular employee=1)	1.331605 *	0.214449	1.258616	0.203652
Gender (female=1)	0.776083 *	0.113033	0.809227	0.118079
small(10~99) *2	0.559349 ***	0.111223	0.481608 ***	0.097527
middle(100~299)	0.652822 *	0.149541	0.510655 ***	0.119938
large(300~999)	0.730351	0.164299	0.541422 ***	0.125533
very large(1000~)	1.0549	0.20826	0.713434	0.148811
public	1.041837	0.629367	0.728907	0.446671
Construction *3	2.225441	2.904402	2.184342	2.661112
Manufacturing	2.022877	2.629001	1.826722	2.209115
Electricity, gas and heat supply	1.775413	2.430844	1.606355	2.064122
Telecommunication industry	4.387361	5.711352	4.725435	5.727683
Transportation	1.638414	2.188769	1.410517	1.76031
Retail trade and wholesale	1.00017	1.312957	0.979008	1.198539
Finance	3.170629	4.160639	3.233522	3.957469
Real estate	2.736892	3.69248	2.66807	3.374091
Eating and drinking places, accommodations	1.738549	2.331274	1.631122	2.051467
Medical, health care and welfare	1.464192	1.920032	1.272209	1.555678
Education and learning support	1.913598	2.528954	1.759534	2.17251
Postal service	0.625532	1.139916	0.497534	0.876642
Service industry	2.654918	3.45643	2.592994	3.142353
Public service	0.600363	0.869999	0.551386	0.755678
Other industries	1.92419	2.527812	1.770161	2.168704
Services *4	0.31281	0.397431	0.299955	0.35762
Security guard	0.291054	0.403905	0.315939	0.415551
Transportation and communication	0.232069	0.311842	0.216177	0.274528
Production processes and labour services	0.117302 *	0.150966	0.107208 *	0.129705
Manager	0.657012	0.828693	0.616245	0.727473
Clerical	0.306976	0.384828	0.299202	0.351122
Sales job	0.704674	0.888065	0.690643	0.815358
Professional	0.388198	0.486966	0.374537	0.439857
Other occupations	0.700979	0.885799	0.676261	0.800687
The the discretion right to mode of working	1.480327 ***	0.17719	1.552778 ***	0.187825
Having children=1	0.869475	0.10366	0.867602	0.105044
The discrimination			0.647836 ***	0.035302
There is a trade union			0.766641 ***	0.038367
Occurrence of injured people at workplace			0.863428 ***	0.045997
Occurrence of mentally illness at workplace			1.039573	0.055388
Constant	0.024733 ***	0.024004	0.726647	0.752217
Number of obs	18855		18855	
LR chi2	194.82		335.67	

*1 Elementary or junior-high school=1, Ph.D> degree =8

*2 Base=very small(1~9 people)

*3 Base=Agricultural forestry industries and fisheries

*4 Base=Agricultural forestry and fisheries

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 The coefficients of the telework

Dependent variable=	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Annual income	Annual income	Annual income	Annual income	Productivity 1	Productivity 1	Productivity 1	Productivity 1	Productivity 2	Productivity 2	Productivity 2	Productivity 2
	Male regular employee											
	34.14** (15.28)	29.89** (15.19)	33.09** (15.31)	28.69* (15.21)	0.0226* (0.0126)	0.0199 (0.0126)	0.0250** (0.0126)	0.0223* (0.0126)	0.0120 (0.00760)	0.00999 (0.00757)	0.0140* (0.00760)	0.0120 (0.00757)
	Female regular employee											
	22.45 (23.46)	22.57 (23.43)	22.14 (23.50)	22.18 (23.47)	0.0380* (0.0215)	0.0380* (0.0215)	0.0396* (0.0215)	0.0395* (0.0215)	0.0214* (0.0122)	0.0214* (0.0122)	0.0223* (0.0122)	0.0222* (0.0122)
	Male regular employee; telework time is fewer than 18 hours											
	56.43*** (17.67)	51.17*** (17.57)	55.43*** (17.69)	50.00*** (17.58)	0.0345** (0.0145)	0.0310** (0.0145)	0.0367** (0.0145)	0.0332** (0.0145)	0.0192** (0.00877)	0.0166* (0.00873)	0.0212** (0.00876)	0.0185** (0.00872)
	Female regular employee; telework time is fewer than 18 hours											
	26.19 (26.19)	26.52 (26.15)	25.84 (26.24)	26.08 (26.20)	0.0165 (0.0238)	0.0167 (0.0238)	0.0181 (0.0238)	0.0182 (0.0238)	0.0151 (0.0136)	0.0151 (0.0136)	0.0161 (0.0136)	0.0160 (0.0136)
	Male regular employee; telework time is fewer than 8 hours											
	49.41** (19.64)	44.01** (19.52)	48.53** (19.65)	42.98** (19.53)	0.0135 (0.0161)	0.00975 (0.0160)	0.0156 (0.0161)	0.0118 (0.0160)	0.0139 (0.00975)	0.0112 (0.00970)	0.0156 (0.00973)	0.0129 (0.00969)
	Female regular employee; telework time is fewer than 8 hours											
	27.54 (27.76)	27.42 (27.73)	27.22 (27.80)	27.02 (27.77)	0.0234 (0.0251)	0.0234 (0.0251)	0.0248 (0.0252)	0.0247 (0.0251)	0.0194 (0.0143)	0.0193 (0.0143)	0.0203 (0.0144)	0.0201 (0.0143)
	Bothe genders; regular employee; telework time is fewer than 8 hours											
	41.82*** (16.11)	38.71** (16.04)	41.24** (16.13)	37.99** (16.06)	0.0157 (0.0136)	0.0134 (0.0135)	0.0180 (0.0136)	0.0156 (0.0135)	0.0146* (0.00810)	0.0129 (0.00807)	0.0163** (0.00810)	0.0147* (0.00807)
	Full-time teleworkers											
	-42.37** (21.43)	-41.82* (21.36)	-44.73** (21.43)	-44.38** (21.37)	0.00371 (0.0198)	0.00398 (0.0198)	0.00637 (0.0198)	0.00657 (0.0198)	-0.0259** (0.0108)	-0.0257** (0.0108)	-0.0250** (0.0108)	-0.0249** (0.0108)
	Male non-regular employee											
	100.0*** (27.30)	94.41*** (27.16)	97.08*** (27.40)	91.52*** (27.26)	0.0421 (0.0401)	0.0366 (0.0401)	0.0476 (0.0402)	0.0421 (0.0402)	0.0513*** (0.0184)	0.0476*** (0.0183)	0.0499*** (0.0185)	0.0463** (0.0184)
	Female non-regular employee											
	-5.566 (17.51)	-9.120 (17.48)	-6.386 (17.51)	-10.05 (17.48)	-0.0204 (0.0256)	-0.0217 (0.0256)	-0.0199 (0.0256)	-0.0212 (0.0256)	-0.00320 (0.0113)	-0.00463 (0.0113)	-0.00341 (0.0113)	-0.00486 (0.0113)
	Male non-regular employee; telework time is fewer than 18 hours											
	109.4*** (33.75)	103.2*** (33.53)	106.9*** (33.79)	100.8*** (33.57)	0.0559 (0.0497)	0.0497 (0.0496)	0.0600 (0.0497)	0.0539 (0.0496)	0.0531** (0.0228)	0.0490** (0.0227)	0.0519** (0.0228)	0.0479** (0.0227)
	Female non-regular employee; telework time is fewer than 18 hours											
	-2.224 (20.73)	-5.832 (20.69)	-3.107 (20.72)	-6.831 (20.68)	-0.0201 (0.0303)	-0.0214 (0.0303)	-0.0196 (0.0303)	-0.0209 (0.0303)	-0.00241 (0.0133)	-0.00386 (0.0133)	-0.00260 (0.0133)	-0.00408 (0.0133)
	Male non-regular employee; telework time is fewer than 8 hours											
	93.57** (41.13)	88.95** (40.86)	88.92** (41.19)	84.37** (40.91)	-0.00544 (0.0607)	-0.01000 (0.0606)	0.000225 (0.0608)	-0.00427 (0.0607)	0.0208 (0.0277)	0.0177 (0.0276)	0.0182 (0.0278)	0.0152 (0.0276)
	Female non-regular employee; telework time is fewer than 8 hours											
	8.557 (24.00)	4.583 (23.95)	7.306 (24.00)	3.189 (23.95)	-0.0154 (0.0350)	-0.0169 (0.0351)	-0.0146 (0.0350)	-0.0161 (0.0351)	-0.00108 (0.0154)	-0.00268 (0.0154)	-0.00138 (0.0154)	-0.00301 (0.0154)
Overcapacity job	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
The discretion *1	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Controlled by industry, occupation, firm size, education and age

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Productivity1: Annual income/(working days per week×48)=daily income; (daily income×7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

*1 The discretion right to mode of working; well-suited and suited=1

Table 6 The effect of commuter time, rush and urban areas

Commuter time:	All			Less than one hour			1~2 hours		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variables=	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2
Base estimation									
telework	40.28** (20.06)	0.0369** (0.0172)	0.0204** (0.0103)	94.44*** (31.94)	0.0450 (0.0281)	0.0436*** (0.0164)	262.2* (150.8)	0.300** (0.124)	0.175** (0.0782)
commuter time	0.176*** (0.0443)	0.000135*** (3.72e-05)	0.000108*** (2.23e-05)	0.569*** (0.136)	0.000429*** (0.000114)	0.000296*** (6.68e-05)	-0.0126 (0.243)	1.35e-05 (0.000200)	4.30e-06 (0.000127)
telework × commuter time	-0.0798 (0.229)	-9.89e-05 (0.000194)	-5.56e-05 (0.000116)	-1.689** (0.751)	-0.000431 (0.000649)	-0.000790** (0.000380)	-2.249 (1.494)	-0.00256** (0.00122)	-0.00148* (0.000775)
Adding Rush dummy									
telework	49.00*** (18.02)	0.0382** (0.0153)	0.0253*** (0.00912)	52.30*** (19.80)	0.0435*** (0.0168)	0.0272*** (0.00982)	-44.10 (59.34)	-0.0340 (0.0485)	-0.0140 (0.0307)
rush	31.81*** (5.227)	0.0348*** (0.00437)	0.0230*** (0.00262)	27.74*** (6.686)	0.0333*** (0.00559)	0.0204*** (0.00329)	21.01** (9.989)	0.0255*** (0.00820)	0.0202*** (0.00519)
telework × rush	-30.79 (26.12)	-0.0178 (0.0222)	-0.0189 (0.0133)	-61.15* (33.60)	-0.0468 (0.0287)	-0.0415** (0.0169)	104.3 (66.94)	0.100* (0.0548)	0.0522 (0.0346)
commuter time	0.0385 (0.0489)	-1.73e-05 (4.09e-05)	7.54e-06 (2.45e-05)	0.321** (0.143)	0.000173 (0.000119)	0.000126* (7.02e-05)	-0.143 (0.242)	-0.000141 (0.000199)	-0.000104 (0.000126)
Adding Urban dummy									
telework	28.83 (19.62)	0.0354** (0.0165)	0.0231** (0.00984)	23.51 (22.31)	0.0361* (0.0188)	0.0221** (0.0110)	31.84 (49.80)	0.0216 (0.0408)	0.0222 (0.0258)
urban	34.56*** (4.347)	0.0277*** (0.00365)	0.0186*** (0.00219)	33.31*** (5.209)	0.0260*** (0.00437)	0.0182*** (0.00256)	30.51*** (9.311)	0.0270*** (0.00767)	0.0172*** (0.00486)
telework × urban	6.541 (26.18)	-0.0123 (0.0222)	-0.0137 (0.0133)	11.49 (31.85)	-0.0201 (0.0272)	-0.0203 (0.0160)	8.901 (59.48)	0.0336 (0.0487)	0.00762 (0.0308)
commuter time	0.0809* (0.0449)	5.85e-05 (3.76e-05)	5.67e-05** (2.26e-05)	0.377*** (0.135)	0.000311*** (0.000113)	0.000199*** (6.64e-05)	-0.133 (0.240)	-0.000107 (0.000198)	-6.92e-05 (0.000125)
Adding Urban2 dummy									
telework	36.73* (21.99)	0.0455** (0.0184)	0.0288*** (0.0110)	29.18 (24.84)	0.0448** (0.0208)	0.0269** (0.0121)	37.03 (57.15)	0.0274 (0.0468)	0.0245 (0.0297)
urban2	36.73*** (4.308)	0.0290*** (0.00362)	0.0190*** (0.00217)	36.18*** (5.016)	0.0274*** (0.00420)	0.0191*** (0.00247)	29.39*** (10.03)	0.0293*** (0.00827)	0.0153*** (0.00524)
telework × urban2	-5.511 (27.22)	-0.0255 (0.0230)	-0.0200 (0.0137)	1.085 (32.27)	-0.0305 (0.0274)	-0.0244 (0.0160)	2.076 (65.12)	0.0235 (0.0533)	0.00428 (0.0338)
commuter time	0.0861* (0.0445)	6.38e-05* (3.74e-05)	6.14e-05*** (2.24e-05)	0.353*** (0.135)	0.000296*** (0.000113)	0.000189*** (6.65e-05)	-0.128 (0.241)	-0.000107 (0.000198)	-6.36e-05 (0.000126)
Observations	9,090	9,001	8,973	6,579	6,512	6,489	1,824	1,806	1,803
R-squared	0.369	0.265	0.323	0.350	0.248	0.308	0.407	0.321	0.358

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Productivity1: Annual income/(working days per week×48)=daily income ; (daily income×7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

Controlled by industry, occupation, firm size, education, age and gender

Rush: rush=1 if the employee commutes by train or bus, =0 otherwise

Urban: urban=1 if the employee lives in prefectures where many people commute by train or bus, =0 otherwise

Urban2: urban2= 1 if the employee lives in the prefectures of major economic zones (urban2 = urban+ Aichi and Fukuoka prefectures)

Table 7 the effect of teleworking by commuter length and method

Commuter time:	Less than one hour					1~2 hours				
	※		※			※		※		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable=	Annual income	Productivity1	Productivity1	Productivity2	Productivity2	Annual income	Productivity1	Productivity1	Productivity2	Productivity2
telework	30.02* (16.09)	0.0287** (0.0137)	0.0322** (0.0156)	0.0139* (0.00804)	0.0162* (0.00913)	38.79 (27.60)	0.0459** (0.0226)	0.0295 (0.0247)	0.0280* (0.0143)	0.0252 (0.0158)
Commuter time	0.507*** (0.134)	0.000416*** (0.000112)	0.000423*** (0.000112)	0.000272*** (6.58e-05)	0.000274*** (6.60e-05)	-0.0709 (0.240)	-5.40e-05 (0.000198)	-2.84e-05 (0.000196)	-3.50e-05 (0.000125)	-2.52e-05 (0.000125)
Observations	6,579	6,512	6,477	6,489	6,455	1,824	1,806	1,797	1,803	1,794
R-squared	0.345	0.243	0.244	0.302	0.303	0.405	0.316	0.323	0.355	0.359

Commuter time:	No rush(commuting by foot, car, bicycle, motorcycle, and other)						Rush (commuting by train or bus)					
	All		More than one hour		1~2 hours		All		More than one hour		1~2 hours	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable=	Productivity1											
tele	0.0273* (0.0147)	0.0259* (0.0146)	-0.0368 (0.0359)	-0.0325 (0.0361)	-0.0673 (0.0547)	-0.0677 (0.0547)	0.0259 (0.0161)	0.0252 (0.0161)	0.0485** (0.0201)	0.0494** (0.0201)	0.0699*** (0.0237)	0.0699*** (0.0237)
urban		0.0226*** (0.00471)				0.0147 (0.0150)		0.0142** (0.00677)				0.0230** (0.0102)
Commuter time				-4.16e-05 (3.87e-05)						-4.84e-05 (3.86e-05)		
Observations	5,946	5,946	873	873	630	630	3,252	3,252	1,812	1,812	1,176	1,176
R-squared	0.248	0.251	0.253	0.254	0.299	0.300	0.279	0.280	0.331	0.331	0.368	0.371
Dependent variable=	Productivity2											
tele	0.0192** (0.00852)	0.0182** (0.00850)	-0.0105 (0.0194)	-0.00452 (0.0194)	-0.0227 (0.0307)	-0.0228 (0.0307)	0.00802 (0.00986)	0.00753 (0.00986)	0.0266** (0.0131)	0.0277** (0.0131)	0.0397** (0.0162)	0.0397** (0.0162)
urban		0.0150*** (0.00275)				0.00130 (0.00845)		0.0101** (0.00413)				0.0157** (0.00699)
Commuter time				-5.88e-05*** (2.08e-05)						-5.47e-05** (2.53e-05)		
Observations	5,927	5,927	868	868	627	627	3,241	3,241	1,810	1,810	1,176	1,176
R-squared	0.306	0.310	0.329	0.335	0.352	0.352	0.344	0.345	0.369	0.371	0.384	0.387

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

※ exclude teleworkers who work more than 18 hours.

Controlled by industry, occupation, firm size, education, age and gender.

Productivity1: Annual income/(working days per week×48)=daily income ; (daily incomex7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

Table 8 The effect of telework and rush when the effect of urban area is controlled

Dependent variable=	(1) Annual income	(2) Annual income	(3) Productivity1	(4) Productivity1	(5) Productivity2	(6) Productivity2
Commuter time=all						
telework	46.97*** (17.99)	47.20*** (17.98)	0.0371** (0.0153)	0.0374** (0.0152)	0.0246*** (0.00910)	0.0247*** (0.00910)
rush	18.59*** (5.623)	18.17*** (5.576)	0.0260*** (0.00471)	0.0257*** (0.00467)	0.0171*** (0.00282)	0.0171*** (0.00280)
telework × rush	-30.47 (26.07)	-29.82 (26.06)	-0.0177 (0.0221)	-0.0174 (0.0221)	-0.0188 (0.0132)	-0.0186 (0.0132)
urban	29.16*** (4.637)		0.0194*** (0.00389)		0.0131*** (0.00233)	
urban2		31.47*** (4.562)		0.0209*** (0.00382)		0.0137*** (0.00229)
commuter time	0.0179 (0.0489)	0.0224 (0.0488)	-3.14e-05 (4.10e-05)	-2.84e-05 (4.09e-05)	-1.92e-06 (2.46e-05)	4.08e-07 (2.45e-05)
Observations	9,090	9,090	9,001	9,001	8,973	8,973
R-squared	0.369	0.370	0.267	0.268	0.325	0.326
Commuter time=less than one hour						
telework	50.29** (19.76)	49.91** (19.75)	0.0425** (0.0168)	0.0423** (0.0168)	0.0265*** (0.00980)	0.0265*** (0.00980)
rush	14.75** (7.070)	13.65* (7.024)	0.0250*** (0.00592)	0.0244*** (0.00588)	0.0142*** (0.00348)	0.0138*** (0.00345)
telework × rush	-62.20* (33.53)	-59.23* (33.50)	-0.0476* (0.0287)	-0.0458 (0.0287)	-0.0421** (0.0169)	-0.0408** (0.0169)
urban	30.29*** (5.461)		0.0194*** (0.00457)		0.0143*** (0.00268)	
urban2		33.30*** (5.231)		0.0212*** (0.00438)		0.0155*** (0.00257)
commuter time	0.294** (0.142)	0.277* (0.142)	0.000155 (0.000119)	0.000144 (0.000119)	0.000113 (7.01e-05)	0.000105 (7.01e-05)
Observations	6,579	6,579	6,512	6,512	6,489	6,489
R-squared	0.349	0.350	0.249	0.250	0.309	0.310
Commuter time=1~2 hours						
telework	-20.99 (64.08)	-17.17 (64.12)	-0.0106 (0.0518)	-0.00739 (0.0518)	-0.0140 (0.0307)	-0.0130 (0.0307)
rush	8.054 (11.19)	11.15 (11.02)	0.0151* (0.00906)	0.0158* (0.00891)	0.0151*** (0.00581)	0.0171*** (0.00572)
telework × rush	95.91 (72.75)	91.12 (72.81)	0.0507 (0.0588)	0.0466 (0.0588)	0.0522 (0.0346)	0.0509 (0.0346)
urban	27.09*** (10.35)		0.0202** (0.00840)		0.0106** (0.00538)	
urban2		23.96** (11.00)		0.0216** (0.00892)		0.00747 (0.00572)
commuter time	-0.153 (0.242)	-0.154 (0.243)	-0.000123 (0.000197)	-0.000125 (0.000197)	-0.000107 (0.000126)	-0.000107 (0.000126)
Observations	1,815	1,815	1,797	1,797	1,803	1,803
R-squared	0.411	0.410	0.330	0.330	0.363	0.362

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Controlled by industry, occupation, firm size, education and age

Productivity1: Annual income/(working days per week×48)=daily income; (daily incomex7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

Table 9 The effect from the interruption

Dependent variable=	(1) Annual income	(2) Annual income	(3) Productivity1	(4) Productivity1	(5) Productivity2	(6) Productivity2
telework	45.34*** (14.70)	7.533 (19.04)	0.0296** (0.0124)	0.0120 (0.0161)	0.0174** (0.00739)	0.00825 (0.00954)
interruption dummy	1.077 (4.168)	-0.740 (4.207)	0.000776 (0.00348)	-5.07e-05 (0.00351)	0.000889 (0.00207)	0.000455 (0.00209)
telework × interruption		92.54*** (29.62)		0.0433* (0.0251)		0.0227 (0.0150)
Aggregated effect*1				0.0005672** (0.0002391)		0.0003343** (0.0001429)
Observations	9,231	9,231	9,141	9,141	9,112	9,112
R-squared	0.361	0.362	0.259	0.260	0.319	0.319
Excluding the employees who do the telework more than 18 hours						
telework	28.29** (12.84)	-5.856 (16.76)	0.0268** (0.0109)	0.00605 (0.0142)	0.0142** (0.00647)	0.00249 (0.00845)
interruption dummy	1.496 (4.160)	-0.636 (4.212)	0.00132 (0.00348)	6.92e-05 (0.00352)	0.00124 (0.00207)	0.000527 (0.00210)
telework × interruption		81.56*** (25.75)		0.0495** (0.0219)		0.0281** (0.0130)
Aggregated effect*1				0.0006761** (0.0002766)		0.0003585** (0.000165)
Observations	9,291	9,291	9,198	9,198	9,169	9,169
R-squared	0.359	0.360	0.257	0.257	0.317	0.317

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Controlled by industry, occupation, firm size, education and age

Productivity1: Annual income/(working days per week×48)=daily income ; (daily incomex7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

*1 Aggregated effect= the cross term +the effect of telework

Table 10 the effect from the length of service

	(1)	(2)	(3)	(4)	(5)
Dependent variable=	Annual income	Productivity1	Productivity1	Productivity2	Productivity2
telework	51.11*** (16.89)	0.0567*** (0.0143)	0.0593*** (0.0165)	0.0287*** (0.00852)	0.0317*** (0.00983)
never turnover	54.48*** (4.546)	0.0381*** (0.00381)	0.0379*** (0.00380)	0.0265*** (0.00226)	0.0264*** (0.00226)
telework × never turnover	-39.06 (25.50)	-0.0644*** (0.0217)	-0.0580** (0.0249)	-0.0293** (0.0129)	-0.0254* (0.0148)
Aggregated effect*1		0.0007464*** (0.0002754)	0.0566024*** (0.0054363)	0.0004135** (0.000164)	0.0003931*** (0.0001408)
Observations	9,291	9,198	9,139	9,169	9,110
R-squared	0.369	0.265	0.268	0.327	0.329
			never turnover		
telework	40.23** (16.12)	0.0501*** (0.0142)	0.0508*** (0.0163)	0.0239*** (0.00825)	0.0258*** (0.00951)
Observations	5,135	5,090	5,055	5,075	5,040
R-squared	0.305	0.197	0.199	0.254	0.256
			Turnover		
telework	17.75 (20.17)	-0.00306 (0.0167)	0.00539 (0.0190)	0.00256 (0.0100)	0.00903 (0.0114)
Observations	4,156	4,108	4,084	4,093	4,069
R-squared	0.409	0.313	0.315	0.377	0.379

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Controlled by industry, occupation, firm size, education, gender and age

Productivity1: Annual income/(working days per week×48)=daily income; (daily incomex7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

*1 Aggregated effect=the effect of telework+the effect of cross term

(3) and (5) are excluded the employees who do the telework more than 18 hours

Table 11 Telework and the stress

Dependent variable=	Regression model			Order logit model		
	(1)	(2)	(3)	(4)	(5)	(6)
	Stress					
	Both genders					
telework	-0.193*** (0.0698)	-0.0607 (0.0653)	-0.135** (0.0627)	-0.339*** (0.118)	-0.108 (0.120)	-0.239** (0.122)
hapiness			-0.301*** (0.0106)			-0.629*** (0.0227)
overcapacity job		0.232*** (0.00958)	0.208*** (0.00922)		0.462*** (0.0192)	0.433*** (0.0193)
Observations	9,169	9,169	9,169	12,486	12,486	12,486
R-squared	0.030	0.163	0.230			
	Male regular employees					
telework	-0.257*** (0.0814)	-0.116 (0.0760)	-0.206*** (0.0728)	-0.448*** (0.136)	-0.225 (0.138)	-0.376*** (0.141)
hapiness			-0.309*** (0.0128)			-0.653*** (0.0275)
overcapacity job		0.246*** (0.0117)	0.220*** (0.0112)		0.495*** (0.0236)	0.464*** (0.0237)
Observations	6,262	6,262	6,262	8,325	8,325	8,325
R-squared	0.024	0.163	0.235			
	Female regular employees					
telework	0.0110 (0.137)	0.115 (0.129)	0.0843 (0.125)	0.0303 (0.238)	0.280 (0.241)	0.197 (0.243)
hapiness			-0.286*** (0.0193)			-0.583*** (0.0402)
overcapacity job		0.205*** (0.0170)	0.187*** (0.0164)		0.402*** (0.0334)	0.378*** (0.0335)
Observations	2,906	2,906	2,906	4,161	4,161	4,161
R-squared	0.031	0.151	0.211			
	Both genders with cross term					
telework	-0.261*** (0.0809)	-0.121 (0.0756)	-0.210*** (0.0726)	-0.457*** (0.136)	-0.237* (0.137)	-0.383*** (0.140)
hapiness			-0.302*** (0.0106)			-0.629*** (0.0226)
overcapacity job		0.232*** (0.00958)	0.208*** (0.00922)		0.463*** (0.0192)	0.434*** (0.0193)
female	-0.181*** (0.0288)	-0.182*** (0.0268)	-0.261*** (0.0258)	-0.327*** (0.0497)	-0.356*** (0.0504)	-0.527*** (0.0511)
telework × female	0.264* (0.158)	0.235 (0.147)	0.291** (0.141)	0.474* (0.270)	0.516* (0.272)	0.577** (0.276)
Observations	9,169	9,169	9,169	12,486	12,486	12,486
R-squared	0.030	0.163	0.231			

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Controlled by industry, occupation, firm size, education and age

Stress to balance between work and dpmestic chores: stressful=1, stress-free=5

Hapiness: very happy=1, unhappy=5

Table 12 The estimation results of logit model

	2006		2007		2008		2009		2010		2011		2012	
	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.
ch_sns	8.139 **	8.375	4.257 **	2.562	1.944	0.855	1.993	0.885	1.818 *	0.609	2.236 ***	0.511	2.049 ***	0.445
ch_cloud			1.658 *	0.442	1.387 *	0.265	1.015	0.189	1.977 ***	0.348	1.648 ***	0.319	1.532 **	0.285
ch_ICT	2.326 ***	0.497	2.262 ***	0.514	2.002 ***	0.356	2.227 ***	0.375	1.898 ***	0.301	2.130 ***	0.402	1.645 ***	0.307
the class of capital	1.259 ***	0.078	1.318 ***	0.093	1.423 ***	0.070	1.431 ***	0.066	1.221 ***	0.058	1.208 ***	0.072	1.183 ***	0.076
the number of employment	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000
sales per worker	0.999	0.001	0.999	0.002	1.000	0.000	1.000	0.000	1.001 ***	0.000	1.003 ***	0.001	1.001	0.001
payroll per worker	1.104 ***	0.033	1.000	0.038	1.022	0.016	1.000	0.006	1.068 ***	0.025	1.049	0.032	1.103 ***	0.034
Construction	0.503 *	0.187	0.511 *	0.185	0.259 ***	0.085	0.510 **	0.137	0.706	0.189	0.735	0.220	0.895	0.265
Manufacturing	1.501	0.452	0.809	0.268	0.952	0.219	0.996	0.216	1.206	0.297	0.969	0.278	1.060	0.304
Transportation	0.481	0.216	0.333 **	0.170	0.184 ***	0.075	0.184 ***	0.074	0.359 ***	0.125	0.261 ***	0.114	0.452 **	0.170
Retail trade and wholesale	1.113	0.360	1.077	0.353	0.870	0.219	0.511 ***	0.130	1.091	0.270	0.955	0.278	0.923	0.276
Finance and insurance	0.149 ***	0.081	0.397 **	0.170	0.218 ***	0.072	0.222 ***	0.071	0.416 ***	0.135	0.529 *	0.204	0.456 **	0.175
Real estate	0.407	0.236	0.643	0.316	0.279 ***	0.107	0.229 ***	0.093	0.410 **	0.145	0.420 **	0.184	0.420 *	0.194
Constant	0.002 ***	0.002	0.004 ***	0.003	0.009 ***	0.004	0.013 ***	0.006	0.017 ***	0.007	0.020 ***	0.006	0.024 ***	0.008
Number of obs	1330		1623		1957		1802		2065		1873		1563	
LR chi2(12)	149.230		81.480		204.460		231.740		142.900		121.800		107.570	
Prob > chi2	0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Pseudo R2	0.163		0.107		0.155		0.167		0.102		0.116		0.103	

	2013		2014		2015		2016		Pooled		Pseudo panel (random)	
	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.	Odds Ratio	Std. Err.
ch_sns	2.090 ***	0.393	1.486 **	0.264	1.426 **	0.225	1.490 **	0.243	1.811 ***	0.125	23.968 ***	8.739
ch_cloud	1.524 ***	0.245	1.823 ***	0.284	2.099 ***	0.317	2.031 ***	0.325	1.600 ***	0.088	2.418 ***	0.757
ch_ICT	1.968 ***	0.326	2.813 ***	0.461	2.156 ***	0.320	1.670 ***	0.256	2.063 ***	0.110	27.981 ***	10.007
the class of capital	1.305 ***	0.066	1.243 ***	0.062	1.207 ***	0.054	1.281 ***	0.059	1.275 ***	0.020	2.742 ***	0.295
the number of employment	1.000	0.000	1.000 ***	0.000	1.000	0.000	1.000 **	0.000	1.000 ***	0.000	1.000 ***	0.000
sales per worker	1.001	0.000	1.000	0.000	1.000	0.000	1.001	0.001	1.000	0.000	1.000	0.001
payroll per worker	0.999	0.022	1.032	0.023	1.017	0.013	1.006	0.017	1.007 *	0.004	1.020	0.046
Construction	1.265	0.382	0.598 *	0.169	0.792	0.207	0.635	0.180	0.675 ***	0.061	0.043 ***	0.022
Manufacturing	1.688 *	0.494	1.215	0.309	1.567 *	0.389	1.314	0.321	1.252 ***	0.102	1.196	0.637
Transportation	0.836	0.297	0.323 ***	0.128	0.380 ***	0.124	0.479 **	0.150	0.354 ***	0.041	0.025 ***	0.016
Retail trade and wholesale	1.528	0.458	1.018	0.266	1.489	0.364	1.200	0.301	1.097	0.092	1.359	0.715
Finance and insurance	0.958	0.333	0.710	0.222	0.915	0.274	0.803	0.247	0.527 ***	0.054	0.183 **	0.122
Real estate	1.080	0.388	0.655	0.230	0.815	0.257	1.107	0.342	0.493 ***	0.057	0.101 ***	0.066
Constant	0.012 ***	0.004	0.019 ***	0.005	0.029 ***	0.008	0.023 ***	0.006	0.019	0.003	0.000 ***	0.000
Number of obs	2158		2083		1811		1998		18933		17590	
LR chi2(12)	152.560		241.340		199.240		204.710		1755.9		Wald chi2(32)=218.14	
Prob > chi2	0.000		0.000		0.000		0.000		0.000		0.000	
Pseudo R2	0.114		0.164		0.129		0.133		0.1354			

Dependent variable is one if the firm introduces teleworking, otherwise zero.

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

ch_sns, ch_cloud, ch_ICT are the dummy variables that equal one if the firm uses the social network services, cloud services, and ICT, respectively.

Industry is the dummy variable. Reference is service industry.

“Pooled” is the estimation result using the data that this study simply aggregates the data of each year.

“Pseudo panel (random)” is the estimation result using the data that this study merges the data of each year by introduction status of teleworking, using status of the social network service, cloud service and ICT, capital size and industry.

The data of 2006 is excluded in the cases of pooled and pseudo panel estimation. Regional and year dummies are additionally included as explanatory variables for those estimations.

Table 13 The estimation results of regression model

	Regression (Pooled)				Pseudo panel estimation			
	(1)		(2)		(3)		(4)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Telework	142.745 ***	14.163	65.417 ***	13.805	32.23 **	13.96	28.92 *	16.36
Operating profit			0.001 ***	0.000	0.00154 ***	0.000175	0.00166 ***	0.000177
the number of employment			-0.016 ***	0.002	-0.0217 ***	0.00178	-0.0223 ***	0.0018
ch_cloud	36.952 ***	9.695	0.779	9.819	-0.299	9.212	-3.201	11.8
ch_ICT	144.040 ***	9.089	75.386 ***	8.964	73.96 ***	9.678	71.45 ***	12.41
ch_sns	7.516	8.734	2.417	11.764	17.22 *	10.24	20.15	12.84
Industry (dummy variable, reference is service industry)								
Construction	-415.539 ***	14.964	-504.721 ***	14.761	-509.3 ***	14.83	-543.4 ***	19.77
Manufacturing	84.966 ***	14.364	22.184	14.095	55.9 ***	14.2	24.29	19.18
Transportation	-343.553 ***	14.843	-365.992 ***	14.255	-378.7 ***	14.17	-408.4 ***	19.47
Retail trade and wholesale	-88.880 ***	14.657	-127.252 ***	14.173	-148.9 ***	14.29	-175.9 ***	19.32
Finance and insurance	-378.840 ***	17.845	-652.356 ***	19.615	-620.2 ***	20.48	-647.1 ***	25.55
Real estate	-400.864 ***	18.799	-543.411 ***	18.414	-522.5 ***	18.92	-548.5 ***	24.39
Capital class (dummy variable, reference is over fifty hundred million Japanese yen)								
less than ten million			-557.548 ***	30.000	-598.4 ***	28.78	-597.7 ***	36.1
Ten million~ less than thirty million			-465.320 ***	20.440	-482.2 ***	21.61	-490.5 ***	26.23
Thirty million~less than fifty million			-368.139 ***	21.324	-368.3 ***	22.76	-368.2 ***	27.79
Fifty million~less than one hundred million			-319.674 ***	19.779	-322.9 ***	21.21	-326.1 ***	25.75
One hundred million~less than five hundred million			-216.864 ***	19.137	-173.1 ***	21.08	-188.5 ***	25.6
Five hundred million~less than ten hundred million			-168.503 ***	27.298	-188.4 ***	29.18	-187.8 ***	34.34
Ten hundred million~less than fifty hundred million			-64.761 ***	21.626	-61.6 ***	23.28	-60.08 **	28
Region (dummy variable, reference is Kyusyu·Okinawa)								
Hokkaido			-86.637 ***	22.826	-104.7 ***	22.6	-87.93 ***	22.44
Tohoku			-38.498 *	20.758	-13.16	20.74	-10.73	20.61
North Kanto			-54.639 **	23.317	0.644	23.29	10.91	23.24
South Kanto			156.424 ***	15.580	165.5 ***	15.88	168.8 ***	15.85
Hokuriku			-74.272 ***	24.660	-52.88 **	25	-56.52 **	24.81
Koshinetsu			-49.499 **	22.501	-39.49 *	22.8	-33.13	22.6
Tokai			61.651 ***	18.091	50.61 ***	18.62	59.18 ***	18.53
Kinki			136.713 ***	17.363	127.2 ***	17.75	127.2 ***	17.68
Chugoku			-28.854	21.249	16.50	22.01	18.15	21.92
Shikoku			-146.389 ***	24.823	-90.36 ***	26.79	-89.97 ***	26.66
Year (dummy variables, reference is 2006)								
2015			13.815	18.177	24.34	17.12	24.76	16.45
2014			-50.236 ***	17.529	-48.11 ***	17.08	-48.53 ***	16.46
2013			-25.681	17.443	-6.832	17.18	-6.278	16.58
2012			97.424 ***	19.019	101.7 ***	17.65	103.5 ***	17.05
2011			18.743	18.261	-14.46	17.78	-14.29	17.22
2010			-75.739 ***	19.608	-63.26 ***	18.45	-66.69 ***	17.99
2009			-37.243 *	20.337	-26.75	18.94	-33.87 *	18.5
2008			-46.018 **	20.021	-87.61 ***	19.09	-94.17 ***	18.66
2007			175.169 ***	20.682	162.7 ***	19.83	156.2 ***	19.37
Constant	583.095 ***	11.725	947.098 ***	28.993	939.2 ***	30.04	970.4 ***	34.29
Number of obs	18934				17,615			
F test	266.22		154.42		0.220			
Prob > F	0		0					
R-squared	0.1233		0.1861					
Adj R-squared	0.1229		0.1849					
Root MSE/Number of ID	586.12		565.01				3,500	

Dependent variable is labor productivity.

telework, ch_sns, ch_cloud, ch_ICT are the dummy variables that equal one if the firm introduces the telework, or uses the social network services, cloud services, and ICT, "Regression (pooled)" is the estimation result using the data that this study simply aggregates the data of each year. "Pseudo panel estimation (pooled/ random effect model)" is the estimation result using the data that this study merges the data of each year by introduction status of teleworking, using status of the social network service, cloud service and ICT, capital size and industry.

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 14 The estimation results of regression model by the industry

	Construction		Manufacturing		Transportation		Retail trade and wholesale		Finance and insurance		Real estate		Services	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Telework	-2.630	15.208	121.289 ***	36.328	-77.709 **	32.520	6.957	33.046	27.140	27.910	11.680	39.415	146.676 ***	41.793
Operating profit	0.004 ***	0.001	0.001	0.001	0.002 ***	0.001	0.003 *	0.002	0.001 ***	0.000	0.018 ***	0.002	0.042 ***	0.005
ch_number of employment	-0.012 *	0.006	-0.024 ***	0.005	-0.011 ***	0.002	-0.022 ***	0.004	-0.017 ***	0.002	-0.136 ***	0.017	-0.029 ***	0.004
ch_cloud	24.795 **	10.250	-17.602	29.885	11.961	15.425	31.198	24.225	17.339	22.306	-42.009 *	24.770	13.394	29.458
ch_ict	21.092 **	9.288	89.361 ***	26.156	25.392 *	14.058	68.905 ***	22.681	33.106	21.916	36.667	23.379	197.392 ***	26.626
ch_sns	-15.805	14.132	-67.486 *	37.054	4.349	17.390	-44.473	28.423	17.473	29.957	25.236	29.454	48.838	32.427
Capital class (dummy variable, reference is over fifty hundred million Japanese yen)														
less than ten million	-199.515 ***	55.048	-615.059 ***	95.352	-727.218 ***	52.681	-577.990 ***	87.619	-421.473 **	202.539	-468.655 ***	95.556	-486.690 ***	103.739
Ten million~less than thirty million	-129.884 ***	25.976	-490.787 ***	58.913	-680.163 ***	43.554	-452.448 ***	72.534	-193.722 ***	53.199	-486.504 ***	59.153	-440.588 ***	94.681
Thirty million~less than fifty million	-86.321 ***	25.210	-408.881 ***	60.576	-654.786 ***	44.630	-299.682 ***	73.359	-271.559 ***	70.243	-450.109 ***	63.887	-290.275 ***	97.052
Fifty million~less than one hundred million	-85.289 ***	23.274	-310.328 ***	54.753	-626.039 ***	43.973	-277.726 ***	71.266	-171.626 ***	52.932	-447.984 ***	58.252	-282.128 ***	95.440
One hundred million~less than five hundred million	-53.758 **	22.632	-172.404 ***	54.028	-525.606 ***	44.504	-200.201 ***	70.643	-124.925 ***	32.411	-353.940 ***	54.100	-88.688	94.875
Five hundred million~less than ten hundred million	-26.876	30.153	-235.856 ***	86.079	-384.515 ***	63.925	-51.976	90.842	-183.816 ***	36.302	-261.225 ***	69.601	108.270	123.122
Ten hundred million~less than fifty hundred million	-44.855 *	25.726	-48.147	62.717	-305.730 ***	50.020	-5.690	76.047	-104.691 ***	29.575	-149.026 ***	56.253	219.547 **	109.938
Region (dummy variable, reference is Kyusyu+Okinawa)														
Hokkaido	-48.792 **	21.933	-152.075 *	78.055	-61.321 *	32.039	-104.467 *	54.635	92.000	73.659	-51.665	64.458	-125.361 *	65.827
Tohoku	-0.653	20.934	-56.514	60.945	-54.737 *	30.150	-54.589	48.891	25.273	55.703	6.676	88.297	-32.856	60.493
North Kanto	-32.693	26.269	102.395	64.321	-22.100	33.804	-48.777	56.203	-40.698	77.342	-26.775	96.110	-143.388 **	62.661
South Kanto	86.681 ***	16.542	298.887 ***	49.655	60.813 ***	22.537	228.594 ***	39.499	128.833 ***	33.838	54.323	44.924	216.326 ***	45.970
Hokuriku	0.839	24.950	-17.056	68.025	-76.570 **	36.168	-107.349 *	59.905	-16.905	80.494	12.500	99.444	-121.580 *	70.390
Koshinetsu	-3.383	22.187	-5.777	61.332	-0.948	33.827	10.611	55.413	34.106	64.639	-98.798	97.073	-153.869 **	66.516
Tokai	42.303 **	19.579	169.715 ***	51.191	37.778	25.478	69.653	45.297	19.977	50.006	-69.938	55.772	64.095	54.031
Kinki	64.012 ***	18.487	330.555 ***	51.849	66.671 ***	25.021	157.813 ***	43.210	85.284 **	42.418	-20.809	48.691	113.305 **	52.148
Chugoku	3.014	22.907	6.833	61.518	17.722	30.500	-31.487	51.033	-12.092	53.548	-28.311	71.969	-65.686	61.492
Shikoku	-32.142	27.095	-180.026 ***	69.135	-118.531 ***	34.259	-151.852 ***	59.268	64.440	75.838	-20.269	115.805	-207.846 ***	70.782
Year (dummy variables, reference is 2006)														
2015	-13.746	18.964	65.358	54.214	7.279	25.580	0.651	45.854	-30.828	44.691	2.917	48.744	69.975	54.667
2014	-55.675 ***	18.736	-26.704	50.545	-17.513	25.231	-58.084	44.034	-43.783	42.900	-34.976	49.024	-77.746	51.809
2013	-69.693 ***	18.432	36.041	50.946	0.907	24.603	0.325	44.668	-26.876	43.090	-52.367	47.367	-24.075	51.813
2012	-27.706	20.022	202.106 ***	55.710	62.608 **	26.336	185.518 ***	49.562	-3.126	46.904	81.078	54.977	177.781 ***	55.715
2011	314.505 ***	19.317	-303.157 ***	54.082	135.555 ***	25.056	-191.407 ***	46.341	804.050 ***	47.222	583.988 ***	52.041	-386.442 ***	53.307
2010	-40.988 *	22.043	30.963	59.568	-21.689	27.779	20.288	48.784	-84.213 *	48.354	-141.104 ***	50.485	-221.737 ***	57.404
2009	31.045	24.002	-5.717	60.253	74.154 **	30.635	-73.922	50.091	-23.250	49.164	-61.094	52.157	-79.128	58.540
2008	28.335	23.253	-10.131	59.578	79.498 ***	29.753	-43.561	50.264	4.138	48.542	-66.077	50.403	-175.120 ***	57.982
2007	454.924 ***	23.106	-61.413	63.010	288.957 ***	28.966	65.833	51.817	1015.897 ***	53.433	637.296 ***	56.811	-240.366 ***	58.540
Constant	234.311 ***	30.519	911.825 ***	77.912	827.387 ***	50.330	805.670 ***	84.250	174.728 ***	51.601	557.939 ***	79.563	894.589 ***	108.763
Number of obs	2929		3454		3081		3153		1668		1395		3251	
F test	49.29		18.52		26.01		15.59		44.39		27.69		29.65	
Prob > F	0		0		0		0		0		0		0	
R-squared	0.3526		0.1476		0.2145		0.1378		0.4649		0.3942		0.2277	
Adj R-squared	0.3455		0.1397		0.2062		0.129		0.4544		0.3799		0.22	
Root MSE	234.77		699.08		325.4		577.5		397.5		401.24		682.76	

Dependent variable is labor productivity.

telework, ch_sns, ch_cloud, ch_ict are the dummy variables that equal one if the firm introduces the telework, or uses the social network services, cloud services, and ICT, respectively.

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 15 the effect of teleworking by industry using individual data

	Manufacturing			Telecommunication			Transportation			Finance		
Dependent variable=	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2
tele	31.23 (28.84)	0.00862 (0.0257)	0.0119 (0.0153)	134.2*** (28.31)	0.0982*** (0.0253)	0.0519*** (0.0163)	39.12 (84.37)	0.196*** (0.0676)	0.0528 (0.0375)	-3.780 (70.71)	-0.00307 (0.0563)	0.0195 (0.0341)
Observations	2,051	2,041	2,035	647	640	639	639	638	634	337	329	328
R-squared	0.447	0.286	0.359	0.459	0.304	0.336	0.232	0.229	0.291	0.358	0.226	0.238

	Constraction			Retail trade and wholesale			Eating and drinking places, acommodations			Service		
Dependent variable=	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2
tele	96.86 (61.95)	-0.0429 (0.0469)	-0.0329 (0.0313)	-0.274 (54.89)	0.0388 (0.0407)	0.0157 (0.0254)	-0.834 (97.05)	-0.0376 (0.103)	-0.0396 (0.0604)	34.60 (42.39)	0.0169 (0.0355)	0.0135 (0.0210)
Observations	619	612	611	781	773	773	202	200	199	883	878	875
R-squared	0.344	0.280	0.300	0.266	0.180	0.223	0.369	0.359	0.315	0.262	0.149	0.204

	Public service			Real estate			Other industries		
Dependent variable=	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2	Annual income	Productivity1	Productivity2
tele	-80.28 (81.69)	-0.0748 (0.0679)	-0.0453 (0.0395)	18.00 (71.83)	0.00347 (0.107)	0.00515 (0.0576)	33.77 (67.61)	0.00607 (0.0588)	0.0116 (0.0350)
Observations	839	826	824	143	142	141	461	456	456
R-squared	0.383	0.289	0.370	0.445	0.141	0.138	0.273	0.173	0.216

Standard errors in parentheses

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Controlled by industry, occupation, firm size, education, gender and age

Productivity1: Annual income/(working days per week×48)=daily income ; (daily incomex7)/working hours per week

Productivity2: Annual income / (working hours per week×48)

Table 16 The estimation results of regression model by the productivity level

	Under 25%		25-50%		50-75%		75-99%	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Telework	0.242	0.919	-0.751	2.921	8.676	5.868	64.603 **	27.695
Operating profit	0.000 *	0.000	0.001 ***	0.000	0.000	0.000	0.001 ***	0.000
the number of employment	0.000	0.000	-0.001 ***	0.000	-0.002 **	0.001	-0.011 ***	0.003
ch_cloud	-0.399	0.661	2.419	1.825	-1.196	3.830	-0.819	22.581
ch_ICT	-1.353 **	0.616	1.763	1.709	12.182 ***	3.403	41.050 **	20.574
ch_sns	-1.377 *	0.794	-0.779	2.133	3.775	4.290	29.964	30.307
Industry (dummy variable, reference is service industry)								
Construction	12.224 ***	1.040	-27.736 ***	2.981	-45.334 ***	5.916	-521.588 ***	50.405
Manufacturing	-1.923 *	1.027	12.368 ***	4.112	12.125 **	5.169	-158.067 ***	27.061
Transportation	2.367 **	0.991	2.605	2.848	-56.455 ***	5.037	-396.694 ***	48.001
Retail trade and wholesale	-1.187	1.028	8.167 **	3.251	4.001	5.035	-259.466 ***	29.119
Finance and insurance	20.557 ***	1.238	-63.161 ***	3.954	-64.809 ***	10.132	-483.218 ***	55.490
Real estate	15.957 ***	1.067	-46.531 ***	3.681	-34.720 ***	8.916	-266.358 ***	60.954
Capital class (dummy variable, reference is over fifty hundred million Japanese yen)								
less than ten million	8.828 ***	1.744	-29.629 ***	5.738	-51.054 ***	12.941	-709.269 ***	89.533
Ten million~ less than thirty million	9.463 ***	1.269	-25.738 ***	4.235	-34.256 ***	9.330	-781.876 ***	47.785
Thirty million~less than fifty million	11.044 ***	1.368	-25.124 ***	4.379	-19.447 **	9.490	-685.063 ***	48.496
Fifty million~less than one hundred million	9.381 ***	1.252	-21.013 ***	4.123	-11.282	9.118	-634.784 ***	42.925
One hundred million~less than five hundred million	6.476 ***	1.203	-14.073 ***	3.962	-1.392	8.922	-487.659 ***	40.920
Five hundred million~less than ten hundred million	7.059 ***	1.743	-2.386	5.308	-2.410	12.180	-431.008 ***	59.631
Ten hundred million~less than fifty hundred million	3.362 **	1.370	-14.156 ***	4.406	-14.215	9.803	-247.350 ***	45.177
Region (dummy variable, reference is Kyusyu•Okinawa)								
Hokkaido	-1.521	1.475	-9.844 ***	3.791	-30.437 ***	8.641	68.035	69.758
Tohoku	-1.365	1.508	-0.201	3.477	-8.492	7.392	38.813	56.559
North Kanto	-2.643	1.625	-1.657	4.188	-10.317	8.156	52.026	61.359
South Kanto	-5.867 ***	1.068	16.388 ***	2.798	-3.358	5.931	314.285 ***	39.107
Hokuriku	0.435	1.701	-10.311 **	4.296	0.726	9.017	-0.657	64.677
Koshinetsu	3.841 **	1.622	-10.351 ***	3.945	-3.800	7.933	34.003	58.471
Tokai	-3.963 ***	1.255	6.749 **	3.343	-3.198	6.580	138.255 ***	44.590
Kinki	-3.649 ***	1.190	10.628 ***	3.237	-2.988	6.559	242.811 ***	42.143
Chugoku	-1.560	1.474	2.688	3.770	-14.620 *	7.714	13.797	54.172
Shikoku	1.047	1.664	-14.717 ***	4.103	-17.179 *	9.091	68.760	77.044
Year (dummy variables, reference is 2006)								
2015	-0.259	1.223	-5.236	3.259	-3.014	7.172	110.037 ***	42.619
2014	-1.333	1.123	-2.602	3.222	2.992	7.039	41.489	42.227
2013	1.172	1.138	-7.967 ***	3.080	7.055	7.167	99.936 **	42.011
2012	29.830 ***	2.028	-6.291 **	3.137	-0.261	7.237	31.488	42.514
2011	-3.683 ***	1.270	0.522	4.042	36.488 ***	6.511	-107.194 **	45.411
2010	-2.180 *	1.252	-4.322	3.569	9.365	7.801	-36.056	49.195
2009	5.060 ***	1.312	-13.451 ***	3.675	-16.508 **	7.986	200.652 ***	51.813
2008	3.696 ***	1.291	-12.414 ***	3.614	-1.754	7.992	152.819 ***	50.536
2007	32.989 ***	3.212	4.948	4.108	30.671 ***	6.987	-80.345	51.473
Constant	-0.097	1.911	215.362 ***	5.838	471.098 ***	12.185	1781.509 ***	66.685
Number of obs	4705		4825		4802		4612	
F test	41.12		21.4		13.31		28.1	
Prob > F	0		0		0		0	
R-squared	0.2509		0.1452		0.096		0.1893	
Adj R-squared	0.2448		0.1385		0.0888		0.1826	
Root MSE	18.688		52.319		105.92		655.55	

Dependent variable is labor productivity.

telework, ch_sns, ch_cloud, ch_ICT are the dummy variables that equal one if the firm introduces the telework, or uses the social network services, cloud services, and ICT, respectively.

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

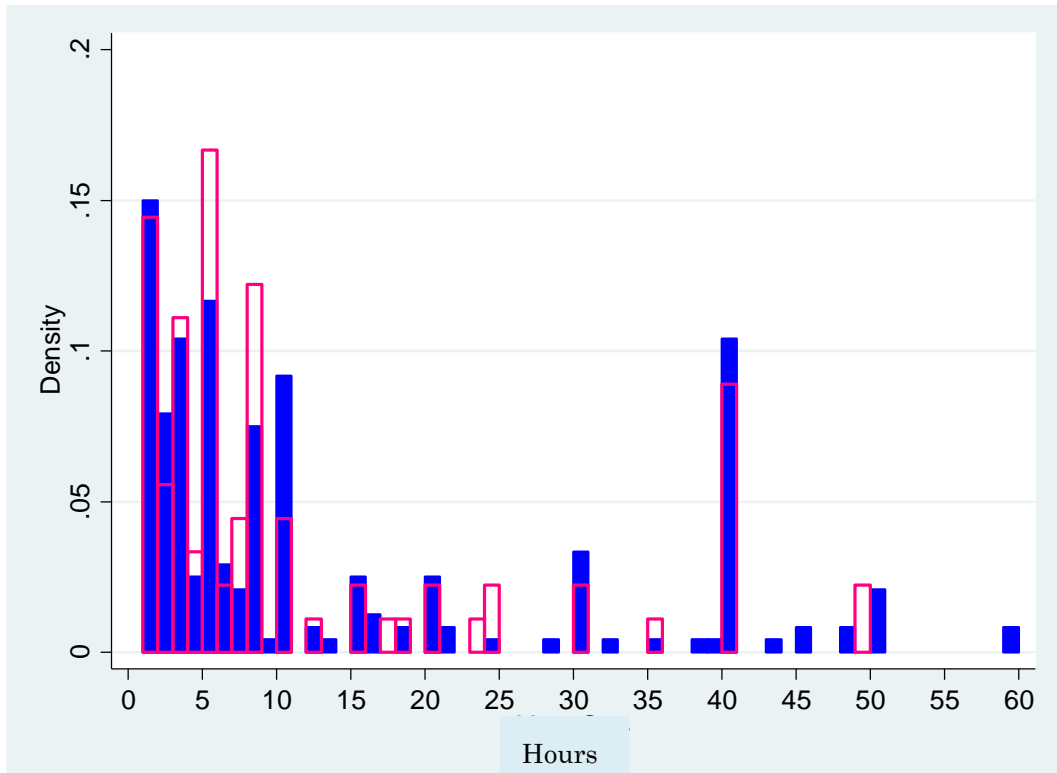


Figure 1 the histogram of hours per week for formal telework of regular employee
 Blue=male/ Pink=female

Note: workers who telework more than 70 hours per week are dropped.

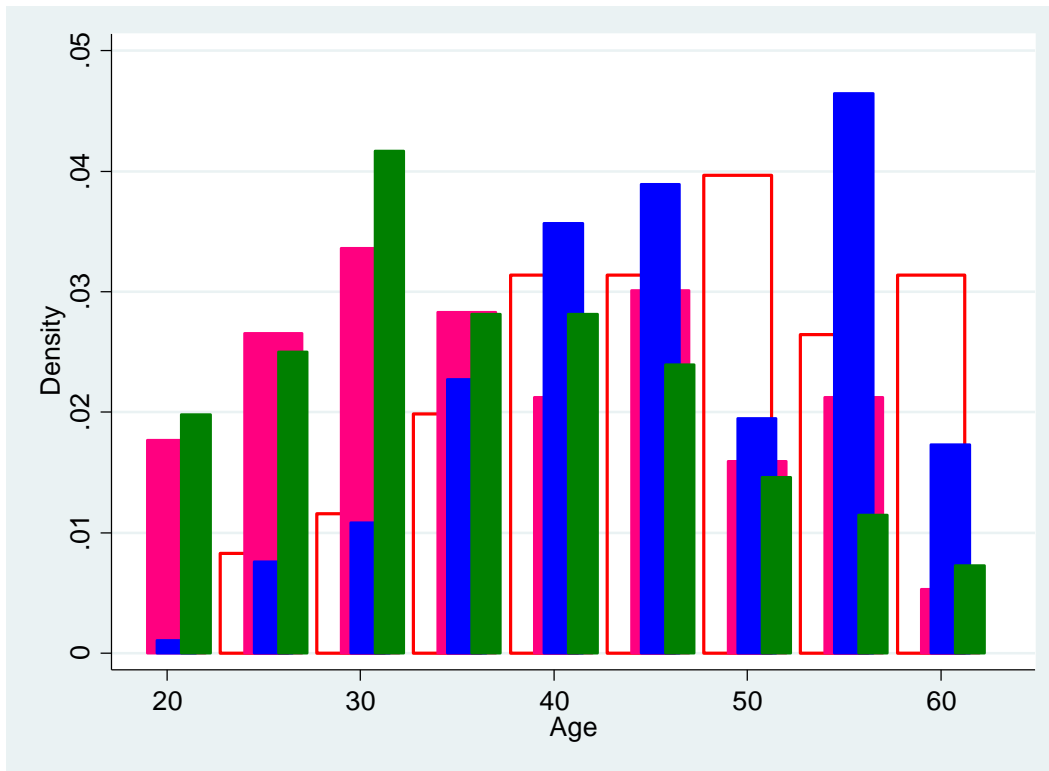


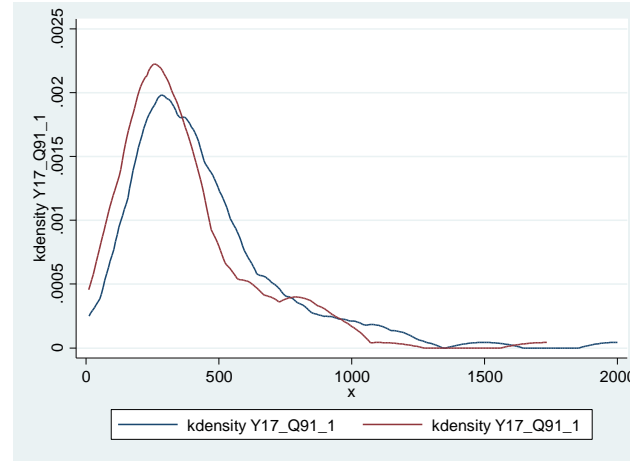
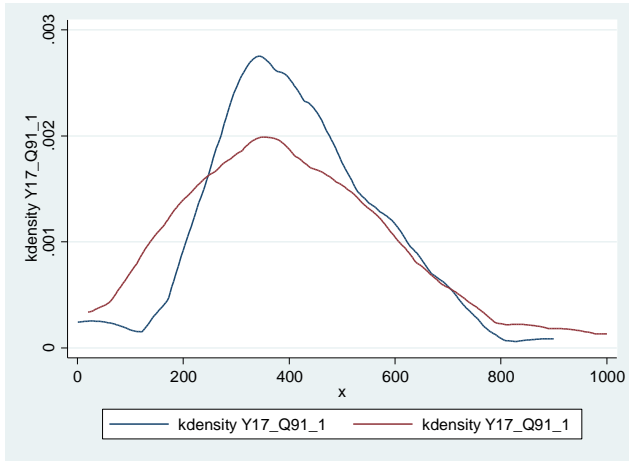
Figure 2 the histogram of age for formal teleworker

Blue=male teleworkers who have children.

Green=male teleworkers who have not children

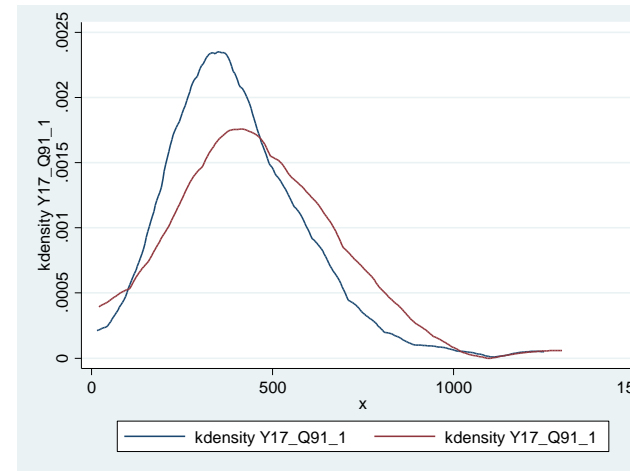
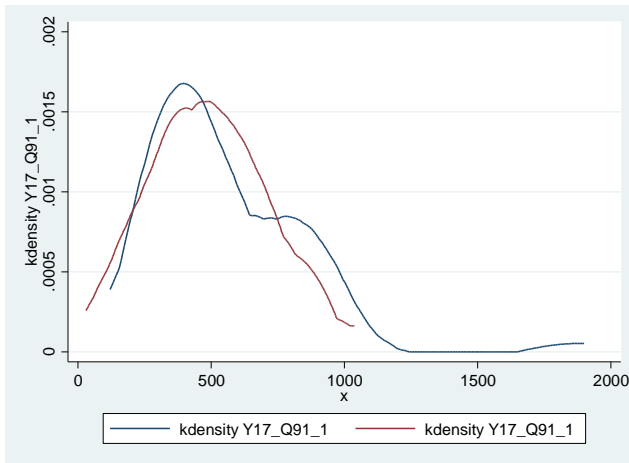
Red=female teleworkers who have children

Pink=female teleworkers who have not children.



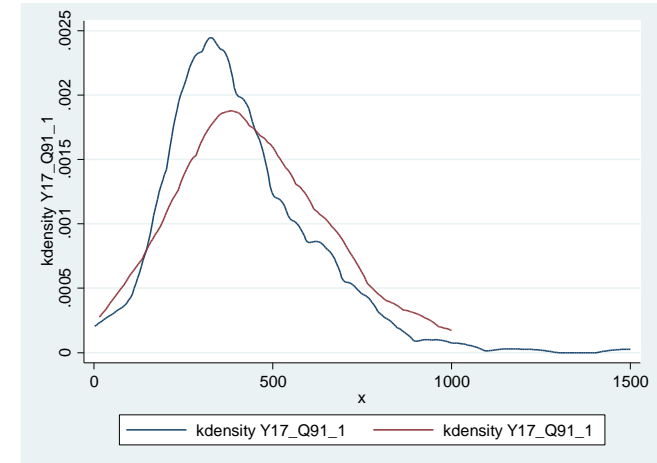
Internet based service industries

Insurance industries



Other finance industries

Retail estate



Construction

Figure 3 The distribution of annual income for industries

Red=teleworkers, blue=non-teleworkers

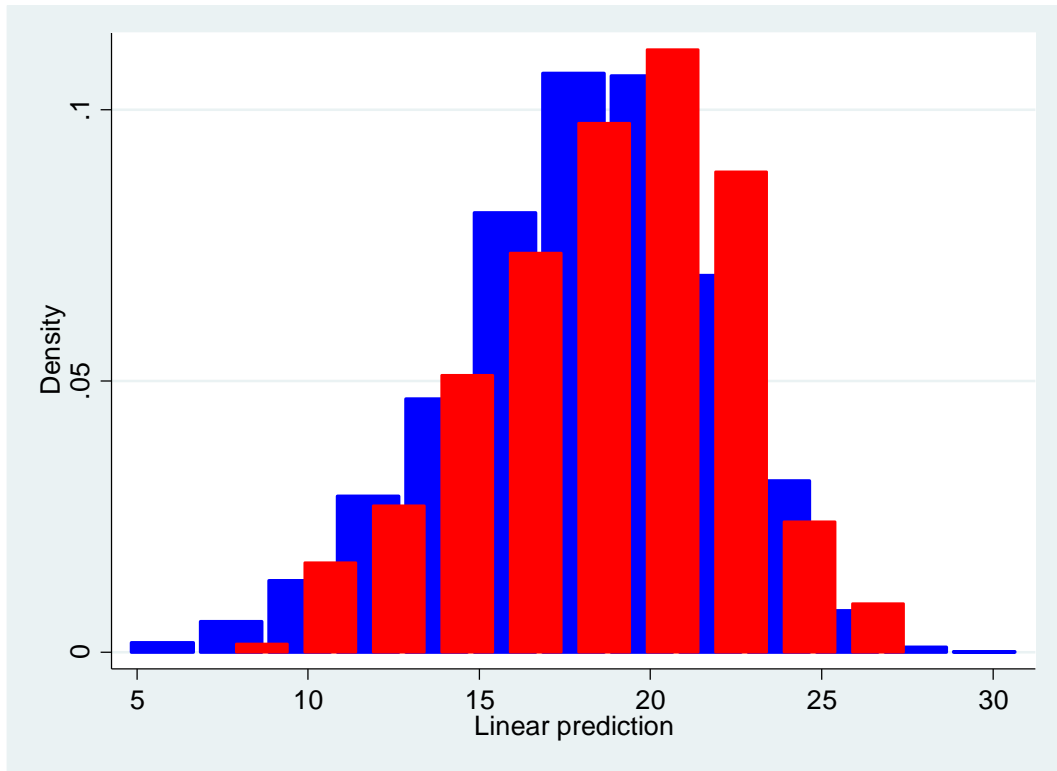


Figure 4 the ratio of predicted trivial duties in the working duties per day
Red=teleworkers, blue=non-teleworkers

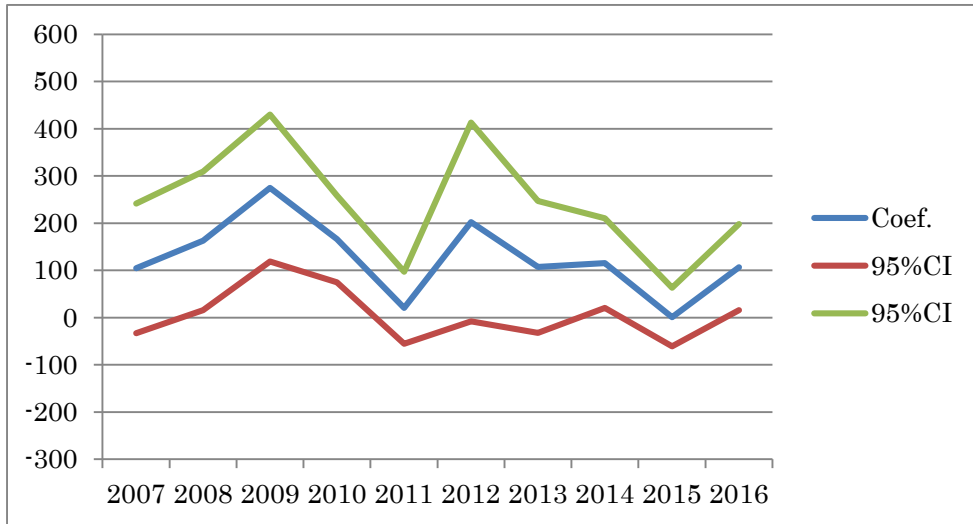


Figure 5.1

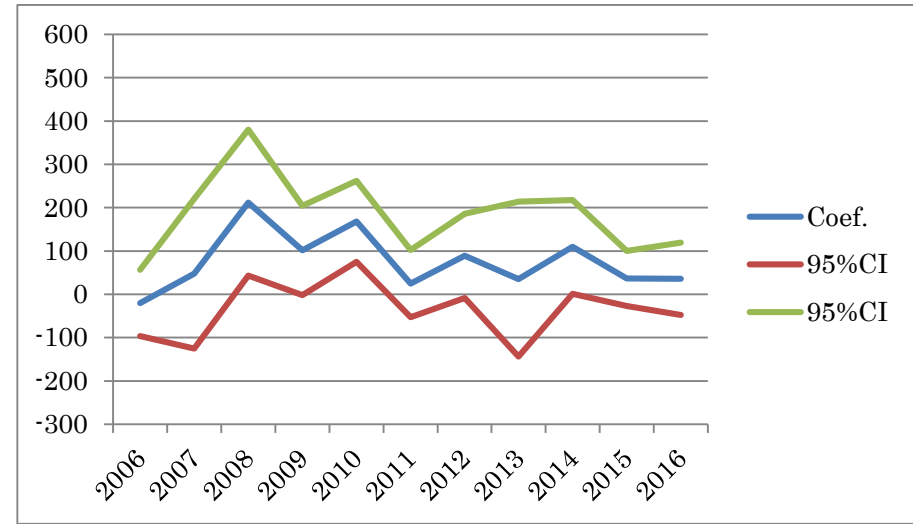


Figure 5.2

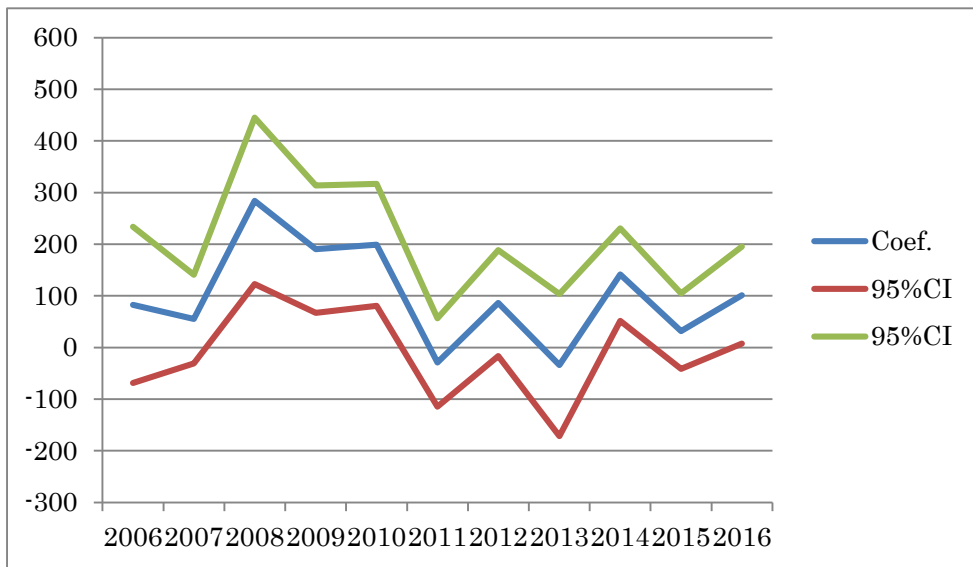


Figure 5.3

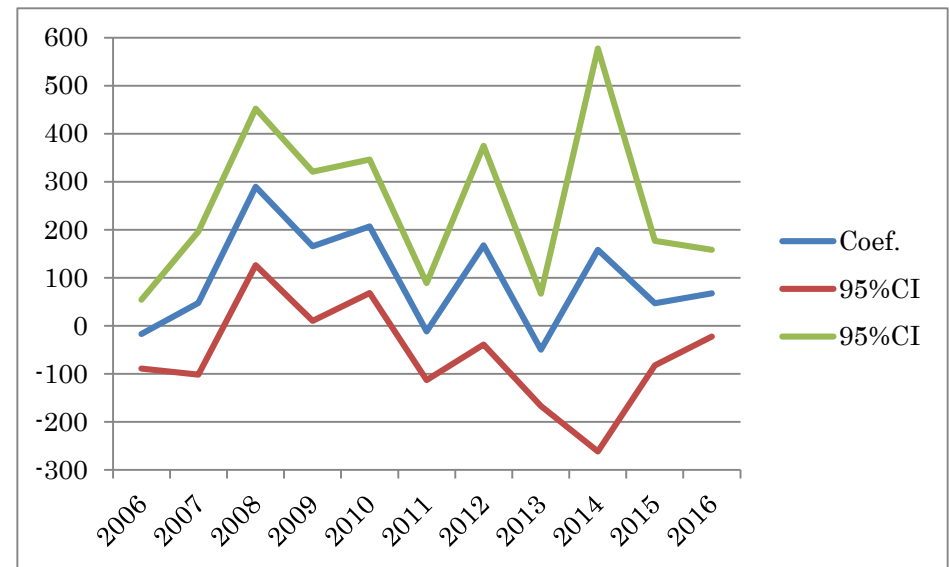


Figure 5.4

Figure 5.1 through Figure 5.4 use the industry, sales per worker to match similar firms. Additionally, this study uses the usage of cloud service, ICT, and social network service for Figure 5.1, 5.2 and 5.3, respectively, and all three variables for Figure 5.4.