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Productivity of Working from Home during the COVID-19 Pandemic: Evidence from a Firm Survey

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Abstract

This study examines the prevalence, frequency, and productivity of the working from home (WFH) arrangement in Japan during the COVID-19 pandemic using data from an original firm survey. The results reveal that about half of the firms that responded to the survey adopted the WFH arrangement. The mean WFH intensity, or the contribution of WFH to the total labor input, was approximately 23% among firms that adopted the WFH arrangement. The mean WFH productivity relative to working at the typical workplace was approximately 68%. However, large dispersions are observed in both WFH intensity and WFH productivity. The results obtained from the firm survey are generally consistent with the observations from the employee survey.

Keywords: COVID-19, working from home, productivity

JEL Classification: D24, J22, J24, M12, M54

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1. Introduction

Owing to the spread of the COVID-19 pandemic, the working from home (WFH) arrangement has been increasingly adopted in major advanced countries since March 2020. Concurrently, epidemiology models extended by augmenting economic behaviors have been developed, and some of these models explicitly consider the role of WFH in mitigating the tradeoff between health and economic activities (e.g., Akbarpour *et al*., 2020; Aum *et al*., 2020; Bodenstein *et al*., 2020; Brotherhood *et al*., 2020; Jones *et al*., 2020). Along with the accumulated data on the number of COVID-19 infections, the number of empirical evaluations on the effects of WFH has been increasing (e.g., Adams-Prassl *et al*., 2020; Alipour *et al*., 2020; Béland *et al*., 2020a, 2020b; Fadinger and Schymik, 2020; Lin and Meissner, 2020; Mongey *et al*., 2020). These studies generally confirm that the WFH arrangement suppresses the spread of the COVID-19 pandemic and/or lessens the negative impact of the pandemic on economic activities.

Similar to other countries, the number of workers engaging in the WFH arrangement in Japan substantially increased, especially when the "state of emergency" was issued in April 2020. After the "state of emergency" was lifted, the number of workers commuting to their workplace have gradually increased. However, the number of teleworkers remains large compared to before the onset of the COVID-19 pandemic. Hence, the WFH arrangement may continuously be adopted widely as a new workstyle, even after this pandemic is over.

Whether the WFH arrangement will be a prevailing workstyle after the COVID-19 pandemic is over depends strongly on (1) the productivity of employees working at their homes and (2) employees' preferences to WFH.[1] Eventually, wages should depend on productivity; hence, if productivity at home is lower than that at the workplace, then the relative wages of teleworkers would likely decline. In this case, those employees who are concerned with higher wages would

[1] Morikawa (2020) provides an overview of studies on the WFH arrangement prior to the onset of the COVID-19 pandemic. A representative study, Bloom *et al*. (2015), analyzed the effect of working from home on firm productivity based on a field experiment with call center employees in China and found that this work arrangement improved TFP by 30%.

opt to work in their workplace. Conversely, those employees who strongly prefer to have work–life balance, quiet environment, and large housing may opt for the WFH arrangement at the expense of reduced wages to some extent. However, if WFH is more productive than that in the workplace, such tradeoff will not exist. In other words, the productivity of the WFH arrangement should be an important determinant whether this workstyle will prevail.

Morikawa (2020) analyzed WFH productivity in Japan based on a survey of individuals conducted in June 2020. The result shows that the subjective productivity of employees adopting the WFH arrangement during the COVID-19 pandemic is on average 30–40% lower than that at the workplace. In particular, the productivity of WFH employees who started after the COVID-19 was significantly lower than that for those who had adopted the workstyle prior to the pandemic. However, the WFH productivity has substantially large dispersion, with a small number of employees being more productive than those in the workplace. Significant differences exist in productivity depending on the industry, occupation, and educational background.[2]

To verify the finding of Morikawa (2020) from an employer's viewpoint, in this study, we conducted a similarly designed firm survey to investigate the adoption, frequency, and productivity of the WFH arrangement and compared the results with the findings from the employee survey.[3]

The main findings indicate that about half of the responding firms adopted the WFH arrangement during the COVID-19 pandemic. The mean WFH intensity, the contribution of WFH hours to the total labor input calculated as the share of employees adopting WFH multiplied by the mean frequency of WFH, was 23.3% for firms adopting the WFH arrangement. The weighted mean calculated by using the number of employees as weight and including firms that did not adopt the WFH arrangement was 12.6%. The mean productivity when working at home relative to that at the workplace was 68.3%, although a large variation among firms exists. Firms that

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[2] A similar study abroad is Etheridge *et al*. (2020), which is based on a survey of individuals in the UK. The results show that, on average, WFH productivity is not significantly different from that of workplace productivity, but it varies depending on individual socio-economic status, industry, and occupation. Barrero *et al*. (2020), based on a survey of individuals in the U.S., indicate that a majority of respondents who have adopted WFH practice reports higher WFH productivity than expectation before the start of the pandemic.

[3] Empirical studies investigating the productivity of WFH under the COVID-19 from the firm side have been rare. An exception is Bartik *et al*. (2020), which, using data from a survey of small- and medium-sized firms in the US from March to April 2020, report a decrease in productivity of about 20% on average.

adopted the WFH arrangement prior to the onset of COVID-19, those in the information and telecommunications industry, those located in Tokyo, those with a high proportion of female workers, and those with high wages tend to show higher WFH productivity. These results, including the WFH productivity, are generally consistent with those obtained from the employee survey reported in Morikawa (2020).

The remainder of this paper is organized as follows. Section 2 explains the survey used in this study. Section 3 reports the prevalence, frequency, and productivity of WFH during the COVID-19 pandemic by focusing on the differences in firm characteristics. Finally, Section 4 summarizes the conclusions and discusses the implications of the study.

2. Survey Design

This study uses data from the "Survey of Corporate Management and Economic Policy" (SCMEP), which was designed by the author of this paper and conducted by the Research Institute of Economy, Trade, and Industry (RIETI) from late August to early September 2020. The survey questionnaire was sent to 2,498 Japanese firms that responded to the previous SCMEP in early 2019. The number of firms that responded to the current SCMEP was 1,579 (with the response rate of approximately 63%). The questionnaire of the SCMEP in 2019 was sent to 15,000 firms that operate in the manufacturing and service industries, which were randomly selected from the registered list of the Basic Survey of the Japanese Business Structure and Activities (BSJBSA), an annual statistical survey conducted by the Ministry of Economy, Trade and Industry (METI).[4] The firms registered in the BSJBSA have at least 50 employees and capital of at least 30 million yen among firms with business establishments that belong to the manufacturing, wholesale, retail, and service industries. In other words, the SCMEP does not include small firms with less than 50 employees or capital of less than 30 million yen. The SCMEP in 2019 asked for the firm characteristics in detail, and this paper uses some of that information.

The distribution of the firms that responded to this survey by industry is manufacturing 53.5%, information and communications 5.3%, wholesale 17.8%, retail 10.2%, service 9.0%, and others

[4] The respondents to the SCMEP were the managers themselves or departments that can write their opinions on their behalf. The annual reports of the BSJBSA can be obtained from the website of METI (https://www.meti.go.jp/english/statistics/tyo/kikatu/index.html).

4.2%.[5] In terms of firm size (classified by capital over 100 million yen or less), 34.8% are large firms, whereas 65.2% are small- and medium-sized firms.[6]

The following are main questions regarding WFH: (1) whether the WFH arrangement has been implemented, (2) the percentage of employees who have adopted this workstyle (at the maximum), (3) the mean WFH frequency of teleworkers (at the maximum), (4) the mean productivity of WFH relative to the workplace, (5) factors that affect the adoption of the WFH arrangement and productivity of employees adopting this workstyle, and (6) specific regulations or rules restrictive to the adoption of the WFH arrangement and productivity of employees adopting this workstyle. The specific wording of the questions and choices are explained in the next section as well as the results. Further, the SCMEP also asked about the industries (six categories) of firm's main business, number of standard and nonstandard employees, and number of employees by gender.

As mentioned previously, given that the current survey targets firms that responded to the 2019 SCMEP, information on the firm characteristics collected in the 2019 survey is available. In this paper, we use the percentage of employees who have a university degree or higher in the analysis. By linking with BSJBSA's data for the fiscal year 2018, information available in the BSJBSA can be used as well. This study uses capital, mean wages (total cash salary divided by the number of employees), and location of firm headquarters (prefectures) from the BSJBSA. **Table 1** presents the major variables and summary statistics.

3. Results

3.1. Adoption of the WFH arrangement

The question regarding whether the WFH arrangement has been adopted is as follows: "Did your firm implement the WFH arrangement during the spread of the COVID-19?" The three options are the following: "1) The WFH arrangement have been adopted before the onset of the COVID-19 pandemic," "2) The WFH arrangement were introduced after the spread of the COVID-19," and "3) The WFH arrangement was not adopted."

[5] "Other industries" include firms with unknown classification.
[6] The capital of the firm uses the 2018 BSJBSA data.

Table 2 presents the tabulation results. The percentage of firms that adopted the WFH system prior to the onset of the COVID-19 pandemic ("early WFH adopters") was 4.1%, 45.5% introduced it after the pandemic ("new WFH adopters"), and 50.4% have not adopted it. By firm size, the WFH adoption rate is high in large firms. By industry, the information and communications industry is the highest. Regional differences are observed in the adoption of the WFH arrangement, and the table shows the results of tabulating Tokyo and other prefectures separately. Meanwhile, a significant difference is observed between firms headquartered in Tokyo and in other prefectures.

Table 3 compares the firm characteristics between the WFH system adopters and non-adopters, focusing on the composition of employees. Firms adopting the WFH arrangement have low ratios of female and non-regular employees, although the quantitative differences are small: the difference in the female ratio is 2.1%, and the non-regular ratio is 5.6%. The major difference is found in the educational background of employees: the mean ratio of university graduates or higher is 41.9% for firms that adopt the WFH arrangement, and 21.6% for those that do not. This indicates that employees adopting this workstyle were concentrated in highly educated white-collars. In addition, firms adopting the WFH system are mostly large and pay high wages. When converted to percentages, the difference in mean wages is at least 20%. In summary, the results obtained from the firm-level survey are generally consistent with those from the employee survey (Morikawa, 2020), indicating that WFH adopters were highly educated, worked for large firms, and tended to receive high wages.

Table 4 shows the results of probit estimation with WFH adoption used as the binary dependent variable. In particular, the larger the firm size (logarithm of the number of regular employees), the higher its probability of adopting the WFH system. By industry, firms in the information and communications industry have high probability, whereas those in the retail industry have a low probability of adopting the WFH system. Firms headquartered in Tokyo, those with a large share of female and highly educated employees, and those paying higher wages have a higher probability of adopting the WFH arrangement (column (1)). The coefficient for the female employee ratio is positive and significant, which is different from the simple tabulation result reported in **Table 3**. In other words, after controlling for other firm characteristics, firms with a high proportion of female employees tend to implement the WFH arrangement. When the population density of the head office location is used as the explanatory variable, rather than the Tokyo dummy, the coefficient of population density is positive and significant at the 1% level

(column (2)). Quantitatively, doubling the population density, the probability of adopting the WFH arrangement is approximately 7% higher. In this specification, no essential difference is observed in the coefficients of other explanatory variables.

Even for firms that have adopted the WFH system, not all their employees exploited this workstyle. The share of employees covered by the WFH system may differ by firm. In this regard, the survey asks "What percentage of your employees adopted the WFH system after the spread of COVID-19?" The tabulation result is presented in column (1) of **Table 5**. The mean percentage of WFH adopting firms is 30.7%. The percentages are 49.1% for early WFH adopters, and 29.0% for new WFH adopters. This result shows that firms that are relatively easy to introduce the WFH arrangement due to the nature of their businesses adopted it earlier, and large percentages of employees tend to telework during the COVID-19 pandemic. By industry, the information and communications industry (59.6%) is the highest, and the manufacturing industry (18.8%) is the lowest. By firm size, large firms have higher percentages than small firms, and by region, firms headquartered in Tokyo have a high share of teleworkers.

Even for employees who adopted this workstyle, they were not necessarily full-time teleworkers (i.e., working at home on all working days) as many of them went to the workplace several days per week. Thus, the survey asks "What was the average number of WFH days per week for employees who adopted the WFH arrangement?" The tabulation results are summarized in column (2) of **Table 5**. The mean frequency of WFH implementation was 3.67 days per week. Assuming that the normal working days are five days a week, teleworkers spend more than 70% of their work hours at home.

Similar to the share of teleworkers, employees of firms that have adopted the WFH arrangement prior to the COVID-19 pandemic implemented this workstyle frequently, with an average of 4.54 days. Conversely, the average of firms that introduced it after COVID-19 was 3.59 days. Specifically, the teleworkers of early WFH adopters were performing about 90% of their work at home during the peak when the "state of emergency" was declared. However, no significant difference is observed by firm size. By industry, the information and communications industry (4.28 days) is the highest, whereas the retail industry (3.39 days) has the lowest frequency. The WFH system was somewhat more frequently conducted in firms headquartered in Tokyo, but the quantitative difference with firms in other prefectures is small.

Next, we calculate the WFH intensity at the firm level as the ratio of WFH employees multiplied by the frequency of WFH per week (converted into percentage), which indicating the

contribution of WFH hours to the total labor input.[7] As we do not have information on the working hours of individual employee, this calculation assumes that the working hours of all employees are equal. In addition, even on the WFH day, it is possible that he or she may go to the workplace for several hours. Therefore, we should emphasize that the WFH intensity calculated here is only an approximation.

The results are presented in column (3) of **Table 5**. The mean WFH intensity of firms adopting the WFH system was 23.3%. Even if a firm adopts this workstyle, many employees did not exploit it, and even those who adopted this work arrangement did not necessarily work at home throughout the week; hence, the mean contribution of the WFH system to labor input was less than a quarter. Firms that have adopted the WFH arrangement before the COVID-19 pandemic, large firms, and those headquartered in Tokyo show high WFH intensity. By industry, the information and telecommunications industry is the largest at 51.1%. This indicates that, at the time when the WFH intensity was at its peak, about half of the total labor input was performed at home. Conversely, the manufacturing industry is the smallest at 13.6%, reflecting the difficulty of implementing the WFH system at factory production sites.

Figure 1 depicts the WFH intensity by industry. The simple average is the same as in **Table 5**, which is calculated for firms adopting the WFH arrangement. The weighted average is calculated by using the number of employees as weight and including the WFH non-adopters, whose WFH intensity is regarded as zero. In other words, it shows the contribution of the WFH system to the total labor input of the industry. The weighted average is 12.6% for all industries: the contribution of WFH to labor input is surprisingly small, even during the period when WFH peaked. By industry, the information and telecommunications industry is the highest at 41.1%, whereas the retail industry is extremely small at 3.2%. This is an unsurprising result, as more than 70% of firms in the retail industry did not implement the WFH system (**Table 2**).

Figure 2 depicts the distribution of the WFH intensity by the timing of introducing the WFH system. Unlike that of the early WFH adopters, the WFH intensity of the new WFH adopters is distributed on the left side. However, even among each type, a significant heterogeneity is observed among firms. This is because the quantitative amount of WFH depends on various

[7] The frequency of working from home is converted into percentage terms, assuming the standard working days of five days per week. Among the responding firms, 11 firms answered that the number of WFH days per week exceeded 5. Hence, the WFH frequency of these firms was considered 100%.

factors, such as the nature of businesses, the composition of employees, and firms' labor management policy.

Table 6 shows the results from the OLS estimations that explain the WFH intensity by various firm characteristics. In columns (1) and (2), only firms that adopted the WFH system during the COVID-19 pandemic are used as samples. Information from the 2019 SCMEP is used to calculate the ratio of university graduates or higher, and that from the BSJBSA for the fiscal year 2018 is used to calculate the mean wages. Considering that the reference category of the industry dummy is manufacturing, the coefficient of each industry indicates a difference with manufacturing.

From the estimation results, the information and communications and service industries have a high WFH intensity. The coefficient of Tokyo is a relatively large positive value: the WFH intensity is about 15% higher than that of firms headquartered in other prefectures. The coefficient of the female ratio is positive despite the low significance level, and the coefficient of nonstandard ratio is negative and significant at the 5% level. The coefficient of the ratio of employees with university degrees or higher is positive and significant at the 1% level. These results indicate that firms with high female, standard, and educated employees have a high WFH intensity after accounting for the other firm characteristics. In terms of the coefficient of mean wages, despite the low significance level, it is positive, suggesting that firms paying higher wages tend to have higher WFH intensity. When the prefectural population density is used, instead of the Tokyo dummy, the result is presented in column (2). The WFH intensity is higher for firms headquartered in densely populated prefectures. Even in this specification, the coefficients of other variables are generally the same as the result of column (1), except that the coefficient of the wholesale industry becomes positive and significant.

In these estimations, firms that did not adopt the WFH system were excluded from the sample. The results of the same estimations but included firms that did not adopt WFH, of which the WFH intensity is regarded as zero, are shown in columns (3) and (4) of the table. In this case also, the results are essentially the same as in columns (1) and (2).

3.2. Productivity of working from home

The question about WFH productivity evaluated from the employer's viewpoint, which is the main interest of this study, is "Suppose that employees' productivity at the workplace is 100, how

do you evaluate their productivity at home? Please answer the mean productivity by considering all tasks covered by the WFH system." The questionnaire noted that "If the WFH system is more productive than the workplace, please answer a figure over 100." Thus, the respondents can answer the possibility that the WFH system is more productive than the workplace.[8]

The tabulation results are presented in **Table 7**. The simple average of firms adopting WFH is 68.3. According to a survey of employees, the mean subjective productivity of WFH was 60.6 (Morikawa, 2020). As the firms surveyed in this study are those with at least 50 employees, we should be careful in comparing the figures simply, but the figures are slightly higher than the subjective productivity of employees. **Figure 3** compares the productivity distributions of employee and firm surveys. The dispersion of firm survey is smaller than that of the employee survey, which is unsurprising given that the firm survey asked the average figure of teleworkers in the firm.

The WFH productivity is 81.8% and 67.0% for the early and new WFH adopters, respectively. The 14.7 points difference is statistically significant at the 1% level. **Figure 4** depicts the productivity distributions of these firms. Noticeably, the productivity distribution of the early WFH adopters is located on the right side, despite the quite large dispersion. In the employee survey, a large difference (18.7 points) in productivity was observed between those who had adopted the WFH arrangement before the COVID-19 pandemic and those who adopted it after the spread of COVID-19. The results of this study are consistent with those of the employee survey. However, even firms that have adopted the WFH system before the COVID-19 might expand their coverage to employees who had not exploited this work arrangement until the spread of the COVID-19 infection. Therefore, it should be noted that the teleworkers in the firm survey did not necessarily experience WFH prior to the onset of the COVID-19 pandemic.

Almost no difference is found by firm size. By industry, the mean WFH productivity of the information and telecommunications industry is the highest at 80.3, and the figures for the rest of the industries are between 62.6 and 69.5. The mean figure of firms headquartered in Tokyo is 72.0, and that in other prefectures is 66.8: a difference of 5.2 points. As this is only a simple comparison wherein other factors were not controlled for, differences in the composition of industries and employees are reflected. However, as will be described later, even if regression analysis is

[8] In fact, 9 firms answered that the productivity of WFH exceeds 100 (the maximum was 120), and 50 firms answered exactly 100.

conducted, the coefficient of Tokyo is positive and statistically significant. The result is similar to that from the employee survey. We conjecture that, as a large number of employees working with firms located in Tokyo commute for a long distance, it may be related to the reduction in fatigue caused by long commuting hours.

Table 8 shows the OLS estimation results to explain the WFH productivity using the same explanatory variables as in the previous regressions. The coefficient of firm size is insignificant, confirming the simple tabulation result reported in **Table 7**. By industry, the coefficient for information and telecommunications industry is positive and that for retail is negative, and they are both highly significant, reflecting the nature of businesses. The coefficient of Tokyo is positive and significant at the 5% level, and the interpretation is the same as stated above. The coefficient of the female ratio is positive and significant at the 5% level. This indicates that firms' evaluation of WFH productivity is higher in firms with a large share of female employees after accounting for the other firm characteristics. The coefficient of the nonstandard ratio is insignificant. Although firms with a large share of nonstandard workers have low WFH intensity, as mentioned previously, no significant difference is observed in terms of productivity. The coefficient for the share of university graduates or higher is positive but statistically insignificant, and this result differs from that of the employee survey. The coefficient of mean wages is positive and significant at the 5% level; this indicates that firms paying higher wages tend to be more productive in the WFH system. This is similar to the results of the employee survey.

In summary, the WFH productivity pattern based on the firm survey is generally consistent with the results of an employee survey (Morikawa, 2020). A few exceptions are that the coefficients of higher education and non-regular employment are statistically insignificant in the firm survey.

By multiplying the WFH intensity with the productivity of WFH, the degree of contribution of teleworking to the production of firms can be approximated. **Figure 5** depicts the aggregation results by industry. The simple average of all industries is 17.2%, indicating that the contribution to production during the period when WFH implementation was the highest was less than 20%. By industry, the information and telecommunications industry has a high WFH contribution (43.1%), while the manufacturing industry (9.8%) and retail industry (10.8%) have a low WFH contribution. The service industry is in the middle, at 22.3%. While the service industry includes industries strongly affected by COVID-19, such as restaurants and entertainment services, it also includes business services that were relatively unaffected by the pandemic. The weighted average

in **Figure 5** is the contribution of WFH to aggregate production weighted by the number of employees, including firms that do not implement the WFH arrangement. The figure shows 9.4% for all industries. The information and telecommunications industry is the highest at 33.3%, whereas the retail industry is very low at 2.2%. Hence, the WFH contribution to aggregate production is surprisingly small: less than 10%.

3.3. Factors affecting the adoption and productivity of the WFH arrangement

The firm survey asked multiple-choice questions about factors negatively affecting the adoption and productivity of WFH. The specific question is "Were there any obstacles or limitations in adopting or expanding the WFH arrangement or matters that negatively affected WFH productivity?" There are nine choices for this question: 1) "Poor telecommunication environment at home relative to the workplace," 2) "Rules and regulations that require some tasks to be conducted in the office," 3) "Some tasks cannot be conducted at home although these are not required by the rules and regulations," 4) "At the employees' home, it is difficult to concentrate on working owing to the presence of family members," 5) "Some employees do not have their private room suitable for teleworking," 6) "Loss of immediate communication that is only possible through face-to-face interactions with colleagues at the workplace," 7) "Lack of pressure from boss, colleagues, and subordinates," 8) "Much of the work requires direct interaction with customers," and 9) "Other reasons." These choices are basically the same as the survey for employees (Morikawa, 2020), but the choice 8 is added in the firm survey.

The tabulation results are presented in **Table 9**. A large number of firms chose, in descending order, "Some tasks cannot be conducted at home although these are not required by the rules and regulations" (76.1%), "Poor telecommunication environment at home relative to the workplace" (60.8%), "Rules and regulations that require some tasks to be conducted in the office" (57.7%), and "Loss of immediate communication that is only possible through face-to-face interactions with colleagues at the workplace" (46.0%). The table shows the results of the employee survey for comparison purposes. Although the percentages are different, these four reasons are expected to occupy the top positions.

In addition to the question above, the survey asked "Were any of the following regulations or rules restrict your firm's adoption of WFH?". The choices are 1) "Permission or licenses on

businesses," 2) "Labor regulations," 3) "Environmental regulations," 4) "Land use/building regulations," 5) "Regulations on protecting consumers/personal information," 6) "Corporate law," 7) "Occupational licensing system," 8) "Tax system," 9) "Social security system," and 10) "Guidance of government/municipality not based on the law." The tabulation results are reported in **Table 10**. A relatively large number of firms chose "Labor regulations" (26.9%) and "Regulations on protecting consumers/personal information" (25.9%).

In summary, the results suggest that the feasibility of the WFH system has room for improvement and WFH productivity can be enhanced by improving the information and communication environment at home for teleworkers and by revising existing laws and regulations, as well as internal rules inhibiting work at home. However, in reality, the tasks that must be performed at the workplace and the difficulty of an efficient face-to-face communication at home are likely to continue as restrictions to the diffusion of the WFH arrangement.

4. Conclusion

This study used the data from an original survey of Japanese firms and determined the prevalence, frequency, and productivity of employees implementing the WFH arrangement during the COVID-19 pandemic. Many of the questions are aligned with the employee survey (Morikawa, 2020); hence, the two surveys can be compared. The main findings are summarized as follows.

First, nearly half of the responding firms adopted the WFH arrangement during the COVID-19 pandemic, but most of them introduced this work arrangement after the spread of COVID-19. Firms belonging to the information and telecommunications industry, those headquartered in Tokyo, those with a high share of highly educated employees, and those paying high wages have a higher probability of adopting the WFH system.

Second, even for firms that have adopted the WFH system, the mean WFH intensity (i.e., the contribution of WFH to total labor input) is 23.3%. The weighted average, including firms that did not adopt the WFH arrangement, is 12.6%. However, both the percentage of employees who adopted this workstyle and the frequency of WFH are highly heterogeneous among firms. Meanwhile, firms belonging to the information and telecommunications industry, those located in Tokyo, those with high ratios of female employees and university graduates, and those paying

high wages demonstrate high WFH intensity, and those with a large share of nonstandard workers have low WFH intensity.

Third, the mean of the firm's evaluation of WFH productivity (workplace = 100) for their employees is 68.3. The figure is slightly higher than the mean productivity of employees adopting the WFH system in the employee survey (60.6), but it is still more than 30% lower than their productivity at the workplace. As a result, the aggregate contribution of WFH to production is less than 10%.

Fourth, for firms that have adopted the WFH system prior to the onset of the COVID-19 pandemic, the mean productivity of WFH is 81.8, which is still lower than that of workplace productivity. However, it is significantly higher than that of firms that adopted the WFH system after the spread of COVID-19 (67.0). This pattern is similar to the result of the employee survey. The WFH productivity is widely dispersed among the responding firms, but it is relatively high for firms in the information and telecommunications industry, those located in Tokyo, those with a high proportion of female employees, and those paying high wages.

Fifth, the factors that restrict the WFH adoption and negatively affect WFH productivity include the existence of tasks difficult to perform at home, poor telecommunication environment at home, and loss of efficient face-to-face communication at the workplace.

In summary, the findings from a firm survey on the prevalence, intensity, and productivity of WFH are generally consistent with the results obtained from the employee survey. Although the WFH arrangement is attracting attention due to COVID-19, its productivity is far lower than that in the workplace, at least on average, and the contribution of this workstyle to aggregate production is limited. Considering the possibility that the WFH system becomes a new workstyle even after this pandemic is over, further development of information and communication infrastructure and revisions of rules and regulations hindering WFH is required. However, even firms that have adopted the WFH system do not necessarily apply it to all their employees, and employees engaged in full-time WFH are rare. Human resources management will play an important role in the selective application of the WFH arrangement to employees who are engaged in tasks suitable for this workstyle. In addition, using new communication tools, such as teleconference systems, should be considered depending on their advantages and disadvantages relative to real face-to-face communications.

Finally, the following are some of the limitations of this study. First, the survey used in this study covers only firms with at least 50 employees, and the sample size is limited to about 1,500

firms. Although the difference in WFH intensity and WFH productivity by firm size is small in this sample, it cannot be disregarded that the situation may different for very small firms with less than 50 employees. Second, the differences by individual characteristics within the same firm are outside the scope of this study. Such an analysis should be conducted using employer–employee-linked data. Third, the difference in WFH intensity and productivity by the timing of adopting the WFH arrangement reflects both the selection effect and the learning effect. Future research should quantitatively distinguish the contribution of these effects by constructing panel data.

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Table 1. Summary statistics.

	Nobs.	Mean	Std. Dev.
WFH adoption	1,579	0.495	0.500
WFH intensity	741	0.299	0.286
WFH intensity (adjusted)	1,579	0.140	0.246
WFH productivity	762	68.281	23.440
WFH productivity (adjusted)	1,579	32.951	37.814
Number of employees	1,561	4.973	0.879
Tokyo	1,579	0.168	0.374
Population density (log)	1,579	6.573	1.497
Female ratio	1,561	0.311	0.196
Nonstandard ratio	1,552	0.234	0.240
Ratio of university or higher	1,364	0.315	0.246
Mean wages (log)	1,514	1.411	0.394

Notes: WFH intensity is calculated as the ratio of WFH employees multiplied by the frequency of WFH per week (expressed as a percentage). "Adjusted" figures are calculated by including WFH non-adopters, whose WFH intensity and productivity are zero.

Table 2. Adoption of the WFH arrangement.

	(1) Early WFH adopters	(2) New WFH adopters	(3) Non-adopters
Total	4.1%	45.5%	50.4%
Large firms	5.3%	57.8%	36.9%
Small & medium firms	3.5%	38.9%	57.5%
Manufacturing	3.0%	42.6%	54.4%
Information & communications	20.5%	75.9%	3.6%
Wholesale	2.1%	57.1%	40.7%
Retail	1.2%	28.6%	70.2%
Services	5.6%	38.0%	56.3%
Other industries	10.6%	51.5%	37.9%
Tokyo	11.1%	73.7%	15.3%
Other prefectures	2.7%	39.9%	57.4%

Notes: "Early WFH adopters" are the firms adopting the WFH arrangement before the COVID-19 pandemic. "New WFH adopters" are the firms adopted the WFH arrangement after the COVID-19 pandemic (N = 1,574).

Table 3. Comparison of WFH adopter and non-adopter.

	Adopters	Non-adopters	Diff.	Early adopters	New adopters	Diff.
Female ratio	0.321	0.301	0.021 **	0.303	0.281	0.022
Nonstandard ratio	0.262	0.205	0.056 ***	0.207	0.190	0.017
Ratio of university or higher	0.216	0.419	-0.203 ***	0.412	0.496	-0.084 **
ln employees	4.881	5.113	-0.233 ***	5.088	5.409	-0.320 ***
ln mean wages	1.297	1.527	-0.230 ***	1.523	1.566	-0.042

Notes: ***: $p < 0.01$ and **: $p < 0.05$ by t-test. The ratio of employees with university or higher education was taken from the survey conducted in 2019. The number of employees and mean wages are calculated from the BSJBSA for the fiscal year 2018.

Table 4. Determinants of WFH adoption.

	(1) dF/dx	(2) dF/dx
Number of employees (log)	0.1352 ***	0.1427 ***
	(0.0245)	(0.0244)
Information & communications	0.3598 **	0.4015 ***
	(0.1004)	(0.0818)
Wholesale	-0.0502	-0.0179
	(0.0472)	(0.0475)
Retail	-0.2598 ***	-0.2333 ***
	(0.0519)	(0.0535)
Services	-0.0531	-0.0565
	(0.0589)	(0.0579)
Other industries	0.0221	0.0323
	(0.0832)	(0.0812)
Tokyo	0.3376 ***	
	(0.0383)	
Population density (log)		0.0946 ***
		(0.0115)
Female ratio	0.2669 **	0.2932 ***
	(0.1069)	(0.1079)
Nonstandard ratio	-0.0735	-0.1366
	(0.0847)	(0.0853)
University or higher	0.6918 ***	0.5943 ***
	(0.0849)	(0.0868)
Mean wages (log)	0.2928 ***	0.2734 ***
	(0.0593)	(0.0585)
Nobs.	1292	1292
Pseudo R^2	0.2307	0.2356

Notes: Probit estimations with robust standard errors are in parentheses. ***: $p < 0.01$, **: $p < 0.05$. The reference category of industries is manufacturing.

Table 5. Share, frequency, and intensity of WFH.

	(1) Share of employees using WFH	(2) Frequency of WFH per week	(3) WFH intensity
Total	30.7%	3.67	23.3%
Early WFH adopters	49.1%	4.54	41.4%
New WFH adopters	29.0%	3.59	21.7%
Large firms	34.6%	3.61	25.5%
Small & medium firms	27.7%	3.71	21.7%
Manufacturing	18.8%	3.64	13.6%
Information & communications	59.6%	4.28	51.3%
Wholesale	38.2%	3.41	27.4%
Retail	21.8%	3.39	15.2%
Services	41.8%	3.77	32.1%
Other industries	49.6%	3.93	42.1%
Tokyo	48.4%	3.82	38.2%
Other prefectures	23.7%	3.61	17.3%
Nobs.	778	771	741

Notes: WFH intensity—contribution of WFH hours to total hours—is calculated as the ratio of WFH employees multiplied by the frequency of WFH per week (expressed in percentage).

Table 6. Determinants of WFH intensity.

	(1)	(2)	(3)	(4)
Number of employees (log)	0.000	0.005	0.009	0.013 *
	(0.010)	(0.010)	(0.007)	(0.007)
Information & communications	0.243 ***	0.278 ***	0.262 ***	0.295 ***
	(0.042)	(0.040)	(0.040)	(0.039)
Wholesale	0.034	0.048 **	0.010	0.024 *
	(0.022)	(0.022)	(0.013)	(0.014)
Retail	-0.024	-0.027	-0.025 **	-0.013
	(0.035)	(0.034)	(0.012)	(0.012)
Services	0.159 ***	0.162 ***	0.073 ***	0.075 ***
	(0.039)	(0.037)	(0.022)	(0.021)
Other industries	0.194 ***	0.206 ***	0.133 ***	0.144 ***
	(0.044)	(0.046)	(0.034)	(0.036)
Tokyo	0.150 ***		0.164 ***	
	(0.021)		(0.018)	
Density (log)		0.043 ***		0.036 ***
		(0.006)		(0.004)
Female ratio	0.117 *	0.151 **	0.120 ***	0.129 ***
	(0.060)	(0.059)	(0.032)	(0.032)
Nonstandard ratio	-0.114 **	-0.145 ***	-0.062 **	-0.086 ***
	(0.045)	(0.044)	(0.025)	(0.024)
University or higher	0.249 ***	0.206 ***	0.234 ***	0.207 ***
	(0.042)	(0.043)	(0.029)	(0.029)
Mean wages (log)	0.061 *	0.059 *	0.072 ***	0.068 ***
	(0.034)	(0.034)	(0.020)	(0.020)
Cons.	-0.072	-0.355 ***	-0.182 ***	-0.395 ***
	(0.074)	(0.080)	(0.043)	(0.045)
Nobs.	623	623	1292	1292
R-squared	0.4300	0.4232	0.4577	0.4357

Notes: OLS estimations with robust standard errors are in parentheses. ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

Table 7. Mean productivity of WFH relative to the productivity at the workplace.

	Productivity
Total	68.3
Early WFH adopters	81.8
New WFH adopters	67.0
Large firms	69.4
Small & medium firms	67.4
Manufacturing	68.0
Information & communications	80.3
Wholesale	65.0
Retail	62.6
Services	66.5
Other industries	69.5
Tokyo	72.0
Other prefectures	66.8
Nobs.	762

Note: Productivity of WFH is relative to productivity at the workplace (= 100).

Table 8. Determinants of WFH productivity.

	(1)		(2)	
Number of employees (log)	1.1618		1.3139	
	(0.9494)		(0.9400)	
Information & communications	9.9362	***	10.9508	***
	(3.4900)		(3.4371)	
Wholesale	-5.2989	*	-4.9490	*
	(2.8741)		(2.8571)	
Retail	-14.6403	***	-14.8426	***
	(5.0829)		(5.1068)	
Services	-4.9088		-4.9938	
	(3.6171)		(3.6204)	
Other industries	-0.7288		-0.5032	
	(3.8798)		(3.9589)	
Tokyo	4.2168	**		
	(1.8757)			
Density (log)			1.4576	**
			(0.6259)	
Female ratio	14.2984	**	15.2744	**
	(6.5183)		(6.4910)	
Nonstandard ratio	1.1535		0.3975	
	(5.3693)		(5.3576)	
University or higher	2.1069		0.5982	
	(4.2979)		(4.3555)	
Mean wages (log)	7.9482	**	7.8098	**
	(3.2441)		(3.2297)	
Cons.	44.2034	***	34.8289	***
	(7.7638)		(8.5170)	
Nobs.	615		615	
R-squared	0.0714		0.0732	

Notes: OLS estimations with robust standard errors are in parentheses. ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

Table 9. Factors affecting adoption and productivity of WFH.

Factors	Percentage	(Reference) Survey of employees
Poor telecommunication environment at home relative to the workplace	60.8%	34.9%
The requirements by rules and regulations that some tasks must be	57.7%	33.1%
Some tasks cannot be conducted at home even though these are not required by rules and regulations	76.1%	32.5%
It is difficult to concentrate on job because of the presence of family	33.0%	19.9%
Lack of a private room specifically designed for work	36.9%	15.1%
Loss of quick communication that is only possible through face-to-face interactions with their colleagues at the workplace	46.0%	38.5%
Lack of pressure from the boss, colleagues, and subordinates	36.4%	19.3%
Much of the work requires direct interaction with customers	34.3%	—
Other reasons	4.1%	10.2%

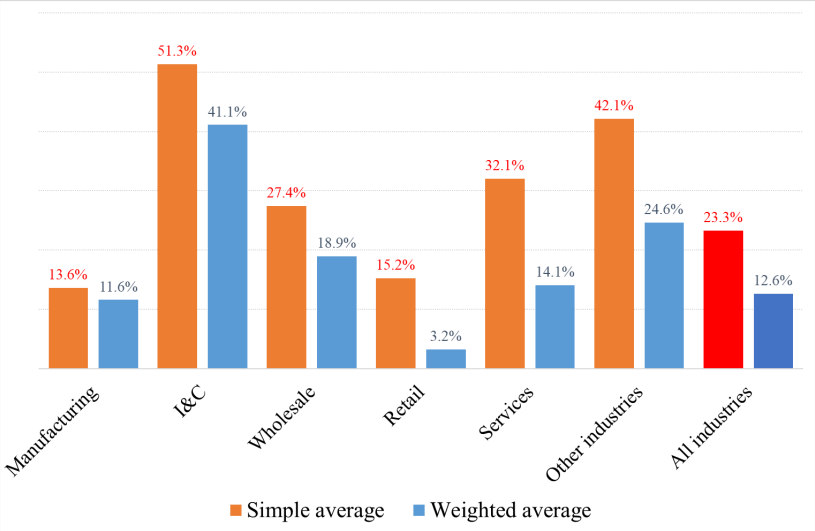
Notes: Multiple choices (N = 781). The survey of employees is taken from Morikawa (2020).

Table 10. Regulations or rules restrictive to the adoption and productivity of WFH.

Regulations or rules	Percentage
Permission or licenses on businesses	6.0%
Labor regulations	26.9%
Environmental regulations	6.9%
Land use/building regulations	0.3%
Regulations on protecting consumers/personal information	25.9%
Corporation law	10.0%
Occupational licensing system	1.5%
Tax system	2.7%
Social security system	5.2%
Guidance of government/municipality not based on the law	2.4%

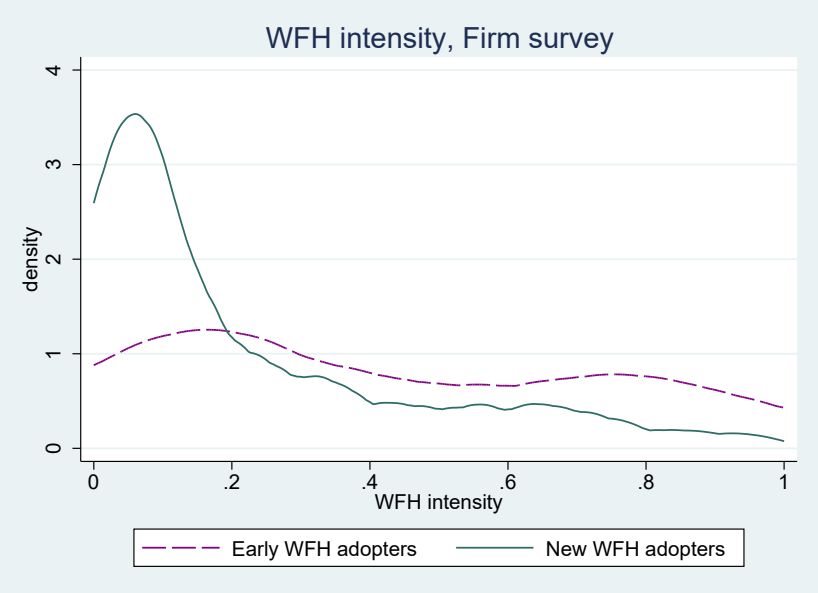
Notes: Multiple choices (N = 781).

Figure 1. WFH intensity by industry.



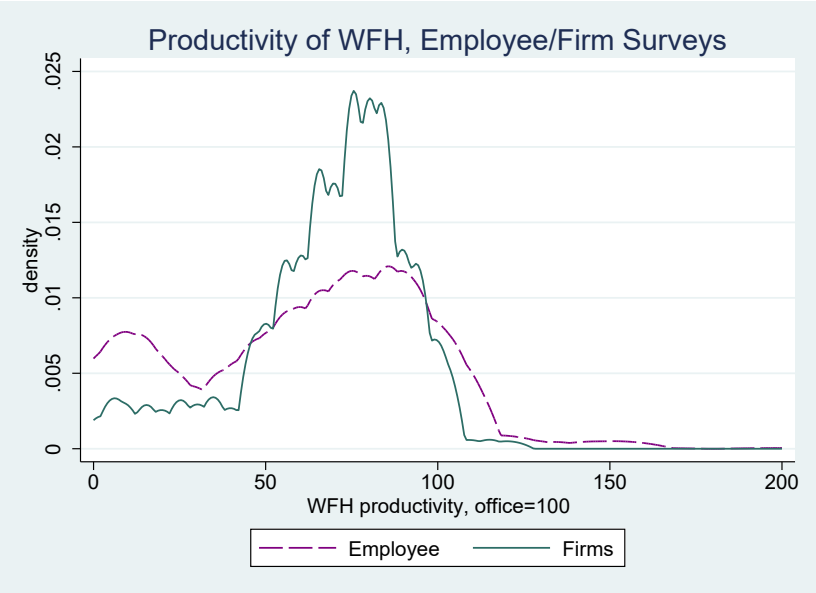
Notes: WFH intensity is calculated as the ratio of WFH employees multiplied by the frequency of WFH per week (expressed as a percentage). The weighted average is calculated by using the number of employees as weight and including WFH non-adopters, whose figure is treated as zero. I&C is the abbreviation of information and communications industry.

Figure 2. Distribution of WFH intensity.



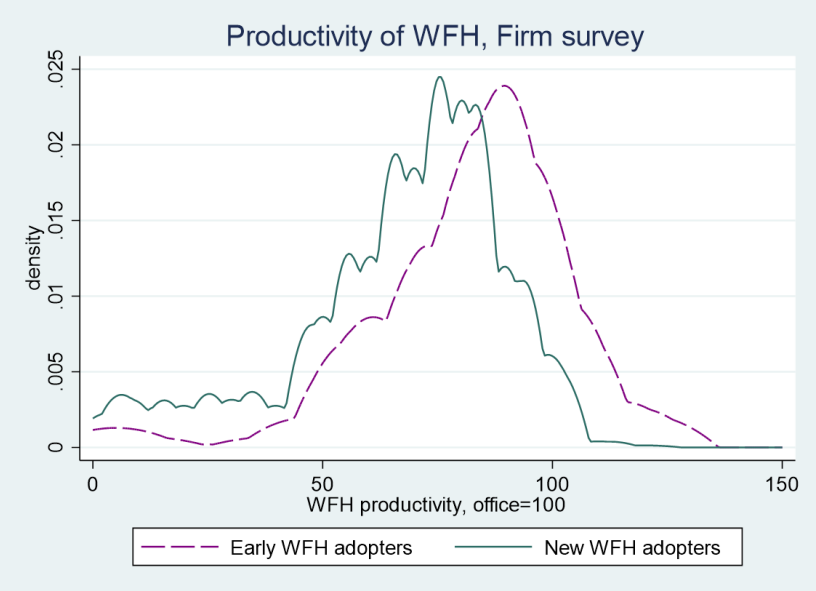
Notes: WFH intensity is calculated as the ratio of WFH employees multiplied by the frequency of WFH per week (expressed as a percentage).

Figure 3. Distribution of WFH productivity: Comparison of firm and employee surveys.



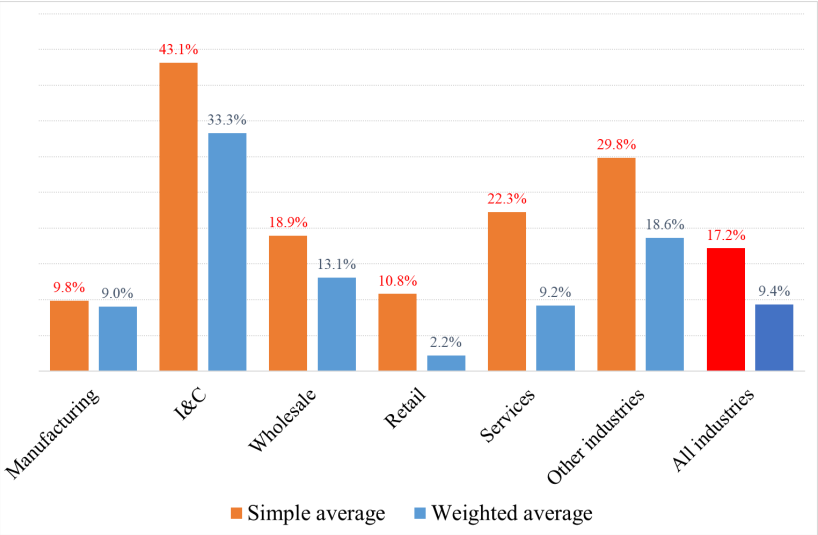
Note: See Morikawa (2020) for details of the employee survey.

Figure 4. Distribution of WFH productivity by the timing of adoption.



Notes: "Early WFH adopters" are the firms adopting the WFH arrangement before the COVID-19 pandemic. "New WFH adopters" are the firms adopted the WFH arrangement after the COVID-19 pandemic.

Figure 5. Contribution of WFH to production.



Notes: Contribution of WFH to production is calculated as the ratio of WFH*frequency of WFH*WFH productivity. The weighted average is calculated by using the number of employees as weight and including WFH non-adopters, whose figure is treated as zero. I&C is the abbreviation of information and communications industry.