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DISCUSSION PAPER SERIES

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ABSTRACT

Work from Home, Management, and Technology*

We empirically examine whether and how management facilitates Work From Home (WFH) arrangements using data from the 2020 Management and Organizational Practices Survey conducted in Japan (2020 JP MOPS). In this study, we view WFH arrangements as choices made by establishments/firms and analyze the variation in these arrangements across establishments/firms through the lens of managerial heterogeneity. Our empirical investigation reveals the multi-faceted roles management plays in WFH arrangements. First, well-managed establishments tend to adopt advanced digital technologies that support WFH arrangements, positioning management as a mediator in this context. Second, well-managed establishments are more likely than their poorly managed counterparts to implement WFH arrangements independent of technological factors. Performance-based systems with appropriate rewards appear to effectively incentivize remote workers. Finally, WFH arrangements are positively correlated with labor productivity when management scores are high but show no correlation when management scores are low. Thus, management plays a moderating role in the relationship between WFH arrangements and labor productivity. The overall findings from this study suggest that heterogeneity in management among establishments contributes to the variation in WFH arrangements.

JEL Classification: M54, L25, O33

Keywords: WFH, structured management, advanced technology

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1. Introduction

Working from home[1] (WFH hereafter) has become an increasingly important working arrangement, accelerated by the onset of the COVID-19 pandemic. According to the OECD report, WFH rates more than doubled compared to one year before the onset of the COVID-19 pandemic in many countries such as France, Japan, Italy, and Brazil (OECD, 2021). Although WFH arrangements have risen sharply, several studies have documented that there is considerable variation in WFH rates not only across but also within occupations, firms, and industries (Dingel and Nieman, 2020; Adams-Prassl et al., 2022). Some jobs are difficult to perform remotely, and individuals differ in their ability to work from home, contributing to the observed variation in WFH rates. These studies often attempt to examine and explain this variation in terms of how WFH arrangements can be used to perform jobs remotely (i.e., demand-side factors). However, worker and job characteristics do not fully account for the variation in WFH rates, leaving part of the variation unexplained (Adams-Prassl et al., 2022).

In this paper, we take a different approach to explaining the variation in WFH by focusing on the mechanisms through which firms provide WFH arrangements for their employees (i.e., supply-side factors). Bick et al. (2023) construct a model in which firms optimally choose to offer the WFH option. Their model offers broad insights that firms may strategically leverage WFH options to improve recruitment and retention, moderate pay growth, reduce space needs, and lower overhead costs. Our analytical lens in this study is similar to theirs in that WFH arrangements are decisions made by the firm. More specifically, we shed light on firm/establishment-level heterogeneity regarding management and examine how managerial heterogeneity affects a choice of WFH arrangements. As discussed in the context of ICT use (Bresnahan et al., 2002; Bloom et al., 2012), WFH arrangements may need complementary workplace circumstances to be effective, and the attractiveness of implementing WFH arrangements may vary with managerial capacity. Empirical evidence remains limited regarding whether management facilitates WFH arrangements and, if so, what mechanisms facilitate them through management. We aim to address this gap in the literature and provide some evidence to explain the variation in WFH arrangements through the lens of managerial heterogeneity.

Our data come from the Japanese version of the Management and Organizational Practices Survey for 2020 (manegimento-ya-soshiki-ni-kansuru-chosa, henceforth

[1] We use "WFH" to describe a situation where employed workers perform tasks remotely (mainly from home) rather than onsite. Our choice of WFH is primarily based on our empirical context, where the survey questions of this study ask how often employees work from home. However, we use WFH in this paper to mean more broadly, including WFH and remote work.

referred to as the 2020 JP MOPS). The 2020 JP MOPS collects information on management practices within establishments by closely following the methodology established by the US MOPS (Bloom et al., 2019). We calculate management scores based on the survey questions related to these practices. These management scores constitute some of our primary research variables and reflect managerial efficiency in terms of production and human resource management. Unlike the US MOPS, the JP MOPS asks what percentage of employees work from home, allowing us to explore the relationships between management and WFH arrangements. Additionally, the 2020 JP MOPS contains data on the use of advanced digital technologies associated with Internet of Things (IoT) devices, Artificial Intelligence (AI), and 3D CAD/CAM. Since advanced digital technologies support remote work and their adoption is a decision made by firms/establishments, including technology factors in our empirical analyses enables us to examine the mediating role of management in WFH arrangements through these technologies and helps mitigate potential omitted variable biases stemming from firms' behaviors. Consequently, we can create empirical measures of WFH, management, and technology to better understand the multifaceted roles that effective management plays in shaping WFH environments.

The main results of this paper are summarized as follows. First, management scores are positively associated with the likelihood of adopting advanced digital technologies that facilitate WFH arrangements. Efficient management plays a mediating role in WFH arrangements: Well-managed establishments tend to have advanced digital technologies in place, promoting WFH arrangements.

Second, management scores are positively associated with the likelihood of arranging WFH environments even after technology factors are controlled for. This indicates that efficient management plays a direct role in WFH arrangements. Our analysis shows that this direct relationship is mainly driven by human resource management. One interpretation is that performance-based systems with appropriate rewards seem to incentivize remote workers effectively even in WFH environments, independent of technology factors.

Finally, WFH arrangements are positively correlated with labor productivity when management scores are high but not when management scores are low. Efficient management plays a moderating role in the productivity and WFH relationships. However, this moderating effect disappears when the uncertainty of business conditions is controlled for. This indicates that, when management scores are low and when uncertainty is not controlled for, the WFH dummy partially reflects the negative impact of uncertainty on labor productivity. On the other hand, well-managed establishments

appear to make such negative impacts from uncertainty irrelevant by coping with adversity well (Lamorgese et al., 2024).

The overall findings from this study suggest that establishment-level heterogeneity regarding management contributes to variation in WFH arrangements. This heterogeneity helps explain an unexplained part of the variation reported in extant studies using worker and occupation data.

The paper is structured as follows: In Section 2, we briefly review the literature on the factors influencing WFH arrangements and their impact on performance. Section 3 describes the 2020 JP MOPS and explains how empirical measures of WFH arrangements, management, and technology are constructed. In Section 4, we first investigate the relationship between WFH arrangements and advanced digital technologies. Then, we analyze several management roles in arranging WFH environments. Section 5 provides the conclusion.

2. Brief Literature Review

Previous studies examine crucial factors influencing employees' ability to work from home (Lee, 2023). One strand of this research focuses on the capacity to perform tasks remotely. Dingel and Nieman (2020) utilize the O*NET database to determine the proportion of jobs that can be done from home, reporting that this WFH measure varies significantly across occupations. According to their calculations, over 95 percent of jobs can be performed at home in computer, education, and legal fields, while the corresponding figures for farming, production, and construction occupations are only 1 percent or even 0 percent. Adams-Prassl et al. (2022) analyze survey data from workers in the United States and the United Kingdom, finding significant variation in the capacity to work from home, not only across but also within occupations and industries. Their estimation results suggest that occupation and industry fixed effects account for only about one-quarter of the variation in the share of tasks that can be performed from home. They also document that, within occupations and industries, workers' attributes are significant; male workers, those with a university degree, and employees with permanent contracts can complete a higher percentage of their tasks from home compared to female workers, those without a university degree, and workers with temporary contracts. Barrero et al. (2023) report similar findings, noting that WFH intensity varies by demographic characteristics such as age, gender, family composition, and education.

The importance of demographic characteristics aligns with another strand of study that examines workers' preferences and benefits related to WFH. A notable benefit for workers working from home is to save time on commuting while having the flexibility

to work in a schedule and environment that suits them, which can also enhance their productivity. Barrero et al. (2021) find that reducing commuting time leads to productivity gains, and Bloom et al. (2015) noted that the observed improvements in productivity stem from the flexibility and convenience afforded by WFH. Flexible schedules and locations also enable individuals to increase job satisfaction and achieve a better work-life balance (Angelici and Profeta, 2024). The effects of productivity and preferences associated with WFH carry several implications for wages.

Some evidence suggests that workers are willing to sacrifice their earnings for WFH arrangements (Barrero et al., 2021), which, in turn, incentivizes employers to offer WFH options to their employees. Bick et al. (2023) develop a model in which workers find it more beneficial to work from home rather than on-site when they can do so effectively. In their model, firms can increase profits by providing WFH options because workers are willing to accept lower wages due to compensational differences. More generally, firms may strategically leverage WFH options to enhance recruitment and retention, moderate pay growth, minimize space requirements, and reduce overhead costs. Barrero et al. (2023) argue that favorable experiences from the experiment during the COVID-19 pandemic prompted employers and employees to reoptimize working environments.

While setting up WFH environments offers certain benefits, employers are concerned that WFH might reduce employee productivity and lower profits due to challenges in monitoring, as well as diminished learning opportunities and peer interactions. As a result, firms strive to mitigate the drawbacks of WFH arrangements while maximizing their benefits. However, empirical evidence remains limited on how a firm's management and organizational style influence this balance of benefits and drawbacks. Bloom et al. (2015) propose that WFH can be viewed as a management practice that enhances productivity by allowing flexible working hours and styles. Kawaguchi and Motegi (2021) emphasize that employees whose employers implement effective human resource management practices are more likely to work remotely, and companies that expanded their remote workforce during the pandemic were able to navigate the COVID-19 crisis more effectively. A few studies examine the relationship between management and WFH using some version of the Management and Organizational Practices Survey (MOPS) and report a positive correlation between WFH rates and management scores. Groenewegen and Hardeman (2024) document that structured management practices are positively associated with WFH arrangements at extensive and intensive margins.

This paper sheds light on employers' decisions and characteristics in arranging WFH environments for their employees. In contrast to studies examining workers' decisions and occupational traits, empirical evidence from this lens is scant and needs to be accumulated. Specifically, we investigate the multi-faceted roles of management to understand how WFH arrangements vary across firms/establishments. WFH can be viewed as one of the management practices that significantly impact firm performance. Since management practices tend to complement one another, our study can also be viewed as examining whether WFH requires other complementary management practices.

3. Data

This study uses establishment-level data to examine whether and how efficient management facilitates establishments to arrange WFH environments. The unit of analysis in this study is an establishment, and we construct establishment-level variables that reflect its choices and characteristics. To answer our research question, we construct empirical measures of WFH and management from the 2020 JP MOPS. This survey was conducted from January 25th to March 12th of 2021 by using a similar survey protocol as in the previous waves of the JP MOPSs (See Kambayashi et al., 2021 for the results from the previous JP MOPSs). Survey questionnaires were mailed to 40,000 manufacturing establishments with at least 30 employees, and 4,344 establishments responded to the survey via mail or online. The response rate for this survey is 10.9 percent.

Survey respondents were instructed to answer most survey questions based on their experiences in January 2020, December 2020, and 2015, respectively. COVID-19 infections were not widespread in Japan in January 2020, whereas various preventive measures were enacted regarding social and economic behaviors and activities in December 2020. Thus, the responses from January 2020 provide insights into the situation before the onset of the COVID-19 pandemic, while the responses from December 2020 offer information about the situation after it. This enables us to track changes in remote work arrangements before and after the pandemic.

Our key dependent variable is the establishment's adoption of WFH. The 2020 JP MOPS contains information on the WFH arrangements for each establishment. Survey respondents were asked to indicate what percentage of employees work from home at least once a week for each of the five worker categories: managers, IT and data specialists, other specialists, full-time workers, and part-time workers. We use this data to create an empirical measure that reflects the adoption of WFH at the establishment level. This measure is a dummy variable that indicates whether an establishment has adopted any

form of WFH at a given time. This variable is valued at one if some workers in at least one category work from home and valued at zero if no workers in all five categories work from home.

Our key independent variable is management scores. In the 2020 JP MOPS, survey respondents were asked to answer 16 management questions concerning monitoring, targeting, bonuses, promotion, and dismissal practices. We follow the methodology used in the management survey literature (Bloom et al., 2019, for US MOPSs; Kambayashi et al., 2021, for JP MOPSs) and utilize this information to create a measure of how each establishment is managed regarding production and human resource management. Specifically, we evaluate a respondent's answer to each of these management questions on a scale from 0 to 1, considering incentives and production efficiency, and compute a simple average of the scores from the 16 questions. This average score is referred to as the "management score" and aims to capture managerial efficiency. Previous studies have indicated that management scores are positively correlated with establishment/firm performance indicators such as productivity, survival, and profitability (Bloom and Van Reenen, 2007; Bloom et al., 2019; Kambayashi et al., 2021). In this study, we interpret a high management score as suggesting that an establishment is managed effectively.

We also utilize the information regarding each establishment's technology from the 2020 JP MOPS. Advanced digital technologies can be crucial in creating remote work environments, potentially leading to significant omitted variable biases when not included in our regression analyses. We are also interested in examining the mediating role of management in remote work arrangements through advanced digital technologies. Survey respondents were asked to indicate the extent to which their establishment adopts and uses Internet of Things (IoT) devices, Artificial Intelligence (AI), and 3D CAD/CAM. For instance, in the Artificial Intelligence survey question, respondents were required to select one answer from the following four options: "1. An establishment has not yet introduced AI and does not plan to," "2. An establishment has not yet introduced AI but intends to," "3. An establishment has already integrated AI into some processes," and "4. An establishment has already implemented AI in most processes." Based on this information, we create a dummy variable indicating whether an establishment has already adopted each of these technologies. Additionally, we develop a "technology score" by assessing the use of each technology on a scale of 0 to 1 and calculating their simple average. A high technology score indicates that establishments extensively introduce and utilize IoT, AI, and 3D CAD/CAM in their production processes.

To dig deep into the roles of management in remote work arrangements, we

examine the relationship between WFH and labor productivity. We use establishment-level information from the Japanese Manufacturing Census and construct a labor productivity measure as a ratio of production values to the number of employees. [2]

An important control variable in our analysis is an uncertainty measure that turns out to help reveal intriguing relationships between WFH and labor productivity. This uncertainty measure is constructed from a JP MOPS survey question that asks how an establishment forecasts its future shipment values for three scenarios (high, medium, and low realization) and assigns a probability to each scenario. We use this information to calculate the weighted variance of shipment value growth rates. When this variance is large, establishments subjectively perceive their business conditions as unstable, and a degree of uncertainty is interpreted as high. The other control variables in our empirical analyses come from the 2020 JP MOPS and include the number of employees, the year established, a dummy variable for headquarters, factory types, and dummy variables for three-digit industry codes.

The data used for our analysis are primarily cross-sectional, although the information regarding WFH, management, and technology was collected in January and December 2020. Several factors prevent us from using panel data estimation methods. First, our control variables are constructed from annual data, which does not allow for panel data analysis with these control variables. Second, our panel estimation may not accurately estimate the effects of management on WFH because "stayers" and "changers" are not appropriate comparisons in our analysis. In our data, stayers are establishments that either arranged WFH in both January and December 2020 or did not arrange WFH during both months. The former group of stayers would not serve as the right comparison. Lastly, and relevant to the second point, we created a dummy variable indicating WFH arrangements in December 2020, conditional on no WFH arrangements in January 2020. We then conducted all the analysis by examining changes in WFH status between these periods, obtaining qualitatively similar results. Generally, it is challenging to find and exploit exogenous variation in management scores, and this study is no exception. Thus, these limitations affect the empirical analysis of this study. However, we also have empirical variables, such as technology variables, that are often omitted from standard regression analyses. Our empirical approach aims to minimize potential endogeneity issues by including important control variables, although we do not intend to claim any causal inferences from our empirical results.

4. Results

[2] Both of MOPS and Census of Manufacturers do not include information on hours worked.

4.1 Summary Statistics

We first use the WFH dummy variable to see how prevalent WFH arrangements are in our sample of Japanese manufacturing establishments. Table 1A presents the percentages of the establishments by worker category where some workers work from home at least once a week for January 2020 and December 2020. Note that the 2020 JP MOPS was conducted in early 2021.

Two features are noteworthy in Table 1A. First, most establishments in our sample did not adopt WFH across all the worker categories in January 2020 and December 2020. In January 2020, less than 10 percent of the establishments arranged once-a-week WFH for each of the five worker categories. As the WFH dummy indicates, only about 10 percent of the establishments arranged once-a-week WFH for their workers. The Cabinet Office Japan (2022) reported that 10.3 percent of workers engaged in some form of telework as of December 2019. Morikawa (2000) reports that 10.6 percent of Japanese workers surveyed engaged in WFH arrangements before the COVID-19 pandemic, increasing to 35.9 percent during the pandemic. Although the WFH rate in our sample is low by international standards, it likely reflects the average WFH rate in Japan at that time.

The second notable feature is that the percentage of establishments adopting once-a-week WFH more than doubled in most worker categories from January 2020 to December 2020. For example, this WFH percentage for managers rose to 17.0 in December 2020 (after the onset of the COVID-19 pandemic) from 7.7 in January 2020 (before the onset of the COVID-19 pandemic). We can thus see the onset of the COVID-19 pandemic acted as a catalyst for the adoption of WFH at the establishment level. This finding is consistent with other studies (Cabinet Office Japan, 2022; Kawaguchi and Motegi, 2021).

Table 1B reports the percentages of workers at each establishment who work from home, given that some form of WFH has been arranged (i.e., the WFH dummy takes the value of 1). As we can see, the average percentage of workers at each establishment who work from home increased between January 2020 and December 2020 in all the worker categories except the full-time worker category. It is important to note that this average percentage is influenced by composition effects because the composition of establishments arranging WFH differs between January 2020 and December 2020. Our close examination reveals that the percentage of workers who WFH is much smaller for the establishments that did not arrange WFH in January 2020 but arranged WFH in December 2020 than the establishments that arranged WFH at both points in time.[3] Even

[3] The average percentage of workers who WFH in December 2020 is 14.76 for the establishments

though the latter type of establishment, on average, increased the percentage of full-time workers who work from home, the composition effect from the former type of establishment is strong enough to drive down the overall average percentage of full-time workers who work from home. In sum, the Japanese establishments in our sample increased the percentage of workers involved in WFH arrangements after the onset of the COVID-19 pandemic while those establishments that started adopting WFH arrangements after the onset of the COVID-19 pandemic did so on a small scale.

[Table 1 here]

We next look at summary statistics on management scores and technology variables. Table 2A reports summary statistics on management scores, human resource management scores, and non-human resource management scores. As explained above, management scores are the overall average scores from the 16 management questions. We break management scores into human resource management scores and non-human resource management scores. The former scores are the average scores from bonus and promotion practices questions, whereas the latter scores are the average scores from monitoring and targeting practices questions. The average management score is 0.503, which can be interpreted as indicating that a typical establishment in the sample adopts about 50 percent of the "best" management practices that are evaluated based on incentives and efficiency. The maximum management score is 0.901, and the minimum management score is 0. Consistent with the results from past studies, the management scores vary considerably across the establishments in the sample. The average human resource management score is 0.627, and the average non-human resource management score is 0.523. Both scores also vary considerably across the establishments in the sample.

Each establishment's overall technology adoption is measured by its "technology score." In December 2020, the average technology score is 0.244, and the median is 0.220. These numbers show that most establishments in the sample did not adopt advanced technologies. About 43 percent of the establishments in the sample adopted IoT, and only nine percent adopted AI.

Management scores remain similar between January 2020 and December 2020 for most establishments. The average change in management scores during the period is

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that did not arrange WFH in January 2020 but arranged WFH in December 2020. The corresponding number is 39.89 for the establishments that arranged WFH at both points in time. For the latter type of establishments, the average percentage of WFH workers increased between January 2020 and December 2020.

-0.003. Technology scores do not change significantly, either. The average change in technology scores during the period is 0.018

[Table 2 here]

4.2 Analysis of the Relationship between WFH, Management, and Technology

We first examine whether efficient management facilitates the adoption of advanced digital technologies that will likely help workers work remotely. In this examination, the dependent variables are dummies for adopting each technology (IoT, AI, and 3D CAD/CAM) and the technology scores for January and December 2020. The main independent variable is the management scores. The number of employees, the year established, a dummy for headquarters, factory types, and dummies for three-digit industry codes are also included as control variables in the estimation equation.

Table 3 presents estimation results for the relationship between management and advanced digital technologies. In all the specifications, the coefficient on the management score is positive and statistically significant at the one percent significance level. This result shows that well-managed establishments are more likely to adopt IoT, AI, and 3D CAD/CAM and they have higher technology scores than their poorly managed counterparts.

[Table 3 here]

Next, we examine the relationship between WFH and management by incorporating technology scores into logit model estimations. The primary goals of this estimation are to determine whether advanced digital technologies indeed facilitate WFH arrangements and to explore if better-managed establishments are more likely to offer remote work environments once technology factors are accounted for. Since management scores are positively correlated with technology variables, they can potentially serve as a proxy for the adoption of advanced digital technologies and vice versa when one of these variables is unavailable for estimations.

Table 4 presents the estimation results from logit model analyses using data from January 2020 and December 2020. First, the coefficient on the technology scores is positive and statistically significant at the one percent level in all specifications. This finding indicates that advanced digital technologies indeed facilitate WFH arrangements. Second, we observe a significant difference between the January 2020 and December 2020 data regarding the impact of efficient management on WFH arrangements. While

the coefficient on the management score is not statistically significant at conventional levels for the January 2020 data, it is positive and statistically significant at the one percent level in all specifications for the December 2020 data, even after controlling for technology factors. The estimated coefficient for the management scores more than doubles from 0.366 in January 2020 (before the onset of the COVID-19 pandemic) to 0.819 in December 2020, while their standard errors do not differ significantly. Although not reported here, a Blinder-Oaxaca decomposition reveals that over 95 percent of the difference in observed WFH adoption rates between January 2020 and December 2020 can be attributed to changes in coefficients.

[Table 4 here]

The estimation results in Tables 3 and 4 show that well-managed establishments are more likely than poorly managed ones to implement advanced digital technologies, which facilitate WFH arrangements. Additionally, well-managed establishments are more likely than their poorly managed counterparts to create remote work environments when the need for WFH arises. They appeared to adapt to a significant change in WFH demands due to the widespread COVID-19 infection. Although we do not report it, all results qualitatively remain unchanged when we replace the dependent variable with a change in the WFH dummy variable from January to December 2020, provided there was no WFH in January 2020.

4.3 Roles of Efficient Management in Arranging WFH Environments

The estimation results above show that efficient management has a direct impact on the WFH arrangement for December 2020. This finding leads us to wonder what role efficient management plays in WFH arrangements. To gain insights into this issue, we first investigate which management practice impacts WFH arrangements by decomposing the management score into human resource management score and non-human resource management score and using them as the main independent variables in the estimation specifications in Table 4.

Table 5 presents estimation results when the management scores are decomposed into human resource management and non-human resource management aspects. The coefficient on the human resource management scores is positive and statistically significant at the one percent significance level for December 2020. In contrast, the non-human resource management scores are not correlated with the WFH dummy. Non-human resource management scores typically reflect the effectiveness of

monitoring and targeting at production facilities, which does not necessarily enhance the efficiency and benefits of WFH arrangements. Although we do not report estimation results, when the technology score is dropped from this regression, the coefficient on non-human resource management scores becomes positive and statistically significant at the five percent significance level. Therefore, the technology scores appear to absorb the effect of non-human resource management, suggesting that the function of on-site non-human resource management is partly substituted by advanced digital technologies.

Human resource management scores are tied to how managers and employees are evaluated concerning promotions and bonuses. More specifically, human resource management scores are high when promotions are based on performance and ability instead of tenure or family connections and when most managers and employees receive performance bonuses. Such evaluation systems seem to function more effectively to incentivize remote workers appropriately. One possible interpretation of the result is that establishments with high human resource scores perceived such benefits, especially compared to those with low human resource scores, and introduced WFH environments when the onset of the COVID-19 pandemic forced them to reoptimize work environments.

[Table 5 here]

We next examine how efficient management moderates the relationship between WFH and labor productivity to understand the roles played by management in WFH arrangements. If efficient management enhances the relationship between WFH and labor productivity, well-managed establishments would be more likely to arrange WFH environments than poorly managed ones.

Table 6 shows the estimation results of the relationship between WFH and labor productivity, with labor productivity in 2020 (i.e., production value divided by the number of employees) as the dependent variable. According to column (1), the WFH dummy is positively correlated with labor productivity, suggesting that establishments with WFH arrangements are more productive than their counterparts. We divided the sample into establishments above and below the median management score. The coefficient for the WFH dummy is 0.113 and is statistically significant at the five percent level in the sample of establishments above the median management score (see column (2)). In contrast, the coefficient for the WFH dummy is 0.062 but is not distinguishable from zero in the sample of establishments below the median management score. These results indicate that the relationship between WFH and labor productivity is influenced by effective management, and that the impact of WFH on labor productivity is

particularly strong for establishments with high management scores. Additionally, the technology scores have a positive association with labor productivity, implying that establishments with advanced technology attain higher productivity than those without it.

[Table 6 here]

Why do poorly managed firms fail to leverage the potential benefits of WFH? To further probe the roles of management in the relationship between productivity and WFH, we conduct regressions similar to those in Table 6 by additionally including our measure of uncertainty. Table 7 presents the estimation results from this regression. First, the coefficient on the uncertainty measure is negative and statistically significant at the one percent level, indicating that labor productivity declines when establishments believe that their business conditions are uncertain. Second, the coefficient on the WFH dummy remains positive and statistically significant in the sample of establishments with management scores above the median (see column (2)). Finally, and perhaps most importantly, for the sample of establishments with management scores below the median, column (3) demonstrates that the coefficient on the WFH dummy becomes large and statistically significant at the ten percent level when the uncertainty measure is included.

When controlling for uncertainty factors, the effect of WFH on labor productivity is positive and similar, regardless of management scores. This suggests that uncertainty negatively affects the relationship between WFH and labor productivity at low management scores, while effective management alleviates these negative effects by minimizing uncertainty.

[Table 7 here]

5. Conclusion

We empirically examined the factors that facilitate WFH arrangements using data from the 2020 JP MOPS. Our investigation uncovered several relationships between WFH, management, and technology. First, well-managed establishments are more likely to adopt digital technologies that support remote work arrangements. Thus, efficient management mediates WFH arrangements through this channel. Second, well-managed establishments are more likely than poorly managed ones to arrange remote work, even after accounting for technology factors. This indicates that efficient management directly influences the adoption of WFH arrangements. Third, while non-human resource management practices do not affect WFH arrangements, human resource management

practices do facilitate them. Finally, efficient management moderates the relationship between WFH and labor productivity. It appears that this moderation effect comes from the role of management in mitigating adverse effects from uncertainty.

These results provide several fresh insights into potential drivers for WFH arrangements. First, this study utilized establishment-level variation in management and technology, demonstrating that these factors positively affect WFH arrangements. This highlights the significance of establishment-level characteristics, such as management and work environments, in determining WFH arrangements. Second, efficient management serves multi-faceted roles in remote work arrangements. It mediates remote work arrangements through technology adoption while ensuring efficient human resource management incentivizes remote workers appropriately. Efficient management also moderates the relationship between labor productivity and WFH and enhances labor productivity gains from WFH. Finally, given the nature of our management measure, a high management score indicates that an establishment uses objective goals and evaluations and manages production processes and human resources effectively. As discussed by Groen et al. (2018) and Kawaguchi and Motegi (2021), our results suggest that objective management and advanced digital technologies make output controls easily implementable, which in turn facilitates WFH arrangements. WFH can be regarded as a good management practice complementary to other management practices (Bloom et al., 2015).

This study is descriptive in nature and is unable to disentangle one mechanism of WFH arrangements from another one. Therefore, the findings from this study should be interpreted as suggestive, and further investigation is required to draw definitive conclusions. It is also worth mentioning that most establishments in our sample were forced to respond to the need for WFH due to the onset of the COVID-19 pandemic. Thus, our findings may be specific to this context, and may not apply to remote work arrangements under normal circumstances. Nonetheless, this study sheds light on the relationships between WFH, management, and technology that past studies have not examined sufficiently by exploiting variations in firm/establishment characteristics. This study also shows that establishment heterogeneity regarding management and technology can account for an unexplained part of the variation in WFH arrangement within a given occupation.

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Tables

Table 1A: Percentages of establishments arranging WFH by worker category

	January 2020		December 2020	
	No WFH	Some WFH	No WFH	Some WFH
Managers	92.3	7.7	83.0	17.0
IT & Data specialists	96.4	3.6	91.3	8.7
Other specialists	96.4	3.6	91.2	8.8
Full-time workers	94.8	5.2	86.5	13.5
Part-time workers	97.2	2.8	95.4	4.6
WFH dummy	89.5	10.5	76.6	23.4

Note) WFH dummy takes "Some WFH" (the value of 1) if some workers in at least one worker category, and takes "No WFH" (the value of 0) if no workers in all the five categories.

Table 1B: Average and median percentages of WFH by worker category

Given WFH dummy = 1 at each time

	January 2020		December 2020	
	Mean	Median	Mean	Median
Managers	12.8	10.0	16.4	10.0
IT & Data specialists	11.3	10.0	23.2	7.5
Other specialists	18.4	9.0	20.5	10.0
Full-time workers	37.4	25.0	23.8	10.0
Part-time workers	18.6	10.0	18.4	10.0

Table 2: Summary statistics on management and technology scores

	January 2020						
	Min	25th	Med	Mean	75th	Max	Observations
Management score	0.000	0.4007	0.510	0.503	0.613	0.901	3935
Human resource management score	0.000	0.417	0.627	0.578	0.750	1.000	3935
Non-human resource management score	0.000	0.380	0.523	0.523	0.665	1.000	3935
Technology score	0.000	0.000	0.220	0.225	0.387	0.917	4033
	December 2020						
	Min	25th	Med	Mean	75th	Max	Observations
Management score	0.000	0.3969	0.505	0.500	0.611	0.901	3939
Human resource management score	0.000	0.415	0.604	0.567	0.750	1.000	3939
Non-human resource management score	0.000	0.380	0.529	0.524	0.666	1.000	3939
Technology score	0.000	0.000	0.220	0.244	0.413	0.917	4025

Table 3: Relationship between technology and management

Panel A	Dependent variable：Technology variables (January 2020)			
	IoT	AI	3D CAD/CAM	Technology score
Management score	2.301***	2.859***	1.047***	0.262***
	(0.277)	(0.468)	(0.306)	(0.025)
Model	Logit	Logit	Logit	OLS
Controls	Yes	Yes	Yes	Yes
Log Likelihood/R2	-2,302.70	-1,000.46	-1,962.97	0.251
Observations	3,847	3,773	3,772	3,648
Panel B	Dependent variable：Technology variables (December 2020)			
	IoT	AI	3D CAD/CAM	Technology score
Management score	2.235***	2.724***	0.891***	0.273***
	(0.267)	(0.455)	(0.300)	(0.025)
Model	Logit	Logit	Logit	OLS
Controls	Yes	Yes	Yes	Yes
Log Likelihood/R2	-2,329.44	-1,073.27	-1,972.89	0.258
Observations	3,849	3,763	3,770	3,636

Notes: (i) The 2020 JP MOPS data are used. (ii) Coefficients are estimated by logit model or OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in a t-test for coefficients; *<10% , **<5%, and ***<1%.

Table 4: Relationship between WFH, management, and technology

	Dependent variable：WFH dummy					
	January 2020			December 2020		
	(1)	(2)	(3)	(4)	(5)	(6)
Management score	0.693		0.366	1.192***		0.819**
	(0.435)		(0.452)	(0.325)		(0.337)
Technology score		1.215***	1.108***		1.425***	1.305***
		(0.280)	(0.289)		(0.207)	(0.213)
Model	Logit	Logit	Logit	Logit	Logit	Logit
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Log Likelihood	-1,050.20	-1,068.57	-994.679	-1,645.74	-1,666.90	-1,568.15
Observations	3,190	3,360	3,076	3,211	3,370	3,087

Notes: (i) The 2020 JP MOPS data are used. (ii) Coefficients are estimated by logit model. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in a t-test for coefficients; *<10% , **<5%, and ***<1%.

Table 5: Relationship between WFH, HR and non-HR management

	Dependent variable：WFH dummy		
	December 2020		
	(1)	(2)	(3)
HR Management score	0.507**		0.483**
	(0.216)		(0.219)
Non-HR Management score		0.296	0.193
		(0.269)	(0.273)
Technology score	1.351***	1.354***	1.326***
	(0.211)	(0.213)	(0.213)
Model	Logit	Logit	Logit
Controls	Yes	Yes	Yes
Log Likelihood	-1,568.22	-1,570.46	-1,567.99
Observations	3,087	3,087	3,087

Notes: (i) The 2020 JP MOPS data are used. (ii) Coefficients are estimated by logit model. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in a t-test for coefficients; **<5%, and ***<1%.

Table 6: Relationship between labor productivity and WFH

	Dependent variable：Labor productivity		
	(1)	(2)	(3)
	All	High MS	Low MS
WFH dummy	0.102***	0.113**	0.062
	(0.035)	(0.046)	(0.052)
Management score	0.649***		
	(0.113)		
Technology score	0.310***	0.299***	0.420***
	(0.074)	(0.098)	(0.110)
Model	OLS	OLS	OLS
Controls	Yes	Yes	Yes
Adjusted R2	0.25	0.24	0.21
Observations	2,827	1,440	1,387

Notes: (i) The 2020 JP MOPS data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in a t-test for coefficients; **<5%, and ***<1%.

Table 7: Relationship between labor productivity, WFH, and uncertainty

	Dependent variable：Labor productivity		
	(1)	(2)	(3)
	All	High MS	Low MS
WFH dummy	0.107***	0.085*	0.106*
	(0.037)	(0.049)	(0.056)
Uncertainty	-1.289***	-0.967*	-1.792***
	(0.386)	(0.516)	(0.561)
Management score	0.612***		
	(0.121)		
Technology score	0.311***	0.278***	0.391***
	(0.081)	(0.107)	(0.115)
Model	OLS	OLS	OLS
Controls	Yes	Yes	Yes
Adjusted R2	0.23	0.23	0.25
Observations	2,358	1,191	1,167

Notes: (i) The 2020 JP MOPS data are used. (ii) Coefficients are estimated by OLS. (iii) Numbers in parentheses are robust standard errors. (iv) The number of asterisks indicates the significance level in a t-test for coefficients; *<10% , **<5%, and ***<1%.