Teleworker Performance in the COVID-19 Era in Japan

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Abstract
This paper investigates teleworker efficiency in Japan in the COVID-19 era by using unique survey data on telework. Many Japanese workers started teleworking during the pandemic and found both benefits as well as impediments. Overall, we find that telework experience and the work environment (e.g., having clearly specified tasks and a flexible working system), changes in work–life balance (e.g., working time), and good mental health improves teleworker efficiency.

1. Introduction

COVID-19 continues to spread around the world, with more than one million deaths as of October 2020. Japan is not an exception, although the number of confirmed cases is lower than in other developed countries and the death rate remains low. Because a vaccine has not yet been developed, countries are adopting a range of non-pharmaceutical policies, such as requesting people to avoid crowded spaces, stay at home, maintain social distancing, and wear face masks.[1] Many countries have also shut down their economy and locked down cities to gain control over COVID-19. The Japanese government declared a state of emergency from 7 April to 25 May. However, the government did not lock down cities or

1 A few current studies investigated the impact of non-pharmaceutical policies on the long-run economic growth in the 1918 influenza pandemic. See, e.g., Beach et al. (2020) and Noy et al. (2020).

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impose any penalties and punishments, but simply requested companies to reduce their operations, and people were asked to stay at home and telework from home. Thus, unlike other developed countries, except perhaps Sweden, Japan adopted a soft approach based on self-restraint without penalties, punishments, regulations, or a lockdown.

Arguably, teleworking is thought of as a promising measure to contain the spread of COVID-19, and many Japanese workers initiated teleworking to avoid infection. However, Japan is well known as a country with long working hours and commuting distances where the use of teleworking is not widespread. Because of this low rate of telework use, the government has campaigned for the introduction of teleworking as part of its labor reforms since 2016 (MLIT 2020). It is therefore worth investigating whether the COVID-19 pandemic has been a driver of teleworking and how it has changed the performance of Japanese teleworkers.

Thus, our aim is to investigate the impact of teleworking on work efficiency during the spread of COVID-19. The paper addresses the following questions: (1) whether teleworking efficiency is enhanced by workers' teleworking experience and/or information and communications technology (ICT) skills; (2) whether workers who had already started teleworking under the labor reforms of former Prime Minister Abe have maintained their work efficiency during the COVID-19 pandemic; (3) the extent to which work efficiency by teleworking can be improved by the employment system, firm organization, and task coordination; and (4) how changes in work–life balance during the pandemic have affected the work efficiency of Japanese teleworkers.

We address these research questions using a unique survey on telework conducted by Keio University and the Nippon Institute for Research Advancement (NIRA) in April and June 2020. The main focus of the survey is on the use of telework—that is, teleworking efficiency, working hours, and frequency of teleworking. Our results make several contributions to research: (1) compared with working as normal, the efficiency of most teleworkers is reduced by around 20 percent on average; (2) longer experience in teleworking helps improve efficiency; with experience, teleworkers become accustomed to teleworking and can improve efficiency; (3) the employment system, such as flexible working time, can contribute to boosting efficiency; and (4) a poorer mental health condition due to the COVID-19 crisis worsens teleworking efficiency.

2. Literature review

Although some surveys have investigated teleworking, overall, many aspects remain unexplored. According to Eurofound and the International Labour Office (2017), in the EU in 2015, about 18 percent of employees were involved in telework and ICT-based mobile work (TICTM): 3 percent of workers mainly performed regular home-based telework,

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5 percent frequent TICTM, and 10 percent occasional TICTM. In the EU-28, Denmark had the highest rate of telework use (37 percent) followed by Sweden (33 percent), and Italy reported the lowest use (7 percent). Overall, Scandinavian countries tend to see higher rates of telework use (see also Parent-Thirion et al. 2007). Noonan and Glass (2012) reported that in the United States, 24 percent of workers worked at home for at least some hours per week. In Australia, only 6 percent of all workers engaged in home-based telework in 2006 (Shieh and Searle 2013). In Japan, according to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT 2020), in 2019, 16 percent of workers performed TICTM. However, using survey data from the 2017 Japanese Panel Study of Employment Dynamics conducted by Recruit Works Institute, Hagihara and Kume (2017) found that only 7 percent of workers teleworked. Thus, Japan generally has much lower rates of telework than in Europe and the United States.

With the spread of COVID-19, more people are required to stay at home and practice teleworking. Eurofound (2020) reported that 37 percent of workers began to telework in Europe in response to the spread of COVID-19. Bick and Blandin (2020) found that the number of those who worked from home in the United States went from 8 percent in February 2020 to 35 percent in May 2020. Boeri et al. (2020) and Alipour et al. (2020) reported that the rate of teleworkers in Europe constitutes 20–50 percent of the workforce.

Telework is not suitable for every worker and every occupation, however; it is highly dependent on the type of task and occupation. Telework is appropriate for managers and technicians (Noonan and Glass 2012) and outcome-based tasks (Turetken et al. 2011). More specifically, teams in new product development projects tend to increase efficiency by teleworking and coupled with a flexible time schedule (Coenen and Kok 2014). Some studies have adopted an experimental approach to investigating the types of tasks that are suitable for telework. Dutcher (2012) conducted an experiment that studied two types of teleworking tasks: creative tasks and dull tasks. He found that teleworking had a positive impact on the productivity of creative tasks but a negative impact on the productivity of dull tasks. On the other hand, in a study of the call center of a Chinese travel agency, Bloom et al. (2015) found that teleworking increased efficiency by 13 percent.

Telework has several advantages in our lives.[2] It allows us to work more flexibly in terms of time and space (Allen et al. 2015; Vilhelmson and Thulin 2016), reducing working hours and business costs, thereby promoting efficiency and improving work-life balance (Di Martino and Wirth 1990; Tremblay 2002; Baines and Gelder 2003; Gajendran and Harrison 2007; Wheatley 2012; Kazekami 2020).[3] Telework also involves several external benefits. It

2 See Bailey and Kurland (2002) for a survey of the literature.

3 Using UK household survey data from 1993 to 2009, Wheatley (2012) found that working hours of male home-based teleworkers (34.6 hours per week) were shorter than male office workers

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allows firms to downsize office space and reduce real estate costs (Matthews and Williams 2005). It also contributes to less commuting, hence less air pollution and urban congestion (Mitomo and Jitsuzumi 1999; Helminen and Ristimäki 2007).

In contrast, some studies have shown that teleworking might be harmful to health (see Tavares 2017), with worsening mental health as one possible risk due to the isolation resulting from reduced social interaction and communication. Cooper and Kurland (2002) found that work efficiency is reduced as a result of deteriorating mental health.

3. Background

In Japan, telework has often been discussed from the perspective of work–life balance, with one of the more serious challenges in the Japanese economy concerning the typical long working hours of employees. The annual total of working hours for regular employees in Japan amounts to around 2,000 hours (MHLW 2019). Moreover, Japanese workers not only tend to work long hours but have long commuting times. Labor reform in this area is thus thought of as bringing a number of advantages, such as less mental illness, more efficient work, and a better work environment. Importantly, considering the drastically declining labor force in Japan, it is considered important to promote such work reforms to help more women and the elderly into active employment.

In 2013, then Prime Minister Abe adopted a range of economic reforms, dubbed "Abenomics," one of which was labor market reform. In August 2016, the Ministry for Work Style Reform was newly established, and in September 2016, the Council for the Realization of Work Style Reform was set up. The reform aimed to reduce long working hours and to promote work efficiency for a better work–life balance. The Council discussed nine detailed issues regarding the labor market and work environment, one of them being the promotion of teleworking, which is considered a key tool in this reform. In 2017, 24 July was declared as "telework day," and more than 900 companies and organizations and 63,000 workers joined the government campaign for a trial of telework use. In April 2019, the Labor Standards Act, which was enacted in 1947, was revised for the first time in history. The revised law promotes shorter working hours and allows for the introduction of a flexible working system.

In sum, since 2016, the Japanese government has campaigned for teleworking along with other reforms, which has gradually drawn the attention of Japanese society. Many companies and organizations have introduced telework associated with a new employment

(37.2 hours per week). Furthermore, female teleworkers worked fewer hours than their male counterparts.

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system such as flexible working time. Some companies in Tokyo made plans to use telework during the Tokyo 2020 Olympic Games to reduce traffic congestion during events. However, despite these initiatives, telework is not yet widespread in Japan, with lower rates of telework than in other developed countries.

In 2020, the COVID-19 pandemic drastically changed the situation. Telework is now thought of as a useful tool to avoid infection and sustain economic activity. Workers are allowed to use telework, and some have either fully switched to home-based teleworking or increased their teleworking hours.

In September 2020, admitting that Japanese society largely lags behind in the digital world, Prime Minister Suga announced a plan to form a new government agency, called the Digital Agency. This new institution is aimed at promoting digitalization for Japan to catch up with other countries in terms of the digital economy. This would help the spread of teleworking and change the work–life balance.

4. Data

During the COVID-19 pandemic, a unique survey on teleworking was conducted by Keio University/NIRA in April 2020 (first wave) and June 2020 (second wave). The survey was named "Questionnaire Survey on the Effects of the Spread of COVID-19 on Telework-based Work Styles, Lifestyle, and Awareness." The sample for the survey is workers living in Japan. The sample size in the first wave was 10,516 workers, of whom 8,407 responded in the second wave. The questionnaire asks about employment status, living situation, and changes in work–life balance as of January, March, and June 2020.[4]

Telework generally refers to an ICT-based mode of working that is not bound by time and space. Furthermore, in the survey and in this paper, telework is defined as working at a specific place (at home or in a public facility) for a specific number of hours using ICT. Thus, our definition does not include ICT-based mobile work such as the use of ICT devices in stations, airport departure lounges, public transportation (buses and trains), cafés/restaurants, and on the premises of clients.

The first wave was conducted in early April 2020 (i.e., before the state of emergency) and the second wave in June 2020 (i.e., after the state of emergency.) Basic questions gathered data on individual characteristics such as sex, age, income, education, residence, occupation, industrial sector, firm size of workplace, and ICT skills. The survey also asked

4 See also Okubo (2020) and Okubo and NIRA (2020a, 2020b). The survey was conducted 1–6 April and 5–18 June on a website hosted by Nikkei Research, Inc.

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about the changes from March to June in terms of working hours, leisure time, housekeeping/childcare time and parental leave, and sleeping time. In addition, we asked about mental health using the K6 index.[5]

In the survey, several questions are specific to teleworking in the COVID-19 era, such as average working hours, per-week frequency of teleworking, and starting period. Some questions are specific to the work environment and telework efficiency. The two main questions on the survey are as follows.

Question 1 (Q1): Work efficiency by teleworking
"Suppose that the COVID-19 pandemic had not occurred and you are now working as normal. Compared with this hypothetical situation, how is your per-hour performance by teleworking as of June 2020? Suppose that your work efficiency is 100 if you were working as normal (i.e., without the COVID-19 pandemic). Then, estimate your efficiency in the range of 0 to 200. For example, if your performance now by teleworking is 1.3 times your normal work efficiency, you would answer 130. If your performance were half, you would answer 50, and so on. Answer in increments of 10 only."

Question 2 (Q2): Sub-questions on task, evaluation, and work environment
"There are seven sub-questions regarding your task. Please respond with one item from 'strongly agree,' 'agree,' 'neutral,' 'disagree,' and 'strongly disagree' for each sub-question.

(1) Your task is clearly defined and well specified.
(2) Your task requires collaboration with your colleagues.
(3) Your company tends to highly evaluate workers who put in long hours.
(4) Your company evaluates outcomes (a results-based system).
(5) You can easily choose your working hours and workplace (e.g., flextime, remote working).
(6) You can easily take childcare and family-care leave without any problem.
(7) Your company has invested heavily on new ICT tools."

5. Stylized facts

Before conducting econometric analysis, some stylized facts are reported from our telework survey data.

Fact 1: The number of teleworkers has increased with the spread of COVID-19
The rate of telework use is displayed in Figure 1. The national average rate steadily increased from 6 percent in January, to 10 percent in March, 25 percent in April and May (i.e.,

5 The six-item Kessler Psychological Distress Scale as proposed by Kessler et al. (2003).

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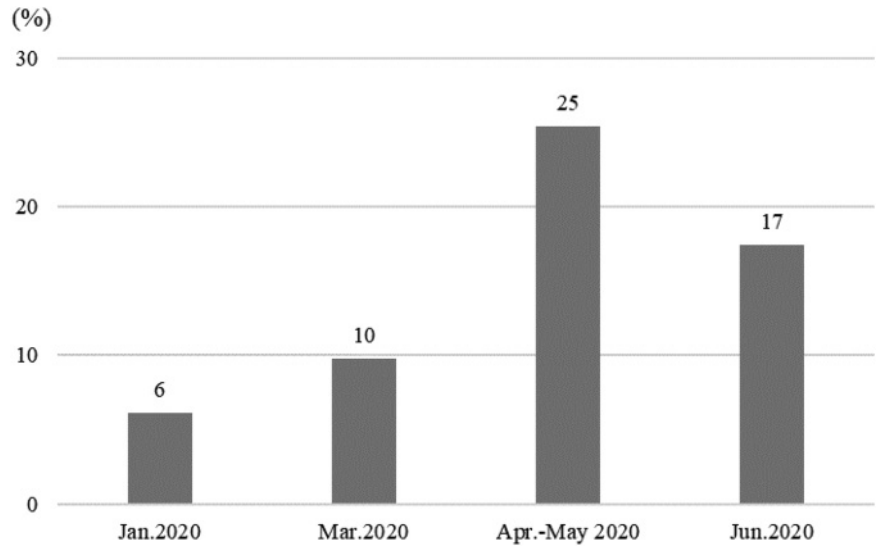
Figure 1. Share of teleworkers



during the state of emergency), and 17 percent in June. Thus, the rate increased by 11 percentage points with the spread of COVID-19.[6]

Fact 2: As of June 2020, 77 percent of teleworkers started teleworking after the spread of COVID-19, while the remainder started in response to the government campaign since 2016

Limiting our sample to only teleworkers as of June 2020, Table 1 shows the starting period of teleworking: 77 percent of teleworkers started with the spread of COVID-19 (i.e., after February 2020), 15 percent started between April 2016 and January 2020 (i.e., the period of the government campaign for teleworking), and only 8 percent started before 2016.

Fact 3: Most telework is combined with working at the office

Table 2 reports the frequency and number of working hours by telework as of June 2020. Many teleworkers combine with commuting and working at the office. On average, the number of teleworking hours per week is 23.6, and the number of working hours per week at the office is 15.9. The frequency of teleworking (for at least one hour) is dispersed. The

6 This is lower than shown in the survey by MLIT (2020) of 16.6 percent as of November 2019, but this is due to MLIT's broader definition of telework, which includes the number of workers who use ICT devices in public transportation spaces, public transportation, and the premises of business partners.

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Table 1. Basic statistics

Variable name	Definition	mean	std	min	max
Perform	Subjective work efficiency (0 to 200)	83.650	32.445	0	200
Period of starting teleworking					
Period_1	After 2020 Feb	0.770	0.421	0	1
Period_2	April 2016 to Jan 2020	0.147	0.354	0	1
Period_3	Before March 2016	0.083	0.276	0	1
Telehour	Working hours by teleworking	23.6	14.4	1	110
ICT_Skills					
No		0.034	0.180	0	1
Preliminary level		0.154	0.361	0	1
Intermediate level		0.624	0.485	0	1
Advanced level		0.188	0.391	0	1
ICT Skills	ICT skills variable used for estimations	1.967	0.690	0	3
Firm size					
1–4 employees		0.088	0.284	0	1
5–99 employees		0.204	0.403	0	1
100–499 employees		0.188	0.391	0	1
More than 500 employees		0.520	0.500	0	1
Work environment					
Task	Task is clearly specified	1.299	1.852	−4	4
Results-based evaluation	Evaluation is based on outcome	0.485	1.814	−4	4
Flextime	Flextime and on-leave for family	0.887	1.976	−4	4
ICT	Firm's ICT investment	0.261	1.076	−2	2
Changes of life in the COVID-19 pandemic					
Working time	Change of time from March to June	−0.358	0.852	−2	2
Housekeeping time	Change of time from March to June	0.245	0.696	−2	2
Sleeping time	Change of time from March to June	0.123	0.711	−2	2
Leisure time	Change of time from March to June	0.255	0.844	−2	2
Mental condition					
K6	K6 index	5.996	6.439	0	24
Sex	Male = 1 and female = 0	0.671	0.470	0	1
Self-emp	Self-employment = 1, otherwise 0	0.074	0.263	0	1
Urban	Live in the Greater Tokyo or Greater Osaka = 1, otherwise 0	0.712	0.453	0	1
Age					
10 to 29		0.129	0.336	0	1
30–39		0.204	0.403	0	1
40–49		0.271	0.445	0	1
50–64		0.323	0.468	0	1
more than 65		0.074	0.261	0	1
Education					
Univ	University degree or higher	0.722	0.448	0	1
Income					
Income	Annual income in 2019 (million yen)	6.163	4.086	0.250	21.250

Table 2. Working hours by telework

Working hours per week	Ave.
Teleworking	23.6
At office	15.9

Frequency of Telework

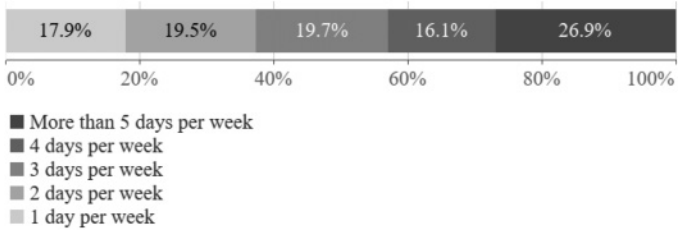

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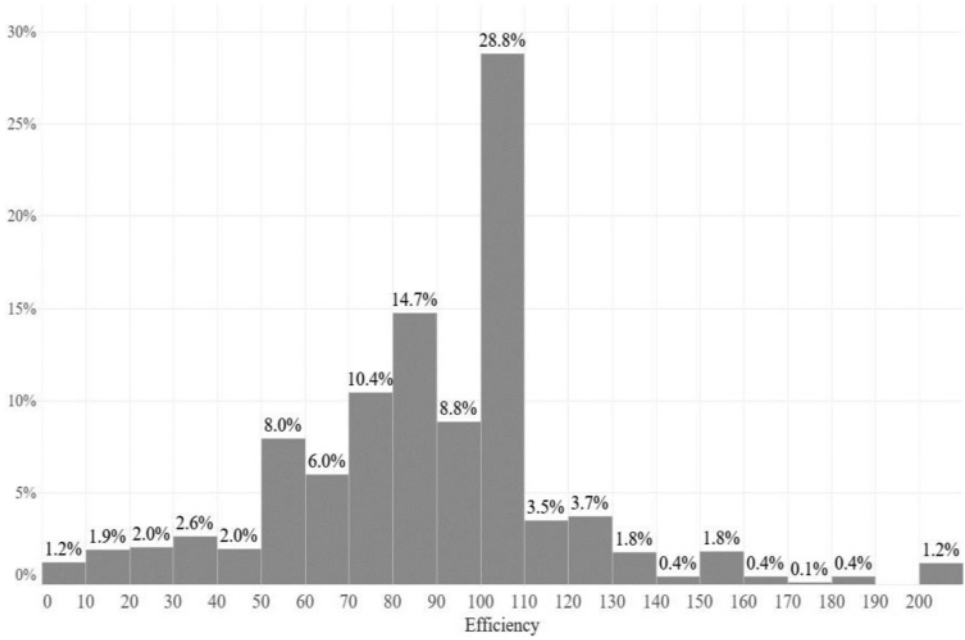
Figure 2. Efficiency distribution



bar graph of Table 2 indicates an almost equal share of each category, from one day per week to more than five days per week, ranging from 16 percent to 27 percent.

Fact 4: Teleworker performance declined by around 20 percent on average during the COVID-19 pandemic

Figure 2 displays the histograms of work efficiency using Q1 in Section 4. The distribution of efficiency ranged from 0 (the lowest efficiency) to 200 (the highest efficiency), where 100 indicates the level of efficiency if the COVID-19 pandemic had not occurred and workers worked as normal.

Figure 2 shows that teleworker efficiency reached a peak at 100 but around 55 percent of teleworkers are distributed below 100, that is, with a left-skewed distribution. The shape of distribution appears substantially asymmetric and thus far from a normal distribution; 29 percent of teleworkers maintain their work efficiency and feel little difference from working as normal (i.e., 100). The average value of efficiency is 84, meaning that work efficiency decreased by around 20 percent on average. There are two possible reasons for the decline in efficiency. First, the COVID-19 pandemic has slowed down the economy, leading to

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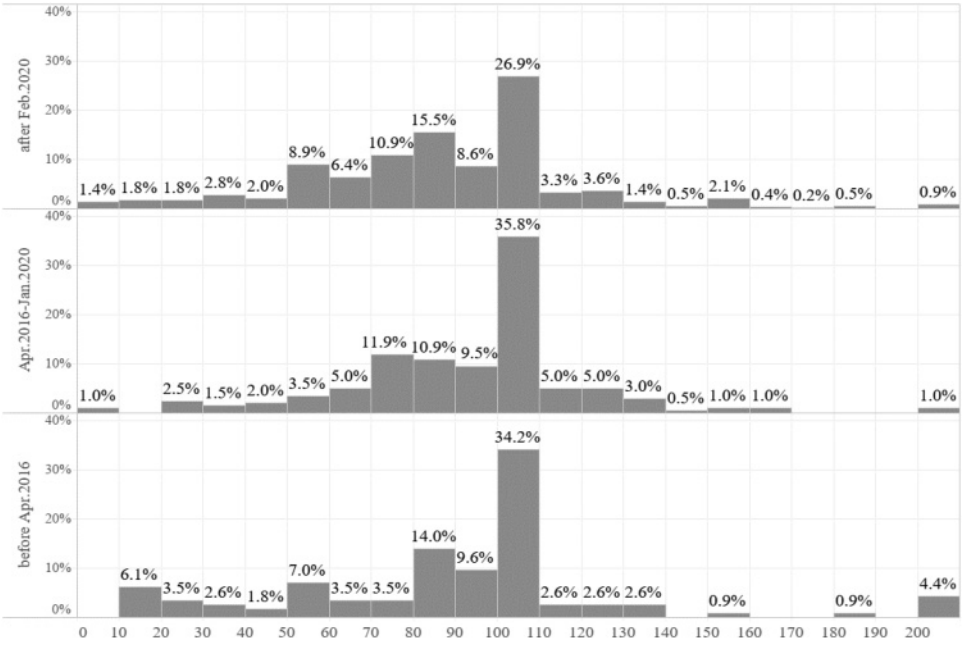
Figure 3. Efficiency distribution by starting period



fewer tasks and lower work efficiency. Second, 77 percent of workers started teleworking after February 2020 during the pandemic. Many of them were required to do so, regardless of whether their work environment and teleworking tasks were suitable. Many teleworkers might struggle with a lack of experience and barriers to teleworking such as unsuitable teleworking space and insufficient telecommunications devices, as well as the general conditions at home. This latter reason in particular might well be crucial to understanding the decline in efficiency.

Fact 5: Teleworkers with longer experience tend to maintain their work efficiency

The shape of the efficiency distribution differs according to when teleworking started. Figure 3 decomposes the distribution by the starting period. Those who started teleworking between April 2016 and January 2020 (i.e., pre-COVID-19), as well as those who started before April 2016, have tended to maintain their efficiency, accounting for around 35 percent of teleworkers in both categories (i.e., 100). The efficiency distribution of those who started between April 2016 and January 2020 shows a thinner left tail, indicating a lower variance and skewness. For example, workers with efficiency below 60 account for only 10 percent of the total. In contrast, the distribution for those who started after February 2020 is biased

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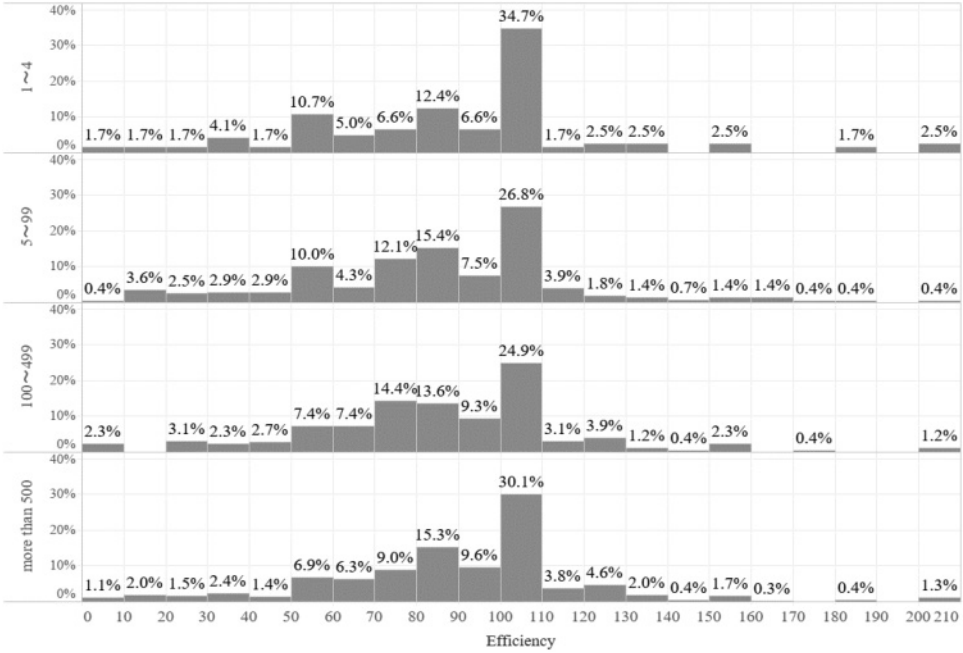
Figure 4. Efficiency distribution by firm size



more toward low values, indicating a higher variance and skewness. Only 27 percent of teleworkers maintain their efficiency (i.e., 100) while the distribution below 90 dominates the other two periods (i.e., from April 2016 to January 2020 and before April 2016). This means that compared with teleworkers before the COVID-19 crisis, new teleworkers tend to have lower efficiency with high variance and skewness.

Fact 6: Teleworkers in large firms or very small businesses tend to maintain their work efficiency

The distribution of work efficiency is also decomposed by firm size. Figure 4 shows that teleworkers in very small (1–4 employees) and the largest firms (>500 employees) are more likely to maintain their work efficiency (35 percent and 30 percent, respectively).

6. Econometric analysis and results

6.1 Teleworking experience vs. ICT skills

We now conduct three estimations. The sample is all teleworkers excluding government officers as of June 2020, giving a sample size of 1,370 in total. The first estimation

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investigates whether teleworkers' ICT skills and/or teleworking experience affect efficiency. The following equation is estimated by ordinary least squares (OLS):

$$Perform_i = \alpha + \sum_{T=1}^{3} \beta_T Period\_T_i + \gamma TeleHour_i + \eta ICT\_Skill_i + \sum_{j=1}^{4} \delta_j Size_{ji} + \zeta Sex_i + \eta Income_i + \xi Urban_i + \gamma Univ_i + \kappa Self\_emp_i + \mu_{age_i} + \mu_{ind_i} + \mu_{occ_i} + \varepsilon_i,$$

where *Perform* is teleworker *i*'s efficiency ranging from 0 to 200 as of June 2020, using Q1 in Section 4. *Period_1* to *Period_3* are dummy variables for teleworker *i*'s starting period of teleworking. *Period_1* takes one if teleworker *i* started telework from February 2020 onward, otherwise zero. *Period_2* (*Period_3*) takes one if teleworker *i* started telework between April 2016 and January 2020 (before April 2016). We note that the Japanese government has campaigned for teleworking since 2016 in a series of labor market reforms. *Telehour* denotes per-week hours of teleworking as of June 2020. *ICT_Skill* is the level of teleworker *i*'s ICT skills: no skills (taking zero), preliminary (taking 1), intermediate (taking 2), and advanced (taking 3). Then, we control for individual characteristics. *Size* denotes size category variables of the employed firm (1–4, 5–99, 100–499, and >500 employees). *Sex* is a sex dummy, where male is one and female zero. *Income* is teleworker *i*'s income in 2019. *Urban* is an urban dummy, taking one if teleworker *i* lives in the Greater Tokyo area (Tokyo, Chiba, Saitama, and Kanagawa prefectures) or the Greater Osaka area (Osaka, Hyogo, and Kyoto prefectures), and zero otherwise. *Univ* is a dummy for holding a university degree. *Self_emp* is a dummy for self-employment. μ_{age_i} is an age category fixed effect, μ_{ind_i} is an industry fixed effect, μ_{occ_i} is an occupation fixed effect, and ε is an error term.

Column 1 of Table 3 reports the results on starting period, teleworking hours, and ICT skills. *Period_2* is significantly positive, while *Period_3* is positive but not significant, given *Period_1* as reference. *Period_2* corresponds to the period of the government campaign for teleworking. Thus, this indicates that the teleworking campaign might have contributed to avoiding reduced work efficiency during the COVID-19 pandemic. *Telehour* is significantly positive. Teleworkers who work longer hours as of June 2020 tend to have higher efficiency. On the other hand, ICT skills are not significant and do not affect efficiency. Therefore, we can say that those with more teleworking experience and those who telework for longer hours tend to maintain and improve their efficiency, whereas a teleworker's ICT skills are not key to improving efficiency.

Firm size also matters. Columns 2 and 3 of Table 3 report the results on firm size. Given the very small firm size (1–4 employees) as reference, all firm size variables are significantly negative. Small or intermediate-size firms (5–99 and 100–499 employees) have larger negative coefficients. As the firm size increases, the magnitude of the coefficients decreases. This means that a firm size of 1–4 employees such as a very small business or independent

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Table 3. Estimation results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Period (Reference: Period_1)							
Period_2	5.299**		4.850**	4.346*	4.028*	5.191**	4.828**
	(2.315)		(2.329)	(2.364)	(2.379)	(2.229)	(2.238)
Period_3	3.034		2.136	2.766	2.024	3.690	2.854
	(3.733)		(3.722)	(3.735)	(3.730)	(3.440)	(3.434)
Telehour	0.163**		0.159**	0.161**	0.159**	0.098	0.097
	(0.071)		(0.072)	(0.071)	(0.072)	(0.070)	(0.071)
ICT_Skill	0.042		0.028	0.047	0.005	−0.044	−0.081
	(1.618)		(1.624)	(1.619)	(1.627)	(1.567)	(1.575)
Size (Reference: 1–4 employees)							
5–99 employees		−10.483**	−9.426**		−8.802*		−7.398
		(4.665)	(4.709)		(4.682)		(4.540)
100–499 employees		−11.828**	−10.791**		−9.959**		−9.503**
		(4.819)	(4.854)		(4.857)		(4.676)
more than 500 employees		−8.991*	−8.581*		−8.176*		−7.771*
		(4.654)	(4.693)		(4.692)		(4.532)
Work							
Task				0.172	0.306		
				(0.543)	(0.537)		
Results-based evaluation				−1.475**	−1.443**		
				(0.576)	(0.576)		
Flextime				1.216**	1.056*		
				(0.560)	(0.558)		
ICT				−0.140	−0.046		
				(1.012)	(1.026)		
Change							
Working time						6.264***	6.197***
						(1.391)	(1.391)
Housekeeping time						−0.973	−1.055
						(1.570)	(1.565)
Sleeping time						0.632	0.553
						(1.726)	(1.718)
Leisure time						0.322	0.344
						(1.379)	(1.375)
K6						−0.675***	−0.671***
						(0.182)	(0.183)
Sex	−0.702	−1.042	−0.847	−0.573	−0.695	−0.712	−0.816
	(2.214)	(2.228)	(2.215)	(2.214)	(2.216)	(2.181)	(2.182)
Urban	5.026**	5.893***	5.261***	4.986**	5.173**	3.850*	4.056**
	(2.027)	(1.997)	(2.021)	(2.022)	(2.018)	(1.982)	(1.979)
Income	0.259	0.408	0.299	0.290	0.325	0.196	0.245
	(0.314)	(0.319)	(0.316)	(0.317)	(0.318)	(0.301)	(0.303)
Univ	2.697	2.967	2.750	2.382	2.467	2.508	2.643
	(2.246)	(2.256)	(2.256)	(2.242)	(2.252)	(2.193)	(2.206)
Self-emp	−2.961	−8.740*	−8.430*	−2.583	−7.680	−1.451	−6.230
	(4.160)	(4.947)	(4.945)	(4.136)	(4.919)	(3.881)	(4.569)
N	1370	1370	1370	1370	1370	1370	1370
R-sq	0.109	0.105	0.113	0.116	0.119	0.154	0.157

Note: ***1%; **5%; *10% ( ): standard deviation. Ind, Occu, and Age fixed effects are omitted to save space.

workers (e.g., freelancers and self-employed workers) tends to see the highest efficiency in teleworking, and the largest firms (>500 employees) see the second highest efficiency. On the other hand, workers for small or intermediate-size firms (100-499 employees) have the lowest efficiency. We can interpret this as meaning that large firms tend to provide ICT tools and introduce an employment system to support teleworking. Under the labor market reform, some large firms joined the government campaign and teleworking trial, and some firms have introduced teleworking associated with a flexible employment system. In contrast, very small firms or independent workers are inherently flexible due to their

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small organization. For these reasons, both large and very small firms tend to maintain higher efficiency.

Both *Income* and *Univ* are not significant. Thus, an individual's income and education do not significantly affect teleworker performance. On the other hand, *Urban* is significantly positive, which indicates that teleworkers in the Greater Tokyo and Greater Osaka areas tend to be more efficient. In this case, the infrastructure of urban areas such as urban amenities and teleworking spaces might help maintain worker efficiency.

6.2 Work environment

The second set of estimations focuses on the effect on performance of a company's working system and circumstances for teleworking. To explore this, using Q2 in Section 4, the values of +2, +1, 0, −1, −2 are allocated to the responses "strongly agree," "agree," "neutral," "disagree," and "strongly disagree," respectively, for sub-questions (1)–(7). Then, we sum up to create four categorical variables. The first variable *Task*, the sum of sub-questions (1) and (2) in Q2, reflects the degree of clearly specified tasks and team-based tasks. A higher value of the task variable indicates that a worker's tasks are clearly specified and require collaboration with colleagues. The second variable, *Results-based evaluation*, the sum of sub-questions (3) and (4) in Q2, reflects employer evaluation. If the employer's evaluation is based on outcome and hard work, then the value is higher. The third variable, *Flextime*, the sum of sub-questions (5) and (6) in Q2, indicates the flexibility of working time including childcare and parental leave. Higher values mean more flexible working hours and greater access to family leave. The fourth variable, *ICT*, sub-question (7) in Q2, concerns a firm's ICT investment, with a higher value indicating more ICT investment in the work environment:

$$Perform_i = \alpha + \sum_{T=1}^{3} \beta_T Period\_T_i + \gamma TeleHour_i + \eta ICT\_skill_i + \sum_{j=1}^{4} \delta_j Size_{ji} + \sum_{P=1}^{4} \beta_P WORK_{Pi} + \zeta Sex_i + \eta Income_i + \xi Urban_i + \gamma Univ_i + \kappa Self\_emp_i + \mu_{age_i} + \mu_{ind_i} + \mu_{occ_i} + \varepsilon_i,$$

where *WORK* is a composition of the four variables for the teleworking environment: *Task*, *Results-based evaluation*, *Flextime*, and *ICT*. The first three variables ranged from −4, 0, to +4, and the *ICT* variable ranged from −2, 0, to +2.

Columns 4 and 5 of Table 3 report the results of the estimation. *Task* is positive but not significant and *Flextime* is positive and significant, while *Results-based evaluation* is significantly negative. *ICT* is not significant. Thus, clearly specified tasks might affect efficiency in teleworking and the flexibility of working hours contributes strongly to higher efficiency. However, results-based evaluation has a negative impact on efficiency. A firm's ICT investment does not significantly affect teleworking performance. Therefore, the key factors for higher teleworking performance are well-specified tasks, non-results-based evaluation,

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and flexibility of working hours. All other individual characteristics such as *Sex*, *Urban*, and *Income* remain same tendency as previous one (columns 1 to 3).

6.3 Work–life changes and psychological well-being during the pandemic

The third estimation concerns the effect of changes in work-life balance during the COVID-19 pandemic. The spread of COVID-19 has clearly changed our social life, such as work–life balance, as well as possibly our mental health and psychological well-being. Such changes will very likely affect teleworking performance.

Changes may involve working hours, leisure time, housekeeping/childcare time and parental leave, and sleeping time in the period March–June 2020. If each time allocation increases (decreases), the variable takes 1 (−1), and no change takes zero. In addition to the change in time allocation, the mental health condition is expressed as the K6 scale index. The scale has been widely used as a screen for mental health problems and as a measure of the severity of impact of mental health problems. The K6 index is based on the sum of six questions on distress, with a higher value indicating higher levels of anxiety and unease, and a more unstable mental condition. The following equation is estimated by OLS:

$$Perform_i = \alpha + \sum_{T=1}^{3} \beta_T Period\_T_i + \gamma TeleHour_i + \eta ICT_i + \sum_{j=1}^{4} \delta_j Size_{ji} + \sum_{l=1}^{4} \beta_l Change_{li} + \lambda K6_i + \zeta Sex_i + \gamma Univ_i + \eta Income_i + \xi Urban_i + \kappa Self\_emp_i + \mu_{age_i} + \mu_{ind\,i} + \mu_{occ\,i} + \varepsilon_i,$$

where *Change* is composed of four variables on life changes: working hours, leisure time, housekeeping/childcare time and parental leave, and sleeping time. If workers spent much longer, longer, no change, shorter, and much shorter time on these activities in June than in March, the values take 2, 1, 0, −1, −2, respectively. *K6* denotes the index of K6, with higher values indicating poorer mental health.

Columns 6 and 7 of Table 3 report the results. *Working hour* is significantly positive, with teleworkers who increased their working hours from March to June tending to increase efficiency. Although the variable is not significant, longer housekeeping/childcare time and parental leave cannot increase teleworkers' efficiency. To do so, more hours need to be spent teleworking. *K6* is significantly negative; clearly, a poor mental health condition reduces efficiency.

7. Conclusion

Although teleworking was not widespread in Japan in the pre-COVID-19 era, the pandemic has clearly promoted teleworking at home. However, there are some impediments to teleworking, many of which reduce efficiency. This paper investigated teleworker efficiency using a unique Keio/NIRA survey on telework. We find that on average teleworker

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efficiency reduced by around 20 percent during the COVID-19 pandemic, although those who had already started teleworking between April 2016 and January 2020 tended to maintain their efficiency. Teleworker efficiency is significantly affected by experience and the number of teleworking hours rather than by workers' ICT skills, income, or education level. Furthermore, teleworking efficiency is positively affected by the work environment (e.g., clearly specified tasks and a flexible working time system), work–life changes during the pandemic (e.g., working hours), and good mental health.

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