Institute for Economic Studies, Keio University

Keio-IES Discussion Paper Series

コロナ禍の日本におけるテレワークの利用

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2021 年 8 月 18 日
DP2021-015
https://ies.keio.ac.jp/publications/14419/

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18 August, 2021

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IES Keio DP2021-015
2021 年 8 月 18 日
JEL Classification: J50
キーワード: テレワーク; コロナ感染症; テレワーク就業可能性; 仕事; 職場環境

【要旨】
コロナ禍におけるテレワークの利用について就業者調査に基づいて分析した。就業者の基本特性、仕事の特性、職場環境、就業規定(フレックス制など)が大きくテレワークの利用に影響している。さらに、様々なITツールの利用、コロナ禍での企業の経営改革への取り組みやデジタルオフィスの推進、政府の推奨するテレワーク推進への取り組み(全社的なテレワーク推奨、時差通勤など)も大きくテレワークを推進している。

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Telework in the spread of COVID-19

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Abstract

In the spread of coronavirus disease (COVID-19), people have been requested to work from home with information and communication technology (ICT) tools, i.e. telework. This paper investigates which factors (infection of COVID-19, individual characteristics, task characteristics, working environments, and COVID-19 countermeasure policies) are associated with telework use in Japan. Using the unique panel survey on telework, we construct occupational indices for teleworkability and the risk exposure to infection. Our estimation finds that although telework use remains low in Japan, educated, high ICT-skilled, younger, and female workers who engage in less teamwork and less routine tasks tend to use telework. Working environments such as the richness of IT communication tools, digitalized offices, flexible-hour working systems, and company-wide reform for teleworking can all promote telework use.

Keywords: telework, COVID-19, teleworkability, survey, tasks, working environments

1 Introduction

In the pandemic of coronavirus disease (COVID-19), people have been requested to work at home and refrain from commuting. Telework, i.e. working at home with information and communication technology (ICT) tools, has drawn considerable attention as an effective countermeasure against infection. However, some impediments hamper the use of telework for some workers. Telework is suitable for some workers (e.g. highly educated young workers) as well as some occupations (e.g. IT engineers and high-skilled freelancers). For a variety of reasons, some countries such as Japan have observed a low percentage of telework utilization. This paper studies telework in Japan with regards to the COVID-19 pandemic.

Japan's approach to infection control is unique. Rather than instituting a complete lockdown or attempting to control the population with penalties and sanctions by laws, the Japanese government has imposed much less restrictive legal requirements and no penalties, restrictions, or sanctions, and instead has sought voluntary co-operation from the public (Aoki, 2021). To contain the surge of waves of COVID-19, Japan has imposed voluntary request-based lockdown (the so-called soft lockdown) a few times, which is unheard of among the developed nations. Despite that, the number of infections has been kept lower than in many other developed countries (Iwasaki and Grubaugh, 2020). By contrast, telework use in Japan remains low. Using unique data on the individual-level surveys, this paper uncovers which factors trigger workers to use telework under such soft lockdown, individual traits (e.g. age, income, education, and ICT skills), task characteristics (e.g. routine work), working environment (e.g. flexible working hours and company-wide reform for employment working system), as well as new cases of infection and individual's countermeasures (e.g. social distancing and avoiding commuting).

Before the pandemic of COVID-19, telework was drawing attention as means of improving work styles and quality of life in the digitalized economy (Gajendran and Harrison, 2007; Bloom et al., 2015; Dutcher, 2012; Gimenez-Nadal et al., 2019). Although the mechanisms that will fully enable telework are not yet in place, it is regarded as a means of increasing work efficiency by reducing commuting (Helminen and Ristimäki, 2007; Mitomo and Jitsuzumi,1999; Haddad et al., 2009) and increasing flexibility in working hours (Coenen and Kok, 2014), giving workers more time for their daily lives (Di Martino and Wirth, 1990; Tremblay,

2002; Baines and Gelde, 2003; Wheatley, 2012; Kazekami, 2020).

While previous efforts were to promote telework to enable better work styles, telework is now promoted as a countermeasure against the spread of COVID-19 infection. The government has requested workers to exercise self-restraint in staying home and has sought to promote telework. The number of new infections of COVID-19 can be pointed to in which telework has been introduced at the request of employers. By contrast, it may also be the case that some occupations and tasks are suited for teleworking, and some working environments and regulations allow workers to use teleworking. Telework use has increased over the world in the pandemic. In the United States, those who work from home increased from 8% in February 2020 to 35% in May 2020 (Bick et al., 2020). According to Eurofound (2020), 37% of workers began to telework in Europe in response to the spread of COVID-19. Alipour et al. (2020) found that the rate of teleworkers comprises 20–50% in Europe. In Japan, the rate increased from 6% in January to 17% in June 2020 (Okubo, 2020).[1]

Further investigations are being conducted by several researchers on telework using unique labour surveys. Telework reduces worker's efficiency (Bartik et al., 2020; Morikawa, 2020; Okubo et al., 2021) but tends to be used by higher-income workers (Mongey et al., 2020; Sostero et al., 2020) and younger and male workers (Adams-Prassl et al., 2020). In the long run, telework will promote income inequality and benefit male and educated workers (Bonacini et al., 2021).

More analytically, the crucial issue is how many jobs can be carried out at home. Some current studies found that working at home is potentially suitable for some specific occupations. Dingel and Neiman (2020) identified which occupations are potentially suitable for remote work.[2] They precisely defined which occupations could be performed entirely at home and estimated how much of the population could possibly work from home using job characteristic information on O*NET and the US Bureau of Labor Statistics data. They found that 37% of workers could possibly perform their jobs entirely at home in the United States.[3] Likewise, some studies in other countries estimated possible jobs for remote work and found that 24% of the jobs in Italy (Boeri et al., 2020) and 39% of the jobs in Norway (Holgerson et al., 2021) are possible to be performed at home.

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[1] According to Gottlieb et al. (2021), the share of workers who work from home in urban areas is 20% in poor countries and 40% in rich countries.

[2] Similarly, using the Surveys of Adult Skills of PIAAC and STEP in 53 countries, Hatayama et al. (2020) estimated jobs' amenability to working from home and then constructed a work-from-home index.

[3] Subsequently, Alon et al. (2020), Leibovici et al. (2020), and Su (2020) identified the jobs that could be done from home based on O*NET.

Our contribution is threefold. First, the literature on a relationship between such estimated occupation-level suitability for remote work and actual telework use is relatively unknown. Previous studies propose suitability for remote work at occupation level based on task information such as O*NET, but do not fully investigate how such occupational suitability results in the actual use of telework and which factors other than occupational suitability would crucially affect actual use of telework. This paper fills this gap. Exceptionally, Adams-Prassl et al. (2020), using a unique survey conducted in the US and UK, found that the tasks that could be done from home in the spread of COVID-19 are highly correlated with extant task measures for the feasibility of working from home. Our paper is in this line.

Second, this work contributes to the literature by calculating occupation-level teleworkability and risk exposure to COVID-19, based on our survey. Dingel and Neiman (2020) constructed a remote workable index and Aum et al. (2020) constructed a risk exposure index, based on task information on O*NET. By contrast, our survey is designed to directly ask respondents whether telework is suitable for their tasks and whether they feel the risk of infections of COVID-19 at the workplace.

Third, four waves of surveys are conducted with 10,000 workers in Japan amidst COVID-19 with the help of Keio University and NIRA(Nippon Institute for Research Advancement). In the literature of telework, most studies conduct experiments (e.g. Battiston et al., 2018; Bloom et al. 2014) or small surveys or interviews on a certain company or group. Our survey involved much larger sample and asked various questions regarding respondents' attitudes to teleworking, working environments, and tasks.

This paper addresses the following questions: to what extent telework is used in Japan in the spread of COVID-19, whether occupation-based suitability of telework can fully explain actual telework use, and how working environments and task characteristics affect telework use. There is an advantage to study the case of Japan. The Japanese infection control measures never exercise sanctions and penalties by law and follow request-based policy. Due to the soft lockdown, people are requested to use telework voluntarily. Some can use telework to prevent the spread of infection, while many workers are allowed to commute as usual. Therefore, this allows us to rigorously investigate which factors affect worker's telework use.

We find several results. First, telework use in Japan remains low. Some

industries and occupations are suitable for telework (e.g. information processing, finance, and insurance), while some are not (e.g. food services, hotel accommodation, doctors, and nurses). Second, female, educated, and younger workers with higher income tend to use telework. Occupational indices for teleworkability and risk exposure are associated with telework use. Third, persons with higher ICT skills and carrying out fewer routine tasks tend to use telework. The workers under flex-time employment system and with a wide variety of available ICT tools tend to use telework. Company-wide organizational reforms in the spread of COVID-19 also promote telework.

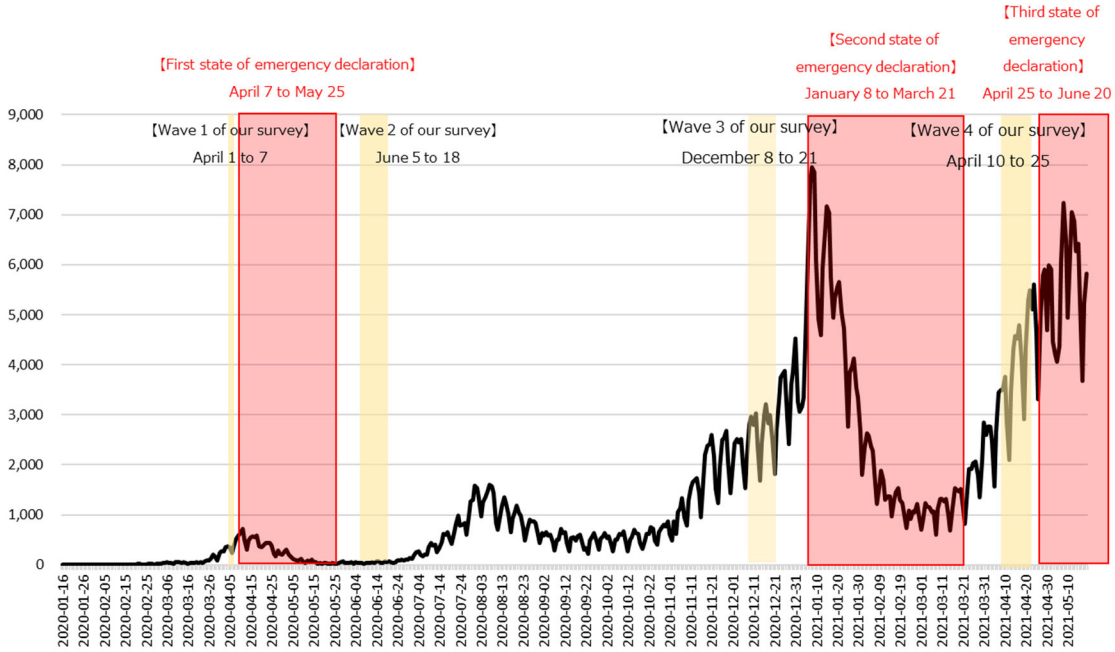
The remainder of this paper is structured as follows. Section 2 describes some narrative facts on the pandemic of COVID-19 and telework in Japan, and Section 3 provides data and stylized facts. Then, some indices for teleworkability and variables are constructed in Section 4. Sections 5 and 6 provide some estimation results. Finally, Section 7 concludes the paper.

2 COVID-19 and Telework in Japan

The COVID-19 virus commenced its worldwide spread in February 2020, and the WHO declared it a pandemic on 11th March 2020. Figure 1 plots the number of daily new cases of infections in whole Japan with state of emergency and timing of our survey (four waves). In the burgeon of the spread of the COVID-19, the Japanese government declared a state of emergency on 7th April 2020. The government urged people to avoid the non-essential trips, to work from home, and to use telework as much as possible, and requested retail shops, department stores, and restaurants to shut down or shorten business hours. Schools, public facilities, and amusement facilities were closed. Economic activity was slowed down, but the lockdown by the state of emergency was soft. Thus, the economy did not completely stop: the public transport system worked as normal, and some people were allowed to commute.

After the first state of emergency was lifted on 25th May, economic activity resumed. In response, in June 2020, the Ministry of Health, Labour, and Welfare announced daily life guidelines against COVID-19, called ‘New Life Style’. These are non-pharmaceutical interventions (NPIs). In the guidelines, the government notified the public about how to use the mask, avoid mass gatherings, and follow social distancing. The public followed the guidelines and took several measures.

Figure 1 Daily number of new infections in Japan



Then the government shifted its focus from the pandemic strategy of reducing the spread of new COVID-19 infections to a strategy focused on economic countermeasures. To recover the economic downturn in particular hotel and accommodation, on 22nd July 2020 the government initiated ‘Go To Travel Campaign’ to cover some percentage of domestic travel expenses. Subsequently, ‘Go To Eat Campaign’ was launched, which covers some eating-out expenses in restaurants and eating/drinking places. Although the second wave of COVID-19 hit Japan in August and September 2020, the number of new infections gradually decreased after reaching the peak in early August without declaring a state of emergency mainly due to people’s countermeasure to reduce infections. The government policy ‘Go To Travel Campaign’ remained in the second wave of COVID-19. However, in December 2020, as the third wave surged, the government again shifted its focus from a strategy focused on economic countermeasures to one of containing the spread of new infections. Finally, on 15th December 2020, the government stopped the ‘Go To Campaign’ policy.

On 8th January 2021, the second state of emergency was declared. This was again ‘soft’ lockdown, and there were no restrictions on rights or penalties for noncompliance with government ordinances. The second state of emergency was much milder than the first one. The declaration was applied to 11 out of 47

prefectures. The requests were made to the restaurant industry to reduce working hours rather than shut down, and schools, public facilities, and department stores remained open. It was not certain that these measures will be sufficient to control the spread of infections going forward. Thus, the number of infections in the third wave was much larger than in the first and second waves (7,880 new infections at the peak of the third wave; see Figure 1). Although the second state of emergency was lifted on 21st March 2021, a further spread of infection was not curbed, and the third state of emergency was declared on 25th April 2021 due to the fourth wave.

3 Data and Stylized Facts

3.1 Data and definition of telework

We use the COVID-19 survey on telework use by workers conducted by NIRA and Keio University entitled 'Questionnaire Survey on the Effects of the Spread of COVID-19 on Telework-based Work Styles, Lifestyle, and Awareness' (Okubo and NIRA, 2020a,b,c, 2021). The survey asked about individual's characteristics and working environments. There were four waves of the survey: March (first wave of the survey), June (second wave), and December (third wave) 2020, and April 2021 (fourth wave). The panel data were composed of four waves. The sample size in the first, second, third, fourth waves was 10,516, 12,138, 10,523, and 9,796, respectively. Many respondents continuously joined the survey for several waves.[4] As shown in Appendix Table 1, 5,384 respondents in the whole sample repeatedly joined the survey for all waves, in which 51% of respondents in the first wave survived. In the second and third waves, 3,731 and 1,322 joined the survey as a new sample. Out of 3,731, 2,010 respondents repeatedly joined all waves after the second wave. Likewise, out of 1,322, 988 respondents joined all waves after the third wave.

Our surveys are conducted between waves of infections and the state of emergency. In Figure 1, the survey periods are shaded yellow, and the states of emergency are shaded red. March 2020, the timing of the first wave of the survey,

[4] The survey was conducted on a website constructed by Nikkei Research Co. The survey takes a stratified random sampling strategy. Japan is stratified into five regions by regional classification and six age groups for each gender (12 age groups per region). The number of samples for 60 region-age groups is determined by population ratio. The Population Census (Ministry of Internal Affairs and Telecommunication) is employed as sampling unit. The survey intends to construct the panel structure and thus keep the same respondents over waves as much as possible. Some respondents repeatedly join the survey and some do not. Thus, new respondents are added to fill in the allocated number of samples in each unit. See Appendix Table 1.

is the early period, before the first state of emergency when COVID-19 was not yet spread in Japan.[5] June 2020, the timing of the second wave of the survey, is the period after the first state of emergency was lifted and the first wave of COVID-19 was contained. December 2020, the timing of the third wave of the survey, is the period after containing the second wave of COVID-19. However, the new cases of infections gradually increased, which is the initiation of the third wave of infection. April 2021, the timing of the fourth wave of the survey, is after the second state of emergency was lifted and the third wave of infection was contained but not fully contained and the new cases of infections continued at a high level.

Importantly, telework in our survey and paper is defined as follows. In general, telework refers to a way of working using ICT tools. However, we adopt a stricter definition. We define telework as working at a specific place (at home or in a public facility) for certain hours. Our definition, therefore, does not include the use of ICT devices at locations such as stations, airports, transportation facilities, and the premises of business partners. In addition, our definition does not include work from home without ICT devices. Although previous studies often use remote work, telework defined in our paper is more limited in the sense of not only working remotely but also using ICT devices.

3.2 Stylized facts

3.2.1 Telework use

In the survey, respondents were asked whether they use telework. Figure 2 presents telework rate over time.[6] The green line indicates national average, and the blue line indicates Greater Tokyo (Tokyo, Kanagawa, Chiba, and Saitama prefectures). In January 2020, before the widespread emergence of COVID-19, the national average of telework was only 6%, and the average for Greater Tokyo was about 10%.[7] In response to the first state of emergency from April to May 2020, the telework rate drastically increased, reaching 25% nationally and 38%

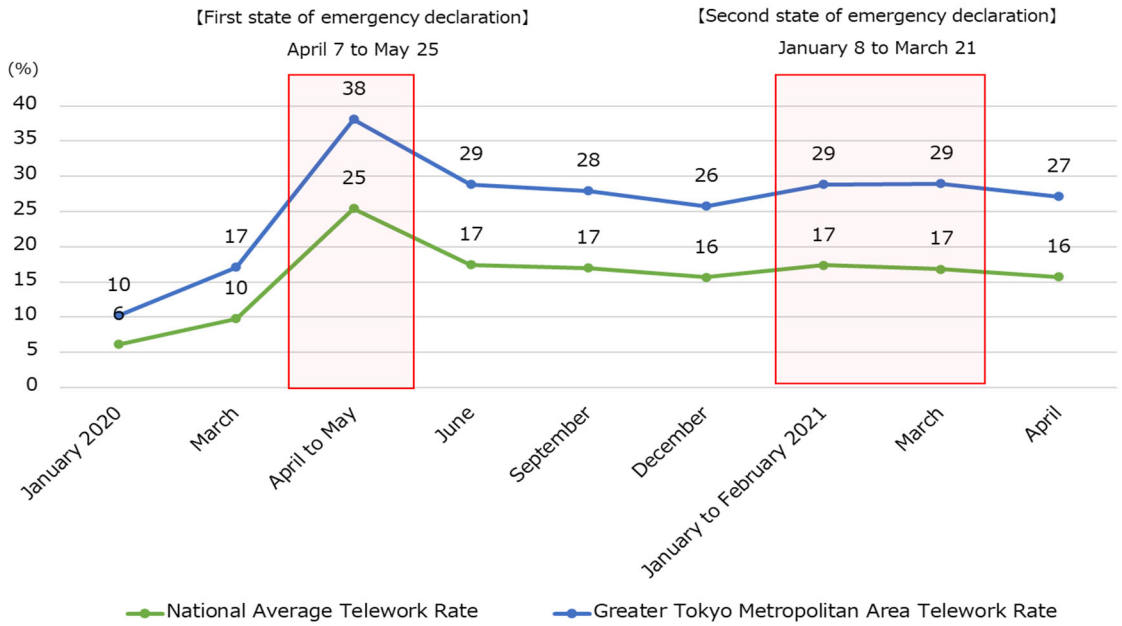
[5] The investigation period of the first wave was from 1st to 6th April, but the survey asks the situation as of March 2020.

[6] Each wave of the survey asks for telework use at multiple time points. January and March 2020 are covered by the first wave of the survey, April–May (under the first state of emergency) and June 2020 are covered by the second wave of the survey, September and December 2020 are covered by the third wave of the survey, and January–February, March (under the second state of emergency), and April 2021 are covered by the fourth wave of the survey.

[7] This is lower than the survey by MLIT (2020), 16.6% as of November 2019 due to MLIT's broader definition of telework. MLIT's definition includes the number of workers who use ICT devices at public transportation spaces, transportation facilities, and the premises of business partners.

in Greater Tokyo. However, after the first state of emergency was lifted in June 2020, the telework rate largely declined. Nonetheless, although the rate has remained lower than that seen during the first declaration of a state of emergency, it has remained higher than pre-COVID-19 pandemic levels, January 2020, and has stabilized with the second wave of the COVID-19 pandemic that began in September 2020, and even more so with the third wave that began in December 2020. Throughout this period, the telework rate has gradually declined from 17% to 16% nationally and from 29% to 26% in Greater Tokyo. When the second state of emergency was declared in January 2021, the telework rate slightly increased (17% in the national average and 29% in Greater Tokyo). However, once the second state of emergency was lifted in April 2021, the telework rate returned to the pre-second state of emergency (16% in whole Japan and 27% in Greater Tokyo). In sum, telework use in Japan remains low regardless of a large increase under the first state of emergency and does not see an over-time increase in the era of the COVID-19 pandemic.

Figure 2: Telework use in Japan



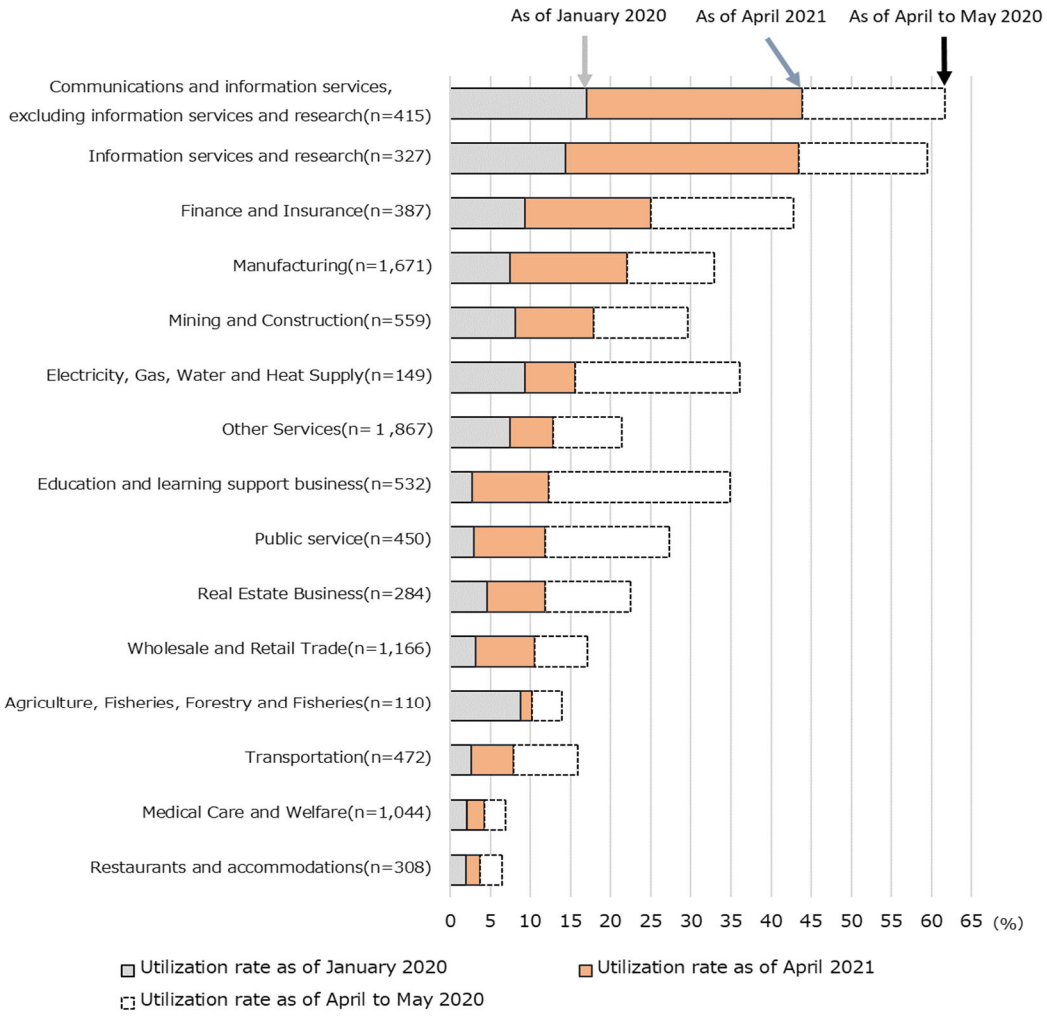
National (January & March 2020: n=10,516, April to May and June: n=12,138, September & December: n=10,523, January to February 2021 & March & April: n=9,796)
Greater Tokyo Metropolitan Area (January & March: n=3,467, April to May and June: n=4,049, September & December: n=3,514, January to February 2021 & March & April: n=3,261)

3.2.2 Telework use by industry and occupation

Figure 3 shows over-time changes in the telework rate by industry. The rate of

telework in almost all industries has increased in the spread of COVID-19 and reached the peak in April–May 2020 under the first state of emergency and then declined and hovered at a certain rate. There are some significant disparities in the telework rate by industry, and there is a particularly large gap between those industries most suitable for telework and those that are less so. For example, the telecommunications and information industries have steadily increased telework and have high rates of telework use (17% in January 2020, 61.6% in April–May 2020, and then 46.3% in April 2021), while face-to-face services such as restaurants and accommodations (2%, 6.5%, and 4%, respectively) and medical care and welfare industries (2.1%, 7%, and 4.4%, respectively) have seen consistently much lower rates, the trend that has not changed over time.

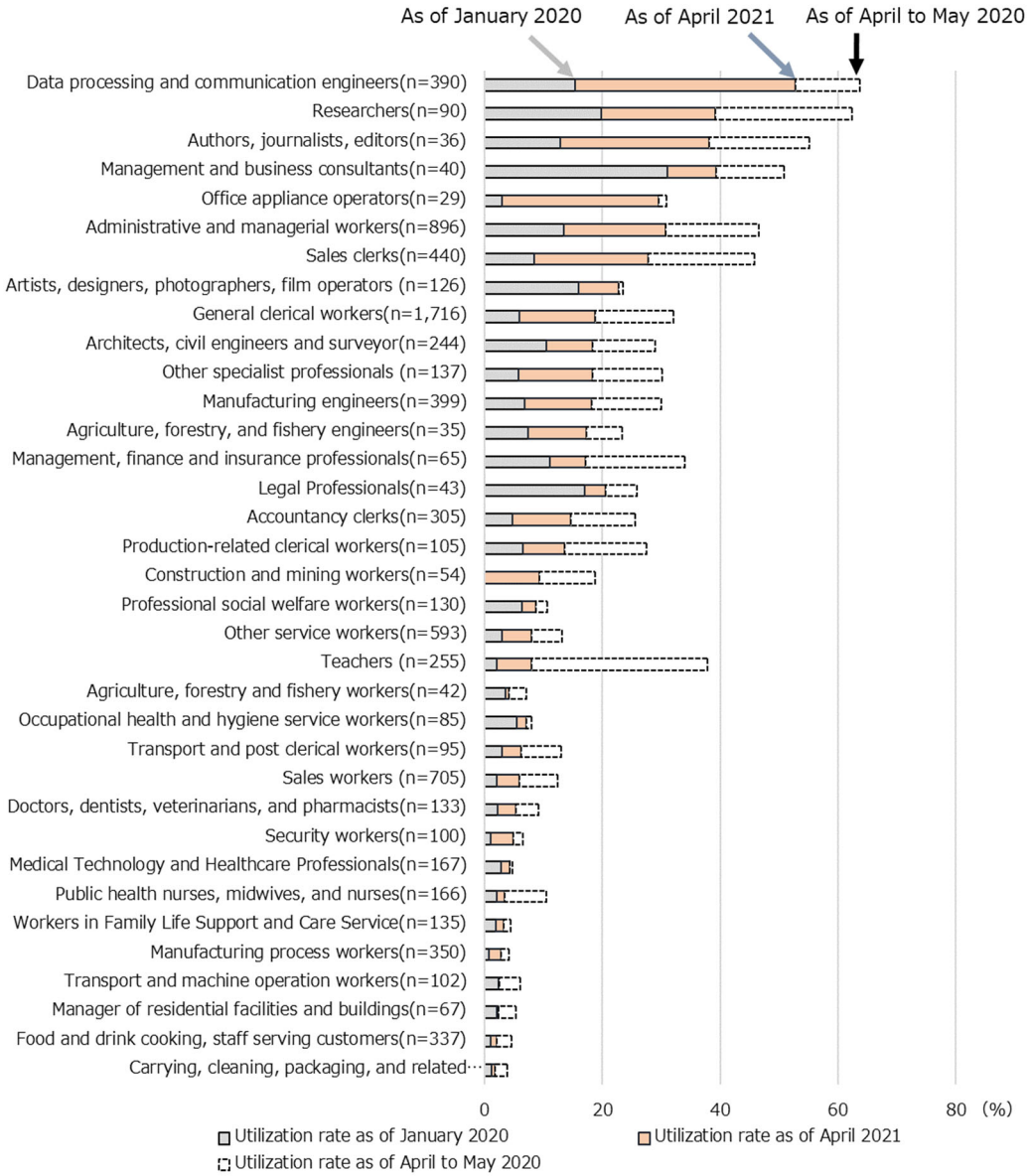
Figure 3: Telework use by industry



Note: The sample size for each industry as of April 2021 is shown in parentheses.

With regards to the occupation (Figure 4), data processing workers (15.3% in January 2020, 63.6% in April–May 2020, and then 53.6% in April 2021), management consultants (36.1%, 50.9%, and 39.3%, respectively), and researchers (19.8%, 62.4%, and 40.9%, respectively) display high rates of utilization of teleworking, while doctors, dentists, veterinarians, and pharmacists (2.1%, 9.2%, and 5.4%, respectively), carrying, cleaning, packaging, and related workers (1.2%, 3.8%, and 1.9%, respectively), and food and drink/cooking and customer service workers (1%, 4.6%, and 2%, respectively) display low rate.

Figure 4: Telework use by occupation



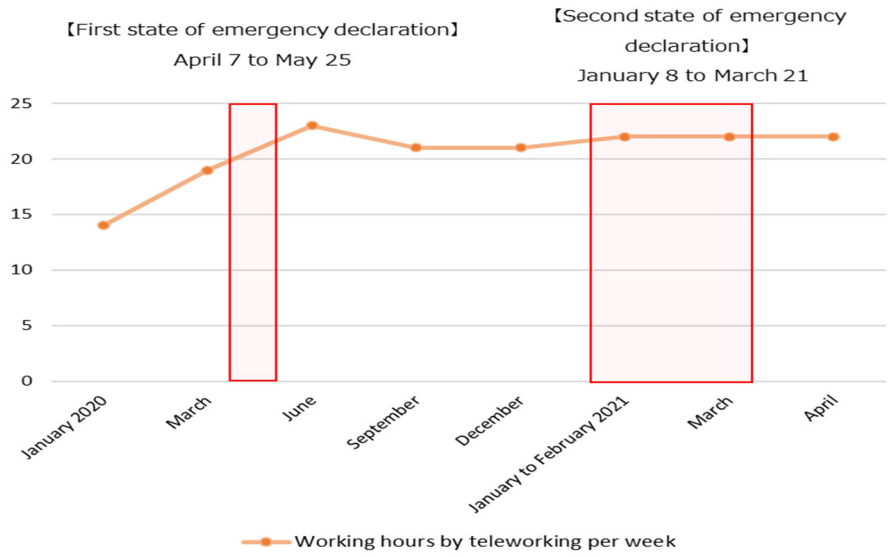
Note: The sample size for each occupation as of April 2021 is shown in parentheses.

These facts indicate that industries and occupations related to information services have a comparatively high rate of the utilization of telework, while telework is not suited to face-to-face services and manual labour industries. This implies that whether to use telework highly hinges on occupational and industrial characteristics.

3.2.3 Teleworking hours and frequency

Now we focus on teleworkers' behaviours. Figures 5 and 6 display per-week teleworking hours and frequency for teleworkers, respectively. Compared with telework use in Figure 2, there are some contrasts. After the first state of emergency, while the use of telework largely declined, the decline in telework hours was smaller, and frequency of teleworking has increased since September 2020.

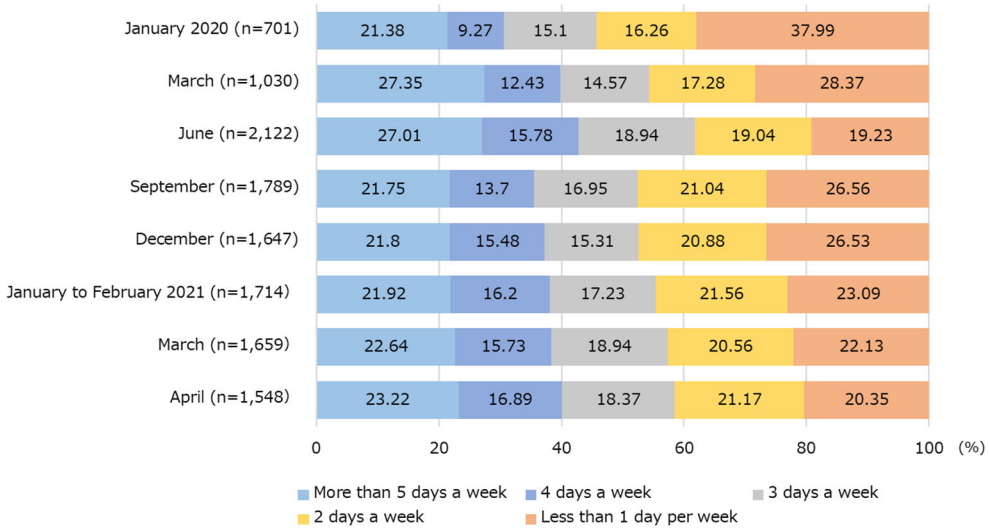
Figure 5: Working hours by teleworking per week



As shown in Figure 5, average per-week telework hours largely increased from January 2020 and peaked at 23 hours per week in June 2020 and then slightly declined and hovered around 21–22 hours per week. A slightly different trend can be observed in the per-week frequency of teleworking. Figure 6 shows how often teleworkers use telework (even in a short time). The number of workers teleworking for more than 3 days per week (i.e. 3, 4, and more than 5 days)

increased and reached a peak (61.7%) in June 2020 and then dropped to 52.4% in September 2020. However, since September 2020, it gradually increased again (55.3% in January and February and 58.5% in April 2021). By contrast, workers teleworking for less than one day per week (1 day per week or a few times per month) accounted for 26.5% in September and December 2020, but steadily declined to 23% in January and February and 20.4% in April 2021.

Figure 6: Telework frequency



Accordingly, teleworkers have been using telework more frequently but for a shorter period of time around since September 2020, maintaining the same level of total teleworking and working hours. Teleworkers might seek the best combination of teleworking and commuting over time. In general, it is known that the relationship between telework hours and job satisfaction is inverse U-shaped (Golden and Veiga, 2005). Moderate level of telework hours is optimal for worker satisfaction. As shown in Figure 6, many teleworkers have been seeking a moderate level of teleworking after September 2020 in the spread of COVID-19.

4 Constructing Variables on Working Environments

4.1 Teleworkability and risk exposure indices

Two occupation-level indices are constructed from our survey, the so-called teleworkability index and infection risk index. Our occupation category follows 38

occupation classifications, based on the middle classification of Japan Standard Occupational Classification.

4.1.1 Teleworkability index

We measured the feasibility of teleworking, taking into account suitability and impediments for teleworking. Our study is in sharp contrast with that of Dingel and Neiman (2020). First, while their index measures the number of occupations that could be performed entirely at home, our measure identifies occupations that are feasible for teleworking. Our focus is teleworking rather than remote work, in the sense of working remotely from the workplace and in addition using ICT tools. Second, they measure the feasibility of remote work based on detailed task information on O*Net, while our survey directly asks respondents about the problems faced during teleworking due to it being unsuited to their job characteristics. Working at home always involves impediments of the working environments (Bloom et al., 2015).

In the survey, all respondents were first supposed to use telework and then were asked about whether teleworking involves problems arising from it being unsuited to their occupational traits and to what extent such problems affect the feasibility of teleworking. Respondents were asked to choose one of the options: (1) no impediments at all, (2) small impediments but feasible, (3) neutral, (4) some impediments and not feasible, (5) serious impediments and not feasible, and (6) not applicable/not sure. We take answers 1, 2, and 3 as teleworkable and 4 and 5 as non-teleworkable. Then binary variable (1 = teleworkable, and 0 = not) is constructed for each respondent, and we take mean of each occupation. The index is occupational level, ranging from 0 to 1. In other words, the occupational index indicates a possible telework rate: when the workers are forced to use teleworking, how they manage to use telework even with some small impediments. Roughly, the index can be interpreted as the maximum level of telework use.

Figure 7: Teleworkability index

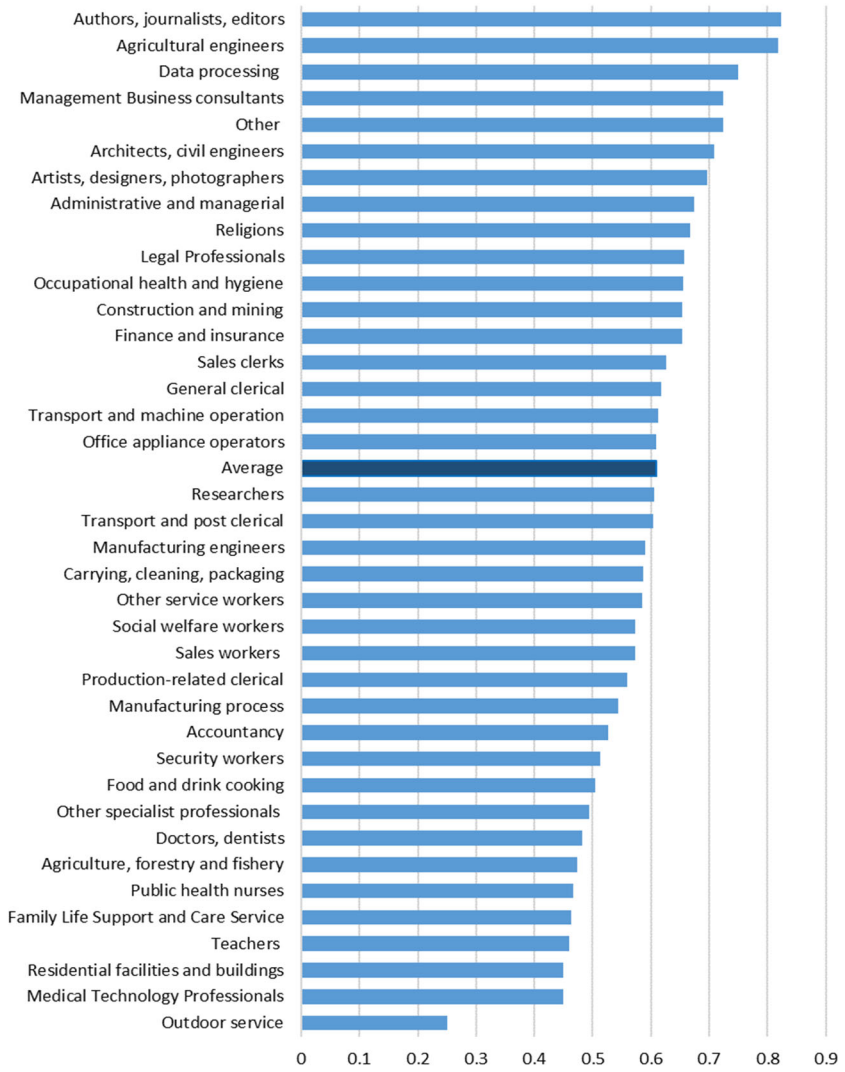
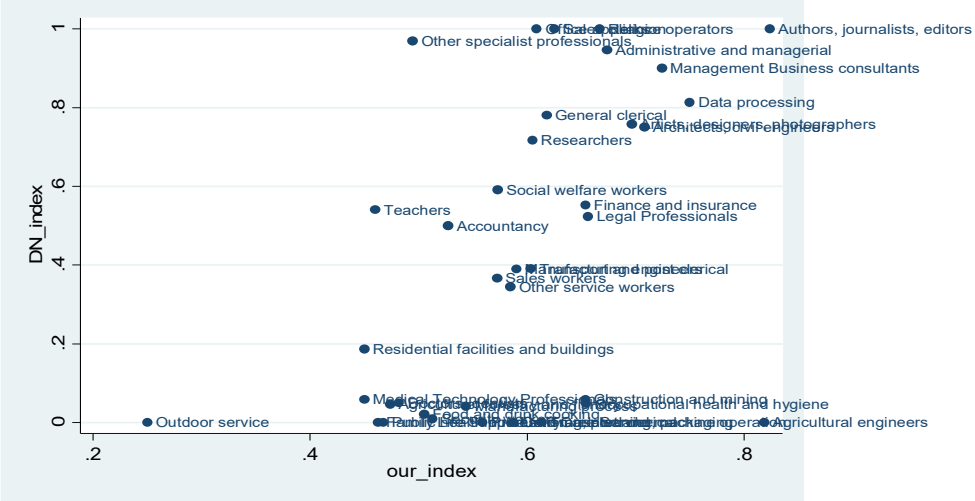


Figure 7 displays the index by occupation in the first wave of our survey in March 2020 (see also Appendix Table 3). In total, the index is 0.61. A total of 61% of workers think teleworking is possible, even though there are some impediments in the job. This implies that 61% is a feasible maximum level of telework rate in Japan. However, there is heterogeneity across occupations. Data processing workers, authors/journalists, and business consultants are in the high group (0.7–0.8), while food services, salespersons, building maintenance, doctors, and nurses are in the low group (0.2–0.5). For comparison, Figure 8 plots our measurement and Dingel and Neiman's (DN) index.[8] These have a significantly positive correlation, +0.45 (p-value = 0.002), and thus our index is

[8] We use Kodera (2020), which provided the DN index in the Japanese occupational classification.

proportional to the DN index.[9]

Figure 8: DN index and our teleworkability index



4.1.2 Risk exposure index

In doing some tasks, some workers face a high risk of infection of COVID-19. The risk thus varies across jobs and occupations. While researchers face fewer risks of infection, face-to-face service workers always face higher risks. Aum et al. (2020) constructed the occupational level measurement for the infection, based on O*NET information on 'physical proximity' and 'exposed to disease or infections' at the occupation level. By contrast, our survey directly asks respondents whether they face a risk of infection when working.

Question: Do you feel fear of infection of COVID-19 when working at your job?
Answer: Strongly agree (=5 for our calculation), agree (=4), neutral (=3), disagree (=2), and strongly disagree (=1).

We take mean values across respondents at each occupation. A large value means occupation with high exposure to infection risk, and vice versa. This question was asked in the second and third waves. To construct the index, we use the second wave (June 2020), just after the first wave of COVID-19 when the first state of emergency was lifted. The first wave of COVID-19 had spread over

[9] We regress our index on the DN index by the simple OLS, then we get

$$Our\_index = \underset{(21.42)^{***}}{0.525} + \underset{(3.34)^{***}}{0.1461}(Dingel\_index)$$

( ): t-value, ***:p < 0.1. (sample size: 37)

Japan, and thus people were fearful and sensitive to the risk of infection.

Table 1 displays the index by occupation. The average score is 2. Public health nurses (2.54), social welfare workers (2.48), doctors and dentists (2.31), and food-service workers (2.34) are placed in the highest group and tend to have high exposure to a risk of infection, while researchers, writers/journalists (1.78), manufacturing engineers (1.71), and agriculture and fishery workers (1.34) are placed in the lowest group and are exposed to less infection risk.

Table 1: Risk Exposure Index

code	Occupation	Risk Exp
1	Administrative and managerial	2.02
2	Researchers	1.89
3	Agricultural engineers	1.89
4	Manufacturing engineers	1.86
5	Architects, civil engineers	1.95
6	Data processing	2.02
7	Doctors, dentists	2.31
8	Public health nurses	2.54
9	Medical Technology Professionals	2.29
10	Social welfare workers	2.48
11	Legal Professionals	1.92
12	Finance and insurance	2.11
13	Management Business consultants	2.02
14	Teachers	2.06
15	Religions	4.00
16	Authors, journalists, editors	1.78
17	Artists, designers, photographers	1.87
18	Other specialist professionals	2.03
19	General clerical	2.18
20	Accountancy	2.09
21	Production-related clerical	2.08
22	Sales clerks	2.22
23	Outdoor service	1.92
24	Transport and post clerical	1.98
25	Office appliance operators	2.14
26	Sales workers	2.21
27	Family Life Support and Care Servic	2.25
28	Occupational health and hygiene	2.26
29	Food and drink cooking	2.34
30	Residential facilities and buildings	2.02
31	Other service workers	2.06
32	Security workers	1.97
33	Agriculture, forestry and fishery	1.34
34	Manufacturing process	1.71
35	Transport and machine operation	1.88
36	Construction and mining	2.03
37	Carrying, cleaning, packaging	1.94
38	Other	1.83

4.2 Individual-level variables for telework use: skills, task, and working environments

The individual-level variables comprise (1) ICT skills, (2) task characteristics, (3) working and employment environments, and (4) ICT tool use at the workplace. Each set of variables is given as follows.

4.2.1 ICT skills

Individual's ICT skills would affect the use of telework. The survey asks about individual's ICT skills for working. ICT skills are measured by four levels: (1) not using PC for work (=0 for our calculation), (2) introductory level (e-mail and data input by PC) (=1), (3) intermediate level (data processing, calculations, and

documentation) (=2), and (4) advanced level (development of software, programming, and network management) (=3). The item of this question follows the questionnaire in PIAAC and De la Rica and Gortazar (2016).[10] Appendix Table 2 reports basic statistics. In our data, the mean value is 1.38, and the standard deviation is 0.91.

4.2.2 Task characteristics

Task characteristics are essentially important for teleworking. The task characteristics are measured by routine task intensity (RTI), proposed by Autor et al. (2006). Our items of question on task follow De la Rica and Gortazar (2016, Table 1) (see Appendix Table 4). Tasks are characterized as abstract, routine, and manual. Abstract is defined as cognitive and interpersonal non-routine tasks, routine includes cognitive and manual routine tasks, and manual includes non-routine manual tasks. Our survey asked respondents about their job tasks (routine, abstract, and manual task), originally from the PIAAC background questionnaire. Then we follow the methodology of Autor and Dorn (2013), in which these three task measures are combined and RTI is constructed for each individual using the formula RTI = R – A – M. R, A, and M denote the values of routine, abstract, and manual task indexes for each respondent, respectively. We construct the indexes for each of three dimensions using the first component of principal component analysis. Then RTI is derived and standardized. The range of RTI is from –3.14 to +1.47 (see Appendix Table 2). The mean value of RTI for teleworkers is –0.264, and that of non-teleworkers is +0.077. Higher values mean more routine tasks, and thus teleworkers' tasks tend to be less routine than those of non-teleworkers on average.

4.2.3 Working environments

A module of our survey asks about working environments in six items on team collaboration, outcome-based evaluation, and flexible employment systems[11]:

1. Your tasks under charge are clearly specified in the team.
2. Your tasks are co-operated by the team.
3. Your workplace highly evaluates working hard without taking care of working hours.

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[10] G_Q06 in PIAAC https://www.oecd.org/skills/piaac/BQ_MASTER.HTM#G_Q06

[11] The items of the question follow Japan Household Panel Survey (JHPS/KHPS) 2019 conducted by Keio University and 'Work-life Balance Survey' by RIETI.

4. Your job evaluation is based on the outcome.
5. You can flexibly choose working hours and places.
6. You can easily take leave due to family reasons (taking care of kids and nursing elderly persons).

In each item, a respondent chooses either disagree (=1 for our calculation), weakly disagree (=2), neutral (=3), weakly agree (=4), agree (=5), or not applicable (e.g. self-employed), counted as neutral (=3).

To construct variables for working environments, we sum up to three categories, characterized by team-based working (Env A), outcome-based evaluation (Env B), and flexible working hours/holiday/on leave (Env C). Env A is calculated by taking mean of the answering values in items 1 and 2, Env B is calculated by taking mean of answers to items 3 and 4, and Env C is calculated by taking an average of the answering values in items 5 and 6. Table 2 reports basic statistics for the fourth wave. Outcome-based evaluation is low (2.95), while flexible working system and team-based task are relatively high (3.01 and 3.49, respectively). Comparing teleworkers with non-teleworkers, teleworkers report higher values in all three working environments. In particular, flexible working systems see a large gap between teleworkers and non-teleworkers (3.54 and 2.92, respectively).

Table 2: Working Environments (average scores)

	ENV A	ENV B	ENV C
	Team-based work	Outcome-based evaluation	Flexible working hours
Non-teleworker	3.475	2.903	2.915
Teleworker	3.537	3.168	3.538
Total	3.485	2.945	3.014

NOTE: The values are as of wave 4

4.2.4 ICT and digitalized offices

Many companies and enterprises have introduced several dimensions of digitalization. The survey asks whether the respondents' companies provide (1) communication, chat, and file-sharing tools, (2) digitalized office management tools (e.g. attendance management, IT accounting system, and health management), and (3) automation office (e.g. virtual office and robotic process

automation (RPA)), for regular use. In detail, the module of the question asks respondents to choose all specific ICT tools from 16 items (see Footnote 12 for details), which they usually use at the workplace.[12] Table 3 reports the percentages of use of ICT tools by teleworkers and non-teleworkers in each category. A total of 82% of teleworkers use (at least one) communication tools, while only 21% of non-teleworkers use them. A total of 50% of teleworkers use IT management tools for business, while only 13% of non-teleworkers use them. A total of 11% of teleworkers use automation office, while only 1% of non-teleworkers use it. Thus, teleworkers tend to use communication tools and IT management tools for business, although many teleworkers do not need to use advanced digitalization such as automation office. For estimation, we construct dummy variables for the three above-mentioned categories: (1) IT communication tools (IT_tool), (2) digitalized office management (Digital_office), and (3) automation office (Auto_office) such that the dummy takes one if at least one item in each category is used.

Table 3: Digitalization at the workplace (%)

	Communi cation	Digitalized office	Auto-Office
Non-teleworker	20.97%	13.13%	1.19%
Teleworker	81.58%	50.14%	11.10%
Total	30.57%	18.99%	2.76%

NOTE: The values are as of wave 4

4.3 Reform and policy variables

The company-wide organizational reforms and government policies in the pandemic might affect telework use. Here, we define three sets of reform and

[12] The questionnaire asked respondents to choose from all 16 items on ICT tools with raising some representative tools available in Japan if they usually use them at workplace: item (1) teleconference and web conference system (e.g. Zoom, Skype), (2) information share (e.g. Slack, Line), (3) sharing file (e.g. Dropbox, One drive), (4) remote access (e.g. SWANStor, Platform V system), (5) task project management (e.g. Trello, Backlog), (6) electric payment (e.g. Creat!Web flow),, (7) attendance management (Office365, Cybozu), (8) mental health management (e.g. jinjer work vital, onsei kokoro bunseki service (voice mental analysis service, MIMOSYS)), (9) business management (e.g. Sales cloud, kintone), (10) sale management, production management, stock management (e.g. Rakusho, Arajin Office), (11) employment management system (e.g. HRMOS Kanri, Jobukan Saiyo Kanri), (12) human resource management (e.g. Smart HR, OBIC7), (13) accounting management (e.g. Yayoi Kaikei, Super-Stream NX), (14) RPA (robotic process automation)(e.g. WinActor, Robotic Crowd), (15) virtual office (e.g. Sococo, Remo), and (16) contactless technology (e.g. robot for automatic operation, automated checkout). In our data, IT communication tool is defined as items 1, 2, and 3. Digitalized office management tool is defined as items 4–13. Automation office is defined as items 14, 15, and 16.

policy variables. First, many companies have reformed working conditions suited to teleworking and more generally took some company-wide reforms and organizational change as a strategy for the post-COVID-19 era. This might facilitate workers to use telework. Second, the government has requested companies and enterprises to reform working conditions suited to telework and for less commuting. Third, the government has taken some NPIs to promote individual's behaviours to prevent infection such as social distancing and use of masks. This might lead workers to feel valued when teleworking.

4.3.1 Organizational reforms in the COVID-19 crisis

The spread of COVID-19 has dramatically changed society and the economy. In response, many companies and enterprises have amended company-wide management policies, working regulations, downsizing office space, and production lines. A module of the survey (second, third, and fourth waves) asked about enforcement of each reform item in respondents' companies or enterprises.

Reform A: Revise company-wide business policies and plans.
Reform B: Reform firm organization.
Reform C: Change transaction partners and/or return overseas branch offices to Japan.
Reform D: Revise working regulations and employment system.
Reform E: Employment adjustment (lay-off).

For each item, respondents choose one of the answers: (1) companies/enterprises in which respondents are employed already carried out reforms or going to do soon in the future, (2) no, and (3) unknown. Then we construct dummies on enforcement for each item, which takes one if companies/enterprises carried out reforms or going to do it soon (answer 1), and zero otherwise (answers 2 and 3). Appendix Table 5 reports the outcome. Overall, 10–30% of firms carried out reforms, and the percentage slightly increased over time. As of April 2021 (wave 4), 30% of firms revised company-wide policy (Reform A), while the change of transaction partners (Reform C) and employment adjustment (Reform E) account for only 13% and 14%, respectively.

4.3.2 Government-request-based amendments

After the first state of emergency was lifted, the government strongly requested companies to amend working systems. In May 2020, Keidanren (Japan Business Federation) announced the guidelines, the Guidelines for Preventing the Spread

of Novel Coronavirus Disease (COVID-19),[13] for companies and enterprises to follow to prevent infections. Regarding telework, companies and enterprises are requested to promote company-wide recommendations for teleworking and introduce staggered commuting, rotation working, and a four-day week work. Based on the guidelines by Keidanren, a module of our survey (fourth wave) asked whether respondents' companies introduced each government request.

Request 1: Company-wide telework recommendations.

Request 2: Staggered commuting.

Request 3: Rotation working and reservation for working desk at the workplace.

Appendix Table 6 reports the basic result. As of April 2021, around 70% of companies and enterprises have no plan to carry out any government-requested amendments, while around 10–20% of companies and enterprises have already carried out the amendments. Based on this question, we construct a variable for the government-requested amendment (govt_reform). If a government request was exercised by responder's company or enterprise, the dummy takes one, and zero otherwise.[14] Then we take an average of three request variables for each respondent.

4.3.3 Impact of non-pharmaceutical interventions (NPIs)

According to Iwasaki and Grubaugh (2020), one of the reasons for fewer infections in Japan compared with other developed countries is the Japanese practice of using the mask and social distancing. As NPIs, the government announced a daily life guideline, 'New Life Style', in June 2020. The guideline specifies how to use the mask, avoid mass gatherings, and follow social distancing. People who carefully take these countermeasures might consider teleworking worthwhile to prevent infection. In response to the New Life Style guideline, the survey in the third and fourth waves asked the frequency of behaviours of (1) washing hands and using the mask and (2) avoiding mass gatherings and following social distancing. The respondents were asked to choose one of the options: 'always', 'frequently', 'sometimes', 'seldom', and 'never'. Appendix Table 7 shows the result. Around 60% of respondents always or frequently take measures of washing hands and using mask, while around

[13] https://www.keidanren.or.jp/en/policy/2020/040.html

[14] In detail, the questionnaire in the fourth wave of the survey asks respondents to answer when government request was exercised by their company or enterprise (1) before June 2020, (2) from June to December 2020, and (3) after January 2021. For each item, we construct a dummy variable. If a firm already carried out reform, the dummy takes one, and otherwise zero.

38% always or frequently keep social distancing. However, regardless of the surge of the number of infections (Figure 1), respondents who answered 'not at all' increased by 3% in both questions, and the number of people who answered 'always' and 'frequently' was unchanged in both questions during the two periods. Although the third wave of infection came between December 2020 and April 2021, people did not understand the magnitude of infection and did not fortify COVID-19 countermeasures in spite of government's strong request. This discrepancy indicates that the voluntary request-based government policy was insufficient in this period. This is consistent with the findings of Hamano et al. (2020). Using the macroeconomics epidemic model, Eichenbaum et al. (2020) found that the number of infections and people's measures for prevention are discrepant due to people's misperception in late 2020. Their findings are consistent with ours. For estimation, we construct a variable for an individual's COVID-19 countermeasure (NPIs) by taking the mean of two variables: (1) washing hands and (2) social distancing.

5 Estimations and Results

5.1 Basic estimation for telework use

First, we conduct basic estimations on the impact of individual characteristics and the infection of COVID-19 on telework use. The panel data are composed of four waves: March, June, and December 2020, and April 2021. Appendix Table 2 provides basic statistics.[15] The equation for estimation is given as

$$TELEWORK_{it} = \beta WCOVID_{j(i)t} + \gamma X_i + Ind_{it} + Emp_{it} + Size_{it} + Prefr_{it} + Prefw_{j(i)t} + \mu_t + \xi_i + \varepsilon_{it}. \quad (1)$$

TELEWORK is the dummy for telework use for worker i at time t (waves of the survey) working at *j*. *TELEWORK* takes one if a respondent uses telework, and zero otherwise. *WCOVID* denotes the number of daily new infections per population at respondent i's working place j (municipality level) at time t (the first day of the month when the survey was conducted).[16] *X* denotes individual's

[15] Our estimation sample eliminated respondents who have no precise information on municipalities of residential and working places or are temporarily unemployed.

[16] In the rural area (villages), the number of new infections is not available at the municipality level but available at the health-centre level jointly handled by multiple municipalities. Thus, the number of the municipality-level patients in the rural area is derived by the number of new infections at the health centre weighted by the population of each municipality.

variables as follows. *Female* is female variable (female=2, male=1), *Age* is age variables (scaled by age 10), *Income* is the annual income in 2019 (scaled by 500 thousand yen), *Univ* is a dummy for a university degree, *house_own* is a dummy for owning a house, and *Com_time* is the time for commuting (minute). *PubTrans* is a dummy for using public transportation for commuting (e.g. trains and buses). Several fixed effects are added. *Ind* is the sector fixed effect, *Emp* is the employment-type fixed effect, *Size* is the firm-size fixed effect, *Prefr* is the residential prefectural fixed effect, *Prefw* is the workplace prefectural fixed effect, μ is the time dummy, and ξ_i is the individual effect.[17] We estimate eq (1) by the linear probability model with random effects.

The first column of Table 4 reports the result. *Female*, university dummy, income, and *house_own* are significantly positive, while age is significantly negative. The number of new daily COVID-19 infections at workplace municipality is significantly positive. Commuting time and the dummy for public transportation for commuting are both significantly positive. In sum, the larger number of new infections at the working place (municipality) is positively associated with telework use. Moreover, female, younger, and educated workers with higher income tend to use telework. This is consistent with the observations in many previous studies. Longer commuters using public transportation tend to use telework. The result on commuting can be interpreted as long commute involves distress. Longer commute reduces well-being (Stutzer and Frey, 2008; Gottholmseder et al., 2009) and involves disutility and compensation (Van Ommeren et al., 2000). The spread of COVID-19 provides workers with the opportunity of teleworking, reducing the distress of long commute.

[17] Ind is two-digit-level industries. Emp is regular employees, non-regular employees, executive management, self-employed business owner (with employees), self-employed business owner (no employees), helping with in-house sales, house-keeper, student, and others. Firm size is categorized as 5–29 employees, 30–99 employees, 100–499 employees, more than 500 employees, and public offices. We note that there are 47 prefectures in Japan.

Table 4: Basic Results

	1		2		3		4	
	Coeff	z	Coeff	z	Coeff	z	Coeff	z
WCOVID	6.143	6.82 ***	6.046	6.72 ***	5.561	6.12 ***	5.442	5.78 ***
Female	0.026	5.00 ***	0.023	4.56 ***	0.024	4.58 ***	0.022	4.02 ***
Age	-0.002	-2.92 ***	-0.002	-2.77 **	-0.002	-2.73 ***	-0.004	-4.16 ***
Univ	0.048	9.95 ***	0.045	9.47 ***	0.045	9.52 ***	0.034	6.79 ***
Income	0.013	13.35 ***	0.013	12.75 ***	0.013	12.72 ***	0.012	11.92 ***
House_own	0.016	3.30 ***	0.016	3.18 ***	0.016	3.19 ***	0.015	2.88 ***
Com_time	0.000	2.79 ***	0.000	2.83 ***	0.000	2.81 ***	0.000	3.08 ***
PubTrans	0.055	8.31 ***	0.051	7.81 ***	0.051	7.86 ***	0.051	7.38 ***
Teleworkable			0.407	12.64 ***				
RiskExp			0.097	6.42 ***				
Teleworkable1					0.140	3.43 ***	0.044	4.83 ***
Teleworkable2					0.530	11.52 ***	0.175	17.50 ***
Teleworkable3					0.448	10.05 ***	0.120	12.20 ***
Teleworkable4					0.524	11.61 ***	0.135	13.56 ***
RiskExp1					0.064	3.87 ***	0.032	1.80 *
RiskExp2					0.140	7.45 ***	0.011	0.52
RiskExp3					0.083	4.34 ***	-0.020	-0.97
RiskExp4					0.092	4.78 ***	-0.024	-1.18
N obs	38,665		38,665		38,665		38,665	
R-sq	0.1927		0.1983		0.1994		0.2103	

NOTE: All fixed effects (Ind, Emp, Size, Prefr, Prefw, Time) are included, but ommited to report from the table. Statistical significance shown by ***1%, **5%, and *10%.

5.2 Occupation-level teleworkability and risk exposure

Next, variables of occupation-level teleworkability and risk exposure indices (section 4.1) are added to the equation:

$$TELEWORK_{it} = \beta WCOVID_{j(i)t} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + Ind_{it} + Emp_{it} + Size_{it} + Prefr_{it} + Prefw_{j(i)t} + \mu_t + \xi_i + \varepsilon_{it}, \quad (2)$$

where *Teleworkable* and *Risk_Exp* denote the indices of teleworkability and risk exposure, respectively. Both indices in the estimations are at the occupational level. The index of teleworkability is measured in March 2020, before the first state of emergency and the first wave of COVID-19 to prevent reverse causality. The risk exposure index is measured in June 2020, after the first wave of COVID-

19. This is because it is impossible to measure the fear of infections in March 2020 when the observed number of infections was still small (Figure 1) and many people were not able to identify the risk of infections.

Column 2 of Table 4 reports the results. Both indices are positive and significant. To investigate the transitional change of the impacts, we decompose the indices by time by interacting with the time dummy (e.g. '*Teleworkable1*' in Table 4 stands for teleworkability index for wave 1, and '*Risk_Exp1*' is risk exposure index for wave 1). Column 3 reports the results. Then the magnitude of teleworkability index in June 2020 (*Teleworkable2*) is the largest and is slightly lower in December 2020 (*Teleworkable3*) and April 2021 (*Teleworkable4*). This looks consistent with the transitional change of telework use as shown in Figure 2. Likewise, the risk exposure index is significant over time. The magnitude of coefficients in June (*Risk_Exp2*) is the largest. Therefore, after the first wave of COVID-19 and the first state of emergency, teleworkability and risk exposure of occupations are crucially associated with telework use.

To check robustness, our teleworkable index is replaced by the remote workability index of Dingel and Neiman (2020). Column 4 of Table 4 reports the result. Teleworkability indices in all periods are significantly positive as in our main results, although the risk exposure index is now insignificant.

5.3 Individual skills, tasks, and working environments

Besides occupation-level teleworkability and risk exposure, some elements related to each worker's ICT skills, task characteristics, and working environments are added to the previous estimation:

$$\begin{aligned} TELEWORK_{it} = \; & \beta WCOVID_{j(i)t} + \gamma X_{it} + \eta Teleworkable_{it} + \delta RiskExp_{it} \\ & + \zeta TaskEnv_{it} + Ind_{it} + Emp_{it} + Size_{it} + Prefr_{it} + Prefw_{j(i)t} + \mu_t \\ & + \xi_i + \varepsilon_{it}, \end{aligned} \tag{3}$$

where *TaskEnv* is a set of variables for each worker's skills, task, and working environments at time t. *TaskEnv* is composed of (1) respondent's ICT skill (*ICT skill*) (Section 4.2.1), (2) routine task intensity measure (*RTI*) (Section 4.2.2), (3) working environments characterized by team-based working (*Env A*), outcome-based evaluation (*Env B*), and flexible working hours/holiday/on leave (*Env C*) (Section 4.2.3), and (4) IT communication tools used at the workplace and for teleworking (*IT_tool*) (Section 4.2.4). We estimate eq (2) by the linear model.

Column 1 of Table 5 reports the results.

Table 5: Working Environment and Reforms

	1		2		3		4		5	
	Coeff	z	Coeff	z	Coeff	z	Coeff	z	Coeff	z
WCOVID	4.369	4.97 ***	1.759	1.82 *	1.641	1.70 *	7.476	6.28 ***	7.469	6.27 ***
Female	0.023	5.19 ***	0.023	4.37 ***	0.022	4.28 ***	0.022	3.80 ***	0.022	3.66 ***
Age	-0.001	-1.02	-0.001	-1.28	-0.001	-1.09	-0.001	-1.04	-0.001	-1.10
Univ	0.014	3.34 ***	0.009	1.85 *	0.009	1.70 *	0.008	1.41	0.008	1.39
Income	0.006	7.36 ***	0.007	6.98 ***	0.006	6.73 ***	0.005	4.55 ***	0.005	4.59 ***
House_own	0.013	3.02 ***	0.012	2.47 **	0.013	2.56 **	0.013	2.29 **	0.013	2.29 **
Com_time	0.000	3.00 ***	0.000	1.86 *	0.000	1.81 *	0.000	1.52	0.000	1.49 ***
PubTrans	0.031	5.54 ***	0.042	6.38 **	0.041	6.21 **	0.022	2.92 **	0.022	2.92 **
Teleworkable1	-0.020	-0.54								
Teleworkable2	0.313	7.37 ***	0.255	5.87 ***	0.259	5.99 ***				
Teleworkable3	0.199	4.80 ***	0.169	3.98 ***	0.158	3.73 **	0.155	3.59 ***	0.156	3.62 ***
Teleworkable4	0.305	7.28 ***	0.285	6.72 ***	0.275	6.50 ***	0.264	6.08 ***	0.265	6.10 ***
RiskExp1	0.017	1.18								
RiskExp2	0.081	4.80 ***	0.075	4.19 ***	0.075	4.24 ***				
RiskExp3	0.009	0.52	0.011	0.57	0.009	0.51	0.002	0.10	0.002	0.08
RiskExp4	0.020	1.18	0.023	1.29	0.020	1.11	0.013	0.69	0.013	0.69
ICTskill	0.023	9.91 ***	0.023	8.29 ***	0.022	7.97 ***	0.020	6.38 ***	0.020	6.34 ***
RTI	-0.007	-3.14 ***	-0.002	-0.91	0.001	0.32	0.004	1.48	0.005	1.58
ENV A	-0.009	-4.32 ***	-0.011	-4.56 ***	-0.012	-4.61 ***	-0.014	-4.45 ***	-0.015	-4.52 ***
ENV B	-0.003	-1.53	-0.003	-1.14	-0.003	-1.25	-0.006	-1.68 *	-0.006	-1.62
ENV C	0.037	18.59 ***	0.036	15.03 ***	0.035	14.84 ***	0.047	14.62 ***	0.047	14.62 ***
IT tool	0.255	40.36 ***	0.201	28.73 ***	0.196	27.94 ***	0.161	19.54 ***	0.161	19.50 ***
Digital Office			0.075	10.22 ***	0.070	9.54 ***	0.045	5.23 ***	0.045	5.19 ***
Auto office			0.103	5.56 ***	0.097	5.21 ***	0.124	5.84 ***	0.124	5.84 ***
Reform A					0.012	1.95 *	0.003	0.43	0.003	0.37
Reform B					0.002	0.33	0.000	0.04	0.000	0.03
Reform C					0.008	0.81	0.003	0.22	0.003	0.26
Reform D					0.035	5.17 ***	0.032	3.71 ***	0.032	3.68 ***
Reform E					0.001	0.08	0.001	0.09	0.001	0.11
govt_reform							0.160	12.49 ***	0.160	12.43 ***
NPI									0.002	1.14
Survey waves	1,2,3,4		2,3,4		2,3,4		3,4		3,4	
N obs	38,665		29,063		29,063		18,339		18,339	
R-sq	0.3299		0.3431		0.3475		0.3643		0.3644	

NOTE: All fixed effects (Ind, Emp, Size, Prefr, Prefw, Time) are included, but ommited to report from the table. Statistical significance shown by ***1%, **5%, and *10%.

Respondent's ICT skill is significantly positive, while *RTI* is significantly negative. Flexible working hours (*Env C*) is also significantly positive, although teamwork job system (*Env A*) is significantly negative, and outcome-based evaluation (*Env B*) is not significant but negative. Moreover, IT communication tool (*IT_tool*) is significantly positive. Therefore, those who have high ICT skills, use IT communication tools for business, and work under flexible working hours

are positively associated with telework use. Workers who do fewer team-based tasks, less outcome-based evaluation, and less routine tasks tend to use telework.

Originally, flexible working hour is a necessary condition for teleworking. Thus, we find that flexible working hours are positively associated with telework use. Thus, this makes sense. Teleworking always faces the risk of information asymmetry and moral hazard. In detail, telework largely reduces the possibility for supervisors to observe workers and deteriorate the ability for fostering relationship with co-workers. As shown in some studies, telework is not suitable for tasks such as teamwork jobs and informationally demanding jobs with homogeneous co-workers (Battiston et al., 2018) and is associated with a decline in the co-worker relationship quality and co-worker satisfaction in high interdependency tasks (Gajendran and Harrison, 2007). This can be seen in our teamwork variable result. Furthermore, outcome-based evaluation mitigates the difficulty of supervising process of tasks. However, our results are the opposite. We can interpret that tasks and occupations in outcome-based evaluation system tend to be not or less interdependent on tasks carried out by co-workers and tend to have a high level of job autonomy and discretion. Thus, they might not need teleworking according to our estimation result.

Further investigation is presented in Column 2 of Table 5. Some variables on digitalized and automation office, i.e. *Digital_office* and *Auto_office* (Section 4.2.4), are added. We note that these variables are available only for waves 2 to 4. These two variables are significantly positive, although the magnitude of coefficients is smaller than IT communication tools (*IT_tool*). This indicates that not only individual ICT skills and use of ICT communication tools but also digitalized offices are crucial for telework use. All of the digitalization can replicate the working space as usual workplace to some extent, which enables us to promote collaboration with co-workers through discussion on the progress of tasks and exchange of ideas. Supporting our result, Turetken et al. (2011) found that teleworkers see a positive relationship between the richness of the communication tools and their performance and that teleworkers communicating more via communication tools such as Zoom and Skype video calls tend to have higher levels of job satisfaction and performance than those using messaging applications and e-mails. According to them, the text-based forms of communication such as e-mail are considered as being removed from in-person and face-to-face communication.

5.4 Company-wide reforms, government-requested amendments, and

non-pharmaceutical interventions

As already mentioned in Section 4.3, many companies have exercised two types of reforms, i.e. company-wide reform and government-request-based amendments for teleworking. Reform variables (*Reforms A–E*, defined in Section 4.3.1, and *govt_reform* defined in Section 4.3.2) are added to eq (3) and estimated by the linear model with random effect. We note that *Reform* variables are available for waves 2, 3, and 4, while *govt_reform* is available for waves 3 and 4 only. Columns 3 and 4 of Table 5 report the results. Regarding the company-wide reform, the revision of working conditions and employment regulations (*Reform D*) is significantly positive. Likewise, the government-request-based amendment for teleworking (*govt_reform*) is significantly positive. Therefore, various reforms directly linked with teleworking, that is, company-wide reforms for relaxing working regulations and the government-request-based amendment for teleworking, are all positively associated with telework use.

Regarding individual's COVID-19 countermeasures, the variable, *NPI* (Section 4.3.3), is added to the previous estimation. NPI is available for waves 3 and 4 only. Column 5 of Table 5 reports the result. *NPI* is positive but not significant. Thus, people's countermeasure is not crucially associated with telework utilization. As mentioned above, the people's countermeasure reflects people's misperception of the infection of COVID-19 (Hamano et al., 2020). Rather than people's countermeasures, the number of new infections at workplace (*WCOVID*) largely affects telework use.

6 Further Investigations

6.1 Telework hours and frequency

Now we focus on teleworkers. A further investigation is conducted on teleworking hours and frequency. The basic trends are shown in Figures 5 and 6. The mean of per-week teleworking hours is 21.9 hours, and per-week teleworking frequency is 2.96 (Appendix Table 2).

Now we use only teleworkers as a sample. We investigate which factors affect telework hours and frequency. In other words, this indicates how much percentage of task per worker is teleworkable. We estimate the following by the linear model with random effect:

$$TELEHOUR_{it} = \beta WCOVID_{j(i)t} + \gamma X_{it} + \eta Teleworkable_{it} + \delta RiskExp_{it} + \zeta TaskEnv_{it} + Ind_{it} + Size_{it} + Emp_{it} + Prefr_{it} + Prefw_{j(i)t} + \mu_t + \xi_i + \varepsilon_{it}. \quad (4)$$

The dependent variable now uses per-week telework hours (ln) (*TELEHOUR*) or per-week frequency (*FREQ*) for teleworker i, while the independent variables are the same as presented eqs (2) and (3). Column 1 of Table 6 reports telework hours results. Overall, teleworkable and risk exposure indices are not significant. By contrast, female, income, individual ICT skills and IT communication use (IT_tool) are significantly positive. *Env C* is significantly positive. Column 2 of Table 6 reports the result on frequency. Results are similar to telework hours. Therefore, female, high income, and high ICT-skilled teleworkers who use IT communication tools and work under flexible hour system tend to work longer hours by telework and more frequently. Rich IT communication tools at the workplace facilitate long working hours and frequent teleworking.

Table 6: Telework Hours and Frequency

	1		2	
	Telehour		Freq	
	Coeff	z	Coeff	z
WCOVID	-8.281	-2.01 *	-10.419	-1.41
Female	0.086	2.48 **	0.191	3.40 ***
Age	-0.010	-1.46	-0.037	-3.56 ***
Univ	0.016	0.44	-0.105	-1.79 *
Income	0.013	2.77 ***	0.023	3.22 ***
House_own	-0.011	-0.34	-0.013	-0.24
Com_time	0.000	0.59	0.001	0.84
PubTrans	0.118	2.73 ***	0.036	0.53
Teleworkable1	0.895	1.59	-0.113	-0.14
Teleworkable2	0.504	1.78 *	0.847	1.77
Teleworkable3	0.749	2.21 **	0.197	0.35
Teleworkable4	0.576	1.78 *	0.669	1.19
RiskExp1	0.217	0.75	0.203	0.48
RiskExp2	0.222	1.36	0.304	1.08
RiskExp3	0.224	1.25	0.058	0.19
RiskExp4	0.374	2.21 **	0.073	0.25
ICTskill	0.191	7.62 ***	0.172	4.58 ***
RTI	0.013	0.73	0.029	1.03
ENV A	-0.020	-1.23	-0.070	-2.64 ***
ENV B	-0.006	-0.35	0.017	0.59
ENV C	0.046	2.84 ***	0.111	4.12 ***
IT tool	0.203	6.67 ***	0.235	4.92 ***
N obs	5,701		5,701	
R-sq	0.21		0.1426	

NOTE: All fixed effects (Ind, Emp, Size, Prefr, Prefw, Time) are included, but ommited to report from the table. Statistical significance shown by ***1%, **5%, and *10%.

6.2 Who stopped and who started teleworking?

As displayed in Figure 2, telework use sharply increased in the first state of emergency, but afterwards largely declined and then hovered over time. As previous estimations tell us, some company-wide reforms and government-requested reform amidst the spread of COVID-19 promoted telework use. By contrast, although some workers initiated teleworking in the first state of emergency, they eventually stopped teleworking. We focus on respondents who joined at least two consecutive waves, i.e. t – 1 as well as t. The upper panel of Appendix Table 8 shows the transition of teleworkers at t – 1. At time t, 60–70% of teleworkers continued teleworking. The below panel of Appendix Table 8 shows the transition of non-teleworkers at t – 1. A total of 5–10% of non-teleworkers at t – 1 started teleworking at t.

We estimate the end of telework. The sample is limited to teleworkers at t – 1. The following equation at t is estimated by the linear model:

$$\begin{aligned} STOP_{it} = \; & \beta WCOVID_{j(i)t} + \gamma X_{it} + \eta Teleworkable_{it} + \delta RiskExp_{it} + \zeta TaskEnv_{it} \\ & + Ind_{it} + Emp_{it} + Size_{it} + Prefr_{it} + Prefw_{j(i)t} + \mu_t + \xi_i + \varepsilon_{it}. \end{aligned} \tag{5}$$

STOP indicates the dummy for stopping telework use. If a respondent used teleworking at t – 1 but stopped teleworking at t, the dummy takes one. If a respondent keeps teleworking at t – 1 and t, then the dummy is zero.

Columns 1 and 2 of Table 7 report the result. *WCOVID* as well as many individual characteristics are insignificant. However, female variable and *PubTrans* are significantly negative. Male and non-public transport system commuters are more likely to stop telework. Then, *IT skills* and *RTI* are significantly negative. Workers with lower IT skills and doing less routine tasks tend to stop teleworking. More importantly, *Env C* is significantly negative. Workers under unavailable flexible working system tend to stop. Furthermore, *IT_tool*, *Digital_office*, and *Auto_office* are all significantly negative. Therefore, workers who are doing less routine tasks with regular working hours but do not use communication IT tools for work, digitalized management tools, and office automation find it difficult to keep on using telework and eventually stop teleworking.

This tells us that the first state of emergency forced some workers to use telework due to the fear of COVID-19 pandemic. However, since they are not

suited to telework, they gradually stopped using it. The poor environment of IT communication tools and non-flexible working environments dissuade the use of telework. In addition, we add variables on company-wide reforms. Column 2 of Table 7 reports the result. Some reforms worked well. *Reform D* (revise working regulations) and *govt_reform* are significantly negative. These reforms for teleworking can function as continuing telework.

Lastly, by contrast, who started teleworking? We estimate the same eq (5) by replacing the dummy for the start of telework, *START*. The sample is now non-teleworkers at t – 1. If a respondent did not use teleworking at t – 1 but started teleworking at t, the dummy takes one. If a respondent keeps non-teleworking at t – 1 and t, then the dummy is zero. Column 3 of Table 7 reports the results. Similar to the results on telework use in Section 6.1, educated, high ICT-skilled, and female workers who use communication IT tools and work under flexible working hour system tend to start telework.

Table 7: Stop and Start of Telework

	Stop		Stop		Start	
	1		2		3	
	Coeff	z	Coeff	z	Coeff	z
WCOVID	0.042	0.02	-0.236	-0.08	-1.171	-1.06
Female	-0.035	-1.81 *	-0.042	-1.87 *	0.015	2.75 ***
Age	0.001	0.24	-0.001	-0.15	-0.001	-1.09
Univ	0.025	1.25	0.009	0.38	0.014	2.80 ***
Income	-0.003	-1.26	-0.001	-0.30	0.005	5.04 ***
House_own	-0.016	-0.90	-0.017	-0.80	0.010	1.97 **
Com_time	0.000	-0.52	0.000	-0.28	0.000	1.49
PubTrans	-0.069	-2.79 ***	-0.053	-1.89 *	0.034	4.81 ***
Teleworkable2	-0.381	-1.53			0.173	3.52 ***
Teleworkable3	-0.160	-0.93	-0.037	-0.22	0.158	3.73 ***
Teleworkable4	-0.322	-1.97 **	-0.229	-1.34	0.211	5.25 ***
RiskExp2	-0.227	-1.78 *			0.033	1.72 *
RiskExp3	0.085	0.84	0.131	1.31	0.012	0.70
RiskExp4	-0.010	-0.11	0.044	0.45	0.008	0.49
ICTskill	-0.067	-5.20 ***	-0.068	-4.55 ***	0.017	5.94 ***
RTI	-0.021	-2.19 **	-0.025	-2.24 **	-0.002	-0.78
ENV A	0.013	1.31	0.027	2.28 **	-0.011	-4.05 ***
ENV B	0.014	1.34	0.003	0.26	0.000	0.16
ENV C	-0.056	-5.69 ***	-0.072	-6.28 ***	0.019	7.60 ***
IT tool	-0.286	-13.03 ***	-0.247	-9.51 ***	0.131	17.42 ***
Digital Office	-0.077	-4.53 ***	-0.040	-2.16 **	0.048	5.88 ***
Auto office	-0.073	-2.78 ***	-0.067	-2.39 **	0.110	3.4 ***
Reform A			-0.023	-1.08		
Reform B			0.024	1.10		
Reform C			0.021	0.76		
Reform D			-0.040	-2.03 **		
Reform E			-0.012	-0.45		
govt_reform			-0.120	-5.24 ***		
Survey waves	2,3,4		3,4		2,3,4	
N obs	3,533		2815		21,144	
R-sq	0.2775		0.2763		0.1774	

NOTE: All fixed effects (Ind, Emp, Size, Prefr, Prefw, Time) are included, but ommited to report from the table. Statistical significance shown by ***1%, **5%, and *10%.

6.3 Which tasks require commuting under the state of emergency?

Some workers must sometimes communicate complex information to their colleagues. According to Battiston et al. (2017), productivity is higher in some tasks when the teammates are in the same room and their desks are close together. Thus, some tasks might involve high opportunity costs of face-to-face communication. Now, we investigate which tasks are not allowed to use telework by utilizing 'soft' lockdown in the first state of emergency. The soft lockdown could be a good experiment to investigate which tasks are crucially impossible to telework and require a workplace and commute. A key is that the government asked people to take voluntary self-restraint and work from home as much as possible. The government did not impose any penalties and asked for co-operation from the people, and the public transportation system was working as normal. In response, telework use sharply increased under the first state of emergency and reached the peak (25%, Figure 2). However, many workers did not spend all working hours on teleworking, and many teleworkers could not help commuting sometimes for certain reasons. In our estimation data, 80.2% of teleworkers (2,477 out of 3,088 teleworkers) could not help commuting at least more than one day despite the state of emergency.

The survey asked all teleworkers about task items at the workplace by commuting under the first state of emergency. They were asked to choose all (at least one) tasks out of 11 items that they did at the office, or otherwise non-commuting.[18] As shown in the left panel of Table 8, item 3 (paper documents and clerical work) and item 4 (communication and meeting) require the largest numbers of teleworkers (821 and 814, respectively), while item 7 (human resource and management) requires the smallest (129). The right panel of Table 8 presents the number of teleworker's tasks at the office. A total of 1,155 teleworkers commuted to engage in one task item at the office, while 536 (306, 143) workers did for two (three, four) task items. Many teleworkers engaged in multiple tasks at the office.

[18] The questionnaire asks 12 items for tasks. Item 1: face-to-face services and manual labour, 2: public administrative tasks, 3: making paper documents and regular clerical work, 4: contact with customers and transaction partners and check post mails, 5: meeting and conference, 6: human resource and management, 7: use of facilities, machines, tools, and office equipment, 8: data and information access, 9: maintenance of facilities and buildings, and 10: research, investigation, and experiments. 11: others. 12: non-commuting. Then we sum up these items into five task categories (T1–T5) and non-commuting (NC): T1: item 1; T2: items 4 and 5; T3: items 7, 9, and 10; T4: items 2 and 3; T5: items 6 and 8; T6: item 11; NC: item 12. We drop item 11 (others).

Table 8: Office Tasks under the First State of Emergency

All teleworkers (choose multiple items)

task item	num
item 1	492
item 2	240
item 3	821
item 4	814
item 5	512
item 6	277
item 7	129
item 8	223
item 9	325
item 10	607
item 11	101
No commuting	557

Teleworkers with commuting

num office tasks	num commuters
1	1,115
2	536
3	306
4	143
More than 5	142
Total	2,242

Then, to construct variables, the items are summed up into five office task categories by taking the average of items for each category for each respondent (from 0 to 1) and in addition non-commuting.

(1) NC: non-commuting and teleworking only.
(2) T1: face-to-face and physical tasks: face-to-face services and manual labour tasks.
(3) T2: meeting and communication: meetings, conferences, contact with business partners, and checking postal mails.
(4) T3: use of facilities and experiment: using office facilities, machine equipment and tools, research, experiments, investigations, maintenance of offices, and working places.
(5) T4: clerical work: office work, paper documents, registration for public offices, and government and formal administration.
(6) T5: management and information access: management, human affairs, information access, and information management.

These variables are used as dependent variables. The sample is teleworkers under the state of emergency. The simultaneous equation system by SUR is given as follows:

$$
\begin{aligned}
NC_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i \\
T1_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i \\
T2_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i \\
T3_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i \\
T4_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i \\
T5_i = \ & \beta WCOVID_{j(i)} + \gamma X_i + \eta Teleworkable_i + \delta RiskExp_i + \zeta TaskEnv_i \\
& + Ind_i + Emp_i + Size_i + Prefr_i + Prefw_{j(i)} + \varepsilon_i .
\end{aligned}
$$

Table 9 reports the result. *WCOVID* is significantly positive in the NC equation, while it is significantly negative in the T1 (face-to-face and manual task) equation. Teleworkable index in the T1 equation is significantly negative, while it is significantly positive in the T2 (communication task), T4 (clerical work), T5 (management task), and NC (non-commuting) equations. Risk_Exp (risk exposure index) in the T2, T4, and T5 equations is significantly positive, while it is significantly negative in the T3 and NC equations. Thus, communication tasks, clerical works, and management tasks complement telework. Even if occupations are teleworkable and face a high risk of infections, these tasks doing at the office helps teleworking. By contrast, face-to-face and manual tasks are not substitutable with telework. Since these tasks are not fully teleworkable, workers need to commute for engaging in the task.

Turning to individual's characteristics and working environments, younger, skilled, and female teleworkers who engage less in team-based working, routine, and teleworkable tasks under flexible employment systems tend to do only telework without commuting. Those who utilize IT tools well and work in autonomy or with less interdependency on co-workers and a high degree of discretion tend to complete their tasks only by telework. This is consistent with the implications and findings of Battiston et al. (2017).

Table 9: SUR estimation

	NC: Non-commuting		T1: Face-to-face		T2: Meeting		T3: Use of facilities		T4: Clerical work		T5: Management	
	Coeff	z	Coeff	z	Coeff	z	Coeff	z	Coeff	z	Coeff	z
WCOVID	72.771	3.95 ***	-92.832	-4.11 ***	11.961	0.59	-31.146	-1.72 *	10.639	0.51	-7.173	-0.40
Female	0.034	4.29 ***	-0.072	-7.35 ***	-0.006	-0.62	-0.051	-6.40 ***	0.103	11.39 ***	0.001	0.08
Age	-0.011	-7.97 ***	-0.009	-5.04 ***	0.012	7.63 ***	0.007	4.97 ***	0.006	3.98 ***	0.007	5.22 ***
Univ	-0.005	-0.66	-0.036	-3.81 ***	0.065	7.54 ***	0.027	3.57 ***	0.045	5.11 ***	0.038	4.98 ***
Income	-0.001	-0.63	-0.003	-1.61	0.009	6.19 ***	0.001	0.72	0.000	0.02	0.005	4.13 ***
House_own	-0.008	-1.10	0.007	0.76	0.003	0.30	-0.005	-0.63	0.017	2.01 **	-0.002	-0.26
Com_time	0.000	0.40	0.000	-1.88 *	0.000	0.11	0.000	-2.17 **	0.000	0.88	0.000	-0.09
PubTrans	0.018	1.86 *	-0.070	-5.84 ***	0.010	0.94	0.001	0.06	0.027	2.48 **	0.003	0.36
Teleworkable	0.115	2.18 **	-0.588	-9.06 ***	0.371	6.33 ***	-0.046	-0.88	0.256	4.30 ***	0.356	6.90 ***
RiskExp	-0.061	-2.42 **	-0.004	-0.13	0.184	6.55 ***	-0.197	-7.91 ***	0.347	12.21 ***	0.043	1.75 *
ICTskill	-0.036	-7.70 ***	-0.078	-13.76 ***	0.052	10.24 ***	0.048	10.51 ***	0.110	21.20 ***	0.056	12.39 ***
RTI	0.034	8.52 ***	-0.085	-17.46 ***	-0.035	-7.99 ***	-0.034	-8.80 ***	0.019	4.33 ***	-0.017	-4.41 ***
ENV A	0.013	1.33	0.027	5.43 ***	-0.006	-1.25	0.006	1.36	-0.005	-0.99	0.010	2.41 **
ENV B	-0.021	-4.98 ***	-0.014	-2.57 **	-0.001	-0.26	0.006	1.44	-0.009	-1.87 *	-0.005	-1.25
ENV C	0.003	0.80	-0.038	-7.95 ***	-0.009	-2.06 **	-0.011	-2.95 ***	-0.002	-0.51	-0.008	-2.12 **
IT tool	0.029	7.31 ***	-0.066	-5.64 ***	0.126	11.90 ***	0.052	5.48 ***	0.020	1.84 *	0.076	8.11 **
RMSE	0.354		0.434		0.393		0.349		0.398		0.346	
R-sq	0.1033		0.1904		0.1638		0.1056		0.1759		0.1288	

NOTE: All fixed effects (Ind, Emp, Size, Prefr, Prefw, Time) are included, but ommited to report from the table. ***: p<0.01, ** p<0.05, * p<0.1

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6.4 Why does telework use remain low in Japan?

So far, our results imply that digitalized offices and company-wide reforms are crucial factors for telework. However, telework always involves information asymmetry among workers. This sometimes causes distress, isolation, procrastination, and moral hazard in teleworkers. To reduce asymmetry and enhance efficiency, task allocations, discretion, more rules for working, close relationship with co-workers, construction of trust and bond, and guidance of supervisors are all necessary and helpful for telework, although these are a huge burden for company managers and teleworkers.

One remaining question is why telework use remains low in Japan. The Japanese corporate culture put stress on commuting and working at the office. Many Japanese companies have a long tradition of working together in the same room within the office and have a hierarchy with tight communication and multidimensional decision-making. This system works well in team-based tasks, informal information-intensive workings, less discretion, less autonomy, and more exchange of tacit knowledge. However, our result implies that all of them are unsuited to teleworking. Furthermore, Japanese society sometimes involves some informal communication and implicit consensus. As seen in the pandemic of COVID-19, the government asked for self-constraint behaviours from the public, and the people understood the importance as a whole society and

followed the guidance. Accordingly, telework might be less suitable in Japan. On the other hand, many workers well understand the effectiveness of teleworking in terms of flexible working and work–life balance in the spread of COVID-19. Thus, the use of telework will steadily increase in the post-COVID-19 era. Many workers might seek the best combination of teleworking and commuting over time.

7 Conclusions

This paper investigates the association of the infection of COVID-19, individual characteristics, task characteristics, working environments, and policies with telework use. Using the unique panel survey on telework, we find that educated, high ICT-skilled, younger, and female workers who engage in fewer teamwork tasks and whose workplace municipalities see the larger number of infections tend to use telework. Working environments are much more crucial. The richness of IT communication tools, digitalized office management, flexible hour working systems, and company-wide reform for teleworking could promote telework use and its continuation.

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Appendix Table 1: Patterns of Respondents across Waves

Wave 1	Wave 2	Wave 3	Wave 4	Num respondents	Subtotal
■	■	■	■	5,384	
■	■	■		842	
■	■		■	600	
■	■			1,581	
■		■	■	413	
■		■		163	
■			■	129	
■				1,404	10,516
	■	■	■	2,010	
	■	■		389	
	■		■	272	
	■			1,060	3,731
		■	■	988	
		■		334	1322
					15,569

NOTE: Shaded cells are the group of respondents joined the survey.

Appendix Table 2: Basic Statistics

stats	mean	min	max	sd	N
TELEWORK	0.147	0.0	1.0	0.355	38,665
WCOVID	0.002	0.0	0.0	0.003	38,665
Female	1.444	1.0	2.0	0.497	38,665
age	7.879	2.0	12.0	2.751	38,665
Univ	0.508	0.0	1.0	0.500	38,665
Income	4.068	0.3	21.3	3.414	38,665
house_own	0.639	0.0	1.0	0.480	38,665
Com_time	34.7	0.0	360.0	30.0	38,665
PubTrans	0.377	0.0	1.0	0.485	38,665
Teleworkable	0.607	0.3	0.8	0.082	38,665
Risk_Exp	2.071	1.3	4.0	0.184	38,665
ICTskill	1.388	0.0	3.0	0.910	38,665
RTI	0.032	-3.1	1.5	0.975	38,665
Env A	3.540	1.0	5.0	0.881	38,665
Env B	2.939	1.0	5.0	0.887	38,665
Env C	3.006	1.0	5.0	0.975	38,665
IT tool	0.281	0.0	1.0	0.449	29,063
Digital Office	0.183	0.0	1.0	0.387	29,063
Auto Office	0.021	0.0	1.0	0.144	29,063
Reform A	0.270	0.0	1.0	0.444	29,063
Reform B	0.199	0.0	1.0	0.399	29,063
Reform C	0.110	0.0	1.0	0.312	29,063
Reform D	0.220	0.0	1.0	0.414	29,063
Reform E	0.151	0.0	1.0	0.358	29,063
govt_reform	0.158	0.0	1.0	0.317	18,339
NPI	2.222	0.0	4.0	1.301	18,339
TELEHOUR(ln)	21.9	0.5	120.0	14.6	5,701
FREQ	2.965	0.5	5.0	1.528	5,701
STOP	0.337	0.0	1.0	0.473	3,551
START	0.078	0.0	1.0	0.268	21,345

Appendix Table 3: Teleworkable Index

code	Occupation	Mean	Min	Max	sd	Num sample
1	Administrative and managerial	0.67	0	1	0.47	646
2	Researchers	0.60	0	1	0.49	81
3	Agricultural engineers	0.82	0	1	0.39	22
4	Manufacturing engineers	0.59	0	1	0.49	261
5	Architects, civil engineers	0.71	0	1	0.46	161
6	Data processing	0.75	0	1	0.43	236
7	Doctors, dentists	0.48	0	1	0.50	83
8	Public health nurses	0.47	0	1	0.50	107
9	Medical Technology Professionals	0.45	0	1	0.50	120
10	Social welfare workers	0.57	0	1	0.50	96
11	Legal Professionals	0.66	0	1	0.48	32
12	Finance and insurance	0.65	0	1	0.48	52
13	Management Business consultants	0.72	0	1	0.45	29
14	Teachers	0.46	0	1	0.50	150
15	Religions	0.67	0	1	0.58	3
16	Authors, journalists, editors	0.82	0	1	0.39	17
17	Artists, designers, photographers	0.70	0	1	0.46	56
18	Other specialist professionals	0.49	0	1	0.50	91
19	General clerical	0.62	0	1	0.49	1,021
20	Accountancy	0.53	0	1	0.50	184
21	Production-related clerical	0.56	0	1	0.50	68
22	Sales clerks	0.63	0	1	0.48	299
23	Outdoor service	0.25	0	1	0.50	4
24	Transport and post clerical	0.60	0	1	0.49	58
25	Office appliance operators	0.61	0	1	0.50	23
26	Sales workers	0.57	0	1	0.50	388
27	Family Life Support and Care Service	0.46	0	1	0.50	80
28	Occupational health and hygiene	0.65	0	1	0.48	55
29	Food and drink cooking	0.50	0	1	0.50	204
30	Residential facilities and buildings	0.45	0	1	0.50	40
31	Other service workers	0.58	0	1	0.49	325
32	Security workers	0.51	0	1	0.51	39
33	Agriculture, forestry and fishery	0.47	0	1	0.51	19
34	Manufacturing process	0.54	0	1	0.50	206
35	Transport and machine operation	0.61	0	1	0.49	62
36	Construction and mining	0.65	0	1	0.49	26
37	Carrying, cleaning, packaging	0.59	0	1	0.49	109
38	Other	0.72	0	1	0.45	489
		0.61	0	1	0.49	5,942

NB: sample: wave 1 (as of March 2020) excl. "not applicable and not sure"

Appendix Table 4: Task question items from PIAAC

Task	Category	Items
Abstract	Cognitive and non-routine	Read diagrams, maps or schematics
		Write reports
		Faced complex problems
		Persuading, influencing people
		Negotiating with people
Routine	Cognitive	Change sequence of task
		Change how do work
		Change speed of work
		Change working hours
		Learn work-related things from co-workers
		Learning-by-doing from tasks performed
		Keeping up to date with new products/services
	Manual Routine	Hand/finger skill accuracy
Manual		Physical work

Source: De la Rica and Gortazar (2016, Table 1)

Appendix Table 5: Enforcement of Reforms (%)

wave	Reform A	Reform B	Reform C	Reform D	Reform E
2	19.71	11.61	7.11	17.94	14.60
3	32.44	24.46	13.42	24.02	16.01
4	29.64	24.78	12.79	24.37	14.48

Appendix Table 6: Government-requested reforms (%)

	Request 1	Request 2	Request 3
Done	17.32	19.12	11.43
Planning	9.81	9.67	10.01
No plan	72.87	71.21	78.56

Appendix Table 7: People's COVID countermeasures (%)

	washing hands		social distance	
	Dec-20	Apr-21	Dec-20	Apr-21
always	33.94	35.28	15.14	15.62
frequently	28.29	26.28	23.69	23.42
sometimes	13.73	12.44	21.81	19.11
seldom	9.66	8.62	15.72	15.29
not at all	14.38	17.38	23.63	26.56

Appendix Table 8: Transitions of Telework Use

Teleworkers at t-1

	t=wave 2	t=wave 3	t=wave 4
Keep teleworking	528	944	1,087
Stop teleworking	301	617	449
Keep rate	0.637	0.605	0.708

Non-teleworkers at t-1

	t=wave 2	t=wave 3	t=wave 4
Start teleworking	908	472	461
Non-teleworking	6,670	7,168	7,799
Start rate	0.120	0.062	0.056