INTERNATIONAL REAL ESTATE REVIEW

2022 Vol. 25 No. 4: pp. 423 – 460

Impact of Teleworking on Childcare Time During the COVID-19 Pandemic: The Role of Owner-Occupied Housing

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Stay-at-home restrictions in several countries to prevent any further transmission of the COVID-19 virus during the pandemic have exogenously encouraged many workers and companies to adopt telework. This study discusses the relationship between teleworking and childcare participation, taking the housing environment into consideration by utilizing data from the Japan Household Panel Survey and its supplementary modules on COVID-19, which were conducted in 2020. After controlling for individual and household attributes, region, and housing characteristics, we find that regular employed male teleworkers living in owner-occupied detached housing increase the ratio of childcare time to work time by 31.6 percentage points than workers living in other housing arrangements during the pandemic. Regular employed female teleworkers increase the same ratio by 125.7

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percentage points in September when regular schooling resumed. This suggests that sufficient space and housing ownership may have a substantial effect on time devoted for childcare by teleworkers.

Keywords

Housing Environment, Telework, Childcare Participation, COVID-19 Pandemic

1. Introduction

Due to the rapid progression of the aging population and falling birthrate, the population in Japan has been forecasted to decrease by 14.8% from 127 million in 2015 to 108 million in 2040, with a total fertility rate of 1.25 (National Institute of Population and Social Security Research, 2017). This population decline has witnessed an increase in the participation of women in the labor force. The number of dual income households outnumber the number of single income households: in 1997, 9.5 million households were dual income which increased to 12.45 million in 2019 (Gender Equality Bureau, 2020). Consequently, achieving a work-life balance has become the goal for such households. To realize this goal, men need to participate in household chores, raise their children, and alleviate the burden of their spouse. However, despite their efforts, the long work hours and less time for leisure and personal care (OECD, 2020) mean that Japan ranks low in the work-life balance index of the OECD or 3.4 (OECD, 2022).

On January 30, 2020, the World Health Organization (WHO) announced an international public health emergency in response to the outbreak of the COVID-19 virus, which originated in Wuhan, China and began to spread globally. A nationwide state of emergency was declared in Japan from April 7 to May 25, 2020. During this period of time, some of the industries that provide in-person services closed temporarily and encouraged teleworking. Working from home was particularly encouraged because restrictions were in place which prohibited people from leaving their home to prevent further transmission of the virus. Japan has a low telework rate due to the corporate system and culture; however, a system for telework implementation had to be developed with the onset of the COVID-19 pandemic. Therefore, it is worthwhile to analyze and discuss how the shift toward telecommuting had brought about changes in the personal behavior of the Japanese.

This study focuses on the impact of teleworking on childcare time during the COVID-19 pandemic.[1] During this period of time, many elementary and high schools in Japan closed temporarily. Consequently, some parents had to care for their child(ren) while working. In this study, we define childcare time in a broader sense, that is, the time taken to care for preschoolers and help elementary to high school students with their homework, to estimate the impact of working from home on childcare time which is done by using the difference-in-differences (DID) method.

Traditionally, telecommuting has been used to balance work and household responsibilities. However, in this situation, endogeneity arises between telecommuting and childcare time which makes it difficult to accurately identify its quantitative effects. These endogeneity issues have not been discussed in previous studies (Wight and Raley, 2009; Genadek and Hill, 2017; Pabilonia and Vernon, 2020; Zhang et al., 2020). During the COVID-19 pandemic, telecommuting has been implemented based on criteria that are beyond work-life balance and childcare; therefore, it is important to tackle the issue of endogeneity. This study contributes to the literature on childcare engagement and teleworking in the context of an exogenous shock, that is, the COVID-19 pandemic.

Furthermore, this study aims to explore the association between working from home and housing characteristics. To work from home, information and communications technology (ICT) tools (i.e., Internet) and work space are needed. Thus, the relationship between housing attributes and telecommuting may become more apparent. Qin et al. (2021) find that the type of housing and the number of rooms are factors that affect telework. However, curiously, housing characteristics have been rarely analyzed in previous studies on teleworking during the pandemic, such as Okubo et al. (2021) and Morikawa (2021). Therefore, we further this strand of research by considering housing characteristics. Our study will contribute to the literature on the ownership of housing and childcare practices (Grinstein-Weiss et al., 2010) in the context of teleworking.

Therefore, the following hypotheses are tested: 1) teleworking impacts childcare time and 2) the relationship between teleworking and childcare time changes depending on the housing characteristics. We test the hypotheses based on three treatment periods, depending on the purpose, to reveal the treatment effects.

The remainder of the paper is structured as follows. In Section 2, the related literature is briefly reviewed, followed by a description of the data in Section 3.

[1] Herein, teleworking is interchangeable with telecommuting. Since the variables of teleworking are derived from questions about working from home, teleworking equals working from home.

The empirical methodology and results are presented in Section 4 followed by a discussion in Section 5 and a summary in Section 6.

2. Literature Review

2.1 Impact of the COVID-19 pandemic on childcare and telecommuting

In many countries, the COVID-19 pandemic has promoted telework which has changed gender roles in the household. Alon et al. (2020) discuss the impact of the COVID-19 pandemic on gender inequality in the United States. They analyze data on the distribution of women, men, and couples by occupation, and the division of labor time. The results show that COVID-19 greatly increases the burden on women. In particular, the COVID-19 pandemic, unlike normal recessions, is more likely to reduce employment in sectors where women constitute a large portion of the labor force.

Craig and Churchill (2020) conduct a survey on the COVID-19 pandemic in Australia and collect 2,722 responses over a three-week period of time during the lockdown (May 7–30, 2020). This survey evaluates changes in employment status and place of work before and after the lockdown due to COVID-19. The results show that the mandatory restrictions during the lockdown increase the childcare time of fathers in dual-earner households, thus reducing the burden gap between couples.

Teleworking was not widespread in Japan before COVID-19, but the pandemic clearly promoted its prevalence. Okubo et al. (2021) analyze the effects of COVID-19 on working from home by using data from a unique survey on telework conducted by the Keio University and the Nippon Institute for Research Advancement (NIRA). They find that, despite the increasing prevalence of teleworking compared to "normal" working conditions, the efficiency of new teleworkers was reduced by approximately 20% on average during the COVID-19 pandemic. Conversely, the efficiency of those who were already working from home pre-pandemic, was maintained.

2.2 Impact of telecommuting and workplace flexibility on childcare time

Using matching data from the Current Population Survey (U.S. Census Bureau and the U.S. Bureau of Labor Statistics) and the American Time Use Survey 2004-2005 (U.S. Bureau of Labor Statistics), Wight and Raley (2009) find that women who work from home spend less time on paid work, and fathers who work from home spend less time on primary childcare. Genadek and Hill (2017) use the same data to analyze more comprehensively the impact of workplace flexibility on the amount of time spent with children. They find that mothers who telecommute spend more time with their children, whereas fathers do not,

and fathers who work on flexible schedules spend less time with their children than those who do not.

More recently, Pabilonia and Vernon (2020) differentiate between full-day and weekend or work-at-home telecommuting—an issue that has been overlooked until their study—and analyze the probability of being a teleworker, weekly earnings on the main job, and time use. The analysis of time use reveals that men spend more time on primary childcare, while women spend more time on physical leisure activities.

Zhang et al. (2020) analyze telework choice based on variables related to life stages, such as gender, marital status, and parenthood, by using unique German microdata, which were collected before the pandemic. They show a complex association between telework behavior and life stages.

These studies analyze the relationship between workplace flexibility, including teleworking, and time spent with the family, such as childcare time; however, the endogeneity of teleworking is not discussed. In analyzing the impact of telecommuting on childcare time, an endogeneity issue arises because having children increases parental responsibilities and workload at home contrary to the facilitation of work-life balance.

2.3 Effect of housing characteristics on telecommuting and childcare time

Qin et al. (2021) analyze telecommuting in relation to housing characteristics. Their study applies a negative binomial regression model to their survey data and finds that the type of housing and the number of rooms significantly affect the probability of telecommuting. In particular, detached and semi-detached townhouses and a larger number of rooms increase the probability of telecommuting. This supports the idea that telecommuting requires a quiet and independent environment for work.

In the urban economics literature, Green and White (1997) test whether homeowning benefits the outcome of children. They use micro data for analysis and focus on households with 17-18-year-old children who are living with their parents. They find that the children of homeowners are in school and their daughters do not have children. This is especially true for lower income households.

In addition, Grinstein-Weiss et al. (2010) analyze parental childcare practices and housing characteristics. They evaluate parental behavior that affects the outcome of children by examining whether parental engagement at home, in school, and in the community differs based on housing characteristics. The results show that households under homeownership have increased organized activities and reduced TV/game time, which means that they are more engaged in childcare; thus, homeownership has a positive impact on child outcomes.

Accordingly, this study aims to determine whether increased teleworking during the COVID-19 pandemic has led to an increase in childcare time by focusing on housing characteristics with a micro-survey. Furthermore, since the COVID-19 pandemic promotes telework as "an exogenous shock" for workers (Zhang et al., 2020), the endogeneity of teleworking could be addressed based on the data collected during the pandemic.

3. Data

3.1 JHPS/KHPS and supplementary modules on COVID-19

We analyze data drawn from the Japanese Household Panel Survey (JHPS)/ Keio Household Panel Survey (KHPS) and its supplementary module on COVID-19 (COVID-19 Supplement), which were conducted in February, May, and September 2020, respectively. The JHPS covers general topics, including employment, education, lifestyle, allocation of time, health, and living environment, along with more detailed factors, such as household composition and income, expenditures, assets, and housing type. The JHPS was originally conducted as two independent panel surveys: the KHPS and the former JHPS. The KHPS and JHPS have been conducted annually since 2004 and 2009, respectively, but eventually combined in 2014 and after that, both surveys were continued under the name of JHPS/KHPS. The initial sample size is 4,005 households for the KHPS and 4,022 households for the former JHPS.

The COVID-19 Supplement included specific questions related to the COVID-19 pandemic to understand how people's lives, attitude, behaviors, and psychological states were affected during the state of emergency. After asking JHPS/KHPS respondents to participate in the COVID-19 Supplement, 3,891 of 5,470 responses were considered usable and analyzed.

The regular JHPS was conducted in February 2020 (JHPS2020) and surveyed responses when fewer new infections occurred. The survey collected information on household and housing characteristics, such as annual household income, number of household members, housing tenure, and industry firm size. Details of the housing and household characteristics are collected only in this survey and not the supplementary modules.

The first supplementary module was conducted from late May to the beginning of July 2020. This period followed immediately the first wave of new infections and the first state of emergency (April 7 to May 25, 2020). This survey includes questions regarding the life of the respondents one month prior (April 2020) to the first state of emergency and school closures (Figure 1).

The second supplementary module was conducted from mid-October to the end of December 2020. This corresponds with the period after the second wave of new infections. This survey also includes questions regarding the life of the

respondents one month before (September 2020) the high rate of infection, wherein a state of emergency was not declared and schools were open (Figure 1).

Figure 1 Number of new infections and stay at home rate

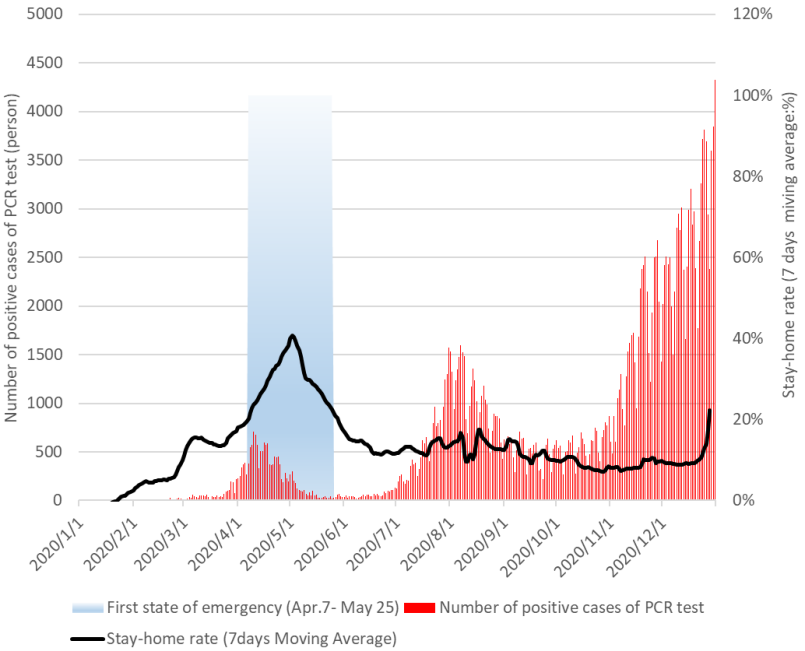


Figure 1 presents the number of polymerase chain reaction (PCR) positives per day (left axis) and the national average stay at home rate[2] per day (right axis) in Japan. In February 2020, the average number of PCR-positive cases was 7.31 and the average stay at home rate was 5.17%, which are relatively low. Accordingly, the Japanese government published basic policies for novel coronavirus disease control measures on February 25, 2020 (Headquarters for Novel Coronavirus Disease Control, 2020). These policies mandated the re-examination of the necessity of hosting public events and promoted teleworking. After February 25, the stay at home rate surged. From March, the average PCR-positive cases increased to 61.29 and stay at home rate increased to 14.75%.

[2] The stay at home rate was calculated by estimating the number of people going out (night population-daytime population) in each residential area (500 m mesh), and adding them up in the area. Then, it was calculated using the ratio during normal times (average from January 6, 2020 to January 31, 2020) and the COVID-19 pandemic. See Mizuno et al. (2021) for more information.

The number of new infections in April was 412, and the stay at home rate was 27.3%. In September, these numbers were 503 and 11.6%, respectively.

In this study, we produce short panel data from the JHPS 2019 and 2020, and the first and second supplementary modules to create variables of household and housing information, and variables related to COVID-19, respectively. Although we could identify the respondents who had moved during the study period, details of household and housing characteristics could not be observed for the April and September samples. Therefore, households that moved during the observation period were excluded from the data. Due to sample size issues, the target audience for childcare are individuals under 18 years of age.

3.2 Estimation samples and descriptive statistics

Table 1 presents the means of childcare time, work time, and teleworking surveyed in February 2019, and February, April, and September 2020. In the supplement module surveys, the respondents were asked to indicate the average hours each week dedicated to childcare and work.[3] After excluding respondents who belong to the top 1% of the distribution of childcare time and work time each week to reduce outliers, the ratio of childcare hours to work hours each week is calculated. From the entire sample (A) in Table 1, the mean of childcare time each week is 12.0 hours in February 2020, which increased to 14.6 hours in April (during the first state of emergency) and 13.0 hours in September. The average work hours each week is 36.7 hours in February 2020, 31.6 hours in April, and 32 hours in September. The ratio of childcare hours to work hours is 0.61 in February, 1.261 in April, and 0.983 in September. The increase of the ratio in April reflects the increase of childcare time due to the decrease of work time. For the male sample (B) in Table 1, the ratio is significantly increased from 0.172 in February to 0.278 in April (by about 10%), thus reflecting the significant increase of childcare time from 5.6 to 7.0 hours[4], and decrease of work hours from 43.8 to 37.6 hours. For the female sample (C) in Table 1, the childcare hours are significantly increased by 3.9 hours, that is, from 19.4 hours in February to 23.3 hours in April. However, their work hours significantly decrease by 3.5 hours, that is, from 28.3 hours in February to 24.8 hours in April. The ratio of childcare time to work time for females is increased significantly from 1.123 in February 2020 to 2.381 in April. Therefore, it can be inferred that childcare is handled by women before and during the pandemic.

[3] The question about childcare time is included in the annual JHPS/KHPS. Precise information of the questionnaire is available at: https://www.pdrc.keio.ac.jp/en/paneldata/datasets/jhpskhps/ (Accessed 9 September 2020).

[4] These findings correspond with a report issued by the Cabinet Office, Government of Japan (2020) which states that, during the COVID-19 pandemic, the number of households where the role of the husband is increased at home accounts for more than 25% of the total households covered by the survey.

In the entire sample, the ratio of teleworkers who conducted telework at least one day of the week, was only 5.9% in February 2020. However, the ratio of teleworkers increased to 28% in April due to the state of emergency. Although a state of emergency was not declared in September, the ratio of teleworkers remained high at 18.1%. From a gender perspective, males tend to perform more telework than females. The percentage of male and female teleworkers in April is 34.8% and 20.3% respectively. Telework in February 2019 represents telework experience from 2018-2019. This variable is surveyed in JHPS/KHPS 2019 and its definition is different from that surveyed in the supplement modules. Only 2.4% of the workers in the entire sample experience telework in February 2019.

Table 1 also includes the implementation status of telework during the observation period. The supplementary modules include questions regarding the implementation status of teleworking in February, April, and September 2020. The mandates of a company reveal the ratio of workers who teleworked. This ratio for the entire sample is significantly increased from 7.5% in February to 28.4% in April, but decreased to 18.3% in September. The ratio for the male sample is 10% in February, 34% in April, and 23.4% in September, versus 4.3% in February, 21.5% in April, and 12.8% in September for the female sample. These differences reflect the difference in employment status by gender. Regular employment accounts for about 96% of male workers and 40% of female workers. Generally speaking, regular employment works according to the mandates of the company. Therefore, we consider that regular male employees were required to telework as mandated by the company. Thus, in the following analysis, we focus on regular workers with children who are 18 years old and younger and teleworked as mandated by the company as the treatment group. However, we do not know whether the respondents who experienced telework in 2019 worked from home as mandated by their employer. Consequently, these respondents were excluded from the sample.

Table 2 presents a breakdown of the employment status of the spouse of the respondents in February 2020 based on the JHPS/KHPS. Since this ratio did not change during the observation period, only the February 2020 values have been tabulated. Regular and non-regular employment, and housework account for the majority or 50%, 24%, and 14% of the entire sample, respectively. However, the ratios differ according to gender. We find that male respondents mainly work (Table 1) while their spouse is in a supporting role by doing housework or working in secondary jobs. The ratio of housewives is 24.2% and that of non-regular employment is 42.3%. The ratio of regular employment of the spouse is 25%. On the other hand, the spouse of the female respondents works in regular and self-employment which comprise 80.2% and 3.8%, respectively. The spouse of the female respondents in non-regular employment and housework comprise only 2.8% and 1.9% respectively. Working single are also in a supporting role. Single workers comprise 10% and are more likely to be women than men.

Table 1 Means of childcare and telework time from sample of workers with children 18 years old and over

Variable	Feb. 2019		Feb. 2020		Apr. 2020		Sept 2020		Feb. 2020 - Feb. 2019	2020 Apr.- Feb	Sep. - Apr. 2020
	N	Mean	N	Mean	N	Mean	N	Mean	t	t	t
(A) Whole											
Childcare hours each week	553	14.3	460	12.0	475	14.6	393	13.0	-1.85*	2.11**	-1.25
Work time each week	553	36.6	460	36.7	475	31.6	393	32.0	0.09	-4.76***	0.32
Childcare hours each week/ work time each week	553	0.739	460	0.610	475	1.261	393	0.983	-1.19	2.81***	-1.05
Telework(=1)	553	0.024	460	0.059	475	0.280	393	0.181	2.76***	9.47***	-3.51***
Mandated by company (=1)			427	0.075	444	0.284	372	0.183		8.38***	-3.44***
Implemented at own discretion (=1)			427	0.026	444	0.025	372	0.048		-0.09	1.77*
Regular employment (=1)	553	0.678	460	0.715	475	0.697	393	0.695	1.28	-0.62	-0.07
(B) Male											
Childcare hours each week	280	5.2	248	5.6	253	7.0	199	6.0	0.57	1.73*	-1.12
Work time each week	280	44.9	248	43.8	253	37.6	199	38.5	-0.92	-4.64***	0.59
Childcare hours each week/ work time each week	280	0.159	248	0.172	253	0.278	199	0.278	0.39	2.53**	-0.01

(Continued…)

(Table 1 Continued)

Variable	Feb. 2019		Feb. 2020		Apr. 2020		Sept 2020		Feb. 2020 - Feb. 2019	2020 Apr.- Feb	Sep. - Apr. 2020
	N	Mean	N	Mean	N	Mean	N	Mean	t	t	t
Telework(=1)	280	0.029	248	0.073	253	0.348	199	0.221	2.28**	8.04***	-3.01***
Mandated by company (=1)			239	0.100	244	0.340	192	0.234		6.64***	-2.45**
Implemented at own discretion (=1)			239	0.025	244	0.037	192	0.063		0.75	1.20
Regular employment (=1)	280	0.961	248	0.964	253	0.960	199	0.965	0.18	-0.19	0.24
(C) Female											
Childcare hours each week	273	23.6	212	19.4	222	23.3	194	20.1	-1.86*	1.68*	-1.35
Work time each week	273	28.0	212	28.3	222	24.8	194	25.3	0.21	-2.60***	0.36
Childcare hours each week/ work time each week	273	1.334	212	1.123	222	2.381	194	1.706	-0.98	2.61***	-1.25
Telework(=1)	273	0.018	212	0.042	222	0.203	194	0.139	1.50	5.27***	-1.73*
Mandated by company (=1)			188	0.043	200	0.215	180	0.128		5.28***	-2.27**
Implemented at own discretion (=1)			188	0.027	200	0.010	180	0.033		-1.21	1.54
Regular employment (=1)	273	0.388	212	0.425	222	0.396	194	0.418	0.80	-0.59	0.44

Notes: Apr.–Feb. and Sept–Apr. represent the results of a t-test with equal means between two samples, using Welch's method under the heteroskedasticity hypothesis. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 2 Employment status of spouses of respondents with children 18 years old and younger in February 2020

Sample	(a) Whole		(b) Male		(c) Female		(b) – (c)
Employment	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**t**
No spouse (=1)	0.063	0.243	0.024	0.154	0.108	0.312	
Housework(=1)	0.139	0.346	0.242	0.429	0.019	0.136	-7.74***
Self-employment(=1)	0.041	0.199	0.044	0.206	0.038	0.191	-0.36
Regular employment(=1)	0.504	0.501	0.250	0.434	0.802	0.400	14.19***
Non-regular employment(=1)	0.241	0.428	0.423	0.495	0.028	0.166	-11.81***
Other (=1)	0.011	0.104	0.016	0.126	0.005	0.069	-1.23
N	460		248		212		

Notes: (b)-(c) represent the results of a t-test with equal means between two samples, using Welch's method under the heteroskedasticity hypothesis. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

We conduct an analysis based on three samples of regular workers with children 18 years old and older: the (i) April-September, (ii) April, and (iii) September samples.

Sample (i) was used to estimate the treatment effects of teleworkers who had teleworked in April and September. This sample comprises respondents who continued to telework at least one day a week in February, April, and September 2020. They are considered to be the treatment group. On the other hand, those who did not conduct telework are considered to be the control group.[5] This sample does not include respondents who teleworked in April but stopped in September and those who did not telework in April but did so in September. The descriptive statistics are summarized in Table A1 in the Appendix.

Sample (ii) is used to estimate the treatment effects of teleworkers who teleworked in April 2020. This sample includes respondents who teleworked in April in the treatment group, while those who did not telework are placed in the control group. Therefore, the sample included respondents who were surveyed in February 2019, February 2020, and April 2020. This analysis of the sample revealed the effect on childcare time during the first state emergency and school closures. The descriptive statistics are summarized in Table A2 in the Appendix.

[5] Only 53 respondents teleworked from February to September and we could not conduct any further analysis. Therefore, we included these respondents in this sample.

Sample (iii) was used to estimate the treatment effects of teleworkers who teleworked in September. This sample includes respondents who teleworked in September as the treatment group and those who did not as the control group. Therefore, the sample comprises respondents who were surveyed in February 2019, February 2020, and September 2020. This analysis of the sample reveals the impact of telework on childcare time when their children went to school or pre-school. The descriptive statistics have been summarized in Table A3 in the Appendix.

Each subsample was then analyzed, excluding respondents with children younger than 6-years old. These respondents account for 25% of those with children 18 years old and older in the April-September sample (Table A1). They are excluded because a number of preschool-age children could have continued to attend daycare facilities even under the state of emergency in April 2020, whereas elementary, middle high, and high school students were unable to attend school during that time (Yokoyama and Takaku, 2020).

Therefore, these three samples are analyzed to identify the causality between telework and the ratio of childcare time to work time.

4. Econometric Analysis and Results

4.1 Identification strategy

This section discusses the econometric methods used in this study. The models are estimated by using the DID method for 1) COVID-19 and 2)housing characteristics.
We use the DID method because the COVID-19 pandemic has a confounding impact on both childcare time and teleworking practices. The former can be attributed to children spending more time at home due to the closure of schools and the mandate to stay at home. Therefore, simply estimating the effect of working from home by using data before and after the onset of COVID-19, is likely to overestimate the effect.

We regard April and September 2020 as the period post COVID-19 pandemic lockdown in Japan. As mentioned in Section 3.1, policies to prevent infections in Japan were adopted on February 25, 2020. Around this time, the February survey had almost been completed. The first state of emergency was declared in April, and schools were closed during the first peak of new infections (Figure 1). However, a state of emergency was not declared in September but the number of new cases kept increasing and the stay at home rate was also high. Therefore, we consider April and September 2020 as the post-treatment periods (Figure 1). Both February 2019 and 2020 are considered to be the pre-treatment periods.

We use the ratio of childcare hours to work hours each week to determine the outcome variable. The increase in childcare hours may have been an effect of the decreasing work hours. Therefore, we use this ratio instead of the number of childcare hours to obtain the substitution effects. We use the dummy variable of telework as the treatment variable, as it indicates those who telework at least one day a week as mandated by the company.

To address the confounding impact on both childcare time and teleworking practices in the post treatment period, we use the DID method to estimate the average treatment effect on the treated, based on a parallel trend assumption. We checked this assumption by comparing the average quasi log-transformed ratio of childcare time to work time from the February 2019 and 2020 surveys after controlling the covariates used in the analysis; see Figure 2.[6] It can be inferred that this assumption is true for the April-September sample because of the 95% confidence intervals overlap and non-existence of any significant difference between the average childcare time of the teleworker and non-teleworker groups between February 2019 and February 2020. We further review the assumption for the subsamples, according to gender. No significant difference can be observed for the male sample. However, we observe a downward trend among teleworkers and rather stable movement among non-teleworkers for the female sample; this difference is not significantly different from zero. Thus, we conclude that in the context of gender, the parallel trend assumptions are satisfied for the entire sample and subsamples (April-September sample). We observe similar results for the April and September samples (Figures A1 and A2, respectively).

4.2 DID approach

The DID approach is a popular method used to observe the difference in the treatment group before and after the treatment. Since the COVID-19 pandemic is an external factor for the survey respondents, we assume that it is a common shock after controlling for the regional differences due to its impact. In this study, treatment is used as the dummy variable for telework. The DID model is as follows:

$$\widetilde{ln}(y_{it}) = \beta_0 + \beta_w W_{it} + \beta_\tau COVID_t + \beta_d W_{it} COVID_t + \beta x_{it} + \epsilon_{it}, \quad (1)$$

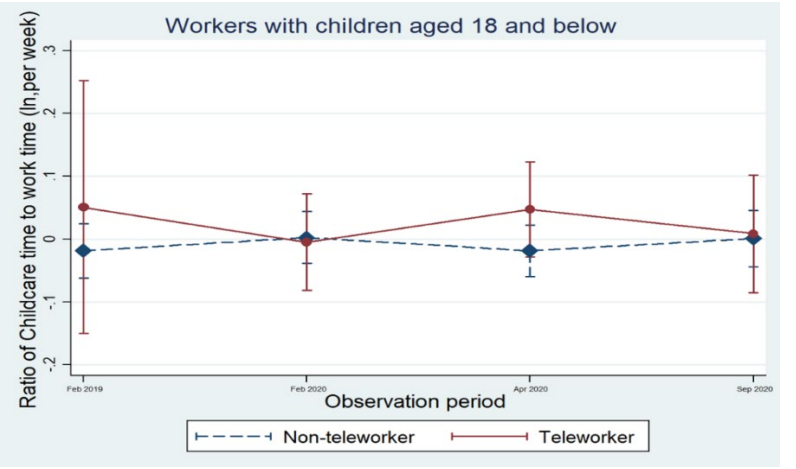
where $\widetilde{ln}(y_{it}) = \ln(y_{it} + 1)$ and

$$y_{it} = \begin{cases} \dfrac{childcare\ time_{it}}{work\ time_{it}} & if\ childcare\ time_{it} \neq 0\ and\ work\ time_{it} \neq 0 \\ 0 & if\ childcare\ time_{it} = 0 \end{cases}$$

[6] Quasi log-transformed ratio of childcare time to work time means that the ratio, y, is transformed as ln(y+1), which is explained in Section 4.2. Covariates used for control are also used in the DID analysis presented in Table A4.

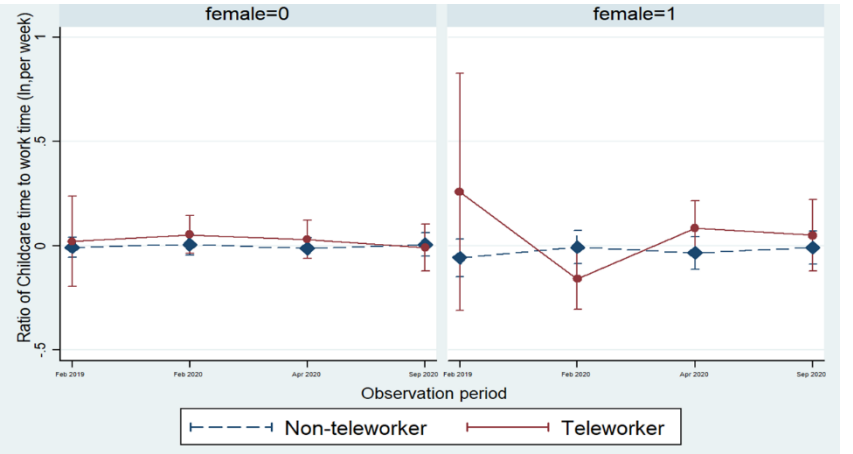
Here, $childcare\ time_{it}$ represents childcare hours each week and $work\ time_{it}$ represents work hours each week. W_{it} indicates telework as mandated by the company and $COVID_t$ is the post-treatment era dummy for April and September 2020. For the control variables, x_{it} includes the variables of the housing characteristics (e.g., size of dwelling space, age of building, etc.), individual and household characteristics (e.g., age of respondents, number of children and household members, household income, employment, industry, company size, commuting time to the office, and industry), and regional and survey period fixed effects. Since the variables of the household and housing characteristics (April and September 2020) are extracted from JHPS/KHPS 2020, they are constant from February to September 2020. We are not able to estimate the fixed effects models of the respondents because we cannot secure enough variation of the covariates from their means. Thus, we select pooled ordinary least squares (OLS) models as the baseline model to include as many covariates as possible. The relative effect of telework during the COVID-19 pandemic on the ratio of childcare time to work time is calculated by using $\exp(\beta_d) - 1$, based on Halvorsen and Palmquist (1980). The standard errors calculated by the delta method are based on the cluster standard errors over the respondents.

Figure 2 Changes in the average ratio of childcare hours to work hours each week according to teleworking status, with 95% confidence intervals



(Continued…)

(Figure 2 Continued)



Notes: These figures are based on the April-September sample. Logarithm of the ratio of childcare time on the vertical axis controlled by the covariates used in Table A2.

The models are estimated for the entire sample and subsets including male and female respondents based on the April-September, April, and September samples. The estimation results of the relative effects of Equation (1) are presented in Table 3, and the full estimation results are presented in Table A4 in the Appendix[7]. The first two columns are based on the entire sample. Column 1 reports the results of regular workers with children 18 years old and older including those who teleworked as mandated by their company. Panel (A) of Table 2 includes the results based on the April-September sample. We obtain a positive and significant estimate of the relative effect on the ratio of childcare time, that is, telework increases the ratio of childcare time to work time by 16.1 percentage points. Column 2 reports the results of the respondents with children between 7 to 18 years old. We obtain significantly positive results and the effect is 12 percentage points. From a gender perspective, we obtain positive but insignificant effects.

Next, we estimate the models by using the April and September samples. We obtain similar magnitude of estimates, that is, 0.144 for workers with children under 18 and 0.110 for workers with children 7-18 years old from the April sample with those of the April-September models. However, they are not

[7] The variance inflation factors of these estimation results are tabulated in Table A5 to check the multicollinearity of the variables. Higher values can be observed among the dummy variables such as COVID and TELEWORK X COVID. However, we consider that these are necessary to identify β_d. We also observe higher values among continuous variables and their indicator variables of missing cases, for instance, monthly household income and its missing cases. We think that they are indispensable for estimating models to retain larger sample sizes.

significant. From the estimates based on the September sample, significant relative effects are observed for the models based on the entire sample, and 13.0 percentage points for workers with children who are 7-18 years old. Furthermore, significantly positive effects are observed for the female subsample: 79.6 percentage points for workers with children under 18 and 119.9 percentage points for workers with children who are 7-18 years old. Thus, telework increases the ratio of childcare time to work time for the April-September sample. We do not obtain significant results for the April sample. The results for the September sample reveal that the ratio increases for regular female workers with children under 18, especially for those with children who are 7-18 years old. These results imply that female teleworkers do not increase the time devoted to childcare when the schools close in April, but are able to increase the ratio when schooling resumed.

Table 3 Estimation results of difference-in-differences models

	Workers with children		**Male workers with children**		**Female workers with children**	
	1. 0-18	2. 7-18	3. 0-18	4. 7-18	5. 0-18	6. 7-18
Variable	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
(A) April-September sample						
Telework(=1)	0.161*	0.120*	0.108	0.113	0.420	0.511
× COVID(=1)	(0.089)	(0.072)	(0.104)	(0.086)	(0.279)	(0.348)
	993	743	731	556	262	187
(B) April sample						
Telework(=1)	0.144	0.110	0.123	0.121	0.399	0.359
× COVID(=1)	(0.093)	(0.084)	(0.103)	(0.094)	(0.297)	(0.271)
	895	674	674	511	221	163
(C) September sample						
Telework(=1)	0.131	0.130*	0.071	0.042	0.796*	1.199*
× COVID(=1)	(0.088)	(0.075)	(0.092)	(0.063)	(0.439)	(0.686)
	764	579	569	438	195	141

Notes: Ratio of childcare time to work time is the dependent variable. The relative effect of telework during COVID-19 pandemic is calculated from $\exp(\beta_d) - 1$. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Standard errors calculated by the delta method based on cluster standard errors over respondents are given in parentheses. Third row of each cell represents the number of observations.

4.3 Heterogeneous effects

We find some significantly positive results for the DID parameters. However, the effects may change depending on respondent heterogeneity, such as their housing characteristics. In previous studies, housing characteristics have been described as a confounding factor that affects both childcare time (Grinstein-

Weiss et al., 2010) and telecommuting (Qin et al., 2021). To capture the differences that arise due to the heterogenous effects of housing characteristics, we use the DID method with interaction terms that facilitates the estimation of the separate effects of housing characteristics.

Before estimating the models, we test the following hypothesis: teleworking is related to housing characteristics. The results are summarized in Table A6 in the Appendix. The results reveal that teleworking is not significantly related to housing characteristics except for the commuting time, which is significantly different from zero for the entire and male samples. This suggests that workers whose commuting time is longer tend to telework. If telecommuting influences childcare, it can become a confounding factor that affects both telecommuting and childcare time. Therefore, commuting time to the workplace is controlled in the models estimated in this article (Table A6).

The DID model that considers housing characteristics is as follows:

$$\widetilde{ln}(y_{it}) = \beta_0 + \beta_g W_{it} + \beta_h H_i + \beta_\tau COVID_t + \beta_{gh} W_{it} H_i + \beta_{g\tau} W_{it} COVID_t + \beta_{h\tau} H_i COVID_t + \beta_d W_{it} H_i COVID_t + \beta x_{it} + \epsilon_{it}, \quad (2)$$

where W_{it} represents teleworking due to the dummy variable – teleworking mandated by company, and H_i indicates the housing characteristics. This model identifies the effect of the treated (W_{it} =1,H_{it}=1) for the post-treatment era dummy $COVID_t = T = 1$, (COVID dummy which indicates April and September). The most important parameter is β_d , which is summarized as:

$$\begin{aligned}\beta_d = {} & [E(\widetilde{ln}(y_{it}) \mid W_{it} = 1, H_i = 1, T = 1]] - E(\widetilde{ln}(y_{it}) \mid W_{it} = 1, H_i = 1, T = 0]] \\ & - [E(\widetilde{ln}(y_{it}) \mid W_{it} = 0, H_i = 1, T = 1) - E(\widetilde{ln}(y_{it}) \mid W_{it} = 0, H_i = 1, T = 0)] \\ & - \begin{bmatrix} E(\widetilde{ln}(y_{it}) \mid W_{it} = 1, H_i = 0, T = 1) - E(\widetilde{ln}(y_{it}) \mid W_{it} = 1, H_i = 0, T = 0) \\ -\{E(\widetilde{ln}(y_{it}) \mid W_{it} = 0, H_i = 0, T = 1) - E(\widetilde{ln}(y_{it}) \mid W_{it} = 0, H_i = 0, T = 0)\} \end{bmatrix} \end{aligned} \quad (3)$$

The estimate $\hat{\beta}_d$ provides information on the net change in the relative effects of the teleworking of workers who are living in housing with specific features(H_i).This model can be called a saturated model (Lee, 2016), where we assume that the slopes of teleworking and housing are time-varying (e.g., $\beta_{g\tau}$ for teleworking and $\beta_{h\tau}$ for housing characteristics in the post-treatment era).

However, many workers started to telework in April: $W_{i,Apr} = 1, COVID_{Apr} = 1$. Therefore, W_{it} and $W_{it} COVID_t$ show a high correlation, especially in the female sample. Thus, to avoid multicollinearity, we exclude $W_{it} COVID_t$ and estimate the following semi-saturated model:

$$\widetilde{ln}(y_{it}) = \beta_0 + \beta_g W_{it} + \beta_h H_i + \beta_\tau COVID_t + \beta_{gh} W_{it} H_i + \beta_{h\tau} H_i COVID_t + \beta_d W_{it} H_i COVID_t + \beta x_{it} + \epsilon_{it} \quad (4)$$

Furthermore, $W_{it}H_i$ and $W_{it}H_iCOVID_t$ are sometimes the same due to the reason stated above, especially for the female sample; in this case, $W_{it}H_i$ is dropped as follows:

$$\widetilde{ln}(y_{it}) = \beta_0 + \beta_g W_{it} + \beta_h H_i + \beta_\tau COVID_t + \beta_{h\tau} H_i COVID_t + \beta_d W_{it} H_i COVID_t + \beta x_{it} + \epsilon_{it} \quad (5)$$

Several variables of housing characteristics are then selected to test whether housing characteristics, such as the dwelling size, housing tenure, and longer commuting time, affect childcare time. The estimates of the coefficients of the interaction terms, β_d, are included in Table 4-6 (based on the three samples).

4.3.1 Size of house

First, we test whether the dwelling size affects childcare time. Here, we consider the number of rooms, number of empty rooms—defined as the difference between the number of rooms and occupants per household, excluding children who are under 10 years of age as they are considered half-occupants (Seko et al., 2019), and floor space. We believe that the number of rooms are important for teleworking to manage the noise generated by other household members, especially children (Qin et al., 2021). After controlling for the number of rooms, number of household members, and floor space, we examine the hypothesis that teleworking is related to housing characteristics by using variable H_i (represents housing characteristics and makes treatment effects heterogenous), such as an indicator of housing with four or more rooms, indicator of one or more empty rooms, and indicator of housing with a floor space larger than 50 m^2.

The results have been tabulated in Table 4. In Panel (A) of the April-September sample results, the most interesting parameter estimates reveal positive but insignificant coefficients, thus indicating that the hypothesis is weakly supported.

In Panel (B) of the April sample results, the indicator of housing with four or more rooms has significantly positive effects for the entire sample and the subsample of male workers with children who are 7-18 years old. In addition, male teleworkers who are living in houses with a floor space larger than 50 m^2 show a significantly positive effect. During the state of emergency in April 2020, staying at home and closure of schools were mandated by the government. Therefore, if both parents and children who are 7-18 years old worked and studied online from home, then rooms are required to facilitate the same.

Table 4 Estimates of interaction terms of difference-in-differences models

	Workers with children		Male workers with children		Female workers with children	
	1. 0-8	2. 7-18	3. 0-18	4. 7-18	5. 0-18	6. 7-18
Variable	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
(A) April-September sample: Telework(=1)×COVID(=1)						
× Four rooms and above(=1)	-0.003	0.131	0.169	0.182	0.042	0.010
	(0.147)	(0.131)	(0.171)	(0.138)	(0.216)	(0.180)
	993	743	731	556	262	187
× One or more empty rooms(=1)	0.236	0.100	0.226	0.161	0.294	-0.065
	(0.163)	(0.119)	(0.180)	(0.165)	(0.299)	(0.153)
	976	730	718	543	258	187
× Larger spaces than 50 m^2 (=1)	-0.103	0.083	0.153	0.066	0.091	0.111
	(0.171)	(0.132)	(0.153)	(0.113)	(0.230)	(0.350)
	993	743	731	556	262	187
(B) April sample: Telework(=1)×COVID(=1)						
× Four rooms and above(=1)	0.294	0.574**	0.298	0.362*	0.515	0.444
	(0.230)	(0.253)	(0.211)	(0.210)	(0.364)	(0.290)
	895	674	674	511	221	163
× One or more empty rooms(=1)	0.357	0.254	0.385	0.345	0.470	0.267
	(0.224)	(0.219)	(0.245)	(0.246)	(0.422)	(0.266)
	874	659	657	496	217	163
× Larger spaces than 50 m^2 (=1)	0.190	0.245	0.475*	0.308	0.254	0.222
	(0.262)	(0.259)	(0.279)	(0.240)	(0.282)	(0.260)
	895	674	674	511	221	163
(C) September sample: Telework(=1)×COVID(=1)						
× Four rooms and above(=1)	-0.074	-0.013	0.059	0.134	0.728*	0.908
	(0.175)	(0.172)	(0.237)	(0.111)	(0.441)	(0.588)
	764	579	569	438	195	141
× One or more empty rooms (=1)	0.146	0.068	0.159	0.193	0.734	0.906
	(0.178)	(0.147)	(0.182)	(0.132)	(0.496)	(0.634)
	751	568	558	427	193	141
× Larger spaces than 50 m^2 (=1)	0.051	0.124	0.107	0.001	1.164*	1.556
	(0.211)	(0.176)	(0.171)	(0.111)	(0.672)	(0.989)
	764	579	569	438	195	141

Notes: Ratio of childcare time to work time is the dependent variable. The relative effect of telework during COVID-19 pandemic is calculated from $\exp(\beta_d) - 1$. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Standard errors calculated by the delta method based on the cluster standard errors over respondents are given in parentheses. Third row of each cell represents the number of observations. The results of female sample are based on Equation (4).

In Panel (C) of the September sample, female workers with children under 18 years old, living in larger housing with four rooms and more, or housing with a floor space larger than 50 m^2 show positive effects. However, these results are not observed for female respondents who do not have pre-school age children. This suggests that female workers with children who are 0 to 6 require more space to care for them. In September, the state of emergency was lifted, and most schools reopened. Therefore, teleworkers could focus on working from home while children under 18 went back to school. This is particularly true for women workers with pre-school age children.

4.3.2 Building type, age, and ownership of housing

Second, we tested whether the quality of housing affects childcare time by using building type and age, along with ownership of the dwelling. The results have been tabulated in Table 5. We use indicators of detached housing and condominiums for type of building. Significantly positive results can be observed for detached housing in the estimates of the models of male workers based on the April-September and September samples. On the other hand, significantly negative results can be observed for condominiums in the models of male workers based on the April-September and September samples. Condominiums include high-rise multiple dwelling units. In previous studies, the psychological well-being of mothers with young children who are living in high-rise, multiple dwelling units is found to be low (Evans, 2003), which can reduce the childcare time of female workers. Our results for the April-September sample indicate that female teleworkers who are living in a condominium show negative effects; however, they are insignificant. Male teleworkers who are living in a condominium have significantly less childcare time.

For the age of the building, we used dwellings built within the past 10 years as an indicator, because the quality of housing is higher in newly built dwellings in Japan. This variable does not have significant results except for the female workers with children who are 7-18 years old, and accidentally have a significantly negative association. In terms of dwelling ownership, we use owner-occupied housing as an indicator. In this case, significantly positive effects can be observed in the male worker models based on the April-September sample, and male and female worker models based on the September sample. In the former, male workers with children under 18 years old have a larger ratio of childcare time relative to work time by 37.9 percentage points, while the estimate is 59.9 percentage points for the September sample. In the latter, the estimate of owner-occupied housing is significantly positive and the magnitude is 81.8 percentage points for female workers with pre-school children, and 123 percentage points for female workers with children who are 7-18 years old. Furthermore, male teleworkers who are living in detached housing, and owner-occupied housing increase their childcare time. An analysis of the September sample reveals that female workers who are living in owner-

occupied housing increase their childcare time when their children attend school.

Table 5 Estimates of interaction terms with building type, age, and housing ownership

	Workers with children		Male workers with children		Female workers with children	
	1. 0-8	2. 7-18	3. 0-18	4. 7-18	5. 0-18	6. 7-18
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
(A) April-September sample: Telework(=1)×COVID(=1)						
× Detached	0.263	0.167	0.321*	0.231	0.295	0.170
housing (=1)	(0.163)	(0.120)	(0.184)	(0.145)	(0.308)	(0.262)
	984	736	724	549	260	187
×Condominium	-0.209**	-0.080	-0.211*	-0.174*	-0.226	0.093
(=1)	(0.099)	(0.092)	(0.109)	(0.096)	(0.233)	(0.529)
	986	738	726	551	260	187
×Built less than	0.253	0.037	0.110	-0.006	-0.050	-0.369***
10 years(=1)	(0.169)	(0.134)	(0.194)	(0.141)	(0.227)	(0.136)
	993	743	731	556	262	187
×Owner-occupied	0.174	0.221	0.379**	0.224*	0.467	0.211
housing (=1)	(0.168)	(0.139)	(0.189)	(0.126)	(0.306)	(0.306)
	993	743	731	556	262	187
(B) April sample: Telework(=1)×COVID(=1)						
× Detached	0.165	0.003	0.025	-0.082	0.421	0.273
housing (=1)	(0.174)	(0.139)	(0.152)	(0.141)	(0.365)	(0.279)
	883	664	664	501	219	163
×Condominium	-0.098	0.029	-0.003	0.057	-0.376	-0.012
(=1)	(0.131)	(0.139)	(0.147)	(0.164)	(0.290)	(0.423)
	885	666	666	503	219	163
×Built less than	0.211	0.048	0.111	0.014	0.455	0.137
10 years(=1)	(0.181)	(0.146)	(0.199)	(0.150)	(0.391)	(0.243)
	895	674	674	511	221	163
×Owner-occupied	0.016	0.064	-0.013	0.042	0.484	0.375
housing (=1)	(0.140)	(0.158)	(0.141)	(0.124)	(0.353)	(0.275)
	895	674	674	511	221	163
(C) September sample: Telework(=1)×COVID(=1)						
× Detached	0.173	0.149	0.372	0.292**	0.794	1.161
housing (=1)	(0.210)	(0.160)	(0.274)	(0.130)	(0.533)	(0.751)
	756	572	562	431	194	141

(Continued…)

(Table 5 Continued)

×Condominium	-0.204	-0.055	-0.238	-0.207***	-0.261	0.220
(=1)	(0.142)	(0.130)	(0.153)	(0.078)	(0.078)	(0.720)
	758	574	564	433	194	141
×Built less than	0.179	-0.038	0.089	-0.008	0.469	-0.040
10 years(=1)	(0.167)	(0.144)	(0.178)	(0.127)	(0.476)	(0.286)
	764	579	569	438	195	141
×Owner-occupied	0.106	0.111	0.599**	0.201*	0.818*	1.230*
housing (=1)	(0.248)	(0.186)	(0.303)	(0.117)	(0.476)	(0.703)
	764	579	569	438	195	141

Notes: Ratio of childcare time to work time is the dependent variable. The relative effect of telework during COVID-19 pandemic is calculated from $\exp(\beta_d) - 1$. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Standard errors calculated by the delta method based on the cluster standard errors over respondents are given in parentheses. Third row of each cell represents the number of observations. The female models are estimated using Equation (4) except the condominium model, which is estimated using Equation (5).

4.3.3 Commuting time

Third, we test whether teleworkers trade their long commuting time for childcare time. We estimate the model by including an indicator for respondents whose one-way commuting time is longer than one hour. The results are summarized in Table 6. Negative estimates can be observed in general for the male worker models. On the other hand, for the model of female workers with children who are 7-18 years old, significantly positive estimates can be observed in Panel (A) of the April-September sample and Panel (C) of the September sample. These female workers increase the relative ratio of childcare time by 122.6 percentage points (April-September sample) and 161.4 percentage points (September sample). Thus, these results suggest that female teleworkers with children who are 7-18 years old trade their commuting time for childcare time in September when their children returned to school.

4.3.4 Heterogenous effects of owner-occupied housing

From the results above, we can see that owner-occupied housing is one of the housing characteristics that influences the childcare time of teleworkers. Previous studies, such as Green and White (1997) and Haurin et al. (2002), show that the outcome of children who are living in owner-occupied housing is better than that of other housing tenure. As Green and White (1997) suggest, homeowners have higher moving costs and tend to remain in neighborhoods longer than renters. This makes them better at monitoring and influencing the behavior of children, especially bad behavior which may reduce the attractiveness of the neighborhood and threaten the value of the houses. The

same reasoning can be applied to Japanese society which is characterized by a lower mobility rate and higher participation rate of local neighborhood associations as shown by Schoppa (2012). Therefore, we evaluate whether the heterogeneity of ownership of housing affects childcare time.

Table 6 Estimates of interaction terms with commuting time

	Workers with children		**Male workers with children**		**Female workers with children**	
	1. 0-8 Estimate	2. 7-18 Estimate	3. 0-18 Estimate	4. 7-18 Estimate	5. 0-18 Estimate	6. 7-18 Estimate
(A) April-September sample: Telework(=1)×COVID(=1)						
×Commuting time longer than 1 hour, one-way(=1)	-0.119	-0.111	-0.126	-0.206	0.406	1.226**
	(0.115)	(0.112)	(0.150)	(0.145)	(0.388)	(0.596)
	993	743	731	556	262	187
(B) April Sample: Telework(=1)×COVID(=1)						
×Commuting time longer than 1 hour, one-way(=1)	-0.044	-0.013	-0.016	-0.003	-0.150	0.480
	(0.160)	(0.158)	(0.181)	(0.184)	(0.423)	(0.351)
	895	674	674	511	221	163
(C) September sample Telework(=1)×COVID(=1)						
×Commuting time longer than 1 hour, one-way(=1)	-0.042	-0.163	-0.016	-0.248**	0.164	1.614*
	(0.153)	(0.129)	(0.150)	(0.119)	(0.407)	(0.845)
	764	579	569	438	195	141

Notes: Ratio of childcare time to work time is the dependent variable. The relative effect of telework during COVID-19 pandemic is calculated from $\exp(\beta_d) - 1$. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Standard errors calculated by the delta method based on the cluster standard errors over respondents are given in parentheses. Third row of each cell represents the number of observations. The female models are based on Equation (5).

The results are tabulated in Table 7. Owner-occupied dwellings with four or more rooms showed significantly positive effects for the male models in Panel (B) of the April sample, but not the female sample. One or more empty rooms have a significantly positive effect in the male model based on Panel (C) of the September sample. Owner-occupied housing with a space larger than 50 m^2 also have significantly positive effects for male workers with children who are 7-18 years old in Panel (A) of the April-September sample. These effects are not observed in Table 4 and specific to owner-occupied housing. Male teleworkers with children 0-18 years old in the April-September and September samples increase the relative ratio of childcare time by 32.6 and 40.9 percentage points, respectively. Female teleworkers also show a significant and larger

effect: 106 and 147.5 percentage points for females with children below 18 years old and 7-18 years old, respectively, in Panel (C) of the September model.

In the case of owner-occupied detached housing, we observe significantly positive effects in the April-September and September samples. Male teleworkers with children aged 0-18 years old in the April-September sample increase the relative ratio of childcare time to work time by 31.6 percentage points. In the September sample, the same ratio is 36.8 percentage points but insignificant. However, it changed to 29.3 percentage points after excluding pre-school age children, thus becoming significant. We observe that the effect is greater for the female sample. Telework increases the ratio of childcare time by 125.7 percentage points among females with children under 18 years old, and 179.7 percentage points among females with 7-18 year old children. These results are specific to owner-occupied housing. However, these effects are not observed for owner-occupied condominiums. In fact, negative results are observed in the April-September and September samples.

In summary, male teleworkers who are living in owner-occupied housing with a floor space larger than 50 m^2 or detached housing increase their childcare time. These results are specific to owner-occupied housing. On the other hand, female teleworkers who are living in larger housing, with a floor space larger than 50 m^2 and detached housing, increase their childcare time in September when their children return to school. The results of the female sample are similar or larger than the samples who did not consider the ownership of housing.

5. Discussion

The results presented above indicate that teleworking increases the time spent by teleworkers with their children (April-September sample). However, this effect is not observed among the April sample under the state of emergency and closure of schools. However, when schools re-opened in September, regular female workers increased their childcare hours.

The analysis of female teleworkers in the September sample is consistent with previous studies, such as Wight and Raley (2009) and Genadek and Hill (2017). In September when the children returned to schools female teleworkers could work at home and be available for their child when they come home after school. In addition, our results indicate that male respondents living in larger, owner-occupied dwellings increase the time spent with their children.

Significantly positive effects are mainly observed for the male sample. It is well known that children mainly receive care by females in Japan. Before the spread of COVID-19—represented by the February 2020 sample—the average daily childcare time spent by male and female workers is 5.6 and 19.4 hours each week, respectively. This is because male workers are employed as regular

workers, while their spouse support them (Table 2). Therefore, an evident gap in the time spent on childcare existed between the two sexes before the COVID-19 pandemic. This cannot be simply reduced by altering the commute time for males who work from home (Section 4.3). Instead, housing characteristics seemed to play a more significant role in increasing the time that men spend on childcare.

Table 7 Estimates of interaction terms of characteristics of owner-occupied housing

	Workers with children		**Male workers with children**		**Female workers with children**	
	1. 0-8	2. 7-18	3. 0-18	4. 7-18	5. 0-18	6. 7-18
	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate
(A) April-September sample: Telework(=1)×COVID(=1) ×Owner-occupied housing with						
4 or more rooms (=1)	0.051	0.186	0.280	0.230	0.416	0.476
	(0.139)	(0.120)	(0.187)	(0.143)	(0.301)	(0.319)
	993	743	731	556	262	187
One or more empty rooms (=1)	0.268	0.182	0.303	0.263	0.552	0.450
	(0.168)	(0.129)	(0.221)	(0.202)	(0.367)	(0.336)
	976	730	718	543	258	187
Space larger than 50 m^2 (=1)	0.080	0.224**	0.326**	0.183	0.426	0.423
	(0.153)	(0.113)	(0.165)	(0.120)	(0.317)	(0.328)
	993	743	731	556	262	187
Detached housing (=1)	0.248	0.173	0.316*	0.228	0.628	0.651
	(0.158)	(0.120)	(0.183)	(0.144)	(0.430)	(0.491)
	984	736	724	549	260	187
Condominium (=1)	-0.204*	-0.027	-0.131	-0.119	-0.146	0.025
	(0.107)	(0.117)	(0.116)	(0.111)	(0.265)	(0.443)
	986	738	726	551	260	187
(B) April Sample: Telework(=1) ×COVID(=1) ×Owner-occupied housing with						
4 or more rooms (=1)	0.231	0.399**	0.301	0.327*	0.505	0.422
	(0.186)	(0.190)	(0.201)	(0.183)	(0.381)	(0.283)
	895	674	674	511	221	163
One or more empty rooms (=1)	0.322	0.230	0.334	0.325	0.500	0.257
	(0.210)	(0.185)	(0.245)	(0.239)	(0.433)	(0.248)
	874	659	657	496	217	163
Space larger than 50 m^2 (=1)	0.188	0.302	0.345	0.321	0.262	0.125
	(0.208)	(0.212)	(0.224)	(0.198)	(0.288)	(0.193)
	895	674	674	511	221	163
Detached housing (=1)	0.102	-0.009	-0.013	-0.073	0.528	0.384
	(0.159)	(0.131)	(0.146)	(0.139)	(0.408)	(0.352)
	883	664	664	501	219	163
Condominium (=1)	-0.107	0.117	0.021	0.179	-0.320	0.005
	(0.137)	(0.162)	(0.167)	(0.219)	(0.324)	(0.354)
	885	666	666	503	219	163

(Continued…)

(Table 7 Continued)

	Workers with children		Male workers with children		Female workers with children	
	1. 0-8 Estimate	2. 7-18 Estimate	3. 0-18 Estimate	4. 7-18 Estimate	5. 0-18 Estimate	6. 7-18 Estimate
(C) September sample: Telework(=1) ×COVID(=1) ×Owner-occupied housing with						
4 or more rooms (=1)	0.010	0.089	0.236	0.175*	0.705	0.942
	(0.169)	(0.152)	(0.226)	(0.105)	(0.461)	(0.613)
	764	579	569	438	195	141
One or more empty rooms (=1)	0.171	0.123	0.271	0.255*	0.736	0.930
	(0.177)	(0.151)	(0.200)	(0.131)	(0.510)	(0.655)
	751	568	558	427	193	141
Space larger than 50 m^2 (=1)	0.252	0.220	0.409**	0.127	1.060*	1.475*
	(0.202)	(0.144)	(0.193)	(0.100)	(0.595)	(0.895)
	764	579	569	438	195	141
Detached housing (=1)	0.187	0.184	0.368	0.293**	1.257*	1.797*
	(0.210)	(0.164)	(0.274)	(0.130)	(0.727)	(0.993)
	756	572	562	431	194	141
Condominium (=1)	-0.215	-0.104	-0.051	-0.209**	-0.219	0.101
	(0.164)	(0.168)	(0.217)	(0.098)	(0.284)	(0.595)
	758	574	564	433	194	141

Notes: Ratio of childcare time to work time is the dependent variable. The relative effect of telework during COVID-19 pandemic is calculated from $\exp(\beta_d) - 1$. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. Standard errors calculated by the delta method based on the cluster standard errors over respondents are given in parentheses. Third row of each cell represents the number of observations. The female models are estimated using Equation (4) except for the models with interaction term of condominium, which is estimated using Equation (5).

Regarding housing characteristics, respondents who are living in larger, owner-occupied dwellings tend to increase childcare time when working from home. Qin et al. (2021) show that detached housing and dwellings with more rooms are positively related to telecommuting. Additionally, based on Japanese data, Okubo (2021) recently shows that workers who are living in owner-occupied housing tend to telework. In Japan, a large gap exists in the quality of owner-occupied and rental housing. Rental housing is significantly smaller than owner-occupied housing in terms of space. In 2013, the average space per person for owner-occupied housing and private rental housing was 122.32 m^2 and 44.39 m^2, respectively (Statistics Bureau of Japan, 2013). Therefore, homeowners can more easily secure space for both working and living with their family.

To shed light on the mechanisms through which teleworking influences childcare, we believe that teleworking in large owner-occupied housing supports childcare through three variables: psychological distress, work engagement, and financial skill of homeowners.

5.1 Psychological distress

Psychological distress related to homeownership has been discussed by Grinstein-Weiss et al. (2010). Homeownership gives residents more options to manage and reduce the severity of economic hardships, which reduce stress and encourage childcare. Recent studies have shown that school closures in April 2020 increased parental anxiety (Takaku and Yokoyama 2021; Yokoyama and Takaku 2020; Yamamura and Tsustsui 2021). However, these studies do not consider the housing aspect. Therefore, we hypothesize that large-scaled housing or owner-occupied housing can reduce the stress of residents and encourage childcare. We analyze whether respondents in the April-September sample who live in large or owner-occupied houses experience less distress by using the Kessler 6 (K6) scale. The K6 scale is a 6-item self-reporting measure of psychological distress that assesses individual risk of serious mental disorders (Kessler et al., 2002). A higher score on the K6 scale implies the presence of mental disorders. The K6 means have been calculated by gender, teleworking status, and the size of housing (Table 8). Although significant differences are not observed for the male sample due to its small size, teleworkers who are living in housing with one or more empty rooms have lower means corresponding with April and September in Panel (A). Male teleworkers who are living in housing with a floor space larger than 50 m^2 have similar results in Panel (B). For the female sample, smaller values can be observed for those living in large-size housing in September of Panels (A), (B) and (C). In sum, the mental distress of teleworkers who are living in large-size housing tends to be lower compared to other teleworkers. This suggests that teleworkers who are living in large-size housing experience lower levels of stress, which encourages childcare, especially in September when the schools re-open.

Table 8 Means of K6 by gender, teleworking, and scale and housing ownership

Male				Female			
Non-teleworker		Teleworker		Non-teleworker		Teleworker	
(A) The number of empty rooms is more than 1							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
4.901	3.356**	2.667	0.333	3.816	4.857		0
(4.867)	(4.086)	(2.309)	(0.816)	(4.675)	(4.935)		0
91	104	3	6	76	98		2
April, 2020							
5.693	4.878	4.389	3.565	6.354	6.838	3.75	6.462
(5.227)	(4.440)	(3.183)	(4.841)	(5.036)	(5.148)	(2.989)	(5.636)
75	82	18	23	65	99	12	13
September, 2020							
5.703	4.567	5.9	3.25	5.246	5.747	4.857	3
(5.359)	(5.309)	(6.523)	(2.646)	(5.509)	(4.879)	(3.485)	(2.646)
64	60	10	16	65	79	7	7

(Continued…)

(Table 8 Continued)

Male				Female			
Non-teleworker		**Teleworker**		**Non-teleworker**		**Teleworker**	
(B) Floor space larger than 50 m^2							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
4.674	3.911	4	0.75***	4.086	4.548		0
(5.344)	(4.342)	0	(1.488)	(4.536)	(4.963)		0
43	157	2	8	58	126		2
April, 2020							
4.553	5.438	5.6	3.925	6.722	6.592	4	5.722
(5.103)	(4.726)	(6.427)	(4.097)	(5.022)	(5.126)	(4.036)	(4.824)
38	121	5	40	54	120	8	18
September, 2020							
5.9	4.856	7	4.167	5.17	5.59	6	2.9
(5.88880)	(5.156)	(5.148)	(4.733)	(4.678)	(5.278)	(3.162)	(2.47470)
30	97	5	24	47	105	5	10
(C) Owner occupied housing							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
3.179	4.261	0	1.25	4.808	4.242		0
(4.164)	(4.697)		(1.832)	(4.792)	(4.732)		0
28	165	1	8	26	153		2
April, 2020							
4.875	5.313	5	3.917	6.292	6.786	3.2	5.667
(5.432)	(4.769)	(2.121)	(4.563)	(4.048)	(5.268)	(2.588)	(4.872)
24	131	5	36	24	145	5	21
September, 2020							
5.737	5.096	4.333	4.692	5.875	5.331	5.6	3.1
(6.199)	(5.246)	(3.215)	(5.034)	(5.319)	(5.105)	(3.847)	(2.283)
19	104	3	26	24	124	5	10

Notes: In each cell, the first, second, and third rows represent mean, standard deviation, and number of observations, respectively. Results of a t-test with equal means between two samples, using Welch's method under the heteroskedasticity hypothesis are provided: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

5.2 Work engagement

Engagement is defined as "positive, fulfilling, work-related state of mind that is characterized by vigor, dedication, and absorption" (Schaufeli et al., 2002, p. 74). Therefore, work engagement is engagement in one's work. Syrek et al. (2022) consider engagement as a positive outcome of work. It is measured by the short version of the Utrecht Work Engagement Scale or UWES-3 (Schaufeli et al., 2017). The UWES-3 means are calculated according to gender, teleworking status, and the size of housing (Table 9). Higher values mean greater engagement in work. For the male sample in Panel (A), teleworkers who are living in housing with one or more empty rooms have significantly lower values than those living in smaller housing in April. However, they have higher

values in September, but these are not significant due to the small sample size. Male teleworkers who are living in housing with a floor space larger than 50 m^2 have significantly higher values in September of Panel (B). For the female sample in September, larger UWES-3 values can be observed for teleworkers who are living in owner-occupied housing in Panel (C); however, significant differences are not observed due to the small sample size. The results imply that teleworkers who are living in large-sized housing do not demonstrate higher work-engagement during the state of emergency and school closure in April. This is consistent with the results of Syrek et al. (2022) who analyze a German sample and report the decline of work engagement during January to May 2020. However, after the re-opening of schools in September, higher work-engagement can be observed, especially among males who are living in housing with a floor space larger than 50 m^2.

Morikawa (2020) analyzes survey data collected in the early stages of the pandemic (June 2020) and observes that productivity of telework is 60-70% of the productivity at the office. However, teleworkers with lower psychological distress and higher work engagement can increase their productivity. Okubo et al. (2021) finds that poor mental health measured by the K6, reduces the efficiency of the worker. Recently, from their unique survey, Okubo and Nippon Institute Research Advancement (2021) show that having one's own room increases the productivity of the teleworker. If teleworkers living in larger housing worked in their own rooms, their productivity is increased, which gives them additional time to spend with family and practice childcare.

Table 9 Means of UWES-3 by gender, teleworking, and scale and housing ownership

Male				Female			
Non-teleworker		Teleworker		Non-teleworker		Teleworker	
(A) The number of empty rooms is more than 1							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
9.211	8.864	12.333	10.5	9.316	10.177		11.5
(3.64)	(3.47)	(4.163)	(6.221)	(3.823)	(3.939)		(3.536)
90	103	3	6	76	96		2
April, 2020							
9.347	9.512	11	8.652**	8.8	10.01*	10.833	10.231
(4.382)	(3.659)	(3.742)	(3.366)	(4.097)	(3.773)	(3.271)	(3.193)
75	82	18	23	65	99	12	13
September, 2020							
8.688	8.833	7.9	9.5	9.123	9.679	9	10.286
(4.636)	(3.778)	(3.178)	(3.688)	(3.99)	(3.289)	(3.559)	(5.765)
64	60	10	16	65	78	7	7

(Continued)

(Table 9 Continued)

Male				Female			
Non-teleworker		**Teleworker**		**Non-teleworker**		**Teleworker**	
(B) Floor space larger than 50 m^2							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
9.488	8.794	11	10.375	9.526	9.88		11.5
(3.383)	(3.643)	(8.485)	(5.29)	(3.987)	(3.794)		(3.536)
43	155	2	8	57	125		2
April, 2020							
8.947	9.537	7.6	9.575	9.481	9.467	11.875	10.167
(3.876)	(4.044)	(4.722)	(3.748)	(4.129)	(3.87)	(2.9)	(3.312)
38	121	5	40	54	120	8	18
September, 2020							
9	8.67	5.4	9.042*	9.326	9.514	10.8	9.9
(4.41)	(4.135)	(3.286)	(3.617)	(3.836)	(3.476)	(5.63)	(5.63)
30	97	5	24	46	105	5	10
(C) Owner occupied housing							
No	Yes	No	Yes	No	Yes	No	Yes
February, 2020							
9.036	8.871	3	10.625	8.692	9.98		11.5
(3.746)	(3.608)	.	(4.926)	(3.707)	(3.839)		(3.536)
28	163	1	8	26	151		2
April, 2020							
9.083	9.42	11	9.167	8.917	9.614	10	10.857
(3.821)	(4.074)	(5.244)	(3.821)	(3.438)	(4.007)	(4.062)	(3.103)
24	131	5	36	24	145	5	21
September, 2020							
7.895	8.942	9.333	8.308	8.25	9.764*	7.8	11.4
(4.108)	4.159	(5.508)	(3.664)	(3.615)	(3.539)	(6.723)	(3.688)
19	104	3	26	24	123	5	10

Notes: In each cell, the first, second, and third rows represent the mean, standard deviation, and number of observations respectively. Results of a t-test with equal means between two samples, using Welch's method under the heteroskedasticity hypothesis are provided: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

5.3 Financial skills

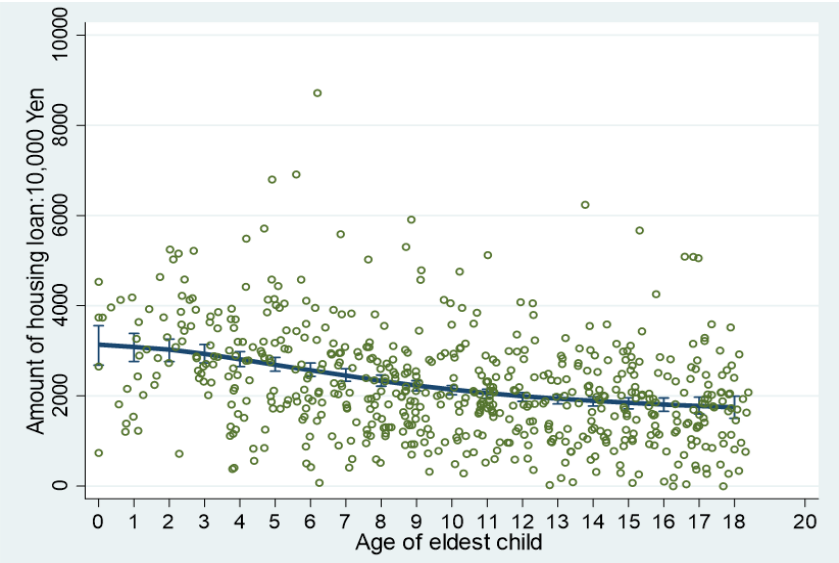
Teleworkers who reside in owner-occupied housing with a floor space larger than 50 m^2 increase their childcare time (Table 7). These results are particular to the respondents who are living in owner-occupied housing. The ownership of housing may imply that the individual has better skills to finance the housing loan before the pandemic; meaning, people who are living in owner-occupied houses have sufficient financial knowledge.

Tax credits for housing loans allow those who bought their house in 2014 or after to deduct one percentage of their mortgage from their income taxes for 10 years. There are several conditions that apply to receive this tax credit. For

example, the annual income of the owner must be less than 30 million yen (285,714 USD at the average rate of 105 yen to the USD in 2020) and the floor space of the house must be larger than 50 m^2.

As the number of household members grows after marriage, many people buy a house due to the shortage of rental housing. Most seek housing loans from banks to buy their house, especially when their children are young. In the JHPS/KHPS survey conducted in February 2020, 99% of the households with children who are 18 years old and over and living in an owner-occupied housing, have a housing loan of an average 22.36 million yen (212,952 USD). There is a negative correlation between the housing loan amount and age of the children of the borrower. Figure 3 is a scatter plot of the housing loan amount of the borrower and the age of the eldest child. Every year, the loan is decreased by 81 thousand yen (771 USD) on average as the child becomes older (p-value=0.00). These households, especially those with children less than 10-years old, can receive a tax credit at the end of the year. This is considered as a kind of a cash handout for households with younger children, which can alleviate economic hardships and increase childcare time.[8]

Figure 3 Amount of housing loan against age of eldest child



Notes: Solid line represents the local linear regression with Epanechnikov kernel. The bandwidth is determined by cross-validation. The 95% confidence intervals are calculated by bootstrapping (N=593, number of replications is 200). 1 USD ≈ 128 yen.

Source: JHPS/KHPS 2020

[8] Milligan and Stabile (2009, 2011) suggest that a cash handout changes parental working hours and improves family and child outcomes, such as parental mental health.

Therefore, we find that teleworkers who are residing in large owner-occupied housing, with low psychological distress, high work engagement, and good financial skills have increased childcare time.

6. Conclusion

This study measures the impact of teleworking on childcare time during the COVID-19 pandemic in Japan. Such an exogenous shock allows us to measure the average treatment effect of teleworking on childcare time, taking housing characteristics into consideration. The following results are observed.

First, male teleworkers who are residing in detached and owner-occupied housing with a floor space larger than 50 m^2 have a significant increase in the ratio of childcare time to work time during the COVID-19 pandemic.

Second, female teleworkers whose one-way commuting time is one hour or more now use the commuting time as childcare time. Furthermore, female teleworkers who reside in larger housing, such as houses with four or more rooms, a floor space larger than 50 m^2, and owner-occupied housing experience an increase in the ratio of childcare time to work time in September, when schools re-open.

Third, teleworkers who are residing in large-size housing have less psychological distress and engage more in work. Teleworkers who are residing in owner-occupied housing with a housing loan can receive a tax credit. Both these conditions facilitate more time for childcare.

Based on a unique survey on teleworking (conducted in 2020 and 2021), Morikawa (2021) suggests that teleworking may become a popular workstyle after the pandemic because the ratio of employees who want to continue teleworking after the end of the pandemic has increased. Therefore, there is the possibility for owners who are residing in owner-occupied detached housing that is larger than 50 m^2 to work from home and enhance their childcare practices. The 50 m^2 of floor space corresponds with the floor space mandated by minimum housing standards for households with four members in the "Housing Life Basic Plan" approved by the Japanese cabinet on March 19, 2021 (Ministry of Land, Infrastructure, Transport and Tourism, 2021). Thus, housing with 50 m^2 of floor space should be retained in the Japanese housing market post-pandemic.

Furthermore, as mentioned before, Japan faces a labor shortage due to its aging population and low fertility rate. Therefore, teleworking facilitates the participation of women in the Japanese labor force. Our results show that teleworking can increase the workstyle options of married women through two

paths: increasing the childcare time of male workers and reducing the commuting time of female workers. Their workstyle is greatly restricted by time for childcare and housework. Thus, they are more likely to be non-regular workers and work less time, as shown in Table 2. Even those who are employed as regular workers and work full time tend to choose work locations closer to home to reduce commuting time. Teleworking allows women to use their time more flexibly.

Finally, the following recommendations are offered for future studies. It is recommended that future studies clarify the mechanism of the causality through which teleworking increases childcare hours for respondents who are residing in large owner-occupied housing. Our analysis is based on the reduced form of the equation from teleworking to childcare, thus implying the importance of welfare, such as psychological distress and work engagement. Therefore, how teleworking affects welfare which further affect childcare practices must be clarified.

Our analysis observes a significant increase of childcare time in large owner-occupied housing. However, our analysis does not compare the outcomes of different forms of ownerships, such as owner-occupied housing and rental housing, with the same attributes used in Grinstein-Weiss et al. (2010). Therefore, further analysis is required.

In this paper, we are not able to conduct an analysis that takes into consideration the fixed effects of households due to data limitations. Therefore, future studies should collect data on household and housing characteristics through annual surveys to conduct an analysis that considers the unobserved heterogeneity of households.

Acknowledgments

We thank Michio Naoi, Tsubasa Itoh, Toshihiro Okubo, Koichi Kume, Atsushi Kawakami, and the participants of the 2021 Virtual Joint Real Estate Conference by AsRES, GCREC, and AREUEA for their valuable comments. We thank two anonymous referees for their valuable and constructive comments. We further thank the Keio University Panel Data Research Center for providing us with the JHPS/KHPS data used in this study.

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Supplementary material

Supplementary material is available at https://sites.google.com/view/kazuto-sumita/about/research?authuser=1