The Impact of Telework on Labor Productivity and Exercise Habits: Evidence from Regional Japan

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Background and Motivation

- The COVID-19 pandemic prompted an unprecedented global expansion of telework (TW), with many countries imposing mandatory lockdowns.
- In contrast, Japan pursued a “soft-commitment” strategy—relying on non-binding requests for firms to reduce in-person operations.
- As a result, TW adoption in Japan was highly discretionary, shaped by local infection risks, firm policies, and individual choices.

- This voluntary policy approach, coupled with sharp regional variation in infection rates, created quasi-experimental variation in TW intensity—providing a unique opportunity to identify its causal effects.

Study Overview

Objective

Estimate the causal effects of TW use on labor outcomes, exercise habits, job content, and use of time saved from not commuting.

Data & Methodology

- Original retrospective survey of 400 firm-based workers in Shikoku and Kyushu
- Labor and exercise outcomes measured at three points: Nov 2019, Aug and Dec 2021
- 2SLS estimation using municipality-level COVID-19 infection rates as instruments
- FE/FEIV for panel outcomes; VA/IV-VA for survey-time outcomes

Key Findings

- Pandemic expansion: ↑ TW → ↓ overtime work, commuting, exercise, ↑ life satisfaction
- Contraction phase: ↓ TW → ↑ overtime work, commuting, walking , ↓ life satisfaction
- TW-exposed workers reallocated time to hobbies, Housework, childcare, and engaged more in coordination/accounting tasks

Contributions

① Novel Identification Strategy

Uses municipality-level COVID-19 infection rates at respondents' workplace/home as an instrument variables for TW intensity.

② Robust Estimation Framework

Combines FE/FEIV (for panel outcomes) and VA/IV-VA (for survey-time outcomes) to address omitted variable bias, selection bias, and reverse causality.

③ Quasi-Panel Construction from One-Wave Survey

Constructs multi-period outcomes using structured recall.

④ Rich Behavioral Outcomes

Goes beyond productivity to examine job content and how saved commuting time is reallocated.

⑤ Temporal Distinction

Identifies asymmetric TW use effects in COVID-19 expansion and contraction phases.

Prior Research: Productivity, Commuting, and Exercise Habits

Productivity

- Gains: Saved commuting time, flexible scheduling, improved satisfaction
  (Barrero et al., 2023; Choudhury et al., 2021; Bloom et al., 2024)
- Losses: Teamwork disruption, childcare burden, mismatch with job type
  (van der Lippe & Lippényi, 2020; Gibbs et al., 2023; Weitzer et al., 2021; Morikawa, 2022, 2024)
- Varies by task and occupation (Kitagawa et al., 2021; Okubo, 2022)

Commuting Behavior

- TW reduces commute time and frequency (Obeid et al. 2024; Reiffer et al., 2023)
- The increase in WFH reduced urban rail commuting demand (Adachi et al., 2025)
- Saved commuting time due to TW use reallocated to work, rest, caregiving
  (Choudhury et al., 2021; Restrepo & Zeballos, 2022)

Exercise Habits

- TW reduces walking and incidental physical activity (Restrepo & Zeballos, 2022)

Prior Literature: Task Composition and Time Use

Task Composition

- TW more common in non-routine, analytical, or ICT-intensive jobs
  (Kawaguchi & Motegi, 2021; Jiang et al., 2024)
- Shift away from manual or teamwork-intensive tasks under TW settings
  (Okubo, 2022)

Time Use

- Japan: ↑ Housework, childcare, and family time with WFH
  (Inoue et al., 2024)
- U.S.: ↑ Work hours, ↓ Leisure and social time
  (Restrepo & Zeballos, 2022)

Main Hypotheses

H1. Local COVID-19 infection rates affect TW adoption

- Higher (lower) infection rates → More (fewer) telework days
- TW was widely recommended to prevent contagion during surges

H2. TW adoption after 2021 does not negatively affect perceived work efficiency

- By 2021, many firms had established functional remote work systems

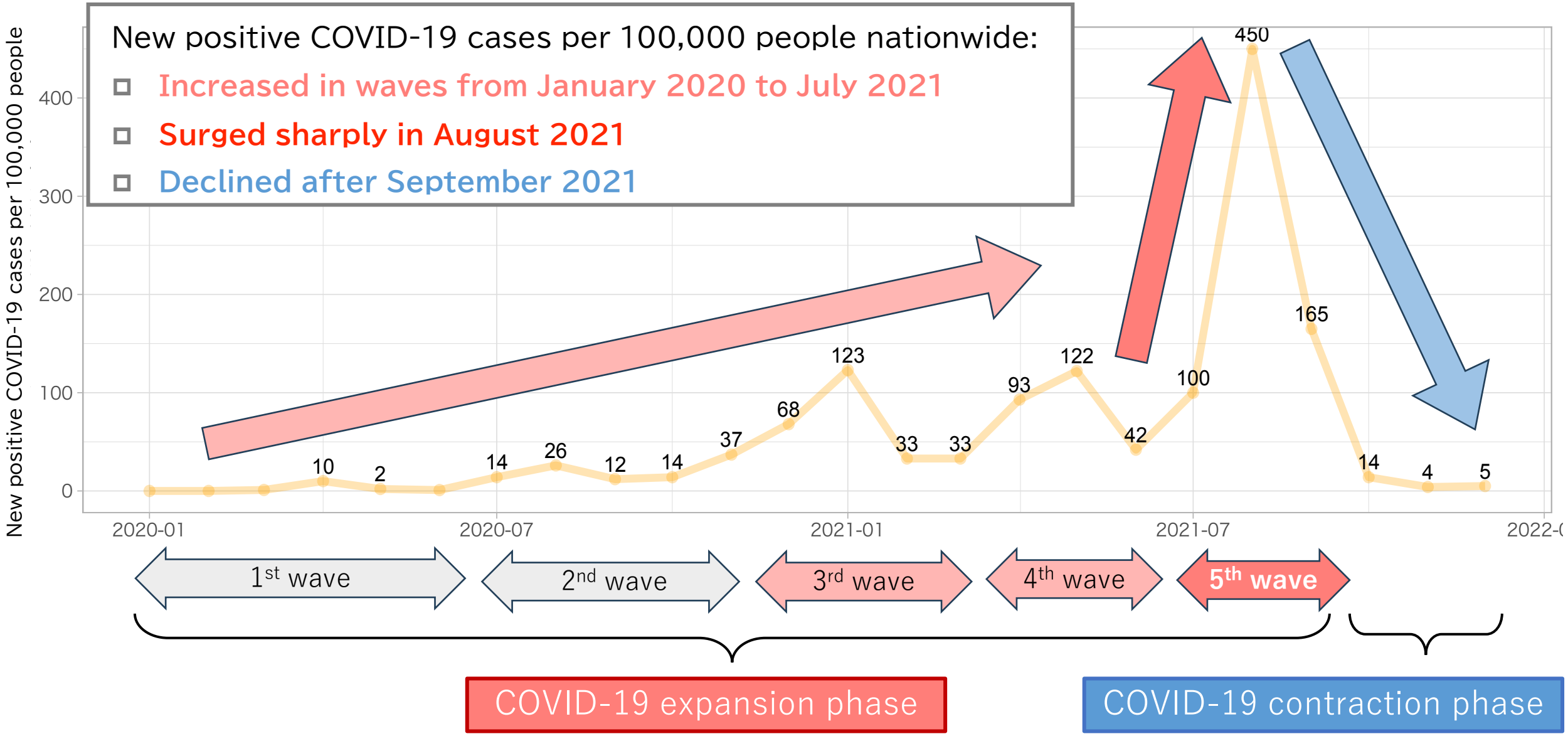
H3. TW reduces commuting time, which affects lifestyle and well-being

- ↑ TW → ↓ Commuting → ↓ Walking/exercise, ↑ Life satisfaction
- We also examine how saved time is reallocated (e.g., hobbies, sleep, childcare)

H4. TW adoption changes task composition

- Examine which types of tasks increase with TW

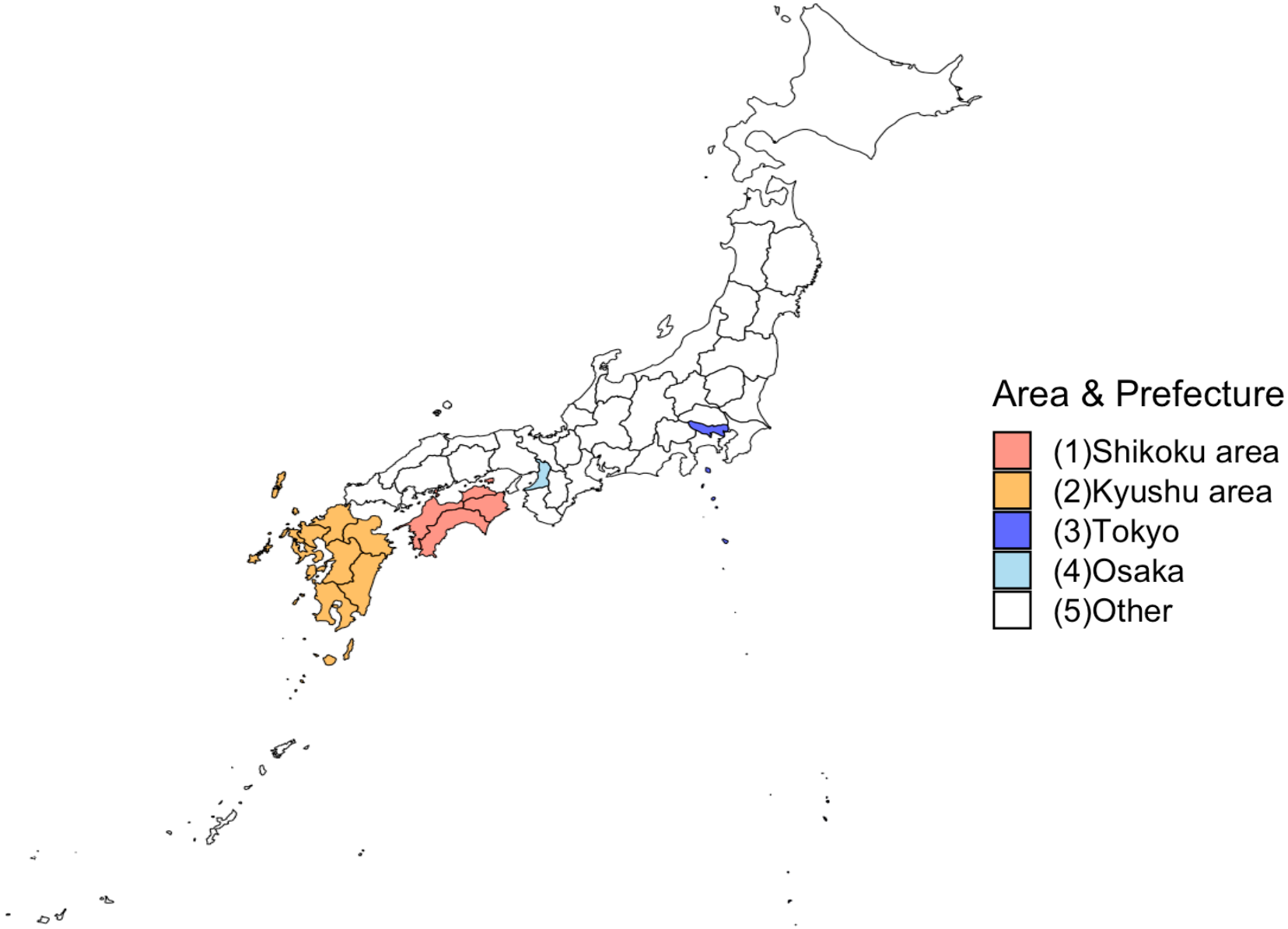
COVID-19 Trends and Pandemic Phases in Japan



Survey Overview

- **Survey Period**: January – April 2022
- **Respondents**: Employees and organizations affiliated with the Kyushu and Shikoku Economic Federations
- **Individual (Employee) Responses**: Total **400 respondents**
  - 337 from Kyushu, 63 from Shikoku
- **Sample for Aug. 2021 Analysis**: **377 individuals**
  - Excluded respondents without workplace zip codes
- **Sample for Dec. 2021 / Survey-Time Analysis**: **349 individuals**
  - Excluded respondents whose TW days increased between August and December 2021

Location of Shikoku, Kyushu Area, Tokyo, and Osaka



Panel Outcomes: Pre-Post COVID Comparison

Time points:

November 2019: Baseline (pre-COVID)

August and December 2021: COVID-19 expansion and contraction phases

Outcome variables (6 items):

Overtime work, Work efficiency, Life satisfaction, Commuting time, Daily walking, Daily physical exercise

Response scale (Five-point scale):

1 = Decreased very much, ⋯, 5 = Increased very much

Recoding for analysis:

- **November 2019**: Fixed baseline, coded as 3
- **August and December 2021**: Responses recoded by subtracting 3
  - Final scale ranges from −2 to +2 (0 = no change from baseline)

Endogenous, Instrumental, Exogenous variables

Endogenous variable

Telework days per week for each respondent in Nov. 2019, Aug. 2021 and Dec. 2021

Instrumental variables

Cumulative number of new COVID-19 cases per 100,000 people in respondent i's work municipality (zip code-based)

- **May–August 2021 cases:** Instrument for TW days in August 2021
- **September–December 2021 cases:** Instrument for TW days in December 2021

Exogenous control variables

- Age, female dummy

Summary Statistics (1)

Timing	(1) Nov.2019			(2) Aug.2021			(3) Dec.2021		
Variable	Obs	Mean	S.D.	Obs	Mean	S.D.	Obs	Mean	S.D.
TW days	380	0.202	0.678	381	1.34	1.35	381	0.797	1.23
New positive COVID-19 cases (workplace)	381	0	0	379	909	625	379	191	114
New positive COVID-19 cases (home)	381	0	0	380	706	440	380	159	87.2
Overtime work	381	0	0	381	-0.0367	0.739	381	0.0236	0.697
Work efficiency	381	0	0	381	0.0446	0.685	381	0.0945	0.666
Life satisfaction	381	0	0	381	-0.412	1.01	381	-0.349	0.944
Commuting time	381	0	0	381	-0.294	0.683	381	-0.202	0.584
Daily walking	381	0	0	381	-0.352	0.816	381	-0.273	0.753
Daily exercise	381	0	0	381	-0.362	0.818	381	-0.331	0.775

Variable	Obs	Mean	S.D.	Min.	Max.
Change in TW days					
Aug 2021 - Nov 2019	380	1.13	1.31	-2.5	5
Dec 2021 - Nov 2019	380	0.597	1.22	-2.5	6
Dec 2021 - Aug 2021	381	-0.542	1.11	-5	6
Change in new positive COVID-19 cases					
Dec - Aug 2021(workplace)	379	-718	519	-1851	0
Dec - Aug 2021(home)	380	-548	362	-1654	0

Telework Intensity (weekly days):

+1.13 days from Nov 2019 to Aug 2021
→ **+909** in workplace COVID-19 cases per 100,000 residents

–0.54 days from Aug to Dec 2021
→ **-718** in workplace COVID-19 cases per 100,000 residents

Summary Statistics (2)

Variable	Obs	Mean	S.D.	Min.	Max.
Jobs during TW					
Documentation	381	0.64	0.481	0	1
Information gathering	381	0.504	0.501	0	1
Data processing	381	0.428	0.495	0	1
Accounting work	381	0.0971	0.297	0	1
Planning and development	381	0.197	0.398	0	1
Design	381	0.0525	0.223	0	1
Online meeting	381	0.486	0.5	0	1
Internal coordination	381	0.52	0.5	0	1
External coordination	381	0.394	0.489	0	1
Internal training	381	0.165	0.372	0	1
External training	381	0.0919	0.289	0	1
Time use of saved time due to TW					
Hobbies / Recreation	381	0.215	0.412	0	1
Sleep	381	0.325	0.469	0	1
Skill Development	381	0.0761	0.266	0	1
Housework	381	0.336	0.473	0	1
Family time	381	0.249	0.433	0	1
Shopping	381	0.113	0.317	0	1
Additional work	381	0.11	0.314	0	1
Child care	381	0.084	0.278	0	1
Individual characteristics					
Age	381	42.3	12.1	21	76
Female dummy	381	0.273	0.446	0	1

TW is primarily used for individual-focused tasks and internal communication

- Documentation: 64%
- Internal coordination: 52%
- Information gathering: 50%
- Online meeting: 49%
- Data processing: 43%

Workers reallocate saved commuting time to housework and well-being.

- Housework: 34%
- Sleep: 33%
- Family time: 25%
- Hobbies / Recreation: 22%

Only about 27% of respondents are female

Empirical Strategies in Prior TW Studies

Related literature:

Instrumental Variable (IV) strategies introduced to improve causal inference

- Job teleworkability (Hara & Kawaguchi, 2022)
- Pre-pandemic suitability (Inoue et al., 2024)
- Regional broadband access (Denzer & Grunau, 2024)

Limitations:

Instruments rely on **pre-pandemic characteristics**

→ May not capture **exogenous variation induced by COVID-19**

→ Risk of **omitted shocks** and **limited identification** during the pandemic

Our study:

Exploit exogenous variation in telework adoption using cumulative COVID-19 cases per 100,000 in the respondent's work municipality (zip-code based)

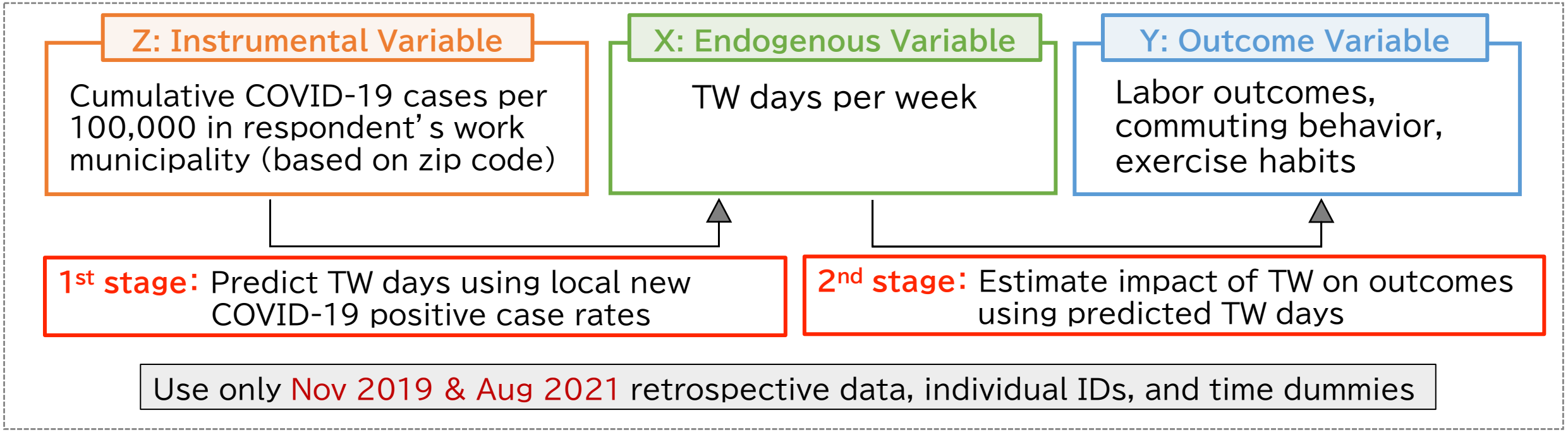
Estimation Framework: TW Effects on Labor Outcomes and Exercise Habits: (COVID19 Expansion Phase, May–Aug 2021)

Period: From pre-COVID (Nov. 2019) to the COVID19 expansion phase (Aug. 2021)

Endogeneity concerns:

- Outcome may influence telework intensity (reverse causality)
- Omitted confounders may bias estimates

Framework: FE and FEIV with individual and time FEs



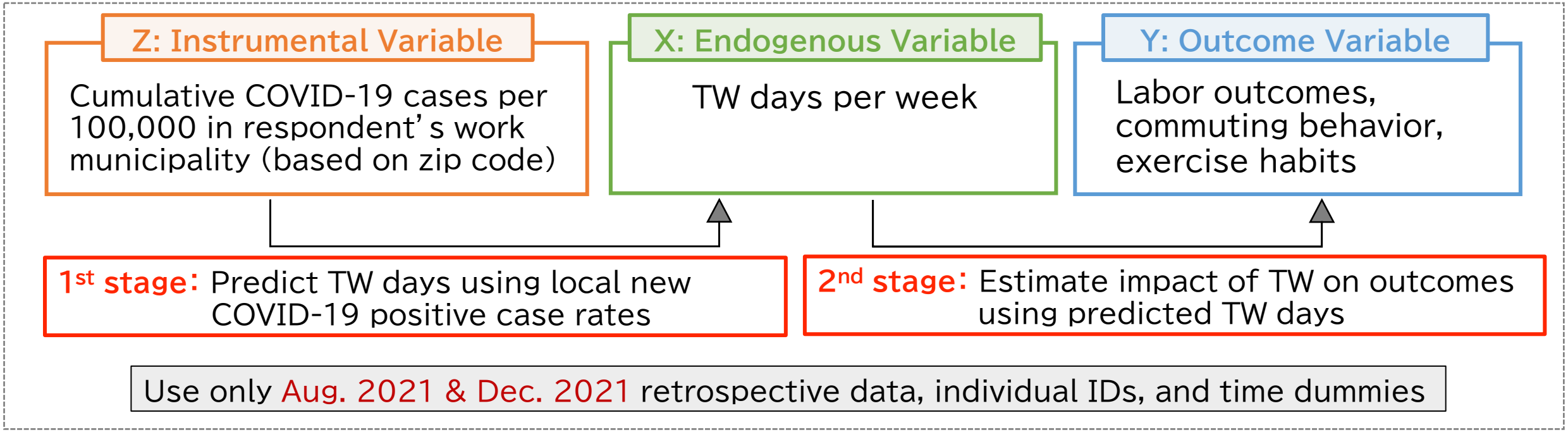
Estimation Framework: TW Effects on Labor Outcomes and Exercise Habits: (COVID19 Contraction Phase , Sep–Dec 2021)

Period: From the COVID19 expansion phase (Aug. 2021) to contraction phase (Dec. 2021)

Endogeneity concerns:

- Outcome may influence telework intensity (reverse causality)
- Omitted confounders may bias estimates

Framework: FE and FEIV with individual and time FEs



Estimation Method (FE and FE-IV Models)

FE model

$$Y_{it} = \beta_1^{FE} telework_{it} + \mu_i + \mu_t + \varepsilon_{it}^{FE}$$

FE-IV model

2nd stage

$$Y_{it} = \beta_1^{FEIV} \widehat{telework}_{it} + \mu_i + \mu_t + \eta_{it}^{FEIV}$$

1st stage

$$telework_{it} = \alpha_1^{FEIV} NewPositiveCases_{it} + \mu_i + \mu_t + \varepsilon_{it}^{FEIV}$$

Variable	Definition
Y_{it}	Outcome variable for individual i at time t
$telework_{it}$	Number of telework days per week for individual i at time t
μ_i, μ_t	Individual and Time fixed effects
$\varepsilon_{it}^{FE}, \eta_{it}^{FEIV}, \varepsilon_{it}^{FEIV}$	Idiosyncratic error terms for each model specification
$NewPositiveCases_{it}$	Instrumental variable for individual i at time t; cumulative COVID-19 cases per 100,000 in the respondent's work municipality (based on zip code)

Estimation Results: COVID19 Expansion Phase (May–Aug 2021)

Outcome Variable	Overtime Work		Work Efficiency		Life Satisfaction		Commuting Time		Daily Walking		Daily Exercise	
	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV
TW days	-0.117***	-0.373*	0.050**	0.042	0.138***	0.436***	-0.192***	-0.496***	-0.198***	-0.126	-0.109***	-0.440*
	(0.028)	(0.187)	(0.023)	(0.156)	(0.032)	(0.096)	(0.015)	(0.127)	(0.019)	(0.087)	(0.017)	(0.219)
Observations	761	759	761	759	761	759	761	759	761	759	761	759
1st stage F-stat.	–	17.2	–	17.2	–	17.2	–	17.2	–	17.2	–	17.2
Adj. R2	0.044	-0.170	0.006	0.003	0.102	-0.029	0.205	-0.106	0.173	0.158	0.113	-0.152
Mean S.D. (Aug 2021)	0.739	0.739	0.685	0.685	1.010	1.010	0.683	0.683	0.816	0.816	0.818	0.818
Effect / S.D. (%)	17.9	57.0	8.2	6.9	15.4	48.8	31.8	82.0	27.5	17.4	15.0	60.8

Key Effects of Telework (FEIV Estimates)

Positive effect: Life satisfaction

Negative effects: Overtime work, Commuting time, Daily exercise

No significant effect: Work efficiency, Daily walking

Effect Sizes (Per 1.13-Day Increase in TW)

Positive effect: Life satisfaction (49% of SD)

Negative effects: Overtime work (57%), Commuting time (82%), Daily exercise(61%)

* The analysis using COVID-19 infection rates from September to December 2021 as an instrumental variable is omitted due to a first-stage F-statistic of 4.57 (results were unchanged).

Estimation Results: COVID19 Contraction Phase (Sep–Dec 2021)

Outcome Variable	Overtime Work		Work Efficiency		Life Satisfaction		Commuting Time		Daily Walking		Daily Exercise	
	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV	FE	FEIV
TW days	-0.065***	-0.134**	-0.011	-0.164	0.024	-0.212**	-0.175***	-0.315***	-0.153***	-0.261**	-0.083***	-0.114
	(0.011)	(0.051)	(0.010)	(0.125)	(0.018)	(0.074)	(0.015)	(0.098)	(0.024)	(0.096)	(0.021)	(0.109)
Observations	714	710	714	710	714	710	714	710	714	710	714	710
1st stage F-stat.	–	15.1	–	15.1	–	15.1	–	15.1	–	15.1	–	15.1
Adj. R2	0.810	0.803	0.699	0.670	0.891	0.860	0.729	0.706	0.858	0.854	0.875	0.874
Mean S.D. (Dec 2021)	0.697	0.697	0.666	0.666	0.944	0.944	0.584	0.584	0.753	0.753	0.775	0.775
Effect / S.D. (%)	5.1	10.4	0.9	13.3	1.4	12.2	16.2	29.2	11.0	18.8	5.8	8.0

Key Effects of Telework (FEIV Estimates)

Positive effect: Overtime work, Commuting time, Daily walking

Negative effects: Life satisfaction

No significant effect: Work efficiency, Daily exercise

Effect Sizes (Per 0.54-Day Decrease in TW)

Positive effect: Overtime work (10%), Commuting time (29%), Daily walking (19%)

Negative effects: Life satisfaction (12% of SD)

* The analysis using COVID-19 infection rates from September to December 2021 as an instrumental variable is omitted due to a first-stage F-statistic of 4.57 (results were unchanged).

Estimation Framework: TW Effects on Job Content and Time Use

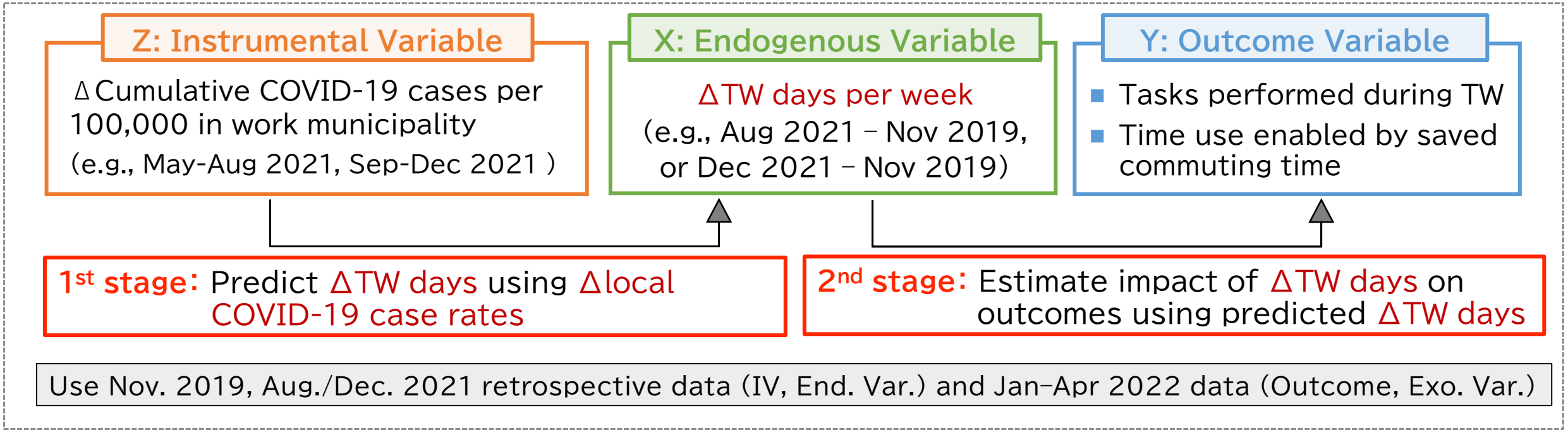
Period:

- Cumulative TW exposure measured from Nov. 2019 to Aug./Dec. 2021
- Outcomes measured once at the time of the survey (Jan–Apr 2022)

Endogeneity concerns:

- Outcome may influence telework intensity (reverse causality)
- Omitted confounders may bias estimates

Framework: Value-Added (VA) / IV-VA models with exogenous controls (Age & Gender)



Estimation Method (VA and IV-VA Models)

Value-added (VA) model

$$Y_i = \gamma_0^p + \gamma_1^p \Delta telework_i^p + \gamma_2^p Age_i + \gamma_3^p Female_i + \varepsilon_i$$

IV-VA model

2nd stage

$$Y_i = \gamma_0^p + \gamma_1^p \widehat{\Delta telework_i^p} + \gamma_2^p Age_i + \gamma_3^p Female_i + \eta_i$$

1st stage

$$\Delta telework_i^p = \pi_0^p + \pi_1^p NewPositiveCases_i^p + \pi_2^p Age_i + \pi_3^p Female_i + u_i$$

Variable	Definition
Y_i	Outcome variable for individual i (binary indicator: tasks performed or time-use activities)
$\Delta telework_i^p$	Change in weekly telework days for individual i over period p (e.g., Aug 2021 – Nov 2019)
$NewPositiveCases_i^p$	Instrumental variable for *i* over period p : Cumulative new COVID-19 cases per 100,000 in workplace municipality
$Age_i, Female_i$	Age and Female dummy of individual i (control variable)
$\varepsilon_i, \eta_i, u_i$	Error terms for each model specification

Estimation Results: Effects of TW on Job Content

Outcome Variable	Documentation		Information Gathering		Data Processing		Accounting Work		Planning and Development		Design	
	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA
TW days (Aug 2021)	0.140***	0.061	0.152***	0.243*	0.150***	0.299*	0.028***	0.334***	0.054*	0.141	0.019	-0.004
	(0.031)	(0.087)	(0.030)	(0.129)	(0.021)	(0.144)	(0.005)	(0.107)	(0.029)	(0.092)	(0.011)	(0.070)
Observations	356	354	356	354	356	354	356	354	356	354	356	354
1st stage F-stat.	–	8.18	–	8.18	–	8.18	–	8.18	–	8.18	–	8.18
Adj. R2	0.151	0.159	0.164	0.091	0.157	-0.021	0.008	-2.14	0.024	-0.097	0.022	0.006
Mean S.D. (Aug 2021)	0.481	0.481	0.501	0.501	0.495	0.495	0.297	0.297	0.398	0.398	0.223	0.223
Effect / S.D. (%)	29.1	12.7	30.3	48.5	30.3	60.4	9.5	113.0	13.6	35.4	8.5	1.8

Outcome Variable	Online Meetings		Internal Coordination		External Coordination		Internal Training		External Training	
	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA
TW days (Aug 2021)	0.167***	0.269	0.162***	0.333***	0.176***	0.242**	0.052	-0.025	0.037**	0.007
	(0.024)	(0.169)	(0.036)	(0.105)	(0.024)	(0.094)	(0.034)	(0.075)	(0.016)	(0.061)
Observations	356	354	356	354	356	354	356	354	356	354
1st stage F-stat.	–	8.18	–	8.18	–	8.18	–	8.18	–	8.18
Adj. R2	0.194	0.117	0.178	-0.016	0.225	0.197	0.033	-0.060	0.028	-0.015
Mean S.D. (Aug 2021)	0.500	0.500	0.500	0.500	0.489	0.489	0.372	0.372	0.289	0.289
Effect / S.D. (%)	33.4	53.8	32.4	66.6	36.0	49.5	14.0	6.7	12.8	2.4

Effect size of Telework (IV-VA Estimates, Per 1.13-Day Increase in TW)

Positive effect:

Information gathering (49% of SD), Accounting work (113% of SD),

Internal coordination (67% of SD), External coordination (50% of SD),

Estimation Results: Effects of TW on Time-Use Outcomes

Outcome Variable	Hobbies and Leisure		Sleep		Skill Development		Housework	
	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA
TW days (Aug 2021)	0.089***	0.290**	0.124***	0.226	0.045**	0.044	0.084**	0.134*
	(0.008)	(0.107)	(0.015)	(0.128)	(0.017)	(0.032)	(0.031)	(0.063)
Observations	356	354	356	354	356	354	356	354
1st stage F-stat.	–	8.18	–	8.18	–	8.18	–	8.18
Adj. R2	0.088	-0.397	0.146	0.083	0.053	0.053	0.065	0.081
Mean S.D.	0.412	0.412	0.469	0.469	0.266	0.266	0.473	0.473
Effect / S.D. (%)	21.6	70.4	26.4	48.2	16.9	16.5	17.8	28.3

Outcome Variable	Time with Family		Shopping		Additional Work Tasks		Childcare	
	VA	IV-VA	VA	IV-VA	VA	IV-VA	VA	IV-VA
TW days (Aug 2021)	0.060**	0.140	0.055***	0.008	0.051***	0.053	0.015***	0.128***
	(0.022)	(0.104)	(0.008)	(0.093)	(0.012)	(0.066)	(0.003)	(0.030)
Observations	356	354	356	354	356	354	356	354
1st stage F-stat.	–	8.18	–	8.18	–	8.18	–	8.18
Adj. R2	0.037	-0.030	0.060	0.002	0.063	0.055	0.004	-0.253
Mean S.D.	0.433	0.433	0.317	0.317	0.314	0.314	0.278	0.278
Effect / S.D. (%)	13.9	32.3	17.4	2.5	16.2	16.9	5.4	46.0

Effect size of Telework (IV-VA Estimates, Per 1.13-Day Increase in TW)

Positive effect:

Hobbies and Leisure (70% of SD), Housework (28% of SD), Childcare(46% of SD)

Summary of Key Findings

Pandemic Expansion Phase (Nov 2019–Aug 2021):

↑ TW → ↓ Overtime Work (57%), ↓ Commuting time (82%), ↓ Daily exercise (61%),
↑ Life satisfaction (49%)

Pandemic Contraction Phase (Aug–Dec 2021):

↓ TW → ↑ Overtime Work (10%) ↑ Commuting time (29%), ↑ Daily walking (19%),
No significant effect on life satisfaction

Long-run Effects (as of Jan–Apr 2022):

TW-exposed individuals more likely to perform:

Internal coordination (67% of SD), External coordination (50%), Accounting work (+113%)

Time saved from commuting reallocated to:

Hobbies and Leisure (70% of SD), Housework (28%), Childcare(46%)

Policy Implications of Telework Adoption

- **Avoid full reversion to pre-pandemic office norms**
  - Rolling back telework entirely risks undoing gains in efficiency, time use, and well-being.
- **Support hybrid and flexible work arrangements**
  - Hybrid models can retain key TW benefits (e.g., reduced overtime, commuting, improved morale) while enabling in-person collaboration.
  - During the pandemic, employees performing remotely suitable tasks—such as coordination and accounting—were more likely to adopt telework.
- **Treat telework as a strategic policy tool**
  - Policymakers and employers should institutionalize TW beyond emergency use.
  - Effective support (e.g., task redesign, digital tools, fair evaluation) is essential to ensure inclusive and sustainable implementation.

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