Teleworking in the US: Where have we been, and where are we going?

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Northwestern University Transportation Center
Critical Issues in Transportation
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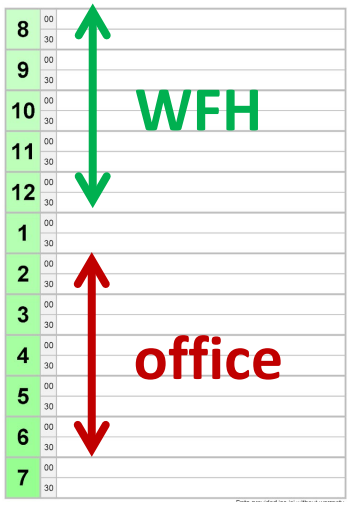
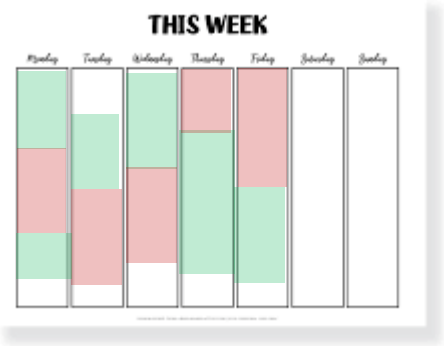
Georgia Tech

Outline



- Terminology
- Historical and current statistics
- American Time Use Survey study of partial-day teleworking
  - Over a **single day**
  - ***Activity and travel pattern differences*** among 4 types of workers
- Georgia Tech/Cintra study of partial-day teleworking
  - As a **multi-day pattern**
  - Impact on ***non-work trips/month***
- Conclusions and research needs



Terminology

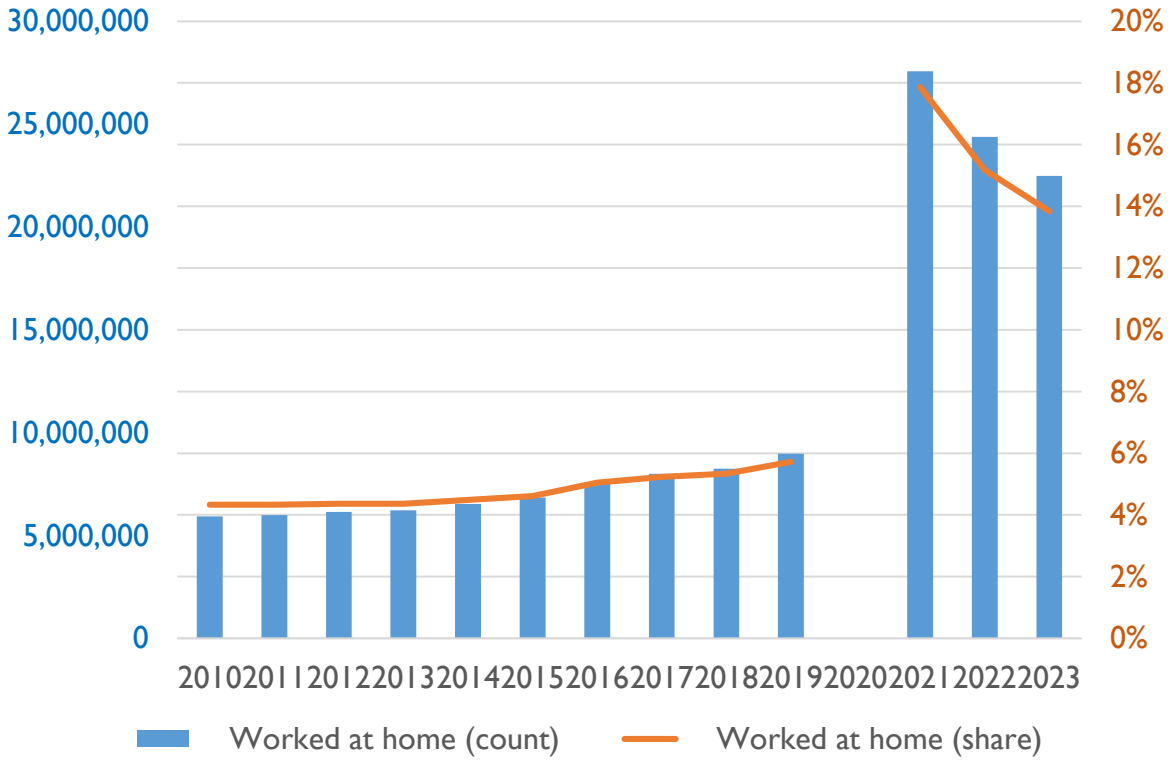
- We will treat the terms
  - Telework (TW, TWing, TWer)
  - Telecommute (TC, TCing, TCer)
  - Remote work
  - Work(ing) from home (WFH)

  interchangeably
- Other terms
  - Hybrid work
  - Partial- /full-day TW
  - Supplementer

  vs
  - Substituter
- will be defined later!

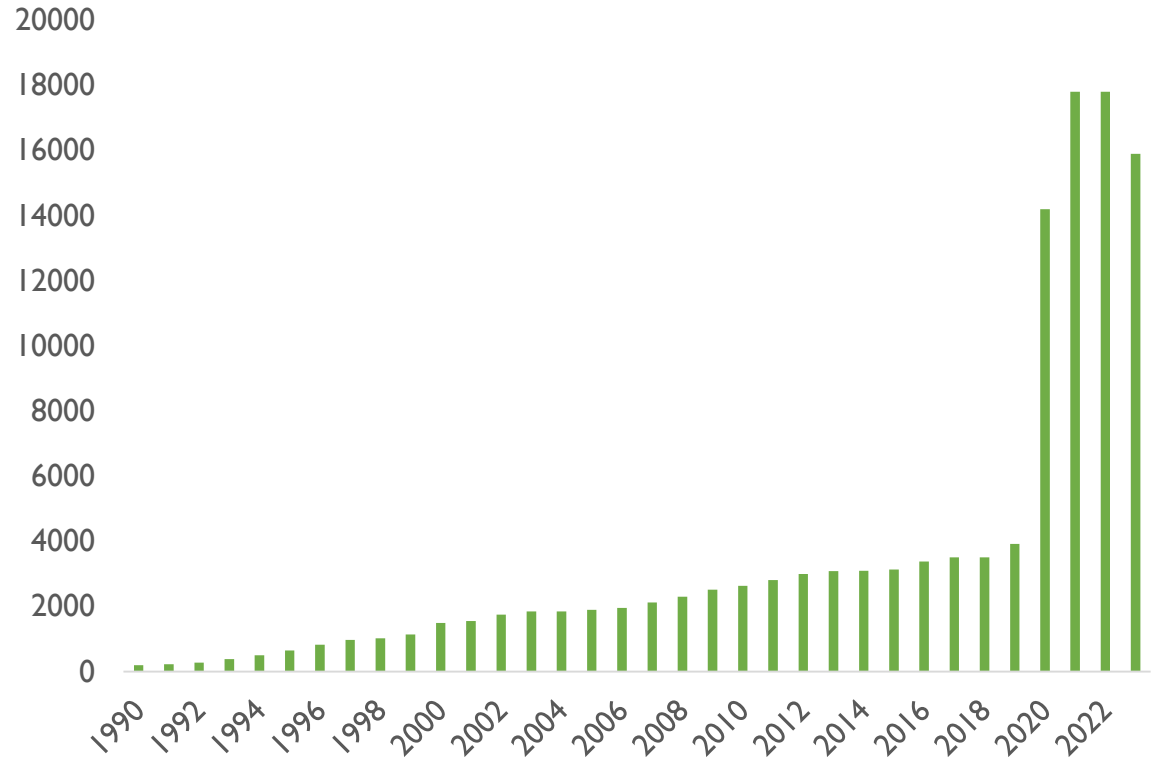
Surge in TWers & TWing research

How did you usually get to work LAST WEEK?



Source: American Community Survey, Table B08006

No. of papers related to "travel" AND "telework"



Source: Google Scholar

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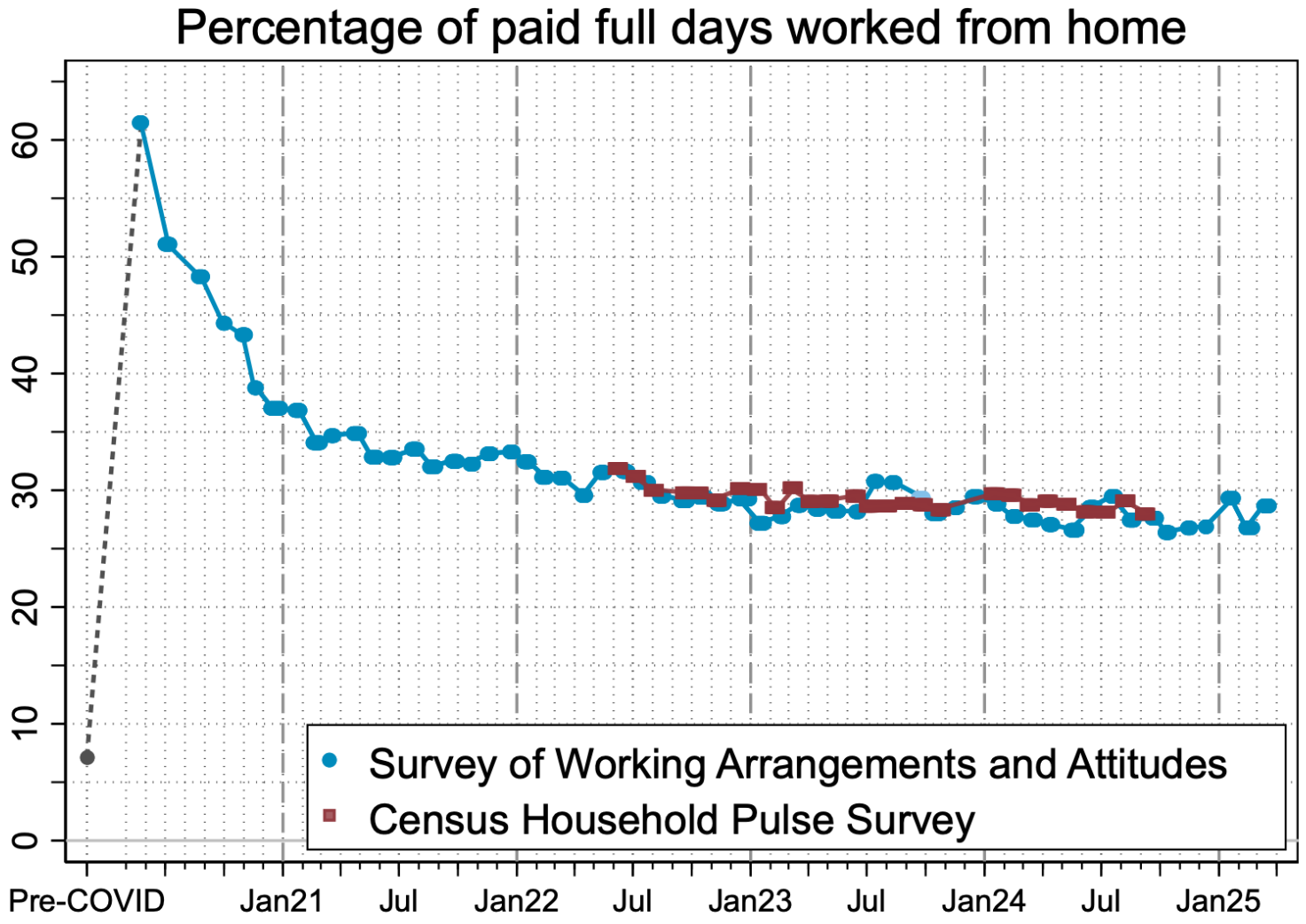
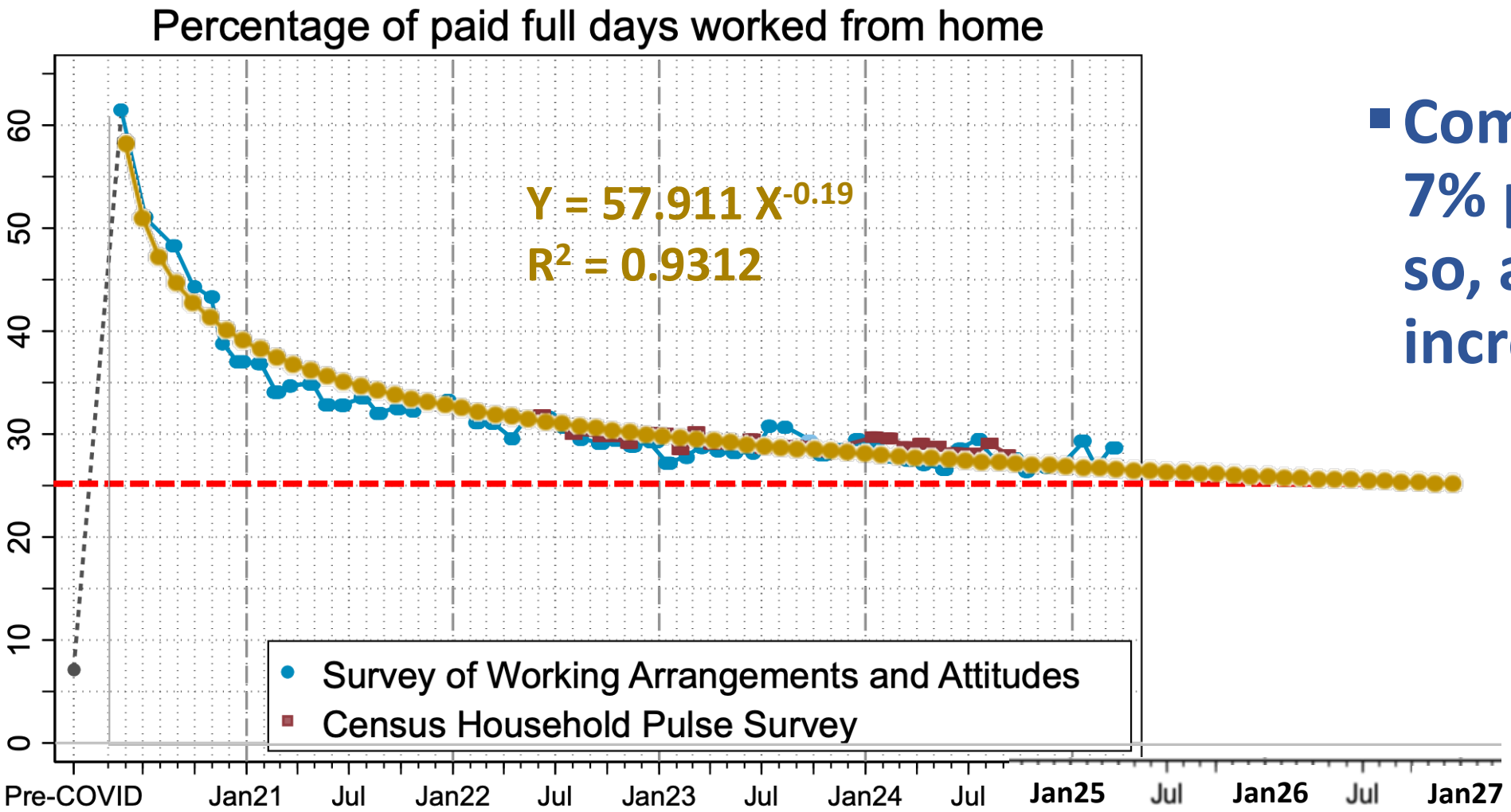
~ 29% of paid days in US were WFH days, 3/2025



- There is clearly a downward drift…

Survey of Working Arrangements and Attitudes (SWAA), www.wfhresearch.com

Which may plateau at 25% of paid days…

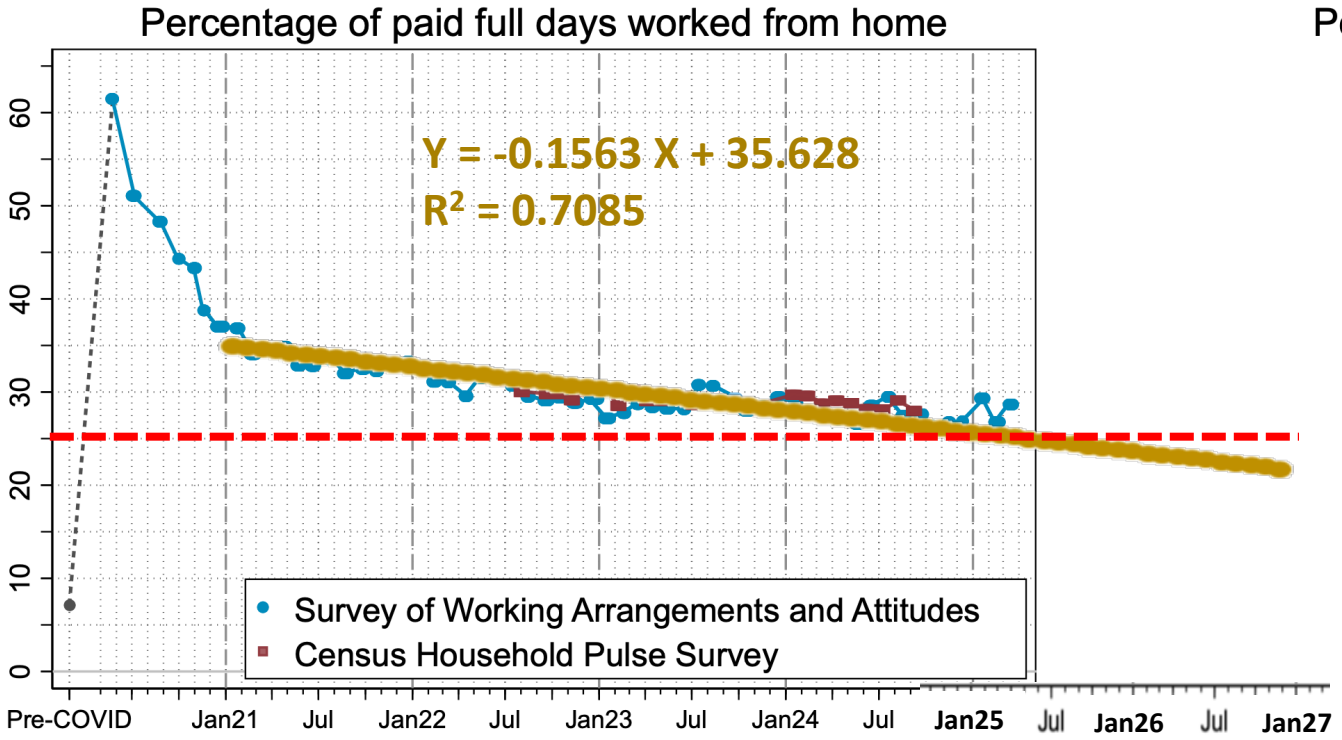


- Compared to 7% pre-COVID, so, a ~3.5x increase

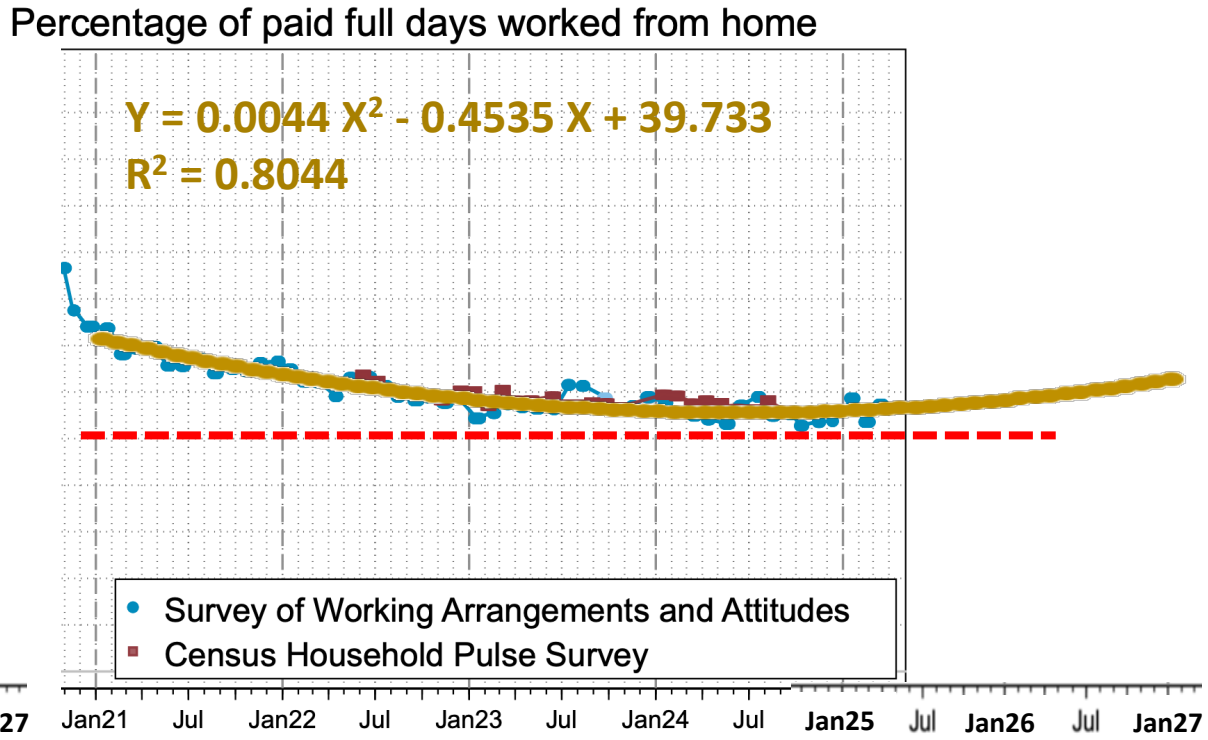
Estimated from SWAA

Or keep declining…

- ~2 %pts / year

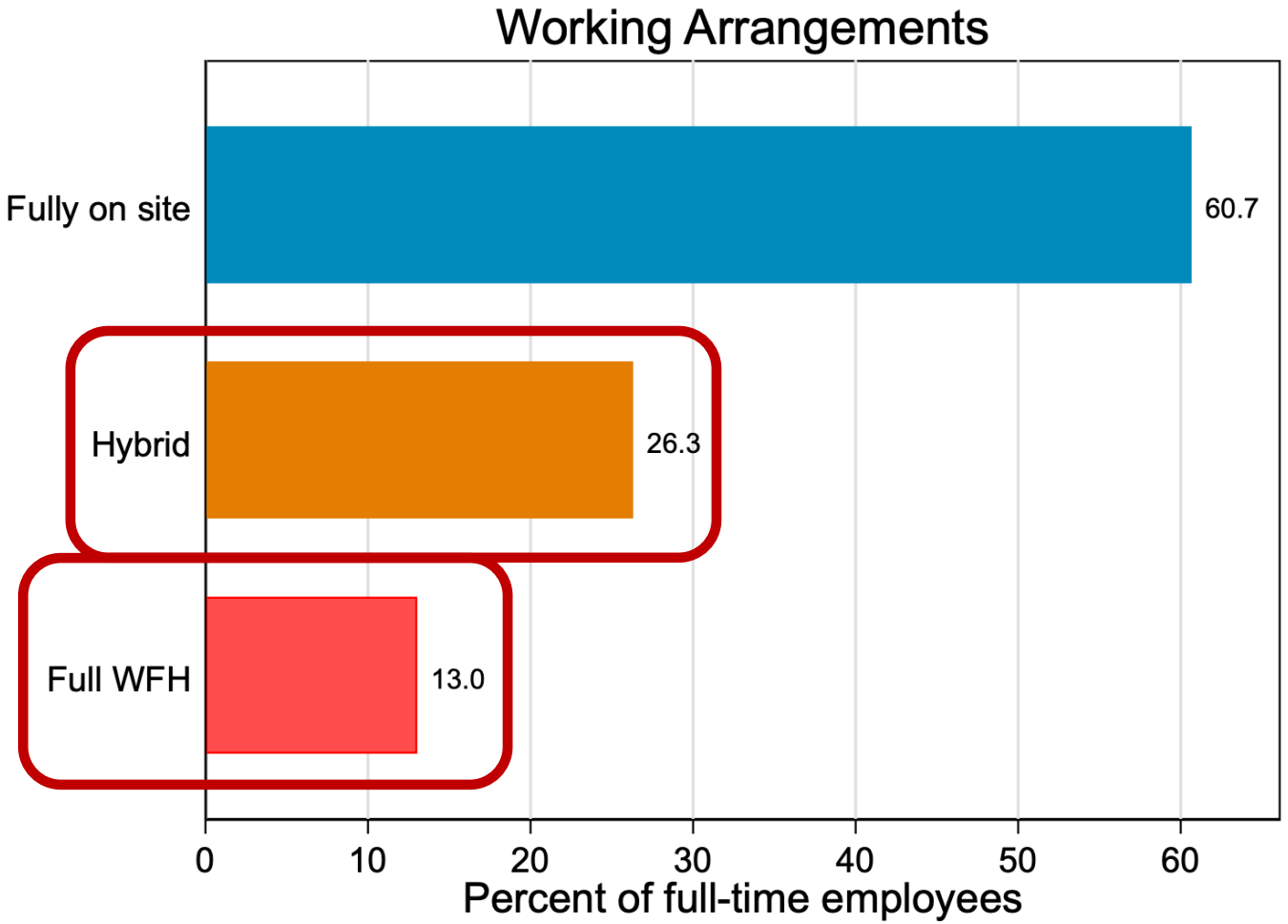


Or start increasing…



Estimated from SWAA

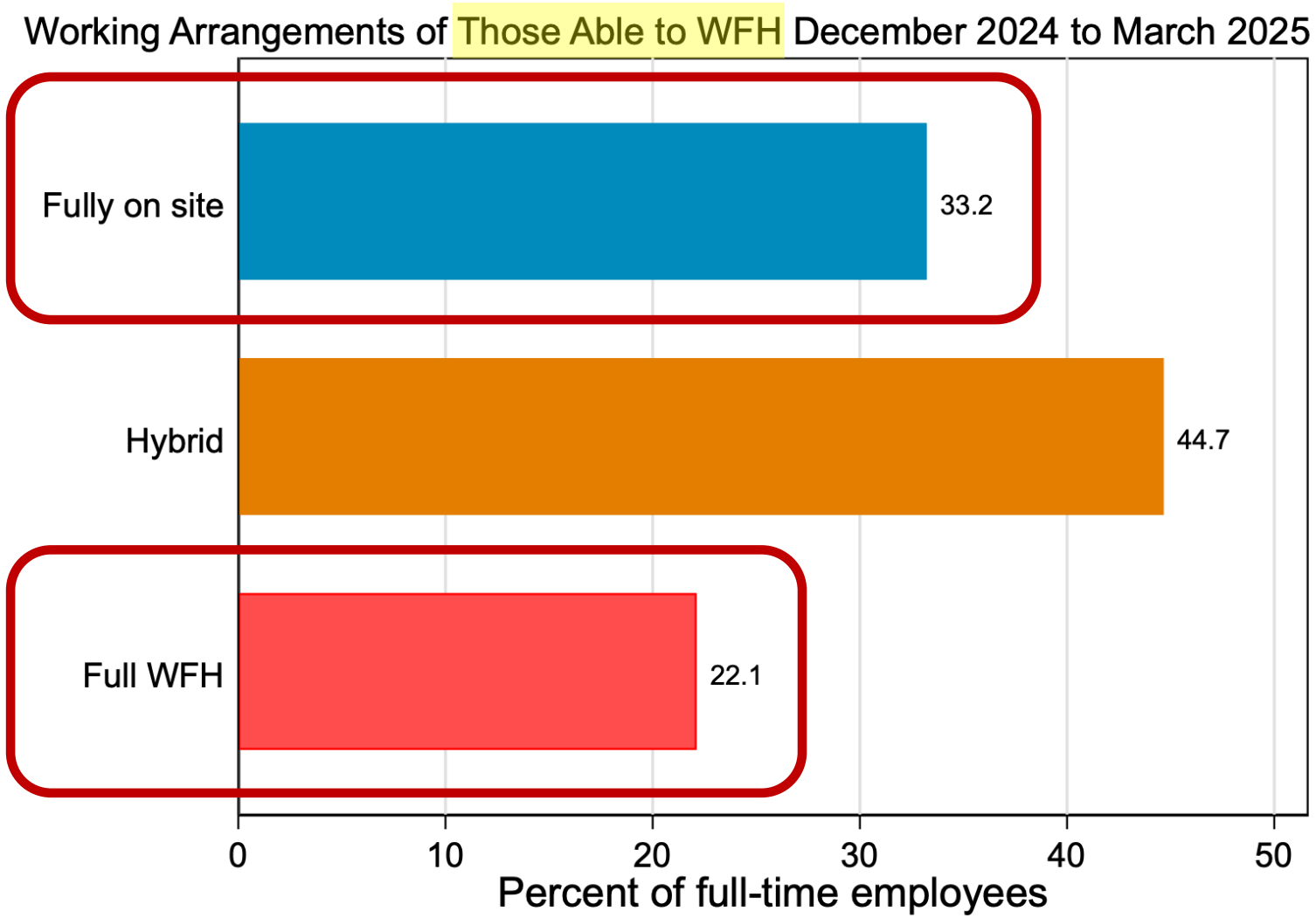
61% of FT employees work fully on site



- **13% fully WFH**
  (~2x the pre-COVID share)
- **~1/4 work a "hybrid" schedule**

SWAA, www.wfhresearch.com

Not everyone who *can* WFH *does*

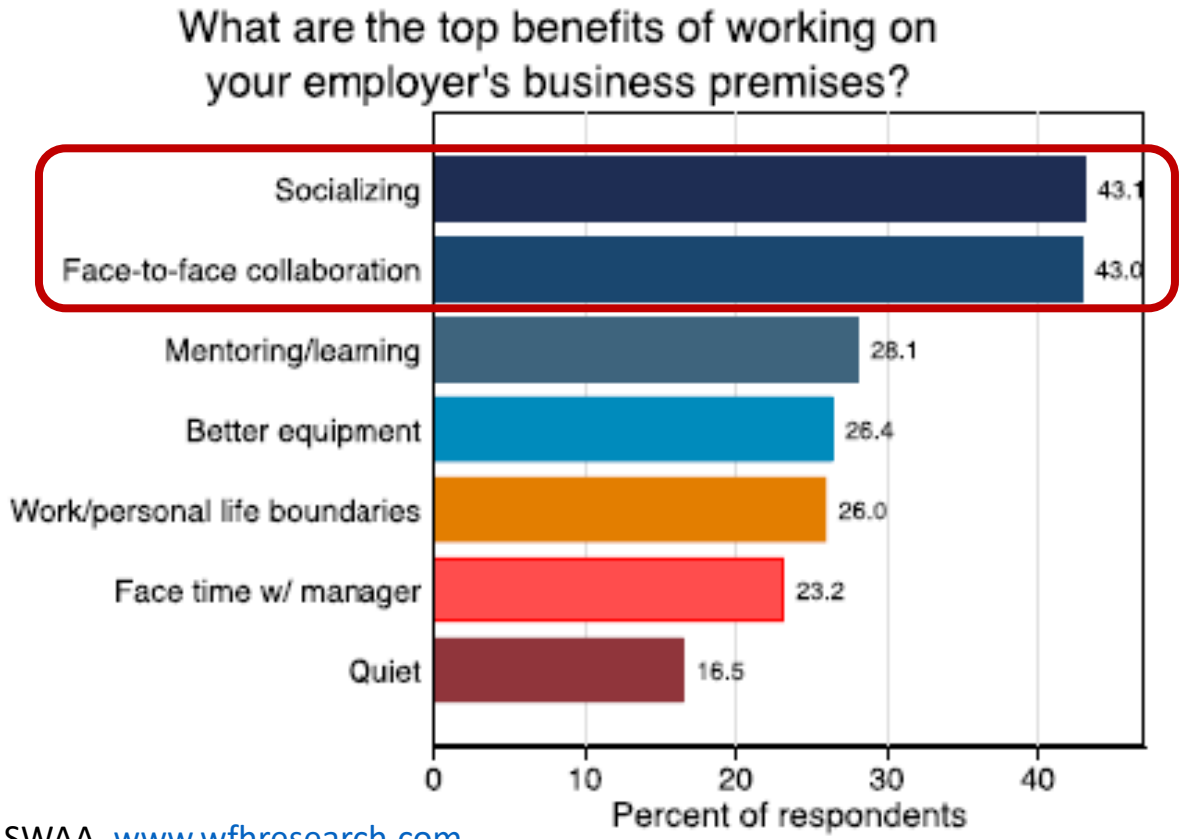


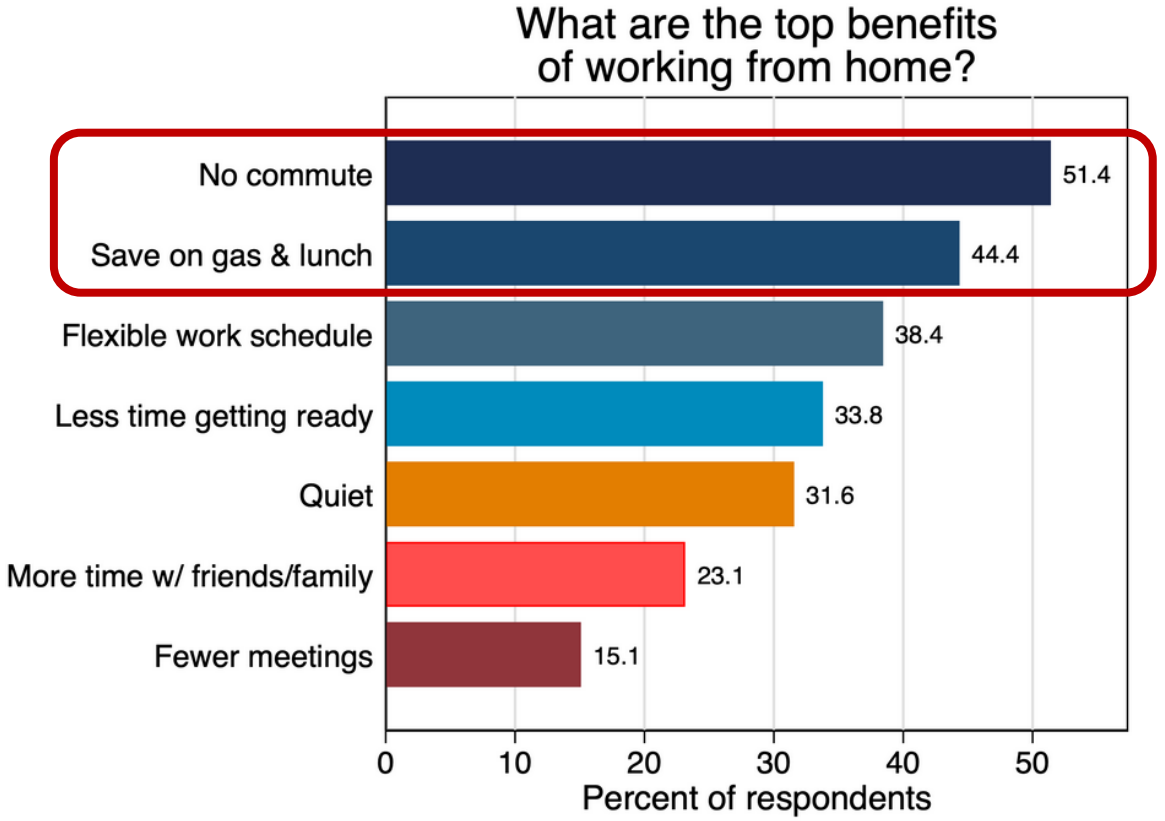
- **1/3 of those who *could* WFH do not**
  - Preferences
  - Constraints
- **Only 22% of those who can WFH do so all the time**

Mokhtarian & Salomon 1996

Workers see value in F2F interaction, but…

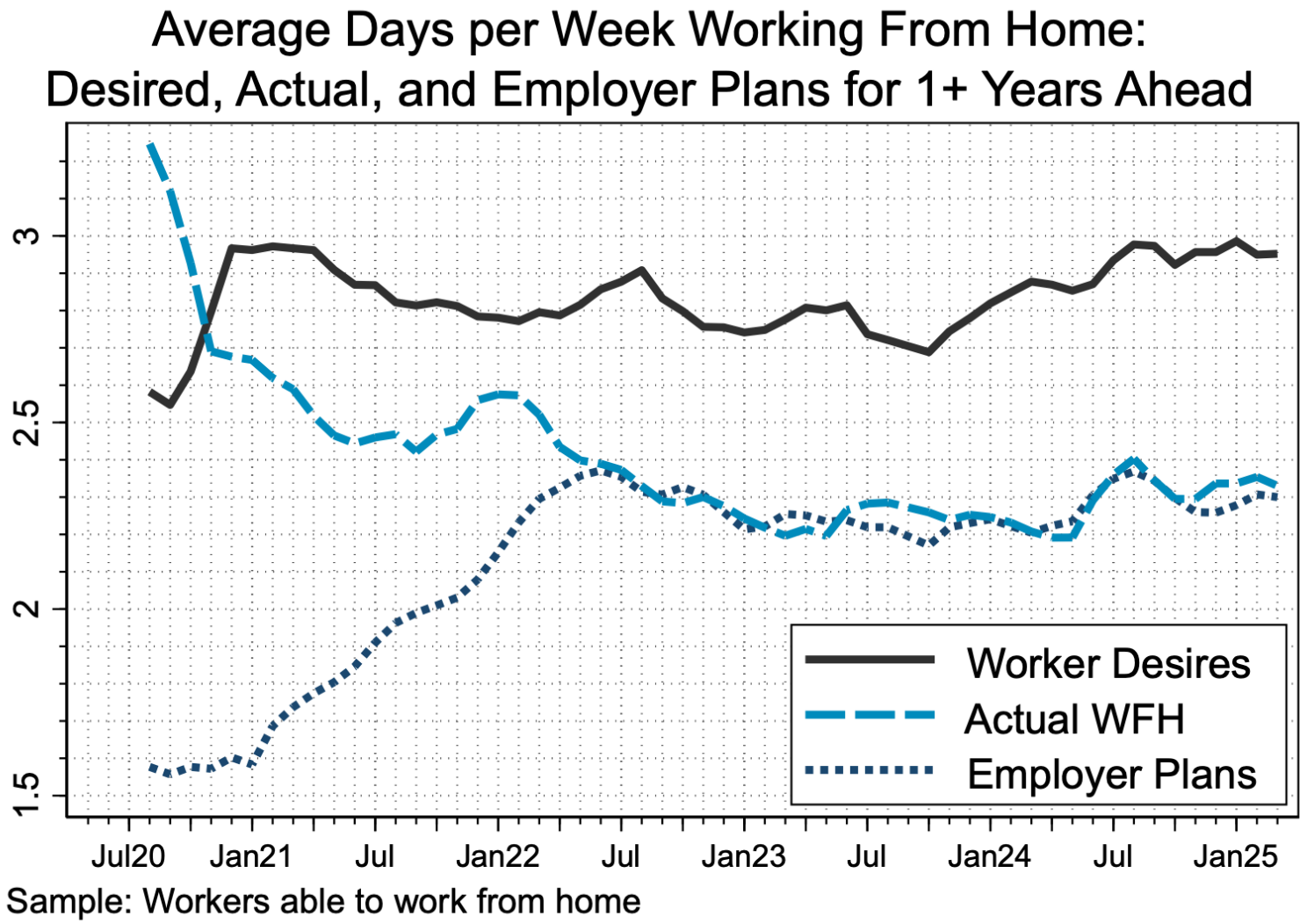
- They sure like not having to commute…
- Helps explain the appeal of hybrid schedules





SWAA, www.wfhresearch.com

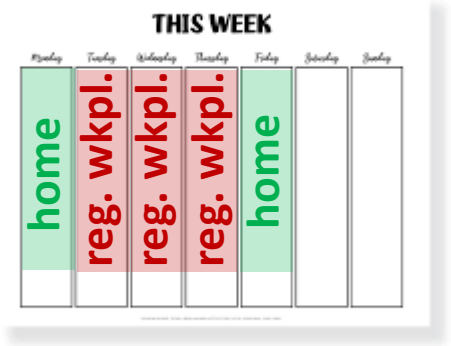
And the desired vs. actual gap persists

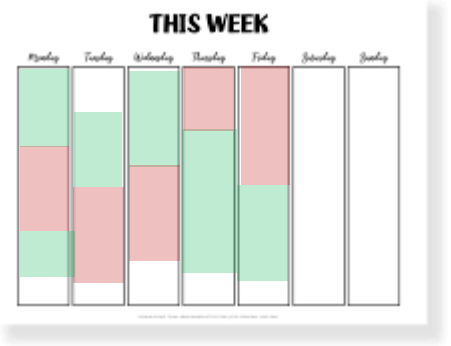


- **"Able" workers want to WFH about 0.6 more days/wk than they actually end up doing**
  - 2.9 desired vs. 2.3 done
  - Largely employer-constrained, but there could be other factors

Not all TW days are created equal

- **Does "hybrid work" mean**
  - **Some full days** at the ***reg. workplace*** & **some full days** at ***home***, or
  - **Part of the day** at the ***reg. workplace*** and **part of the day** at ***home***? "Partial-day TWing"





- **How do 1-day *travel & activity patterns* differ between full-day and partial-day hybrid work patterns?**
- **How do they differ between two kinds of partial-day TW patterns (supplementers and substituters) ?**

American Time Use Survey (ATUS) study

- **How does the *no. of non-work trips* / month differ between full-day-only TWers & partial-day TWers?**

Georgia Tech/ Cintra study

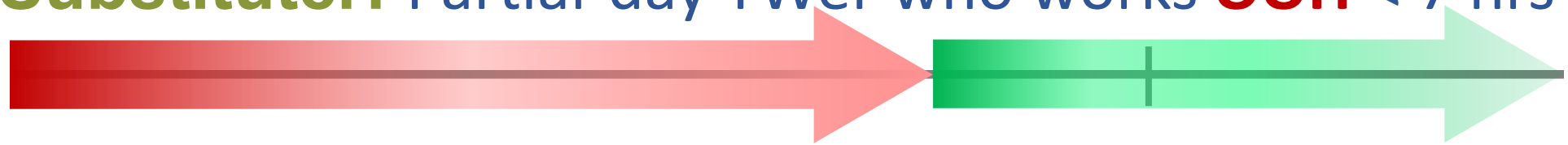
Deng et al. 2015; Ellder 2020; Lyons & Haddad 2008

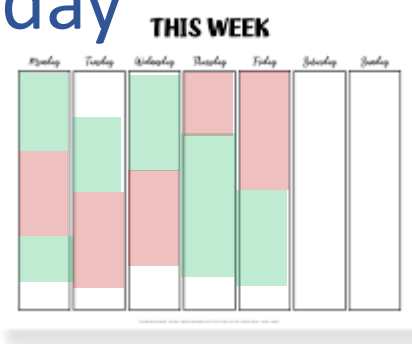
Worker typology (American Time Use Survey - ATUS)

Working sample: full-time worker, single jobholder, weekday, works 7+ hrs on survey day

- **Commuter:** Works only **outside of home (OOH)** on survey day

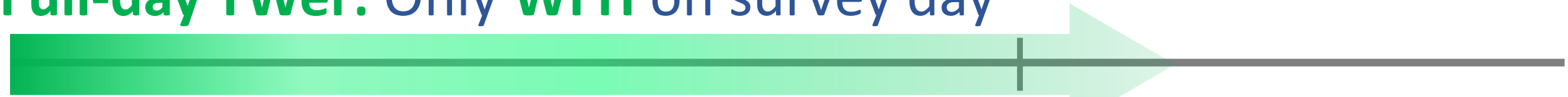
- **Partial-day TWer:** Both works **OOH** and **WFH** on survey day
- **Substituter:** Partial-day TWer who works **OOH** < 7 hrs





- **Supplementer:** Partial-day TWer who works **OOH** 7+ hrs

- **Full-day TWer:** Only **WFH** on survey day



7 hrs

Salomon & Mokhtarian 2008; Circella & Mokhtarian 2017

Typology

- **Supplementer**: Partial-day TWers who work outside home for 7 hours or more
- **Substituter**: Partial-day TWers who work outside home for less than 7 hours

- *According to the U.S. Census, full-time workers are defined as those working at least **35 hours per week**. Assuming a standard work schedule, this equates to approximately 7 hours of work per day.*
- *For partial-day teleworkers, if they work at least 7 hours onsite, they are considered to have fulfilled their full-time work obligation. Any additional time spent working at home is classified as "extra" work, regardless of whether it is compensated.*
- *Conversely, if a worker spends fewer than 7 hours onsite, they are considered to have substituted part of their regular work hours with teleworking from home.*

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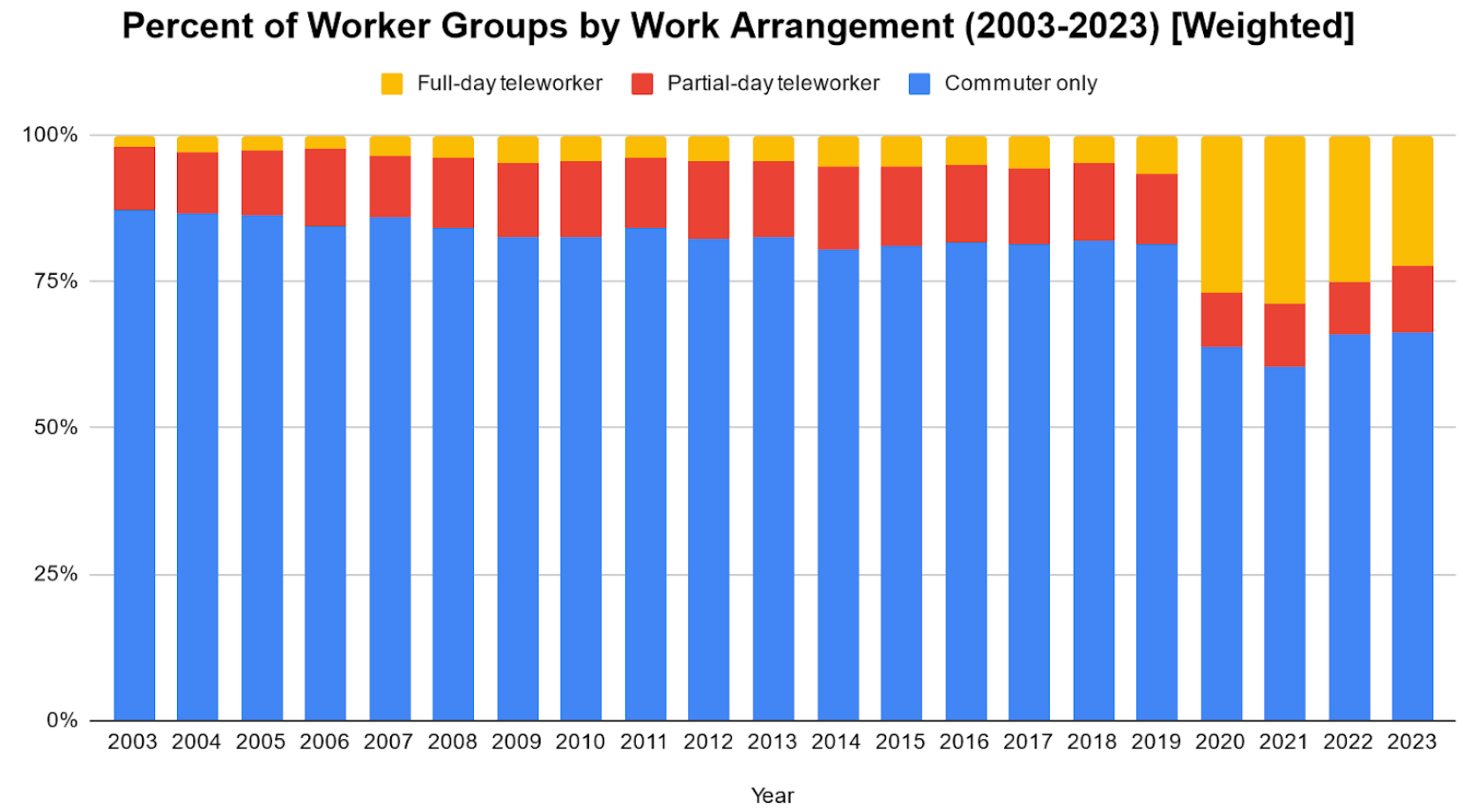
Shares of worker segments over time



- **From 2003 to 2019**, the number of teleworkers grew steadily, albeit at a slow pace
- **Since 2020**, the pandemic has caused a substantial increase in the share of teleworkers
- **2022-2023 work segment share (N=2,625)**
  - **Commuters:** 66.2%
  - **Full-day TWers:** 23.7%
  - **Partial-day TWers:** 10.1%
- Nearly 1/3 of TWers (i.e the partial-day ones) still commute!

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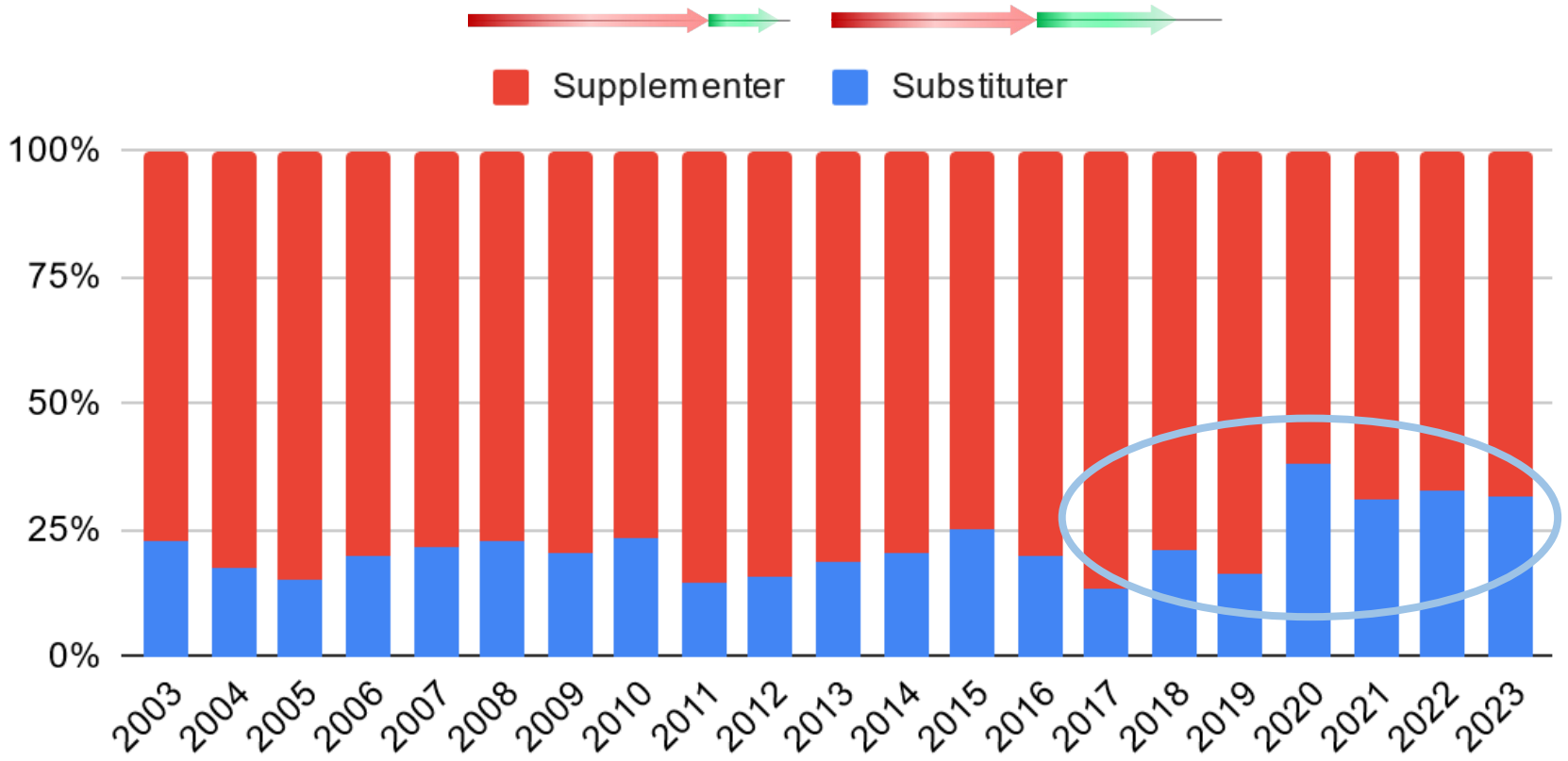
Shares of partial-day TWers over time (weighted samples)



- The majority are **Supplementers**
- The share of **Substituters** has increased since 2020
  - 2018-19: **18.9%**
  - 2022-23: **32.1%**
- Still, 2/3 of partial-day TWers (the **Supplementers**) likely commute ***during peak hours***

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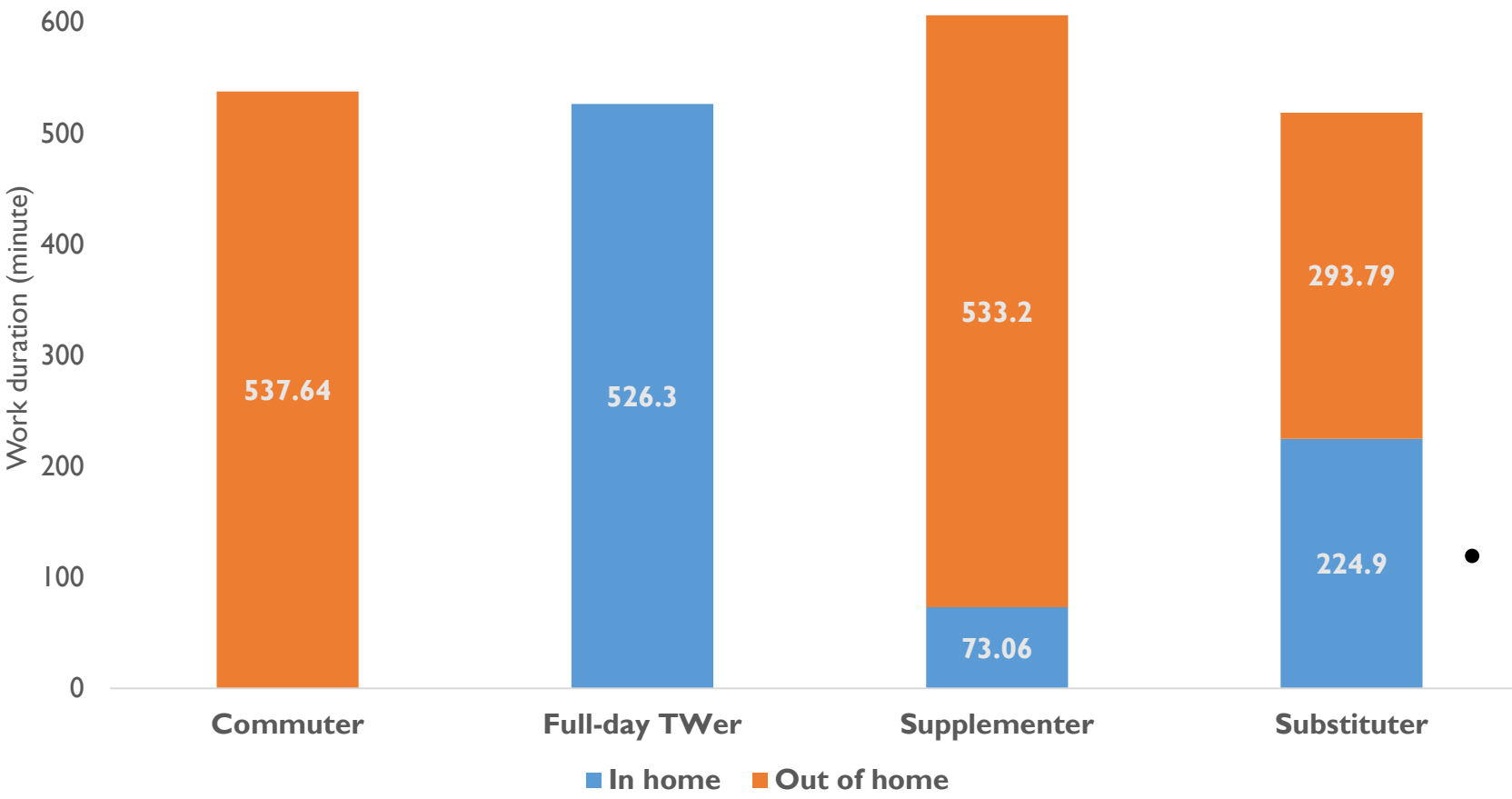
Work hours



- **Commuters**, **full-day TWers**, and **Substituters** have similar total work hours
  - Work hours are almost evenly split between home and other places for **Substituters**
- **Supplementers** work longer than other segments

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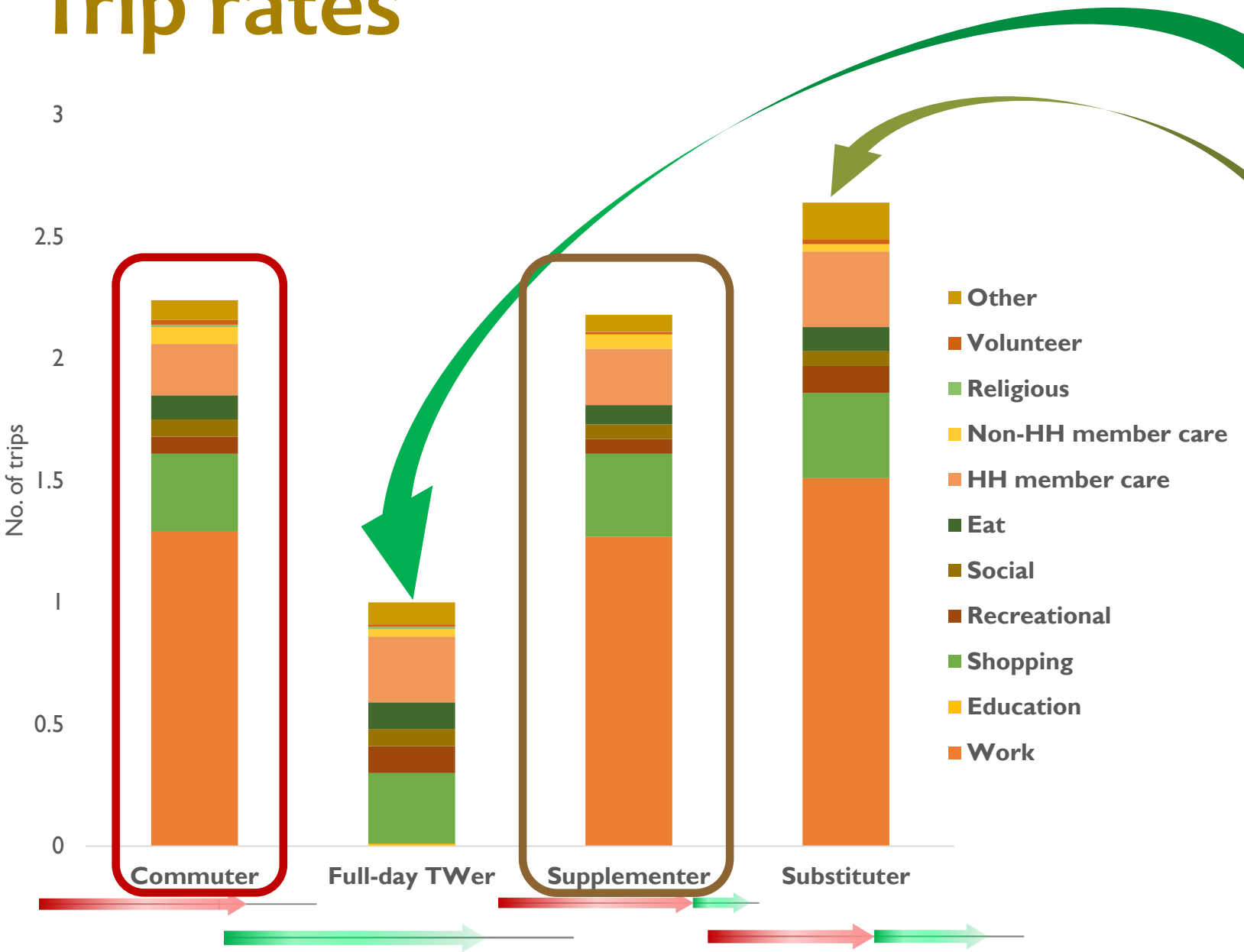
Trip rates



- **Full-day TWers** make the fewest trips
- **Substituters** make more trips **(incl. for work!)** than other worker segments do
- **Commuters & Supplementers** have similar trip rates

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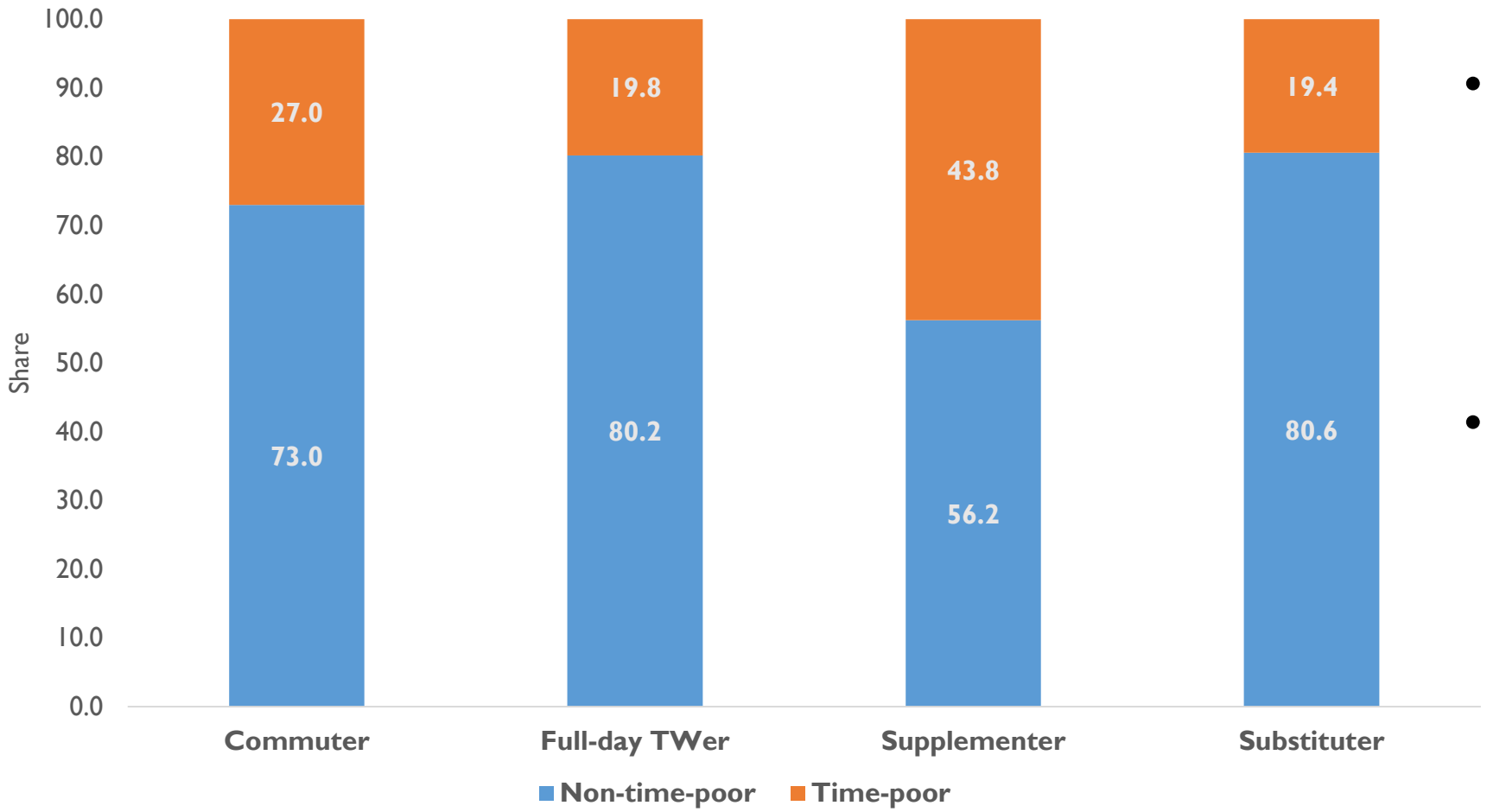
Time poverty

Time-poor: Individuals with discretionary time less than 60% of the population median are deemed time-poor. Similar to income-based poverty, time poverty is linked to poorer wellbeing



- **Full-day TWer**, and **Substituter** have highest proportions of ***non-time-poor*** individuals
- **Supplementer** contains the largest share of ***time-poor*** individuals

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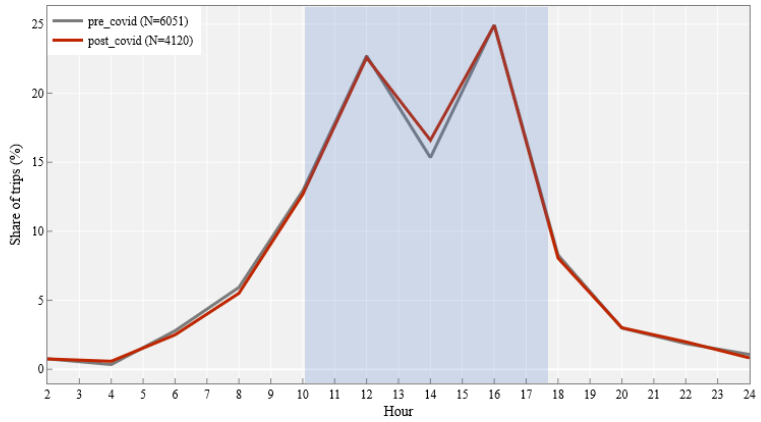
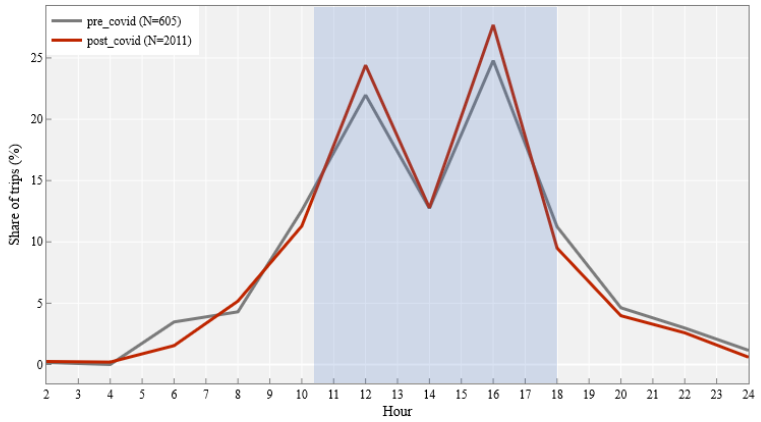
Hourly distribution of ALL work activities

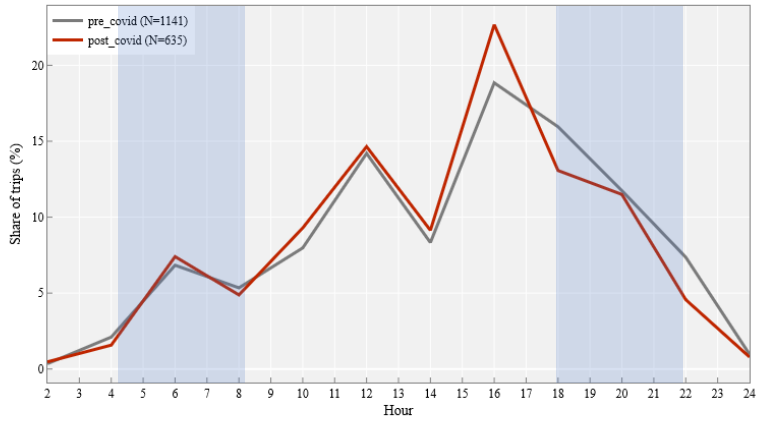
Commuters



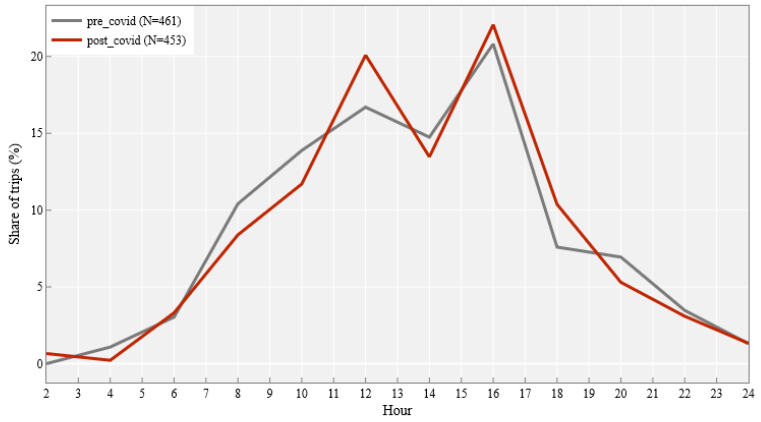
Full-day TWers



Supplementers



Substituters



- **Commuters & Full-day TWers**
  - Different work ***locations*** but similar work ***patterns***
  - Peak in mid-morning and mid-afternoon
  - Slight drop around noon (lunch break)
- **Partial-day TWers**
  - Work activities are more spread out throughout the day
  - **Supplementers**: More work activities in the early morning and late at night

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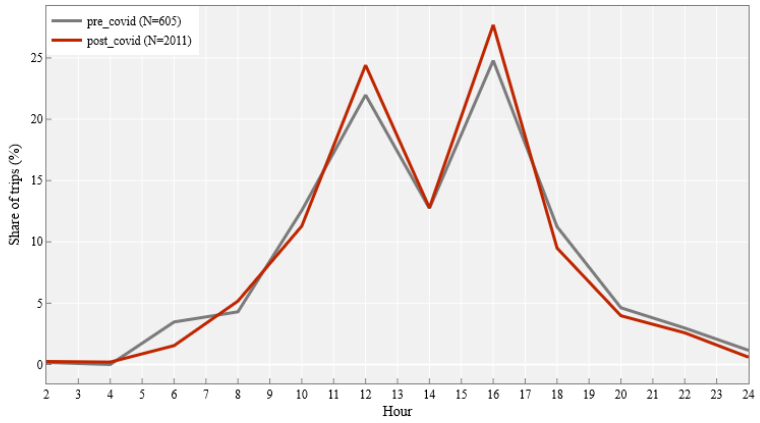
Hourly distribution of IN-HOME work activities

Commuters

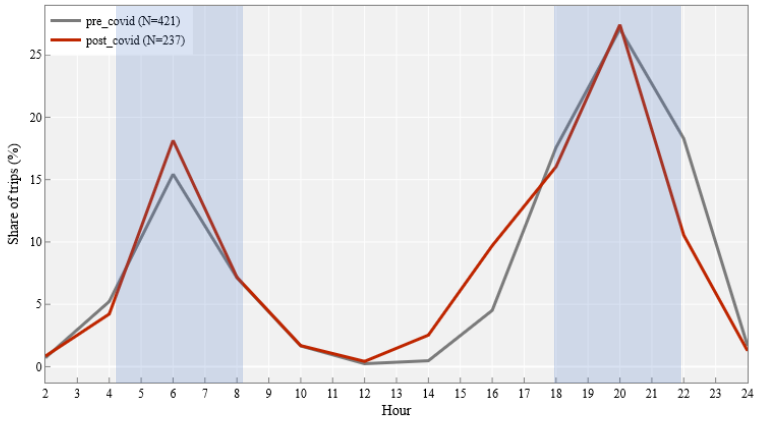
NA

Full-day TWers

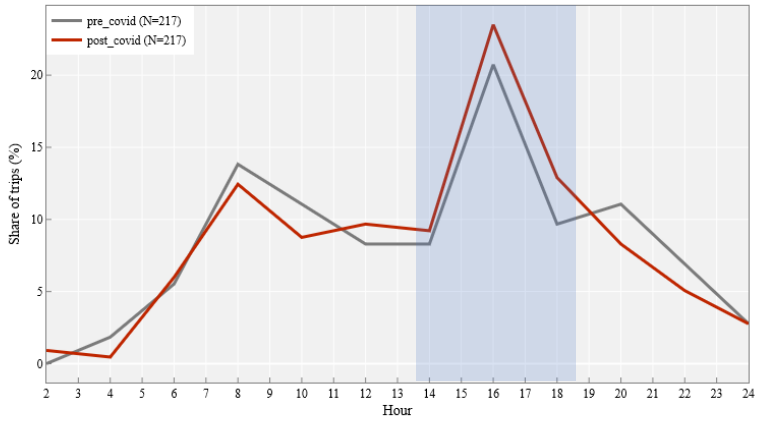


- **Supplementers**
  - WFH early in the morning, with a peak around 6 AM, and again late at night, peaking around 8 PM

Supplementers



Substituters



- **Substituters**
  - WFH episodes spread throughout the day
  - Peaks in the afternoon ~ 4 PM (e.g. after picking kids up from school)

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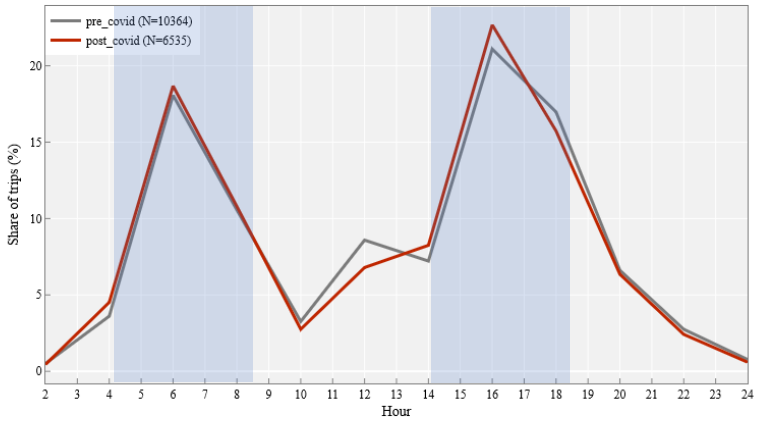
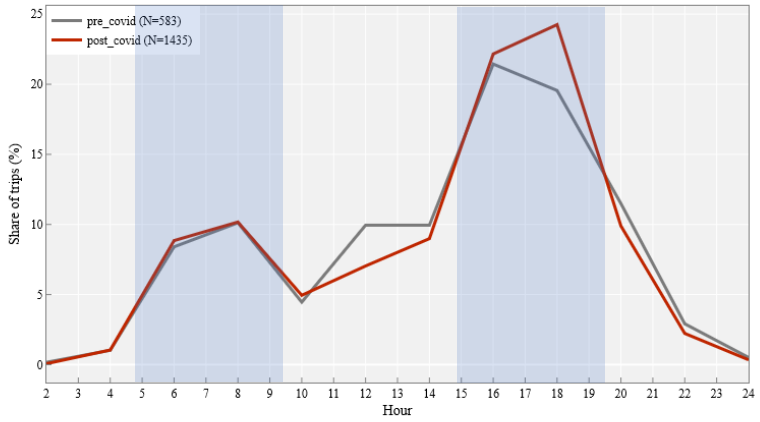
Hourly distribution of ALL trips

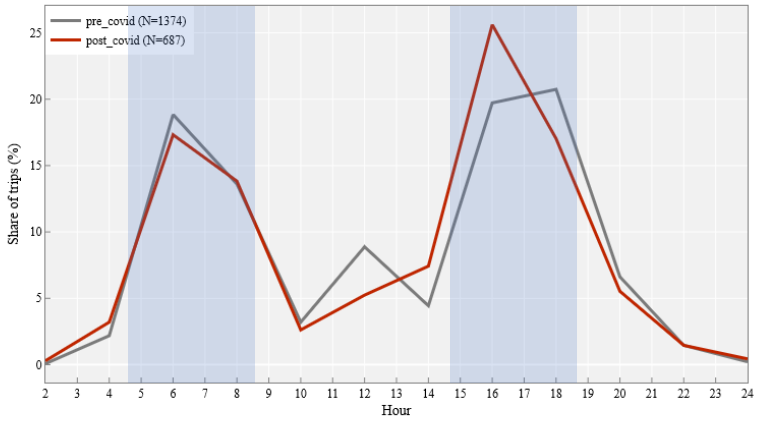
Commuters



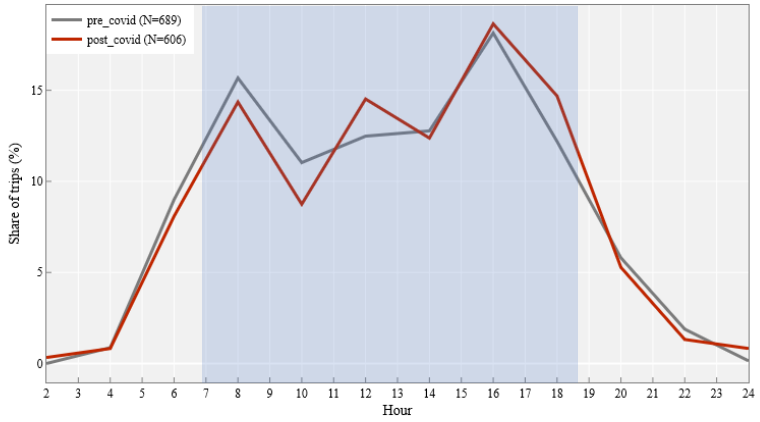
Full-day TWers



Supplementers



Substituters



- **Commuters**: Distinct AM and PM peaks, aligning with standard commuting routines
- **Supplementers**: A similar trip pattern to *Commuters*, with AM and PM peaks, as they continue to work their regular hours OOH
- **Full-day TWers**: Peak in the late afternoon, after regular work hours
  - A small increase during the AM peak, likely due to activities such as dropping off HH members at school or work
- **Substituters**: A steadier trip distribution throughout the day (very different than supplementers!)

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How does the number of non-work (NW) trips / month differ between full-day-only TWers (FDTWers) and partial-day TWers (PDTWers)?

		Partial-day TWing frequency					
		Never	< 1/mo	1-3/mo	1-2/wk	3-4/wk	5+/wk
Full-day TWing freq.	Never	Non-teleworker (**NTWer**)		Partial-day teleworker (**PDTWer**)			
	< 1/mo						
	1-3/mo	Full-day-only teleworker (**FDTWer**)					
	1-2/wk						
	3-4/wk						
	5+/wk						

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Outcome model dependent variable: total number of non-work (NW) trips per month

List of non-work activity types

- ***Drop off / pick up someone*** (e.g. child, partner, friend)
- ***Shop at a physical store*** (e.g. buy groceries, clothes, appliances, gas)
- ***Go out to eat / go get take-out*** (e.g. meal, snack, coffee)
- ***Other general errands*** (e.g. dry cleaners, banking, service a car, pet care, post office)
- ***Recreational activities*** (e.g. visit parks, movies, museums)
- ***Exercise*** (e.g. go for a jog, walk the dog, go to the gym)
- ***Visit friends or relatives***
- ***Health care*** (e.g. medical, dental, therapy)
- ***Religious / volunteer / community activities***

Per-month frequency measure

- Never → 0
- Less than once a month → 0.5
- 1-3 times / month → 2
- 1-2 times / week → 6
- 3-4 times / week → 14
- 5 or more times / week → 20

Separate responses obtained for each trip purpose, then summed across purposes

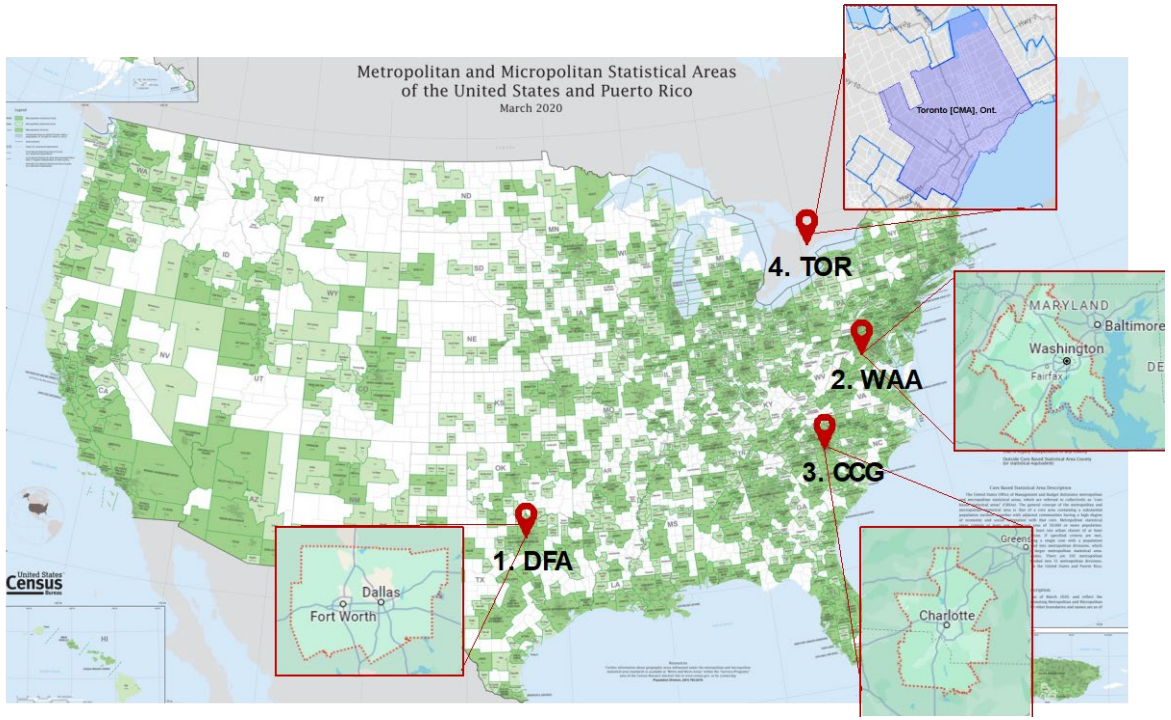
Georgia Tech

21. Nowadays, how often do you do each of the following things these days ***outside the home***?

	Never	*Less than once a* ***month***	*1-3 times a* ***month***	*1-2 times a* ***week***	*3-4 times a* ***week***	*5 or more times a* ***week***
a. Drop off / pick up someone (e.g. child, partner, friend)	☐1	☐2	☐3	☐4	☐5	☐6
b. Shop at a physical store (e.g. buy groceries, clothes, appliances, gas)	☐1	☐2	☐3	☐4	☐5	☐6
c. Go out to eat / go get take-out (e.g. meal, snack, coffee)	☐1	☐2	☐3	☐4	☐5	☐6
d. Other general errands (e.g. dry cleaners, banking, service a car, pet care, post office)	☐1	☐2	☐3	☐4	☐5	☐6
e. Recreational activities (e.g. visit parks, movies, museums)	☐1	☐2	☐3	☐4	☐5	☐6
f. Exercise (e.g. go for a jog, walk the dog, go to the gym)	☐1	☐2	☐3	☐4	☐5	☐6
g. Visit friends or relatives	☐1	☐2	☐3	☐4	☐5	☐6
h. Health care visit (e.g. medical, dental, therapy)	☐1	☐2	☐3	☐4	☐5	☐6
i. Religious / volunteer / community activities	☐1	☐2	☐3	☐4	☐5	☐6

Data overview (N = 2,958)

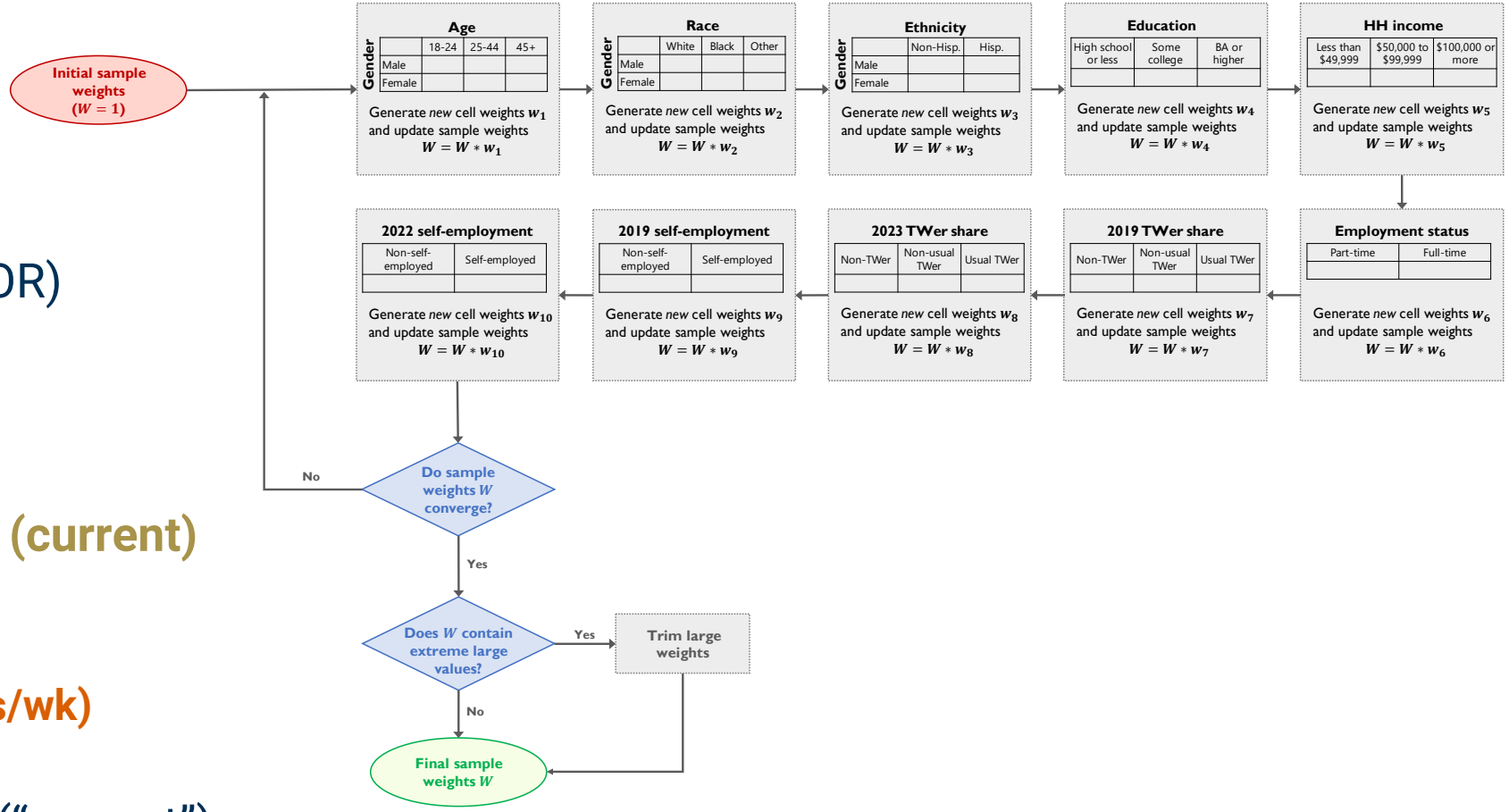
- **Funded by Cintra (Ferrovial)**
  - Impact of COVID-influenced TW on toll revenues
- **Study areas**
  - Dallas-Fort Worth-Arlington, US (DFA)
  - Washington-Arlington-Alexandria, US (WAA)
  - Charlotte-Concord-Gastonia (CCG)
  - Toronto Census Metropolitan Area, Canada (TOR)
- **Data collection March - May, 2023**



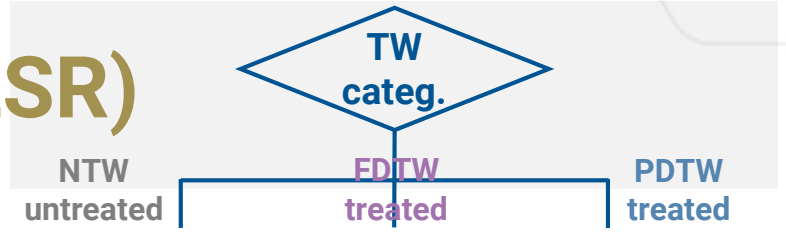
Sample weights

Sample was weighted (by region) to reflect pop. distributions on:

- Gender
- Age
- Race
- Ethnicity (not included for TOR)
- Education
- Household income
- Employment status
- **2019 (pre-COVID) and 2023 (current) shares of**
  - **Non-TWers**
  - **Non-usual TWers (< 3 days/wk)**
  - **Usual TWers (3+ days/wk)**
- 2019 (pre-COVID) and 2022 ("current") self-employment shares
- Employed population by county



Multinomial logit switching regression (MNLSR)



- **A selection model** (multinomial logit, MNL):
  - Utility of TW category *t*: $\mathcal{Z}_t = V_t + \varepsilon_t = \boldsymbol{W}\boldsymbol{\gamma}_t + \varepsilon_t$, t ∈ T = {**NTW**, **FDTW**, **PDTW**)
  - ε_t ~ i.i.d. Gumbel, with mean 0 & variance $\lambda^2/2$
  - $\mathbb{E}[\varepsilon_t|t^*] = \begin{cases} \frac{\sqrt{3}\lambda}{\pi}(-ln\, P^t), & t = t^* \\ \frac{\sqrt{3}\lambda}{\pi}\frac{P^t}{1-P^t} ln\, P^t, & t \neq t^* \end{cases}$
  - Probability for TW category *t* to be selected:

$$P^t = P\left(\mathcal{Z}_t \geq \max_{\substack{t' \in T \\ t' \neq t}} \mathcal{Z}_{t'}\right) = \frac{\exp(V_t \frac{\pi}{\sqrt{3}\lambda})}{\sum_{t' \in T} \exp(V_{t'} \frac{\pi}{\sqrt{3}\lambda})}$$

t* : the **factually-chosen** alt.
t : a **potentially-chosen** alt. (factual or counterfactual)
t′ : a **generic index** when considering all alts. as a set

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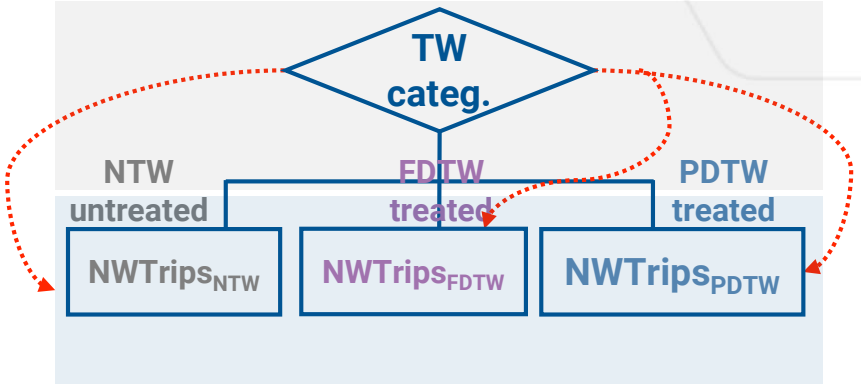
MNLSR (cont'd)



- ||T|| (= 3) **outcome models** (linear regression):

$$NWTrips_t = \boldsymbol{X_t}\boldsymbol{\beta_t} + \eta_t$$

  - $\boldsymbol{X_t}$ = explanatory variables for the t^{th} outcome model, $\boldsymbol{\beta_t}$ = coefficients, $\eta_t \sim N\,(0, \sigma_t^2)$
  - $\mathbb{E}[\eta_t \mid \varepsilon_N, \varepsilon_{FD}, \varepsilon_{PD}] = \frac{\sqrt{2}\sigma_t}{\lambda}\sum_{t' \in T} \rho_t^{t'} \varepsilon_{t'}$ and
  - $Var[\eta_t \mid \varepsilon_N, \varepsilon_{FD}, \varepsilon_{PD}] = \sigma_t^2\left(1 - \sum_{t' \in T}\left(\rho_t^{t'}\right)^2\right)$,

    where $\boldsymbol{\rho_t^{t'}}$ **= Corr(**$\boldsymbol{\eta_t}$ **,** $\boldsymbol{\varepsilon_{t'}}$**)**, fulfilling $\sum_{t' \in T} \rho_t^{t'} = 0, \quad \sum_{t' \in T}\left(\rho_t^{t'}\right)^2 < 1$
  - $\rho_t^{t'} \neq 0 \Rightarrow$ unobserved characteristics that influence a person's propensity to belong to teleworker category t' (i.e. that are in $\varepsilon_{t'}$) also influence the person's *NW trips as governed by the potential teleworking status* t (i.e. are also in η_t)

t : a **potentially-chosen** alt. (factual or counterfactual)
t' : a **generic index** when considering all alts. as a set

Critical formulas

$$NWTrips_t = \boldsymbol{X_t\beta_t} + \eta_t$$

t = (counter)factual state
t* = observed group

- $\mathbb{E}[\eta_t | t^*] = \frac{\sqrt{6}\sigma_t}{\pi} \sum_{t' \in T} \rho_t^{t'} \, CT_{t^*}^{t'} = \sum_{t' \in T} \alpha_t^{t'} \, CT_{t^*}^{t'}$,

  where $\alpha_t^{t'} = \frac{\sqrt{6}\sigma_t}{\pi} \rho_t^{t'}$, and $CT_{t^*}^{t'} = \begin{cases} -ln\, P^{t'}, & t' = t^* \\ \frac{P^{t'}}{1-P^{t'}} ln\, P^{t'}, & t' \neq t^* \end{cases}$.

- Then we have the **expected outcome if {in, moved to} state *t* given observed to belong to group *t****:

  (***t*** , ***t**** ∈ {NTW, FDTW, PDTW} ; **factual** if ***t*** = ***t**** ; **counterfactual** if ***t*** ≠ ***t****)

$$\mathbb{E}[NWTrips_t | t^*] = \boldsymbol{X_{t^*}\beta_t} + \mathbb{E}[\eta_t | t^*] = \boldsymbol{X_{t^*}\beta_t} + \sum_{t' \in T} \alpha_t^{t'} \, CT_{t^*}^{t'}$$

selection bias due to conditioning on belonging to group ***t****

$$= \boldsymbol{X_{t^*}\beta_t} + \sum_{t' \in T} \left(\rho_t^{t'} \sigma_t\right) \left(\frac{\sqrt{6}}{\pi} CT_{t^*}^{t'}\right)$$

alt. **t**'s contribution to bias correction is larger if
(1) its outcome model error is highly correlated with that of **t'** 's selection model error ($\rho_t^{t'}$ is large), and/or if
(2) outcome **t** is poorly predicted (σ_t is large)

Components of treatment effects (TEs)

$\mathbb{E}[NWTrips_t | t^*]$: Expected non-work trips if {in, moved to} state t given observed to belong to group t^*

Observed status	***Potential status***		
	A: If untreated (NTW)	***B: If FDTW-treated***	***C: If PDTW-treated***
NTWer	$\mathbb{E}[NWTrips_{NTW} \mid NTWer]$ Expected non-work trips of a NTWer	$\mathbb{E}[NWTrips_{FDTW} \mid NTWer]$ Expected non-work trips of a NTWer if FDTWing	$\mathbb{E}[NWTrips_{PDTW} \mid NTWer]$ Expected non-work trips of a NTWer if PDTWing
FDTWer	$\mathbb{E}[NWTrips_{NTW} \mid FDTWer]$ Expected non-work trips of a FDTWer if not TWing	$\mathbb{E}[NWTrips_{FDTW} \mid FDTWer]$ Expected non-work trips of a FDTWer	$\mathbb{E}[NWTrips_{PDTW} \mid FDTWer]$ Expected non-work trips of a FDTWer if PDTWing
PDTWer	$\mathbb{E}[NWTrips_{NTW} \mid PDTWer]$ Expected non-work trips of a PDTWer if not TWing	$\mathbb{E}[NWTrips_{FDTW} \mid PDTWer]$ Expected non-work trips of a PDTWer if FDTWing	$\mathbb{E}[NWTrips_{PDTW} \mid PDTWer]$ Expected non-work trips of a PDTWer

FDTWing treatment effect on the untreated

PDTWing treatment effect on the untreated

Treatment effect on the FDTW-treated

Treatment effect on the PDTW-treated

Selection model results: $\mathcal{Z}_t = W\gamma_t + \varepsilon_t$

Reference: NTWer	FDTWer coef. ($\hat{\gamma}$)	p-value		PDTWer coef. ($\hat{\gamma}$)	p-value	
ASC	-7.902	0.000	***	-4.706	0.000	***
Female	0.134	0.026	*	0.187	0.002	**
Age	0.103	0.000	***	0.028	0.014	*
Age^2	-0.00123	0.000	***	-0.000333	0.056	.
Race (ref=White): Black	-0.256	0.001	**	-0.340	0.000	***
Race (ref=White): Asian	0.009	0.895		-0.184	0.008	**
Race (ref=White): Other	0.285	0.000	***	-0.123	0.007	**
Edu (ref=High school or less): Some college	0.909	0.000	***	0.296	0.000	***
Edu (ref=High school or less): Bachelor or higher	1.180	0.000	***	0.788	0.000	***
Residence (ref=Urban): Suburban	0.166	0.004	**	0.102	0.083	.
Residence (ref=Urban): Small town	0.009	0.647		-0.253	0.000	***
Residence (ref=Urban): Rural	-0.151	0.000	***	-0.227	0.000	***
House owner	0.228	0.001	***	0.183	0.008	**
Multi-worker family	-0.269	0.000	***	-0.048	0.448	
HH member(s) need special care	-0.004	0.833		0.094	0.000	***
Multi-job (polyworker)	-0.530	0.000	***	0.420	0.000	***
Occupation: Professional/technical	0.255	0.000	***	0.010	0.834	
Occupation: Manager/administrator	0.316	0.000	***	0.076	0.155	
Occupation: Clerical/administrative support	0.007	0.903		-0.269	0.000	***
Organization size >100	0.067	0.303		-0.432	0.000	***
TWing feasibility: Supervisor willingness	2.014	0.000	***	1.957	0.000	***
TWing feasibility: Job nature	0.595	0.000	***	0.327	0.000	***
Household serving trips: Equally shared among HH members	0.301	0.000	***	0.163	0.010	*
Household serving trips: Another person does most	-0.177	0.000	***	-0.074	0.000	***
Travel stressed	0.031	0.613		0.142	0.021	*
Commute benefit	0.058	0.352		0.125	0.048	*
Work-interferes-with-family	0.198	0.011	*	0.193	0.012	*
TW cost-saving	0.248	0.003	**	-0.022	0.792	
TW effective teamwork	0.254	0.000	***	0.049	0.473	
TW enthusiasm	0.362	0.000	***	0.417	0.000	***
WAA	-0.039	0.508		-0.152	0.012	*
CCG	0.212	0.001	***	0.046	0.464	
TOR	0.197	0.000	***	-0.485	0.000	***

Model fit:

0.557 (EL base);

0.520 (MS base)

. $p < 0.10$
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

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Outcome model results: *t** = NTWer

$$NWTrips_{t*} = \boldsymbol{X}_{t*}\boldsymbol{\beta}_{t*} + \eta_{t*}$$

	Coef. ($\widehat{\beta}$)	Pr(>|t|)
Intercept	30.652	0.000***
Correction term (CT) NTW	-0.563	-
CT FDTW	-1.669	0.779
CT PDTW	2.232	0.714
Age	-0.116	0.002**
Edu (ref=High school or less): Some college	0.343	0.806
Edu (ref=High school or less): Bachelor's degree or higher	2.676	0.042*
Living with child(ren)	5.394	0.000***
Driver	6.679	0.001***
Household serving trips: Another person does most	-4.233	0.019*
Flexible work schedule	5.245	0.004**
Non-car alternatives	2.508	0.000***
Pro-car-owning	1.425	0.015*
Commute benefit	1.609	0.006**
Family-interferes-with-work	1.387	0.008**
TOR	-5.852	0.000***

* p < 0.05
** p < 0.01
*** p < 0.001

R^2: 0.107

ρ_{NTW}^{NTW} = -0.038, ρ_{NTW}^{FDTW} = -0.112, ρ_{NTW}^{PDTW} = 0.150

$\rho_t^{t'} = \text{Corr}(\eta_t , \varepsilon_{t'}) = Corr^{\text{selection eq. error}}_{\text{outcome eq. error}}$

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Outcome model results: *t** = FDTWer

$$NWTrips_{t*} = \boldsymbol{X}_{t*}\boldsymbol{\beta}_{t*} + \eta_{t*}$$

	Coef. ($\hat{\beta}$)	Pr(>|t|)
Intercept	26.571	0.000***
CT NTW	5.716	-
CT FDTW	3.453	0.004**
CT PDTW	-9.169	0.010**
Full-day TWing frequency	0.259	0.016*
Age	-0.196	0.000***
HH income: $50k - $100k	5.639	0.009**
HH income: $100k+	4.777	0.018*
Residence: Rural	-8.089	0.006**
Living with child(ren)	4.098	0.002**
Household serving trips: I do most	4.664	0.000***
Household serving trips: Another person does most	-5.971	0.014*
Non-car alternatives	3.979	0.000***
Pro-car-owning	2.231	0.001***
Family-interferes-with-work	3.111	0.000***
TOR	-3.542	0.016*

* p < 0.05
** p < 0.01
*** p < 0.001

R^2: 0.208

ρ^{NTW}_{FDTW} = 0.424, ρ^{FDTW}_{FDTW} = 0.256**, ρ^{PDTW}_{FDTW} = -0.680**

$\rho^{t'}_{t}$ = Corr(η_t , $\varepsilon_{t'}$) = $Corr^{\text{selection eq. error}}_{\text{outcome eq. error}}$

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Outcome model results: *t** = PDTWer

$$NWTrips_{t*} = \boldsymbol{X}_{t*}\boldsymbol{\beta}_{t*} + \eta_{t*}$$

	Coef. ($\widehat{\beta}$)	Pr(>|t|)
Intercept	49.548	0.000***
CT NTW	1.419	-
CT FDTW	1.647	0.528
CT PDTW	-3.065	0.019*
Age	-0.214	0.001**
Living with child(ren)	6.399	0.000***
Have pet	3.372	0.071.
Household serving trips: Another person does most	-7.886	0.010**
Non-car alternatives	2.768	0.002**
Pro-car-owning	3.180	0.000***
WAA	-6.978	0.002**
CCG	-3.676	0.155
TOR	-3.197	0.189

* p < 0.05
** p < 0.01
*** p < 0.001

R^2: 0.142

ρ_{PDTW}^{NTW} = 0.094, ρ_{PDTW}^{FDTW} = 0.109, ρ_{PDTW}^{PDTW} = -0.202*

$$\rho_t^{t'} = \text{Corr}(\eta_t\ ,\ \varepsilon_{t'}) = Corr^{\text{selection eq. error}}_{\text{outcome eq. error}}$$

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Key model result takeaways

Selection model: non-TWer, full-day-only TWer, partial-day TWer

- Females are more likely to adopt both FD and PD TWing
- The likelihood of FDTWing and PDTWing peaks around 42 years old
- Having household (HH) member(s) requiring special care increases the probability of PDTWing
- Those who have HH serving trips equally shared among HH members are more likely to telework, whereas people are less likely to telework if other HH members do most of the HH serving trips

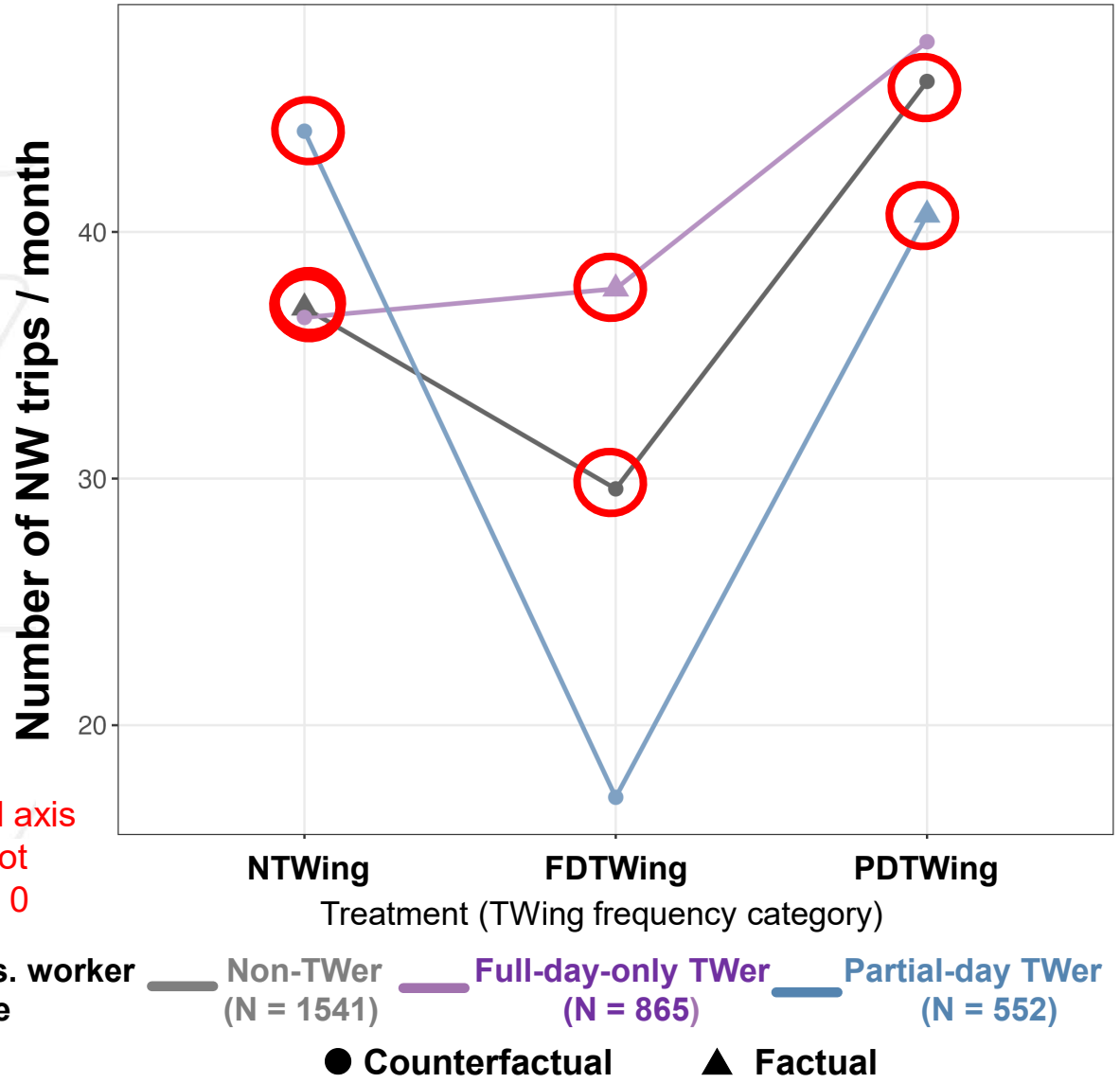
Outcome models: no. of non-work (NW) trips per month

- Age is negatively associated with the number of NW trips for all worker groups
- In general, having children and/or pets would increase the number of NW trips
- For full-day-only TWers, their TWing frequency is positively related to the no. of NW trips
- Having (an)other HH member(s) doing most of the HH serving trips is negatively associated with the no. of NW trips for all worker groups
- Given that NW trips include all travel modes, both pro-car and pro-non-car alternative attitudes are positively associated with the number of NW trips

Summary of treatment effect components (NW trips/mo.)

		Potential Status (t)		
Observed Status (t*) ↓	***Observed***	**Non-TWing**	**Full-day-only TWing**	**Partial-day TWing**
Unweighted				
NTWer	37.23	37.23	29.86	46.58
Full-day-only TWer	38.06	36.79	38.06	48.47
Partial-day TWer	42.00	44.71	18.47	42.00
Weighted				
NTWer	36.29	36.92	29.58	46.10
Full-day-only TWer	36.65	36.53	37.70	47.71
Partial-day TWer	40.59	44.08	17.08	40.69

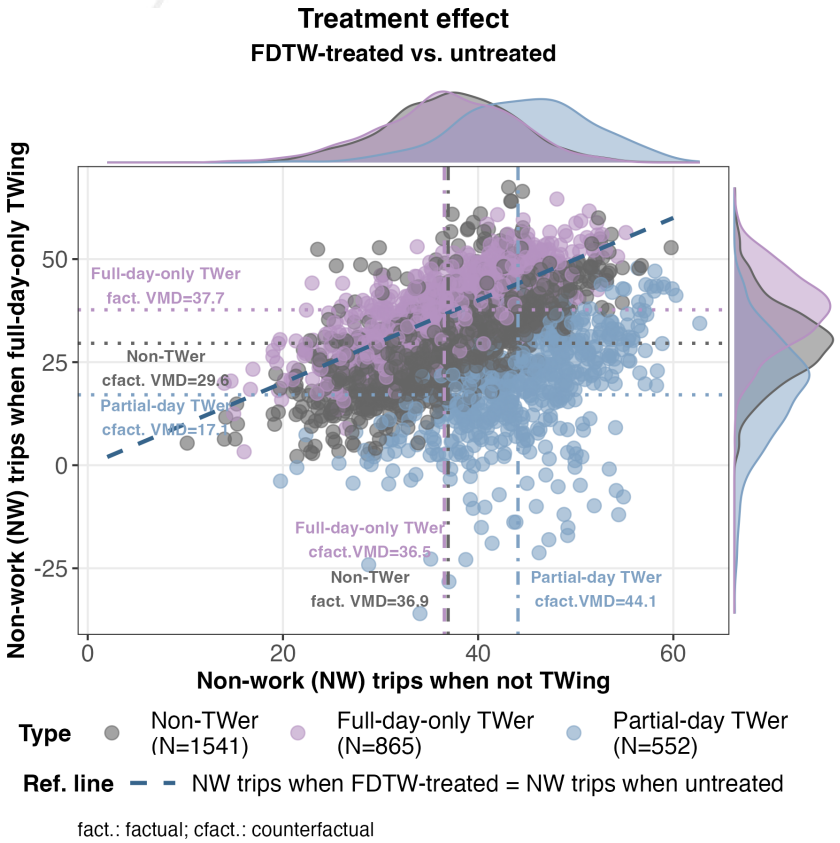
Summary of (weighted) treatment effect components

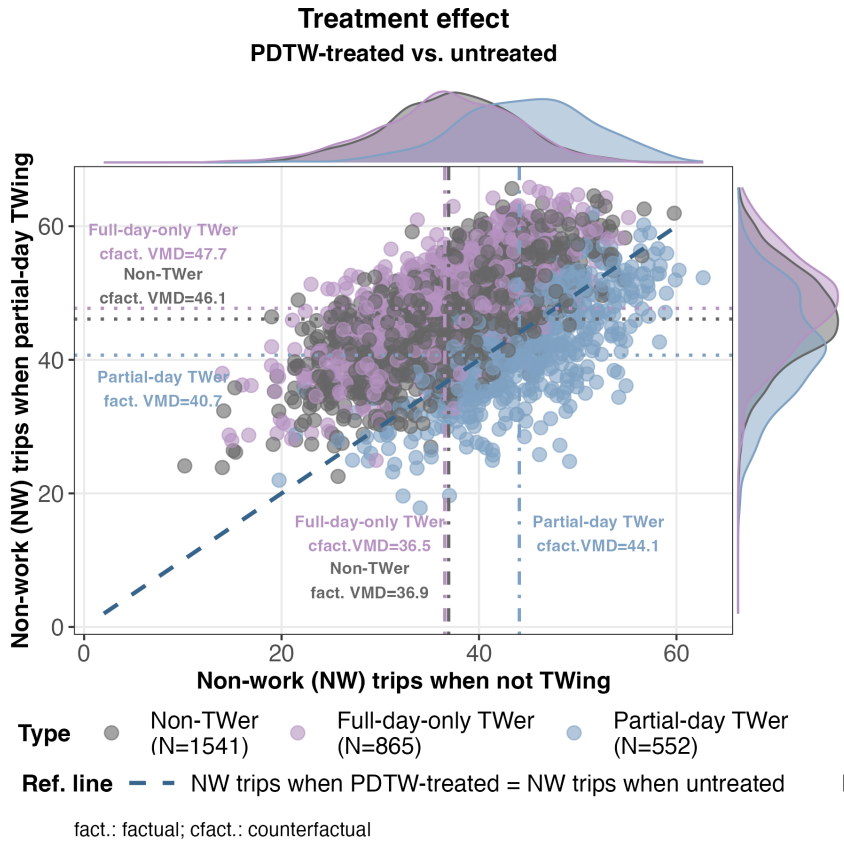


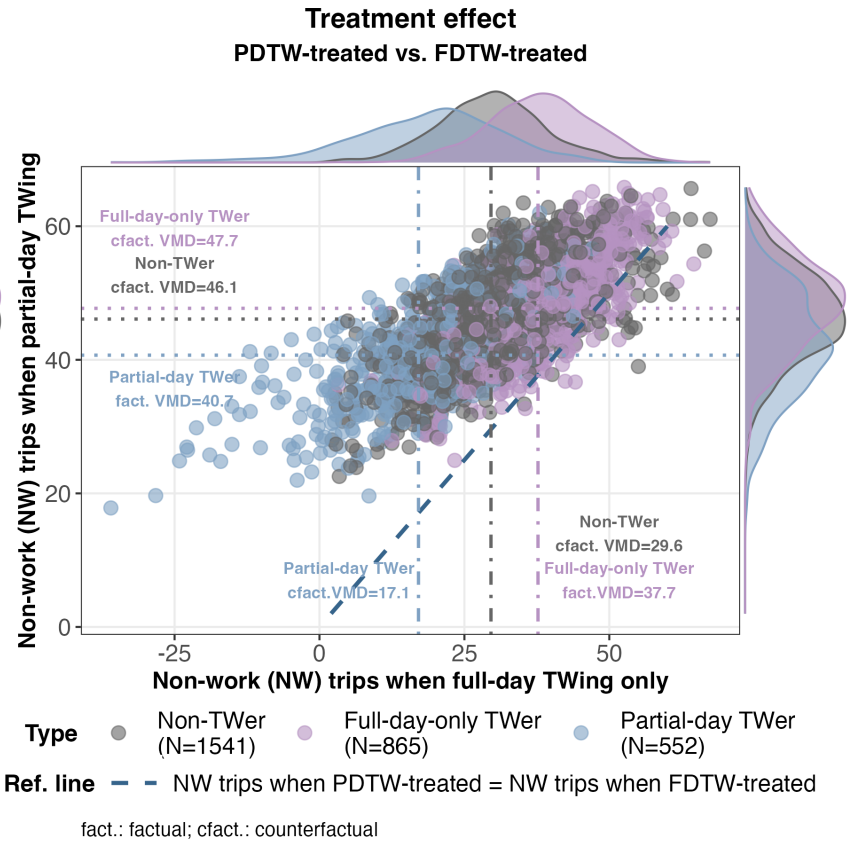
Note: vertical axis does not start at 0

- On ave., non-TWers would make **7.3 *fewer* NW trips / mo** if **FDTWing**, and **9.2 *more* NW trips / mo** if **PDTWing**
- On ave., full-day-only TWers are making **1.2 *more* NW trips / mo** than if **not TWing**
  - But they are ***eliminating*** at least that many ***commute*** trips, so – a net reduction in "*all* trips"
- On ave., partial-day TWers are making **3.4 *fewer* NW trips / mo** than if **not TWing**
  - They are likely ***still making*** some ***commute*** trips, but (probably) not more than if not TWing
  - Notice how, if compared to ***current NTWers***, PDTWers make ***more*** trips
  - ⇒ different effects are obtained from a naïve cross-sectional-only analysis than if taking the longitudinal counterfactual into account

Disaggregate treatment effect plots







- Most (would) make **fewer** NW trips if **full-day-only TWing**, compared to **not TWing**
- Most (would) make **more** NW trips if **partial-day TWing**, compared to **not TWing**
- Nearly everyone (would) make(s) **more** NW trips if **partial-day TWing** than if **full-day-only TWing**

Next steps for Study 2

- Separate sample by “TWing motivation” – Flexibility-motivated vs. other
- Examine treatment effect of full-day and partial-day teleworking on overall travel demand (e.g., weekly VMD, total monthly trips)
- Incorporate full/partial-day TWing *frequency* into the typology

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Selection model dependent variable

<table>
<tr><td colspan="2">Study 1 – Ordinal probit switching regression (OPSR)</td><td colspan="6">Partial-day TWing frequency</td></tr>
<tr><td colspan="2"></td><td>Never</td><td>< 1/mo.</td><td>1-3/mo.</td><td>1-2/wk</td><td>3-4/wk</td><td>5+/wk</td></tr>
<tr><td rowspan="6">Full-day TWing freq.</td><td>Never</td><td colspan="6">Non-teleworker (NTWer)</td></tr>
<tr><td>< 1/mo.</td><td colspan="6" rowspan="3">Non-usual teleworker (NUTWer)</td></tr>
<tr><td>1-3/mo.</td></tr>
<tr><td>1-2/wk</td></tr>
<tr><td>3-4/wk</td><td colspan="6" rowspan="2">Usual teleworker (UTWer)</td></tr>
<tr><td>5+/wk</td></tr>
</table>

<table>
<tr><td colspan="2">Study 2 – Multinomial logit switching regression (MNLSR)</td><td colspan="6">Partial-day TWing frequency</td></tr>
<tr><td colspan="2"></td><td>Never</td><td>< 1/mo.</td><td>1-3/mo.</td><td>1-2/wk</td><td>3-4/wk</td><td>5+/wk</td></tr>
<tr><td rowspan="6">Full-day TWing freq.</td><td>Never</td><td colspan="2" rowspan="2">Non-teleworker (NTWer)</td><td colspan="4" rowspan="6">Partial-day teleworker (PDTWer)</td></tr>
<tr><td>< 1/mo.</td></tr>
<tr><td>1-3/mo.</td><td colspan="2" rowspan="4">Full-day-only teleworker (FDTWer)</td></tr>
<tr><td>1-2/wk</td></tr>
<tr><td>3-4/wk</td></tr>
<tr><td>5+/wk</td></tr>
</table>

Major differences in NTWer definitions

- **Study 1:** Never teleworks for full days, but *may telework partial days*
- **Study 2:** Teleworks *less than once a month for both full days and partial days*

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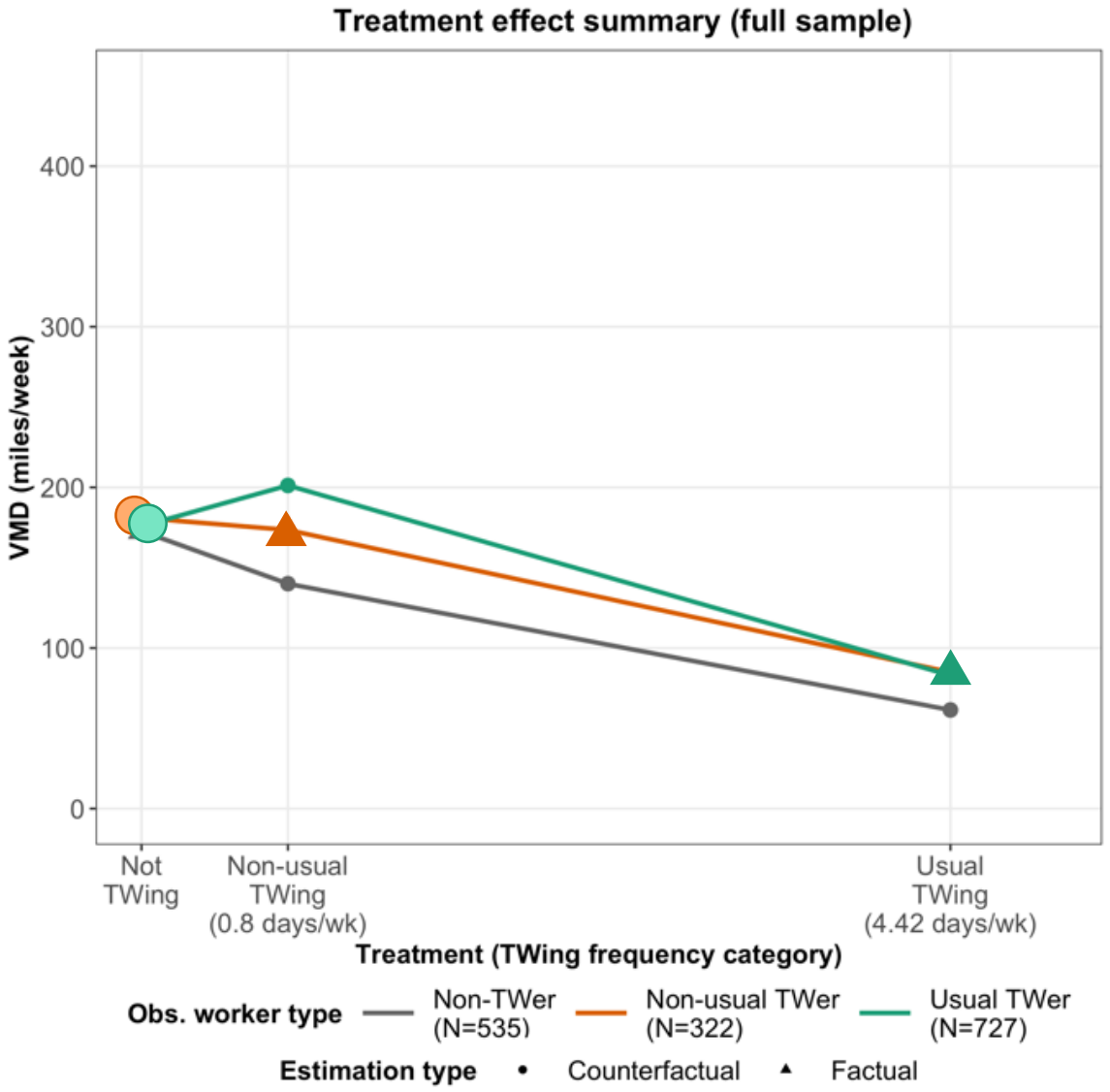
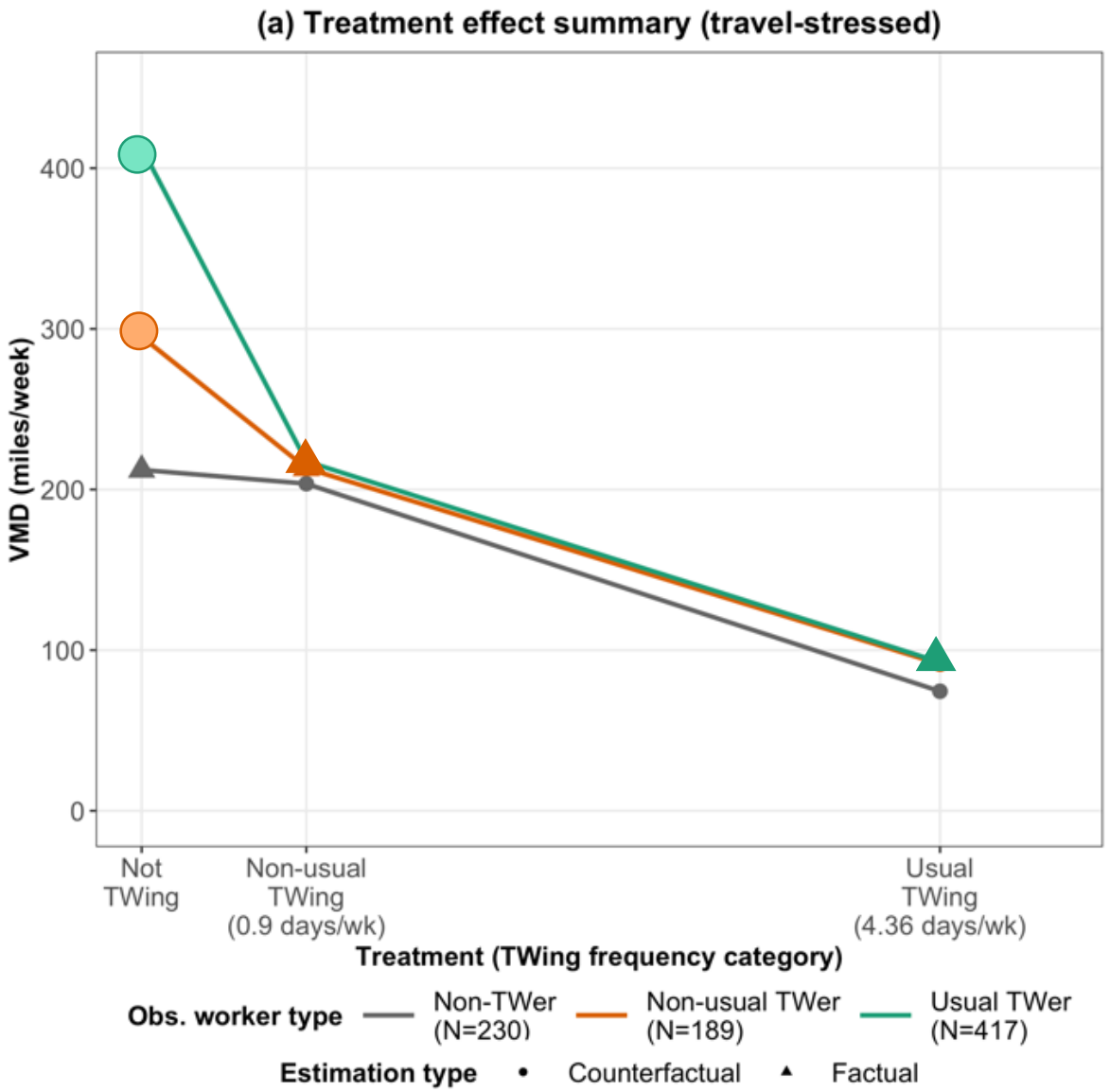
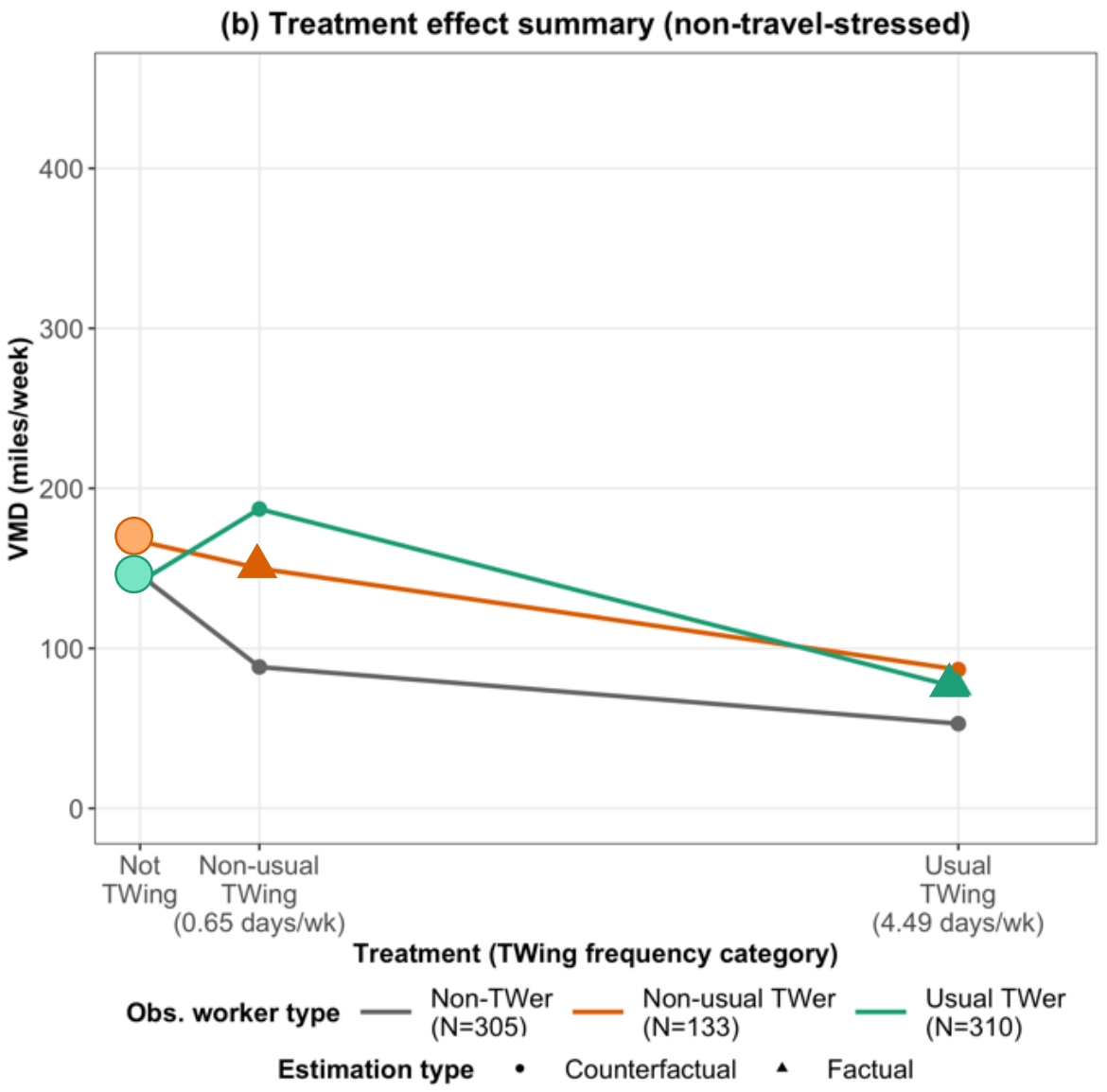
Full sample model (2 treatments: NUTWing & UTWing)



- Focusing on the TEs (compared to not TWing) for the two observed TWer groups:
  - ▲, ▲ = factual
  - ●, ● = (NTW) counterfactual
- **Ave. VMD of non-usual TWers (15% of the sample) barely declines** (not statistically significant)
  - -7.5 mi/wk, or, -9.4 mi/TWing occasion
- **Ave. VMD of usual TWers (28% of the sample) declines substantially** (statistically significant)
  - -92.9 mi/wk, or, -21.0 mi/TWing occasion

Comparison of travel-stressed and non-travel-stressed





Summary of estimated TEs, compared to not TWing

VMD per week

	full model	travel-stressed	non-travel-stressed
current NUTWers	-7.5 (n.s.)	-81.8	-17.0 (n.s.)
current UTWers	-92.9	-320.2	-66.2

n.s. = not statistically different from 0

VMD per TW occasion

	full model	travel-stressed	non-travel-stressed
current NUTWers	-9.4	-91.0	-26.0
current UTWers	-21.0	-73.4	-14.7

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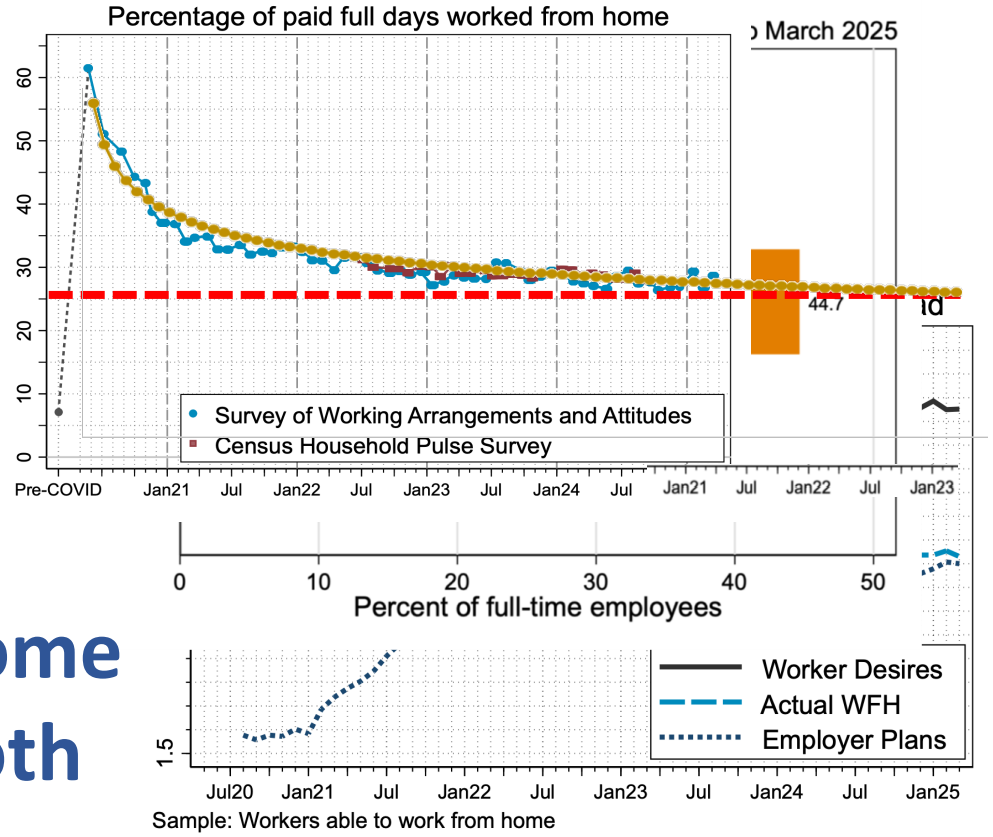
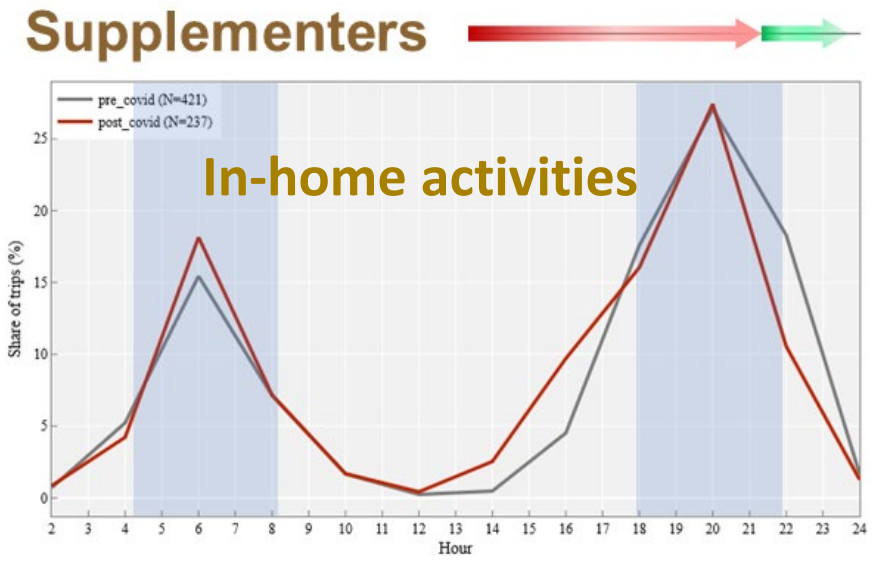
Key takeaways (1)

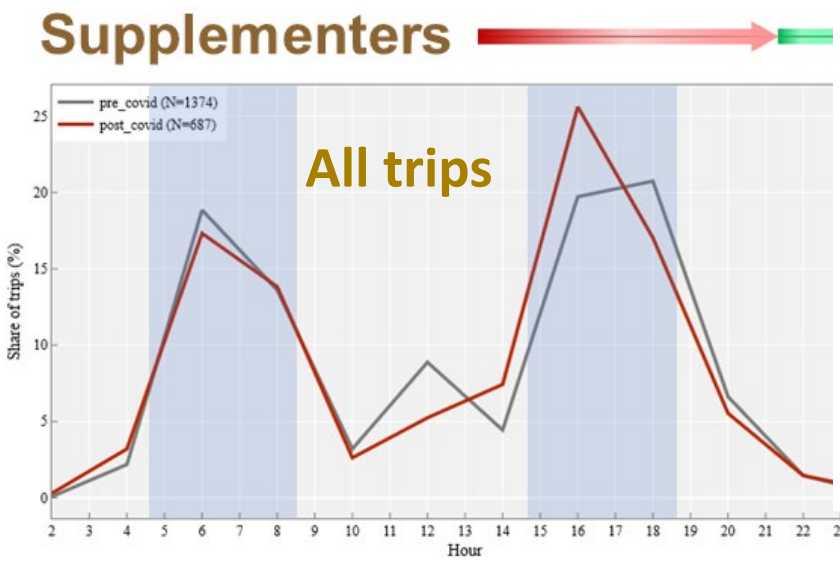
- @29% paid days WFH, we're still at ~4x pre-COVID levels
- But drifting downward, likely not yet plateauing
- 1/3 of those who can WFH don't
- Most who can WFH prefer a mix of home and reg. workplace, seeing good in both
- But they want about 0.6 days/week more WFH than their employers want them to have



Key takeaways (2)

- **Partial-day TWers (~1/3 of TWers) still commute**
  - ¾ of partial-day TWers (**supplementers** ≈ 20% of all TWers) tend to WFH before/after putting in a full day at the reg. workplace
  - As a result, the *temporal distribution* of their trips (as well as their *trip rates*) looks a lot like that of conventional **commuters**





Key takeaways (2)

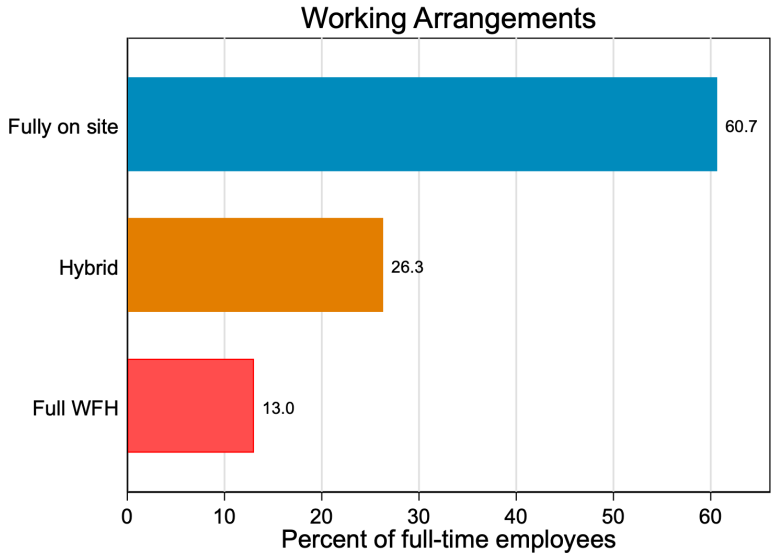
- **Partial-day TWers (~1/3 of TWers) still commute**
  - ¾ of partial-day TWers (**supplementers** ≈ 20% of all TWers) tend to WFH before/after putting in a full day at the reg. workplace
  - As a result, the *temporal distribution* of their trips (as well as their *trip rates*) looks a lot like that of conventional **commuters**
  - **Substituters** make the most trips (including more work trips than commuters do), and those are more distributed throughout the day (less peaked)
- **Full-day TWers make the fewest trips**
  - Though (barely) more non-work trips than if not TWing

Key takeaways (3)

- **Combining non-work and commute trips, TWing *reduces total trips* for both full-day-only TWers and partial-day TWers , compared to what it would be if they did not TW**
- **Previous work** (hidden slides, Wang & Mokhtarian 2024) **has shown that TWing *reduces vehicle-miles driven* for both frequent TWers** (3+ full days/wk) **and less frequent TWers** (< 3 full days/wk)**, compared to what it would be if they did not TW**

Things we still don't know much about (1)

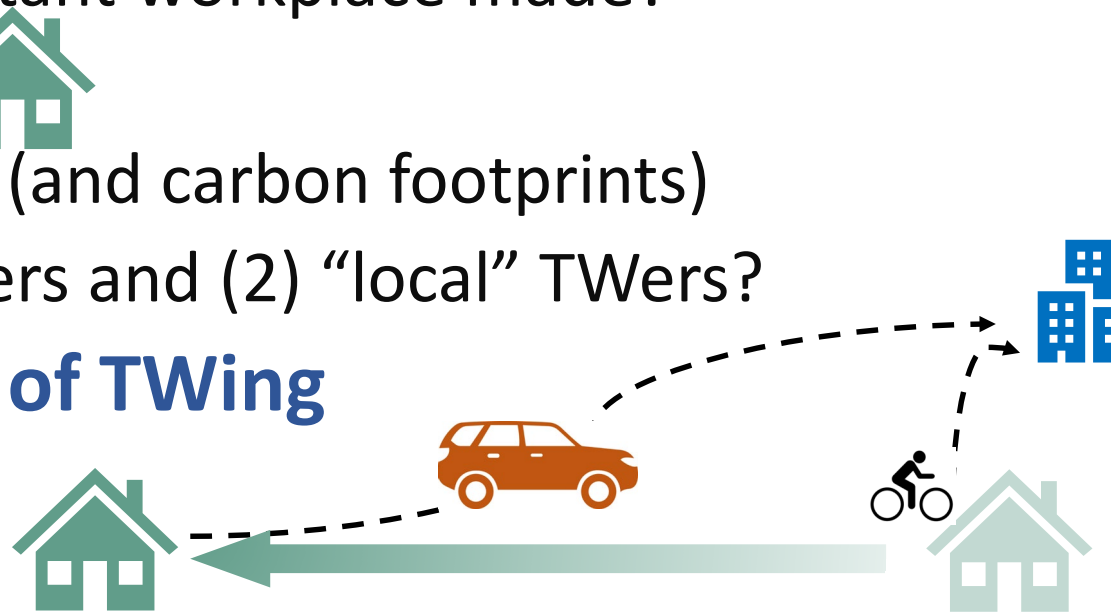
- **Less frequent (< 3x/wk) and occasional TWing**
  - American Community Survey only captures "how you **'usually'** got to work last week"
  - How much less-frequent & occasional TWing is there? What is the frequency distribution?
  - Who does it?
  - Travel impacts



- **Partial-day TWing!**
  - Extent (how many, how much) and nature (how distributed)
  - **Supplementer** vs. **Substituter** distinction
  - Impacts on travel and activity patterns

Things we still don't know much about (2)

- **Amounts and nature of very long-distance TWing**
  - How many are doing it?
  - How often is a commute to a distant workplace made?
  - What mode(s) is (are) used?
  - How do "typical" travel patterns (and carbon footprints) differ from those of (1) commuters and (2) "local" TWers?
- **Residential relocation impacts of TWing**
  - How many are doing it?
  - How far away are they moving?
  - Net impacts on total commute distance
  - Mode differences?



Ory & Mokhtarian 2006

Some graphics borrowed from Dr. Xinyi Wang

Thank you! Questions?

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Happy to share the slides

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