

Measuring the Productivity of Working from Home

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Question

- **Questions**

- How much do we work at home and why?
- Are we more productive or do we prefer it?
- How have productivity and preferences changed?

- **Relevance**

- Pandemic forced more to work from home
- What will happen in long run?
- Can we learn anything from what happened before?

What do we know so far

- Productivity at home - literature is mixed
 - call center studies: 4% – 8% more productive
 - Bloom et al. (2014), Harrington and Emanuel (2022)
 - worker and firm survey during pandemic mixed
 - Morikawa (2022), Barrero et al. (2020)
 - large difference across people
 - Morikawa (2022), Etheridge et al. (2020)
- What we add
 - estimate productivity before pandemic using model
 - *Advantage*: productivity is consistently and clearly defined
 - *Disadvantage*: do not know why productivity changed, ie, changes in monitoring technology or changes in tasks at home

What do we know so far

- Preferences and ability to work at home
 - large difference across occupations
 - Dingel and Neiman (2020), Hensvik et al. (2020), Adams-Prassl et al. (2020), Bick et al. (2020)
 - large difference worker characteristics
 - Bick et al. (2020), Etheridge et al. (2020), Pabilonia and Vernon (2022)
 - preference during pandemic changed
 - Barrero et al. (2020)
- What we add
 - estimate preferences structurally
 - *Advantage*: see changes before pandemic
 - *Disadvantage*: do not know why, ie, changes in stigma or changes in commuting times

What We Do

- Document rising work from home (WFH) since 2003
 - increase in teleworking
 - increase in workers splitting workday across office and home
- Document large difference of WFH across occupations
 - large intensive differences: 4% to 30%
 - large extensive differences: 1 hour 40 min - 4 hours 10 min

What We Do

- Document rising work from home (WFH) since 2003
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- Document large difference of WFH across occupations
 - large intensive differences: 4% to 30%
 - large extensive differences: 1 hour 40 min - 4 hours 10 min
- Estimate structural model with differences in
 - relative productivity of WFH over time
 - relative disutility of WFH over time
- Conduct counterfactuals to analyze observed increase in WFH
 - change in preferences vs change in productivity
 - change in demographics vs change in occupational employment

What We Find

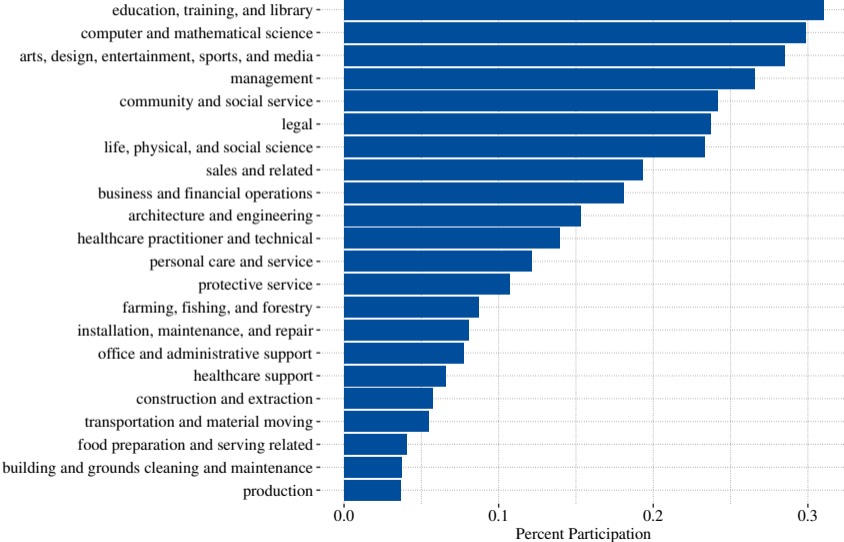
- Occupational differences in relative productivity of WFH
 - average relative productivity $\sim 40\%$
 - computer & mathematical, management, business occ. large increases
 - production, construction, food service, no increase
- Demographic difference in relative disutility of WFH
 - average relative disutility of WFH 6% more
 - increasing in education
 - lower from women with children than men
- Accounting for increase in WFH
 - Changes in relative disutility account for little
 - Changes in demographic composition account for little
 - Changes in relative productivity account for full increase
 - Changes in occupational employment account for 60%

Data

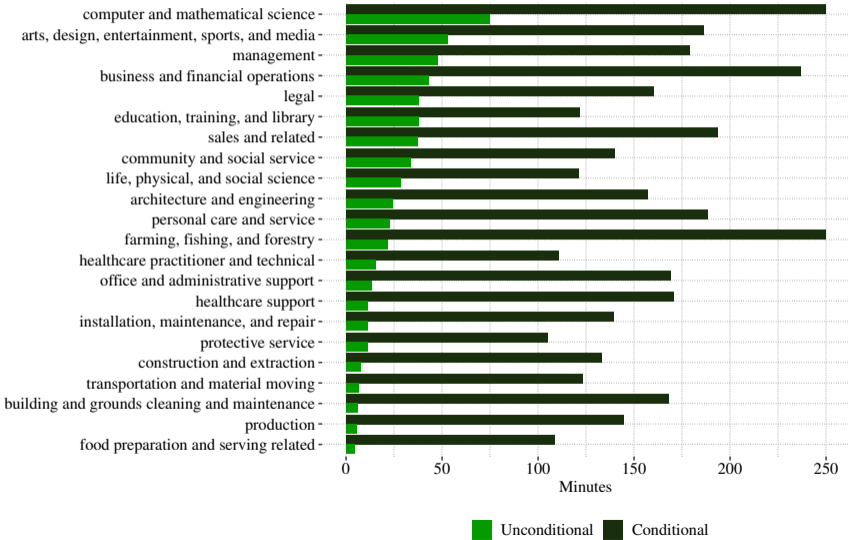
Data

- American Time Use Survey 2003 - 2019
- Interviews CPS respondents 2-5 months after CPS
 - interviewed only about 1 day
- Asks people **what**, **where**, and how long they did activities throughout the day
 - activities are classified into 400 categories
 - Time working at the office
 - **WFH**: work done anywhere else
- Samples selection
 - Employed, private and public (no self-employed), age 25-64
 - Interviewed on a weekday

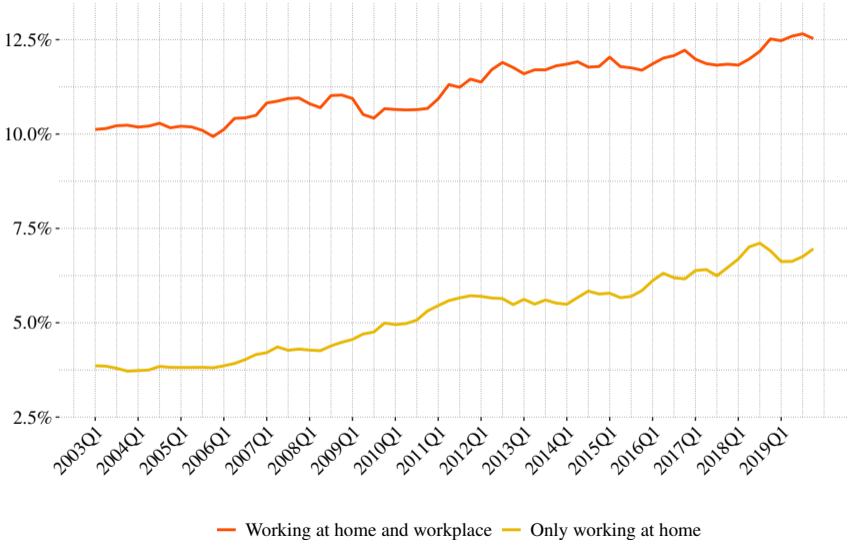
ATUS Work From Home by Occupation: Participation



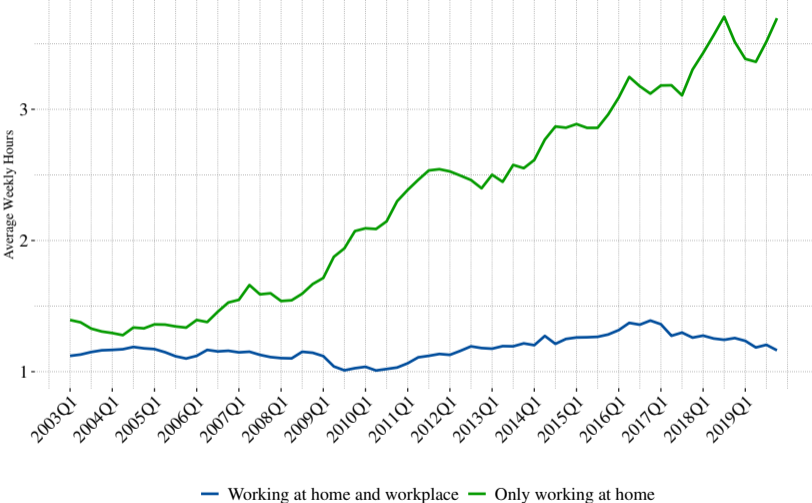
ATUS Work From Home by Occupation: Minutes



ATUS Work From Home over time: Participation



ATUS Work From Home over time: Minutes



Model

Model: The Goal

- We want a model that can
 - match hours and participation in WFH
 - allow for difference in preferences
 - allow for differences in relative productivity
- With the model we will decompose the rise in WFH
 - changes in preferences vs changes in productivity
 - changes in demographics vs changes in occupational employment

Model: Firms

- Firms are identical
 - allow work from home
 - demand labor input
 - pay marginal products
- Labor input is

$$\ell_{ijt} = h_{ijt}^w + \gamma_{ijt} h_{ijt}^h$$

- i - individual, j - occupation, t - time
- h^w - hours worked at the workplace
- h^h - hours worked at home
- γ_{ijt} is the relative productivity, a draw from F_{jt}

Model: Workers

- Workers are employed, can not save, and maximize

$$\begin{aligned} \max_{\{c_{it}, h_{ijt}^h, h_{ijt}^w\}} & \log(c_{it}) - \eta_i [(\chi_{it} h_{ijt}^h)^\rho + (h_{ijt}^w)^\rho]^{\frac{1}{\rho}} \\ \text{s.t.} & c_{it} = w_{ijt}(h_{ijt}^w + \gamma_{ijt} h_{ijt}^h) \end{aligned}$$

- η_i - disutility of work
 - χ_{it} - relative disutility of working from home
 - ρ - substitution parameter in preferences $\rho > 1 \rightarrow$ substitutes
- Optimal Hours Worked

$$h_{ijt}^h = \frac{\chi_{it}^{\frac{\rho}{1-\rho}} \gamma_{ijt}^{\frac{1}{\rho-1}}}{\eta_i \left[1 + \chi_{it}^{\frac{\rho}{1-\rho}} \gamma_{ijt}^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}}} \qquad h_{ijt}^w = \frac{1}{\eta_i \left[1 + \chi_{it}^{\frac{\rho}{1-\rho}} \gamma_{ijt}^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}}}$$

Estimation

Estimation

- Optimal Hours Ratio

$$\frac{h_{ijt}^h}{h_{ijt}^w} = \left(\frac{\gamma_{ijt}}{\chi_{it}^\rho} \right)^{\frac{1}{\rho-1}}$$

- Parameters to be estimated

- $\rho, \{\chi_{it}\}, \{F_{jt}\}, \eta_i$

- Identification given and estimate of ρ using ATUS hours ratio

- $\{\chi_{it}\}$ - variation in hours ratio across individuals and over time

- $\{F_{jt}\}$ - variation in hours ratio across occupation and over time

Estimating ρ

- Logged hours ratio

$$\ln \frac{h_{ijt}^h}{h_{ijt}^w} = \frac{1}{\rho - 1} \ln \gamma_{ijt} + \frac{\rho}{1 - \rho} \ln \chi_{it}$$

- Job Leave and Flexibility Module 2017-2018 from ATUS

summary

- "Are you paid for the hours that you work at home, or do you just take work home from the job?" \sim proxy for γ_{ijt} a dummy $paid_i$
 - paid: $paid_i = 1$
 - take work home $paid_i = 0$
 - both $paid_i = 1$

Estimating ρ

- Specification

$$\ln \frac{h_{ijt}^h}{h_{ijt}^w} = \beta_1 \text{paid}_i + \beta_2 X_i + \delta_j + \varepsilon_{ijt}$$

- paid_i - proxy for γ_{ijt}
 - X_i - vector of observables, including reason for wfh
 - δ_i occupational FE
- The our estimate of ρ

$$\hat{\rho} = 1 + \frac{1}{\hat{\beta}}$$

Estimating ρ

Table: Elasticity of Substitution Estimates

| | All | Paid vs Take home |
|---------------|---------------------|---------------------|
| paidhome | 0.574*** (0.214) | 0.897*** (0.221) |
| ρ | 2.741 (0.650) | 2.115 (0.275) |
| Occupation FE | Yes | Yes |
| Observations | 450 | 400 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Estimating Preferences and Productivity

- Structural assumptions on Productivity

- $\gamma_{ijt} \sim \text{Gamma}(k_j, \theta_{jt})$

- $\theta_{jt} = \theta_j^0 + \delta_j^\theta \cdot t$

- Structural assumptions on Preferences

- $\chi_{it} = \chi_i^0 + \delta_i^\chi \cdot t$

- i are 24 demographic groups

- sex, marital status, children, and three education levels

- $\eta_i = \exp(\beta Z_i)$

- full-time, diary day, sex, marital status, children, five education levels, and four age categories

Estimating Preferences and Productivity

- Maximize the likelihood of observed hours ratio
- For corner solutions
 - report no work at home $\rightarrow h_{ijt}^h < 1/60$

$$P(h_{ijt}^h < 1/60 | \rho) = F(\underline{\gamma}_{it} | \rho; \eta_i, \chi_{ijt}, k_j, \theta_{jt})$$

- report no work at the workplace $\rightarrow h_{ijt}^w < 1/60$

$$P(h_{ijt}^w < 1/60 | \rho) = 1 - F(\bar{\gamma}_{it} | \rho; k_j, \theta_{jt})$$

- Interior solution: $h_{ijt}^h / h_{ijt}^w = \tilde{h}_{ijt}$

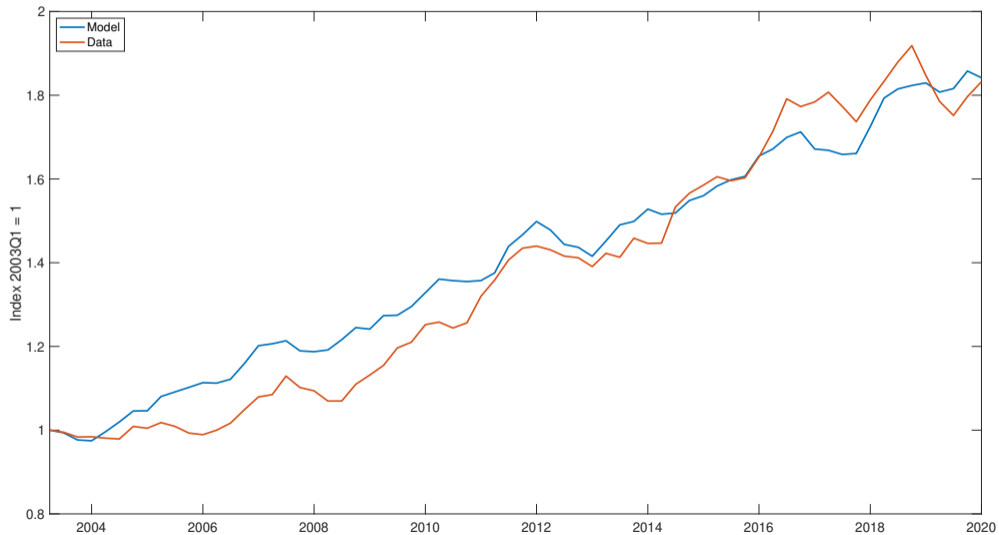
$$P(h_{ijt}^h / h_{ijt}^w = \tilde{h}_{ijt} | \rho) = (\rho - 1) \tilde{h}_{ijt}^{\rho-2} \chi_{it}^\rho \cdot f(\chi_{it}^\rho \tilde{h}_{ijt}^{\rho-1} | \rho; k_j, \theta_{jt})$$

Model Fit

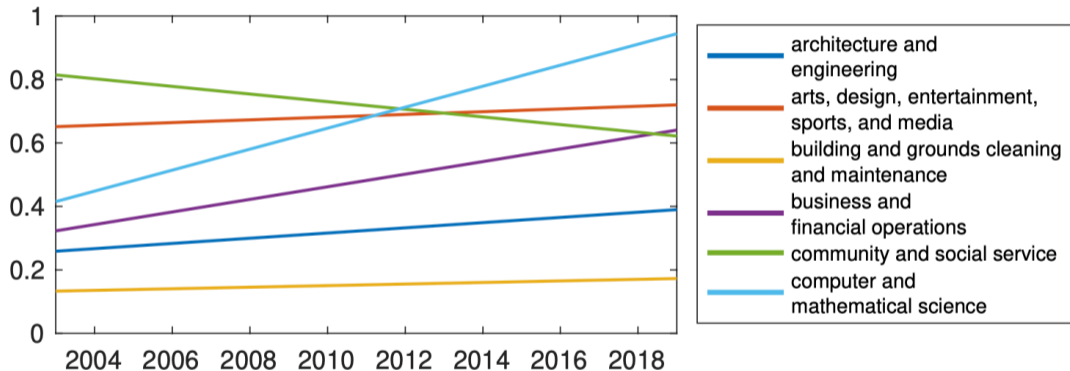
Table: Model and Data Moments

| | Data | Model |
|-----------------------------|-------|-------|
| Hours ratio | 0.383 | 0.370 |
| $P(h^h > 0 \ \& \ h^w > 0)$ | 0.107 | 0.103 |
| $P(h^h = 0)$ | 0.828 | 0.830 |
| $P(h^w = 0)$ | 0.065 | 0.067 |

Model Fit



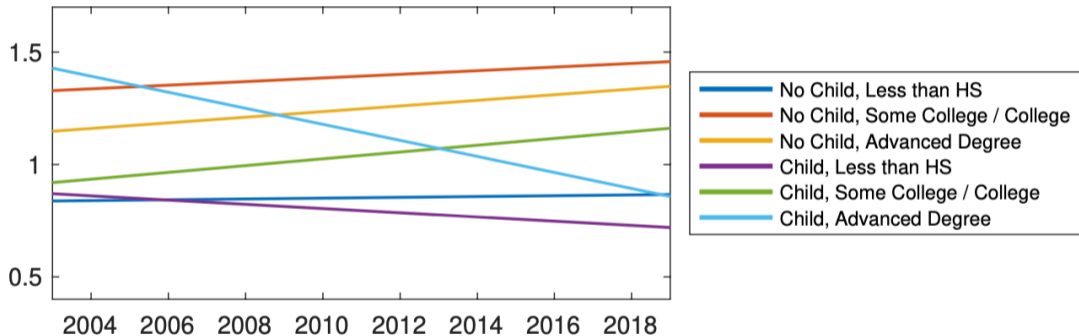
Estimates: Relative Productivity



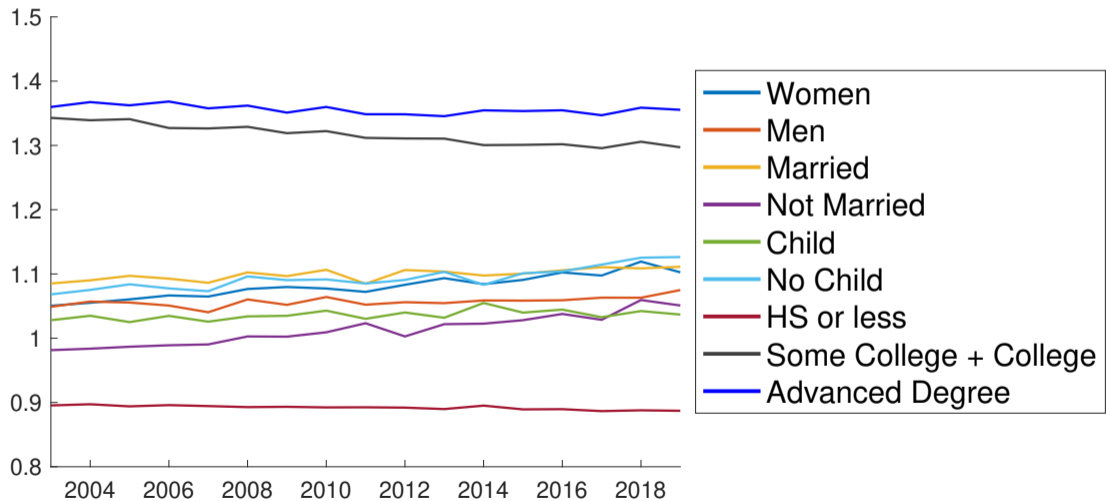
others

Estimates: Relative Disutility

Not Married Men



Estimates: Relative Disutility

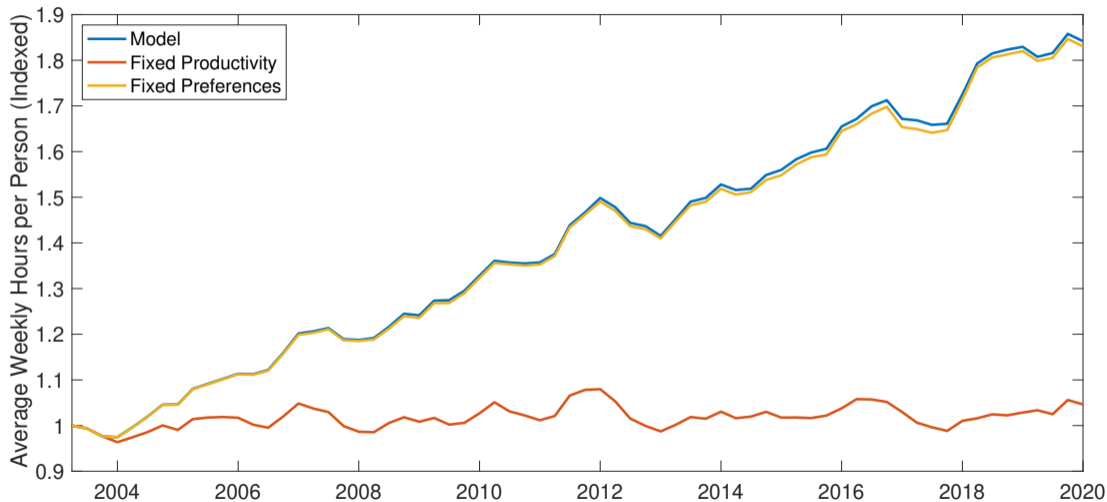


Counterfactuals

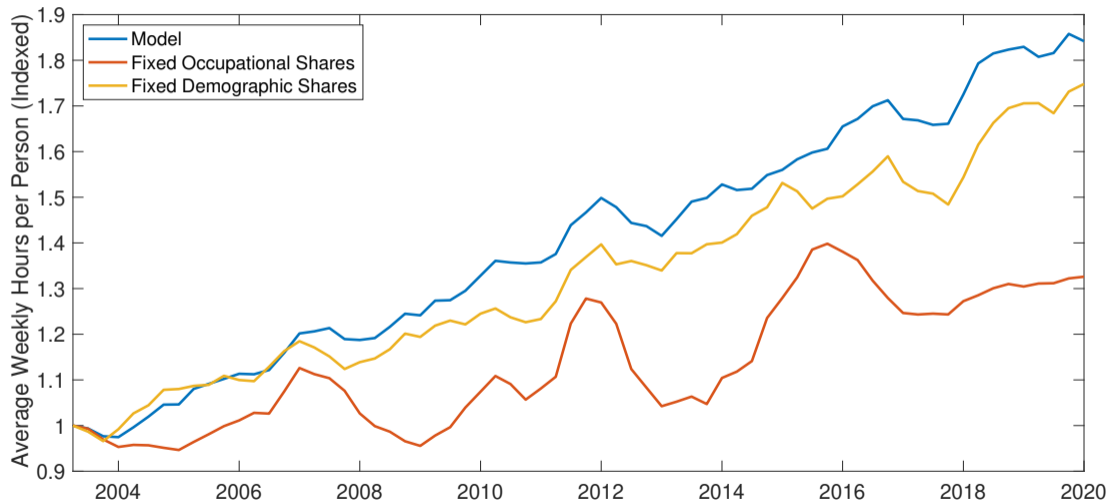
Counterfactuals

- Preferences vs Productivity
 - predict hours worked at home if preferences had not changed $\delta_i^x = 0 \quad \forall i$
 - predict hours worked at home if productivity had not changed $\delta_j^\theta = 0 \quad \forall j$
- Demographic vs Occupational Employment Composition
 - aggregate hours worked at home if demographic comp. had not changed
 - aggregate hours worked at home if occupational employment comp. had not changed

Preferences vs Productivity



Demographic vs Occupational Employment Composition



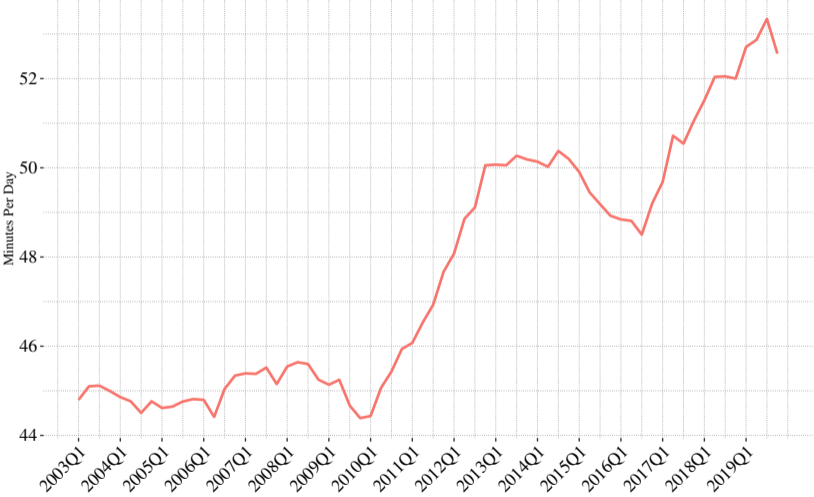
Conclusion

- Document a doubling of hours worked at home pre pandemic
- Document large difference across occupations
- Estimate relative productivity and disutility of WFH
- Preference and demographic changes account for little of the increase
- Productivity and occupational employment changes account for the rise in WFH

Appendix: ATUS Hours Worked Summary

| | Sample Mean |
|------------------------------|-------------|
| Panel (a): All Work | |
| <i>Participation</i> | 0.85 |
| <i>Unconditional Hours</i> | 6.92 |
| <i>Conditional Hours</i> | 8.15 |
| Panel (b): Work at Workplace | |
| <i>Participation</i> | 0.79 |
| <i>Unconditional Hours</i> | 6.50 |
| <i>Conditional Hours</i> | 8.19 |
| Panel (c): Work at Home | |
| <i>Participation</i> | 0.15 |
| <i>Unconditional Hours</i> | 0.42 |
| <i>Conditional Hours</i> | 2.86 |
| Total number of Observations | 47,792 |

Appendix: ATUS Commute to work



Appendix: JFL Summary Statistics

Table: Job Flexibility and Leave Module Summary Statistics

| | Mean | | Mean |
|--------------|-------|---------------------------------|-------|
| Female | 0.46 | Advanced Degree | 0.35 |
| Married | 0.67 | White | 0.84 |
| Age | 42.45 | Black | 0.08 |
| Child | 0.45 | Other | 0.09 |
| Less than HS | 0.00 | Full Time | 0.93 |
| High School | 0.06 | Paid work at home | 0.75 |
| Some College | 0.14 | Take work home | 0.12 |
| College | 0.44 | Both paid at and take work home | 0.12 |
| Observations | | | 1,363 |

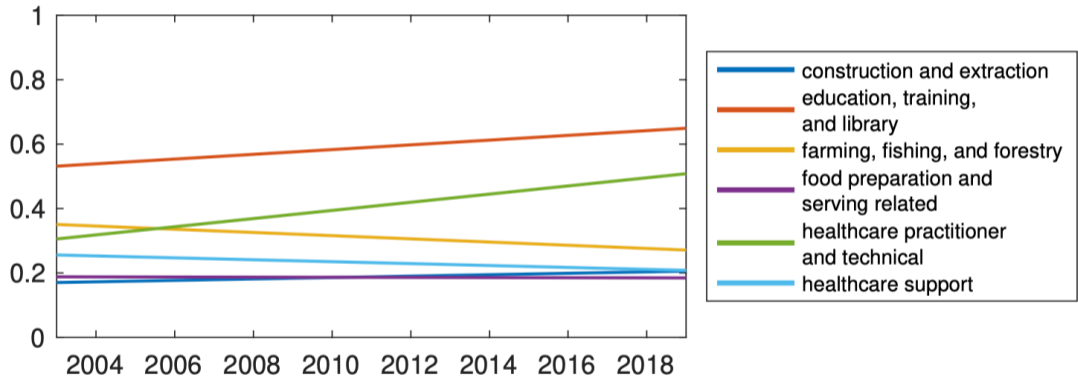
Appendix: Days at home distribution

Table: Summary Statistics: Hours ratio and Days ratio

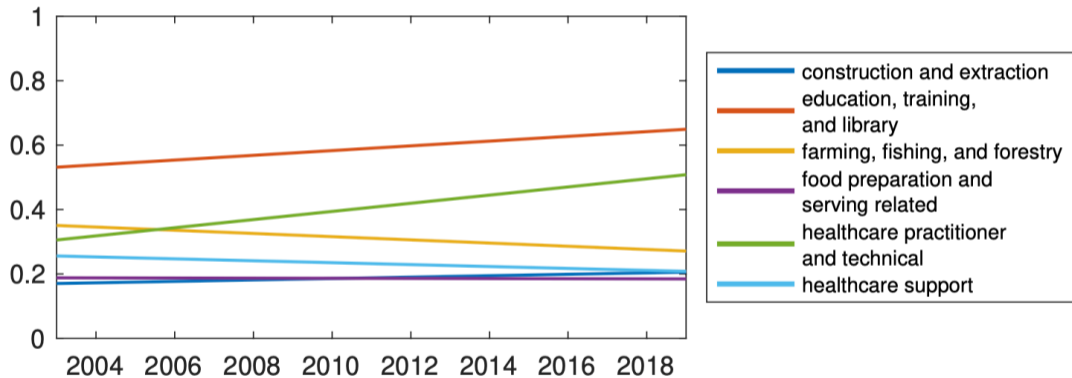
| | Minimum | 25th percentile | Median | Mean | 75th percentile | Max |
|-------------|---------|-----------------|--------|--------|-----------------|---------|
| Hours Ratio | 0.0012 | 0.0531 | 0.1333 | 0.4758 | 0.3131 | 95.0000 |
| Days Ratio | 0.0161 | 0.0465 | 0.1111 | 0.6086 | 0.4286 | 10.0000 |

[back](#)

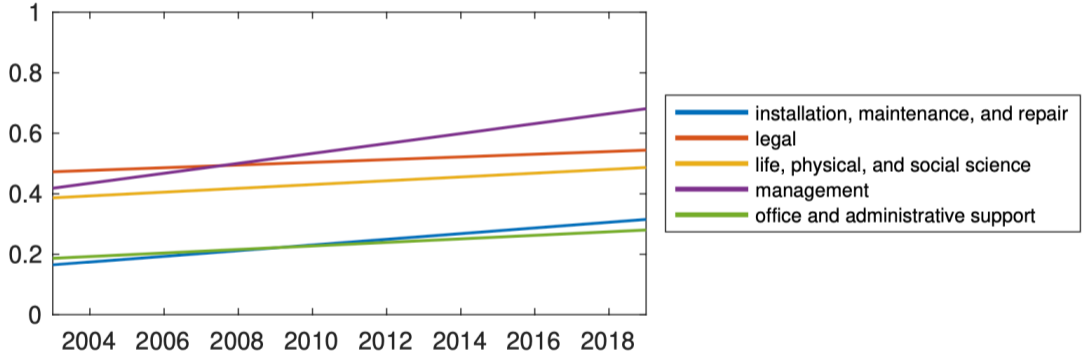
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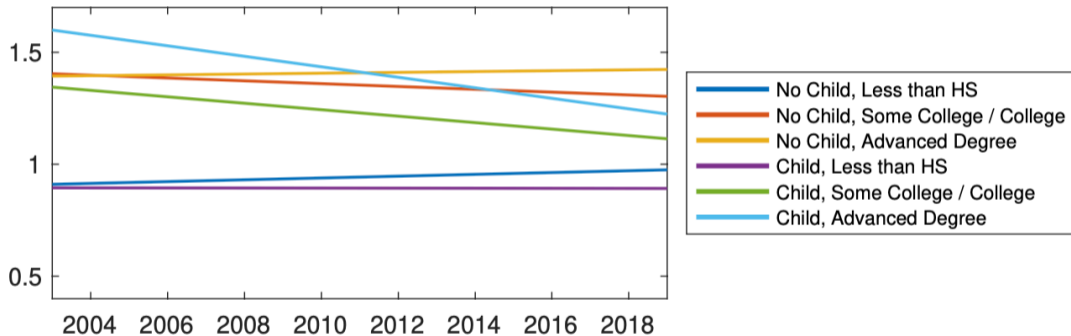


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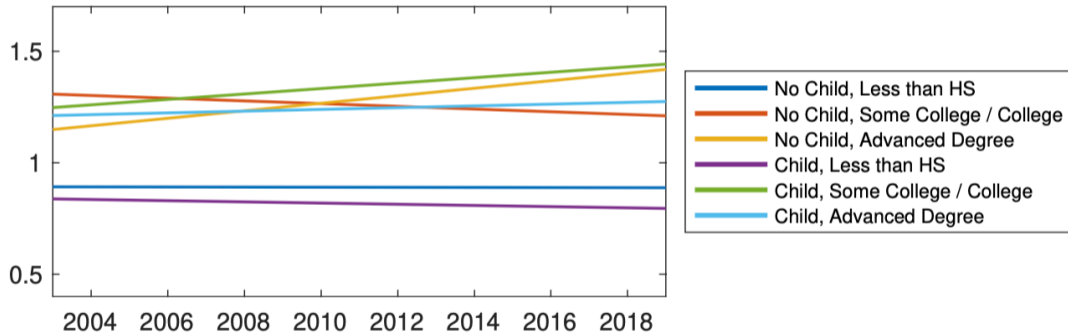
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Not Married Women



Estimates: Relative Disutility

