

TRANSPORT FINDINGS

Factors Influencing Teleworking Productivity – a Natural Experiment during the COVID-19 Pandemic

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Findings

Of 2174 surveyed adults who were teleworking following the implementation of a Covid-19 work-from-home policy, 23.8% reported an increase in productivity, 37.6% no change, and 38.6% a decrease in productivity compared to working at their prior workplace. After controlling for feelings of depression and anxiety likely caused by pandemic-related circumstances, the socioeconomic characteristics associated with no change or an increase in productivity after shifting to teleworking included being older; not employed in higher education; having lower education attainment; and not living with children. Respondents with longer commute trips in single-occupancy vehicles prior to teleworking were more likely to be more productive but those with longer commute by walking were not. Lifestyle changes associated with increased productivity included better sleep quality, spending less time on social media, but more time on personal hobbies.

RESEARCH QUESTIONS

The Covid-19 pandemic has rekindled interest in teleworking as a potentially promising work arrangement. A preferred protective option as long as the virus cannot be contained (Baert et al. 2020), teleworking can also serve in the long term as a viable strategy for Transportation Demand Management (TDM) and specifically for Commuting Trip Reduction (CTR) (Hook et al. 2020). While the effects of CTR on transportation efficiency and environmental benefits of CTR are well known, those of working from home (WFH) on work productivity remain under-researched (Kazekami 2020; Nakrošienė, Bučiūnienė, and Goštautaitė 2019; Neufeld and Fang 2005; Ruth and Chaudhry 2008; Aboelmaged and El Subbaugh 2012; Pignini and Staffolani 2019). This study took advantage of a recent WFH policy, which acted as a natural experiment to learn about personal factors associated with “successfully” WFH. A survey administered around Seattle, Washington, aimed to identify the characteristics of people more suited to WFH so that a portion of the Covid-19 WFH population might continue to do so after Covid-19, which would contribute to TDM and CTR outcomes while maintaining workforce productivity (Organisation for Economic Co-operation and Development (OECD) 2020). Specific questions focused on:

1. The socioeconomic characteristics (SES) and commuting patterns of the population that continued to be productive during Covid-19 WFH
2. The lifestyle changes that helped the WFH population continue to be productive while teleworking

METHODS AND DATA

Study and Survey Design

We conducted the survey between April and June 2020 in the four counties of the central Puget Sound (Seattle) region, Washington, and asked participants about changes in their work productivity, daily routines, and mental wellbeing since WFH during Covid-19. We used convenience sampling, with a target population of adults older than 18 living in the region's four counties. The survey was managed online and distributed through professional email lists of public agencies, non-government organizations, universities and colleges, as well as other public community groups. There was no financial incentive for participation. We obtained responses from 2174 adults from 83% of the ZIP Codes in the four counties, who had shifted from working away to WFH since Covid-19. Compared to central Puget Sound region general population, 69% of our participants had a household income higher than the region's median; 67% were female (50% in the region) and 52% had graduate degrees or above (32% in the region) ([Table 1](#)). Detailed information on the survey was documented elsewhere (Puget Sound Regional Council 2020).

Variables

The unit of analysis was the participant. The outcome of interest was self-reported change in productivity since WFH. Participants were given three options: no change, a decrease or an increase in productivity. Productivity was treated as an ordinal variable with decrease in productivity as the reference. Hypothesized predictors of productivity change came from four domains: socioeconomic status (SES), previous commute trip mode and duration, lifestyle changes (sleep quality, food consumption, amount of exercise, time spent on social media or personal hobby), and mental wellbeing. Mental wellbeing variables served to control for potential effects on people caused by Covid-19 circumstances. To evaluate depression, we used two questions from the Patient Health Questionnaire (PHQ-2, (Kroenke, Spitzer, and Williams 2003): how often participants felt depressed or had little interest in doing things on a 4-point Likert scale (0 = Not at all; 1 = Several days; 2 = More than half the days; 3 = Nearly every day). To evaluate anxiety, we used 6 questions from the Brief Symptom Inventory (BSI, (Derogatis and Melisaratos 1983) on a 5-point Likert scale (0=Not at all, 1=A little bit, 2=Moderately, 3=Quite a bit, 4=Extremely). Depression

Table 1. Characteristics of participants, their SES, prior commute trip patterns, mental wellbeing status, lifestyle changes since Covid-19 (N=2174)

<i>Outcome</i>			
Variables	Descriptive Statistics		
Productivity (outcome)			
Less productive	839 (38.6%)		
No change	817 (37.6%)		
More productive	518 (23.8%)		
<i>Domain: SES</i>			
Variables	Descriptive Statistics	Sig.¹	
Age		*	
18 to 29	389 (17.9%)		
30 to 39	538 (24.7%)		
40 to 49	455 (20.9%)		
50 to 59	483 (22.2%)		
60 and above	306 (14.1%)		
Not applicable	3 (0.1%)		
Gender			
Female	1499 (69.0%)		
Male	646 (29.7%)		
Other	29 (1.3%)		
Income		*	
below 40k	145 (6.7%)		
[40k-90k)	478 (22.0%)		
[90k-150k)	757 (34.8%)		
above 150k	735 (33.8%)		
Not applicable	59 (2.7%)		
Employment		*	
Professional	1178 (54.2%)		
Student	249 (11.5%)		
Faculty	122 (5.6%)		
Education			*
High school or 2yr college	251 (11.5%)		
4yr college	777 (35.7%)		
Graduate or post graduate	1129 (51.9%)		
Not applicable	17 (0.8%)		
Housing status			*
Own	1411 (64.9%)		
Rent	715 (32.9%)		
Not applicable	48 (2.2%)		
Living arrangement			*
Partner	876 (40.3%)		
Live alone	316 (14.5%)		
Friends & relatives	308 (14.2%)		
Children	619 (28.5%)		
Not applicable	55 (2.5%)		
Dog ownership			
Yes	756 (34.8%)		
No	1418 (65.2%)		
Vehicle ownership			
Yes	2029 (93.3%)		
No	145 (6.7%)		
<i>Domain: mental wellbeing</i>			
Variables	Descriptive Statistics		Sig.
Depression measure			*
Mean (SD)	1.45 (1.48)		
Median [Min, Max]	1.00 [0, 6]		
Anxiety measure			*

Staff	444 (20.4%)	Mean (SD)	4.02 (4.14)
Business person	131 (6.0%)	Median [Min, Max]	3.00 [0, 24]
Others	50 (2.3%)		

Note 1 – significant in univariate models.

Table 1 (continued). Characteristics of participants, their SES, prior commute trip patterns, mental wellbeing status, lifestyle changes since Covid-19 (N=2174)

<i>Domain: lifestyle changes</i>			<i>Domain: previous commute trip duration (one-way trip) by mode</i>		
Variables	Descriptive Statistics	Sig.	Variables	Descriptive Statistics	Sig.
Sleep quality		*	Walking		*
1-Decreased a lot	216 (9.9%)		0-do not use	1603 (73.7%)	
2-Decreased somewhat	654 (30.1%)		1-<15min	235 (10.8%)	
3-No change	820 (37.7%)		2-16 to 30min	179 (8.2%)	
4-Increased somewhat	384 (17.7%)		3-31 to 45min	80 (3.7%)	
5-Increased a lot	97 (4.5%)		4-45 to 60min	43 (2.0%)	
Not applicable	3 (0.1%)		5->1hr	34 (1.6%)	
Amount of food consumption			Biking		
1-Decreased a lot	21 (1.0%)		0-do not use	1877 (86.3%)	
2-Decreased somewhat	258 (11.9%)		1-<15min	54 (2.5%)	
3-No change	1060 (48.8%)		2-16 to 30min	109 (5.0%)	
4-Increased somewhat	738 (33.9%)		3-31 to 45min	63 (2.9%)	
5-Increased a lot	97 (4.5%)		4-45 to 60min	46 (2.1%)	
Not applicable	0 (0%)		5->1hr	25 (1.1%)	
Amount of exercise		*	Transit		*
1-Decreased a lot	567 (26.1%)		0- do not use	1018 (46.8%)	
2-Decreased somewhat	552 (25.4%)		1-<15min	92 (4.2%)	
3-No change	297 (13.7%)		2-16 to 30min	299 (13.8%)	
4-Increased somewhat	542 (24.9%)		3-31 to 45min	297 (13.7%)	
5-Increased a lot	207 (9.5%)		4-45 to 60min	296 (13.6%)	
Not applicable	9 (0.4%)		5->1hr	172 (7.9%)	
Time on social media		*	Single Occupancy Vehicle (SOV)		*
1-Decreased a lot	23 (1.1%)		0- do not use	946 (43.5%)	
2-Decreased somewhat	76 (3.5%)		1-<15min	300 (13.8%)	
3-No change	828 (38.1%)		2-16 to 30min	435 (20.0%)	
4-Increased somewhat	781 (35.9%)		3-31 to 45min	278 (12.8%)	
5-Increased a lot	293 (13.5%)		4-45 to 60min	146 (6.7%)	
Not applicable	173 (8.0%)		5->1hr	69 (3.2%)	
Time on personal hobby		*	High Occupancy Vehicle (HOV)		
1-Decreased a lot	118 (5.4%)		0- do not use	1882 (86.6%)	

2-Decreased somewhat	194 (8.9%)	1-<15min	62 (2.9%)
3-No change	862 (39.7%)	2-16 to 30min	90 (4.1%)
4-Increased somewhat	701 (32.2%)	3-31 to 45min	78 (3.6%)
5-Increased a lot	193 (8.9%)	4-45 to 60min	40 (1.8%)
Not applicable	106 (4.9%)	5->1hr	22 (1.0%)

and anxiety measures were indexed by summing all scaled question results, with higher scores indicating higher levels of perceived depression (range = 0 to 6) or anxiety (range = 0 to 24). The details of the method can be found elsewhere and both measures have been tested for validity in previous studies (Cohen-Cline, Turkheimer, and Duncan 2015; Duncan et al. 2020). [Table 1](#) shows how the variables were coded.

Statistical Analysis

Partial proportional odds (PPO) models, also referred to as generalized ordered logit models were used in the analysis, which relax the parallel line assumption for variables having different relations with each pair of ordinal outcome groups (Williams 2016). Brant test was used to screen the variables that did not meet the assumption. In PPO models, for variables that met the parallel assumption, one set of coefficients were estimated; while for others, two coefficients corresponding to decrease vs. no change and no change vs. increase were estimated separately. We first tested univariate models for all hypothesized predictors. A full PPO model was then estimated with all the predictors significant in univariate models. A final, reduced model included only the variables that had remained significant in the full model ([Table 2](#), [Figure 1](#)). VIF scores showed no issue with collinearity. For each model, we used listwise deletion where only observations with complete information were included.

FINDINGS

Change in productivity since teleworking

Of the 2147 survey respondents, 38% reported being less productive since shifting to WFH; 37.6% reported having no change; and 23.8% reported being more productive than prior to teleworking ([Table 1](#)). The WFH arrangement, which respondents worked under between April and June 2020 mandated telecommuting every workday, which is a more restricted condition than most WFH where workers may have more choices regarding the number of days and times of teleworking. All these conditions may affect the productivity of WFH.

Domains of influence on teleworking productivity

SES

After controlling for mental status, people aged 30 and above had a higher probability of reporting no change or an increase in productivity after shifting to teleworking. Respondents not living with children, and therefore less likely to experience unexpected interruptions, were more likely to report no change or increase in productivity. Those in higher education, including students, faculty, and staff, tended to report being less productive. Those with higher educational attainment (having a graduate degree and above) also tended to report being less productive. This is likely due to the nature

Table 2. Association between reported productivity, SES, mental wellbeing, previous commute trip mode and duration, and lifestyle changes (N=1846)

Domains	Predictors	Reduced Model ¹		
		OR	95% CI	p
Dependent Variable: Productivity (decrease [ref.], no change, increase)				
SES	Age			
	• 18 to 29	0.48	0.33 – 0.69	<0.001
	• 30 to 39	0.93	0.68 – 1.27	0.655
	• 40 to 49	1.10	0.79 – 1.31	0.573
	• 50 to 59	1.00	0.73 – 1.37	0.988
	• 60 and above		Reference	
	Employment			
	• professionals		Reference	
	• student	0.41	0.28 – 0.59	<0.001
	• faculty	0.47	0.30 – 0.72	0.001
	• staff	0.76	0.61 – 0.95	0.017
	• business person	0.77	0.53 – 1.12	0.176
	• others	0.99	0.56 – 1.72	0.961
	Education			
	• high school or 2yr college	1.32	0.98 – 1.79	0.072
	• 4yr college	1.36	1.11 – 1.66	0.003
• graduate and above		Reference		
Living arrangement				
• partner		Reference		
• live alone	0.96	0.73 – 1.25	0.756	
• friends & relatives	1.18	0.88 – 1.57	0.263	
• children	0.63	0.50 – 0.80	<0.001	
Previous Commuting Trip Mode and Duration	Walking	0.90	0.83 – 0.98	0.022
	SOV	1.14	1.07 – 1.22	<0.001
Lifestyle Changes	Sleep quality	1.19	1.08 – 1.31	<0.001
	Time on social media	0.84	0.75 – 0.94	0.002
	Time on personal hobby ²			
	• (Decrease vs. No change)	1.10	0.98 – 1.22	0.074
• (No change vs. Increase)	1.24	1.08 – 1.39	0.001	
Mental Wellbeing	Depression measure	0.83	0.79 – 0.91	<0.001
	Anxiety measure ²			
	• (Decrease vs. No change)	1.00	0.97 – 1.03	0.855
	• (No change vs. Increase)	1.05	1.02 – 1.09	0.001
Log-likelihood		-1825.94		

Note 1 – This reduced PPO model excluded variables that were not significant in the full model (income, house ownership, transit trip duration, amount of exercise)

Note 2 – In the PPO model, variables violating the parallel line assumption (time on personal hobby and anxiety measure) were estimated with coefficients for each pair of ordinal outcome groups.

of academic work (e.g. teaching and knowledge production), which often relies on specific equipment and facilities not available at home, as well as on in-person communications (Carlino and Kerr 2014; McFadyen and Albert A. Cannella 2016). The population segments associated with no change or

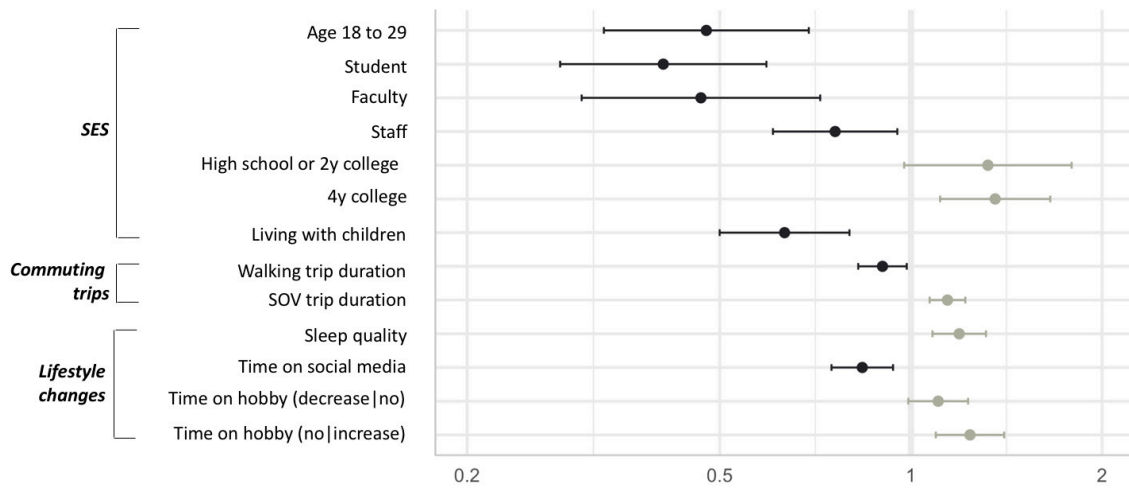


Figure 1. Odds ratio and 95% confidence interval of factors associated with no change or increase in productivity

increase in productivity are potential targets for future long-term teleworking arrangements. Conversely, those who reported a decrease in productivity after shifting to WFH could benefit from additional support from family, employer, and community if continuing to WHF.

PREVIOUS COMMUTE MODE AND DURATION

Participants with longer Single Occupant Vehicle (SOV) trips before having the WFH had a higher probability of reporting no change or an increase in productivity after shifting to teleworking. In contrast, those with longer walking trips, had a higher probability of reporting a decrease in productivity. This is likely because the benefits of eliminating commuting time do not balance off the physical and mental benefits brought by walking to and from work, as suggested by prior studies (Páez and Whalen 2010; Whalen, Páez, and Carrasco 2013).

LIFESTYLE CHANGES

Sleep quality has long been associated with work productivity and quality of life (Kucharczyk, Morgan, and Hall 2012). We found similar positive relationship between sleep quality and reported productivity after shifting to teleworking. More time spent on social media was linked to a decrease in productivity. This was consistent with the negative effects of the distractions, physical discomfort, and negative emotions associated with social media use as reported in previous studies of workplace and office settings (Priyadarshini et al. 2020; Vithayathil, Dadgar, and Osiri 2020). On the other hand, more time spent on personal hobbies, was linked to maintaining the same level of productivity, or to increasing productivity. This suggested that engaging in nonwork related activities helped compensate for the demands of continuous work (Eschleman et al. 2014).

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