Does teleworking work for organizations?

Measuring the impact of working from home on retention and performance

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The last decade has seen increased experimentation in how and where work happens. This is especially true in the US public sector where pressures to reduce costs have led to more opportunities to work from home. This study evaluates the impact of teleworking on the US Patent and Trademark Office (USPTO), where over 50% of staff telework. I find that teleworking not only has significant effects on performance and retention of teleworkers, it also affects those who stay behind and the very nature of the work day. On the one hand, teleworkers' productivity decreases compared to non-teleworkers, but on the other hand, retention is improved. More surprisingly, having more teleworking peers increases productivity for those who stay behind, but it also increases their burnout. Last, I find some suggestive evidence that teleworking may be causing negative selection into the agency. Ultimately, teleworking schemes affect organizations beyond their direct effect on teleworkers and these additional effects must be incorporated into the overall calculation of whether teleworking works for organizations.

I. Overview

As organizations search for new ways to attract talent and improve employee productivity, one area of focus is the work environment itself. The last decade has seen increased experimentation in how and where work happens. This is especially true in the US public sector where pressures to reduce costs have led to more opportunities to work from home. Teleworking is now the most commonly offered Alternative Work Schedule (AWS) in the federal government (Caillier 2013). This policy shift has been actively supported by several laws, including the 2010 Telework Enhancement Act. At the same time, however, there may be a shift away from teleworking in the private sector. While virtual work and telecommuting programs were highly visible in large private sector companies, in 2013 major players like Yahoo and Best Buy announced a scaling back (or end) to their teleworking schemes.[1] Although the trend seems to be one of expansion in the public sector, and possibly contraction in the private sector, few studies exist which can clearly support either position. Indeed, while employees often celebrate the flexibility of teleworking, it is unclear whether such programs are beneficial for the organizations themselves in the medium term. Given that the federal government is the sector with the highest percentage of teleworkers (Lister and Harnish 2011), evaluating teleworking in government is an important first case. More importantly, given that public servants may have different characteristics and motivations, it is important to consider how teleworking works in a public sector environment if we are to make claims about how its expansion in government will affect public service delivery.

While the advantages and disadvantages of teleworking are frequently discussed in the popular press, much of the current academic literature has focused on evaluating the advantages and disadvantages of teleworking for individual employees, such as the effect of teleworking on social isolation, autonomy, overall job satisfaction, and even productivity (see Manoochehri and Pinkerton 2003; Bailey and Kurland 2002; Gajendran and Harrison 2007; Bloom et al. 2013 for examples). When programs are in their infancy, this type of evaluation is appropriate. However, as programs grow, the existence of teleworkers begins to affect those that stay behind in significant ways, as well as the very nature of how work is produced in organizations. In most

[1] To be sure, this need not translate into a generalized trend against teleworking in the private sector– indeed Marissa Mayer, CEO of Yahoo, defended her decision by arguing that it was best for Yahoo, but not necessarily

organizations, teleworkers still account for a small percentage of the overall workforce and so it is difficult to extrapolate how teleworking schemes would affect those who stay behind, team interactions, and overall organizational output. Moreover, the majority of studies in this space use survey-based measures of performance or intention to leave (to proxy for retention) thus conflating the actual effects of teleworking on productivity, with the perceived effects on productivity, an issue that is particularly problematic if face-time is associated with higher evaluations of employees (Elsbach and Cable 2012). Last, many studies are limited in their scope because they are they can only crisply estimate the short-term effects of teleworking, thus ignoring the potential impact of teleworking on selection into or attrition from an organization.

This study addresses previous limitations by using panel data on a long-standing teleworking program in the US Patent and Trademark Office (USPTO), the Patent Hoteling Program (PHP). To my knowledge, this is the first academic study to use administrative data (rather than self-reported surveys) to measure the effects of teleworking on both productivity and retention in the public sector, and the first study to consider the impact of more teleworkers on their peers. The study also considers effects on employee burnout and time use in order to fully explore how teleworking changes work. Because of the size of the teleworking program in the USPTO, with over 50% of patent examiners teleworking, this is a unique case study because it allows for an evaluation of the effect of such programs on individual staff, on teams, and ultimately on organizational output as a whole.

I find that teleworking has significant effects on performance and retention. Teleworkers are much less likely to quit their jobs. The impact on performance is two-fold. On the one hand, a teleworker's productivity (performance per hour) systematically decreases compared to non-teleworkers once they begin teleworking. However, overall production – as measured by claims processed in this case – is *not* negatively affected because teleworkers spend more hours on production-based tasks, and less time on meetings and leave. These effects are partially based on selection – people who choose to telework look different from non-teleworkers – but there is also a direct effect of teleworking on productivity. Given that the very existence of a teleworking program will affect those who stay behind as well, I also consider the effect of having more of your peers working from home on productivity and retention. Having more teleworking peers

actually increases both productivity and burnout, measured according to sick leave. Yet, non-teleworkers also see a change in their time use as more peers telework, leading to fewer meetings (and ultimately more applications examined) for teams as a whole. I also see some suggestive evidence that the existence of the teleworking program may be creating negative selection into the agency.

The rest of the paper is structured as follows. Section II outlines a short literature review on what we know about teleworking and limitations in existing studies. Section III presents the case study while Section IV presents a framework and hypotheses for understanding the effect of teleworking on organizations as a whole. Section V present the econometric models used to evaluate the impact of teleworking and Section VI presents the empirical results. Section VII concludes with an overall discussion of the findings.

II. Literature Review

Understanding Who Teleworks

For all the research on teleworking, we have limited conclusive evidence on who actually would choose to telework if a teleworking program were instituted in an organization. This is central to understanding the potential selection effects in evaluations of teleworking schemes. For example, while teleworking is often discussed as a tool to improve labor market outcomes for women, the demographic information that we have on who teleworks suggests a relatively even split between men and women, although the split seems to be between teleworkers who are male professionals and women who are clerical workers (Bailey and Kurland 2002). In broader studies in both the US and abroad, teleworkers are more likely to be younger, mid-level professionals, and male (see Olszewski & Mokhtarian, 1994, (Luukinen, 1996, (Nicholas and Guzman 2009)). The bias towards males is mostly evident in demographic studies of full-time workers, while part-time teleworkers are more likely to be female (Cyber Dialogue 2000). In terms of age, one study on European employees finds that interest in teleworking is associated positively with technological familiarity and negatively with age (Huws et al., 1990). Yet, newer studies find that millenials are no less likely to prefer teleworking than previous generations (Nicholas and Guzman 2009).

Beyond demographics, a host of studies have considered predictors of teleworking interest, again without a clear consensus. It is not true, for example, that employees with longer commutes are more likely to telework as we might expect (Mokhtarian & Salomon, 1997; Stanek & Mokhtarian, 1998). For females, having children or balancing work-life issues seems to predict interest in teleworking (Duxbury, Higgins, & Neufeld, 1998). Yet, given that teleworkers are not primarily female, and that these results are not as clear in larger studies, it is not obvious that work-life balance questions explain who teleworks. Furthermore, we have little to no evidence on the ability levels of people who choose to teleworkers. That is, we do not know if it is the highly productive members of a team that will choose to telework, if such a program is offered, and/or if highly able people will be attracted to a firm that institutes a teleworking program.

Retention

Much of the asserted relationship between retention and teleworking is based on studies that link teleworking to predictors of retention such as job satisfaction or reported work-life conflict. While some studies find a positive correlation between job satisfaction and teleworking (e.g. Manoochehri and Pinkerton 2003), others suggest that the empirical evidence on this link is unclear (Bailey and Kurland 2002). More recent studies find an inverted U relationship between the extent of teleworking and job satisfaction, showing that employees who report moderate levels of teleworking (a few days a week) are much more satisfied than those who telework fully (see Golden and Veiga 2005; Virick, DaSilva, and Arrington 2010) due to the social and professional isolation associated with working from home. Yet, a reduction in job satisfaction need not predict higher turnover if work-life conflict is improved in other ways. Some studies that find teleworkers to be more professionally isolated (a strong predictor of high turnover in other settings), still show lower turnover intentions for teleworkers (Golden, Veiga, and Dino 2008). That is, improvements in overall work-life balance may allow for high retention of teleworkers, *despite* a decrease in job satisfaction. Indeed, a meta-analysis of 46 studies shows both a negative association between teleworking and reported work-life conflict, as well as a negative association between teleworking and intention to leave (Gajendran and Harrison 2007)**.** It's possible, however, that this impact is significantly different in the private sector than in the public sector where job security (and low turnover overall) has brought many individuals to

public sector careers in the first place. The only analysis on teleworking and intention to leave in the public sector finds no statistically significant correlation between intention to leave and teleworking (Caillier 2013).

Intention to leave, of course, is not the same as actual turnover. While turnover intentions are a predictor of actual turnover, a meta-analysis of studies on this issue find only a .31 to .52 correlation between the two notions (Dalton, Johnson, and Daily 1999), suggesting that more research with actual turnover data is sorely needed. Moreover, most of these studies are cross-sectional and use a binary logistic regression to examine the relationship between retention and teleworking (e.g. Caillier). As such, they may suffer from all of the omitted variable bias that explains why some people choose to telework and others do not. More broadly, given that actual retention at a firm or organization is highly dependent on year-specific labor market conditions, a study that does not observe actual turnover *and* is cross-sectional may be significantly biased either upwards or downwards depending on the labor market in the given year. This study covers eight years of employee behavior. Therefore, it can account for year fixed effects, and can follow employees long enough to see actual turnover rather than intentions.

Productivity

The impact of teleworking on actual productivity is widely discussed but rarely examined empirically. The strength of this assertion may stem from the fact that employees themselves often report improved productivity (see Bailey and Kurland 2002 for a list of relevant studies)**.** Yet, a recent working paper by Dutcher, Glenn, and Saral (2014) finds that individual employees (both teleworkers and non-teleworkers) expect their teleworking team members to be shirkers. Moreover, other studies show that face-time is associated with higher evaluations of performance (Elsbach and Cable 2012). This suggests that using self reported measures of productivity or estimates of perceived performance may not correlate as well with actual production data, when teleworkers are involved. Unfortunately, the majority of studies do in fact use self-reported or peer/supervisor-reported productivity rather than objective production data.

There may also be a divergence between individual productivity and organizational performance when it comes to teleworkers. While one meta-analysis shows a small but positive correlation

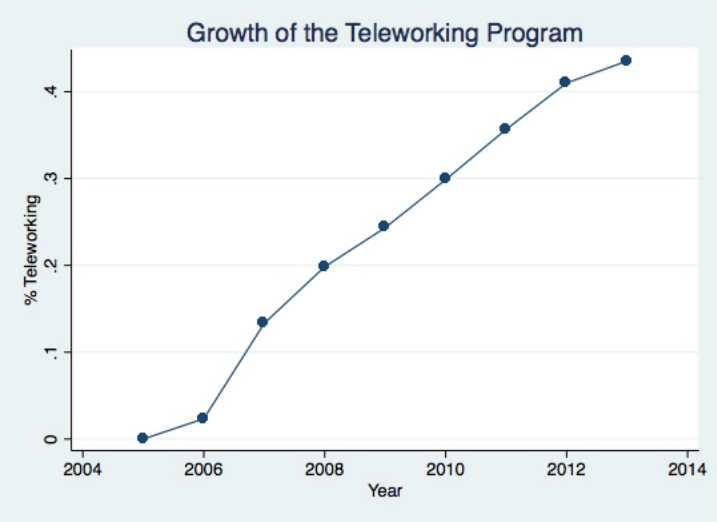
between productivity and teleworking (Martin and MacDonnell 2012), other studies show performance increases because teleworkers work more hours, rather than because they are more productive in a given set of hours (Manoochehri and Pinkerton 2003). Similarly the internal Department of Commerce evaluation of the USPTO initial pilot program found no effect of teleworking on employee productivity, but found increased organizational performance in terms of the overall number of patents examined because teleworkers spent more hours examining patents (Office of the Inspector General 2012). To my knowledge, there is one published paper that uses an experimental design to study teleworking over nine months in a Chinese call center (Bloom et al. 2013). While this paper provides crisper estimates on the direct effects of teleworking on productivity, by default it will not be able to answer questions about retention or changes in productivity over time that are affected by selection or the number of peers who telework. That is, the potential impact of instituting a teleworking program involves estimating the direct effect of teleworking but also understanding selection issues – who will be attracted to a teleworking program within a firm or agency, and who will be attracted to (and remain in) the firm itself because of the existence of a teleworking program. By design, an experimental design avoids the question of selection, which may be key in determining the effects of a program on the organization as a whole. Moreover, it is highly likely that the impact of teleworking in the short term differs from its medium and longer term effects, if it affects the monitorability of effort at work and if having peers that telework affect the quality or work of those who stay behind. As such, it is also important to trace the effects of a program over time to see whether short term effects translate into longer-term impact. This study does just that.

III. Setting: The US Patent Office

This study is based on eight years of production and retention data of patent examiners within the USPTO from 2005 to 2013 including over 10,000 patent examiners. Patent examiners are government employees whose work is highly production based - rewarded based on speed and accuracy (the number of claims examined every two weeks and accuracy with which these are completed). Therefore, the work lends itself to measurable estimates of productivity. All claims are processed electronically, and so the nature of their primary work does not change whether they are working from home or in the USPTO headquarters.

The USPTO launched the Patent Hoteling Program (PHP) in 2006, a program that has been growing steadily ever since. Now, over 50% of patent examiners (and almost 70% of all USPTO employees) work from home. As a comparison, even though the US federal government is the largest employer of teleworkers in the US economy, on average only 6% of federal government employees work from home at least one day a week (PPS 2015). The main characteristic of the program was that eligible employees worked from home at least four days a week (and most work from home full time). In practice, this meant they gave up their office at the USPTO, leading to almost $16 million in annual real estate savings for the agency (Office of the Inspector General, 2012). This also means that the USPTO has the highest levels of teleworking in the US federal government, and allows us to consider the organization-wide effects of teleworking schemes in a way that small pilots do not allow. Specifically, we can consider "general equilibrium" effects, as well as some medium-term effects on agency-wide changes to recruitment because of the sheer size of the program.

Figure 1. Growth of Teleworking Program



During the same period, the USPTO has moved from being one of the lowest ranked agencies in terms of employee engagement to the highest ranks of the "Best places to work in the Federal Government" ratings (USPTO, 2013). Internal anecdotes and public reports attribute this shift to the existence and growth of the teleworking program. Understanding then whether this program

has been an overall organizational success may inform how teleworking spreads to other agencies that are considering expansions of their teleworking programs including the Veterans Benefits Administration (VBA) or the Social Security Administration (SSA).

IV. Framework and Hypotheses

Below I outline a framework for measuring the impact of teleworking in this case.

A public service delivery organization's objective function is to maximize public value, given constraints. In the case of the USPTO, public value is a function of organizational output – the number of correctly adjudicated claims times the value of each of those claims, minus the number of incorrectly adjudicated claims times the value of those incorrect decisions (or the damage caused) – as well as a separate measure for public confidence in the process.[2]

While speed is not separately modeled here, timeliness of adjudication would affect both the value per claim, as well as the overall strength of public confidence in the organization. I do not focus on changes to public confidence, because any drop in public confidence due to fear or confusion about the consequences of teleworking should only have a long-term impact if there is also a direct effect on output. If there is no effect of teleworking on output, then public confidence may vacillate in the short term but return to pre-teleworking levels in the medium term.

As such, it is important to model how organizational output is created. Organizational output is the sum of worker productivity, times the number of workers, times the amount of time spent on cases, minus any cost associated with training workers or providing the infrastructure that allows individuals to produce.

[2] While there is an ongoing debate (see Cotropia, Quillen, and Webster 2013) on whether or not the number of patents provided is the right one in terms of public value, I step away from this debate for the purposes of this study and consider the official USPTO standards to be the correct ones in terms of public value. I also don't consider the broader social value of teleworking that may include the reduction in the carbon footprint of commuters, and the savings in commute time for the city. Previous analyses suggest that the evidence on transport savings and carbon footprint reductions is mixed at best.

Worker productivity is a function of employee engagement, individual "innate" ability, job-specific skills, and characteristics of the unit that include productivity of peers (others on the team) as well as supervisor-specific characteristics.

The effect of teleworking on an organization is, therefore, complex because it can simultaneously affect many terms in this function. In the short term, teleworking may affect:

- Engagement
- Time Spent on Cases
- Costs of infrastructure around employees

In the medium term it should affect:

- Ability and job-specific skills of employees (through recruitment and retention)
- Costs of re-training staff

Below, I outline the mechanisms through which these changes occur[3].

Engagement

Teleworking should directly affect both task visibility and levels of autonomy. More specifically, teleworkers will now have fewer forms of direct monitoring while those who stay in the office may experience greater supervisor monitoring. This can have a dual effect – on the one hand, teleworker productivity should decrease if a supervisor's monitoring incentivizes effort. On the other, increased autonomy over one's day may increase an employee's sense of control over their work, thus reducing burnout, which in much of the literature is perceived as the opposite of engagement (Schaufeli et al. 2002). The converse effect may be expected on those who stay behind - the more peers telework, the more scrutiny for those who are in the office, which could lead to higher productivity but also higher burnout.

The proxies for effort and burnout in this study are productivity per hour and absenteeism respectively, because effort is highly correlated with productivity and sick leave is highly

[3] While cost savings are an important part of the shift to more teleworkers, this has been studied extensively and so I do not model it here, nor do I measure it directly.

correlated with burnout (Borritz et al. 2006). As such, we should see decreased productivity for those who telework, through the channel of monitoring. As more and more peers telework, those in the office should become more productive through the same channel. This should also be correlated with higher absenteeism for those who stay behind and decreased absenteeism for those who telework, through the channel of burnout.

To be clear, much of the literature on teleworking suggests that productivity increases for teleworkers (e.g. Bloom et al. 2013). However, in a public sector environment where there is no benefit – either in terms of promotion or in terms of pay -- to go beyond a set performance standard, productivity improvements when monitoring decreases are unlikely. The only potential mechanisms for improved productivity lie in an individual's improved concentration. This, however, should also be true in an office as more people choose to telework. It is not obvious, ex-ante, if the change in distractions is both larger for those who stay at home, and more significant than the change in task visibility in terms of overall effects on productivity.

Hypothesis 1a: Teleworking will reduce productivity of teleworkers and increase productivity of those that stay behind, as more people telework.
Hypothesis 1b: Teleworking will reduce absenteeism of those who telework and increase absenteeism of those that stay behind, as more people telework.

Time Spent on Cases

A second component of the work environment that is affected by teleworking is time use. When teams are not co-located, the friction costs of arranging meetings or even informal gatherings increase. It is likely, therefore that teams with a higher proportion of teleworkers will arrange fewer in-person meetings and experience less informal socialization. If informal knowledge sharing happens in such in-person gatherings, their reduction may decrease quality of work over time. To be clear, this only holds true if the other tasks done at the office are positively correlated with organizational output. That is, if time spent on other tasks (beyond examining claims) is either negatively correlated with overall organizational output, or unrelated to it, its reduction need not seem worrisome from an organizational perspective. If the additional experience from examining an additional case is the main mechanism through which quality

improves, less time spent on meetings and socialization may improve quality in the long run. Given that teleworkers are more senior on average, it is plausible that knowledge sharing is reduced as teleworking increases[4].

I hypothesize, then, that as more people telework, both teleworkers and non-teleworkers will spend more time examining applications and less time in other meetings or on other types of activities. This does not include time spent on other activities that are not recorded or recordable (such as general shirking), but rather time that is officially recorded as part of the work stream.

Hypothesis 2: Teleworking will increase the amount of time spent examining cases and will reduce the amount of time spent on other organizational activities.

Retention and Ability

In the medium- to long-term, a teleworking scheme should also affect the characteristics of the workforce itself through impacts on selection into, and attrition from, the organization. By default, an effect on retention also has a subsequent effect on the cost of re-training new staff. Teleworking is a voluntary scheme that requires an up-front investment in additional training. By revealed preference and due to these investments, those who choose to telework should be strictly better off teleworking than not teleworking. As such, in a world where teleworking is still relatively rare in the public sector, the existence of the scheme should reduce attrition for teleworkers. All else equal, this should increase the overall ability of the workforce, because those who stay longer have already developed job-specific skills. Yet, it is possible that teleworking disproportionately attracts either high ability or low ability staff. On the one hand, a larger potential applicant pool may increase the quality of the average new entrant. On the other hand, teleworking may be more attractive to individuals who anticipate a drop in their productivity, thus causing negative selection into the agency. While it is not obvious ex-ante if new entrants would be higher or lower ability, we can find suggestive evidence of negative or positive selection into the agency by comparing newer teleworking cohorts to older ones.

[4] While I cannot observe the effects on long-term changes in quality in this study, I can measure whether teleworking changes time use for both teleworkers and their peers, as a first step.

Hypothesis 3: Teleworking should reduce attrition of teleworkers.

V. Empirical Model

The primary analysis aims to evaluate the effect of teleworking on productivity and attrition using a difference-in-difference model that includes time and individual employee fixed effects. That is, I compare a teleworker to herself before she joined the program, as well as to others who are non-teleworkers in the same period. The data set includes both "switchers," individuals who we see before and after they begin teleworking, and "never switchers," individuals who do not telework throughout the eight year period under study.

The secondary analyses consider several types of selection bias. Employees who chose to telework may differ from non-teleworkers in terms of underlying individual characteristics. Beyond incorporating individual fixed effects in my analyses, the analysis also limits the scope of the model to those individuals who will -- at some point -- become teleworkers, thus placing bounds on the potential size of the "selection" effect. Second, employees may choose to start teleworking at times that correlate with an expected change in their performance. To address this issue, I also show the same regressions for those individuals who began teleworking in the first six months they were eligible - a relatively exogenous date that depends on their start date in the agency. Therefore, these regressions exclude teleworkers who joined the program at a seemingly non-exogenous time. Last, employees may be joining the agency in anticipation of a switch to teleworking as soon as they become eligible. To address this issue, we can also limit the regressions to consider effects only on those who were employed before the teleworking program was introduced.

To further bolster the results of my difference-in-difference analysis, the tables below also show the results of a propensity score matched model on the same outcomes, matching teleworkers with non-teleworkers on the characteristics that seem to predict selection into the program. Specifically, I match employees using nearest neighbor matching, using Mahalanobis distance based on previous productivity, age, start date, GS-level and marital status.

Basic model:

$$Y_{it} = T_{it} + T_{it} * P_{it} + P_{it} + Q_t + I_i + C_t + \varepsilon_{it}$$

Where

Y is the outcome variable (the probability of quitting in a given year, productivity in a given quarter, applications examined etc.);

T is a dummy variable for being a teleworker in a given fiscal quarter

P is the percentage of an individual's peers who are teleworkers in a given fiscal quarter

Q is a dummy variable for each fiscal quarter

I is a dummy variable for each individual employee

C are controls that are time-variant (GS-level and experience)

errors are clustered at the individual employee level.

V. Main Results

General descriptive statistics on the employees, both in general and by group are presented below. Employees at the USPTO are primarily male, with a wide range of ages. Attrition is low but this is highly dependent on the year as can be seen in Figure 2. About half of the sample will, at some point, become a teleworker, although the mean number of teleworkers in a given fiscal quarter is 25%.

Table 1a: Summary statistics on individuals

Variable	Mean	Std. Dev.	Min	Max	Observations
Age	38.975	10.843	20.425	76.672	n = 10395
Male	0.721	0.445	0	1	n = 8703
Experience (Years)	7.646	5.911	0.162	48.778	n = 10862
Grade	12.127	2.370	5	15	n = 10898
Annual Attrition	0.021	0.269	0	1	n = 10898
Team Size	21.795	15.610	1	126	n = 10898
Ever a Teleworker	0.518	0.477	0	1	n = 10898

Table 1b below shows both individual variability in production and leave over time, as well as between-individual variability. Productivity refers to a standardized production percentage that accounts for the GS-level and the technical difficulty of the claims examined. That is, all employees are considered "fully successful" if they hit 95 on this production percentage score, but getting to that score depends on the technical area of the claim (e.g. plastics) and the GS-level of the employee**.** Regular hours are the number of examining hours an employee has in a given quarter. These are affected by the number of other activities (such as training or meetings) that an employee is involved in. All estimates are quarterly measures. The cutoff on regular hours is at 80 and there is a second minimum cutoff on productivity at 50 and maximum cutoff at 200. These cutoffs were selected based on the USPTO's understanding of what constitutes a full time patent examiner who is not on another mission during the quarter. Changing these cutoffs did not change any of the results.

Table 1b: Summary statistics on productivity

Variable		Mean	Std. Dev.	Min	Max	Observations
Productivity	overall	106.709	18.112	50	200	N = 175161
	between		15.936	50	177.667	n = 10898
	within		13.889	6.376	212.442	T-bar = 16.0728
Regular Hours	overall	390.810	77.319	80	672	N = 175161
	between		54.288	80	558	n = 10898
	Within		66.347	42.442	695.727	T-bar = 16.0728
Overtime Hours	overall	25.948	50.812	0	400	N = 175161
	between		35.383	0	280	n = 10898
	Within		34.388	-216.624	355.448	T-bar = 16.0728
Leave Hours	overall	55.530	38.740	0	472	N = 175161
	between		19.423	0	208	n = 10898
	Within		35.997	-145.470	464.330	T-bar = 16.0728

Table 2: Who is a teleworker? (Pre-Treatment Characteristics)

VARIABLES	(1) Teleworker	(2) Teleworker (First Cohort)	(3) Teleworker (Subsequent Cohorts)
Productivity	0.00446***	0.00507***	0.004315***
	(0.00041)	(0.0008)	(0.00047)
Regular Hours	0.00041***	-0.000838***	0.000126
	(0.00011)	(0.00021)	(0.00013)
Overtime Hours	0.00102 ***	0.000934***	0.001114***
	(0.00019)	(0.00028)	(0.00026)
Leave Hours	-0.00016	-0.000369	4.92e-06
	(0.00027)	(0.00049)	(0.00034)
Age	-0.00786***	-0.00741***	-0.00795***
	(0.00067)	(0.00119)	(0.00079)
Male	-0.03174**	-0.04529*	-0.02426*
	(0.01275)	(0.02373)	(0.01443)
Married	0.0776***	0.1616***	0.14298***
	(0.0124)	(0.02064)	(0.01461)
GS-Level	0.0463***	0.0354***	0.05100***
	(0.00321)	(0.00429)	(0.00456)
Observations	8,279	2,597	5,682
Pseudo R-squared	0.0952	0.0729	0.0812

Table 2 presents the marginal effects of a logistic regression on who chooses to enter teleworking, by considering their pre-treatment characteristics. Given that people become eligible after two years of service, and may start changing their behavior in anticipation of joining the teleworking scheme, I only consider the values of the independent variables in the first year we observe a given employee. Beyond grade (GS-level), which is a formal component of teleworking eligibility, teleworkers tend to be younger and are more likely to be female and much more much likely to be married, suggesting that work-life balance may affect the choice to telework. Surprisingly, while some pre-teleworking productivity and work characteristics are statistically significant, they are not practically significant predictors of who chooses to telework, (it is neither the high producers nor the low producers that are more likely to telework). It is also interesting that those teleworkers who were already employees at the USPTO do not look different in terms of pre-treatment productivity and performance measures. This information will be used as controls in the difference-in-difference estimates below and in propensity score matching estimates.

Table 3 considers the effect of teleworking on productivity, first measured according to the USPTO's official productivity measure. This measure is standardized across GS-level and type of patent examined, comparing actual applications examined against the expected time a given patent application should take. An employee's quarterly production percentage, measured here, is the number of standardized patents examined, as a percentage of the number of hours allocated to examining time. In practice, this outcome is a measure of productivity per hour allotted to application examination.

Column 1 considers the effect of being a teleworker on productivity, in a model that includes individual fixed effects, time fixed effects, and controls for grade and experience. In Column 2, I limit my teleworker sample to those employees who chose to telework in the first six months that they were eligible (a seemingly exogenous date). In order to estimate the potential size of the direct effect vs the selection effect, Column 3 limits the sample to those employees who will, at some point, telework. That is, the comparison group in this case is individuals who are currently not teleworking but who will select into teleworking at some point. As such, if Column 3 represents the most robust difference-in-difference estimator (where there is some exogeneity in when someone joins the program), Column 4 represents the first difference of that estimate. In order to place bounds on the selection effect into the agency, Column 4 limits the sample to those employees who were already employed before the program began and who joined as soon as the program was available. Column 5 presents the average treatment effect, using a propensity score matched model. The model uses nearest neighbor matching on previous productivity, age, start date, and GS-level, with exact matches on gender and marital status.

Table 3: Effect on Productivity

VARIABLES	(1) Productivity	(2) Productivity (Only exogenous)	(3) Productivity (only Teleworkers)	(4) Productivity (Only pre-2006 exogenous)	(5) Productivity (Propensity Score Matched ATE)	(6) Productivity (Propensity Score Matched ATE – Later Cohorts)
Teleworker	-3.584***	-2.298***	-4.428***	-2.516***	-0.4619	-1.732***
	(0.181)	(0.518)	(0.201)	(0.514)	(0.31926)	(.4206)
Constant	87.41***	89.24***	87.48***	89.96***		
	(0.664)	(0.891)	(0.999)	(1.127)		
Observations	173,272	97,317	90,621	58,198	5,496	3,374
R-squared	0.446	0.486	0.404	0.487		
Clusters	10803	7645	3838	2871		

As is clear, there is a negative effect of teleworking on productivity. Controlling for all other factors, including individual characteristics and time trends, being a teleworker reduces one's productivity compared to non-teleworkers by one to four points (where the productivity score required to be fully successful is 95). Interestingly, when running a propensity score matched model, the effect only seems to remain statistically significant for later cohorts, and the effect is slightly smaller. This may suggest part of the negative effect is explained by selection into teleworking, and potentially selection into the agency.

I run the same analysis on the probability of quitting, to ascertain the effect of teleworking on retention, acknowledging that part of the effect will be due to teleworking itself while part of the effect will be due to selection. Given that an individual can only quit once, I consider the probability of quitting at any time after becoming a teleworker for the propensity score matched estimates, rather than per year. Another way to model attrition is with a Cox proportional hazards model, estimating the risk of quitting in a given year for teleworkers versus non-teleworkers, taking into account that once an employee has quit they then cannot re-appear in the sample. Column 6 shows the hazard ratio on the risk of quitting for teleworkers, adjusting for

individual characteristics including age, gender, marital status, experience, and GS-level, as well as performance characteristics, including productivity, overtime, and regular hours worked.

Table 4: Effect on Attrition

VARIABLES	(1) Annual Attrition	(2) Annual Attrition (only Exogenous)	(4) Annual Attrition (Only pre-2006 exogenous)	(5) ATE (Propensity Score Matched)	(6) Hazard Ratio
Teleworker	-0.00477***	-0.0251***	-0.0235***	-.0269***	.360***
	(0.00116)	(0.00305)	(0.00298)	(0.00555)	(0.0270)
Constant	-0.0662***	-0.123***	-0.145***		
	(0.00455)	(0.00841)	(0.0144)		
Observations	173,272	97,317	58,198	8,261	132,218
R-squared	0.596	0.628	0.588		
Clusters	10803	7645	2871		

As is clear, here it seems that teleworking itself is causing a drop in retention, where the effect is much larger when we only consider those employees that seem to become teleworkers at an exogenous time. This suggests that some people may choose to telework when they are already considering quitting as an alternative option, thus reducing the seeming effect of teleworking on retention. Given that retention rates are very high during this period in general, and in the public sector more broadly, this change in attrition is particularly impressive.

As described above, measuring the impact of teleworking on an organization requires a broader understanding of how the scheme affects both teleworkers and non-teleworkers in the same team. A broader measure of the effect of teleworking on an organization, therefore, is an impact measure on teams. Over the course of the eight years, we have a large variation in the percentage of teams with teleworkers, as well as the number of teleworkers on a team. We can use this information to consider the effect of more teleworkers on teams, as long as we control for year fixed effects since the increase in teleworking is highly correlated with time. Table 5 below shows the effect of an increase in the percentage of teleworkers on team outcomes. In terms of overall organizational output, productivity per hour is extremely important but so is

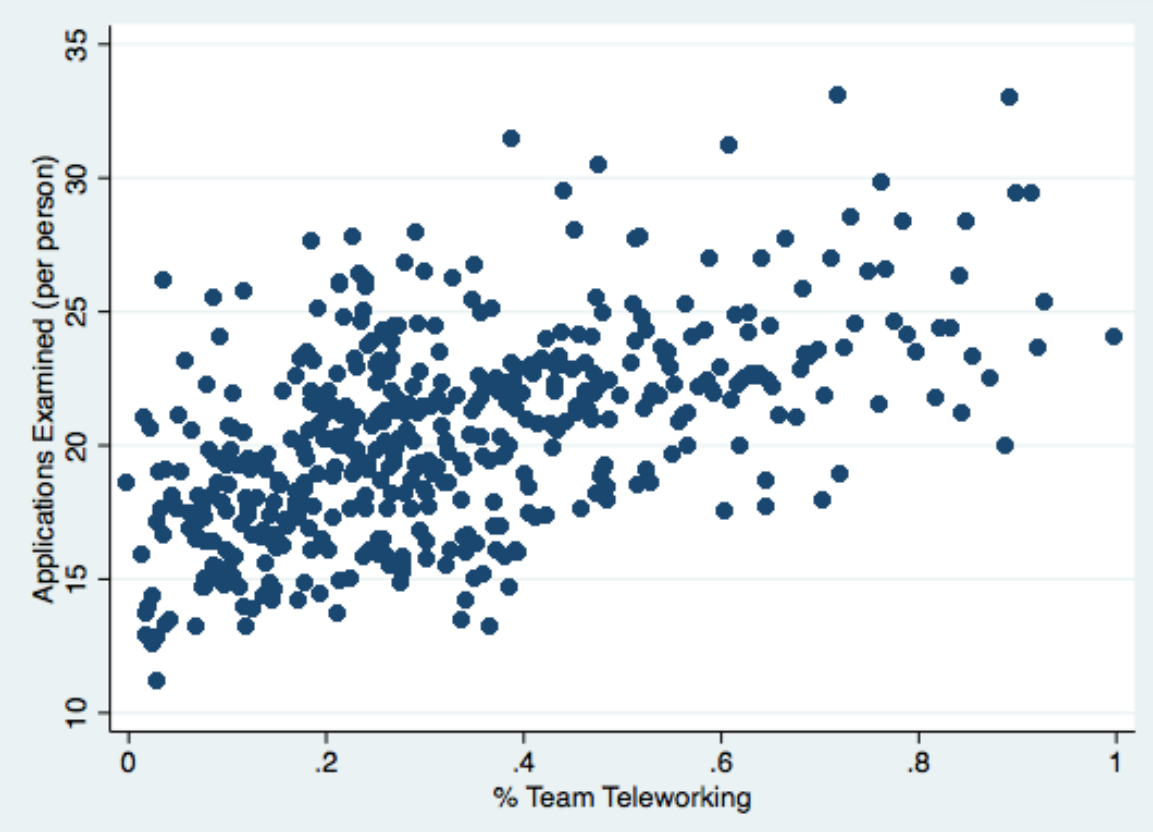
overall performance – that is the number of applications actually examined, irrespective of how long it takes to examine them in a day. To measure performance in this way, I create a new performance measure that multiplies the number of applications examined times the amount of time officially allotted to that type of claim, at a given GS-level. Below, I consider the effect of teleworking on team productivity, overall applications examined per person, as well as mean attrition, and the mean quality score. This is the score that an independent evaluator gives to a random selection of an employee's decisions, to check quality of decision-making. The quality score data only covers two years, and therefore only provides an early indication of the effect on quality.

Table 5: Effect on Teams

VARIABLES	(1) Mean productivity	(2) Total Applications Examined per person*	(3) Mean Annual Attrition	(4) Mean QA score	(5) Total Leave Hours
% Team Teleworking	-3.183***	1.358***	-0.305**	-0.00488	-50.11
	(0.836)	(0.399)	(0.150)	(0.0544)	(34.39)
Constant	81.93***	-4.664***	2.259***	2.598***	-1,043***
	(2.830)	(1.040)	(0.442)	(0.150)	(143.7)
Observations	175,149	175,149	175,149	72,705	175,149
R-squared	0.669	0.949	0.635	0.802	0.955
Clusters	620	620	620	559	620

While overall mean productivity decreases, the total number of applications examined per person increases, as more people telework. Moreover, there is a statistically significant decrease in mean annual attrition with both leave and quality scores remaining unaffected. Figure 3 confirms that the relationship between team performance and the percentage of a team that is teleworking is linear, and there is no U-shaped curve, where having a threshold percentage of teleworkers is either more or less effective for team-level outcomes.

Figure 3: Cases per Person By % Teleworking



This seems counterintuitive at first glance. If teleworkers are each less productive per hour, the explanation to overall applications increasing is either found in non-teleworkers performing better when their teleworking peers are out of the office, or in the overall time spent examining cases. Below, I find evidence of both these possibilities.

Table 6 considers the individual effect of teleworking on productivity, performance and time use, interacting the teleworker status of an individual with the percentage of her peers that are also teleworkers. This allows us to see the effect of teleworking on the teleworker, but also the ones who stay behind, as team composition changes.

Table 6. Effect on Productivity with Interactions

VARIABLES	(1) Productivity	(2) Productivity	(3) Productivity (Newly Eligible Teleworkers)	(4) Productivity (Ever Teleworkers)	(5) Productivity (Pre-2006 Employees)
Teleworker	-3.715***	-2.266***	-2.511***	-2.328***	-3.359***
	(0.181)	(0.286)	(0.597)	(0.327)	(0.339)
Teleworker X		-4.247***	-0.531	-7.954***	3.403***
%Peers		(0.728)	(1.350)	(0.958)	(0.909)
% Peers	6.887***	8.352***	8.000***	9.934***	-1.728**
Teleworking	(0.519)	(0.599)	(0.765)	(0.966)	(0.747)
Constant	89.04***	89.61***	91.30***	90.36***	93.33***
	(0.671)	(0.681)	(0.918)	(1.030)	(1.156)
Observations	173,243	173,243	97,293	90,616	105,306
R-squared	0.448	0.448	0.488	0.406	0.458
Clusters	10800	10800	7642	3838	4473

Teleworker productivity decreases further as more peers choose to telework. Moreover, the drop in productivity seems to be smaller for those employees that were already in the USPTO before teleworking was instituted. This suggests that teleworking may be associated with negative selection into the agency. The effect of having peer teleworkers on non-teleworkers is reflected in the co-efficient on the percentage of peer teleworkers. In line with my hypotheses, having more teleworking peers increases one's productivity in the office. This is not true for the subsample of employees who were employed before the program began. This suggests that much of the jump in productivity for those still in the office is associated with newer employees, including those that may choose to telework in the future.

Table 7: Time Use and Performance

VARIABLES	(1) Applications Examined	(2) Regular Hours	(3) Overtime Hours	(4) "Other Time" Hours	(5) Leave Hours
Teleworker	11.08***	18.36***	1.144	-12.64***	-0.359
	(1.778)	(1.334)	(1.185)	(1.112)	(0.652)
Teleworker X % Peers	-36.82***	-13.88***	-8.235***	14.32***	-2.538*
	(4.411)	(3.178)	(2.805)	(2.731)	(1.529)
% Peers Teleworking	79.01***	46.34***	3.904**	-46.20***	6.129***
	(3.605)	(2.485)	(1.678)	(2.094)	(1.039)
Constant	302.2***	322.4***	-35.21***	31.31***	-30.78***
	(3.606)	(2.436)	(2.018)	(2.029)	(1.144)
Observations	173,243	173,243	173,243	173,243	173,243
R-squared	0.502	0.552	0.583	0.455	0.225
Clusters	10800	10800	10800	10800	10800

As is clear in Table 7, while productivity of teleworkers goes down, overall performance of teleworkers only decreases as more and more peers choose to telework. This is due to a statistically significant difference in the number of hours employees spend on examining, rather than other activities. If the additional tasks that employees are called to perform during work hours are not central to organizational goals, the drop in teleworker productivity should not be worrisome from the organizational perspective. In contrast, if the additional tasks that employees do in the office are important for long-term organizational performance, the rise of teleworking may have negative effects on these other areas. The fact that the proportion of peer teleworkers is positively correlated with the number of hours spent on examining applications confirms that teleworking changes work conditions for non-teleworkers as well in meaningful ways. Unfortunately, this new work environment is positively associated with leave – that is,

having more teleworking peers increases the amount of leave taken for non-teleworkers. Given that absenteeism is a strong proxy for employee burnout, this increased productivity may not be a positive outcome for the organization over time, and may explain the increased attrition rates for non-teleworkers as the program expands, presented below.

Table 8. Effect on Attrition with Interactions

VARIABLES	(1) Annual Attrition	(2) Annual Attrition	(3) Annual Attrition (Newly Eligible Teleworkers)	(4) Annual Attrition (Pre-2006 Employees)
Teleworker	-0.00501***	-0.00186	-0.0287***	-0.00713***
	(0.00116)	(0.00198)	(0.00381)	(0.00215)
Teleworker X % Peers		-0.00926**	0.00796	0.00672
		(0.00446)	(0.00727)	(0.00480)
% Peers Teleworking	0.0122***	0.0154***	0.0245***	-0.00430
	(0.00332)	(0.00395)	(0.00598)	(0.00483)
Constant	-0.0635***	-0.0623***	-0.118***	-0.0780***
	(0.00459)	(0.00470)	(0.00868)	(0.00749)
Observations	173,243	173,243	97,293	105,306
R-squared	0.596	0.596	0.628	0.547
Clusters	10800	10800	7642	4473

Table 8 shows the relationship between teleworking and attrition using a difference-in-difference estimator. Column 1 considers the effect of being a teleworker on the probability of quitting in a given year, controlling for the proportion of team members who are teleworkers, in a model that includes individual fixed effects, time fixed effects, and controls for grade and experience. Column 2 interacts teleworking status with the percentage of peers who are teleworkers, and Columns 3 and 4 consider the same subsamples as above – newly eligible teleworkers and pre-2006 employees. As above, teleworking has a robust, statistically significant negative effect on attrition of teleworkers. Yet, interestingly, as the proportion of peers teleworking increases, the probability that an employee will quit increases for non-teleworkers.

VI. Discussion

The rise in teleworking in the USPTO is emblematic of a broader shift in how we see work. While the option has existed in a variety of different settings, its growth in the USPTO allows us to evaluate the "general equilibrium" effects of instituting large-scale teleworking schemes in a manner that only the past few years have allowed. The program has existed long enough and the data is rich enough to be able to answer questions about how teleworking affects organizations as a whole, rather than just the people who choose to participate. As might be expected, the main impact on teleworkers suggests a trade-off between reduced productivity and increased retention. Perhaps less expected are the additional impacts of teleworkers on an organization. The growth of teleworking affects those who stay behind as well as the work environment itself. Employees who have more teleworking peers display higher rates of attrition but also higher rates of productivity. Both teleworkers and non-teleworkers alter their time use as teleworking expands. This should have long-term effects on the quality of services provided, that could move in either direction. If the extra time once spent on non-case work is correlated with quality assurance or mentorship, this shift in work days may reduce quality overall. More worrisome, however, from an organizational perspective is how large-scale teleworking schemes affect selection into an agency. While some have celebrated the rise of teleworking as a way to increase the available applicant pool for a given agency, and therefore increase the quality of new recruits, this study provides some suggestive evidence that selection into the agency may be negative. We find that productivity of later cohorts may be worse than that of the earlier cohorts, even though both new and old cohorts are less likely to leave once they begin teleworking.

There is still limited evidence about how teleworkers interact with citizens or the public more broadly. Indeed, as government modernizes, the new federal agency could look a lot more like a collection of individuals across the country than like a building in the capital. How this affects public opinion or trust in government services is yet to be understood. Future research should also consider whether incentives and opportunities for career progression may be affected for individuals interested in a career in government. If senior management continues to work from the office, as they do today, do the perks of teleworking mean that qualified federal workers will choose to forgo promotions? Will a junior non-teleworker be less likely to have good mentors if

many of the senior staff are working from home? Ultimately, we are still at the beginning of our understanding of how teleworking will change work and government, but given its support with both unions and management, it seems likely that this approach to work is here to stay.

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