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An emerging form of remote work allows employees to *work-from-anywhere*, so that the worker can choose to live in any geographic location of choice. While traditional "work-from-home (WFH)" programs offer the worker temporal flexibility, "work-from-anywhere (WFA)" programs offer *both* temporal and geographic flexibility. We study the effects of WFA on productivity at the United States Patent and Trademark Office (USPTO) and exploit a natural experiment in which the implementation of WFA was driven by negotiations between managers and the patent examiners' union, leading to exogeneity in the timing of individual examiners' transition from a work-from-home to a work-from-anywhere program. This transition resulted in a 4.4 percent increase in output without affecting the incidence of rework. We also report several results related to mechanisms, notably a correlation between examiners relocating to below-median cost of living locations and increased productivity. We also study how geographic flexibility affects the location choice of WFA workers and find a correlation between career stage and the decision to move to Florida. We additionally employ illustrative field interviews and micro-data on geographic distance from the headquarters, an exogenous mandate to use IT, and proxies for examiner effort to shed further light on mechanisms.

Running Head: **Work-from-anywhere: Productivity effects**

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1. INTRODUCTION

Human capital has been documented as a critical source of firm competitive advantage (Campbell, Coff, & Kryscynski, 2012; Coff & Kryscynski, 2011; Ganco, Ziedonis, & Agarwal, 2015; Starr, Ganco, & Campbell, 2018). Within this literature, a growing body of work documents the role of nonpecuniary incentives in shaping motivation of workers (e.g., Campbell et al., 2012; Carnahan, Agarwal, & Campbell, 2012; Kryscynski, 2011; Sauermann & Cohen, 2010). However, from the perspective of the firm, it is also critical to study the productivity effects of provisioning such incentives. An example of a nonpecuniary incentive that has attracted much debate is remote work, in which an employee is allowed to work outside of the office, either part or full time. Despite a few high-profile retreats from remote work by companies like Yahoo! and IBM (Simons, 2017; Swisher, 2013), many organizations such as Amazon, Apple, American Express, and Glassdoor offer remote work programs to employees (Glassdoor, 2019). Demand for remote work and other flexible work arrangements is increasing (Gallup, Inc., 2017) and the value that employees place on remote work arrangements is driven in large part by the costs of commuting, childcare, and eldercare faced by a population increasingly comprised of dual-career families (Council of Economic Advisers, 2010).[4]

To date, research on remote work, including the recent Bloom, Liang, Roberts, & Ying (2015) study, has focused largely on the effects of *working from home* (WFH), in which the employee may conceivably still be living within commuting distance of the office. In recent years, however, another form of remote work—*work-from-anywhere* (WFA)—has begun to emerge. Here, workers are no longer required to live in the same geographic location as the firm and have greater flexibility to choose where to live. Organizations with WFA policies include Gitlab, Akamai, Github, NASA, and

[4] Another survey finds that "74 percent of employees say they would quit their jobs to work for an organization that would allow them to work remotely more often, even if their salary stayed the same" (Softchoice 2017, p. 3). A contemporaneous benefits survey reports that 40 percent of surveyed firms indicated that offering more flexible work arrangements was one of their most effective recruiting strategies (Society for Human Resource Management, 2017, p.12). In this survey, 62 percent of firms reported allowing some type of remote work/telecommuting (Ibid).

DataStax, among others (Fatherly, 2016, Glassdoor, 2018; NASA, 2018; Reynolds, 2019). However, to the best of our knowledge, there is no research on the productivity effects of WFA policies. One of the comprehensive literature reviews on telecommuting states (emphasis added), "*Home* was the primary location for telecommuting in nearly all the studies included in this meta-analysis" (Gajendran & Harrison, 2007, p. 1525). In other words, the prior telecommuting and remote work literature focused on studying the effects of moving the worker from one workspace (within the firm's office), to an alternative workspace (within the home of the worker, typically in the same geographic location as the firm office). In contrast, WFA gives the worker the additional choice of deciding to move to a geography of their choice.

We argue that WFA is fundamentally different from WFH in how it might affect worker productivity. Previous research on WFH has identified benefits to employee performance via mechanisms such as reduced commute times and fewer sick days (Bloom et al., 2015), which can be attributed to increased *temporal flexibility* (Evans, Kunda, & Barley, 2004). WFH also allows workers to control ambient workspace elements such as clothing, layout, music, ventilation, etc. (Gajendran & Harrison, 2007). WFA goes further by eliminating the traditional link between the geography of home and work location, resulting in *geographic flexibility*, in which a worker can remain employed at a firm without needing to live within commuting distance of the firm's office location. In the case of WFA, employers cede to workers control of the geography in which they choose to live, *in addition* to ceding the temporal control afforded by WFH (Evans et al., 2004). In this sense, WFA is perhaps better titled "Live Anywhere," as the benefits that distinguish it from WFH derive from employees' ability to choose where they live. Contingent on the firm not adjusting wages downwards for workers transitioning into a WFA program and the worker relocating to a lower cost-of-living location, real income might rise. This addresses concerns about the rising cost of living for knowledge workers (Moretti, 2013). In addition, geographic flexibility might enable the knowledge worker to move to a location affording the worker greater psychic benefits such as better climate or proximity to family (Greenwood, 1975).

These differences between WFA and WFH, along with the general increase in both worker demand for and employer provision of WFA policies, lead us to our main research question: How does the geographic flexibility provided by WFA affect individual worker productivity? Bloom et al. (2015)'s research in a Chinese travel agency shows positive causal productivity effects of moving a worker from an in-office setting to a WFH regime. We ask whether there are causal productivity effects of moving a worker from a WFH regime to a WFA regime. We also attempt to shed light on the mechanisms underlying the effects of WFA on knowledge worker productivity.

Our setting, the United States Patent and Trademark Office (USPTO), and in particular, the job of patent examiner, is in many ways the ideal setting for our research questions. First, our setting allows us to exploit a natural experiment related to the implementation of a WFA policy. The bureaucratic processes governing the implementation of WFA at the USPTO allow us to mitigate endogeneity concerns related to worker selection into the WFA policy. More specifically, the implementation of WFA was driven by negotiations between USPTO managers and the union of patent examiners, leading to a monthly enrollment quota that created exogeneity in the *timing* of individual examiners' transition to WFA. Second, the role of a patent examiner is relatively independent. Third, examiners in our sample had spent at least two years in the USPTO office and additional time in a traditional WFH program before taking on a WFA assignment. These conditions help us in three ways. First, the independent nature of the task performed by patent examiners and the mandate to spend two years in the office help us (at least partially) control for adverse effects of remote work (e.g., effects of additional coordination costs and reduced learning effects from colocated peers) that might lead to confounding concerns in a more general setting. Second, given that all WFA employees in our study first transition from being an "in-office worker" to a "WFH worker" before further transitioning into a "WFA worker", we are able to isolate a productivity effect of geographic flexibility awarded by WFA vis-à-vis WFH. Third, the exogenous timing of transitioning from WFH to WFA enables us to estimate a causal comparison of productivity under the two regimes. These conditions not only present a clean empirical setting, but also serve as important boundary conditions to our findings and suggest a future research agenda.

To preview, we exploit this bureaucratic policy-induced variation and employ examiner fixed effects, finding that examiners enjoy an increase in work output of 4.4 percent when in the WFA program compared to the baseline of when the worker was in the WFH program, with no significant increase in the amount of rework. It is important to point out that to the best of our knowledge, with the exception of the Bloom et al. (2015) study, there are no other studies in the remote work/teleworking literature that document causal productivity results. Furthermore, while Bloom et al. (2015) document causal results related to WFH, this study documents causal results related to transitioning from WFH to WFA. Our secondary analysis compares WFH productivity to in-office productivity, finding an increase in productivity similar to that identified in Bloom et al. (2015). These two analyses give a sense of the stepwise progression that can take place (at least in some organizational contexts) as employees move from in-office, to WFH, and ultimately to WFA work.

We also exploit institutional details of our setting to isolate WFA mechanisms. First, our analysis shows a correlational relationship between examiners relocating to below-median cost-of-living locations and greater productivity increases, suggesting that one of the motivating benefits of WFA for workers could be an increase in real income. Second, we present correlational results showing that workers with greater tenure are more likely to choose Florida, arguably a "retirement-friendly" destination where they might derive additional psychic benefits. Crucially, we also show that the productivity effects of WFA cannot be explained by alternative mechanisms such as reduced commute time and reduced monitoring. We also document illustrative evidence of how geographic flexibility affects productivity using field interviews.

In supplementary analyses, we also examine work practices associated with enhanced productivity for the sample of WFA examiners. In particular, we exploit a bureaucratic mandate requiring WFA employees to utilize informational technology tools for online coordination and find that mandating this practice does result in an increase in productivity for WFA employees whose work needs to be certified by a supervisor. Finally, we test whether measures related to examiner effort and leniency change when an employee transitions to WFA: We find no evidence of increased leniency or reduced effort as measured by examiner-added citations.

Our findings make an original contribution to the literature on remote work. While prior literature has documented robust productivity effects of working from *home* (e.g., Bloom et al., 2015), our study goes a step beyond in documenting the productivity effects of working from *anywhere* compared to WFH, and demonstrates that the benefits of WFA derive from additional mechanisms not triggered by WFH policies alone. Our results also contribute to the literature on the effects of nonpecuniary incentives (Kryscynski, 2011; Sauermann & Cohen, 2010; Stern, 2004), demonstrating that the application of a WFA policy can provide employees both direct economic value, in the form of reduced cost of living, and intrinsic value, in the form of increased psychic benefits from geographic flexibility, while also increasing firm productivity and profits.

2. WORK-FROM-ANYWHERE AND GEOGRAPHIC FLEXIBILITY

In this paper, we examine the productivity effects of moving workers from a traditional WFH regime to a WFA regime that grants workers geographic flexibility, i.e. the flexibility to choose a geographic location in which to live, which we theorize as differing from both the temporal flexibility and flexibility to design the workspace granted by a WFH policy. In this section, we situate

WFA within the larger body of research on nonpecuniary incentives and identify mechanisms that we argue distinguish WFA from WFH.

Nonpecuniary incentives such as authority, independence, and company reputation have been linked to employees' decisions to stay or leave a firm (Agarwal & Ohyama, 2013; Cable & Turban, 2003; Fehr, Herz, & Wilkening, 2013; Sauermann & Stephan, 2013). Kryscynski (2011) argues that incentives encompass any aspects of the employment relationship valued by workers, regardless of whether those aspects are directly or indirectly bestowed, created, or tied to individual membership, effort, or performance. Certain non-pecuniary incentives provided by firms to workers—such as challenge and autonomy (Sauermann & Cohen, 2010), information on quality of work (Kolstad, 2013), and tolerance of early failure (Azoulay, Zivin, & Manso, 2011; Ederer & Manso, 2013)—have been shown to influence worker productivity in ways that are incremental to the effects of pecuniary incentives. Sauermann & Cohen (2010) argue that pecuniary incentives are designed to appeal to employees' extrinsic motivations, while non-pecuniary incentives appeal to employees' intrinsic motivations by enabling them to gain greater satisfaction from the work itself.

Remote work programs such as WFH and WFA are non-pecuniary incentives designed to offer the worker *flexibility*. Evans et al. (2004) define flexibility in the employment relationship as "ceding control to workers over the circumstances of their work by enabling them to vary those circumstances to address personal and family needs and uncertainties" (Ibid, p. 2). WFH policies are an increasingly common means of granting temporal flexibility to employees, among other practices that give employees more control over the hours in which they complete their work (e.g., Briscoe, 2007). The benefits of granting temporal flexibility (such as flexible work hours) to employees have been well-documented in the research on family-friendly work policies and WFH policies, with particular emphasis on improvements in work-life balance and reductions in work-family conflict. Bloom et al., (2015) found evidence that WFH led to a 13 percent performance increase (compared to working from office), of which 9 percent was due to fewer breaks and sick days, and 4 percent was due to a "quieter and more convenient" work environment (p.165). Work-life balance is generally seen to improve when employees are able to work from home (Gajendran & Harrison, 2007), though some negative impacts have been noted in the areas of work-life boundary maintenance (Kossek, Lautsch, & Eaton, 2006) and family-to-work conflict (Golden, Veiga & Simsek, 2006). Improved work-life balance can increase the intrinsic motivation of employees (particularly employees whose identity and motives are tied to family), helping maintain a balance between work and personal life (Akerlof & Kranton, 2005; Sauermann & Cohen, 2010). Research on remote work has previously linked temporal flexibility to increased perceptions of job autonomy (Bélanger, 1999; Gajendran & Harrison, 2007), and autonomy has been related to increased motivation on the job (e.g., Hackman & Oldham, 1976; Ryan & Deci, 2000).

A WFA policy affords employees all of the benefits of a WFH policy, but additionally awards the worker geographic flexibility. We argue that there are two significant additional advantages of WFA to workers that are not covered by the provision of WFH. The first of these is the ability to live in a location with a lower cost of living than the location of the employer, enabling the employee to enjoy higher real income without an increase in nominal salary. Moretti (2013) deflates nominal wages using a location-specific cost-of-living index and finds that the difference between the wage of college graduates and high school graduates in the U.S. is lower in real terms than in nominal terms; at least 22 percent of the documented increase in college premium is accounted for by spatial differences in the cost of living. Given the opportunity to relocate anywhere in the U.S., knowledge workers might choose to move to a lower cost-of-living region, thus allowing the worker to enjoy greater real income, holding nominal income constant—especially when the employer is based in an urban area with a relatively high cost of living. There is also a literature summarized by Leana & Meuris (2015) that documents how income is related to worker satisfaction.

The second benefit is that if allowed geographic flexibility, employees may also choose to move to a location that awards the worker "psychic benefits," such as living in a location with a more attractive climate (Greenwood, 1975). There is also a nascent literature that looks at revealed preferences of scientists, engineers, and entrepreneurs to choose work that is close to home (Dahl & Sorenson, 2010a, 2010b). Using panel data on the Danish population, Dahl & Sorenson (2010a) estimate a strong revealed preference of scientists and engineers to live close to family and friends. In another paper, they note that "one commonly cited reason for why people do not move more often is that they value being near family and friends, or at least the more frequent and more extended interactions that propinquity allows" (Dahl & Sorenson, 2010b, p. 637). A related concept in economics is the construct of psychic costs of migration (Sjaastad, 1962; Schwartz, 1973). These studies suggest that the provision of geographic flexibility should benefit employees in ways that are *incremental to the benefits of temporal flexibility*. While temporal flexibility allows employees to spend more time with immediate family, geographic flexibility enables employees to relocate to a location that has lower cost of living and/or where the worker experiences psychic benefits. In addition to more attractive weather and being closer to family and friends, a geographic location of choice could also offer other psychic benefits to a worker, such as pursuit of a personal interest outside of work (e.g., skiing in Colorado). As another example, early-career workers wishing to raise families can move to a family-friendly locale.

However, from the perspective of the firm, provisioning policies such as WFH and WFA could lead to additional costs, including increased coordination costs. The organization of workers into a firm has been viewed as a system to coordinate effort and communicate knowledge across multiple intrafirm actors (Grant, 1996; Srikanth & Puranam, 2014; Thompson, 1967). Altering the spatial distribution of employees changes the means of coordination, limiting the ability of workers to rely on tacit coordination mechanisms (Srikanth & Puranam, 2014), and potentially leading to increased coordination costs via difficulties in knowledge sharing (Cramton, 2001; Gibson & Gibbs, 2006). Second, social and professional isolation is a well-documented challenge in the research on remote workers (e.g., Cooper & Kurland, 2002; Golden, Veiga, & Dino, 2008). Managers and organizations can help mitigate these challenges through the provision of structures that facilitate social interaction among remote employees, and ground rules for the use of information technology tools, to facilitate communication (Makarius & Larson, 2017).

In summary, prior research on incentives has argued that employers should design incentives to best attract an ideal employee; WFA is an example of such an incentive that offers workers both geographic and temporal flexibility. However, given the constraints of coordination and isolation, an important question remains from the perspective of firms: whether the provisioning of such an incentive creates value for the firm. The hedonic wage analysis literature predicts a "negative trade-off between wages and 'positive' job attributes, attributes like status or flexibility in hours of work" (Lazear & Shaw, 2007, p.102–3). Indeed, empirical research demonstrates at least some willingness to exchange wages for non-monetary benefits (Stern, 2004). Mas & Pallais (2017) find that on average, workers are willing to accept 8 percent lower wages in exchange for a remote work option, suggesting that remote work policies are perceived as a valuable non-pecuniary benefit by employees. However, in some cases (such as the USPTO), the firm does not decrease wages for employees choosing a WFA regime. As stated earlier, this raises an interesting question for scholars of strategic human capital, economists, and practitioners alike: holding wages equal, when workers are moved from a WFH regime to a WFA regime, does the additional geographic flexibility provided lead to higher productivity?

3. EXPLORATORY FIELDWORK AND RESEARCH CONTEXT

Because of the nascent stage of WFA research (Edmondson & McManus, 2007), we undertook some exploratory qualitative, inductive work to better understand the research context, and to identify potential mechanisms underlying the productivity effect of switching to a WFA regime. This exploratory work included 26 interviews with various USPTO managers, patent examiners, and the Patent Office Professional Association (POPA; labor union) leaders (details in Appendix 1). We also gathered online reviews posted by current and former patent examiners on the review site Glassdoor.com (details in Appendices 2, 3).

The USPTO is the federal government agency authorized to evaluate patent and trademark applications. It is headquartered in Alexandria, VA, and employs about 13,000 people, including slightly more than 8,000 patent examiners. Patent examination comprises roughly 90 percent of the USPTO's work; in 2015, the USPTO received 629,647 patent applications and granted 325,979 patents across many industries and technologies (Choudhury, Khanna, & Mehta, 2017).

A patent application specifies a set of "claims" that defines the invention the applicant wishes to protect. Applications are assigned to examiners based on the required area of technical expertise (software, chemicals, mechanical, etc.). Examiners are organized into nine "technology centers," each made up of smaller "art units." Within a given art unit, a supervisory patent examiner (SPE) assigns each new patent application to a patent examiner (Lemley & Sampat, 2012). The examiner is then responsible for reviewing the claims and moving the application through the examination process, with minimal supervisory oversight. Examiners must determine whether patent claims in applications meet the criteria of "novelty" and "nonobviousness" in order to be patentable. In order to determine the validity of claims in an application, the patent examiner uses several proprietary search tools to review the body of publicly available work (called "prior art," it includes existing patents, published patent applications, academic and trade journal articles, and other publications). In order to determine "novelty," the examiner must determine that the claims within the application are not already wholly addressed by another single patent or published work.

Once the examiner has (to her knowledge) exhausted the existing prior art, she issues a "first office action," (FOA) which can be an "allowance," accepting all claims as patentable or, more commonly, a "nonfinal rejection," which indicates that some or all claims are not patentable, and gives the basis for rejection. Applicants can respond by withdrawing, narrowing, clarifying, or providing further evidence to support the rejected claim. The examiner then reviews the response, accepts additional claims as applicable, and issues another office action. This process continues until the examiner believes that no further response will change the outcome of an application, at which point she issues a "final action." Upon receiving a final action, the applicant has the choice of abandoning all remaining rejected claims, appealing the action to a board of appeal, or restarting the application process by paying an additional $1,200 fee to initiate a "request for continued examination" (RCE). The RCE restarts the entire examination process, but is carried out by the same examiner and takes into account all prior communication. There is no limit on the number of RCEs an applicant may file, and approximately one-third of all applicants file at least one RCE, though few file more than three.

Patent examiners are typically highly educated, holding undergraduate degrees in science and engineering, and some holding advanced degrees in technical fields. New employees are hired at a specific grade level (in line with hiring and employee ranking procedures at all federal agencies) based on their experience and skills. At the USPTO, examiners are hired at the civil servant "grade levels" GS-5, GS-7, GS-9, GS-11, GS-12, GS-13, GS-14, or GS-15, with pay and responsibilities increasing with each grade. During labor negotiations, examiners are represented by the USPTO's union, POPA. Examiners advance up to GS-13 automatically, based largely on tenure. Upon reaching GS-13, an examiner can enter into a signatory review program in which the examiner's work is evaluated. Upon passing this review, the examiner is designated a partial signatory (PS) and can sign nonfinal office actions. After six months of PS status, examiners are eligible for a secondround work review. Upon passing this review, the examiner attains full signatory (FS) status, indicating that the examiner can sign all decisions (including FOAs and final actions).

The USPTO measures examiner productivity using the number of actions completed by an examiner within a given period of time in relation to an expected productivity level, which is determined based on examiner grade level (a proxy for experience) and examiner-specific case mix—examiners in more nuanced or complex fields are granted more time to examine a given application. Following the USPTO's measures, we take the number of actions in a given period as the measure of examiner output. We consider the number of RCEs in a given period to serve as a measure of rework. While we recognize that this is an imperfect measure (an inventor is well within rights to doggedly pursue a patent claim via an unlimited number of RCEs, regardless of the accuracy and quality of the examiner's ruling), an RCE mechanically leads to rework, as the examiner must search prior art again to write the next decision. Furthermore, our field interviews further support the assumption that, on balance, a greater number of RCEs for a given examiner is likely to indicate a greater need for rework.

The process of patent examination is largely an individual exercise, but with some supervisory constraints. At lower grade levels, patent examiners are typically newer and less experienced in their fields and, therefore, must obtain approval on their actions from either their assigned SPE or a senior patent examiner. However, given the independent nature of the task, even for junior examiners, there is relatively little coordination that needs to be managed between the examiner and his or her supervisor (Choudhury et al., 2017; Lemley & Sampat, 2012).

To further enrich our understanding of the examiners' perspective on their jobs, we gathered qualitative data from 258 online employee reviews at Glassdoor.com (details in Appendices 2, 3). The reviews contained a number of consistent themes. Temporal and geographic flexibility are both cited as highly valuable aspects of the examiner job that enable a desirable level of work-life balance.

Furthermore, there are frequent mentions of the independent nature of the job, giving further confirmation that our research context is one of pooled interdependence (Thompson, 1967). The job is also described as highly routine and repetitive, suggesting that routineness is a further scope condition of our findings. There is extensive discussion of the emphasis placed on meeting performance targets for actions. This theme further supports our use of the number of total actions as a valid measure of employee productivity in this context (details in Appendix 3).

Remote work programs at the USPTO

We will focus on two prominent telework programs at the USPTO: WFA (i.e., the Telework Enhancement Act Pilot Program or TEAPP program) and WFH (i.e., the Patents Hoteling Program or PHP program). The USPTO introduced the voluntary PHP in January 2006 with an initial cohort of 500 patent examiners. PHP provides eligible employees with equipment and remote access to systems and allows them to WFH up to four days per week. When they report to the office, they reserve desk space through an online system. PHP is a classic WFH program that offers temporal flexibility, but less geographic flexibility than WFA. In addition, participants must have worked at the USPTO for at least two years and demonstrated "satisfactory performance." Eventually, the PHP program grew to include two subprograms: (1) the "PHP within 50 miles" program (i.e., those examiners who lived within the 50-mile radius of the USPTO headquarters in Alexandria and reported to the USPTO headquarters at least once per week); and (2) the "PHP greater than 50 miles" program (i.e., those examiners who lived at least 50 miles from headquarters but were still required to report to the USPTO headquarters at least once a week).

In December 2010, President Barack Obama signed the Telework Enhancement Act, which set standard rules and regulations for remote work at federal government agencies. In early 2011, the USPTO began planning to pilot a WFA program (i.e., TEAPP), allowing employees to work anywhere in the contiguous U.S. (greater than 50 miles from the USPTO) and travel to headquarters periodically at their own expense, thus awarding eligible patent examiners geographic flexibility. Importantly for our purposes, the USPTO did not adjust wages for employees opting to participate in either the WFH or WFA programs; this helps us test the net impact on firm productivity of the WFA benefit in the absence of any offsetting reduction in wages.

Employees were eligible to participate in WFA if they: (1) were already enrolled in the "PHP > 50 miles" program; (2) had access to the Internet and USPTO systems; (3) agreed to change their "duty station" (i.e., home office) to a location greater than 50 miles from USTPO headquarters; and (4) waived their rights to travel reimbursement for required trips back to headquarters. The USPTO capped the number of trips that teleworking employees would need to make to headquarters at 12 days and/or five trips during a fiscal year. The USPTO also provides WFA workers with online communication tools such as Microsoft Lync, WebEx webinar services, and Cisco Voice over Internet Protocol (VoIP). On January 30, 2012, the USPTO officially launched the WFA program. On June 24, 2013, the USPTO (in negotiation with POPA) amended the WFA agreement to include the following: "the above tools (instant messaging, document/desktop sharing, virtual meeting, video communication, and a presence indicator) would be mandatory for…full-time teleworkers," noting that "the purpose of requiring the use of these tools was to encourage collaboration" (Chu, Bergrud, Lavigna, McGrath, & Reeder, 2015, p. 70). Employees who had been located in the Alexandria headquarters for at least two years were eligible for the "PHP > 50 miles" program.

4. HYPOTHESES: WFA AND PRODUCTIVITY

We first examine the productivity effects of moving a worker from a WFH regime to a WFA regime. As discussed earlier, in the former regime, the worker experiences temporal flexibility and control of ambient workspace elements. In the latter regime, the worker additionally experiences geographic flexibility, which might enable the worker to move to a lower cost-of-living location and raise real income. Geographic flexibility might also help the worker relocate to a location which affords the worker higher psychic benefits, such as being in a location with better climate (Greenwood, 1975). Given this, we hypothesize that remote work offering both geographic and temporal flexibility (i.e., WFA) has greater productivity benefits compared to remote work offering temporal flexibility alone (i.e., WFH).

Generally, the provisioning of WFA could lead to increased coordination costs, isolation, and fewer opportunities to learn from colocated peers. However, we argue that *in our setting* neither of these things are likely to affect rework, especially given that patent examiners were allowed to self-select into a WFA program only when they had spent at least two years at the USPTO headquarters and had achieved a baseline level of task-specific human capital. As prior research (Argote & Miron-Spektor, 2011; Katila & Ahuja, 2002; Rosenkopf & McGrath, 2011) has shown, learning by doing is accrued through the experience of performing a task repeatedly. Given their preexisting tenure of at least two years at the USPTO headquarters and the routine nature of patent examination, experienced patent examiners are likely to have already developed the requisite absorptive capacity (Cohen & Levinthal, 1990) and task-specific human capital (Gibbons & Waldman, 2004) to perform tasks such as a prior art search. Second, as described earlier, patent examiners carry out their tasks (researching, searching for prior art, writing decisions, and communicating with applicants) independently, and there are relatively few requirements to coordinate with peers. In this pooled-interdependence setting, patent examiners reach out to peers mainly to seek advice on relevant prior art. Experienced examiners could continue to leverage their intraorganizational social ties even after migrating to a WFA program to mitigate isolation, and our field interviews yielded examples of experienced WFA examiners calling peers (based in Alexandria or elsewhere) and sharing computer screens on the videoconferencing calling tool WebEx to ask: (1) "Do you have a search for me?" (that is, have you searched this topic previously and, if so, could you share the results?); or (2) "Can you take a look at my drawings and suggest prior art?" In summary, experienced examiners have already developed firm- and task-specific human capital and have the technological means to reach out and seek advice from prior colocated colleagues. Given this, we anticipate that, on balance, even as the amount of output increases, the amount of rework will *not* increase after such employees move to a WFA regime. We hypothesize:

Hypothesis 1a. *For workers in a pooled interdependence (low coordination) setting with a baseline level of task-specific human capital, moving the worker from a WFH to a WFA regime leads to an increase in output.*

Hypothesis 1b. *For workers in a pooled interdependence (low coordination) setting with a baseline level of task-specific human capital, moving the worker from a WFH to a WFA regime does not lead to an increase in rework.*

As our previous hypotheses focus on the progression from WFH to WFA, it is important that we also document the relationship between these workers' WFH productivity and their previous in-office productivity in order to eliminate the possibility that productivity had previously declined when the worker was moved from an "in-office" regime to WFH. We expect that the benefits identified in Bloom et al. (2015) would be mirrored in our context with an implementation of WFA resulting in increased work output compared to when the worker was in-office:

Hypothesis 2. *For workers in a pooled interdependence (low coordination) setting with a baseline level of task-specific human capital, WFH is associated with greater productivity than working in the office.*

5. DATA

This paper draws on multiple sources of data. We begin with a unique administrative dataset obtained from the USPTO for the years 2007–2015 that reports, annually, all patent examiners on the USPTO payroll, their general schedule (GS) pay level, and a benchmark measure of productivity used for promotion decisions (as a function of the "United States Patent Classification" or USPC class of their examined patents). We link this data to a separate administrative dataset, again obtained from the USPTO, that identifies which examiners are enrolled in each remote work program, their current home office location, and when they began remote work. From here, we link the combined examiner datasets to publicly available USPTO data on applications and transactions (such as RCEs) to quantify examiner-level output and rework.

Examiner personnel data

The first dataset used for this study is an annual record of all patent examiners active at the USPTO from 2007–2015, with 9,210 unique examiners over these eight years, inclusive. This data also provides the GS of every USPTO examiner, data that is otherwise not public. As described earlier, the GS of an examiner is of particular importance: it serves as a natural hierarchy for promotions, it is mechanically correlated with tenure and experience, and higher-grade examiners have increasing levels of autonomy in their workflows. Hence, controlling for GS is important to account for unobservable task-specific human capital of examiners (Gibbons & Waldman, 2004).

We also utilize a second unique, USPTO-provided, personnel dataset specifically focused on remote workers. This dataset includes examiner identifiers, as well as the remote work program(s) in which the examiner enrolled: WFA and PHP (<50 miles and >50 miles combined). Figure 1 shows the growth in remote working across the three programs from 2007–2015; WFA appears to gain an increasing share of the teleworking population as examiners substitute away from PHP programs. The examiner-specific start date for each specific telework program is also available to us, allowing us to track an examiner across programs. This data also identifies the city and state of a teleworking examiner (as of August 2016), which is important for spatial analyses (to be described later).

[Figure 1 here]

USPTO patent data

Data on patents and patent application-level transactions were collected from a combination of two publicly available datasets: USPTO's Public Patent Application Information Retrieval (PAIR) dataset and PatentsView. Application data collected includes the name of the examiner assigned to a patent, the examiner's art unit, and the USPC classification of the application. For each patent, we then collected data on all transactions executed by an examiner, focusing on two specific metrics of productivity: total actions (measure of output) and RCEs.[5] Total actions is a measure of aggregate output delivered by an examiner, and aligns with the PTO's internal performance measure of expectancies. The second measure, RCEs, are a measure of *rework*.

Spatial data

City and state data on the most recent location of teleworking patent examiners was obtained through the USPTO administrative dataset on teleworkers. This data was then geocoded using commercially available GIS tools, and measures of the spatial concentration of WFA examiners were calculated.

6. IDENTIFICATION STRATEGY: NATURAL EXPERIMENT

To provide robust econometric estimates related to how the implementation of WFA affected output and rework, we exploit a natural experiment within the USPTO. As noted earlier, the implementation of WFA was driven by negotiations between the USPTO management and POPA. Specifically, these negotiations resulted in a monthly quota for eligible examiners transitioning to WFA in the first 24 months of program implementation. Our field interviews indicated that the monthly quotas were oversubscribed, and eligible examiners often had to wait for several months to

[5] We assume here that shirking—another possible negative outcome associated with increased autonomy—is reflected in the productivity measure, given that we are using an objective measure of productivity. Concerns about shirking were addressed at the USPTO in a contemporaneous time frame, with claims of "examiner fraud" and "attendance abuse" made by *The Washington Post* (Rein, 2014; 2016), based on critical findings from the U.S. Department of Commerce's Office of the Inspector General. However, all of these findings related to either (1) overreporting of hours worked or (2) shifts in the timing of work completed, such as backloading at the end of a calendar quarter, which raised concerns about the accuracy and quality of work completed. USPTO Office Director Michelle K. Lee told lawmakers that she and her team "do not tolerate any kind of attendance abuse" (Rein, 2016). Our measure of productivity is only output dependent, so overreporting of time worked would not affect this measure. Second, our measure of rework—while not a perfect proxy for quality—should capture any substantial degradation in work quality due to backloading or other timing shifts. In robustness checks (available upon request), we also employ month fixed effects to test our causal results, and results remain robust.

transition into the WFA program. While it is likely that observable and unobservable factors determine whether or not examiners transition into WFA, we circumvent these concerns by focusing on the sample of examiners who selected to transition into the WFA program over the first 24 months and exploit variation in *when* (i.e., which month) the examiner could transition into WFA, variation that is exogenous given the monthly quotas determined by the USPTO management and POPA. Below we provide further details of how the implementation of the WFA program lends itself to a natural experiment.

As a result of the negotiations conducted between the USPTO management and POPA, the USPTO planned to enroll participants in the WFA program in phases. Additionally, and importantly for the purpose of identification, there was an exogenous quota imposed for eligible examiners enrolling in the WFA program. The number of slots was decided by a committee comprising management and union members. If a slot was not available, the prospective enrollee was placed on a waiting list. Our field interviews indicated that all slots allocated for the first several months were exhausted, implying that even if an examiner was eligible for WFA, he or she would have had to wait an unknown length of time before transitioning to WFA. As such, the timing of an eligible examiner's transition to WFA was relatively exogenous. Our field interviews indicated that prior tenure, experience, or performance were *not* considered in allocating slots to eligible examiners.

To validate our natural experiment and the insights generated by the field interviews, we test whether the variation in WFA transition time was truly exogenous by regressing the time it took an eligible examiner to transition to WFA on observable measures of past performance. As our main results analyze productivity (and include a measure of the expected work as a control), we regress "months to WFA" on measures of total examiner-level output, rework, and expectancy (a measure of expected output in the previous year). Results from these analyses are reported later in the paper:

We find no evidence of selection on prior performance (or other observables), validating our principal identification strategy.

7. ESTIMATION AND RESULTS

We focus on utilizing the natural experiment and limit our sample to examiners who enrolled in WFA in either 2012 or 2013. Within this sample, we exploit bureaucratic process-induced variation in enrollment dates to identify the effect of receiving WFA *earlier* than another examiner. As both examiners in this exercise must be eligible and have selected into the program, we avoid the traditional identification issues that arise from self-selection—all examiners in our sample can be thought of as treated, varying only in the amount of time they have had to wait to be exposed to the treatment (WFA). Moving forward, we refer to this sample as the "WFA sample." The WFA sample comprises 831 examiners (out of the 9,210 examiners). Table 1 reports summary statistics for the full sample. For summary statistics of the WFA sample, see Appendix 4.

[Table 1 about here]

Causal estimation of the effect of WFA on productivity as compared to WFH baseline

Hypotheses 1a and 1b state that for workers in a pooled-interdependence (low-coordination) setting with a baseline level of task-specific human capital, moving the worker from a WFH to a WFA regime leads to an increase in output but does not an increase in rework. We utilize the natural experiment described above, employing the following examiner month-level specification to test these hypotheses:

$$Output_{it} = \alpha_i + \beta_{it} * WFA + \xi_{it} + \gamma_t + \lambda_i + \epsilon_i$$

where *WFA* is a binary indicator that turns on (and stays on) when an examiner enrolls in WFA during the 2012–2013 timeframe. As described earlier, we use two different measures of individual-level output: for individual output using total actions and for individual rework using the number of RCEs. ξ_{it} is a vector of controls that includes examiner month-specific grade level and examiner month-specific expectancy, while γ_t is a full set of time (month) fixed effects and λ_i is an optional set of examiner fixed effects. Standard errors are clustered at the art unit level to account for concerns regarding intra-art unit correlation of error terms, particularly as they relate to unobserved routines. Columns 1–4 of Table 2 provide the focal set of results evaluating the effect of WFA on productivity.

[Table 2 about here]

Columns 1 and 2 report results relevant to output. Specifically, Column 1 identifies the effect of WFA on the total number of actions completed by each examiner in a given month, with Column 2 including a set of examiner fixed effects to identify the effect not just within the sample of examiners transitioning to WFA in 2012 and 2013, but also *within* each examiner. There is a positive, highly significant effect of WFA on overall output of 0.574 actions (p-value = .000), roughly corresponding to a 4.42 percent increase in the total number of actions on a mean of 12.97 per month. Columns 3 and 4 present results indicating that WFA does not increase the amount of RCEs an examiner engages in (with or without examiner fixed effects, p-values = .293 and .973, respectively). In summary, Hypotheses 1a and 1b are both supported. It is important to note that since workers had to first transition into the WFH program prior to transitioning to the WFA program, the baseline level of productivity here is productivity of the examiner while on WFH.

Baseline comparison of WFH productivity and in-office productivity

Hypothesis 2 states that for workers in a pooled-interdependence (low-coordination) setting with a baseline level of task-specific human capital, WFH is associated with greater productivity than working in the office. To recap, the USPTO experimented with a series of remote work programs. There was a WFA program (i.e., TEAPP) that allowed eligible examiners to live and work at any location in the U.S., and the USPTO implemented remote work programs such as PHP that offered examiners less autonomy on location choice and were akin to WFH programs. Given that the bureaucratic assignment to remote work is valid only for WFA, we can no longer rely on the natural experiment in this setting, and we estimate the specification below within the full sample of existing examiners across all months (576,267 examiner-months from 2007–2015):

$$Output_{it} = \alpha_i + \beta_{1it} * WFA + \beta_{2it} * PHP_{<50} + B_{3it} * PHP_{>50} + \xi_{it} + \gamma_t + \lambda_i + \epsilon_i$$

where WFA, $PHP_{<50}$, and $PHP_{>50}$ are indicator variables for when an examiner enrolled in either of the three programs, indicators that remain on until the examiner switches programs. As before, ξ_{it} is a vector of controls that includes examiner month-specific grade level and examiner month-specific expectancy, while γ_t is a full set of time (year) fixed effects and λ_i is a set of examiner fixed effects, which are of particular importance in this exercise as they allow us to track examiners as they switch from program to program. As before, standard errors are clustered at the art unit level. Table 3 provides results from this estimation exercise:

[Table 3 about here]

Column 2 reports the most restrictive specification with examiner fixed effects. As this model includes examiner fixed effects, we note that the coefficients are semi-additive: WFA captures the effect of remote work above and beyond PHP (>50 miles), as examiners must enroll in the latter before being eligible for the former. Hence, in this model, all telework programs incrementally increase productivity compared to working in the office, validating Hypothesis 2. The traditional WFH program, titled PHP (>50 miles), having the lowest productivity increase, while the other traditional WFH program, i.e. PHP (<50 miles), has roughly twice the impact as PHP(>50 miles) (p-value = .000 and .000 respectively). The impact of WFA, when interpreted additively with PHP (>50 miles), is far beyond the WFH programs (p-value = .000). It is important to note that we interpret these results in the context of one another rather than as causal estimates; the full sample regressions illuminate the relative differences between the remote work programs rather than the absolute improvements themselves.

8. EVIDENCE ON MECHANISMS: FINGERPRINT OF GEOGRAPHIC FLEXIBILITY

We now turn to establishing a fingerprint for mechanisms through which geographic flexibility can affect productivity. In doing so, we work within the constraints of available data and acknowledge that unobservable mechanisms might be in play. Our field interviews indicated that geographic flexibility benefitted individuals in a myriad of ways. To quote one examiner, "I'm a military spouse, which means I live in a world with frequent moves and personal upheavals that prevent many spouses from pursuing lasting careers, especially careers of their choice. WFA has been the most meaningful telework program that I have encountered in the military social sphere, as it allows me to follow my husband to any state in the U.S. at a moment's notice, and… pursue my own aspirations to contribute both to my home and to society. " Another examiner explained the benefit of geographic flexibility to his family as follows: "I have a daughter with a medical condition that, because of WFA, my family and I were able to search the northeast looking for the ideal location that would provide the services and supports for my daughter that we felt were best for her. As a result, we moved to Pennsylvania a little over two years ago. I cannot fathom what it must be like to uproot one's family AND have to find a new job in the process. I feel so lucky that I was able to make the move… to get the care my daughter needs and be able to keep the job I love doing."

Our field interviews also indicated that moving to lower cost-of-living locations was a common benefit awarded by geographic flexibility. To quote another examiner, "I selected the Patent Office as D.C. seemed an interesting place to live with the understanding that I would make a lateral move to a private law firm in the D.C. area to improve my professional experience and to enhance my chances of leaving the D.C. area when I was ready to start a family. After three years, the Office began offering full-time telework schedules and I saw some of my colleagues depart D.C. to move to areas that were considerably more affordable….I have been a TEAPP worker for the last 4 years living in Alabama with my wife and two children."

We next turn to empirical analysis and first examine whether WFA examiners relocate to counties that lower their cost of living and, in effect, increase their real income. Utilizing previously described county-level cost-of-living data, we estimate the effects of telework on an examiner's current home cost-of-living index relative to Alexandria, VA, within both the full sample and the sample of examiners transitioning to WFA in 2012-2013. We estimate:

$$Cost\_of\_Living\_Reduction_{it} = \alpha_i + \beta_{1it} * WFA + \beta_{2it} * PHP_{<50} + B_{3it} * PHP_{>50} + \xi_{it} + \gamma_t + \lambda_i + \epsilon_i$$

where $Cost\_of\_living\_reduction_{it}$ is an examiner-specific measure of the reduction in the county cost-of-living index relative to Alexandria, VA, while *WFA*, $PHP_{<50}$, and $PHP_{>50}$ are indicator variables defined as before. This model similarly includes controls for year, grade level, and expectancy, but does not include examiner fixed effects, as those would absorb all time-invariant, examiner-specific variation in cost-of-living reductions. Table 4, Column 1 reports results from regressions utilizing the full sample of examiners.[6] We find evidence of substantial cost reductions associated with PHP (>50 miles) and WFA, on the order of two standard deviations in the distribution of cost reductions across all teleworking examiners (p-value = .000). As expected, PHP (<50 miles) does not show evidence of cost reductions, as those examiners must live in and around Alexandria, VA. The results remain robust in the WFA sample (Column 2, p-value = .000).

[Table 4 about here]

Next, we turn to studying whether cost-of-living benefits are correlated to output, given that wages and wage dispersion are arguably related to satisfaction and productivity of knowledge workers (Leana & Meuris, 2015; Pfeffer & Langton, 1993). A simple test of this potential mechanism is to compare the productivity of examiners that relocate to below-median cost-of-living

[6] As reported in Table 1, this sample has 576,274 examiner-month-level observations. We dropped a few observations, corresponding to examiners without worker location data.

locations with those that relocate to above-median cost-of-living locations, within the causal sample of WFA employees. More specifically, we estimate

$$Output_{it} = \alpha_i + \beta_{1it} * WFA + \beta_{2it} * WFA * below\_median\_COL_i + \xi_{it} + \gamma_t + \lambda_i + \epsilon_i$$

where $below\_median\_COL_{it}$ is an examiner-specific identifier that equals 1 when the examiner moves to a below-median cost-of-living location. This model includes controls for year, grade level, and examiner fixed effects. Table 5, Column 1 shows that examiners relocating to below-median cost-of-living locations may experience increased output gains ($p < .006$).[7]

We next study WFA workers' geographic locational choices and their potential effects on productivity. As part of our examination of the data on WFA examiner location (Figure 2), we noticed clusters of examiners in a number of major metropolitan areas, including New York, Chicago, San Francisco, and Los Angeles, among others. These clusters can be expected given the concentration of population in these metropolitan areas. However, it also became clear there was a cluster of examiners in Florida, which cannot be explained by population alone.

[Figure 2 here]

We posited that a common reason for relocation to the coastal areas of Florida is seeking alternate living arrangements when workers are close to retirement. We asked whether it was possible that more senior patent examiners were relocating to Florida at a higher-than-average rate, possibly as a first step toward retirement. Table 6, Column 2 indicates a positive and statistically significant correlation between tenure at the USPTO and the probability of choosing to live in Florida (p-value = .001).

[Tables 5 and 6 about here]

[7] Heteroskedasticity-robust standard errors were used for this estimation exercise as there is little to no intra-art-unit variation across different geographies.

We now look to see whether examiners relocating to a preferred location (e.g. Florida) perform equally with their peers. Results from this estimation exercise can be found in Table 5, Column 2, where we see that examiners relocating to Florida do not experience any statistically significant reductions (or gains) in productivity relative to their WFA peers (p-value = .361).

We also seek to identify whether the productivity improvements associated with a WFA regime are driven simply by mechanisms similar to those in WFH regimes, such as reductions in commute time and/or reduced monitoring. In order to estimate this, we compare examiners residing 50–75 miles from Alexandria, VA while working on the WFA regime to examiners residing over 75 miles away while working on the WFA regime. Examiners living 50–75 miles away from Alexandria, VA likely did *not* relocate as a result of moving from a WFH to a WFA regime and have likely self-selected into the geographic location of choice while being a WFH examiner. However, these examiners (i.e. living 50–75 miles away from Alexandria, VA) stopped commuting to the USPTO headquarters once they transitioned from a WFH regime to a WFA regime. To recap, on the WFH regime (i.e. PHP program), examiners were required to travel back to Alexandria, VA one day a week, incurring commute time and monitoring costs.

In contrast, examiners living over 75 miles away from Alexandria, VA while working on the WFA program have likely relocated beyond a reasonable commuting distance as they moved from the WFH to WFA regimes. These examiners too (like their peers on WFA in the 50–75 mile radius) experience a reduction in their weekly commute and monitoring. However, it is only when they move from WFH to WFA that they presumably experience the benefits of geographic flexibility for the first time. In other words, when examiners in the 50–75 mile radius move from WFH to WFA, they experience lower commute costs and less monitoring, given that they are presumably already in their geographic location of choice. In contrast, workers in the over 75 mile zone experience lower commute costs, less monitoring, and additionally experience the benefits of geographic flexibility for the first time when they move from WFH to WFA. Table 10 reports results for examiners residing 50–75 miles away from Alexandria, VA in Column 1, and examiners residing over 75 miles away in Column 2. We find that the WFA effect is driven entirely by examiners residing over 75 miles away, pointing to productivity being driven by geographic flexibility, above and beyond the flexibility to reduce a commute (p-value = .000). We note that results are robust to other cutoffs, most notably 100 miles (rather than 75 miles).

While these results begin to paint a picture of geographic locational choices under a WFA regime, it is important to note that they do not capture the full range of possible mechanisms at play. For example, a worker may choose to relocate to a given location due to proximity to family (elderly parents, for example) or to return to a location where they have more friends and family (e.g., Dahl & Sorenson, 2010a, 2010b). We expect there are a number of mechanisms not captured in the current analysis that could be highlighted by future research.

9. WORK PRACTICES THAT ENHANCE PRODUCTIVITY OF WFA WORKERS

We conducted supplementary analyses to study productivity effects of work practices within the USPTO that might be correlated with work output of examiners in the WFA program. While an exhaustive examination of all relevant work practices is beyond the scope of this paper, our analysis is motivated by an observable work practice change where we could measure productivity effects. A USPTO directive in June 2013 mandated all teleworking patent examiners to utilize USPTO IT tools (e.g., logging into the USPTO virtual private network (VPN) and using USPTO messaging services). This provides us with the ability to measure the impact of IT tool use on productivity for a sample of WFA examiners. We postulate that the use of IT tools will enhance the productivity of WFA workers, especially WFA workers with a greater need for coordination (assistant examiners without signatory authority who had to coordinate with their supervisors). Research on remote work has indicated that the use of IT tools that foster situational awareness of the task helps in coordinating geographically dispersed workers (Malhotra & Majchrzak, 2014). IT tools that are directed toward synchronous communication could arguably aid situational awareness and productivity of remote workers. Table 7 provides results from this estimation exercise. Column 1 reports results for total actions, where the IT mandate improved output by 3 percent (off a mean of 12.9) exclusively for those examiners without signatory authority, that is, examiners who have to coordinate with their supervisors to get their work checked (p-value = .000). Column 2 reports results for RCEs, where we find no significant impact of the IT policy (p-value = .371).

[Table 7 about here]

10. ROBUSTNESS CHECKS

To test for concerns around time trends and reversion of performance to the mean post treatment (due to reciprocity or other unobserved mechanisms), we plot month-specific fixed effect coefficients in Figure 3 and find no evidence of post-treatment reversion to the mean. This analysis was repeated for a longer time window, and results remain robust. Given the point estimate of the month prior to treatment revealed in Figure 3, we additionally drop the two months prior to treatment from our regression analysis, and all results remain robust. Further, in order to validate our natural experiment, we look for evidence of selection in the time-to-WFA variation for those employees enrolling in WFA in 2012 or 2013. We estimate a model to determine whether previous performance, expected performance (expectancy), or rework is correlated with how soon an examiner receives WFA. In order to do so, we limit our sample to those examiners who obtained WFA in 2012 or 2013 and estimate variations on the following model:

$$Months_i = \alpha_i + \beta_{1i} * X_{it,<2012} + \xi_{it} + \epsilon_i$$

Where $Months_i$ is an examiner-specific measure of the number of months (0–23) it took an eligible examiner to actually get in the program. X refers to total actions, total RCEs, or expectancy; hence, $X_{it,<2012}$ refers to an examiner's annual prior performance, rework, or expected performance. ξ_{it} is a set of controls for an examiner's GS at the month level. Table 8 presents results showing no evidence of previous performance, expected performance, or rework being correlated with the amount of time it took an examiner to transition to WFA, validating our identification strategy (all p-values > .100). We also conduct a placebo treatment test, explained and reported in Figure 4.

[Figure 3, Table 8 and Figure 4 here]

A potential concern is that examiners, upon transitioning to WFA, may scale back or distort effort relative to the *quality* of their work prior to being a WFA worker. For instance, while examiners may increase overall output, it is *ex ante* unclear whether leniency and/or effort change. Table 9 reports results from this exercise. Considering Columns 1 and 2, we find that the increase in first office actions is matched by a proportional increase in rejections (p-values = .038 and .032, respectively). We interpret this as evidence that examiners are no more or less lenient upon transitioning to WFA. Column 3 reports results for examiner-added citations—we are unable to distinguish from the null here (p-value = .401); there appears to be no reduction in examiner-added citations for those examiners transitioning to WFA.

[Table 9 here]

11. WELFARE ESTIMATES

Using our estimates of a 4.4 percent increase in examiner-level production with no increase in the amount of RCEs, we make back-of-the-envelope calculations that suggest the following welfare gains: an increase in annual fees collected to the tune of $132 million, a one-time reduction of $0.7 million in hiring costs and a continuing annual cost savings of $2.75 million (see details in Appendix 5). In 2013, due in part to the agency's remote work options, the USPTO was ranked highest on the "Best Places to Work in the Federal Government" survey (USPTO, 2013). Environmental benefits also accrue from the program; the agency estimated that in 2015, its remote workers avoided driving 84 million miles, thereby reducing emissions by more than 44,000 tons. Finally, in 2015, the USPTO estimated that it saved $38.2 million in real estate avoidance costs due to remote workers freeing up office space at headquarters (USPTO, 2015).

Finally, one particular feature specific to our setting is that the USPTO also helps set the rate of U.S. innovation, standing as one last bottleneck in the traditional innovation process. A 4.4 percent increase in patent grants could lead to innovation spillovers that amount to a total of $1.3 billion. We arrive at this estimate through back-of-the-envelope calculations. Choudhury et al. (2017) indicate that the average number of patent grants from 2009–2012 was 211,973 patents per year; this figure, taken into consideration with our estimated 4.4 percent increase in production, would lead to roughly 9,326 more patents being granted every year. Prior literature also indicates that the mean value for patents granted to U.S. patentees was $78,168 in 1992 dollars (Bessen, 2008), with a median value of a patent to a U.S. assignee of $7,175 in 1992 dollars. We convert the mean and median values of a patent to a U.S. assignee to 2018 dollars and estimate that a 4.4 percent increase in production of patents at the USPTO creates $120 million in value for the U.S. economy (considering the median value of a patent in 2018 dollars) and $1.3 billion in value for the U.S. economy (considering the mean value of a patent in 2018 dollars).

12. DISCUSSION

We study the relationship between geographic flexibility granted through a WFA program and worker productivity in a highly skilled work context. Our choice of setting presents us with two important empirical opportunities. First, the presence of a natural experiment originating from a bureaucratic policy allows us to mitigate the impact of endogeneity of selection into a WFA regime. Second, the dual mandate—to first spend two years in the office with other coworkers and then spend time in a traditional WFH program prior to becoming a WFA worker—allows us to control for the negative effects of remote work and to compare the productivity effects of WFH and WFA.

We find robust productivity effects, with a 4.4 percent increase in work output under WFA in comparison to WFH, and no effect on additional rework. In examining the increase to productivity under WFA, we conduct supplementary analyses that rule out WFH-related mechanisms such as lower commute time and reduced monitoring. These findings are important, as they suggest that WFA (and geographic flexibility) is a novel construct with unique benefits, not simply an extreme case of WFH. We provide evidence on mechanisms that could be driving the productivity increase under WFA. WFA examiners relocate to lower cost-of-living locations and we report a correlation between relocating to a below-median cost-of-living location and productivity. We also study the choice of geographic location made by WFA workers and find a correlation between tenure at the USPTO and the likelihood of moving to a "retirement-friendly" location such as Florida. We also study conditions under which WFA worker productivity is further enhanced. Mandating IT usage appears to relax coordination constraints (and, thus, increase productivity) for employees requiring supervisory approval of work. A back-of-the-envelope calculation suggests that the increase in patents granted due to higher examiner productivity could result in $1.3 billion of added value to the U.S. economy in the best-case scenario. We also validate the Bloom et al. (2015) result that WFH is related to higher productivity compared to working in office.

This paper makes contributions to research in the areas of remote work and non-pecuniary incentives. Our context of work-from-anywhere related to the construct of *geographic flexibility* distinguishes our study from prior research on remote work and working from home. WFH offers the worker temporal flexibility and flexibility in choosing working conditions (Gajendran & Harrison, 2007). In contrast, WFA affords all of the benefits of WFH, plus the flexibility to relocate to a geographic location different from the location of the firm. As a result, while the WFH literature, notably Bloom et al. (2015), identifies productivity-enhancing mechanisms such as reduced commute time, fewer work breaks, sick days, and the benefits of a quieter work environment, our focus on geographic flexibility points to additional mechanisms unique to WFA, such as the benefits of moving to a lower cost-of-living location, and increased psychic benefits to employees. As such, we argue that WFA needs to be studied as a separate form of remote work, with some underlying mechanisms similar to those of WFH, but with its own unique set of effects on workers and organizations. We also present a nuanced result related to the degree of geographic flexibility. Specifically, we find that a "middling" amount of geographic flexibility (i.e., PHP>50) is worse than very little flexibility (i.e., PHP<50) or a very strong case of geographic flexibility (i.e., WFA), evinced by the relative comparison of work output reported in Table 4. This finding has practical implications for managers, suggesting that if a company hopes to enjoy the motivational benefits of increased perceived autonomy through the provision of a WFA regime, it must "cut the umbilical cord," giving employees true autonomy, rather than a piecemeal granting of autonomy.[8]

We also contribute to the literature on incentives (Gambardella, Panico, & Valentini, 2015; Kryscynski, 2011; Sauermann & Cohen, 2010; Stern, 2004). Our study suggests that the provisioning of an incentive such as WFA can create value for the firm while keeping wages constant, via an increase in worker productivity. In particular, we find not only that WFA workers who relocated were more likely to move to lower cost-of-living locations, but also that the workers who enjoyed higher-than-average cost-of-living savings (and thus a higher effective increase in real wages) demonstrated higher increases in productivity than relocating employees enjoying lower-than-average cost-of-living savings. These two findings taken together suggest a scenario in which a nonpecuniary incentive results in a pecuniary benefit to employees and firms alike. The pecuniary benefit of a reduced cost of living is equivalent to an increase in real income, which has been linked to increased employee satisfaction and productivity (Leana & Meuris, 2015). While this result may not replicate for all types of workers in all organizations, it suggests that WFA could potentially be

[8] Wiedner & Mantere (2019) make a similar argument in the context of organizational separation.

used as an effective firm-specific incentive to attract and retain skilled employees (Coff & Kryscynski, 2011; Kryscynski, 2011).

Our study has several limitations. Similar to Bloom, et al. (2015), our study is focused on a single organization. Additionally, it is plausible that in other settings where workers have greater dependence on coworkers and supervisors to accomplish their tasks, increased coordination costs might offset the gains from higher productivity. Future work should validate our findings in other settings that exhibit other forms of interdependence (i.e. sequential and reciprocal interdependence), where the worker might not have relevant prior task-specific human capital, and/or where the task is more or less routine compared to patent examination. Building on Kryscynski (2011), we posit that nonpecuniary incentives such as WFA can and should be firm specific. For instance, a firm could choose to provide a WFA option to experienced employees if the tasks performed by knowledge workers in the firm exhibit properties of pooled interdependence. However, WFA may not create value for other firms with stronger (i.e., reciprocal or sequential) interdependence regimes, and future research could examine this proposition.

Our results showing that differences in tenure at the USPTO are correlated to the worker's choice of geographic location open up avenues for future research. Our correlational finding that higher-tenured workers are more likely to choose a geographic location such as Florida (which is arguably better suited as a preretirement destination) suggests that future work can explore whether WFA could have *career-extending* benefits, motivating workers closer to retirement to remain in the workforce and be productive.

Our research contributes to a very active managerial debate on the effectiveness of WFA. In February 2013, then-CEO Marissa Mayer famously rescinded the remote work program at Yahoo!, explaining in a company memo, "Some of the best decisions and insights come from hallway and cafeteria discussions, meeting new people, and impromptu team meetings. Speed and quality are often sacrificed when we work from home. We need to be one Yahoo!, and that starts with physically being together" (Swisher, 2013). Yet, along with these highly visible retreats from WFA regimes, other employers continue (typically with less fanfare) to increase WFA opportunities and more generally support the concept of remote work. Akamai's "Akamai Anywhere" WFA policy is one such example (Mayer, 2017). In promoting the agency's WFA policy, NASA's Chief Technology Officer noted that, "The potential exists for… an employee's office to expand from a 12' by 12' room to virtually everywhere" (Porterfield, 2016).

A series of empirical studies around WFA could help resolve this debate. It is plausible that the gains from WFA are restricted to settings where workers are approaching diminishing returns in learning from peers and/or are relatively less dependent on coworkers and supervisors to accomplish their tasks. Hence, it would be interesting to replicate our study in settings with varying degrees of worker interdependence (e.g., designers, software developers). Future research could also study the duration of physical colocation required for new hires to acquire the tacit knowledge needed to perform the task with no increase in rework after moving to a WFA program. Similarly, study of the conditions (if any) under which workers could benefit from learning from other remote workers and knowledge spillovers among WFA workers could be beneficial. For example, it has been suggested that "innovation spaces," such as coworking spaces and incubators, are becoming a source of knowledge transfer that promotes innovation and collaboration (Wagner & Watch, 2017). This argument suggests that there could be an optimal WFA policy that allows employees to interact to some degree with professional peers in a *physical* collaborative setting close to their chosen geography. These workers may experience increased productivity benefits from knowledge spillovers in their home geography, though this empirical question requires further exploration.

Thinking beyond the immediate debate around WFA and firm productivity, we believe that future research on WFA could also help inform managerial decision-making in the context of newer structures used to organize knowledge workers. A number of firms, primarily in the software and technology fields (such as Mozilla and Art & Logic), are structured as virtual organizations in which WFA is the dominant form of work (Reynolds, 2014). Many of these "all-remote" firms have also adopted new-generation technology tools; internal social tools such as Slack, Yammer, and Chatter, or embedded applications such as Microsoft Teams and JIRA are being implemented at a staggering rate Leonardi & Neeley (2017). With these technologies further enabling WFA, researchers and firms will likely continue to explore the conditions under which geographic flexibility can contribute positively to remote worker productivity. Finally, the notion of geographic flexibility introduced in this study might have career-enhancing and career-extending effects; future research should study whether and when firms can extend the productivity of aging workers by giving them autonomy to relocate to "retirement-friendly" destinations.

As technology continues to expand avenues for communication and collaboration among virtual coworkers, and as major business centers grow more populous and congested, there is a need to develop our understanding of how granting geographic flexibility via policies such as WFA affects productivity. To the best of our knowledge, our study represents the first set of robust econometric results on the productivity effects of moving workers from a WFH to a WFA regime and makes a contribution to the literature on remote work, nonstandard work, and nonpecuniary incentives.

References

Agarwal, R., & Ohyama, A. (2013). Industry or Academia, Basic or Applied? Career Choices and Earnings Trajectories of Scientists. *Management Science*, *59*(4), 950–970.

Akerlof, G. A., & Kranton, R. E. (2005). Identity and the Economics of Organizations. *Journal of Economic Perspectives*, *19*(1), 9–32.

Argote, L., & Miron-Spektor, E. (2011). Organizational Learning: From Experience to Knowledge. *Organization Science*, *22*(5), 1123–1137.

Azoulay, P., Graff Zivin, J. S., & Manso, G. (2011). Incentives and creativity: Evidence from the academic life sciences. *RAND Journal of Economics*, *42*(3), 527–554.

Bélanger, F. (1999). Workers' propensity to telecommute: An empirical study. *Information & Management*, *35*(3), 139–153.

Bessen, J. (2008). The value of U.S. patents by owner and patent characteristics. *Research Policy*, *37*(5), 932–945.

Bloom, N., Liang, J., Roberts, J., & Ying, Z. J. (2015). Does Working from Home Work? Evidence from a Chinese Experiment. *The Quarterly Journal of Economics*, *130*(1), 165–218.

Briscoe, F. (2007). From Iron Cage to Iron Shield? How Bureaucracy Enables Temporal Flexibility for Professional Service Workers. *Organization Science*, *18*(2), 297–314.

Cable, D. M., & Turban, D. B. (2003). The Value of Organizational Reputation in the Recruitment Context: A Brand-Equity Perspective. *Journal of Applied Social Psychology*, *33*(11), 2244–2266.

Campbell, B., Coff, R., & Kryscynski, D. (2012). Rethinking sustained competitive advantage from human capital. *The Academy of Management Review*, *37*(3), 376–395.

Carnahan, S., Agarwal, R., & Campbell, B. A. (2012). Heterogeneity in turnover: The effect of relative compensation dispersion of firms on the mobility and entrepreneurship of extreme performers. *Strategic Management Journal*, *33*(12), 1411–1430.

Choudhury, P., Khanna, T., & Mehta, S. (2017). *The Future of Patent Examination at the USPTO* (No. HBS No. 617-027). Harvard Business School Publishing.

Chu, D., Bergrud, E., Lavigna, R. J., McGrath, B., & Reeder, F. S. (2015). *The USPTO: A Telework Internal Control and Program Review* (No. 2194). Retrieved from National Academy of Public Administration website: http://www.laipla.net/wp-content/uploads/2015/08/NAPAtelework2015.pdf

Coff, R., & Kryscynski, D. (2011). Invited Editorial: Drilling for Micro-Foundations of Human Capital–Based Competitive Advantages. *Journal of Management*, *37*(5), 1429–1443.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35*(1), 128–152.

Cooper, C. D., & Kurland, N. B. (2002). Telecommuting, professional isolation, and employee development in public and private organizations. *Journal of Organizational Behavior*, *23*(4), 511–532.

Council of Economic Advisers. (2010). *Work-life balance and the economics of workplace flexibility*. Washington, D.C.: Executive Office of the President, Council of Economic Advisers.

Cramton, C. D. (2001). The Mutual Knowledge Problem and Its Consequences for Dispersed Collaboration. *Organization Science*, *12*(3), 346–371.

Dahl, M., & Sorenson, O. (2010a). The migration of technical workers. *Journal of Urban Economics*, *67*(1), 33–45.

Dahl, M., & Sorenson, O. (2010b). The Social Attachment to Place. *Social Forces*, *89*(2), 633–658.

Ederer, F., & Manso, G. (2013). Is Pay for Performance Detrimental to Innovation? *Management Science*, *59*(7), 1496–1513.

Edmondson, A. C., & McManus, S. E. (2007). Methodological Fit in Management Field Research. *The Academy of Management Review*, *32*(4), 1155–1179.

Evans, J. A., Kunda, G., & Barley, S. R. (2004). Beach Time, Bridge Time, and Billable Hours: The Temporal Structure of Technical Contracting. *Administrative Science Quarterly*, *49*(1), 1–38.

Fatherly. (2016, May 10). 30. Akamai: The Best Places for New Dads to Work In 2016. Retrieved April 15, 2019, from Fatherly website: https://www.fatherly.com/love-money/work-money/akamai-50-best-places-for-new-dads-to-work-for-in-2016/

Fehr, E., Herz, H., & Wilkening, T. (2013). The Lure of Authority: Motivation and Incentive Effects of Power. *American Economic Review*, *103*(4), 1325–1359.

Gajendran, R., & Harrison, D. (2007). The good, the bad, and the unknown about telecommuting: Meta-analysis of psychological mediators and individual consequences. *Journal of Applied Psychology*, *92*(6), 1524–1541.

Gallup, Inc. (2017). *State of the American Workplace 2017*. Washington, D.C.: Gallup, Inc.

Gambardella, A., Panico, C., & Valentini, G. (2015). Strategic incentives to human capital: Strategic Human Capital. *Strategic Management Journal*, *36*(1), 37–52.

Ganco, M., Ziedonis, R. H., & Agarwal, R. (2015). More stars stay, but the brightest ones still leave: Job hopping in the shadow of patent enforcement. *Strategic Management Journal*, *36*(5), 659–685.

Gibbons, R., & Waldman, M. (2004). Task-Specific Human Capital. *American Economic Review*, *94*(2), 203–207.

Gibson, C. B., & Gibbs, J. L. (2006). Unpacking the Concept of Virtuality: The Effects of Geographic Dispersion, Electronic Dependence, Dynamic Structure, and National Diversity on Team Innovation. *Administrative Science Quarterly*, *51*(3), 451–495.

Glassdoor. (2018, November 14). 7 Companies with Work-From-Anywhere Jobs. Retrieved April 15, 2019, from Glassdoor website: https://www.glassdoor.com/blog/companies-work-from-anywhere-jobs/

Glassdoor. (2019, November 18). 11 Companies That Let You Work Remotely. Retrieved April 15, 2019, from Glassdoor website: https://www.glassdoor.com/blog/companies-that-let-you-work-remotely/

Golden, T. D., Veiga, J. F., & Dino, R. N. (2008). The impact of professional isolation on teleworker job performance and turnover intentions: Does time spent teleworking, interacting face-to-face, or having access to communication-enhancing technology matter? *Journal of Applied Psychology*, *93*(6), 1412–1421.

Golden, T. D., Veiga, J. F., & Simsek, Z. (2006). Telecommuting's differential impact on work-family conflict: Is there no place like home? *Journal of Applied Psychology*, *91*(6), 1340–1350.

Grant, R. M. (1996). Toward a Knowledge-Based Theory of the Firm. *Strategic Management Journal*, *17*, 109–122.

Greenwood, M. J. (1975). Research on Internal Migration in the United States: A Survey. *Journal of Economic Literature*, *13*(2), 397–433.

Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: Test of a theory. *Organizational Behavior and Human Performance*, *16*(2), 250–279.

Katila, R., & Ahuja, G. (2002). Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction. *The Academy of Management Journal*, *45*(6), 1183–1194.

Kolstad, J. T. (2013). Information and Quality When Motivation is Intrinsic: Evidence from Surgeon Report Cards. *American Economic Review*, *103*(7), 2875–2910.

Kossek, E. E., Lautsch, B. A., & Eaton, S. C. (2006). Telecommuting, control, and boundary management: Correlates of policy use and practice, job control, and work–family effectiveness. *Journal of Vocational Behavior*, *68*(2), 347–367.

Kryscynski, D. (2011). The Strategic Implications of Firm-Specific Incentives—Dissertation. *SSRN Electronic Journal*.

Lazear, E. P., & Shaw, K. L. (2007). Personnel Economics: The Economist's View of Human Resources. *Journal of Economic Perspectives*, *21*(4), 91–114.

Leana, C. R., & Meuris, J. (2015). Living to Work and Working to Live: Income as a Driver of Organizational Behavior. *The Academy of Management Annals*, *9*(1), 55–95.

Lemley, M. A., & Sampat, B. (2012). Examiner Characteristics and Patent Office Outcomes. *The Review of Economics and Statistics*, *94*(3), 817–827.

Leonardi, P., & Neeley, T. (2017). What Managers Need to Know About Social Tools. *Harvard Business Review*, *95*(6), 118–126.

Makarius, E. E., & Larson, B. Z. (2017). Changing the Perspective of Virtual Work: Building Virtual Intelligence at the Individual Level. *Academy of Management Perspectives*, *31*(2), 159–178.

Malhotra, A., & Majchrzak, A. (2014). Enhancing performance of geographically distributed teams through targeted use of information and communication technologies. *Human Relations*, *67*(4), 389–411.

Mas, A., & Pallais, A. (2017). Valuing Alternative Work Arrangements. *American Economic Review*, *107*(12), 3722–3759.

Mayer, K. (2017, September 10). Benefits Professional of the Year creates a balance for Akamai employees. Retrieved November 25, 2019, from Employee Benefit News website: https://www.benefitnews.com/news/benefits-professional-of-the-year-creates-a-balance-for-akamai-employees

Moretti, E. (2013). Real Wage Inequality. *American Economic Journal: Applied Economics*, *5*(1), 65–103.

NASA. (2018). Work From Anywhere – NASA's Telework Program. Retrieved April 15, 2019, from https://searchpub.nssc.nasa.gov/servlet/sm.web.Fetch/2018_Work_From_Anywhere_Notice.pdf?rhid=1000&did=6071742&type=released

Pfeffer, J., & Langton, N. (1993). The Effect of Wage Dispersion on Satisfaction, Productivity, and Working Collaboratively: Evidence from College and University Faculty. *Administrative Science Quarterly*, *38*(3), 382–407.

Porterfield, M. (2016, May 31). Work From Anywhere: How to Land That Bigger Office. Retrieved November 25, 2019, from NASA website: http://www.nasa.gov/content/work-from-anywhere-how-to-land-that-bigger-office

Rein, L. (2014, August 10). Patent office filters out worst telework abuses in report to its watchdog. *The Washington Post*. Retrieved from https://www.washingtonpost.com/politics/patent-office-filters-out-worst-telework-abuses-in-report-to-watchdog/2014/08/10/cd5f442e-1e4d-11e4-82f9-2cd6fa8da5c4_story.html

Rein, Lisa. (2016, August 31). Patent office workers bilked the government of millions by playing hooky, watchdog finds. *The Washington Post*. Retrieved from https://www.washingtonpost.com/news/powerpost/wp/2016/08/31/patent-office-workers-cost-taxpayers-millions-by-playing-hooky-watchdog-finds/?arc404=true

Reynolds, B. W. (2014, March 14). 26 Virtual Companies That Thrive on Remote Work. Retrieved November 25, 2019, from FlexJobs website: https://www.flexjobs.com/blog/post/25-virtual-companies-that-thrive-on-remote-work/

Reynolds, B. W. (2019, August 12). Top 25 Companies Hiring for Work-from-Anywhere Remote Jobs. Retrieved September 15, 2019, from FlexJobs website: https://www.flexjobs.com/blog/post/top-companies-work-from-anywhere-remote-jobs/

Rosenkopf, L., & McGrath, P. (2011). Advancing the Conceptualization and Operationalization of Novelty in Organizational Research. *Organization Science*, *22*(5), 1297–1311.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Sauermann, H., & Cohen, W. M. (2010). What Makes Them Tick? Employee Motives and Firm Innovation. *Management Science*, *56*(12), 2134–2153.

Sauermann, H., & Stephan, P. (2013). Conflicting Logics? A Multidimensional View of Industrial and Academic Science. *Organization Science*, *24*(3), 889–909.

Schwartz, A. (1973). Interpreting the Effect of Distance on Migration. *Journal of Political Economy*, *81*(5), 1153–1169.

Simons, J. (2017, May 18). IBM, a Pioneer of Remote Work, Calls Workers Back to the Office. *Wall Street Journal*. Retrieved from https://www.wsj.com/articles/ibm-a-pioneer-of-remote-work-calls-workers-back-to-the-office-1495108802

Sjaastad, L. A. (1962). The Costs and Returns of Human Migration. *Journal of Political Economy*, *70*(5, Part 2), 80–93.

Society for Human Resource Management. (2017). *2017 Employee Benefits: Remaining Competitive in a Challenging Talent Workplace*. Alexandria, VA.

Softchoice. (2017). Collaboration Unleashed. Retrieved November 22, 2019, from Softchoice website: https://m.softchoice.com/web/newsite/documents/research/SoftchoiceResearchStudy_CollaborationUnleashed.pdf

Srikanth, K., & Puranam, P. (2014). The Firm as a Coordination System: Evidence from Software Services Offshoring. *Organization Science*, *25*(4), 1253–1271.

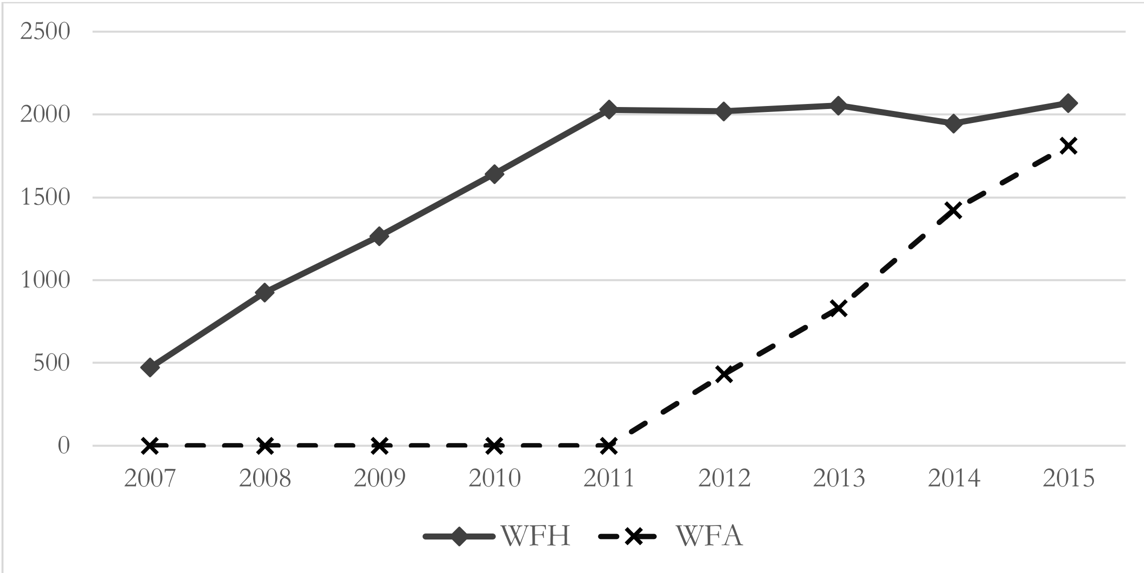
Starr, E., Ganco, M., & Campbell, B. A. (2018). Strategic human capital management in the context of cross-industry and within-industry mobility frictions. *Strategic Management Journal*, *39*(8), 2226–2254.

Stern, S. (2004). Do Scientists Pay to Be Scientists? *Management Science*, *50*(6), 835–853.

Swisher, K. (2013, February 22). Here's the Internal Yahoo No-Work-From-Home Memo. Retrieved November 18, 2019, from: http://allthingsd.com/20130222/physically-together-heres-the-internal-yahoo-no-work-from-home-memo-which-extends-beyond-remote-workers/

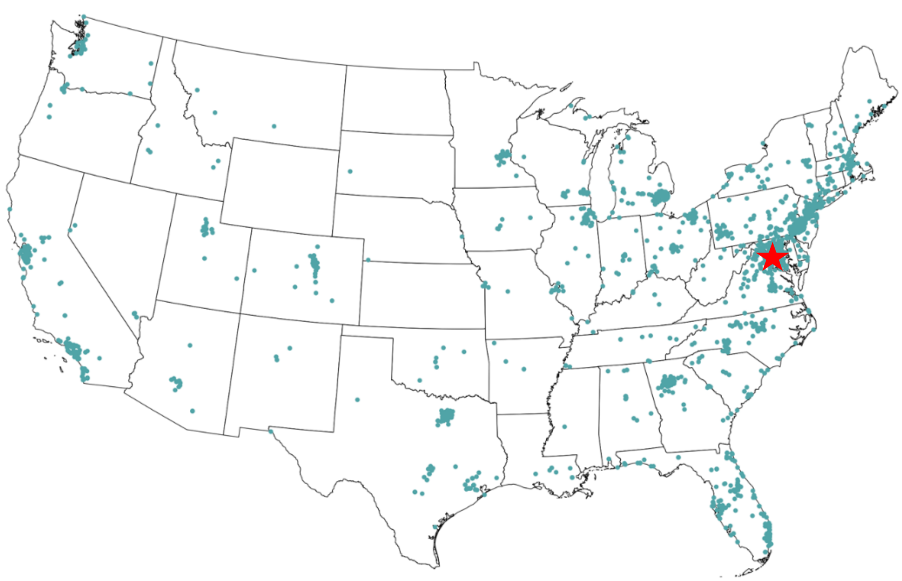
Thompson, J. D. (1967). *Organizations in action*. New York: McGraw-Hill.
United States Government Accountability Office. (2008). *U.S. Patent and Trademark Office: Hiring Efforts Are Not Sufficient to Reduce the Patent Application Backlog, Testimony Before the Subcommittee on Courts, the Internet, and Intellectual Property, Committee on the Judiciary, House of Representatives.* (GAO Report No. GAO-08-527T). Retrieved from https://www.gao.gov/new.items/d08527t.pdf
United States Patent and Trademark Office. (2013, December 18). U.S. Patent and Trademark Office Ranks #1 in Best Places to Work in the Federal Government. Retrieved November 25, 2019, from https://www.uspto.gov/about-us/news-updates/us-patent-and-trademark-office-ranks-1-best-places-work-federal-government
United States Patent and Trademark Office. (2015). *USPTO Telework Annual Report 2015*. Retrieved from https://www.uspto.gov/sites/default/files/documents/TeleworkAnnualReport2015-508.pdf
United States Patent and Trademark Office. (2017). *Performance and Accountability Report FY 2017*. Retrieved from https://www.uspto.gov/sites/default/files/documents/USPTOFY17PAR.pdf
Wagner, J., & Watch, D. (2017). *Innovation Spaces: The New Design of Work*. Retrieved from The Brookings Institution website: https://www.brookings.edu/wp-content/uploads/2017/04/cs_20170404_innovation_spaces_pdf.pdf
Wiedner, R., & Mantere, S. (2019). Cutting the Cord: Mutual Respect, Organizational Autonomy, and Independence in Organizational Separation Processes. *Administrative Science Quarterly*, *64*(3), 659–693.

FIGURE 1 Growth in Number of Remote Workers at the USPTO



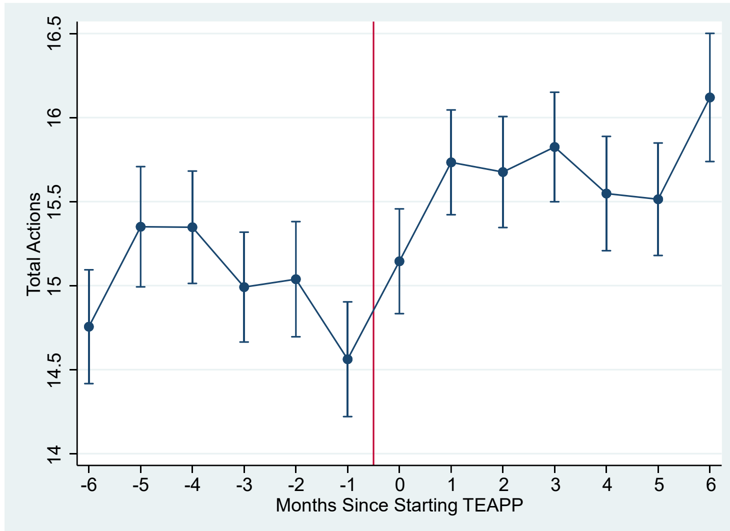
This figure illustrates the annual number of examiners enrolled in two remote work programs at the USPTO: WFA (TEAPP) and PHP.

FIGURE 2 WFA Examiner Locations



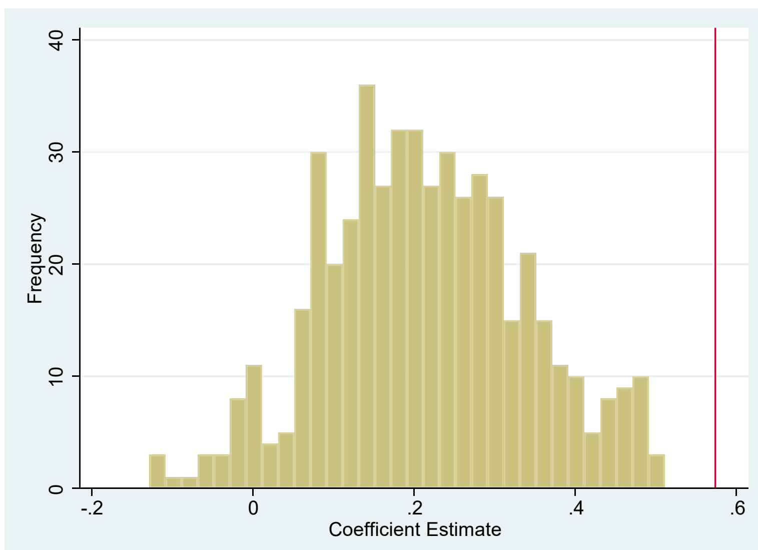
This figure illustrates the spatial distribution of WFA examiners at the USPTO as of August 2016. Each dot corresponds to a single unique examiner. Alexandria, Virginia (USPTO headquarters) is denoted by a red star.

FIGURE 3 Difference-in-Differences Graph for Treatment



This figure plots the month-specific fixed effect coefficients estimated from a regression of total actions on controls for examiner, expectancy, grade level, and year. Standard errors are clustered at the art unit level. Treatment (TEAPP) is indicated with the red vertical line.

Figure 4 Placebo Test



Notes. The analyses conducted here are as follows: There are 831 patent examiners in our dataset. For each of these examiners, we know the month they started participating in TEAPP. To perform one iteration of the placebo test, we shuffle the start month for all examiners—that is, we randomly assign, without replacement, when each examiner starts TEAPP. We merge these placebo treatments back into the panel dataset and recompute the WFA dummy that indicates whether the current month t is greater than or equal to examiner i's start month. We re-estimate the regression associated with Table 2 Column 2 with this new dummy variable (all other variables are the same), and we record the coefficient estimate associated with the synthetic treatment variable. We do this 500 times with different random shuffles of start date. Finally, we calculate a p-value by computing the proportion of the 500 iterations that yield coefficient estimates larger than what we find using the true data. None of the 500 estimates are greater than 0.574 ($p < 0.002$).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
TABLE 1 Descriptive Statistics and Correlation Matrix: Full Sample													
(1) Total Action	1.000	0.431	0.589	0.734	0.457	0.093	0.118	0.016	-0.242	0.023	0.032	0.291	0.261
(2) Total RCE		1.000	-0.074	0.260	0.239	0.098	-0.028	0.019	-0.006	-0.061	-0.010	0.082	-0.004
(3) FOA			1.000	0.433	0.177	-0.044	0.129	0.008	-0.247	0.078	0.040	0.168	0.246
(4) Reject				1.000	0.722	0.159	0.016	-0.022	-0.165	-0.055	0.016	0.111	0.064
(5) Examiner Cites					1.000	0.127	-0.097	0.001	-0.084	-0.123	-0.009	-0.076	-0.129
(6) WFA (TEAPP)						1.000	-0.325	-0.164	0.025	-0.456	0.029	0.143	0.053
(7) PHP (<50 miles)							1.000	-0.288	-0.031	0.642	0.006	0.383	0.357
(8) PHP (>50 miles)								1.000	0.014	-0.402	0.027	0.084	-0.024
(9) Mean Expectancy									1.000	-0.034	-0.074	0.027	-0.005
(10) Nearby Examiners										1.000	-0.038	0.183	0.220
(11) Distant Examiners											1.000	0.026	0.031
(12) GS												1.000	0.690
(13) Primary Examiner													1.000
Mean	11.375	1.347	4.306	6.500	15.238	0.076	0.198	0.070	23.183	1258.06	149.586	12.552	0.403
Std Dev	7.039	1.581	3.931	4.329	13.835	0.264	0.399	0.255	5.143	1131.38	362.223	1.919	0.490
Min	1	0	0	0	0	0	0	0	6.6	0	0	0	0
Max	167	18	160	58	208	1	1	1	31.6	2399	2263	15	1
n (non-missing)	576,274	576,274	576,274	477,305	477,305	576,274	576,274	576,274	576,274	322,155	322,155	576,274	576,274

Notes. Observations are at the examiner-month level. The full sample uses all examiners in our dataset, regardless of their remote work status. The "WFA causal sample" (reported in Appendix 4) refers to examiners who transitioned to WFA in 2012 or 2013.

TABLE 2 Causal Estimates of WFA on Productivity

Variables	(1) Total Actions	(2) Total Actions	(3) Total RCEs	(4) Total RCEs
WFA	0.509	0.574	-0.0540	0.00123
	p = 0.014	p = 0.000	p = 0.293	p = 0.973
Controls:				
Expectancy	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Grade Fixed Effects	Yes	Yes	Yes	Yes
Examiner Fixed Effects	No	Yes	No	Yes
Observations	65,694	65,694	65,694	65,694
Adjusted R-squared	0.358	0.553	0.143	0.279

Notes. Standard errors are clustered at the art unit level. Observations are at the examiner-month level and utilize the "WFA sample" of experienced examiners for Columns (1) through (4)—a subset of the main dataset that is limited to examiners who transitioned to WFA in 2012 or 2013. WFA is an indicator variable that turns on for examiner-months that transitioned into the WFA (i.e. TEAPP) program. Controls are indicated in the table above. All columns utilize data from 2007–2015.

.**TABLE 3** Degree of geographic flexibility – WFA vs. WFH

Variables	(1) Total Actions	(2) Total Actions
PHP (<50 Miles)	1.339	1.035
	p = 0.000	p = 0.000
PHP (>50 Miles)	1.131	0.487
	p = 0.000	p = 0.000
WFA	1.792	1.022
	p = 0.000	p = 0.000
Controls:		
Expectancy	Yes	Yes
Year Fixed Effects	Yes	Yes
Grade Level Fixed Effects	Yes	Yes
Examiner Fixed Effects	No	Yes
Observations	576,267	576,267
Adjusted R-squared	0.354	0.562

Notes. Standard errors are clustered at the art unit level. Observations are at the examiner-month level and utilize the full sample of examiners. WFA is an indicator variable that turns on for examiner-months that transitioned into the TEAPP WFA program. PHP <50 and >50, respectively, are indicator variables that identify examiner-months that have transitioned into the two PHP programs. The two PHP programs are akin to a traditional WFH program, with less geographic flexibility than a WFA program. Controls are indicated in the table above and may include year fixed effects, grade level (GS) fixed effects, expectancy (a measure of expected effort/output on an examiner-month level), and examiner fixed effects).

TABLE 4 Cost-of-Living Reduction

Variables	(1) Cost-of-Living Reduction	(2) Cost-of-Living Reduction
PHP (<50 Miles)	0.00335	
	p = 0.938	
PHP (>50 Miles)	18.57	

	p = 0.000	
WFA	18.54	3.030
	p = 0.000	p = 0.000
Controls:		
Expectancy	Yes	Yes
Year Fixed Effects	Yes	Yes
Grade Level Fixed Effects	Yes	Yes
Examiner Fixed Effects	Yes	Yes
Observations	576,002	65,437
Adjusted R^2	0.828	0.761

Notes. Standard errors are clustered at the art unit level. Column (1) reports results from a regression of Cost-of-Living Reductions, indexed to 0 for Alexandria on dummies for being in either PHP program and being in WFA. Column (1) utilizes the full sample of examiners. In order to align with our main results, Column (2) reports results from the "causal sample" of examiners who transition to WFA in 2012 to 2013. Both columns limit samples to those locations with cost-of-living data and include controls for expectancy, year, and grade level, as well as examiner fixed effects. All columns utilize data from 2007–2015.

TABLE 5 Location drivers of productivity

Variables	(1) Total Actions	(2) Total Actions
WFA	0.311	0.556
	p = 0.013	p = 0.000
Below-Median Cost-of-Living * WFA	0.302	
	p = 0.006	
Florida * WFA		0.592
		p = 0.361
Controls:		
Year	Yes	Yes
Expectancy	Yes	Yes
Grade	Yes	Yes
Adjusted R^2	65,694	65,694
Observations	0.553	0.553

Notes. Observations are at the examiner-month level and utilize the 'WFA sample' of experienced examiners across both columns—a subset of the main dataset that limits to examiners that transition to WFA in 2012 or 2013. WFA is an indicator variable that turns on for examiner-months that have transitioned into the WFA (i.e. TEAPP) program. Controls are indicated in the table above, and include year fixed effects, grade level (GS) fixed effects, and expectancy (a measure of expected effort/output on an examiner-month level). All columns utilize data from 2007–2015. Heteroskedasticity-robust standard errors were used in this estimation exercise.

TABLE 6 Choice of Geographic Location by WFA Examiners

Variables	(1) In Florida	(2) In Florida
Grade 14 and Above	0.008	-0.229
	p = 0.579	p = 0.156
Tenure (Years)		0.006
		p = 0.001

Observations	2,064	2,064
Pseudo R-squared	0.001	0.007

Notes. Table presents coefficient estimates from two OLS regressions. Heteroskedasticity robust errors appear in parentheses. Observations are at the examiner level. The sample is restricted to examiners participating in the WFA (i.e., TEAPP) program.

TABLE 7 Effects of Mandated IT Use

Variables	(1) Total Actions	(2) Total RCEs
Examiner Needing Supervision	-1.119	-0.0311
	p = 0.000	p = 0.697
Mandated IT	-0.291	-0.0169
	p = 0.079	p = 0.758
Mandated IT * Examiner Needing Supervision	0.920	0.0659
	p = 0.000	p = 0.371
Controls:		
Expectancy	Yes	Yes
TEAPP Experience	Yes	Yes
Examiner Fixed Effects	Yes	Yes
Observations	19,255	19,255
Adjusted R^2	0.499	0.244

Notes. Standard errors appear in parentheses and are clustered at the art unit level. Observations are at the examiner-month level and are limited to those examiners on WFA before June 2013. Column (1) reports results from a regression of Total Actions, and Column (2) reports results for Total RCEs. Mandated IT is an indicator variable that turns on post-June 2013, and 'Examiner Needing Supervision' is an indicator for whether an examiner does not have "Full Signatory" authority and hence the work, while conducted alone, needs to be certified by a supervisor. Both columns include Expectancy, Year, and Examiner Fixed Effects, the latter of which absorbs nontemporal variation in Examiner status (i.e. needing supervision or not).

TABLE 8 Robustness tests for Selection into WFA

Variables	(1) Months to WFA	(2) Months to WFA	(3) Months to WFA
Total Action	0.00436		
	p = 0.452		
Expectancy		0.0867	
		p = 0.209	
Total RCE			0.0429
			p = 0.147
Controls:			
Grade	Yes	Yes	Yes
Observations	2,771	2,771	2,771
Adjusted R-squared	0.002	0.003	0.003

Notes. All columns reflect regressions with the sample of examiners who received WFA in 2012 or 2013, limited to years prior to 2012 in order to observe pre-WFA performance. Observations are at the examiner year level, where Columns (1)–(3) estimate models testing whether prior output, expectancy, and rework are associated with the time it takes for an examiner to transition to WFA, the key source of causal variation in this study. Standard errors are clustered at the grade level.

TABLE 9 Robustness Tests for Examiner Effort and Leniency

Variables	(1) FOAs	(2) Rejections	(3) Examiner-Added Citations
WFA	0.135	0.194	-0.242
	p = 0.038	p = 0.032	p = 0.401
Controls:			
Expectancy	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Grade Fixed Effects	Yes	Yes	Yes
Examiner Fixed Effects	Yes	Yes	Yes
Observations	55,791	55,791	55,791
Adjusted R^2	0.325	0.392	0.467

Notes. Standard errors are clustered at the art unit level. Observations are at the examiner-month level, where Column (1) utilizes first office actions (FOAs) as an outcome variable, Column (2) utilizes rejections as an outcome variable, and Column (3) utilizes examiner-added citations as an outcome variable. All regressions reflect analyses on the "WFA sample," limited to those with data on FOAs, rejections, and examiner-added citations. WFA is an indicator variable that turns on for examiner-months that have transitioned into the TEAPP WFA program. Controls are indicated in the table above, and include year fixed effects, grade level (GS) fixed effects, examine fixed effects, and expectancy (a measure of expected effort/output on an examiner-month level).

TABLE 10 Ruling Out Alternative Mechanisms such as Commuting Distance and Monitoring

Variables	(1) Total Actions	(2) Total Actions
TEAPP	-0.0568	0.548
	p = 0.953	p = 0.000
Controls:		
Expectancy	Yes	Yes
Year	Yes	Yes
Grade	Yes	Yes
Adjusted R^2	0.591	0.550
Observations	2,308	62,960
Sample	Examiners between 50–75 miles	Examiner >75 miles

Notes. Standard errors are clustered at the art unit level. Observations are at the examiner-month level and utilize the 'WFA sample' of experienced examiners limited to those residing within 50-75 miles of Alexandria, VA for Column (1), and those residing above 75 miles away from Alexandria, VA in Column (2)—a subset of the main dataset that limits to examiners that transition to WFA in 2012 or 2013. WFA is an indicator variable that turns on for examiner-months that have transitioned into the WFA (i.e. TEAPP) program. Controls are indicated in the table above, and include year fixed effects, grade level (GS) fixed effects, and expectancy (a measure of expected effort/output on an examiner-month level). All columns utilize data from 2007–2015.