

ONLINE APPENDIX

PROCRASTINATION IN THE WORKPLACE: EVIDENCE FROM THE U.S. PATENT
OFFICE

MICHAEL D. FRAKES AND MELISSA F. WASSERMAN

Details on Docket Management Process

In addition to meeting production quotas, patent examiners are also expected to meet workflow or docket management goals. The workflow or docket management goals seek to ensure that the flow of patent applications through the examination process align with prescribed time periods set by the Patent Office. Patent examiners have five different dockets of patent applications, wherein each docket contains patent examinations in a different stage of review. More specifically, these five dockets include: (1) new patent applications; (2) patent applications which have been amended in response to an office action; (3) patent application for which a final office action has been sent; (4) patent application in which a supervisor has issued a correction; (5) patent application on an accelerated examination schedule. Each docket has an “expected average days” for completion. Once a patent application is docketed, a clock begins to count down from the expected average days for review for that docket. Examiners are expected to complete review of an application before its workflow clock expires. As a result, examiners must meet both production quotas—complete a certain number of work credits every bi week—and workflow goals—complete stages of examination review in certain timeframes. Notably, workflow goals largely align with production quotas. That is, the expected average days for completion overwhelmingly expire at the end of a production bi-week. Thus, we refer to the quota in our paper to encompass both production and workflow goals.

Model of Patent Examiner Behavior

A) Time-consistent benchmark

As a starting point, given the role of quotas in personnel outcomes at the Patent Office, we assume that patent examiners will be incentivized to hit their bi-weekly (and quarterly) production targets.¹ The question facing us is how they space out their work efforts over the observation period to reach this target. One can readily predict that a time-consistent examiner that is motivated as such will reach her goals while roughly smoothing her work efforts evenly throughout the observation period. For these purposes, we set forth a model inspired by Fischer (2001), which is well suited for our needs in that it contemplates a situation where the execution of a task requires a number of hours to complete, where those hours can be spread out over a designated period of time. With this model, we attempt to predict the time path that a rational, time-consistent patent examiner will follow over the course of the 10 working days in a bi-week period.

On any given day, examiners receive utility of $u(24-h)$ for receiving $24-h$ hours of leisure, where h represents the number of hours spent that day reviewing applications and where u is strictly increasing and concave. Examiners are expected to spend 80 hours over the bi-week reviewing applications, though are not obligated to spend 8 hours each day on such tasks. We assume however, that they are monitored enough that they spend greater than 0 hours per day on examinations (to avoid discussing the other corner solution possibility, we also assume that examiners will not spend the full 24 hours of any given day reviewing applications). B^t represents the exponential discount factor. Examiners select the amount of time spent reviewing applications on each of the 10 working days in the bi-week (h_0, h_1, \dots, h_9) by solving the following:

¹ This assumption is supported by our interviews with examiners and former Supervisory Patent Examiner.

$$\text{Max}_{h_0, h_1, \dots, h_9 \in (0, 24)} U = \sum_{t=0}^9 u(24 - h_t) \beta^t$$

s.t.

$$\sum_{t=0}^9 h_t = 80$$

The first order conditions from this problem suggest the following relationship:²

$$u'(24-h_0) = u'(24-h_1)\beta = \dots = u'(24-h_9)\beta^9 \quad (1)$$

For any $\beta < 1$, in light of the concavity of u , it is readily apparent from these first order conditions that the number of hours selected will increase to some extent over time as the 10th day approaches.

The following equation demonstrates the degree to which hours worked change over time:³

$$\frac{h_{t+1} - h_t}{h_t} \approx \frac{(1 - \beta)}{\beta} \left(\frac{u'(24 - h_t)}{-u''(24 - h_t) * h_t} \right) \quad (2)$$

The first term on the right simply captures the degree to which examiners prefer the present. If examiners do not discount at all over this short time period, this term equals zero and examiners do not change their hours day-by-day and instead smooth their work efforts over time. The second term captures the elasticity of intertemporal substitution for leisure (EIS). Essentially, whatever change in the temporal work path brought about by general time preferences is mediated by the degree to which examiners will entertain deviating from a smooth leisure profile over time.

Noting that the literature generally estimates an EIS of less than 1, Fischer (2001) conservatively assumes an EIS of 1 and thereafter suggests that a daily change in hours worked of just 1% would

² This follows naturally from the fact that each first order conditions suggests $u'(24-h_t)\beta^t = \lambda$, for each t .

³ To derive this equation, we follow Fischer (2001) and start with the observation that $u''(24-h_t) \approx -\Delta u'(24-h_t) / \Delta h_t = -(u'(24-h_{t+1}) - u'(24-h_t)) / (h_{t+1} - h_t)$. From this, we derive $(h_{t+1} - h_t) / h_t = -(u'(24-h_{t+1}) - u'(24-h_t)) / u''(24-h_t)h_t$. The next step is to replace the numerator of the right-hand-side of this preceding equation. For these purposes, we note that the first order conditions from the above maximization problem suggests: $u'(24-h_t)\beta^t = u'(24-h_{t+1})\beta^{t+1} = \beta^{t+1} (u'(24-h_{t+1}) - u'(24-h_t)) + \beta^{t+1} u'(24-h_t)$. Reorganizing, this suggests that $u'(24-h_{t+1}) - u'(24-h_t) = ((\beta^t - \beta^{t+1}) / \beta^{t+1}) * u'(24-h_t)$. Inserting this into the above equation, we find: $(h_{t+1} - h_t) / h_t = -((1 - \beta) / \beta) * (u'(24-h_t) / (u''(24-h_t)*h_t)) = ((1 - \beta) / \beta) * (u'(24-h_t) / (-u''(24-h_t)*h_t))$.

require an annual rate of time preference ($\frac{1-\beta}{\beta}$) of 3800% or an annual β of a staggeringly low 0.026.⁴ If instead one assumes a perhaps more reasonable annual β of 0.75, this analysis would suggest a near 0% daily increase in hours worked—i.e., a smooth time path in work effort over relatively short periods of time.⁵ Accordingly, we predict that a patent examiner that discounts future utility exponentially and that has time-consistent preferences will tend to smooth her work efforts near evenly over the bi-week observation period (a prediction that is intuitive in light of the assumed concavity in utility for leisure).

B) Time-Inconsistent Predictions

The above framework can be extended to introduce sources of time-inconsistency in behaviors. For instance, examiners might discount future leisure in a quasi-hyperbolic manner (Laibson 1997). That is, an examiner at time 0 may discount leisure at time 1 at $B\delta$, leisure at time 2 at $B^2\delta$, and so on and so forth; essentially, in this framework, the examiner wants to discount tomorrow's leisure by $B\delta$, even though the examiner today wants her future self to follow normal, exponential discounting at B^t thereafter. The time inconsistency in behavior arises because tomorrow's examiner—when tomorrow arrives—will likewise tend to assign that additional δ discount for all periods beyond that date. Modifying the above framework to incorporate a present bias of this nature, examiners at time t solve the following:

$$\begin{aligned} & \text{Max} \\ & h_t, h_{t+1}, \dots, h_9 \in (0, 24) \quad U = u(24 - h_t) + \sum_{i=1}^{9-t} u(24 - h_{t+i}) \beta^i \delta \end{aligned}$$

s.t.

⁴ O'Donoghue and Rabin (2015) provide a similar discussion.

⁵ While the discount rate implied by an assumed 1% change in daily work effort may not comport with our expectations of general exponential time preferences, consider the discount rates implied by the degree of work effort changes we actually observe. In our analysis below, we find that nearly half of the work effort is completed at the end of the bi-week period suggesting as much as a 10% daily change in hours worked, which, under the same assumptions, would suggest an annual β of essentially 0 (reflecting a near complete preference for the present). This is possible but unlikely in the face of a rational, exponential discounter.

$$\sum_{i=1}^{10-t} h_i + S_t = 80$$

where S_t represents the inherited stock of hours worked from hours worked decisions in the time periods prior to t ($h_1 + h_2 + \dots h_{t-1}$). Assuming that examiners are naïve hyperbolic discounters that are not aware in time t of the fact that examiners at time $t+1$ will also attach the additional δ discount factor to periods $t+2$ and beyond, it is straightforward (based on the above analysis) to show that the first order conditions from this problem imply the following:

$$u'(24-h_0) = u'(24-h_1)\beta\delta = \dots = u'(24-h_9)\beta^9\delta \quad (3)$$

which suggests:

$$\frac{h_1 - h_0}{h_0} \approx \frac{(1 - \beta\delta)}{\beta\delta} \left(\frac{u'(24 - h_0)}{-u''(24 - h_0) * h_0} \right) \quad (4)$$

With the presence of δ , which often is thought to capture a substantial degree of discounting of tomorrow, the degree to which examiners would discount time 1 at time 0 may now be considerable enough that one would predict a notable increase in the hours worked between today and tomorrow (as distinct from the discussion above).⁶ The remainder of equation (3) suggests that the planned rate of change in hours worked over time from period 2 onwards will follow the rule set forth in equation (2) above. Of course, when period 2 arrives, the examiner will again apply a present bias in her optimization problem at that time, suggesting an hours worked amount in period 2 less than what she plans to apply in period 3, and so on and so forth. The implication of this pattern is that examiners will end-load their work efforts at the deadline, assuming again that examiners are ultimately motivated to hit their 80 hours per bi-week requirement of work.

⁶ For instance, if one assumes a δ of 0.75 (again assuming an intertemporal elasticity of substitution of 1), one would expect a roughly 1/3 increase in work effort between time 0 and time 1.

In a companion to her 2001 paper, Fischer (2001) extends this framework to allow for a sophisticated hyperbolic discounter who, at time t , decides on her current hours allocation knowing that her future self tomorrow will likewise incorporate a δ discount between tomorrow and the next day. Interestingly, Fischer's model predicts an even greater degree of procrastination to the extent that a worker today knows that her future selves will heavily prioritize current leisure, thereby encouraging her to work even less today in order to force her future selves to work more.

Accordingly, while time-consistent examiners will tend to spread their work out evenly over the observation period, examiners with present-biased preferences (or examiners who exhibit differentially discounting) will tend to delay their initial intentions to begin working towards their bi-weekly goal and cluster their work near the deadline. In the first exercise of our empirical analysis below, we test for the presence of procrastination by first assessing whether examiners indeed bunch their work product around the end of the bi-weekly (and quarterly) quotas.

Additional references:

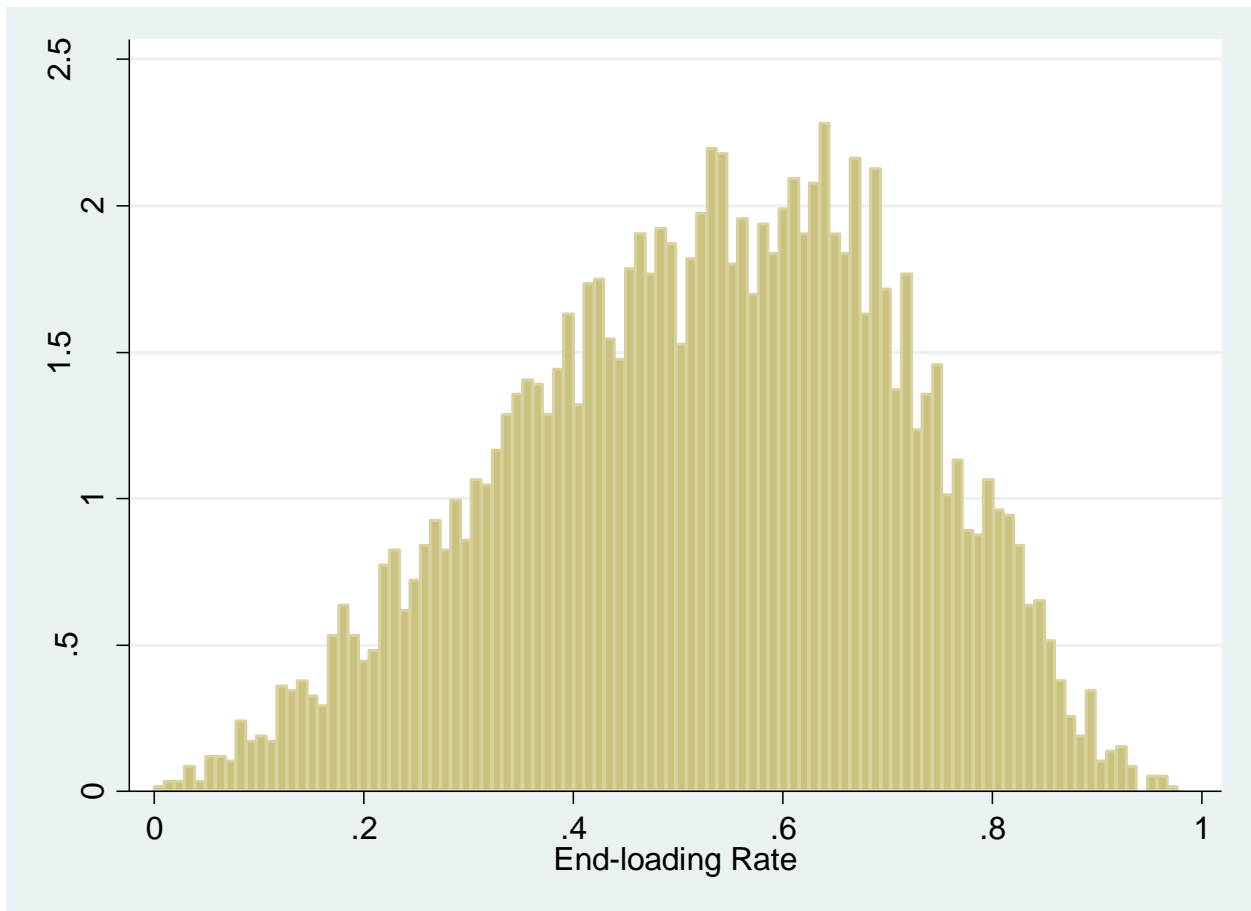
Fischer, Carolyn, "Read This Paper Even Later: Procrastination with Time-Inconsistent Preferences," RFF Discussion Paper 99-20 (2001).

End-loading Heterogeneity

To complement our demonstration of average end-loading in application reviews, we consider the possibility of heterogeneity in end-loading practices across examiners. To the extent this end-loading is indeed reflective of procrastination, we acknowledge that not all examiners are likely to exhibit the same degree of time inconsistency in work efforts. To assess the degree of heterogeneity in such behaviors, we calculate the mean rates by which each examiner completed a FOAM on the last day of a quota period and then present the distribution of these mean rates across examiners in Figure A1. Though there is considerable variance in end-loading rates across examiners, Figure A1 does demonstrate that the vast majority of examiners exhibit some striking degree of end-of-period clustering of reviews. Even at the 20th percentile of examiners (ranked according to their end-loading tendencies), nearly 35 percent of FOAMs reviewed fell on the last day of the quota period. If examiners were to smooth their workload over the 10 business days inherent in the bi-week period, one would instead expect to observe only 10 percent of applications being processed on the final day.

FIGURE A1

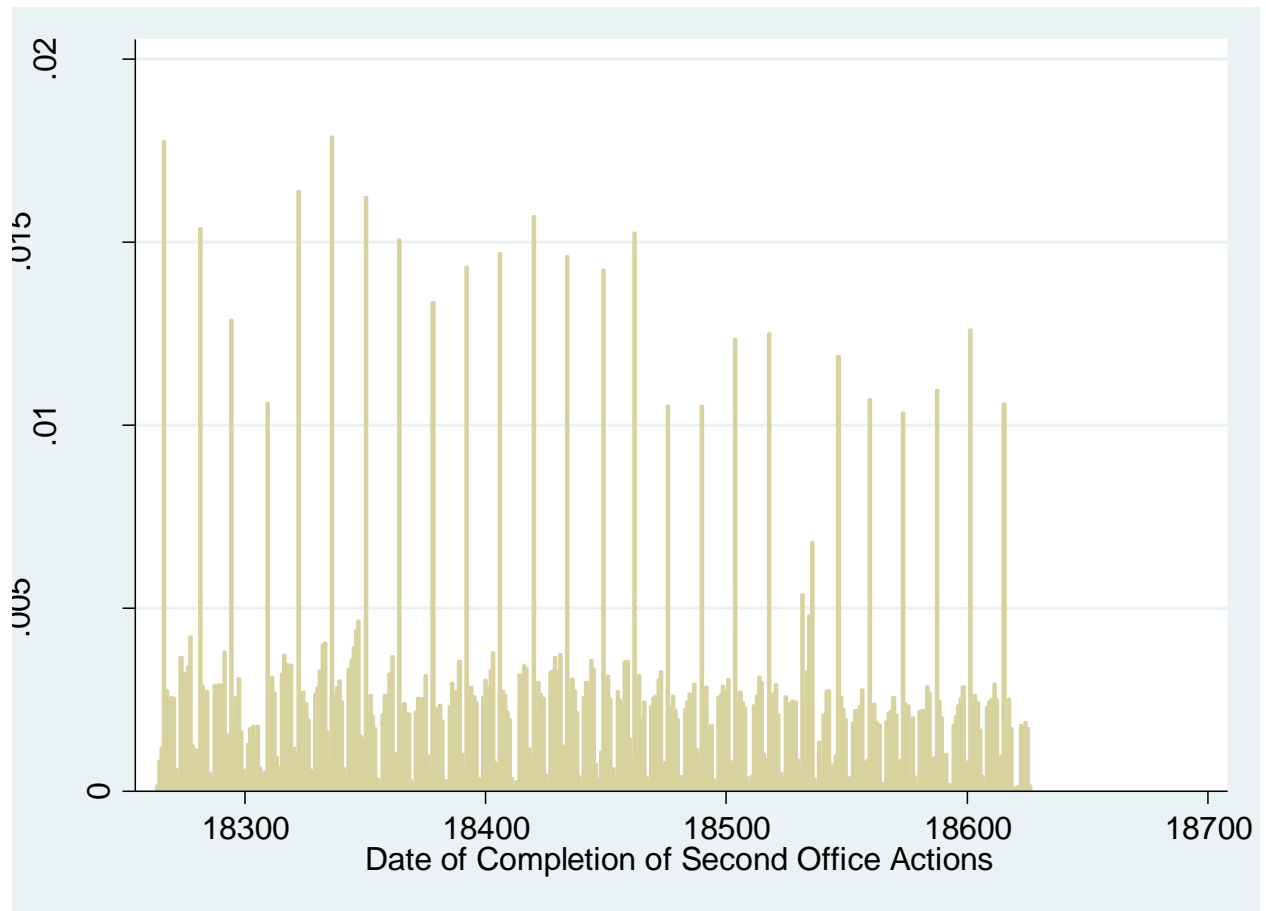
Distribution of Mean End-loading Rates across Examiners



Notes: this histogram is derived from a sample of 9,639 examiners completing first office actions represented in the Patent Office's PAIR database between March, 2001 and July, 2012 (for applications filed after March, 2001).

FIGURE A2

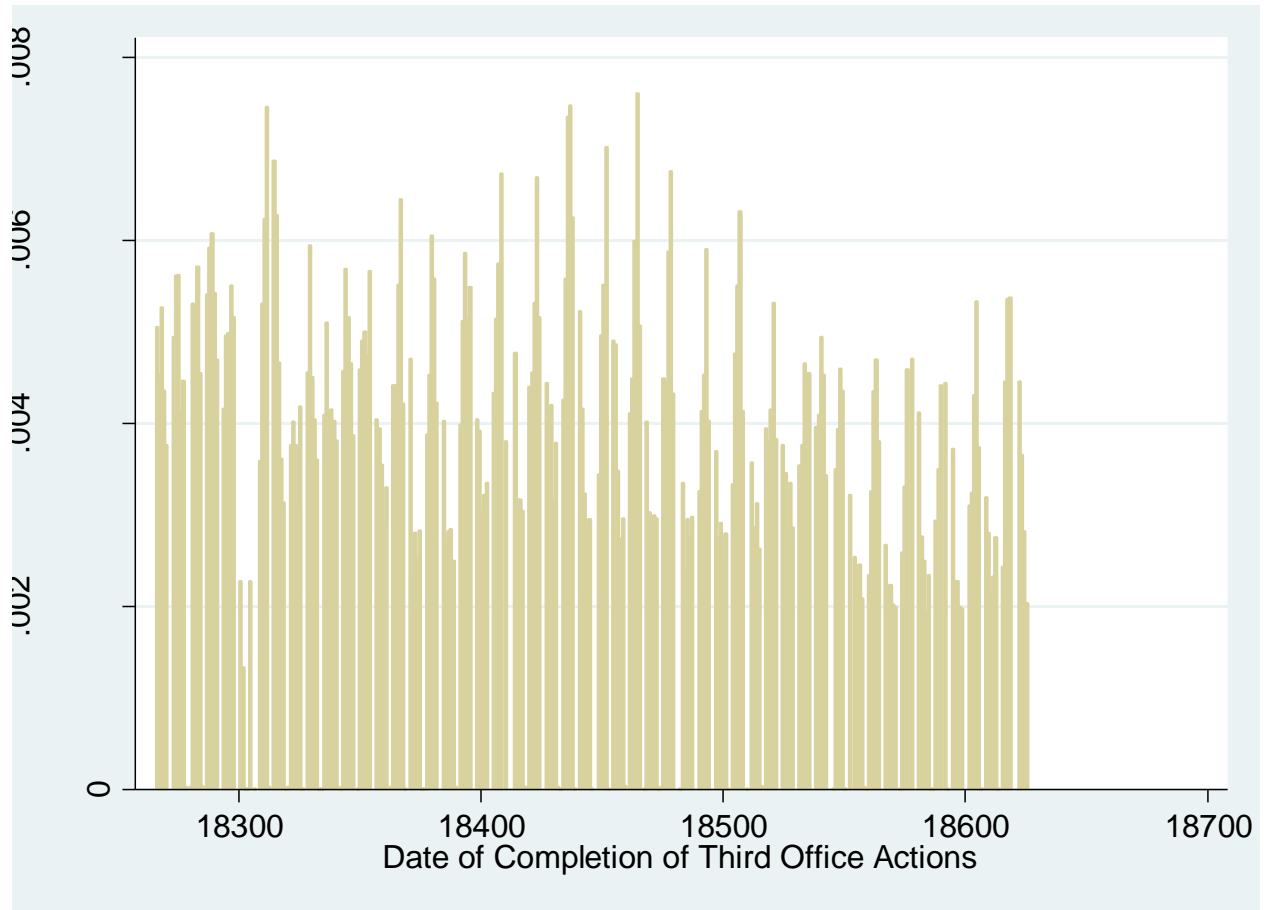
Frequency Distribution of Second-Office-Action Reviews across Individual Days in 2010



Notes: Frequency counts are from the universe of second office actions completed during the course of 2010 and were obtained from the Transaction History File of the Patent Office's PAIR database.

FIGURE A3

Frequency Distribution of Third-Office-Action Reviews across Individual Days in 2010

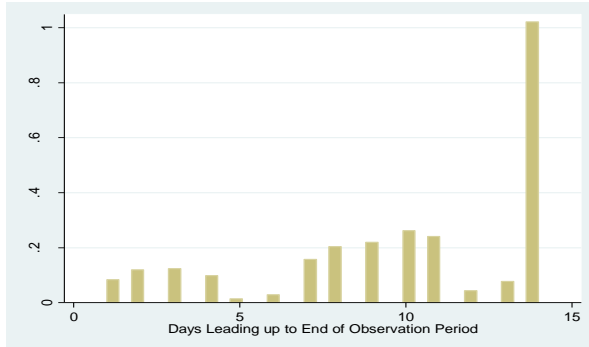


Notes: Frequency counts are from the universe of third office actions completed during the course of 2010 and were obtained from the Transaction History File of the Patent Office's PAIR database.

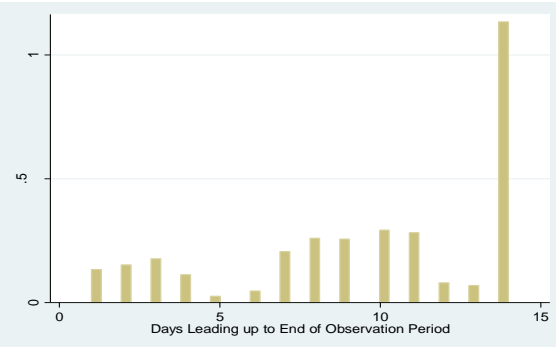
FIGURE A4

Generalized Bi-Weekly Histogram of FOAM Counts by NBER Technology Sub-Category

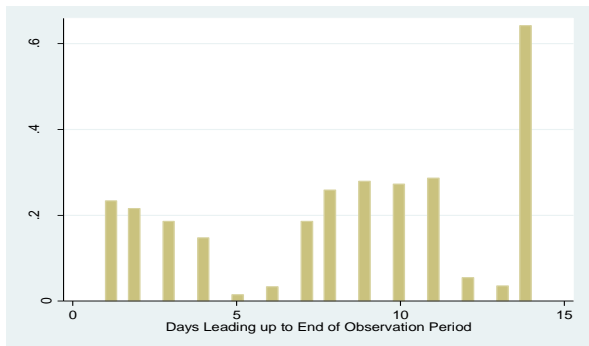
Agriculture Food and Textiles



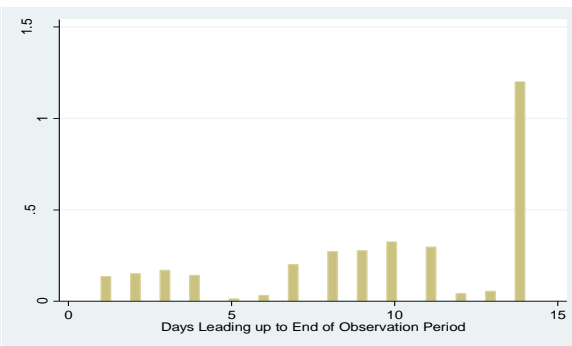
Coating



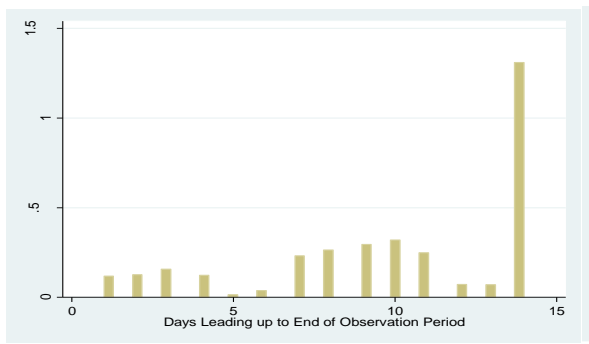
Gas



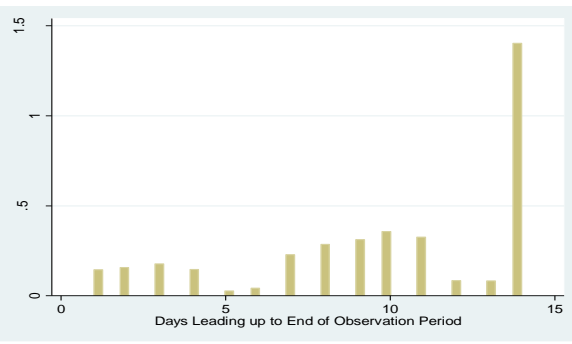
Organic Compounds



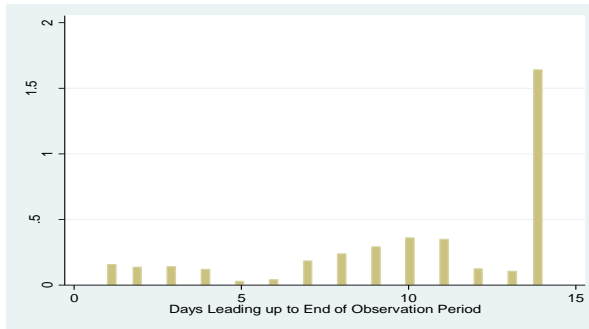
Resins



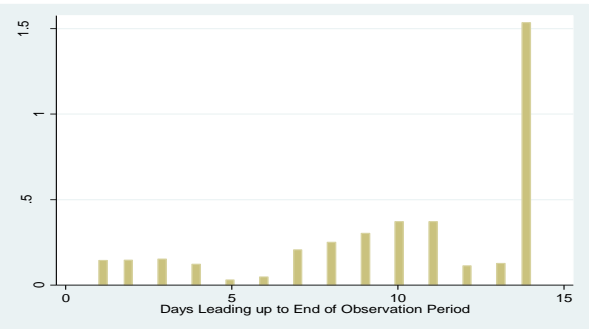
Miscellaneous Chemical



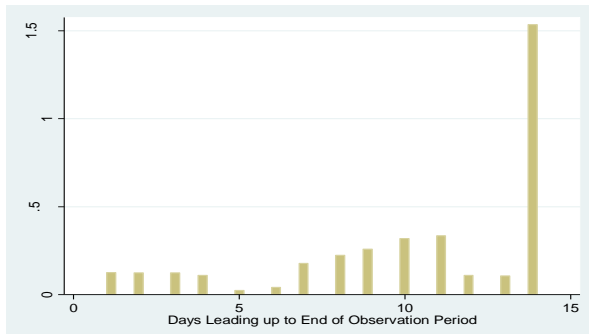
Communications



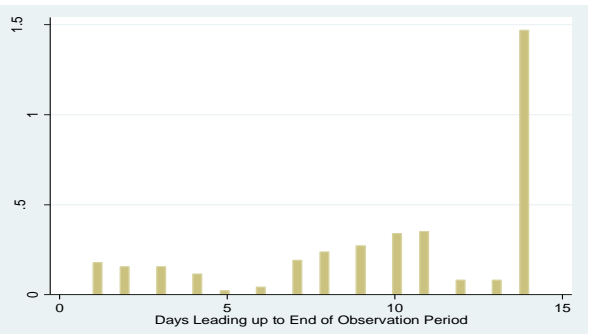
Computer Hardware & Software



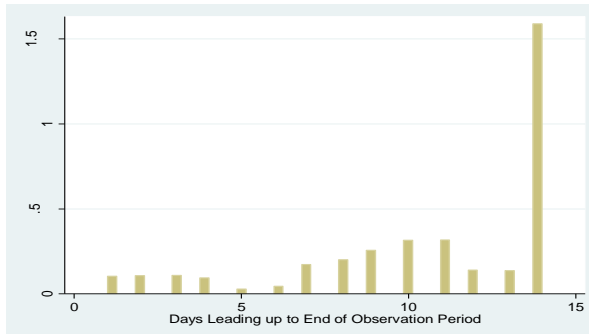
Computer Peripherals



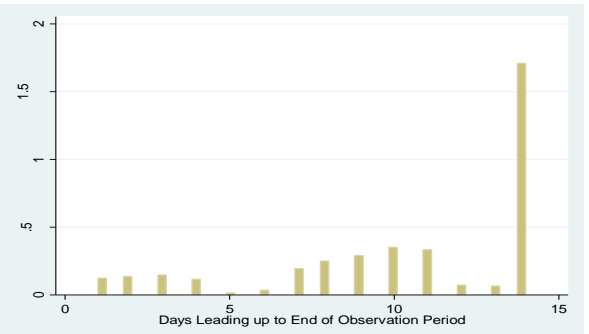
Information Storage



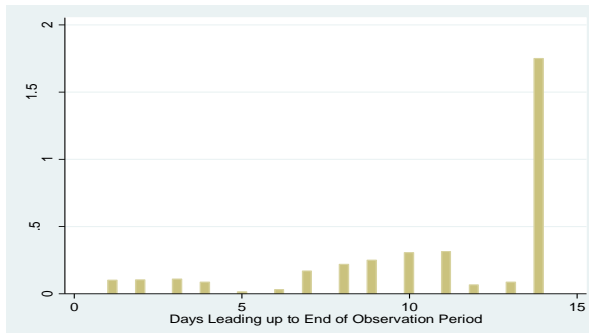
Electronic Business Methods and Software



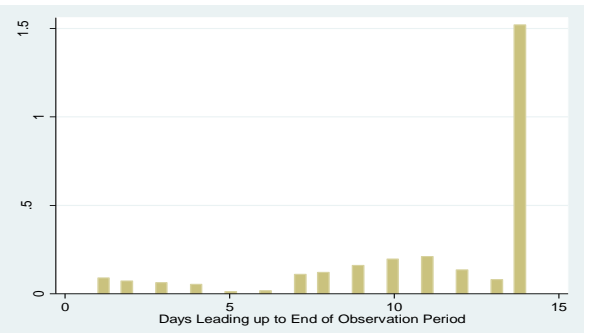
Drugs



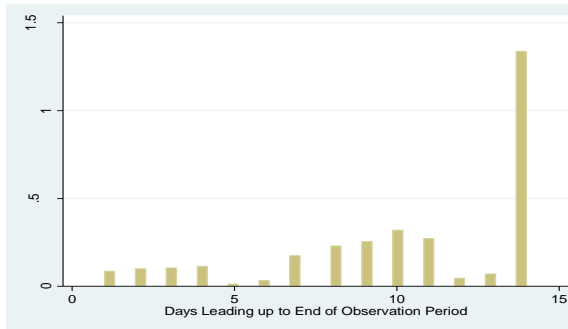
Surgery and Medical Instruments



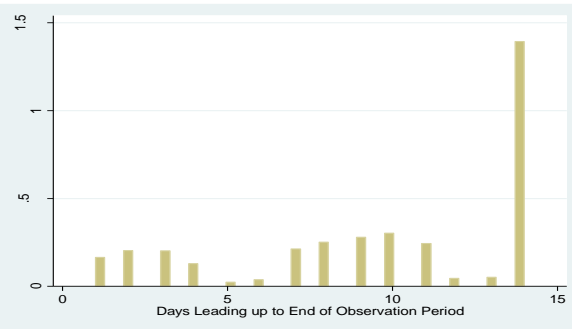
Genetics



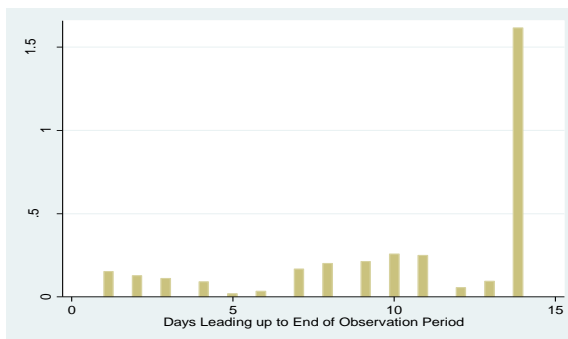
Miscellaneous Drugs and Medical



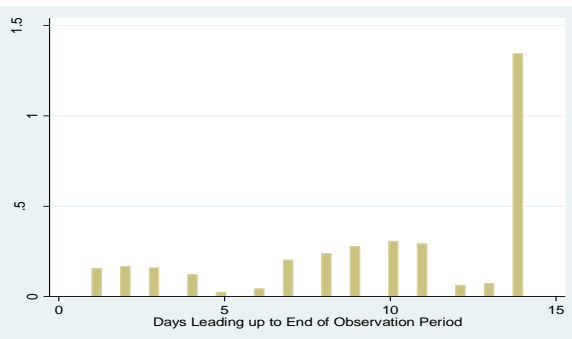
Electrical Devices



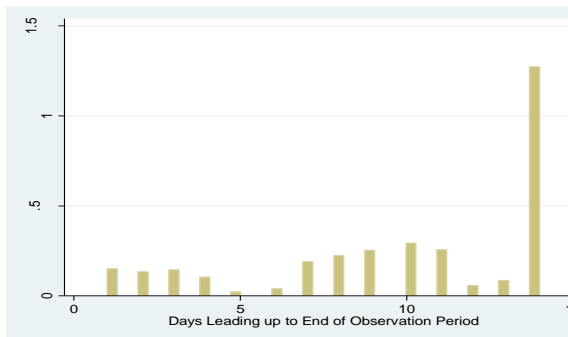
Electrical Lighting



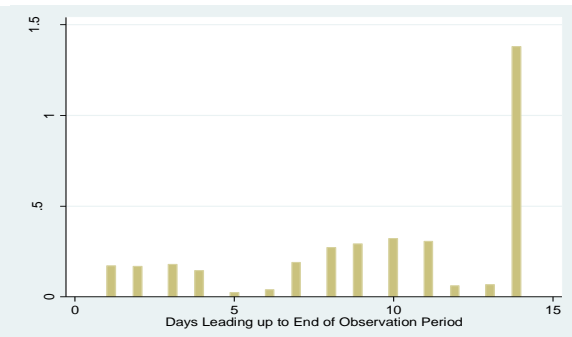
Measuring and Testing



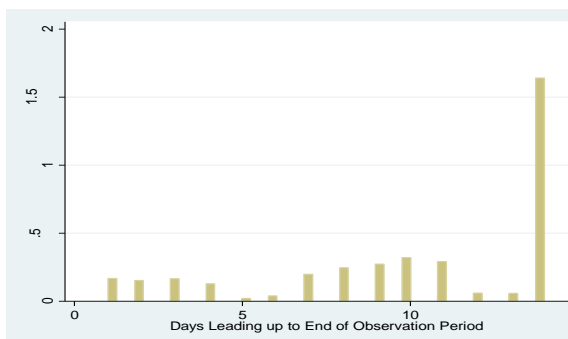
Nuclear & X-Rays



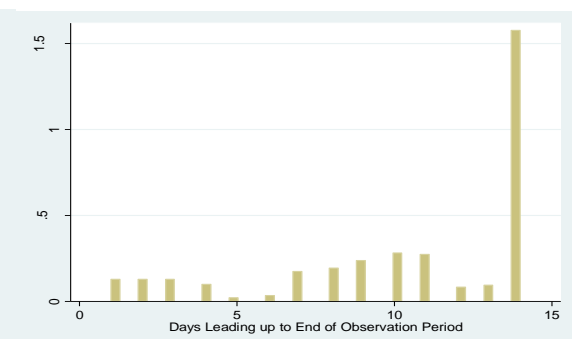
Power Systems



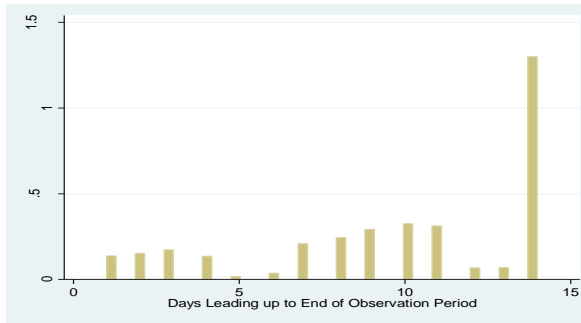
Semiconductor Devices



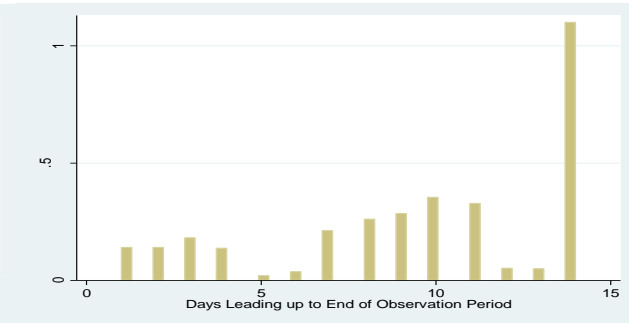
Miscellaneous Electrical



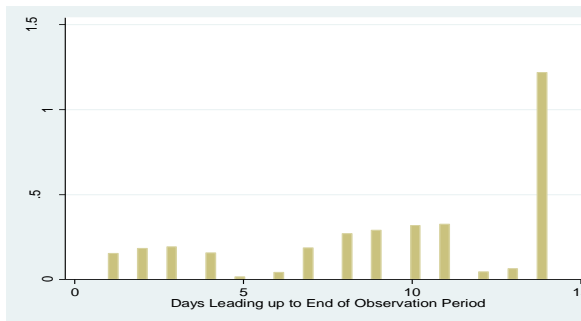
Materials Processing and Handling



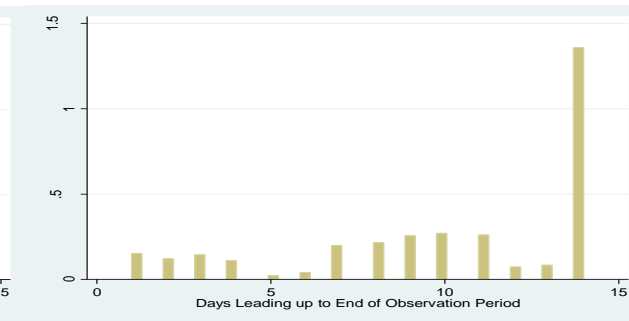
Metal Working



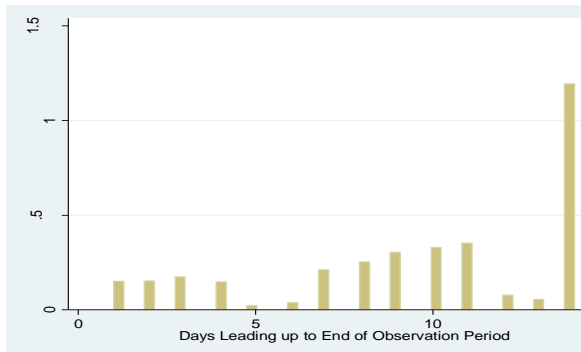
Motors, Engines and Parts



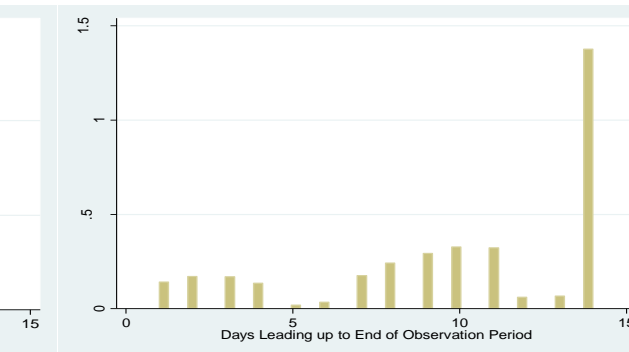
Optics



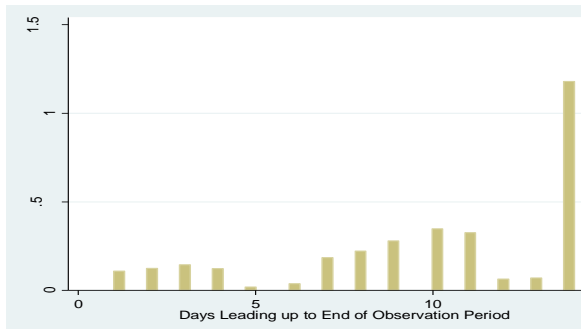
Transportation



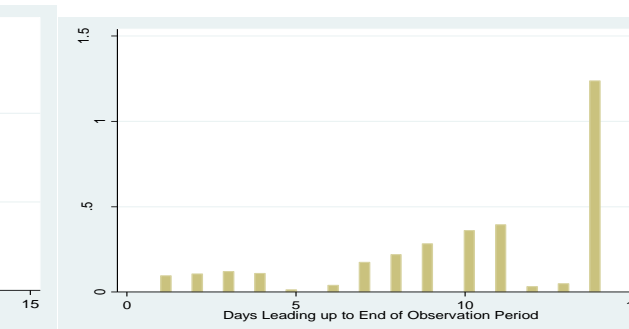
Miscellaneous Mechanical



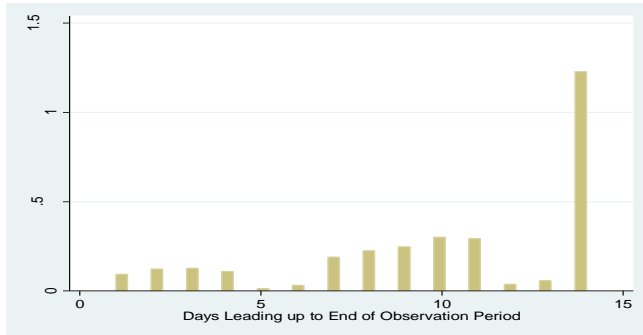
Agriculture, Husbandry and Food



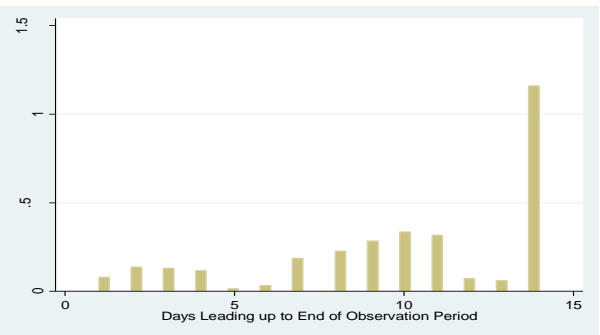
Amusement Devices



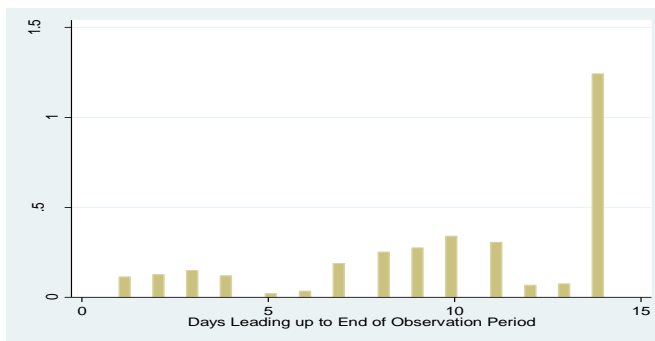
Apparel and Textiles



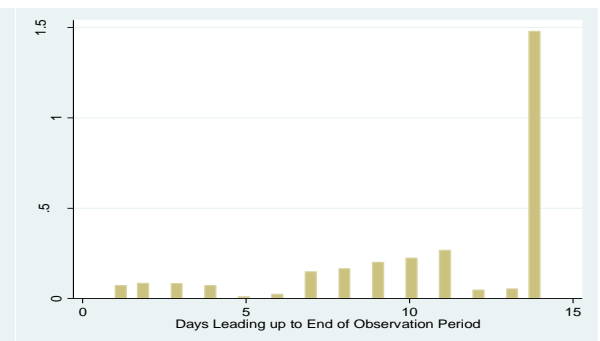
Earth Working and Wells



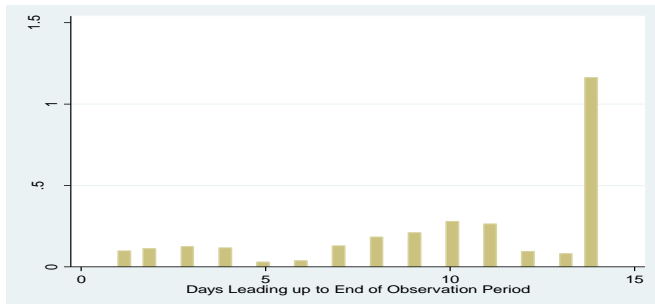
Furniture & House Fixtures



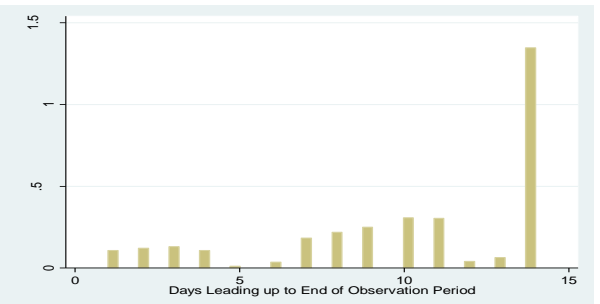
Heating



Pipe & Joints



Receptacles



Miscellaneous Other

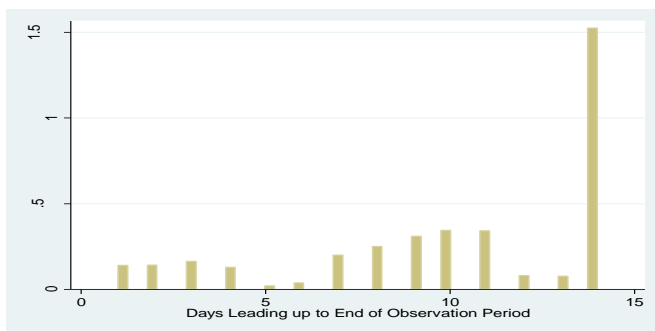


TABLE A1

Relationship between Examiner Telecommuting and the Likelihood that First Office Actions Are Completed on the Last Day of the Quota Period: Event-Study Results

| | (1) | (2) |
|---------------------------------------------------|---------------------|---------------------|
| (Omitted: > 4 Years Prior to Telecommuting Dummy) | | |
| 4-Years Prior to Telecommuting Dummy | 0.002 (0.004) | 0.002 (0.004) |
| 3-Years Prior to Telecommuting Dummy | 0.009* (0.005) | 0.008 (0.005) |
| 2-Years Prior to Telecommuting Dummy | 0.014** (0.006) | 0.010* (0.006) |
| 1-Year Prior to Telecommuting Dummy | 0.010 (0.006) | 0.003 (0.006) |
| Year Starting Telecommuting Dummy | 0.072*** (0.008) | 0.065*** (0.008) |
| 1-Year Post Starting Telecommuting Dummy | 0.051*** (0.009) | 0.046*** (0.009) |
| 2-Years Post Starting Telecommuting Dummy | 0.021** (0.009) | 0.016* (0.009) |
| 3-Years Post Starting Telecommuting Dummy | 0.017 (0.010) | 0.011 (0.010) |
| >= 4-Years Post Starting Telecommuting Dummy | 0.001 (0.012) | -0.003 (0.012) |
| Examiner and Year Fixed Effects? | YES | YES |
| Other Covariates? | NO | YES |

Standard deviations are indicated in parenthesis and are clustered at the examiner level. Estimates are from a sample of 1,741,500 first office actions completed between March, 2001 and July, 2012 (focusing only on applications filed after March, 2001).

TABLE A2

Mean Rates of End-loading of First-Office Actions on the Merits at Quota-Period Ends, Separately by Examiner Status

| | (2) | (3) |
|------------------|------------------------------------------------------------------|---------------------------------------------------------------|
| | APPLICATIONS REVIEWED BY THOSE WITHOUT SIGNATORY AUTHORITY | APPLICATIONS REVIEWED BY THOSE WITH SIGNATORY AUTHORITY |
| End-loading Rate | 0.532 (0.498) | 0.436 (0.495) |

Standard deviations are indicated in parenthesis. Statistics are from a sample of 1,741,500 first office actions completed between March, 2001 and July, 2012 (focusing only on applications filed after March, 2001). Examiners with General-Schedule pay levels below GS-13 need supervisory approval on the first office actions that they submit, while those above GS-13 need no such approval.

TABLE A3

Falsification Tests. Relationship between Examiner Telecommuting and Certain Immutable Characteristics of the Application:

Dynamic Difference-in-Difference Regression Results

| | (1) | (2) |
|----------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------|
| | Incidence of Large Entity Applicant (Mean = 0.72) | Incidence of Previous Filing at the EPO or JPO (Mean = 0.06) |
| (Omitted: > 4 Years Prior to Telecommuting Dummy) | | |
| 4-Years Prior to Telecommuting Dummy | -0.002 (0.002) | -0.002* (0.001) |
| 3-Years Prior to Telecommuting Dummy | -0.000 (0.003) | -0.003** (0.001) |
| 2-Years Prior to Telecommuting Dummy | -0.002 (0.003) | -0.003** (0.001) |
| 1-Year Prior to Telecommuting Dummy | -0.006* (0.003) | -0.005*** (0.001) |
| Year Starting Telecommuting Dummy | -0.002 (0.004) | -0.004** (0.002) |
| 1-Year Post Starting Telecommuting Dummy | 0.001 (0.004) | -0.006** (0.002) |
| 2-Years Post Starting Telecommuting Dummy | 0.002 (0.005) | -0.006** (0.002) |
| 3-Years Post Starting Telecommuting Dummy | 0.004 (0.005) | -0.006** (0.003) |
| >= 4-Years Post Starting Telecommuting Dummy | 0.005 (0.006) | -0.008** (0.003) |
| Examiner and Year Fixed Effects and Other Covariates? | NO | YES |

Standard deviations are indicated in parenthesis and are clustered at the examiner level. Estimates are from a sample of 1,741,500 first office actions completed between March, 2001 and July, 2012 (focusing only on applications filed after March, 2001). All regressions include examiner and year effects.