Examination Incentives, Learning, and Patent Office Outcomes: The Use of Examiner's Amendments at the USPTO

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Abstract

We investigate how U.S. Patent and Trademark Office (USPTO) patent examiner experience and seniority-based incentives affect the innovation ecosystem. First, we show that examiners respond to production incentives and demonstrate learning by increasing the use of examiner's amendments in both experience and seniority, a mechanism not previously studied. Second, this examination procedure directly benefits innovators and firms by significantly reducing prosecution processing time without impacting patent quality. Finally, after considering

[*] The views expressed are those of the individual authors and do not necessarily reflect official positions of the Office of Chief Economist or the U. S. Patent and Trademark Office. USPTO Economic Working Papers are preliminary research being shared in a timely manner with the public in order to stimulate discussion, scholarly debate, and critical comment.

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examiner's amendments, the negative relationship between examiner characteristics and patent examination quality found in the previous literature does not persist at first action, a decision point that allows for the clear measurement of examiner behavior. Our results demonstrate a need for reformulated policy recommendations related to the structure of examination at the USPTO. *JEL* Codes: O3, O31, O38, J22, J24.

1 Introduction

The quality of patent examination decisions depends on examiner experience, ability, the time allocated per decision, and other incentives. The examination incentive system should attempt to maximize decision quality while minimizing the cost of production, though, as in any production function, inefficiencies can occur. Prior research has studied the impact of patent examination characteristics and examination incentives at the U.S. Patent and Trademark Office (USPTO) on the innovation ecosystem, finding theoretical and empirical evidence of economic inefficiency (for examples see Cockburn *et al.*, 2002; Mann and Underweiser, 2012; Langinier and Marcoul, 2012, 2016; Cotropia *et al.*, 2013; Frakes and Wasserman, 2016, 2017, 2020; Kovacs, 2017; Lei and Wright, 2017; Tabakovic and Wollmann, 2017; and Whalen, 2018.) This strand of research focuses on two patent office outcomes, patent examination quality (the validity of granted patents) and prosecution time (patent pendency), which have critical economic consequences. Low-quality examination leads to "low quality" patents, which in turn may reduce innovation, limit competition, and encourage abusive patent litigation (Merges 1999; Barton 2000; Lemley and Shapiro 2005; Bessen and Meurer, 2008; Farrell and Shapiro 2008; Choi, 2010; Choi and Gerlach, 2015.) Patent pendency is a crucial determinant of prolonged uncertainty in intellectual property rights, and affects the ability of firms to efficiently contract in the markets for technology, as well as to obtain start-up financing quickly for increased sales and employment growth (Gans, Hsu and Stern 2008; Harhoff and Wagner 2009; Spulber 2015; Farre-Mensa, Hegde, and Ljungqvist 2019; Hegde et al. 2020).

Since Jaffe and Lerner (2004), high patent allowance rates at the USPTO are seen as an indication of low quality patent examination (Lemley and Sampat, 2008, 2012; Frakes and Wasserman, 2012, 2017; Schuett, 2013). At the USPTO, examiner output requirements (referred to as "production requirements") vary by seniority to account for decreasing the expected time required to examine an application due to experience effects. Researchers have analyzed the influence these differential incentives have on patent examination quality (Lemley and Sampat, 2012; Frakes and Wasserman, 2017). Lemley and Sampat (2012) find that more experienced examiners are more likely to allow a patent application both overall and after the first round of review. The authors interpret these first-round allowances, also referred to as first-action allowances, as a clear indication of lower quality examination. Frakes and Wasserman (2017), using the overall allowance rate as a measure of examination quality, find that the increasing production requirements imposed by the USPTO on more senior patent examiners decreases examination quality.

In this paper, we build on this literature by providing an alternative view of the relationship between examiner characteristics and patent office outcomes, developing and testing several hypotheses related to experience, incentives, and examiner behavior. Our results show that examiners learn with experience and conduct more efficient examination. Additionally, examiners respond with more efficient examination as production requirements increase with promotion. We analyze a popular USPTO examination tool called an examiner's amendment, used on nearly a third of granted patents between 2001 and 2017. This tool allows examiners to negotiate with applicants early on in the prosecution process, and is designed to expedite patent prosecution. Our findings show that examiners increasingly use examiner's amendments with both increasing experience and increasing seniority, which leads to benefits for both inventors and firms. We find that the use of an examiner's amendment is associated with a 50% decrease in post-first-action pendency without impacting patent quality.

Our results demonstrate a positive view of the relationship between examiner characteristics and patent office outcomes that is inconsistent with the results found in the prior literature. Given this inconsistency, it is necessary to reconcile our results. We devise an empirical strategy that (1) takes into account previously unaccounted for institutional details that influence the examination outcomes and (2) builds on the empirical framework of Lemley and Sampat (2012), focusing solely on the first-action allowance decision. This restriction allows us to focus solely on examiner behavior and mitigates several endogeneity issues present with overall allowance decisions. Further, our methodology accounts for recent research suggesting that applications are pseudo-randomly assigned based on technological specialization (Righi and Simcoe 2019).

After re-running examination quality regressions using our preferred specification, we find that the negative relationship between the studied examiner characteristics and examination quality from prior literature does not persist, demonstrating that examiners do not conduct lower quality examination at first action as they gain experience or are promoted. These results, however, have limitations and should not be interpreted as a complete refutation of prior literature on examiner experience and seniority based incentives. Instead, we offer a more nuanced view that encourages more research to clarify the appropriate policy response. We show that examiner experience and seniority lead to more efficient prosecution early in patent examination. Frakes and Wasserman (2017) show that more senior examiners are more likely to allow patent applications overall. Additionally, Lemley and Sampat (2012) show that more experienced examiners are likely to allow early in the examination process (to which we provide counter-evidence), but also more likely to allow overall. Despite our reservations regarding the empirical validity of an estimation strategy using overall allowance rates as a dependent variable, carefully described at the end of the paper, our two views may not be incompatible.

Policy prescriptions arguing for increased examination time have gained traction in the United States Executive Branch (GAO 2016) and the U.S. Congress; for example, in the 2019 Senate Judiciary Hearing titled “Promoting the Useful Arts: How can Congress prevent the issuance of poor quality patents?"[1] Our results suggest that these prescriptions should be reconsidered. In particular, Frakes and Wasserman (2017) suggest that the USPTO should increase time allocations for each examination seniority level. Utilizing the examiner's amendment, our results show that the argument (Lemley and Sampat 2012) for this view based on increasing first-action allowance rates for more experienced examiners is not supported by empirical evidence. More experienced and senior examiners do issue more first action allowances, but this increase is generally accounted for by more efficient examination very early in prosecution. Further, rather than reducing patent quality, use of the examiner's amendment maintains quality while benefiting innovators and firms by reducing patent pendency. Re-configuring time allocations would reduce the incentive to use this pendency saving mechanism, and could potentially harm, rather than enhance the innovation ecosystem. Taking into account the totality of evidence in this literature, we end our paper by carefully describing necessary further research for settling the question of the impact of examiner incentives and experience on the innovation ecosystem. At the very minimum, stakeholders and policy makers should wait for further analysis to shed light on these issues before enacting time based reforms for patent examiners at the USPTO.

Our findings advance the understanding of the relationship between examiner characteristics, patent office outcomes, and optimal patent office policy. We find that examiner experience and seniority significantly and positively impact examination efficiency without sacrificing quality and estimate the benefits of this efficiency gain for innovators and firms.

[1] https://www.judiciary.senate.gov/meetings/promoting-the-useful-arts-how-can-congress-prevent-the-issuance-of-poor-quality-patents?fbclid=IwAR1Xq0YU7rVXkAlZO5v6H7hJhgRKlSKmzXVIprsixyX3dQ21OwbCxc4ZBdM

2 Institutional Background

2.1 Patent Examination Process

The patent examination process begins with an applicant's submission of a patent application to the USPTO. Once submitted, the office classifies the application by technological area according to the U.S. Patent Classification (USPC) system and dockets the application to an examiner skilled in that area. The patent examiner's role in this process is to evaluate and determine if the application meets all standards and requirements set forth in Title 35 of the United States Code. The applicant is entitled to an allowance unless the examiner determines that the patent application does not meet at least one of the standards or requirements. An examiner typically begins the prosecution process by first determining if the patent contains a single invention and performing a double patenting search. After these steps are completed, the examiner searches and evaluates existing literature or "prior art" as it pertains to the patent application under consideration. Depending on the outcome of the previously mentioned tasks, the examiner will draft either an initial rejection or allowance (called a first action decision). For a more in-depth overview of patent prosecution, see (Marco *et al.* 2017).

With the paid application fees, the applicant is entitled to two rounds of prosecution. Occasionally, the application is allowed after a single round of prosecution (called a first action allowance). More frequently, an application is given a first-round rejection (called a non-final rejection). In this case, the applicant can modify the application to address the bases for the rejection, appeal the rejection, or abandon the application. If the modified application meets all aforementioned standards and requirements, the examiner will allow the application. After two unsuccessful rounds of prosecution (receiving a non-final then final rejection), an applicant can file for a Request for Continued Examination (RCE) and obtain two more rounds of prosecution or abandon the application.

2.2 USPTO Incentive-based Production System

Examination activities are assigned "counts." Currently, an examiner will receive 1.25 counts for a non-final rejection, 0.75 counts for an allowance or final rejection after the initial non-final rejection, 0.75 counts if the applicant abandons the application after the first action, or the full 2 counts for a first-action allowance (Marco, Toole, *et al.*, 2017). The completed round of examination (ending in either a disposal, that is an allowance or abandonment by the applicant, or an RCE filing) is called a balanced disposal (BD).

Examiners receive credit for meeting their production goals (the amount of production required per pay period - a bi-week) according to the number of counts they process. This implies that production goals also determine how much time an examiner is given on average to process a count (the unit of production). Each application is worth the same amount of production (2 counts), although the path taken affects the amount of production counts provided per unit of time. For example, a first-action allowance is the fastest way to receive production counts, since the application is completed in the first round of prosecution, providing 2 counts.

Examiner seniority levels are determined by the federal grade scale,[2] and a few other relatively rare categories of examination (for example, senior and expert examiners). These seniority levels are assigned "position factors", which determine how much time an examiner is given to complete activities relative to a GS-12 in the same technology. Specifically, the amount of time an examiner is given to examine an application decreases with seniority level. For example, GS-12 examiners in the bridge technology area (USPC 14) are given 17.5 hours per balanced disposal (Marco *et al.*, 2017). Using the examiner's expectancy formula, GS-7 and GS-14 examiners have 27.5 and 15.46 hours, respectively, to complete a single balance disposal in this technology, a difference of over twelve hours.

Although these incentives impact all aspects of prosecution, their potential effect on

[2] Typically, the GS-levels for a patent examiner include 5, 7, 9, 11, 12, 13, 14, and 15. Depending on prior experience, an examiner may start at a higher GS-level.

the first action decision is especially important. As noted earlier, an allowance on the first action decision is the fastest way to achieve production requirements. Therefore, if examiner incentives are mis-aligned with the ability of examiners to efficiently prosecute applications, then examiners could compensate by issuing more allowances during the first round of prosecution. For this reason, carefully using the first action decision is a promising way to understand the impact of examiner experience and incentives.

2.3 Examiner's Amendments

In addition to rejections and allowances, there is another category of patent examination response that has not been explored in the literature: examiner's amendments. When evaluating an application at any stage of the patent prosecution process, examiners may identify patentable subject matter and discuss potential changes to the claims with the applicant in order to render the application allowable. *Any aspect* of the claims may be changed in an examiner's amendment. From the Manual of Patent Examining Procedure (MPEP), "An examiner's amendment may be used to correct informalities in the body of the written portions of the specification as well as all errors and omissions in the claims" (MPEP section 1302.04). If the applicant agrees to such changes, the examiner will draft an examiner's amendment, detailing changes made, which is included in the notice of allowance. Examiners utilize examiner's amendments to effectively perform the same operations as the first office action rejection, without requiring another round of review, thus expediting the process.

This examination tool is frequently used by USPTO examiners. In fact, over one million patents granted by the USPTO between 2001 and 2017 contained an examiner's amendment. The use of an examiner's amendment is also inline with the USPTO's "compact prosecution" policy (MPEP - Section 2173). According to the policy, "The goal of examination is to clearly articulate any rejection early in the prosecution process so that the applicant has the chance to provide evidence of patentability and otherwise reply completely at the earliest opportunity."[3] In other words, the examiner is encouraged to provide all the grounds for rejection at the earliest opportunity. In an examiner's amendment, the examiner provides the grounds for rejection to the applicant before the official decision, and both parties successfully agree to modifications of the claims to immediately bring the application to allowance. The use of an examiner's amendment reduces pendency by eliminating further rounds of formal prosecution, and therefore satisfies the Office's policy of "compact prosecution".

Although examiner's amendments may be used at any stage of patent prosecution, we focus on it's use for the first action decision for two reasons. First, as noted earlier, if examiner incentives are misaligned with their ability to process patent applications, then allowing early in the process (on the first action) is the fastest way to satisfy production requirements (and as others argue, at the cost of lower patent quality). Second, as carefully described later, the first action decision is the cleanest way to identify examiner behavior, avoiding several potential endogeneities with the overall application outcome.

3 Theory

This section identifies the potential relationship between examiner experience and seniority based incentives, the examiner's amendment, and benefits to the innovation ecosystem. The first mechanism is examiner learning. As an examiner becomes more experienced, the examiner might be more likely to issue an examiner's amendment on the first action for a variety of reasons. First, after gaining experience in both prosecuting patents and acquiring domain-specific technical knowledge, the examiner might be able to quickly identify eligible subject matter in the patent claims, or the specification more broadly. Second, through repeated interaction with applicants, a more experienced examiner may have higher negotiating ability. Third, a more experienced examiner may more likely have the confidence necessary to avoid the full patent prosecution process and negotiate an examiner's amendment on the first action to expedite prosecution. Thus, we expect examiners will use the

[3] https://www.uspto.gov/web/offices/pac/mpep/s2173.html\#d0e219183

examiner's amendment more as they gain experience:

Hypothesis 1. *Ceteris paribus, examiners are increasingly likely to issue examiner's amendments on the first office action with experience.*

The second mechanism through which examiners might issue more examiner's amendments on the first office action relates to examiner incentives. Recall that examiners are given less time to prosecute patent applications at higher seniority levels. Successfully negotiating an examiner's amendment before the first action significantly reduces the amount of time to prosecute an application. Therefore, utilizing the examiner's amendment is one way to compensate for less time provided with promotion. This leads to the second hypothesis.

Hypothesis 2. *Ceteris paribus, examiners with higher seniority are more likely to issue an examiner's amendment on the first office action.*

The third hypotheses relates to pendency, and describes the channel through which innovators and firms benefit through the use of examiner's amendments at the USPTO. At the first-action decision, an examiner can choose to issue a non-final rejection or attempt to negotiate with the applicant. *Ceteris paribus*, the use of an examiner's amendment at this juncture should lead to shorter pendency, benefiting the applicant.

Hypothesis 3. Ceteris paribus*, patent applicants achieve lower pendency through the use of examiner's amendments relative to an office-action rejection.*

Even if the first three hypotheses are true, increasing use of the examiner's amendment on the first action decision could result in lower patent quality, and therefore negatively impact the innovation ecosystem. That is, rather than delivering benefits to firms through shorter pendency, increased use of these amendments could reflect inefficient negotiation by the examiner that could have been avoided by a thorough multi-round examination. In fact, this is more likely if examiners are increasingly time constrained because of improperly aligned time based incentives. If examiners are unable to keep up with reduced time requirements, then they may be more likely to issue poor quality examiner's amendments early in prosecution. Our final hypothesis formally states this potential relationship.

Hypothesis 4. *Ceteris paribus, if examiner learning rates are properly aligned with incentives, then patent quality should not deteriorate with increased use of examiner's amendments on the first office action with experience and seniority.*

4 Data

The sample is comprised of 4.68 million public patent applications filed at the USPTO with a first action completed between 2001 and 2017 (variable descriptions in Table 1 and summary statistics in Table 2). These data were provided in a bulk downloadable format by the USPTO's Office of Chief Economist (OCE) in the Patent Examination dataset, called the Patent Examination Research Dataset, or simply PatEx (Graham, Marco, and Miller, 2018). The application data includes overall prosecution outcome, filing and disposal dates, anonymized USPTO examiner identification numbers, U.S. patent classification (USPC), technology center (TC), and other patent application characteristics. In addition to the application data, PatEx includes a history of all patent office events (both by the applicant and the USPTO) for each application from filing to disposal, disposal type, and expiration date (if the patent expired). The transaction history includes a list of all USPTO office actions, including rejections, notice of allowances, restrictions, and Quayle actions.[4] We assume that the examiner's first action is the first instance of a non-final rejection, final rejection, notice of allowance, restriction or Quayle action in the PatEx transaction history. From the PatEx transactions data, we also obtain the occurrence and date of examiner's amendments, identified using the transaction code "Ex.a".

[INSERT TABLE 2 HERE.]

[4]According to the MPEP, "Under the decision in Ex parte Quayle, 25 USPQ 74, 1935 C.D. 11; 453 O.G. 213 (Commr Pat. 1935), after all claims in an application have been allowed the prosecution of the application on the merits is closed even though there may be outstanding formal objections which preclude fully closing the prosecution," (MPEP 714.14).

Examiner promotion and grade data at first action were taken from internal USPTO databases and observations with examiner GS-levels 5 and 15 were dropped from the sample due to infrequency. Examiner experience was calculated using the examiner promotion data by measuring the length of time, in months, between the first action and the examiner's start date.

To control for additional application-level heterogeneity, we include scope and parent type variables in our sample. According to Marco *et al.* (2019), patent scope can be measured simultaneously by the length of the shortest independent claim (ICL) and the independent claim count (ICC).[5] These scope measures can be calculated both at publication and at grant[6] and are computed from the text of the pre-grant publication (PGPub) and issued patents provided by USPTO.[7] We use these text-based variables also to assess changes in patent scope. Specifically, we use the change in independent claim count, and the change in shortest independent claim length between the PGPub claims and the granted patent claims. Marco *et al.* (2019) show that these variables capture the degree to which an application's scope is changed from filing to grant, and that patent scope typically narrows during the course of patent prosecution for granted patents. Because of this direct link between patent scope and patent quality, we use the change in scope variables to proxy for the quality of examination, conditional on incoming scope.

[INSERT TABLE 1 HERE.]

We also account for the application parent type (continuation, divisional, continuation-in-part, or new application), the application priority type (*e.g.*, foreign priority), and whether

[5]Kuhn and Thompson (2019) provides an alternative measure of both patent scope and its evolution over patent prosecution, measuring patent scope by the length of the first independent claim instead of the shortest.

[6]The USPTO's Office of Chief Economist parsed the pre-grant publication (PGPub) and patent text and calculated the measures. Data through 2014 is available publicly through 2014 on the USPTO's Office of the Chief Economist web site. We also utilized a yet-to-be-released USPTO data product that contains the updated measures through the end of 2017 because the publicly-available patent scope data only contains the measures through 2014.

[7]The USPTO's Bulk Data Products can be found at `https://www.uspto.gov/learning-and-resources/bulk-data-products`.

the application stemmed from a Patent Cooperation Treaty (PCT) application. To determine the overall application parent type, we combine these two variables (foreign priority type and parent type) from the PatEx data to create a modified application parent type variable (see Figure 1). From this variable, we can differentiate by continuity (e.g. continuation application), application route (e.g. PCT application), and whether an application had been filed previously within another jurisdiction.

[INSERT FIGURE 1 HERE.]

Finally, we develop a measure of examiner specialization, computed at the examiner and year level, which allows us to control for the degree to which an examiner specializes in a particular technology. We use Term Frequency-Inverse Document Frequency (TF-IDF) cosine similarity,[8] a natural language processing technique, to identify the pairwise similarity between the patent claims of all publicly-available applications an examiner evaluated on the first action in the previous year. We define our time varying examiner specialization measure to be the average of these similarities. When using the similarity measure of specialization, we also control for the standard error of the mean similarity.

[8]The TF-IDF cosine similarity method is becoming increasingly popular in the innovation economics literature. The use of similarity measures in the analysis of patent text was introduced by Kuhn and Younge (2016), and validated further in recent work (Arts *et al.*, 2018; deGrazia *et al.*, 2019). Term frequency was first used in information retrieval (Sparck 1972) as a means to compare texts; inverse document frequency re-weights down the terms that are common across documents. Specifically, Cosine Similarity is defined as:

$$cos\_sim(X, Y) = \frac{XY}{|X||Y|} \tag{1}$$

where X, Y are two vectors of the same dimension n and n is equal to the number of words in the patent corpus. The vectors X and Y comprise the TF-IDF-weighted counts of words appearing in the claims of a particular application, A, at filing (X) and after the text has been modified through an examiner's amendment (Y). The elements of each vector correspond to a weighted word count from the set of all words that appear in the patent corpus. If a word appears in document i's claims ($i \in \{A, B\}$), the word count is weighted by the term-frequency-inverse-document-frequency of the particular word. If the word does not appear in the document's claims, the value for the corresponding element is equal to zero. The combination of term frequency and inverse document frequency is the standard method of processing the similarity between texts (Wu et al. 2008), and is appropriate for our purposes since we use it to identify documents with varying degrees of changes to the application on the examiner's amendment.

5 Empirical Methodology and Results

5.1 Experience, Incentives, and the Examiner's Amendment

The first set of regressions explores how examiner experience and seniority affect the likelihood of an examiner's amendment. Through this empirical framework we are able to directly test whether examiners exhibit learning (Hypothesis 1) or respond to time-based incentives (Hypothesis 2). Equation (2) shows our specification, where the dependent variable, $Exam\_Amend_{eit}$, is equal to one if the examiner issued an examiner's amendment on the first action, and $Exam\_Amend_{eit} = 0$ otherwise.

$$Exam\_Amend_{eit} = \beta_0 + \beta_1 Exper_i + \beta_2 ICL_i + \beta_3 ICC_i + \gamma_p + \gamma_t + \gamma_e + \gamma_g + \epsilon_{eit} \quad (2)$$

In equation (2), γ_t are first-action year fixed effects (t is the first action year), γ_e are examiner fixed effects, γ_p are application parent type fixed effects, and γ_g are examiner grade at first-action fixed effects, relative to GS-9. We include claim scope measures at pre-grant publication (ICL_i and ICC_i), and examiner experience ($Exper_i$) in months at the application first-action date. This regression assesses the degree to which grade and experience influences the likelihood of an examiner's amendment at first-action. A positive and significant relationship between experience and the probability of a first-action examiner's amendment would validate Hypothesis 1, while a positive and significant relationship between grade and the probability of a first-action examiner's amendment would validate Hypothesis 2.

Our identification strategy is based on the pseudo-random assignment of patent applications to examiners within art units at the USPTO. Researchers have used this research design to answer questions related to the patent system (Lemley and Sampat, 2012; Frakes and Wasserman, 2017; Williams 2013; Farre-Mensa, Hegde, and Ljungqvist 2017). This strategy is validated in the literature through discussions with patent examiners (Lemley and Sampat, 2012) and recent empirical research (Righi and Simcoe, 2019) suggesting that patent applications are generally pseudo-randomly assigned within USPTO art units by technology groups. However, Righi and Simcoe (2019) also find evidence that more specialized examiners have lower grant rates. For this reason, it's important for us to control for the degree of examiner specialization. We argue that non-random assignment based on examiner technological specialization could be absorbed by the examiner fixed effects, and as shown in robustness checks, technology fixed effects. Despite this, examiner specialization may be time varying. For this reason, we add a measure capturing the similarity of patent claims examined by each examiner in the previous period to proxy for time-varying examiner specialization.

Office policy effects on examiner behavior are absorbed in the year fixed effects (Frakes and Wasserman, 2013; Frakes and Wasserman, 2014). Since examiner cohorts (Frakes and Wasserman, 2016) and initial examiner ability might impact prosecution behavior, we note that the examiner fixed effects control for starting grade, cohort, and ability, since none of these vary within examiner. We also note that our micro-level data allows us to identify both the GS-level and experience of the examiner at first-action simultaneously. Experience and grade do not increase in lock step because starting grades and time to promotion for each grade vary across examiners.

We run the regression described in Equation 2 on two sets of data: first, we estimate Equation 2 using the entire sample. Second, we limit the applications to only new applications. By new, we only consider new regular utility applications (applications without a "parent" application) without a foreign priority filed at the USPTO. The purpose of examining this subset is to exclude applications with any prior examination, abroad or at the USPTO. Without excluding these applications, our regressions could be susceptible to bias if examiners with varying grade and/or experience were differentially likely to receive these types of applications.

In Table 3, we find that the probability of a first-action examiner's amendment is increasing in both grade and experience. For all applications, Column (1) demonstrates that the probability of a first-action allowance with an examiner's amendment is increasing from GS-9 through GS-14, providing evidence that higher grade examiners are more likely to use this tool to prosecute patent applications. From column (1), relative to a GS-9 examiner, the probability of an examiner's amendment associated with a first action is 0.33, 0.6, 1.02, and 1.63 percentage points higher for GS-11, GS-12, GS-13, and GS-14 examiners, relative to GS-9. Relative to the mean first action allowance rate from Table 2, examiners are 3.7, 6.7, 11.5 and 18.3 percent more likely to issue allowances (by utilizing the examiner's amendment) for GS-11, GS-12, GS-13, and GS-14, respectively. Column (2) shows that the result is similar, although the magnitudes are smaller when only considering new applications. This is consistent with the fact that senior examiners are more likely to receive continuation applications, which are more likely to benefit from an examiner's amendment since they've already received some degree of examination and therefore may require fewer changes to reach an allowance. Columns (3) and (4) include the examiner specialization variables. Importantly, adding the degree of specialization slightly reduces the magnitudes of the grade effects. More specialized examiners could be better at finding allowable subject matter in patent claims, and therefore more easily pursue an examiner's amendment, explaining the decrease in magnitude for the grade effects (although the specialization variable - Exam. Spec. (Avg.) - is individually insignificant in both columns (3) and (4)). Overall, these results confirm Hypothesis 2, that examiners increasingly use examiner's amendments with higher seniority.

The coefficient on experience is positive and statistically significant in all regressions. For example, with the point estimate in column (4), each additional 5 years of experience leads to a 1 percentage point increase in the probability of using an examiner's amendment on the first action (experience is measured in months, and $.0179 \cdot 12 \cdot 5$ is 1). Evaluated from the mean first action allowance rate, each additional year of experience increases the first action allowance rate (by utilizing the examiner's amendment) by 11.8 percent. This verifies Hypothesis 1, that *ceteris paribus*, more experienced examiners are more likely to use examiner's amendments.

[INSERT TABLE 3 HERE.]

5.2 Impact of Examiner's Amendments on Pendency

In Section 3, we argued that the use of examiner's amendments is indicative of efficient examination and intuitively should lead to both shorter patent pendency and longer effective patent term (Hypothesis 3), providing economic benefits to innovators and firms. In this section, we quantify these benefits by estimating the effect of a first-action examiner's amendment on logged post-first-action pendency. The empirical specification for this regression is:

$$ln(PEND_{eit}) = \beta_0+\beta_1 Exper_i+\beta_2 ICL_i+\beta_3 ICC_i+\nu Exam\_Amend_{eit}+\gamma_p+\gamma_t+\gamma_e+\gamma_g+\gamma_u+\epsilon_{eit} \tag{3}$$

where $PEND_{eit}$ is defined to be post-first-action pendency (issue month - month of first action) and the covariates are similar to those defined for the previous set of regressions. We restrict the underlying sample to only those granted patents with a first-action examiner's amendment, or those applications receiving a single non-final rejection followed by an allowance decision. Because of this sample restriction, we are careful to only interpret our estimates for incoming applications similar to those in the selected sample. In particular, our sample does not contain high-quality incoming applications that were allowed on the first action (without an examiner's amendment), nor very low incoming quality applications that required multiple rounds of review before either being granted, or ultimately abandoned. Despite this, the restricted sample is not overly limiting since we are interested in the patent quality trade-off between first-action examiner's amendments, and longer prosecution through the non-final rejection to allowance examination route.

The examiner's decision to use a first-action examiner's amendment rather than more traditional patent prosecution is likely positively correlated with incoming patent quality, leading to omitted variable bias. Therefore, we utilize two additional empirical approaches to overcome this issue. The first is directly controlling for incoming patent scope by including the PGPub ICL and ICC. Despite this, additional components of incoming patent quality may reside in the error term. To account for this, we turn to an instrumental variable approach. In particular, we use the examiners leave-one-out first-action examiner's amendment rate to instrument for the examiner's first-action decision on the current application. In particular, for each application i examined by examiner e, we compute the fraction of examiner e's earlier first-action decisions that resulted in a first-action examiner's amendment, relative to the total number of first-action decisions that resulted in a first-action examiner's amendment, or non-final rejection to allowance (that is, relative to all examiner $e's$ earlier first-action decisions in the sample). This IV approach is similar to the leave-one-out examiner grant rate utilized in the literature (Farre-Mensa, *et al.*, 2019, Sampat and Williams, 2019). Finally, we use examiner and USPC fixed effects (γ_e and γ_u), along with our direct measures of examiner specialization discussed earlier, to control for examiner technological specialization (Righi and Simcoe, 2019).

[INSERT TABLE 4 HERE.]

The IV regression results are shown in Table 4. We first regress post-first-action pendency on a binary indicator, where indicator $Exam\_Amend$ takes value one if the application was allowed on the first action with an examiner's amendment and zero if the application was allowed after a single non-final rejection. We repeat this regression in column (3), but only include applications without a parent (i.e., new U.S. applications). We find that relative to those granted patents that received at least one office action rejection, a first-action allowance with an examiner's amendment decreases pendency by more than 50 percent,[9] confirming Hypothesis 3.

[9] In these regressions, the dependent variable ($ln(PEND_{eit})$) is logged and the covariate of interest ($Exam\_Amend_{eit}$) is a dummy variable. To obtain the percentage change in pendency from a single rejection to a first-action allowance with an examiner's amendment, one must transform the coefficient using the following formula: $100 * (e^{\beta} - 1)$.

Instrumenting for examiner's amendment using 2SLS, the leave-one-out examiner's amendment rate for each examiner should be correlated with the first-action decision to use an examiner's amendment but uncorrelated with the quality of the examined application. The F-statistic for the first stage (results not shown) is above 1285 for column (2) and 380 for column (4), satisfying the F-statistic cutoff of 10 for weak instruments suggested in (Stock, Wright, and Yogo 2002; Cameron and Trivedi 2010). These F-statistics, though large, are consistent with the magnitude of the first stage F-statistic from Sampat and Williams (2019), which also uses a similar leave-one-out examiner decision. Interestingly, the results are consistent across methods (OLS and IV) and sample (full sample and the restricted sample to U.S. new applications).

Our results demonstrate that increased examiner's amendment use, *ceteris paribus*, leads to shorter pendency. The literature on pendency and firm outcomes provide evidence that the reduction in pendency could benefit both innovators and firms in several ways. For example, decreased patent grant delays will hasten the resolution of uncertainty regarding granted patent scope and intellectual property rights conferred to assignees (Gans, Hsu and Stern 2008). This reduction of uncertainty should in turn mitigate frictions related to technology transfer.

5.3 Impact of Examiner's Amendments on Patent Quality

Our previous results identify the relationship between examiner experience and seniority based incentives on an examination behavior (first-action examiner's amendment) that significantly reduces patent grant delay, and therefore likely benefits innovators and firms. Despite this, a potential cost arises in the form of reduced patent quality if use of the examiner's amendment lowers examination quality relative to the traditional multi-round examination procedure. For example, increasingly time-constrained examiners may pursue an examiner's amendment to meet output (examination) requirements, when several rounds of additional examination could have lead to higher quality examination. As stated in Hypothesis 4, we test the examination quality of an examiner's amendment relative to more traditional prosecution.

Marco *et al.* (2019) finds that patent prosecution generally narrows the patent application claims and that the change in patent scope during prosecution embodies one component of patent examination quality. The authors argue that changes in patent scope over the patent examination process can be measured by the difference between the scope measure (ICL or ICC) at filing and at grant (ΔICL or ΔICC). Using $\Delta Scope$ as a dependent variable allows us to estimate the relative change in scope due explicitly to an examiner's amendment, where $\Delta Scope$ is measured as the simple difference between the patent scope measures (ICL and ICC) at grant and at the pre-grant publication of the application (PGPub) (that is, difference = scope at grant − scope at pre-grant publication). Since more independent claims indicate broader scope, claim narrowing is *decreasing* in ΔICL. On the other hand, since more words in the shortest independent claim indicates narrower scope, claim narrowing is *increasing* in ΔICL. We estimate the following specification:

$$\Delta Scope_{eit} = \beta_0 + \beta_1 Exper_i + \beta_2 ICL_i + \beta_3 ICC_i + \nu Exam\_Amend_i + \gamma_p + \gamma_t + \gamma_e + \gamma_g + \gamma_u + \epsilon_{eit} \tag{4}$$

where $\Delta Scope_{eit}$ is either ΔICL_{eit} or ΔICC_{eit}, e indicates the examiner, t is the first-action year, u indicates the U.S. patent classification and the remaining variables are described above. For these regressions, the sample is the same as the pendency regressions described in Section 5.2, where we compare first-action allowances with an examiner's amendments to allowances with a single non-final rejection. Similarly to the pendency regressions, the unobserved quality of the application will be correlated with both the decision to issue a first-action allowance with an examiner's amendment and the necessary changes required for patentability, leading to omitted variable bias. Therefore, we again instrument for the examiner's amendment decision by using the leave-one-out examiner's amendment rate. In addition to the full sample, we also run models on the sub-sample restricted to granted patents with no parent application (*i.e.*, U.S. new applications).

[INSERT TABLE 5 HERE.]

The regression results are shown in Table 5. In columns (1) and (3) we find that the use of an examiner's amendment is associated with 14 fewer words added to the shortest independent claim from filing to grant compared to those applications with a single non-final rejection. However, as noted above, this statistical relationship is expected since use of the examiner's amendment is likely positively correlated with incoming patent quality. Therefore, we turn to the instrumental variable regressions in columns (2) and (4). The IV estimates are insignificant but much less precise than the OLS estimates. Following the interpretation of insignificant IV estimates in Sampat and Williams (2019), we rule out relative decreases in scope narrowing (scope narrowing is increasing in ΔICL) of greater than 6.96 (for new applications) to 9.21 (for all applications) words compared to a single non-final rejection. Columns (5) through (8) in Table 5 show a similar set of regressions using ΔICC as the dependent variable. The IV estimates are mostly insignificant, ruling out relative decreases in scope narrowing (scope narrowing is decreasing in ΔICC) greater than 0.144 claims (for only new applications). The coefficient on the examiner's amendment variable is negative and significant for all applications in column (6). This result indicates that the examiner's amendment route narrows the patent application claims more than traditional prosecution.

Overall, these IV estimates demonstrate that examination quality, to the extent described above, is not significantly different between issuing an examiner's amendment and extending examination to a single non-final rejection. Despite this, since our IV results are insignificant, we do not find evidence that examination quality is negatively affected by the use of examiner's amendments.

6 Reconciling Results with the Prior Literature

The previous section demonstrates that examiner experience and seniority-based incentives positively influence the innovation ecosystem through increased examination efficiency. With both experience and seniority, examiners increasingly use examiner's amendments, reducing patent application pendency without sacrificing quality. The prior literature on examiner characteristics and patent office outcomes, however, finds evidence of economic inefficiency related to examiner seniority and experience (Lemley and Sampat 2012; Frakes and Wasserman 2017). To the extent possible, we re-analyze and reconcile these results with our own. We evaluate the existing empirical methodologies (Lemley and Sampat 2012; Frakes and Wasserman 2017), arguing that empirical frameworks using the overall allowance decision to study examiner behavior are susceptible to multiple endogeneities, biasing results. In addition, we argue that one can mitigate these biases by, first, focusing on the first-action allowance decision (Lemley and Sampat 2012) and, second, by addressing and incorporating previously neglected institutional details into an empirical strategy (like the examiner's amendment).

Our results show that examiner experience and seniority are generally uncorrelated with the probability of a first-action allowance, providing direct counterevidence to the first-action regression results of Lemley and Sampat (2012) but also demonstrating that the binding time constraints hypothesis of Frakes and Wasserman (2017) does not hold at first action. We note that our results are limited to the first-action decision but, in light of this new evidence, we describe the implications of our results for USPTO examination policy.

6.1 Identifying the Impact of USPTO Examiner Incentives on Allowance Rates

Lemley and Sampat (2012) and Frakes and Wasserman (2017) utilize the pseudo-random assignment of patent applications to identify the impact of examiner characteristics and incentives on patent office outcomes using overall allowance decisions. The overall allowance decision is the ultimate outcome of an application, which may only result in an allowance, or abandonment (often after one or more RCEs). Several studies have noted, however, that identifying the impact of patent examination using the full allowance decision is empirically complex (Lemley and Sampat 2012; Cotropia, Lemley and Sampat 2013; Farre-Mensa, Hegde and Ljungqvist 2019; Hegde and Raj 2019). We agree. In this section, we argue that even under the assumption of pseudo-random assignment, estimated effects of examiner characteristics and incentives on overall allowance decisions are likely biased and that researchers should use the first-action decision to study examiner behavior, as used in Lemley and Sampat (2012). We also explain why previously unincorporated institutional details, including the use of examiner's amendments, must be taken into account to ensure accurate identification of characteristics affecting first action allowance decisions.

The overall allowance depends not only on examination quality and examiner negotiation ability but also unobserved applicant behavior (the persistence of applicants after rejections, the willingness of applicants to narrow the claims to meet patentability requirements, etc.), which increases the complexity of identifying examiner behavior. Under the assumptions of random assignment, unobserved application characteristics (quality, characteristics of applicants, etc.) should not be correlated with examiner characteristics including seniority and experience. However, even under the pseudo-random assignment assumption, examiner and unobserved applicant characteristics may *become* correlated, leading to omitted variable bias. Specifically, more persistent applicants are likely to continue prosecution after the initial final rejection. This unobserved persistence will be positively correlated with both the likelihood of allowance and time-based examiner characteristics including seniority and experience, upward biasing this estimated relationships in full allowance regressions. This upward bias could lead to statistically significant results suggesting that more experienced and senior examiners are more likely to allow applications, where no such relationship exists.

Another point of concern with the overall allowance decision is the relationship between unobserved patent quality and the evolution of the examiner's docket. Under the assumptions of random assignment, the quality of an incoming application should not be correlated with examiner seniority and experience. However, the quality of existing applications on an examiner's docket may become correlated with grade as the examiner climbs the GS scale. For example, taking the set of randomly assigned applications docketed to a new examiner, only a fraction of these applications will be disposed before the examiner's next promotion. If applications in one tail of the quality distribution are disposed faster than the other, then, as an examiner is promoted or becomes more experienced, the remaining set of applications differs in quality compared to the original set. This differential quality would also lead to omitted variable bias, the direction of which depends on relative pendency between high and low quality applications. Future research on the evolution of an examiner's document would be useful for clarifying this potential issue.

A related problem exists when considering continuation applications, as in Frakes and Wasserman (2017). Even if the original application was randomly assigned, continuing applications are generally assigned to the same examiner as the earlier application, violating the random assignment assumption. Given the length of patent prosecution, more senior and experienced examiners may be more likely to have continuing applications. If these applications are more likely to be allowed (for example, because of the persistence of applicants employing these strategies), then estimates for time based incentives (grade and experience estimates) in full disposal regressions that include continuing applications will be biased upward.

A final concern relates to the use of overall allowance decisions as a basis for examination quality. Two examiners may have different overall allowance rates because one examiner is much better at negotiating with the applicant to reveal allowable subject matter. Differences in observable overall allowance rates for these reasons do not reflect low quality patent examination outcomes with increasing overall allowance rates.

Lemley and Sampat (2012) address these endogeneity problems (1) by using the first-action decision as the dependent variable instead of the overall allowance decision and (2) by removing continuing applications (continuations and continuations in-part). The first-action decision captures both examiner behavior and examination quality, but occurs early in examination, mitigating concerns related to subsequent applicant behavior and the evolution of an examiner's docket. Lemley and Sampat (2012) argue that, at first action, the examiner's decision is only an evaluation of the application (accept or reject) and that examiners do not negotiate with applicants to modify the application to meet the standards of patentability. However, this assumption is not true. Examiners can negotiate with the applicant at first action to modify the application using an examiner's amendment. In light of this institutional detail, the first-action decision framework should be adjusted accordingly: to observe the original intent of Lemley and Sampat (2012), one should evaluate examination quality using the examiner's decision, at first action, to allow an application without any modifications (including without an examiner's amendment). Any positive correlation between examiner characteristics and this outcome would be indicative of lower-quality examination.

6.2 First Action Allowance Rates

To assess the importance of examiner's amendments for assessing examination quality on the first action decision, we first create the first-action allowance regressions from Lemley and Sampat (2012) using our own data and then re-run the same regressions using our revised definition of a first-action allowance, *i.e.*, an allowance on the first-action without an examiner's amendment. We begin by running the following patent application-level empirical specification to ensure that the results of Lemley and Sampat (2012) for first action allowances hold with our data:

$$FA\_Allow_{eit} = \beta_0 + \beta_1 Exper_i + \beta_2 ICL_i + \beta_3 ICC_i + \gamma_p + \gamma_t + \gamma_e + \gamma_g + \epsilon_{eit} \qquad (5)$$

where $FA\_Allow_{eit} = 1$ if the application i was allowed on the first action by examiner e, and

$FA\_Allow_i = 0$ otherwise. Our access to internal USPTO data allows us to capture examiner characteristics more precisely than Lemley and Sampat (2012), including the measurement of both seniority and experience at the date of first-action. In addition, we deviate from Lemley and Sampat (2012) by using months of experience rather than the more coarse multi-year experience fixed effects.[10]

Frakes and Wasserman (2017) argues that more senior examiners lack the time to properly evaluate applications, finding a positive relationship between the overall allowance decision and examiner seniority. Equation 5 is similar to the regression run in Frakes and Wasserman (2017), except that we replace the overall allowance decision with the first-action allowance decision. An increasing first-action allowance rate with examiner seniority would be consistent with Frakes and Wasserman (2017) under a more thorough identification of examiner behavior (on the first action, rather than overall application outcome).

Table 6 shows the results for all applications in Column (1) and for new applications in column (2). These results confirm the prior literature (Lemley and Sampat 2012), showing that the probability of a first-action allowance is increasing both in experience (labeled as *Exper*) and grade. As done by Lemley and Sampat (2012), limiting to new applications is critical since the magnitdues of the grade and experience effects are lower in column (2) than (1). For example, a GS-14 examiner is 5.73 percentage points more likely to issue a first action allowance overall, but only 4.04 percentage points on a new application. This likely reflects the fact that senior examiners are more likely to have continuation applications, which have already received some examination. This is a critical point for the allowance regressions in Frakes and Wasserman (2017) since their analysis does not limit to new applications. Some of the impact they attribute to examiner incentives is likely due to a different distribution of new applications for more senior examiners.

Columns (5) and (6) show the results that include the examiner specialization variable. Interestingly, and consistent with Righi and Simcoe (2019), more specialized examiners are

[10]In our robustness checks, we re-run this specification using experience fixed effects.

less likely to allow on the first action. In particular, a one standard deviation increase in specialization leads to a 0.3 percentage point decrease in the first action allowance rate $(0.0385 \cdot (-0.0771))$. This likely reflects the gains from specialization in finding relevant prior art. Also, for new applications, GS-12, GS-10 and GS-7 examiners are no longer statistically different than GS-9, and the magnitudes of the impacts for Grades 13 and 14 are slightly smaller. For example. Grade 14 examiners are 4.04 percentage points more likely to issue a first action allowance, but after including specialization, are 3.81 percentage points more likely. Although the differences are not large, these results suggest that considering examiner specialization is important for identifying the impact of incentives and experience on examination quality.

[INSERT TABLE 6 HERE.]

Next we explore the impact of experience and seniority on the decision to issue a first action allowance without any modifications to the claims; that is, without using an examiner's amendment to allow on the first action. We use Equation 5 but with our redefined first-action allowance (allowances without modifications) as the dependent variable. Column (3) in Table 6 shows the results for all applications, and column (4) for only new applications. Importantly, the grade coefficients for the modified first action allowance in column (3) are significantly smaller than for first action allowances in column (1). For example, GS-14 examiners are 28.4 percent less likely to issue a first action allowance without an examiner's amendment than a first action allowance. By only considering new applications, the difference increases even further. Relative to all applications, the issuance of a first action allowance without an examiner's amendment decreases by 54 percent for grade 14 examiners. Additionally, the grade effects for GS-11, 12, 13 and experience are no longer significantly different than grade 9 is column (4). Columns (7) and (8) show the results for the modified first action allowance while including the specialization variable. The results are similar, but in column (8), the difference between GS-7 and GS-9 is no longer significant as well.

These results suggest that when considering our preferred indicator of examination quality through the first action (the first action allowance without an examiner's amendment), the impacts of examiner incentives generally disappear. A small difference for GS-14 examiners does remain however. Compared to the outcomes using the traditionally-defined first-action allowance rate shown in column (1), GS-14 examiners are 55.75 percent less likely to issue the application without any changes (relative to the estimate in column (8)). There are several possible explanations for the increased modified first-action allowance rate for GS-14 examiners, relative to GS-9 (although far less severe than the overall first-action allowance rate). The difference could be driven by examination time incentives, as described in earlier literature (Frakes and Wasserman 2017), although this is not the only possibility. In particular, additional autonomy and lack of oversight at GS-14 or risk aversion could also drive this result. We discuss this further in the policy discussion section below.

Finally, the insignificant coefficient on the experience variable in columns (6) and (8) shows that more experienced examiners do not conduct lower quality examination at first action, providing counterevidence to the results of Lemley and Sampat (2012). The experience and seniority results from Table 6 demonstrate that institutional details matter in analyzing examination quality and patent office outcomes at the USPTO.

How does this reconcile with the results of Frakes and Wasserman (2017)? The insignificant relationship between lower levels of seniority and first-action outcomes demonstrates that the binding time constraints hypothesis does not hold at first action. We argue that exploiting pseudo-random assignment with examiner specialization, focusing on new applications, and using the first-action allowance without an examiner's amendment is the purest way to analyze examiner behavior. While we have no reason to suspect, at current, that examiner responses to decreasing time allotments should change between first action and the final allowance decision, we cannot definitely rule out this scenario. We discuss the policy implications of our results in the next section.

6.2.1 Discussion and Policy Implication

In recent years, the USPTO has received considerable criticism from academia, journalists, practitioners, and policy-makers over the impact of examiner incentives on patent quality, and related economic outcomes. In 2016, the GAO concluded that the "USPTO has not fully assessed the effects of the time allotted for application examinations or monetary incentives for examiners on patent quality." Further, based upon survey evidence, the GAO estimated that 70 percent of examiners do not have enough time to thoroughly examine patent applications (GAO 2016). Frakes and Wasserman (2017) go further, suggesting that if "all examiners were allocated as many hours as are extended to GS-7 examiners, the Patent Office's overall grant rate would fall by roughly 14 percentage points, amounting to roughly 40,000 fewer patents issued per year." Utilizing estimates in their earlier work, Frakes and Wasserman (2019) perform a cost benefit analysis, and find that doubling the time for patent examination would increase the social welfare of the patent system.

The debate over examiner incentives, patent quality and economic outcomes has several dimensions. First, as discussed in this paper, patent examiners face different incentives based on seniority. If these incentives are improperly aligned with learning rates, then average patent quality will likely vary across examiners. A related, yet different question, is whether society would be better off spending additional resources on patent examination. The fundamental trade-off here is between ex-ante screening and ex-post screening (Lemley, 2001). Ex-ante screening refers to screening patents before grant, while ex-post screening refers to screening patents for validity after grant in the litigation system. Lemley (2001) argues that because patent value is highly skewed (Pakes, 1986), society is better off spending additional resources screening valuable patents ex-post, rather than screening all patents ex-ante. Using a similar method, and estimates from Frakes and Wasserman (2017), Frakes and Wasserman (2019) come to the opposite conclusion. In particular, doubling the amount of time provided to examiners would increase the welfare of the patent system.

Our results primarily contribute to the first question (Are examiner incentives appropriately aligned with learning rates across seniority and experience?), although indirectly contribute to answering the second question (What level of resources should be expended on patent examination?) since grade estimates on allowance rates are used by Frakes and Wasserman (2019) to understand the impact of increasing examination time. As for the incentive alignment question, previous literature suggests that examiner incentives are improperly aligned with learning rates. Our results suggest a different view. After accounting for several features of the data, and misconceptions about patent prosecution, we find that a particularly credible piece of evidence for mis-aligned examiner incentives, that of increasing first-action allowance rates, is misinterpreted in the literature. In particular, the variation in examination outcomes at the first action decision generally disappears after accounting for the examiner's amendment. Further, this mechanism significantly reduces patent pendency without sacrificing examination quality.

Beyond the statistical issues with identifying examiner behavior on overall allowance decisions, we argue that, while our analysis does not directly disprove the "binding time constraints" hypothesis, it is unlikely that the "binding time constraints" hypothesis would hold for overall disposal decisions but not the first action. We note that issuing a first-action allowance decision is the fastest way for an examiner to receive production credit. For this reason, it's unclear why examiners would wait until the final disposal to issue an allowance because of "binding time constraints." Further evidence is needed to reconcile the evidence of "binding time constraints" on full allowance decisions with our finding that first-action allowance rates do not generally increase with seniority and experience on the first action (in a way that leads to low patent quality). Further, if time based incentives are modified, examiners may have less of an incentive to utilize the pendency reducing examiner's amendment mechanism. As noted, the use of examiner's amendments may reduce pendency by approximately 50 percent, and therefore innovators and firms may face longer pendency on average through a modification of examiner incentives for all seniority levels. For this reason, we strongly encourage further research before modifying examiner time based incentives.

Although we find that increasing first-action allowance rates doesn't generally indicate low patent quality, we do find a slight difference in behavior for GS-14 examiners. For this reason, any policy response from our paper should be restricted to these examiners. To determine the appropriate response however, more research is needed. In addition to receiving less time to examine patent applications, GS-14 examiners also receive full signatory authority. This allows them to sign off on their own cases. We can think of three reasons why GS-14 examiners might allow more applications on the first action. First, as studied in previous literature, the time adjustment for GS-14 may be particularly steep. Second, GS-14 examiners may become more lenient with less oversight provided by the full signatory program. Third, without signatory authority, risk averse junior examiners might allow too few applications on the first action. This could be the case since an examiner does not generally get another look at allowed applications, or if the repercussions for allowing an invalid patent are particularly severe. The precise mechanism driving the variation in GS-14 first-action allowance rates will determine the policy response, which we leave for further research.

7 Robustness Checks

We include several general robustness checks to the examiner amendment and first allowance without an examiner's amendment regressions, many of which are similar to those run in Frakes and Wasserman (2017). First, to eliminate the possibility that examiner sorting is driving the results, we run specifications that include technology-by-year (technology center) and United States Patent Classification (USPC) fixed effects.[11]. The technology-by-year fixed effects account for examiners that switch technology centers, and allow for the technology effect to change over time. The USPC fixed effects regressions account for technology at a more dis-aggregated level. Second, we subset the data to only include first-action decisions

[11] Frakes and Wasserman (2017) use NBER categories (37 groups) for technology-by-year fixed effects. We use technology center (7 groups) because the NBER concordance relies upon USPC, which is only publicly available through 2014.

for examiners that begin at GS-7 and are GS-14 by the end of our sample. This accounts for possible selection due to examiners that start at a higher grade, leave the USPTO before becoming GS-14, or decide to not be promoted at some point within the grade scale. Finally, we further explore the contribution of experience by running specifications that include experience fixed effects (at the month level), and 6 month experience bands. The purpose of these regressions is to examine any non-linearity between experience and the probability of issuing an examiners amendment. The regression results are contained in Tables 7 and 8, where the dependent variables are the probability of receiving an examiner's amendment and the probability of allowing the application without an examiner's amendment.

Table 7 shows that our robustness results for the examiner's amendment are qualitatively and quantitatively similar to our main results. For the "balanced sample", we note that there is a loss of statistical significance for the GS-11, GS-12, and experience coefficient. A possible explanation for this loss of significance is the large decrease in the number of observations due to enforcing the balanced panel restriction for this table. Columns (3) and (4) from Table 7 allow for non-linearities in the examiner experience variable. Figure 2 shows that the linear and increasing contribution of experience to the probability of issuing an examiner's amendment holds when we allow for more flexibility in the experience variable (in particular, by allowing a different experience effect for each month of experience). Table 8 shows that our robustness results on the probability of issuing a fist action allowance without an examiner's amendment are both qualitatively and quantitatively similar to our main results. In particular, after incorporating the examiner's amendment, examiners do not differentially use first action allowances with experience and grade, except for GS-14 across the specifications.

As a final robustness check, we limit to examiner first action observations for examiners within three years of promotion. The idea is that examiners on and off the standard promotion path may behave differently. Table 9 shows the results for the probability of issuing an examiner's amendment. Column (1) in Table 9 is for all applications, column (2) is for new applications, column (3) adds examiner specialization for all applications, and column (4) is for new applications with specialization, all with applications examined within three years of promotion. The results are consistent with our earlier results. Table 10 reproduces our main table for the first action allowance, and first action allowance without an examiner's amendment for examiner's within three years of promotion. Qualitatively the results are identical, but the magnitudes of the seniority and experience effects are smaller. For example, including examiner specialization and only considering new applications, the increased probability of issuing a first action allowance without an examiner's amendment as a GS-14 is 2.06 percentage points within three years of examination, relative to the 2.54 percentage points obtained earlier.

[INSERT FIGURE 2 HERE.]

8 Conclusions

In this paper, we explored the relationship between patent examiner experience and time based incentives on patent pendency, and patent quality. We identified and analyzed a feature of patent examination not previously discussed in the literature, the use of examiner's amendments. Examiner's amendments are used in lieu of an office action rejecting claims, to negotiate a set of changes to the application to make it allowable. We found that more experienced and senior examiners provide more value to the patent system by more quickly tailoring otherwise un-allowable applications into patented inventions, without sacrificing patent quality. This behavior is encouraged by the Office's emphasis on compact prosecution, and reduces uncertainty in patent grant delay; the latter of which increases efficiency in the markets for technology (Gans *et al.*, 2008; Hegde and Luo, 2018).

While our study finds evidence linking examiner experience and incentives to more efficient prosecution early on in patent examination, the overall impact of USPTO examination on patent quality and economic outcomes need to be further explored. Although we favor first action decisions for identifying examiner behavior, further research could reconcile the differences between our results, and results obtained by analyzing full allowance decisions. With that said, policy makers should reconsider adjusting time allocations for all examiners in light of our new evidence. Before modifying existing policies, researchers and stakeholders should further explore the variation in outcomes between junior (GS-13 and below) and senior examiners (GS-14) and the impacts of the signatory program, examiner risk aversion, and variation in time allocations. We find differences between examiners (specifically, between grades GS-14 and GS-9) that suggest policy may need to be adjusted for one of these reasons. Finally, we note that our research does not disprove the notion that overall changes in examination time across the board may lead to greater efficiency in the patent system, which is an important question for further research.

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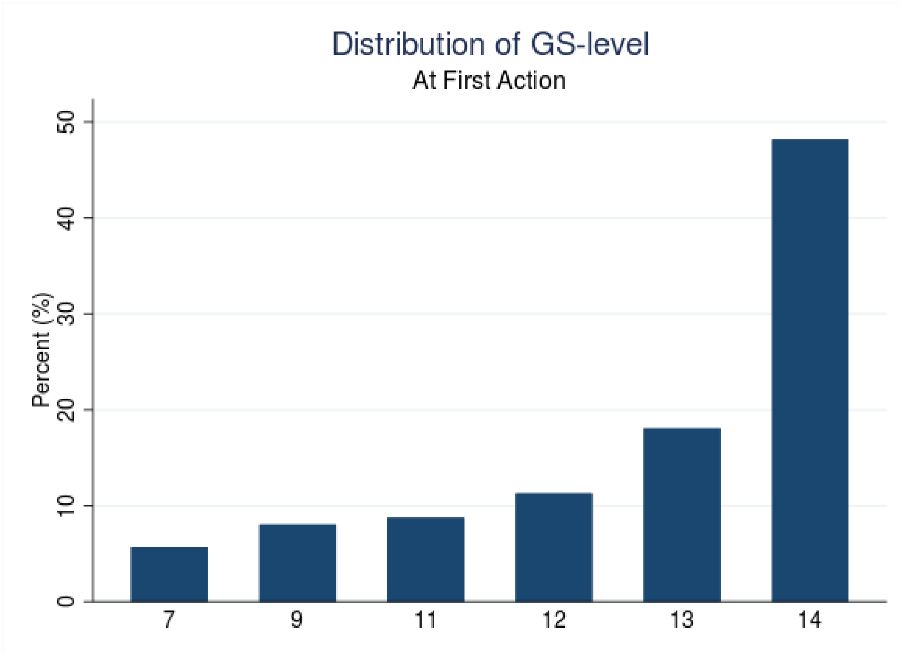
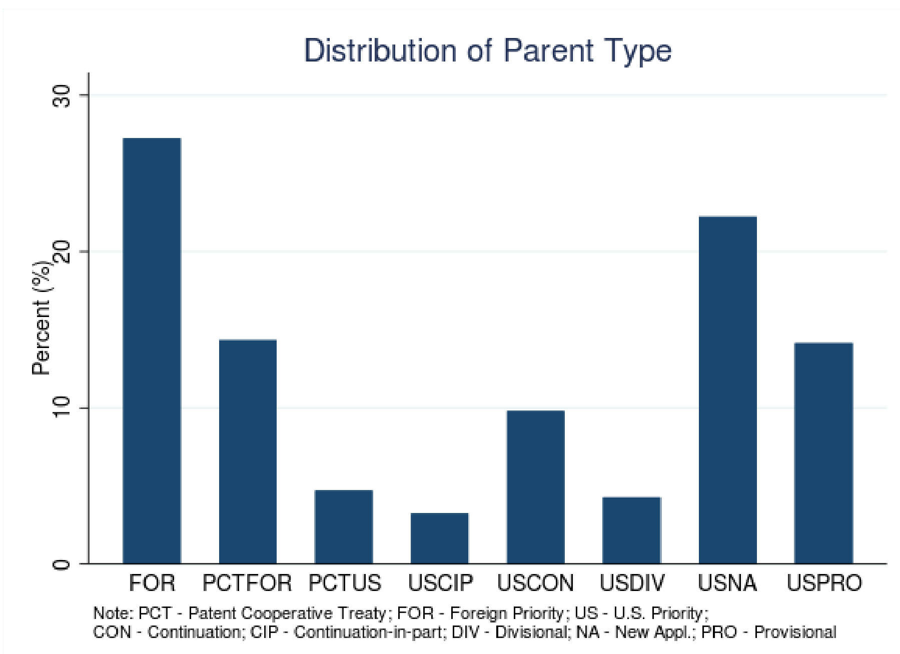
Table 1: Variable Names and Descriptions

Variable	Regression Abreviations	Description	Source
Allowance (First-action)	*FA_Allow*	Binary indicator for patent allowance. 1 = FAOM grant, 0 otherwise.	PatEx - transactions
Allowance (Modified First-action)	*FA_Allow*	Binary indicator for patent allowance without examiner amendment. 1 = FAOM grant without examiner amendment, 0 otherwise.	PatEx - transactions
Application ID	-	Patent application number	PatEx - application_data
Application Parent Type	γ_p	Categorical variable listing the parent type of an application.	PatEx - application_data
Balanced Sample	-	Binary indicator for "balanced sample". 1 = Examiner observed from GS-7 to GS-14.	Internal USPTO data
Examiner Specialization (Avg. and Var. TF-IDF Similarity)	-	Examiner specialization measures the degree of similarity (average and variance of TF-IDF cosine similarity) between pairs of claims from first actions submitted by the examiner in the previous year.	USPTO Bulk Data XML
Examiner's Amendment Indicator	*Exam_Amend*	Binary indicator for an examiner's amendment prior to or including the FAOM decision. Please note that examiner's amendments are not limited to the first-action decision.	PatEx - Transactions
Experience (months)	*Exper*	Examiner experience in months.	Internal USPTO data
Seniority (GS-level)	*Grade* - γ_g	Categorical variable for GS-level of the examiner at First-action on the Merit (FAOM) decision.	Internal USPTO data
Scope: Independent Claim Count	*ICC*	Independent Claim Count or the number of independent claims at PGPub.	Patent Claims Research Dataset
Scope: Independent Claim Length	*ICL*	Independent Claim Length or the number of words in the shortest independent claim at PGPub.	Patent Claims Research Dataset
Post-first-action Pendency	*PEND*	Length of time (in months) between the first-action decision and the disposal of the application.	PatEx - application_data & PatEx - Transactions
Primary U.S. Patent Classification	γ_u	USPC classification	PatEx - application_data
Technology-by-year Fixed Effects	-	Technology Center by year fixed effects.	PatEx - application_data
Three Year Promotion Window	-	Binary indicator for promotion path. 1 = experience in grade < 3 years at FAOM decision, 0 otherwise.	Internal USPTO data
Change in Scope: Independent Claim Count	*Δ Scope*	The change in the number of independent claims from PGPub to grant, calculated by a simple difference.	Patent Claims Research Dataset
Change in Scope: Independent Claim Length	*Δ Scope*	The change in the number of words in the shortest independent claim from PGPub to grant, calculated by a simple difference.	Patent Claims Research Dataset

Figure 1: Distribution of (a) GS-Level and (b) Parent Type at First Action



(a) GS-Level



(b) Parent Type

Figure 2: Examiner Amendment Experience Fixed Effects

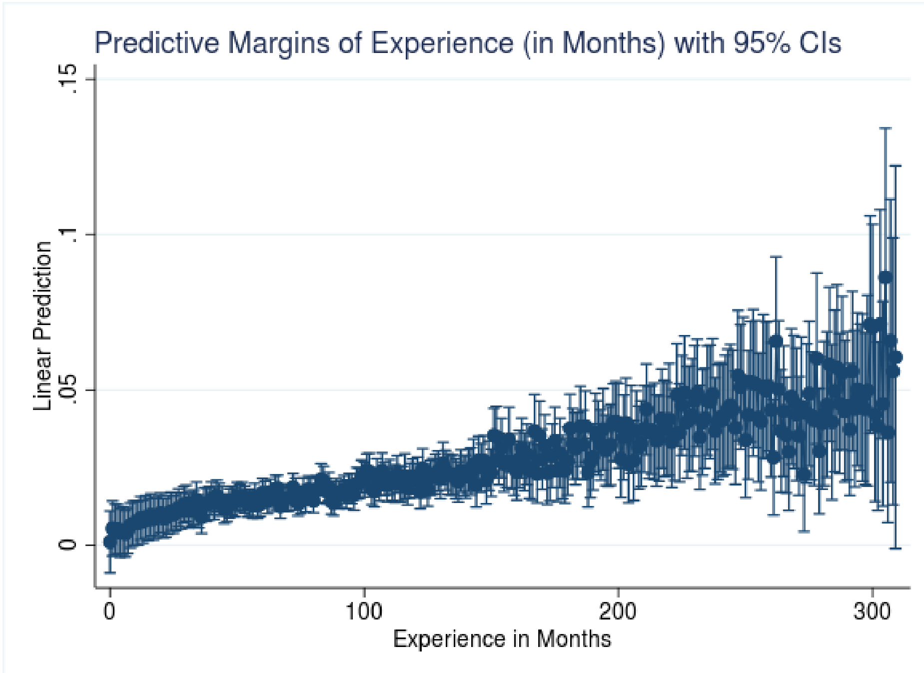


Table 2: Summary Statistics

VARIABLES	N	Mean	St. Dev.	p25	p50	p75
Examiner's Amendment	4,683,000	0.0234	0.151	0	0	0
Experience (months)	4,683,000	97.94	71.94	39	83	143
Three Year Promotion Window	4,683,000	0.598	0.490	0	1	1
ICC	4,683,000	2.880	3.383	2	3	3
ICL	4,683,000	108.9	104.3	58	90	135
First-action Allowance	4,683,000	0.0883	0.284	0	0	0
Balanced Sample (GS-7 to GS-14)	4,683,000	0.284	0.451	0	0	1
Modified First-action Allowance	4,683,000	0.0649	0.246	0	0	0
Examiner Specialization (Avg.)	4,317,000	0.0713	0.0385	0.0471	0.0620	0.0865
Examiner Specialization (Var.).	4,317,000	0.00838	0.00879	0.00431	0.00665	0.00982

Table 3: Examiner Amendment Regressions (Dependent Variable: $Exam\_Amend_{eit}$)

VARIABLES	(1) Baseline	(2)	(3) Examiner Specialization	(4)
Seniority: GS-7	-0.00123**	-0.000293	-0.00135*	0.000968
	(0.000468)	(0.000598)	(0.000626)	(0.000862)
Seniority: GS-11	0.00332***	0.00298***	0.00203***	0.00184**
	(0.000427)	(0.000576)	(0.000505)	(0.000693)
Seniority: GS-12	0.00604***	0.00450***	0.00430***	0.00344***
	(0.000551)	(0.000723)	(0.000621)	(0.000810)
Seniority: GS-13	0.0102***	0.00752***	0.00838***	0.00642***
	(0.000703)	(0.000866)	(0.000761)	(0.000956)
Seniority: GS-14	0.0163***	0.0138***	0.0144***	0.0127***
	(0.00106)	(0.00129)	(0.00111)	(0.00136)
Experience (months)	0.000196***	0.000132**	0.000233***	0.000179***
	(2.41e-05)	(4.27e-05)	(2.62e-05)	(4.74e-05)
Scope (ICC)	-0.000195**	-9.59e-05	-0.000211**	-0.000126*
	(6.59e-05)	(5.42e-05)	(7.35e-05)	(5.98e-05)
Scope (ICL)	8.74e-05***	0.000159***	8.86e-05***	0.000165***
	(8.20e-06)	(4.90e-06)	(8.68e-06)	(5.26e-06)
Exam. Spec. (Avg.)			-0.00868	0.00444
			(0.00960)	(0.0138)
Exam. Spec. (Var.)			0.00687	-0.0347
			(0.0291)	(0.0380)
Constant	-0.0123***	-0.0169***	-0.0132***	-0.0198***
	(0.00151)	(0.00134)	(0.00154)	(0.00145)
Observations	4,682,148	1,047,501	4,315,806	940,589
R-squared	0.008	0.011	0.008	0.010
Number of Examiners	13,760	13,499	12,399	12,161
Only New Applications	NO	YES	NO	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. Regressions include first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Columns (3) & (4) contain examiner specialization similarity variables. Similarity measures are defined as the average (Mean Sim.) and variance (Var. Sim.) of the pairwise TF-IDF cosine similarity for all applications with a first action decision by a given examiner during the previous year. Robust standard errors are clustered by examiner and are reported in parentheses. Columns (2) & (4) include only new applications without a priority. Examiner specialization regressions in columns (3) & (4) do not include observations from the examiner's first calendar year at the USPTO. Columns (1) & (3) include application parent type fixed effects (new application, continuation, Patent Cooperation Treaty applications, etc.). Regressions in this table correspond to equation 2.

Table 4: Examiner Amendments and Log Post-first-action Pendency (Dependent Variable: $ln(PEND_{eit})$)

VARIABLES	(1) OLS	(2) IV	(3) OLS	(4) IV
Examiner's Amendment	-0.788***	-0.753***	-0.779***	-0.818***
	(0.00219)	(0.0281)	(0.00419)	(0.0564)
Experience (months)	0.000991***	0.000964***	0.000310	0.000332
	(9.71e-05)	(9.12e-05)	(0.000220)	(0.000216)
Scope (ICC)	0.00314***	0.00309***	0.00606***	0.00613***
	(0.000381)	(0.000123)	(0.000596)	(0.000502)
Scope (ICL)	-9.10e-05***	-0.000103***	-0.000119***	-9.92e-05**
	(9.78e-06)	(1.03e-05)	(1.40e-05)	(3.06e-05)
Constant	2.255***	2.256***	2.172***	2.171***
	(0.0112)	(0.288)	(0.0237)	(0.299)
Observations	965,593	965,593	188,221	188,221
R-squared	0.421	0.400	0.393	0.400
Number of Examiners	11,248	11,248	9,640	9,640
Only New Applications	NO	NO	YES	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. The sample for each regression in this table includes all applications with a first-action allowance with an examiner's amendment or a single non-final rejection and subsequent allowance. Regressions include first-action year, examiner, U.S. Patent Classification, and GS-level fixed effects. Each regression also contains examiner specialization similarity variables. Similarity measures are defined as the average (Mean Sim.) and variance (Var. Sim.) of the pairwise TF-IDF cosine similarity for all applications with a first action decision by a given examiner during the previous year. Robust standard errors are clustered by examiner and are reported in parentheses. Odd-numbered columns (1, 3, 5, and 7) contain OLS estimates and even-numbered columns (2, 4, 6, and 8) contain IV estimates. Columns (1) & (2) include application parent type fixed effects (new application, continuation, Patent Cooperation Treaty applications, etc.) and columns (3) & (4) include only new applications without a priority. Regressions in this table correspond to equation 3.

Table 7: Robustness Checks: Examiner Amendment Regressions (Dependent Variable: $Exam\_Amend_{eit}$) - TC-Year FE, Balanced Sample, Experience FE, Experience Band FE, and USPC FE.

VARIABLES	(1) TC-Year FE	(2) Bal. Sample	(3) Exp. FE	(4) Exp. Band FE	(5) USPC
Seniority: GS-7	-8.79e-05	-0.00207*	0.000800	0.000684	-0.000300
	(0.000599)	(0.000873)	(0.000724)	(0.000708)	(0.000598)
Seniority: GS-11	0.00250***	0.00117	0.00186**	0.00193**	0.00299***
	(0.000580)	(0.00106)	(0.000700)	(0.000690)	(0.000577)
Seniority: GS-12	0.00398***	0.00102	0.00322**	0.00335**	0.00450***
	(0.000725)	(0.00145)	(0.00105)	(0.00104)	(0.000720)
Seniority: GS-13	0.00664***	0.00653***	0.00664***	0.00679***	0.00758***
	(0.000885)	(0.00171)	(0.00138)	(0.00135)	(0.000863)
Seniority: GS-14	0.0125***	0.0108***	0.0140***	0.0142***	0.0139***
	(0.00128)	(0.00264)	(0.00171)	(0.00169)	(0.00129)
Experience (months)	0.000134**	0.000132	-	-	0.000129**
	(4.29e-05)	(7.73e-05)			(4.26e-05)
Scope (ICC)	-8.13e-05	0.000202	-8.31e-05	-8.57e-05	-9.27e-05
	(5.39e-05)	(0.000103)	(5.38e-05)	(5.39e-05)	(5.45e-05)
Scope (ICL)	0.000158***	0.000185***	0.000158***	0.000158***	0.000159***
	(4.90e-06)	(8.90e-06)	(4.89e-06)	(4.90e-06)	(4.91e-06)
Constant	-0.00967	0.000253	-0.0146*	-0.0142**	-0.00934*
	(0.00506)	(0.00684)	(0.00581)	(0.00490)	(0.00405)
Observations	1,047,501	305,378	1,047,501	1,047,501	1,047,501
R-squared	0.011	0.014	0.012	0.011	0.011
Number of Examiners	13,499	2,536	13,499	13,499	13,499
TC-by-Year FE	YES	YES	YES	YES	NO
Balanced Panel	NO	YES	NO	NO	NO
Exp. FE	NO	NO	YES	NO	NO
Exp. Band FE	NO	NO	NO	YES	NO
USPC FE	NO	NO	NO	NO	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. Regressions include first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Robust standard errors are clustered by examiner and are reported in parentheses. Column (1) contains all new applications in Public Pair with an observed first-action decision between 2001 and 2017. TC-by-year fixed effects were added to Column (1). Column (2) includes only new applications for which the examiner started at GS-7 and was promoted through GS-14. Columns (3) and (4) include experience fixed effects (*e.g.*, months and 6-month bands, respectively). Column (5) contains USPC fixed Effects. Regressions in this table correspond to modified versions of equation 2.

	ΔICL				ΔICC			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Exam. Amend.	-13.54***	2.806	-13.68***	14.28	-0.226***	-0.306*	-0.262***	-0.307
	(0.807)	(6.129)	(0.709)	(10.84)	(0.00870)	(0.142)	(0.00930)	(0.230)
Experience (Months)	0.0417*	0.0296	-0.0564	-0.0730	-0.00224***	-0.00218***	-0.00220*	-0.00217*
	(0.0203)	(0.0199)	(0.0407)	(0.0415)	(0.000497)	(0.000460)	(0.000873)	(0.000881)
Scope (ICC)	0.513***	0.491***	-1.101***	-1.150***	-0.769***	-0.769***	-0.325***	-0.325***
	(0.133)	(0.0268)	(0.156)	(0.0965)	(0.0749)	(0.000620)	(0.0217)	(0.00205)
Scope (ICL)	-0.173***	-0.179***	-0.157***	-0.171***	-0.00107***	-0.00104***	-0.000306***	-0.000283*
	(0.0191)	(0.00225)	(0.0108)	(0.00589)	(0.000251)	(5.21e-05)	(8.58e-05)	(0.000125)
Constant	47.12***	47.90	48.79***	49.49	2.031***	2.027	0.866***	0.865
	(2.587)	(62.83)	(4.515)	(57.45)	(0.244)	(1.453)	(0.140)	(1.219)
Observations	965,596	965,596	188,222	188,222	965,596	965,596	188,222	188,222
R-squared	0.080	0.0658	0.053	0.0497	0.645	0.634	0.139	0.112
Number of Examiners	11,248	11,248	9,640	9,640	11,248	11,248	9,640	9,640
Only New Applications	NO	NO	YES	YES	NO	NO	YES	YES

Significant at *** $p<0.001$, ** $p<0.01$, * $p<0.05$. The sample for each regression in this table includes all applications with a first-action allowance with an examiner's amendment or a single non-final rejection and subsequent allowance. Regressions include first-action year, examiner, U.S. Patent Classification, GS-level, and examiner specialization fixed effects. Robust standard errors are clustered by examiner and are reported in parentheses. Odd-numbered columns (1, 3, 5, and 7) contain OLS estimates and even-numbered columns (2, 4, 6, and 8) contain IV estimates. Columns (1), (2), (5), & (6) include application parent type fixed effects (new application, continuation, Patent Cooperation Treaty applications, etc.). Regressions in this table correspond to equation 4.

Table 5: Examination Quality Regressions (Dependent Variables: ΔICL & ΔICC)

	Baseline				With Examiner Specialization			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First-action Allow		First-action Allow (Modified)		First-action Allow		First-action Allow (Modified)	
Seniority: GS-7	-0.00658***	-0.00242*	-0.00536***	-0.00212*	-0.00483***	0.000238	-0.00349***	-0.000690
	(0.000896)	(0.00106)	(0.000720)	(0.000841)	(0.00127)	(0.00156)	(0.00104)	(0.00128)
Seniority: GS-11	0.00698***	0.00414***	0.00365***	0.00115	0.00482***	0.00229	0.00279***	0.000436
	(0.000786)	(0.000973)	(0.000615)	(0.000767)	(0.000948)	(0.00118)	(0.000762)	(0.000934)
Seniority: GS-12	0.0132***	0.00469***	0.00714***	0.000176	0.0101***	0.00267	0.00579***	-0.000770
	(0.00106)	(0.00128)	(0.000851)	(0.00102)	(0.00122)	(0.00146)	(0.000996)	(0.00118)
Seniority: GS-13	0.0193***	0.00771***	0.00910***	0.000176	0.0163***	0.00555**	0.00787***	-0.000868
	(0.00137)	(0.00162)	(0.00116)	(0.00134)	(0.00152)	(0.00181)	(0.00130)	(0.00151)
Seniority: GS-14	0.0573***	0.0404***	0.0410***	0.0265***	0.0539***	0.0381***	0.0395***	0.0254***
	(0.00206)	(0.00251)	(0.00180)	(0.00211)	(0.00219)	(0.00269)	(0.00193)	(0.00227)
Experience (months)	0.000199***	0.000171*	1.69e-06	3.91e-05	0.000228***	0.000235**	-6.21e-06	5.64e-05
	(4.42e-05)	(7.42e-05)	(3.83e-05)	(6.39e-05)	(4.80e-05)	(8.25e-05)	(4.16e-05)	(7.10e-05)
Scope (ICC)	-0.00117*	-0.00200***	-0.000978*	-0.00190***	-0.00125*	-0.00224***	-0.00104*	-0.00212***
	(0.000512)	(0.000207)	(0.000456)	(0.000188)	(0.000562)	(0.000244)	(0.000498)	(0.000221)
Scope (ICL)	0.000361***	0.000632***	0.000273***	0.000473***	0.000367***	0.000668***	0.000279***	0.000503***
	(3.35e-05)	(1.49e-05)	(2.55e-05)	(1.20e-05)	(3.56e-05)	(1.61e-05)	(2.71e-05)	(1.29e-05)
Exam. Spec. (Avg.)	-	-	-	-	-0.0753***	-0.0771**	-0.0667***	-0.0818***
					(0.0196)	(0.0246)	(0.0164)	(0.0206)
Exam. Spec. (Var.)	-	-	-	-	0.195***	0.192*	0.188***	0.228***
					(0.0566)	(0.0753)	(0.0445)	(0.0632)
Constant	0.0508***	-0.0520***	0.0631***	-0.0351***	0.0632***	-0.00630	0.0764***	0.0135***
	(0.00535)	(0.00378)	(0.00451)	(0.00332)	(0.00527)	(0.00359)	(0.00436)	(0.00318)
Observations	4,682,148	1,047,501	4,682,148	1,047,501	4,315,806	940,589	4,315,806	940,589
R-squared	0.029	0.041	0.023	0.031	0.028	0.042	0.023	0.032
Number of Examiners	13,760	13,499	13,760	13,499	12,399	12,161	12,399	12,161
Only New Apps	NO	YES	NO	YES	NO	YES	NO	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. A first-action allowance is equal to 1 if the examiner issues an allowance on the first action on the merits. A modified first-action allowance is equal to 1 if the examiner issues an allowance on the first action on the merits *without an examiner's amendment*. Regressions include first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Columns (5) through (8) contain examiner specialization similarity variables. Similarity measures are defined as the average (Mean Sim.) and variance (Var. Sim.) of the pairwise TF-IDF cosine similarity for all applications with a first action decision by a given examiner during the previous year. Robust standard errors are clustered by examiner and are reported in parentheses. Even-numbered columns include only new applications without a priority. Examiner specialization regressions in columns (5) through (8) do not include observations from the examiner's first calendar year at the USPTO. Odd-numbered columns include application parent type fixed effects (new application, continuation, Patent Cooperation Treaty applications, etc.). Regressions in this table correspond to equation 5.

Table 6: First-action Allowance Regressions (Dependent Variable: fa_allow_{eit})

Table 8: Robustness Checks: First Action Allow (Modified) - TC-Year FE, Balanced Sample, Experience FE, Experience Band FE, and USPC FE.

VARIABLES	(1) TC-Year FE	(2) Bal. Sample	(3) Exp. FE	(4) Exp. Band FE	(5) USPC FE
Seniority: GS-7	-0.00163	-0.000395	7.51e-05	-0.000274	-0.00212*
	(0.000841)	(0.00123)	(0.00103)	(0.00101)	(0.000841)
Seniority: GS-11	0.00105	0.000952	0.000963	0.000939	0.00114
	(0.000781)	(0.00135)	(0.000993)	(0.000979)	(0.000768)
Seniority: GS-12	0.000429	-4.38e-05	0.00150	0.00168	4.07e-05
	(0.00104)	(0.00186)	(0.00165)	(0.00161)	(0.00101)
Seniority: GS-13	0.000342	-0.00309	0.00377	0.00404	0.000214
	(0.00136)	(0.00221)	(0.00218)	(0.00213)	(0.00133)
Seniority: GS-14	0.0261***	0.0171***	0.0291***	0.0294***	0.0264***
	(0.00212)	(0.00318)	(0.00287)	(0.00283)	(0.00208)
Experience (months)	7.71e-06	0.000180	-	-	3.72e-05
	(6.41e-05)	(0.000104)			(6.38e-05)
Scope (ICC)	-0.00190***	-0.000964***	-0.00190***	-0.00190***	-0.00190***
	(0.000188)	(0.000192)	(0.000187)	(0.000187)	(0.000188)
Scope (ICL)	0.000473***	0.000447***	0.000472***	0.000472***	0.000473***
	(1.20e-05)	(1.76e-05)	(1.19e-05)	(1.20e-05)	(1.20e-05)
Constant	-0.00184	0.0246	0.0289	-0.00528	-0.0434***
	(0.0137)	(0.0172)	(0.0344)	(0.0136)	(0.00861)
Observations	1,047,501	305,378	1,047,501	1,047,501	1,047,501
R-squared	0.033	0.036	0.033	0.033	0.033
Number of Examiners	13,499	2,536	13,499	13,499	13,499
TC-by-Year FE	YES	YES	YES	YES	NO
Balanced Panel	NO	YES	NO	NO	NO
Exp. FE	NO	NO	YES	NO	NO
Exp. Band FE	NO	NO	NO	YES	NO
USPC FE	NO	NO	NO	NO	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. Robust standard errors in parentheses. A modified first-action allowance is equal to 1 if the examiner issues an allowance on the first action on the merits *without an examiner's amendment*. Unless otherwise noted, each regression includes first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Robust standard errors are clustered by examiner and are reported in parentheses. Column (1) contains all new applications in Public Pair with an observed first-action decision between 2001 and 2017. TC-by-year fixed effects were added to Column (1). Column (2) includes only new applications for which the examiner started at GS-7 and was promoted through GS-14. Columns (3) and (4) include experience fixed effects (*e.g.*, months and 6-month bands, respectively). Column (5) contains USPC fixed Effects. Regressions in this table correspond to modified versions of equation 3.

Table 9: Robustness Checks: Examiner Amendment Regressions (Dependent Variable: $Exam\_Amend_{eit}$) - Sample limited to new application and/or applications with a first-action decision within 3 years of promotion.

	(1)	(2)	(3)	(4)
VARIABLES	Baseline		Examiner Specialization	
Seniority: GS-7	-0.00109*	-0.000212	-0.000926	0.00168
	(0.000491)	(0.000625)	(0.000651)	(0.000885)
Seniority: GS-11	0.00291***	0.00284***	0.00180***	0.00174*
	(0.000464)	(0.000617)	(0.000541)	(0.000741)
Seniority: GS-12	0.00497***	0.00438***	0.00332***	0.00311**
	(0.000725)	(0.000875)	(0.000789)	(0.000984)
Seniority: GS-13	0.00871***	0.00757***	0.00693***	0.00609***
	(0.000994)	(0.00123)	(0.00105)	(0.00136)
Seniority: GS-14	0.0144***	0.0143***	0.0124***	0.0125***
	(0.00148)	(0.00181)	(0.00152)	(0.00195)
Experience (months)	0.000179***	0.000126**	0.000235***	0.000215***
	(3.20e-05)	(4.87e-05)	(3.51e-05)	(5.60e-05)
Scope (ICC)	-0.000154**	6.14e-05	-0.000179**	3.28e-05
	(5.63e-05)	(6.33e-05)	(6.27e-05)	(7.29e-05)
Scope (ICL)	9.57e-05***	0.000152***	9.84e-05***	0.000160***
	(1.09e-05)	(5.30e-06)	(1.21e-05)	(5.81e-06)
Exam. Spec. (Avg.)	-	-	-0.00241	-0.0155
			(0.00949)	(0.0137)
Exam. Spec. (Var.)	-	-	0.0344	0.0313
			(0.0310)	(0.0390)
Constant	-0.00164	-0.00692*	-0.00165	-0.00643*
	(0.00243)	(0.00271)	(0.00243)	(0.00255)
Observations	2,799,496	682,717	2,460,848	581,823
R-squared	0.010	0.011	0.009	0.010
Number of Examiners	12,988	12,685	11,581	11,315
Only New Applications	NO	YES	NO	YES
3-year Prom. Window	YES	YES	YES	YES

Significant at *** p<0.001, ** p<0.01, * p<0.05. Regressions include first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Columns (3) & (4) contain examiner specialization similarity variables. Similarity measures are defined as the average (Mean Sim.) and variance (Var. Sim.) of the pairwise TF-IDF cosine similarity for all applications with a first action decision by a given examiner during the previous year. Robust standard errors are clustered by examiner and are reported in parentheses. Columns (1) & (3) include applications where the first-action decision occurred within the first 3 years of promotion to the examiner's current grade. Columns (2) & (4) include include new applications where the first-action decision occurred within the first 3 years of promotion to the examiner's current grade. Regressions in this table correspond to equation 2.

	Baseline				With Examiner Specialization			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First-action Allow		First-action Allow (Modified)		First-action Allow		First-action Allow (Modified)	
Seniority: GS-7	-0.00596***	-0.00252*	-0.00488***	-0.00230**	-0.00442***	0.000444	-0.00350***	-0.00119
	(0.000943)	(0.00108)	(0.000749)	(0.000847)	(0.00126)	(0.00152)	(0.00103)	(0.00123)
Seniority: GS-11	0.00600***	0.00440***	0.00309***	0.00154	0.00432***	0.00293*	0.00251**	0.00119
	(0.000871)	(0.00102)	(0.000667)	(0.000797)	(0.00103)	(0.00123)	(0.000809)	(0.000960)
Seniority: GS-12	0.0106***	0.00528***	0.00559***	0.000881	0.00839***	0.00383*	0.00506***	0.000703
	(0.00140)	(0.00152)	(0.00108)	(0.00119)	(0.00155)	(0.00172)	(0.00122)	(0.00134)
Seniority: GS-13	0.0163***	0.00932***	0.00756***	0.00174	0.0146***	0.00781**	0.00769***	0.00171
	(0.00196)	(0.00216)	(0.00156)	(0.00168)	(0.00211)	(0.00241)	(0.00171)	(0.00188)
Seniority: GS-14	0.0444***	0.0347***	0.0300***	0.0204***	0.0431***	0.0331***	0.0307***	0.0206***
	(0.00297)	(0.00316)	(0.00236)	(0.00245)	(0.00310)	(0.00342)	(0.00252)	(0.00269)
Experience (months)	0.000263***	0.000156	8.30e-05	2.97e-05	0.000299***	0.000253**	6.27e-05	3.71e-05
	(5.84e-05)	(8.39e-05)	(4.73e-05)	(6.98e-05)	(6.42e-05)	(9.60e-05)	(5.24e-05)	(7.96e-05)
Scope (ICC)	-0.00111***	-0.00114***	-0.000955***	-0.00120***	-0.00122***	-0.00139***	-0.00104***	-0.00142***
	(0.000226)	(0.000142)	(0.000177)	(0.000118)	(0.000257)	(0.000163)	(0.000202)	(0.000135)
Scope (ICL)	0.000345***	0.000530***	0.000249***	0.000378***	0.000357***	0.000570***	0.000259***	0.000410***
	(3.90e-05)	(1.32e-05)	(2.82e-05)	(1.04e-05)	(4.37e-05)	(1.47e-05)	(3.17e-05)	(1.17e-05)
Exam. Spec. (Avg.)					-0.0504**	-0.0591*	-0.0482**	-0.0441
					(0.0188)	(0.0276)	(0.0156)	(0.0231)
Exam. Spec. (Var.)					0.162**	0.198*	0.128**	0.168**
					(0.0550)	(0.0778)	(0.0409)	(0.0625)
Constant	0.0317***	-0.0479***	0.0333***	-0.0410***	0.0501***	-0.00612	0.0517***	0.000309
	(0.00666)	(0.00551)	(0.00528)	(0.00477)	(0.00683)	(0.00518)	(0.00535)	(0.00447)
Observations	2,799,496	682,717	2,799,496	682,717	2,460,848	581,823	2,460,848	581,823
R-squared	0.032	0.038	0.023	0.028	0.031	0.039	0.023	0.029
Number of Examiners	12,988	12,685	12,988	12,685	11,581	11,315	11,581	11,315
Only New Applications	NO	YES	NO	YES	NO	YES	NO	YES

Significant at *** $p<0.001$, ** $p<0.01$, * $p<0.05$. A first-action allowance is equal to 1 if the examiner issues an allowance on the first action on the merits. A modified first-action allowance is equal to 1 if the examiner issues an allowance on the first action on the merits *without an examiner's amendment*. Regressions include first-action year and examiner fixed effects. GS-level coefficients are relative to GS-9. Robust standard errors are clustered by examiner and are reported in parentheses. We limit observations in each regression to applications where the first-action decision occurred within the first 3 years of promotion to the examiner's current grade. Odd-numbered columns (1, 3, 5, and 7) contain all such applications in Public Pair with an observed first-action decision between 2001 and 2017. Even-numbered columns (2, 4, 6, and 8) include only new applications without a priority where the first-action decision occurred within the first 3 years of promotion to the examiner's current grade. Regressions in this table correspond to equation 5.

Table 10: Robustness Check: First-action Allowance Regressions (Dependent Variable: fa_allow_{eit}) - Sample limited to new application and/or applications with a first-action decision within 3 years of promotion