The Review of Financial Studies
Peer-reviewed and accepted version

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Published version:
https://doi.org/10.1093/rfs/hhab097

Quick or Broad Patents? Evidence from U.S. Startups [*] [†] [♠]

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June 21, 2021

Abstract

We study the effects of patent scope and review times on startups and externalities on their rivals. We leverage the quasi-random assignment of U.S. patent applications to examiners and find that grant delays reduce a startup's employment and sales growth, chances of survival, access to external capital, and future innovation. Delays also harm the growth, access to external capital, and follow-on innovation of the patentee's rivals, suggesting that quick patents enhance both inventor rewards and generate positive externalities. Broader scope increases a startup's future growth (conditional on survival) and innovation but imposes negative externalities on its rivals' growth.

Keywords: Patents, innovation, scope, entrepreneurship, venture capital

JEL Classification: D23, G24, L26, O34

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[*] We are grateful to Iain Cockburn, Lauren Cohen (the Editor), Stuart Graham, Bronwyn Hall, Sabrina Howell, Adam Jaffe, Ben Jones, Jamie Kucab, Alan Marco, Lisa Larrimore Ouellette, David Schwartz, Carl Shapiro, Toby Stuart, Heidi Williams, two anonymous referees, and audiences at the 2020 NBER Summer Institute, the 2020 NSF "Future of IP" conference, the University of California, Berkeley, the Wharton School of Business, and New York University for helpful comments. Hegde gratefully acknowledges the support of the United States Patent and Trademark Office's Thomas Alva Edison Visiting Scholars program and the Kauffman Junior Faculty Fellowship. Ljungqvist gratefully acknowledges generous funding from the Marianne & Marcus Wallenberg Foundation (MMW 2018.0040, MMW 2019.0006). We thank Chunyang Han and Sebastian Sandstedt at the Wallenberg Lab for outstanding research assistance.

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Patents reward inventors with monopoly rights over their inventions. The extent of the monopoly right depends on the patent's breadth and timing. To maximize their monopoly rents, inventors prefer broader patents and patents that are granted as early as possible, leaving a longer period of exclusivity.[1] In contrast, society is better off with patents that are short-lived and just broad enough for patent-holders to recoup their R&D investments without imposing undue burdens on rival inventors. Not surprisingly, patent scope and timing are considered the two fundamental levers of patent policy that together determine the effects of patents on innovation and economic growth (Gilbert and Shapiro 1990, Klemperer 1990, Chang 1995, Freilich 2015).

Most empirical work studying the effects of patents on firms and industries focuses on the effects of whether or not a patent is granted,[2] ignoring how broad the patent is or how long it took to issue. What little empirical work there is on scope and timing studies their effects in isolation,[3] ignoring the practical and economic trade-offs between scope and timing faced by inventors and policy makers. As a result, we know little about the causal effects on inventors or their rivals of the two most fundamental levers of the patent system.

How do patent scope and timing affect the value of patent rights to their holders and the externalities imposed on their rivals? We answer these questions by estimating the economic value of broader and faster patents for U.S. startups that filed their first patent applications after 2001 and were granted a patent by December 31, 2013. While startups represent a small fraction of all patent applicants in the U.S., focusing on them offers several conceptual and practical advantages. The innovative startups we study represent the population of patenting startups which, upon success, become major contributors to net job growth in the economy, generate

[1] Under current U.S. law, patents expire 20 years after the application date, but the full rights of patents can generally be exercised only upon grant. Thus, patents that are granted sooner enjoy a longer period of exclusivity.
[2] See Arora, Ceccagnoli, and Cohen (2008), Hsu and Ziedonis (2013), Galasso and Schankerman (2015), Sampat and Williams (2019), and Farre-Mensa, Hegde, and Ljungqvist (2020).
[3] See Lerner (1994), Lerner and Merges (1997), Gans, Hsu, and Stern (2008), and Kuhn and Thompson (2019).

wealth for their shareholders and employees, and increase their industry's productivity through large spillovers (Haltiwanger, Jarmin, and Miranda 2013, Wu and Atkinson 2017). For example, the startups in our sample include several firms that have quickly grown to multi-billion-dollar valuations, such as Acceleron Pharma, iRobot, Pandora, Tesla Motors, and Zillow. Our focus on the first patent applications of such innovative startups allows us to assess the impact of patent scope and timing on economically important actors, whose fortunes early on are shaped by their intellectual property (Farre-Mensa, Hegde, and Ljungqvist 2020). As a practical matter, measuring the effects of a startup's first patent permits identification without conflating the effects on firm performance of previously or simultaneously issued patents.

Estimating the effects of patent scope and timing is empirically challenging. To measure the value of scope, we need to consider what economic rents a start-up could earn if its patent had broader or narrower scope. This task is made difficult by a two-fold endogeneity problem. First, unobserved quality differences across firms or inventions may affect both patent scope and a startup's future performance, potentially leading to a spurious correlation between scope and performance: startups of unobserved better quality may seek patents for inventions deserving of broader scope while enjoying better future performance regardless of the number of claims the U.S. Patent and Trademark Office (PTO) grants. Second, given that broader patents tend to take longer to issue, we need to account for the tradeoff between patent scope and timing or else estimates of the effects of scope will be biased. Measuring the value of timely patent grants suffers from similar challenges: if the inherent tradeoff between scope and timing is ignored, estimates of the effects of timing will be biased, as inventions of unobserved higher quality or by unobserved better applicants may be examined more speedily.

To overcome these challenges, we exploit plausibly exogenous variation in the patent examination process through an instrumental-variables approach that leverages examiner-level variation in application review habits. The validity of the approach rests on two features of the patent examination process at the PTO. First, the PTO assigns applications in each technology field (or "art unit") to examiners *randomly* with respect to the characteristics of the underlying invention (Lemley and Sampat 2012). Second, examiners vary in their review habits. Previous work has leveraged differences in examiner leniency with regards to approving patent applications to study the effects of patent grant on startup growth (Farre-Mensa, Hegde, and Ljungqvist 2020), the likelihood of a firm going public or being acquired (Gaulé 2018), and follow-on innovation (Sampat and Williams 2019). We study the effects of patent scope and timing by taking advantage of the quasi-random assignment of applications to examiners who differ in their leniency with regards to patent scope and in their examination speeds.

We utilize a rich data set that combines administrative data from the PTO's internal databases, which cover the population of granted and rejected applications, with data on four types of firm-level outcomes: (i) growth in sales and employment (from Dun & Bradstreet's NETS database); (ii) follow-on patenting and citations (from the PTO's database); (iii) venture funding (from VentureXpert); and (iv) fundraising by startups through initial public offerings (IPOs) (from VentureXpert and Thomson-Reuters' SDC database). Our sample covers all 34,359 first-time patent applications filed by U.S. startups at the PTO since 2001 that received a final decision by December 31, 2013. For our main results considering the effects of patent scope and timing, we focus on the 22,001 of these applications that are ultimately granted.

Our estimates show that delays in granting a startup's first patent have a significant negative effect on its growth. This finding is consistent with a speedier patent grant enabling a startup to more quickly commercialize its invention, while preempting the entry of rivals, and thus to enjoy higher growth. Economically, the effects are large, with a one-year increase in examination time reducing the average startup's growth in employment and sales by 12.8 and 20.4 percentage points over five years, respectively, equivalent to 13.5 fewer person-years of employment and a cumulative loss in sales of $2.6 million over five years. Furthermore, a one-year increase in examination time also halves the likelihood of raising capital via an IPO on the stock market.

The scope of a startup's first patent delivers nuanced benefits: unconditionally, broader scope has little effect on growth in employment or sales, but it marginally reduces a startup's chances of survival (perhaps because it makes the startup an attractive acquisition candidate). Among startups that survive as independent firms, broader scope significantly boosts long-term growth in employment and sales. This finding is consistent with broader scope enabling the startup to exclude more competitors and thus enjoy higher revenues (through greater sales volumes, higher unit prices, or both). In addition, broader scope increases the likelihood of the startup raising IPO capital: each granted claim roughly doubles the likelihood of an IPO.

Broader scope and speedier grant of a first patent spur innovation by the patent-holder. Startups that receive broader patents subsequently innovate more and produce higher-quality inventions. Each additional granted claim in a startup's first patent increases the subsequent number of patents the startup applies for and is granted by 5.9%, the total number of citations to its subsequent applications by 12.7%, and per-patent citations by 6%. Patent grant delays, on the other hand, have a negative effect on innovation at the startup. A one-year increase in examination time reduces the numbers of subsequent patent applications and subsequent patent grants by 8.4%, the approval rate of subsequent applications by 3 percentage points, and the number of citations to subsequent applications by 12.1% in total and 5.3% on average.[4,5]

Finally, we examine the externality effects of a startup's quasi-randomly determined patent scope and timing on other startups that operate in the same narrowly drawn technology area and thus can plausibly be considered rivals. We find evidence that broader scope imposes negative externalities on rivals' growth, consistent with theoretical work arguing that broad patents

[4] Even when a patent is ultimately rejected, a slow review significantly reduces a start-up's probability of survival or going public and the quantity and quality of its follow-on innovation.
[5] We find no significant variation in the effects of patent scope and timing on startup performance by industry or technology area, largely because we run into weak-instrument issues when we subsample our dataset.

increase the cost of entry for competitors (Gilbert and Shapiro 1990). These externalities are large: each additional claim a start is granted reduces its rivals' employment and sales growth by 5.4 and 6.7 percentage points over five years, respectively. Speedier grants, on the other hand, impose positive externalities on rivals with regards to growth, VC funding, and innovation. Again, these externalities are large: a one-year reduction in examination time for the focal startup increases industry sales growth by 5.7 percentage points over five years, the likelihood that a rival obtains VC funding in the next five years by 11.3%, the number of patents its rivals apply for and receive by 16.1% and 15.5%, respectively, and the count of citations to rivals' subsequent patent applications by 14.4%. We suggest that speedier patent grants resolve uncertainty about property rights and thus about the broader intellectual property landscape, facilitating investments by other startups in the patent-holder's industry.

Our findings are robust to concerns stemming from applicants' use of the PTO's continuations procedure, alternative measures of scope, and potential noise in the NETS data that may result from the presence of imputed values for some companies.

Our study contributes to the literatures on innovation, entrepreneurial finance, and economic growth. We provide the first causal estimates of the effects of two key determinants of patent value—scope and timing—on an economically important sample of innovative startups. Prior empirical work on patent characteristics is limited to patent scope. In an important study in this vein, Lerner (1994) uses a sample of 173 venture-backed biotechnology firms and shows that a one-standard-deviation increase in average scope is associated with a 21% increase in firm value. OLS estimates such as Lerner's may capture the positive effects of not only patent scope but also the value of the underlying technology. Our identification strategy disentangles the two and shows that the positive effects of scope in our sample are more nuanced.

Timeliness of patent grant, which has received little attention from empirical scholars, has large positive effects on both the startup and its industry. Patent policy is often characterized as striking a fine balance between rewarding inventors and limiting the negative externalities of exclusionary rights. Our results suggest that speedy patent grants unambiguously improve rewards for first-time startup patentees and may increase overall welfare, through at least three mechanisms: (i) by conferring a longer stream of monopoly rents (as patents are valid for a maximum of 20 years from application but can only be effectively enforced after grant), (ii) by allowing the holder to gain a competitive edge over rivals engaged in a patent race (Reinganum 1982, Gilbert and Newbery 1982, Fudenberg et al. 1983), and (iii) by facilitating investment in the patent-holder's industry through the resolution of uncertainty about the intellectual property landscape in the industry. In contrast, patents that are broad, while privately valuable for startups, impose negative externalities on growth and innovation among the patent-holder's rivals.

Finally, our identification strategy, based on quasi-random assignment of applications to examiners of varying scope leniency and review speed, highlights the profound impact the luck of the draw can have on the fortunes of U.S. startups. Drawing a slow examiner with a tendency to disallow most claims adversely affects a startup's future prospects. More broadly, our findings extend the growing literature in finance that unpacks the effect of policy instruments on the financing and growth of innovation (Acharya, Baghai and Subramanian 2014, Fang, Lerner, and Wu 2017, Heath and Mace 2020).

I. Institutional setting and data

A. The patent examination process

The PTO assigns each incoming patent application to the relevant "art unit" for review. Each art unit consists of a group of patent examiners who specialize in the same narrowly defined technology field. During our sample period, the PTO employed over 13,000 examiners in more than 900 art units. The median art unit has 13 examiners; the largest, more than 100.

In each art unit, applications are assigned to one of the art unit's examiners, who is responsible for evaluating whether or not the claims in the application meet the legal standards for novelty, usefulness, and non-obviousness. As we argue and show below, the assignment of an application to an examiner is orthogonal to the characteristics or quality of the application or of the applicant. This quasi-random assignment is central to our identification strategy.

After being assigned an application, the examiner reviews the application and makes a preliminary decision regarding which, if any, claims in the application will be allowed. This preliminary decision—the "first-action decision"—is communicated to the applicant by letter. Through this letter, the applicant first learns the examiner's identity. On average, sample applications take 0.7 years to be assigned to an examiner, who then takes an additional 1.1 years to make a first-action decision. In our sample of patent applications that are eventually granted, the final decision to accept is made 1.4 years later (i.e., 3.2 years after the application date).

B. Patent data and sample selection

To study the value to a startup of a broader patent and faster examination time, we obtain data on approved patents directly from the PTO's internal research databases, which contain records of all patent applications, both approved and rejected, from 1976 to the present.[6] Our sample starts in 2001, though we use data from previous years in the construction of our instruments for patent scope and examination time.

Since the PTO does not identify startup applicants, we follow Farre-Mensa, Hegde, and Ljungqvist (2020) and construct a sample of startups as follows. First, we restrict the sample to applications by incorporated applicants based in the U.S. Second, we remove not-for-profit organizations such as universities, government research labs, hospitals, and charities, based on a manual review of the patent assignee's name. Third, we construct a mapping from the patent data to Compustat to screen out applicants that are or have previously been listed on a stock market at

[6] Unlike the internal databases we have access to, the PTO's publicly accessible Patent Application Information Retrieval (PAIR) system provides no data on applications that are abandoned prior to public disclosure or on rejected applications filed before 2001.

the time of the application, another mapping to NETS to screen out applicants that are a subsidiary of another firm at the time of the application, and a third mapping to Thomson-Reuters' SDC database to screen out applicants that have been acquired between filing and first-action (as we cannot disentangle the effects of patent scope or examination time from the effects of the acquisition in this case). In each record linkage, we match on standardized assignee name-stems (being careful to take name changes into account using the name change histories available in Compustat, NETS, and CapitalIQ) and block on location at the state and county level. Manual disambiguation and deduplication relies on the patented invention and google searches.

These three steps identify patent applications filed by stand-alone for-profit U.S.-based firms. Not all these firms are startups. We apply two further filters to identify startups. First, we only include filers that qualify for reduced filing fees as "small business entities" under Section 3 of the Small Business Act. Second, we exclude applicants that have filed any patent application in the 25 years before our sample period. This step requires identifying each patent's original applicant (since many patents are reassigned over time) and accounting for name changes.

Our analysis examines how scope and timing affect a startup's ability to grow, fundraise, and innovate over a period of up to five years from the evaluation of its first patent application. To this end, we require firms to receive a first-action decision by the end of 2009 and a final decision by the end of 2013.[7] Because scope is a feature of a *granted* patent, we focus on the 22,001 applicants whose first application was ultimately approved (referred to as sample startups). Of these, 7,437 (33.8%) are granted biochemistry patents (PTO technology centers 16 or 17) and 3,723 (16.9%) are granted IT patents (PTO technology centers 21, 24, 26, or 28).

C. Timing considerations

Outcomes could be measured from three different starting points: the filing date, the first-

[7] The "first application" is classified as the first application the PTO rules on. In 8% of cases, the first ruling a firm receives is not for its first application submitted to the PTO, but for a later one.

action date, or the final-decision date. The appropriate starting point in our setting is the first-action date. The first-action decision resolves a substantial amount of uncertainty regarding the scope (and patentability) of an invention.[8] After first-action, the applicant can take actions that endogenously affect the remaining time it takes the examiner to reach a final decision.[9] Resolution of uncertainty is a necessary but not sufficient condition for an application to affect outcomes, while the endogenous timing of the final decision could confound our estimates.

D. Measuring scope and examination time

Following Marco, Sarnoff, and deGrazia (2019), we measure patent scope as the number of independent claims in a patent grant. The intellectual property protected by a patent is defined by a set of claims made in the application. The broadest of these are called independent claims. These stand independently and do not refer to any other claim in the patent application, while dependent claims reference independent claims and qualify them (Harhoff 2016). Together, the set of claims represents the breadth of the intellectual property covered by the patent. In robustness tests, we consider alternative measures based on the total claim count (Lanjouw and Schankerman 2004) and the word count of the first claim (Kuhn and Thompson 2019).

We measure examination time from the application filing date to the first-action date. As mentioned earlier, subsequent delays are inherently endogenous, as applicants' actions in response to the first-action letter affect the remaining timing of the patent evaluation process.

E. Data on firm outcomes

Because the startups in our sample are privately held, they are not covered in standard financial databases such as Compustat. We collect data on firm outcomes from four sources.

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[8] Carley, Hegde, and Marco (2015) note that first-action letters resolve a substantial amount of uncertainty about the application's ultimate fate, as first-action letters contain a detailed account of the examiner's evaluation of an application. Because the first-action decision is the first communication from the PTO to the applicant regarding the merits of an application, there can be no resolution of uncertainty before the first-action date.

[9] How long it takes an applicant to respond to the examiner's concerns is likely endogenous to the applicant's resources and may reflect its private information regarding the value of greater scope and a faster decision.

- *Dun and Bradstreet's National Establishment Time Series (NETS) database.* NETS is similar to the U.S. Census Bureau's Longitudinal Business Database in that it aims to cover the universe of business establishments in the U.S. but offers the advantage of not requiring special permission for access. The NETS data used in this project cover the period through December 2016, providing us with five years of post-first-action sales and employment data for all firms that we are able to match. To match startups to NETS, we utilize a "fuzzy" matching algorithm (with each candidate match verified manually) based on standardized firm name-stems and locations, in conjunction with information on name changes obtained from NETS and CapitalIQ and location moves obtained from the PTO's firm name and address register. We match 81.5% of sample startups to firms in NETS—a higher match rate than that achieved by studies using Census Bureau data.[10]
- *The PTO's patent database*. This database provides data on sample startups' subsequent patent applications as well as citations to their patents through December 2016.
- *VentureXpert*. This database contains VC funding events. We use it to identify which sample firms go on to raise VC funding after the first-action date through February 2020.
- *The Thomson Reuters Securities Data Company (SDC) database.* We use data from SDC (and VentureXpert) to identify firms that raise capital from public investors via an initial public offering (IPO) of equity on a stock market through November 2018.

Table 1 provides summary statistics for our sample. Panel A shows that at the time of application, the median startup is 2 years old, has 8 employees, and \$0.8 million in sales. Following the PTO's first-action decision, the average startup experiences 21.1% growth in employment and 44.4% growth in sales over five years (Panel B) and produces 2.6 subsequently

[10] Using the Census Bureau's Business Register data, often considered the "gold standard" for its coverage of the population of U.S. business establishments, Balasubramanian and Sivadasan (2011) match 63.7% of patent assignees to firm names and Kerr and Fu (2008) report a match rate of about 70%.

approved patents (Panel C). In the five years following first-action, 9.4% of sample startups raise VC funding and 0.8% of them complete an IPO.

II. Empirical strategy

We focus on how two key examination characteristics—the scope of a granted patent and the length of time an application takes to be examined—affect a startup's subsequent growth in employment and sales, ability to raise external capital, and follow-on innovation. In this section, we outline our empirical strategy, review the main challenge to identification we must overcome, and outline our identifying assumptions. In the next section, we present our findings on the effects of patent scope and examination time on U.S. startups.

A. Empirical setup

We estimate panel regressions of the following general form:

$$\begin{aligned} Firm\ outcome_{ijat+} \ &= \beta_1 patent\ scope_{ijat} + \beta_2 examination\ \ time_{ijat} \\ &+ \Phi X_{ijat} + \nu_{a\tau} + \varepsilon_{ijat+k} \qquad (1) \end{aligned}$$

where i indexes startups, j examiners, a art units, and τ application years. As discussed above, outcomes are measured over up to the five years following the first-action decision the startup receives in year t.[11] Eq. (1) includes both patent scope and examination time because they are inherently related. Marco, Sarnoff, and deGrazia (2019) show that applications with narrower scope are associated with a shorter examination time in comparison to applications with broader scope. The control variables X_{ijat} include headquarter-state fixed effects to control for the confounding effects of geographical differences and (when we model growth in sales and employment) measures of firm size to control for scale differences. In addition, we include art-unit-by-application-year fixed effects, $\nu_{a\tau}$, to control for time-varying industry-level demand or

[11] While we do not observe the contents of the first-action letter, as noted earlier, Farre-Mensa, Hegde, and Ljungqvist (2020) report that first-action letters are highly predictive of final patent application evaluation outcomes.

technology-related shocks that could affect both applications and outcomes.[12,13] Standard errors are clustered at the art unit level to allow for arbitrary correlation of the errors within each art unit. Variable definitions are listed in the Appendix.

B. Empirical strategy and identifying assumptions

The coefficients of interest in eq. (1), β_1 and β_2, capture the average treatment effects of patent scope and examination time, respectively. These average treatment effects capture the conditional average difference in outcomes between a startup that receives a patent of given scope in a given timeframe compared to a startup subject to identical demand and technology conditions that is granted a patent of different scope in a different timeframe. The key challenge to identification is to ensure that differences in scope and timing do not reflect differences in the quality or characteristics of the underlying invention, the applicant, or the application.

In an ideal experiment, we would randomize patent scope and examination time to ensure that unobserved quality differences do not confound the effects of patent scope and examination time. While this ideal experiment is not feasible, we exploit two lottery-like features of the PTO's review process that have been employed in previous research:[14] patent applications are assigned to examiners within an art-unit in a quasi-random fashion; and patent examiners differ systematically in their review habits. This second feature has been used to argue that more lenient examiners are more likely to grant a patent than are stricter examiners, holding the quality of the invention constant (Sampat and Williams 2019, Farre-Mensa, Hegde, and Ljungqvist 2020). Under these assumptions, previous research has used examiner leniency with respect to patent approval as an instrument for the approval of a patent, allowing for causal estimation

[12] For example, a technological breakthrough could increase the number of patent applications in a technology area, affecting both examination times and the growth rate of firms in that area.
[13] Art units are narrowly defined (they span 495 different technology fields in our sample). The inclusion of art-unit-by-application-year fixed effects allows us to control for time-varying demand and technological changes at a very fine level and greatly mitigates concerns that unobserved industry-level shocks might confound our findings.
[14] Examples include Cockburn, Kortum, and Stern (2002), Lichtman (2004), Sampat and Lemley (2010), Lemley and Sampat (2012), Gaulé (2018), Sampat and Williams (2019), and Farre-Mensa, Hegde, and Ljungqvist (2020).

using 2SLS. We extend this logic from patent approval to patent scope and examination time, on the assumption that randomly assigned patent examiners vary systematically in their propensity to allow more or fewer claims and in how long it takes them to arrive at a first-action decision.[15]

Our baseline specification measures examiner scope leniency as the average historic number of independent claims granted by examiner j belonging to art unit a assigned to review startup i's patent application with a first-action date prior to time τ:

$$Examiner\ scope\ leniency_{ija\tau} = \frac{\#\ independent\ claims\ granted_{ja\tau}}{\#\ patents\ granted_{ja\tau}}, \tag{2}$$

where $\#\ independent\ claims\ granted_{ja\tau}$ is the number of claims across all ultimately granted patents examiner j has reviewed prior to first-action date τ, and $\#\ patents\ granted_{ja\tau}$ is the number of patents on which examiner j has taken a first-action prior to first-action date τ.[16]

Our instrument for examination time has two components. The first is the examiner's average historical time to reach a first-action decision:

$$Examiner\ review\ speed_{ija\tau} = \frac{t_{\text{first-action time}_{ja\tau}}}{\#\ patents\ reviewed_{ja\tau}}, \tag{3}$$

where $t_{\text{first-action time}_{ja\tau}}$ is the total first-action time across all patents examiner j has reviewed prior to first-action date τ (not including the administrative lag from application filing to docketing with the examiner), and $\#\ patents\ reviewed_{ja\tau}$ is the number of patents examiner j has reviewed prior to first-action date τ.[17] The second component, which we add to the examiner's review speed, is $docket\ date\ lag$, the application-specific administrative lag from the time the application is filed at the PTO to the time it is docketed with a specific examiner.

[15] Kuhn and Thompson (2019) construct an alternative instrument for examiner scope leniency. Their instrument differs from ours in that it relies on the word count in the first claim of a patent, a measure that is available for only around half the firms in our sample. As we show in Section III.B, our results are robust to following their approach.
[16] Neither the numerator nor the denominator in eq. (2) includes patent application i, as it has not been reviewed prior to date τ. To ensure that we measure approval rates accurately, we exclude startups whose application is assigned to an examiner with fewer than 10 prior reviews. All results are robust to alternative cutoffs.
[17] Again, neither the numerator nor the denominator in eq. (3) includes application i.

The use of two examiner characteristics as instruments raises the question whether these characteristics are sufficiently distinct from each other to permit causal inference of both patent scope and timing, or whether they reflect unobserved characteristics that drive both (say, "attention to detail"). Figure 1 graphs the joint distribution of scope leniency and review speed (residualized against a full set of art-unit-by-application-year fixed effects). The figure shows that examiners vary independently in their scope leniency and review speed. Independence is stronger than necessary for causal inference of both scope and timing, which only requires that the two instruments not be perfectly multicollinear (Stock and Watson 2015, ch. 12).

Figures 2 and 3 show the marginal distributions of residualized examiner scope leniency and review speed. Both characteristics vary substantially across examiners (even within art unit and year), which bodes well for our ability to use these examiner characteristics to identify eq. (1). To illustrate, compare an examiner at the 25th percentile to an examiner at the 75th percentile. This corresponds to a difference of 0.4 claims allowed and 6.4 months to first-action. To put these numbers in perspective, 0.4 claims represent a 14.3% increase relative to the median number of claims. Based on Kogan et al. (2019), the median patented invention is worth around $6.4 million in 2012 dollars. Assuming value increases linearly in the number of claims, a 14.3% broader patent might then be worth around $0.5 million more. A time saving of 6.4 months represents a 38.2% reduction in the median first-action examination time in our sample.

C. First-stage estimates

Given two endogenous variables, patent scope and examination time, our 2SLS model has two first-stage regressions, each of which includes both instruments in the usual way:

$$\begin{aligned} Count\ of\ independent\ claims_{ijat} = {} & \theta\ Examiner\ scope\ leniency_{ija\tau} \\ & +\varphi(Examiner\ review\ speed + docket\ date\ lag)_{ija\tau} \\ & +\Pi X_{ijat} + \nu_{a\tau} + u_{ijat} \end{aligned} \quad (4)$$

$$\begin{aligned} \textit{First-action examination time}_{ijat} &= \delta(\textit{Examiner review speed} + \textit{docket date lag})_{ija\tau} \\ &+ \omega\ \textit{Examiner scope leniency}_{ija\tau} + \Gamma X_{ijat} + \nu_{a\tau} + \zeta_{ijat} \qquad (5) \end{aligned}$$

where all variables are defined as before.

The first-stage estimates of equations (4) and (5) are reported in Table 2, Panels A and B, respectively. Both first-stage estimates suggest that our instruments satisfy the relevance condition for identification in a 2SLS framework. The estimates of θ and δ confirm that an examiner's past scope leniency is a strong predictor of the number of claims she will grant in a given application and that her average past review speed combined with the docket date lag is a strong predictor of how long she will take to reach a first-action decision. The coefficient estimate for θ in column 1 in Panel A suggests that an increase in scope leniency of one independent claim leads to a 0.52 increase in the number of independent claims in the patent granted to the startup (p<0.001). Similarly, a one-year increase in the review speed in Panel B leads to an increase of 0.53 years (6.3 months) in first-action examination time (p<0.001). Both instruments are statistically strong, with F-statistics well above the rule-of-thumb value of 10. This ensures that our 2SLS estimates are not likely subject to weak-instrument bias.

D. Threats to identification

For our instruments to be valid, they must satisfy two further conditions. First, they must meet the exclusion restriction, which requires that each instrument has no direct effect on the outcome except through the treatment. In this case, quasi-random assignment of patent applications to patent examiners ensures that the exclusion restriction is plausibly justified.

The second condition requires that the instruments must not correlate with omitted variables that could drive a startup's future success. If this were the case, our instruments would not be "as good as randomly assigned conditional on covariates" (Angrist and Pischke 2009, p. 117). This could happen if the characteristics of the startup or the application influenced assignment of an application to an examiner. We investigate this threat to identification in three ways. First, based on prior literature and institutional grounds, we argue that patent applications are in fact assigned quasi-randomly within art units. Second, we conduct Righi and Simcoe's (2019) validation test of quasi-random assignment. Third, we examine if an examiner's review habits correlate with observable characteristics of the applicant or the application.

As noted above, a large body of literature argues that the PTO assigns applications to examiners quasi-randomly. The precise details and procedures of the assignment process vary across art units,[18] but they have in common that they are consistent with our identifying assumption that applications are assigned randomly with respect to application or applicant quality. Importantly, given our focus on scope, Righi and Simcoe (2019) report that there is no evidence that particularly important or broad applications are assigned to specific examiners.

We next implement Righi and Simcoe's (2019) validation test. Under the null of quasi-random assignment, the first-stage estimates of θ and δ in equations (4) and (5) should be invariant to the characteristics of the startup, application, and examiner. Accordingly, adding further controls to our first-stage regressions shown in Table 2 should not change $\hat{\theta}$ and $\hat{\delta}$. Specifically, we add size and growth (in sales and employment) at the time of first-action to investigate the possibility of assignment based on applicant characteristics (columns 2 and 3), highly granular technology-subclass-by-year fixed effects to investigate the possibility of assignment based on technological specialization (column 4), and examiner tenure and seniority to investigate the possibility of assignment based on examiner experience (column 5).

Adding controls makes little difference to the first-stage coefficient estimates of θ and δ. In Table 2, Panel A, the coefficients for patent scope vary between 0.49 and 0.55. In Table 2, Panel B, the coefficients for review speed vary even less, ranging from 0.52 to 0.53. Both instruments thus pass Righi and Simcoe's (2019) validation test. None of our measures of applicant quality

[18] For example, some art units assign applications based on the last digit of the randomly assigned application serial number; others use a "first-in-first-out" rule.

predicts patent scope or the length of examination time. Examiner tenure and seniority, on the other hand, do influence patent scope and examination time: examiners with longer tenure grant broader patents, and more senior examiners reach first-action decisions more quickly. However, this does not undermine identification, given random assignment, and adding these examiner characteristic does not significantly alter the estimates of θ and δ. In short, Table 2 is consistent with our assumption that unobserved examiner or applicant characteristics are unlikely to be correlated with both our instruments and our outcomes of interest (i.e., startup success).

To shed further light on the random-assignment assumption, Table 3, Panels A and B test whether our two instruments correlate with observable characteristics of the applicant or the application, in which case selection into the sample might be a concern. Columns 1 and 2 in each panel show that applicant characteristics such as size, growth, and age do not predict the type of examiner who is assigned, as regards examiner scope leniency or review speed. Column 3 shows that application characteristics (including claim count at pre-grant publication, average word count across claims, count of backwards citations, and count of citations to non-patent literature) do not predict examiner assignment either. Columns 4 and 5 report a placebo test which exploits the fact that a subset of startups file for patent protection not just in the U.S., but also at the European Patent Office and/or Japanese Patent Office. For this subset of applications, we use foreign patent grants as a measure of the quality of the applicant or the underlying invention to validate the quasi-random-assignment assumption. Specifically, we test whether applications granted by a foreign patent office are more likely to have been assigned to more scope-lenient or faster U.S. examiners. Consistent with quasi-random assignment, we find no such evidence.

III. The private effects of patent scope and examination time

A. Employment growth, sales growth, and firm survival

Table 4 presents baseline results for the effects of patent scope and examination time on a startup's subsequent growth in employment and sales and its survival.[19,20,21] Panel A focuses on employment. The effect of patent scope on employment growth is positive but not statistically significant at any horizon. In contrast, longer examination time leads to large and significant reductions in employment growth in the years following first-action. Economically, an additional year of examination time reduces a startup's employment growth rate by 3.5 percentage points in the first year after first-action (p=0.016). Over time, the negative effect of longer reviews increases: an additional year of examination time reduces cumulative employment growth by 8.4 percentage points over two years, 10.5 percentage points over three years, 12.1 percentage points over four years, and 12.8 percentage points over five years (all significant at p<0.01).

To gauge the economic significance of these estimates, consider the median startup in our sample, which has eight employees at the time of first-action. All else equal, an additional year of examination time as a result of randomly being assigned to a slower examiner results in a reduction of 3.8 person-years of employment over five years. Considering the average startup in our sample rather than the median, a one-year increase in examination time results in a cumulative reduction of 13.5 person-years of employment.

Table 4, Panel B shows a similar pattern for sales growth: patent scope has no significant effect on sales growth, while a longer examination time significantly hurts sales growth from year 2. On average, a one-year increase in examination time reduces sales growth by a cumulative 8.3 (p=0.062), 12.0 (p=0.049), 17.1 (p=0.013), and 20.4 percentage points (p<0.001)

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[19] The corresponding OLS estimates can be found in Table IA.1 in the Internet Appendix.

[20] Our findings are robust to including the examiner's grant leniency (Farre-Mensa, Hegde, and Ljungqvist 2020), which is positively correlated with her scope leniency ($\rho = 0.24$) and negatively correlated with her review speed ($\rho = -0.22$). As Table IA.2 in the Internet Appendix shows, the effect of grant leniency on startup growth and survival is economically small and statistically insignificant *conditional on grant*. This (along with the results in Table 3) helps mitigate concerns that selection into the sample of patent grantees drives our results or that faster and broader scope empirically tends to come from more grant-lenient examiners.

[21] Given random assignment, dropping the controls for HQ-state fixed effects and firm size should make no difference to our estimates. This is indeed the case (see Table IA.3). Our findings are also robust to controlling for the number of claims the startup filed in its application, which has no effect on startup growth (see Table IA.4).

over the two, three, four, and five years post-first-action, respectively. For the median startup in our sample, with sales of $0.8 million at first-action, an additional year of examination time reduces cumulative sales over five years by $487,200. Considering the average startup in our sample instead, the corresponding figure is $2.6 million. In short, randomly longer waits appear to be costly for innovative startups, consistent with delays at the PTO hampering their ability to quickly exploit their market opportunity before rival firms can enter and gain a foothold.

Table 4, Panel C reports the effects of scope and timing on survival as an independent company.[22] While we do not find any evidence that scope affects survival significantly in the first four years after first-action, we find a marginally significant negative effect over five years, when the grant of an additional claim reduces the likelihood of survival by 2.7 percentage points (p=0.092). A possible explanation is that firms with broader patents are more likely to eventually be acquired and so lose their independence (Abrams et al. 2019). A longer examination time affects survival negatively. Having to wait an additional year for a first-action decision reduces a startup's chances of surviving the next year by 1.4 percentage points (p=0.009), taking the one-year mortality rate from 3.1% to 4.5%. The magnitude of this negative effect grows with time. An additional year's wait reduces the likelihood of survival by 3.1 percentage points over two years (p<0.001), 3.6 percentage points over three years (p<0.001), 4.1 percentage points over four years (p<0.001), and 3.0 percentage points over five years (p=0.017).

The finding that broader scope reduces long-term survival as an independent company, perhaps because startups with broader (and thus potentially more valuable) patents are more often acquired, motivates us to estimate the effect of scope on growth conditional on survival. This yields evidence that scope affects long-term growth significantly for firms that stay alive.

[22] We code a startup as surviving as an independent company in year $t + k$ if its parent ID (*HQDuns*) continues to exist in the NETS database in that year. Dun & Bradstreet, the source of the NETS database, carefully examines firm exits due to death or acquisition, distinguishing them, for example, from simple relocations. Neumark, Zhang, and Wall (2005) provide a comprehensive account of the D&B methodology.

Specifically, Table 5 shows that conditional on survival, each additional independent claim granted increases a startup's growth in employment by 11.4 percentage points over four years (p=0.055) and 19.4 percentage points over five years (p=0.007) and its growth in sales by 17.6 percentage points over four years (p=0.051) and 26.7 percentage points over five years (p=0.017). In other words, while broader scope results in a lower chance of long-term survival, for those startups that do survive, scope boosts growth in employment and sales by economically substantial magnitudes. This is consistent with broader scope allowing the patentholder to exclude a larger number of competitors from a larger area of product space and thus to enjoy higher revenues (through higher licensing fees, greater sales volumes, or higher unit prices).

B. Robustness of the growth results

Our baseline results for the effects of scope and timing on startup growth are robust to a battery of alternative specifications, reported in the Internet Appendix. Specifically, our results are robust to replacing our measure of scope (the number of independent claims granted) with either the sum of independent and dependent claims (Table IA.5), or with Kuhn and Thompson's (2019) measure of scope based on the count of words in the first independent claim (Table IA.6), to using claims reduction (i.e., the difference between the number of granted claims and the number of claims filed in the startup's application) as an instrument for final scope (Table IA.7), and to including finely-grained technology-subclass-by-year fixed effects to address the concern that the assumption of quasi-random assignment may not be met because examiners specialize at a more granular level than the art unit, as suggested by Righi and Simcoe (2019) (Table IA.8).

Our results are also robust to accounting for the strategic use of "continuations," used in roughly a quarter of patent applications. These procedures include non-serialized continuations, continuations-in-part, and divisionals. They are used by applicants to either keep claims related to an original application alive or to defer examination and are thus a way for applicants to influence the scope and timing of their patents (Hegde, Mowery, and Graham 2009, Yamauchi and Nagaoka 2015). Our results are robust to excluding applications that are non-serialized continuations (Table IA.9) and applications that are continuations of previously rejected applications (Table IA.10); to including rejected applications that spawn eventually accepted continuations, continuation-in-parts, or divisional applications (Table IA.11); and to excluding continuations, continuations-in-part, and divisionals from the construction of our instruments, given that examiners who review continuations of previous examinations may be familiar with the subject matter and so issue quicker decisions (Table IA.12).[23]

Next, our results are robust to excluding the small fraction (0.6%) of applications requesting accelerated examination via a "petition to make special."[24] This addresses the concern that such applications may induce a positive correlation between scope and timing, as accelerated approval can impose limits on scope (Table IA.13). They are also robust to excluding applications with a counterpart at the European Patent Office or the Japanese Patent Office (22.1% of applications). This addresses the concern that the availability of information regarding the application from international search reports or reviews may have an impact on the scope or timing (Table IA.14).

Finally, our results are robust to the presence of imputed observations in the NETS data (Crane and Decker 2019). Specifically, our finding that longer examination time significantly reduces sample startups' growth in employment and sales is not driven by the presence of imputed data in NETS; if anything, the effect is stronger when using non-imputed data than when using imputed data, especially for sales growth (Table IA.15).

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[23] While our results are not biased by continuations, we stress that our empirical design identifies the effects of exogenously induced delays on startups. Some applicants may benefit from endogenously prolonging examination to delay patent grant. Historically, the benefit of delaying grant was to keep the invention secret for longer. Recent law changes (the 1995 change of patent term to 20 years from application date rather than 17 from grant date, the 18-month disclosure requirement for applications mandated by the American Inventors Protection Act of 1999, and the 2011 America Invents Act that transitioned the U.S. to a first-to-file system) all undercut the benefits of delay.
[24] Fewer than 0.5% of applications qualify for a "petition to make special," namely those filed after 2006 by older applicants and those able to materially enhance environmental quality or national security. See https://www.uspto.gov/patent/initiatives/accelerated-examination.

C. Fundraising in the VC and IPO markets

Patent grants can have a sizable impact on a startup's ability to raise capital via the VC and IPO markets (Farre-Mensa, Hegde, and Ljungqvist 2020). We next consider whether patent scope and examination time affect a startup's ability to raise external capital. Table 6 shows that patent scope has no meaningful effect on a startup's likelihood of obtaining VC funding over a five-year horizon.[25] Faster examinations, on the other hand, increase the likelihood of raising VC funding, especially over a two- to three-year horizon. Each additional year of examination time reduces the likelihood of obtaining VC funding by a marginally significant 1 percentage point over two years (p=0.059) and three years (p=0.065). Economically, the effects are sizeable. For example, the three-year estimate in column 3 represents a 13.2% reduction from the 7.6% unconditional probability of raising VC funding in our sample.

Column 6 considers the likelihood that a startup raises external capital on the stock market through an IPO. Here, patent scope makes a large difference. Each additional claim allowed in a granted patent increases the likelihood of an IPO by 0.8 percentage points (p=0.012), a striking 101.3% increase from the unconditional IPO probability in our sample. Apparently, therefore, broader scope in a startup's first patent facilitates access to the stock market. As before, delays are costly. Each additional year of examination time reduces the likelihood of an IPO by 0.4 percentage points (p=0.077), equivalent to 50.6% of the unconditional IPO probability.

D. Falsification Test

Figure 4 shows a falsification test, asking if treatment (broader scope or faster grants) affects outcomes ahead of treatment. To this end, we estimate an alternative version of eq. (1) in which

[25] This result contrasts with Lerner's (1994) finding that patent scope is positively associated with the likelihood of obtaining VC funding in his sample and over his earlier time period. Methodologically, the main differences between our approach and Lerner's are that we use an instrument to remove the potentially confounding effects of the quality of the underlying invention and that we use the count of independent claims to measure scope, while Lerner reports OLS regressions and uses the total claim count. We report OLS regressions in Table IA.16 in the Internet Appendix. We continue to find no effect of patent scope on the likelihood of raising VC funding.

the dependent variables are annual (rather than cumulative) growth in sales or employment and the annual (rather than cumulative) likelihood of receiving VC funding and in which we include the three years before the first-action date. As Figure 4 shows, neither scope nor timing affects startup growth or access to VC funding in the years before the first-action date.

E. Follow-on innovation

We next examine how patent scope and examination time affect a startup's ability to continue innovating. Following Farre-Mensa, Hegde, and Ljungqvist (2020), we measure follow-on innovation using the log number of patent applications filed after first-action on the first application; the log number of subsequent applications that are approved; the approval rate of subsequent applications; the log number of citations received by all subsequent applications combined; and the log average number of citations per subsequent application.[26]

Table 7, columns 1 and 2 show that startups that receive broader patents go on to file significantly more subsequent patent applications and have more subsequent applications approved. Being granted one additional claim leads to a 5.9% ($= e^{0.057} - 1$) increase in the number of patents a startup subsequently applies for (p=0.056) and the number of patents it is subsequently granted (p=0.040). Examination time, meanwhile, has a negative effect. An additional year of waiting for a first-action decision reduces the numbers of subsequent patent applications and granted patents by 8.4% (both significant at p<0.001). While patent scope has no significant effect on the approval rate of subsequent applications, examination time has a negative effect, reducing the approval rate by 3 percentage points (p=0.007).

Columns 4 and 5 show that patent scope and examination time affect not just the quantity of follow-on innovation but also its quality. Startups granted broader property rights in their first application go on to obtain patents that receive more citations, both in total (column 4) and on

[26] The corresponding OLS estimates can be found in Table IA.17 in the Internet Appendix.

average (column 5). Each additional claim granted in the first patent leads to a 12.7% increase in the number of citations to subsequent patents (p=0.011) and a 6.0% increase in per-patent citations for subsequent approved patents (p=0.024). Slower examination, on the other hand, leads to less impactful subsequent patents. An additional year of examination time reduces citations to subsequent patents by 12.1% in total (p=0.001) and 5.3% on average (p=0.014).

F. Rejected patents

We briefly consider whether the adverse effects of slower patent reviews depend on whether the application was ultimately granted or rejected.[27] The results are summarized in Figure IA.1 in the Internet Appendix.[28] While employment and sales growth and the likelihood of VC funding within five years of first-action are unaffected by how long it takes the PTO to issue a first-action on an ultimately rejected application, we find that slower reviews significantly reduce a startup's chances of going public and the quantity and quality of its follow-on innovation.

These results are striking. They suggest that slower examination has adverse consequences for startups, whether the patent application is ultimately granted or rejected. A plausible explanation is that a faster rejection benefits startups by more quickly resolving uncertainty around their intellectual property rights, allowing startups to more quickly pivot to alternative patenting strategies or to pursue different means of appropriating the gains from their inventions.

G. Subsequent patents

Farre-Mensa, Hegde, and Ljungqvist (2020) argue that a startup's first patent is special, in that it helps the startup obtain external funding (perhaps because it signals quality) and so boosts growth and follow-on innovation. Once on this high-growth trajectory, subsequent patents are less important. In the Internet Appendix, we investigate if broader scope and shorter examination times similarly affect startups only in their first patent. The results, shown in Table IA.21, add

[27] Scope is a feature of granted patents only and is therefore not considered in this section.
[28] The corresponding estimates can be found in Tables IA.18 through IA.20 in the Internet Appendix

nuance to Farre-Mensa, Hegde, and Ljungqvist's conclusion: broader scope and faster decisions continue to have positive effects on startup growth and survival even beyond the first patent.

IV. Externalities of patent scope and examination time

Our analysis shows that scope and especially examination time have clear effects on the innovating startup. We next ask if they also affect the firm's rivals. There are good economic reasons to expect externalities: faster resolution of uncertainty for one firm may benefit other firms by clarifying property rights, or it may harm them by making it more difficult to raise external funding in a patent race they appear to have lost, while broader scope may hurt other firms by excluding them from more product space and restricting the room for future innovation.

To measure the externality effects of patent scope and timing, we focus on how the examination characteristics of a focal patent affect other startups pursuing patents in the same narrow technology field. Subclasses represent the most granular technological areas in the PTO's classification system, allowing us to capture firms that are likely closely related. We adapt eq. (1) to consider the effects of the scope and timing of startup i's patent decision on not itself but other startups in its technology subclass. To this end, we measure our various outcome variables at the subclass level. Specifically, we aggregate sales and employment in subclass k and year t across all sample startups whose first patent application falls in subclass k (excluding the focal firm) and use these aggregate values to construct growth rates. We similarly aggregate our measures of follow-on innovation at the subclass level. Finally, we calculate the fraction of startups in a subclass (excluding the focal firm) that survive, raise VC funding, or go public following the first-action decision on the focal patent application. Given quasi-random assignment of applications to examiners, our estimates here identify the causal effects of the scope and timing of a startup's patent on future prospects of its industry peers.[29]

[29] The corresponding OLS estimates are reported in Tables IA.22 through IA.24 in the Internet Appendix.

In total, there are 1,480 subclasses that are potentially affected by a sample startup's patent grant, with the average subclass experiencing 10.7 "shocks" over our sample period. To reflect the repeated nature of the shocks, we include subclass fixed effects (which isolate the effects of variation in scope and timing of a focal firm's patent on its subclass peers) and cluster the standard errors by subclass. To remove technology-specific trends, we include art-unit-by-application-year fixed effects.

Table 8 shows that both scope and examination time impose externalities on rivals' growth and survival. Broader scope negatively affects rivals' employment growth over three- to five-year windows and sales growth over a five-year window. Specifically, each granted claim reduces rivals' employment growth by 3 percentage points over three years (p=0.065), 4.5 percentage points over four years (p=0.026), and 5.4 percentage points over five years (p=0.029), and their sales growth by 6.7 percentage points over five years (p=0.023).

Longer examination times similarly impose externalities on rivals' growth. The effect on employment growth averages minus two to three percentage points but is statistically significant only over a two-year window (p=0.020). The effect on sales growth is larger and more consistently significant. A one-year increase in examination time reduces rivals' sales growth by 1.7 percentage points over one year (p=0.082), 4.7 percentage points over two years (p=0.002), 6.5 percentage points over three years (p=0.003), 5.9 percentage points over four years (p=0.029), and 5.7 percentage points over five years (p=0.048). Longer examination times also reduce rivals' chances of survival, by 1.1, 1.9, 2.5, 3.4, and 3.7 percentage points over one to five years, respectively, for each additional year the focal startup has to wait for a first-action decision on its application (p<0.001).

Table 9 considers access to VC and IPO funding. While scope does not give rise to externalities, examination time has a large and significant effect on the likelihood that the focal startup's subclass peers obtain VC funding. To illustrate, each additional year of examination time reduces the fraction of startups in the same technology subclass that obtain VC funding by 0.3 percentage points over two years (p=0.047), 0.4 percentage points over three years (p=0.001), 0.6 percentage points over four years (p<0.001), and 0.8 percentage points over five years (p<0.001). Economically, these externality effects are sizeable. For example, the five-year estimate in column 5 represents a 11.1% reduction in the fraction of VC-funded startups from the unconditional sample mean of 7.2%. In conjunction with the adverse effect on survival, this suggests that prolonged uncertainty around a front-runner's intellectual property may adversely affect the ability of other startups in its space to raise the capital required to fund their operations.

Table 10 considers externalities on follow-on innovation in the subclass. Examination time affects both the quantity and quality of rivals' follow-on innovation. To illustrate, a one-year increase in the focal startup's examination time reduces the number of subclass peers' subsequent patent applications and eventually granted patents by 16.1% and 15.5%, respectively, and citations to their subsequent patents by 14.4% (all significant at p<0.001). In contrast to these negative externality effects, examination time imposes a positive externality on peers' subsequent patent approval rates, with a one-year increase in the focal startup's examination time increasing peers' approval rates by 0.6 percentage points on average (p<0.051), equivalent to a 1% increase from the unconditional approval rate. These positive externalities on rivals' approvals may be due to the resolution of uncertainty about the focal patentees' intellectual property that facilitates grants for other applicants. Scope, on the other hand, has no effect on rivals' follow-on innovation, except that it reduces their average number of citations (p=0.062).

In sum, we find evidence that a startup's patent scope and timing impose externalities on its peers, at least among rival innovators, with regards to growth, survival, VC funding, and follow-on innovation. Longer examination times suppress rivals' growth, hamper rivals' access to VC funding, and appear to stifle follow-on innovation, consistent with investors considering wider trends in patenting in narrowly defined technology areas in their funding decisions and faster resolution of uncertainty allowing rival startups to more quickly pivot to alternative strategies. A broader patent hampers rivals' growth prospects, perhaps by increasing their cost of entering product markets or curtailing their market share (Merges and Nelson 1990, Shapiro 2001).

V. Concluding thoughts

We investigate the causal effects of the two key levers of patent systems—scope and timing—on a range of economically important outcomes. In particular, we estimate the causal effects of patent scope and examination time on growth, access to external capital, and follow-on innovation for U.S. startups that receive a first patent and the externalities the scope and timing of these patents impose on other startups in their space. We focus on innovative startups for their outsized contributions to economic growth and on the effects of their first applications both for their importance for the startup and for pragmatic measurement-related reasons that allow us to better isolate the effects of an individual patent's characteristics on outcomes. We disentangle the effects of scope and timing from the unobserved quality of the underlying inventions by taking advantage of plausibly exogenous variation in scope and timing owing to the quasi-random allocation of applications to patent examiners who differ in their propensity to grant narrow patents and in their review speed.

Understanding the causal effects of scope and timing informs the trade-off that startup inventors face between pursuing broader patents that likely take longer to issue and narrower patents that may be granted more quickly. It also informs the constrained optimization problem faced by the PTO: how to craft patents that adequately reward inventors without blocking follow-on inventors given the limited resources and time available for patent examination.

Our results show that broader scope delivers nuanced benefits to startups: unconditionally, scope has little effect on growth in sales or employment, but it reduces a startup's chances of long-term survival (perhaps because broader scope makes it a more attractive acquisition candidate) such that among those startups that survive as independent companies, broader scope boosts long-term growth in employment and sales by substantial margins. In addition, scope boosts a startup's subsequent innovation. Finally, broader scope imposes negative externalities on the long-term growth prospects of a startup's technology rivals.

Faster review times at the PTO, on the other hand, have clear and substantial positive effects on both startups and their startup rivals. Faster reviews allow startups and their peers to create more jobs, generate higher sales, innovate more successfully, and more readily access VC funding. The PTO introduced new rules in 2011 allowing inventors to choose among (i) prioritized examination with a guaranteed final decision on the application within 12 months of being accorded priority status (for the payment of an additional $4,800 in fees), (ii) traditional examination under the process outlined in Section I.A, and (iii) an applicant-controlled delay of up to 30 months prior to docketing for examination. The PTO reports that nearly half of the applicants that use this accelerated procedure are small firms (which account for less than 10% of all applications). Our findings from a sample of startups rationalize this statistic and suggest that for most startups, the benefits of seeking prioritized examination far outweigh the corresponding additional processing costs.

Our causal estimates of the effects of scope and timing provide new micro insights into the effects of the patent system on inventors and spillover effects on others. Our results suggest that the speed of patent examination has large and meaningful effects not just for startup inventors, but also for other startups in the industry. This finding has important implications for the patent system, as one of its implicit policy goals is to facilitate economic growth by promoting startups and small inventors who typically do not have alternative mechanisms to protect their intellectual property. We acknowledge that the effects of a single patent's scope or timing may have less striking effects on large firms or holders of large patent portfolios. Nevertheless, given the importance of innovative startups in models of economic growth (such as Aghion et al. 2009), our results merit consideration by policymakers in any reform of the intellectual property system.

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Appendix. Variable definitions

Count of independent claims equals the number of independent claims allowed in a granted patent application.

First-action examination time equals the time between the patent application date and the first-action date, in years.

Examiner scope leniency is the average count of independent claims in patents previously allowed by an examiner. Examiner scope leniency is calculated as of the focal patent's first-action date.

Examiner review speed is the average first-action examination time in years for patents previously examined by an examiner. Examiner review speed is calculated as of the focal patent's first-action date.

Firm survival during year t after the first-action decision on a firm's patent application is set to 1 for firms matched to NETS for which employment or sales data are available either for year t or for any subsequent year, and zero otherwise.

Employment growth after the first-action decision on a firm's patent application is measured as $employment_{t+k}/employment_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. If a firm dies or is acquired and thus does not appear in NETS in year $t + k$, we set $employment_{t+k} = 0$.

Sales growth after the first-action decision on a firm's patent application is measured as $sales_{t+k}\,/sales_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. If a firm dies or is acquired and thus does not appear in NETS in year $t + k$, we set $sales_{t+k} = 0$.

Pre-patent-filing employment growth equals $employment_\tau/employment_{\tau-1} - 1$, where τ is the year in which the firm's patent application is filed.

Pre-patent-filing sales growth equals $sales_\tau\,/sales_{\tau-1} - 1$, where τ is the year in which the firm's patent application is filed.

No. subsequent patent applications is the number of applications by the focal firm with a filing date greater than the first-action date of the firm's first application.

No. subsequent approved patents is the number of approved applications by the focal firm with a filing date greater than the first-action date of the firm's first application.

Approval rate of subsequent patent applications is defined as $(no.subsequent\ approved\ patents)\,/\,(no.subsequent\ patent\ applications)$ for the focal firm. This measure takes the value 0 if the focal firm does not apply for any other patents within our timeframe.

Total citations to all subsequent patent applications is the combined number of citations received by all subsequent patent applications filed by the focal firm. This number includes citations to the relevant granted patents following an application's approval. It is zero for firms with no subsequent applications. We measure citations over the five years following each patent application's public disclosure date, which is typically 18 months after the application's filing date. Patents for which the application's public disclosure date is missing are omitted. This measure takes the value 0 if the focal firm does not apply for any other patents within our timeframe.

Average citations-per-patent to subsequent patent applications is the average number of citations received by subsequent patent applications by the focal firm. This measure takes the value 0 if the focal firm does not apply for any other patents within our timeframe.

Examiner experience is the number of years since the examiner joined the PTO.

Examiner grade is the examiner's grade according to the government's General Schedule. Most examiners start at grade GS-7 or GS-9. Examiners at grades GS-7 through GS-11 need senior examiners to sign off on their decisions.

GS-13 examiners undergo a period in which they have partial signatory authority (during which time their work is subject to random checks). Examiners at levels GS-14 and above have full signatory authority.

Subclass classification is the technology subclass classification for the startup's patent application. Subclasses represent the most granular division of technological subject matter at the PTO. Subclass classifications are used to assign firms to specific product market areas.

Subclass-level employment growth after the first-action decision on the focal firm's patent application is $industry\ employment_{t+k} / industry\ employment_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. Industry employment equals aggregate employment at all sample startups in the focal firm's subclass, excluding the focal firm itself.

Subclass-level sales growth after the first-action decision on the focal firm's patent application is $industry\ sales_{t+k} / industry\ sales_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. Industry sales equals aggregate sales by all sample startups in the focal firm's subclass, excluding the focal firm itself.

Subclass-level survival equals the fraction of sample startups in the focal firm's subclass still alive in year t, excluding the focal firm itself.

Subclass-level no. subsequent patent applications is the aggregate number of patent applications filed by sample startups in the focal firm's subclass that are filed after the first-action date of the focal firm's first patent application, excluding subsequent applications by the focal firm itself.

Subclass-level no. subsequent approved patents is the aggregate number of approved patent applications filed by sample startups in the focal firm's subclass that are filed after the first-action date of the focal firm's first patent application, excluding subsequent applications by the focal firm itself.

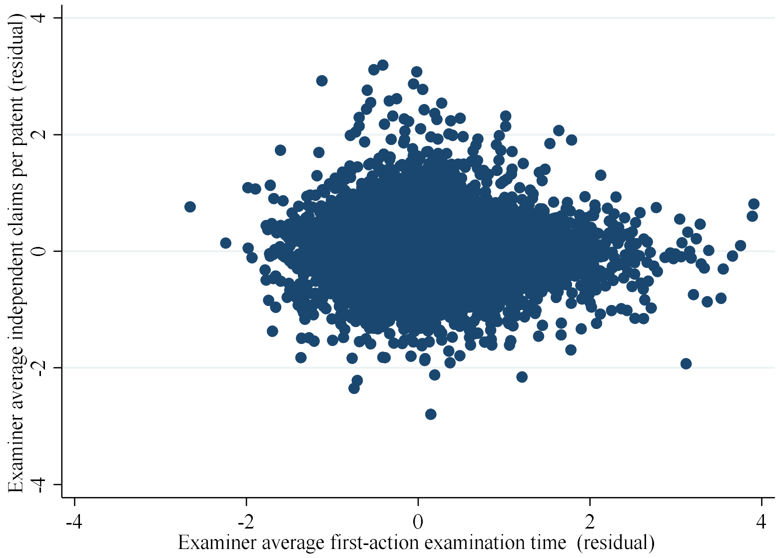
Subclass-level approval rate of subsequent patent applications is defined as the ratio of *subclass-level no. subsequent approved patents* and *subclass-level no. subsequent patent applications.* This measure takes the value 0 if no other sample startup in the focal firm's subclass applies for patents within our timeframe.

Subclass-level total citations to all subsequent patent applications is the aggregate number of citations received by all patent applications filed by sample startups in the focal firm's subclass that are filed after the first-action date of the focal firm's first patent application, excluding subsequent applications by the focal firm itself. We measure citations over the five years following each patent application's public disclosure date, which is typically 18 months after the application's filing date. This measure takes the value 0 if no other sample startup in the focal firm's subclass applies for patents within our timeframe.

Subclass-level average citations-per-patent to subsequent patent applications is the average number of citations received by all patent applications filed by sample startups in the focal firm's subclass that are filed after the first-action date of the focal firm's first patent application, excluding subsequent applications by the focal firm itself. This measure takes the value 0 if no other sample startup in the focal firm's subclass applies for patents within our timeframe.

Figure 1. Joint Distribution of Examiner Scope Leniency and Examiner Review Speed.
The figure shows the joint sample distribution of examiner scope leniency and examiner review speed. Examiner scope leniency is defined as the average count of independent claims in patents previously allowed by an examiner, estimated within art unit and year using a regression of the count of independent claims on a full set of art-unit-by-application-year fixed effects. Examiner review speed is defined as the review speed from application date to first-action date, estimated within an art unit and year using a regression of examiner review speed on a full set of art-unit-by-application-year fixed effects. In Panel B, data points are grouped into 100 equally-sized bins and an aggregate statistic is used to summarize each bin. The OLS line drawn in Panel B has a slope of 0.006 with a *p*-value of 0.217.

Panel A. Scatterplot.



Panel B. Binned scatterplot.

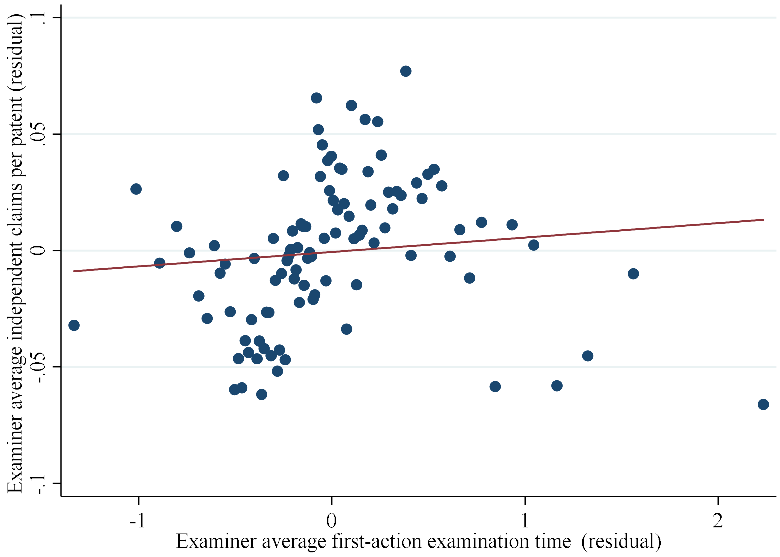


Figure 2. Distribution of Examiner Scope Leniency.
The figure shows the sample distribution of examiner scope leniency, defined as the average count of independent claims in patents previously allowed by an examiner, estimated within an art unit and year using a regression of the count of independent claims on a full set of art-unit-by-application-year fixed effects.

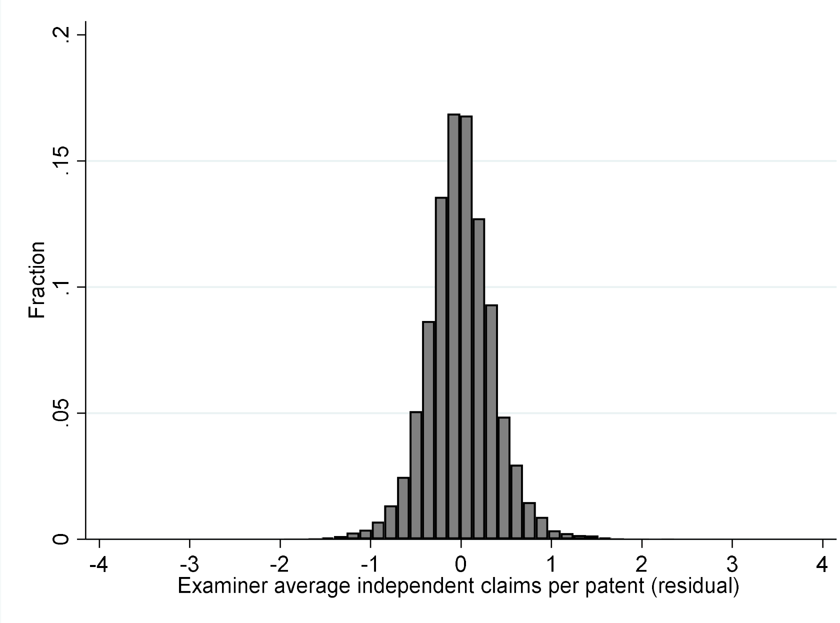


Figure 3. Distribution of Examiner review speed.
The figure shows the sample distribution of patent examiners' historic review speeds measured from application date to first-action date, estimated within an art unit and year using a regression of examiner review speed on a full set of art-unit-by-application-year fixed effects.

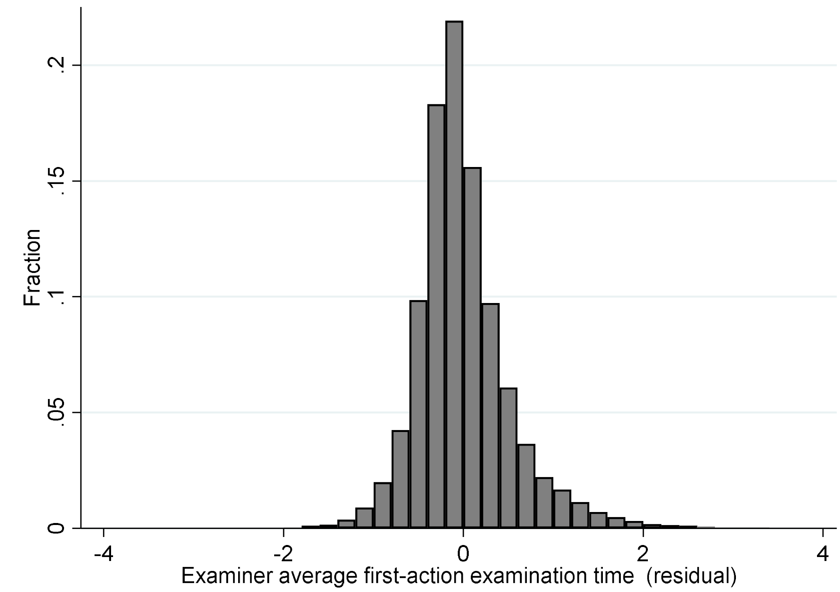
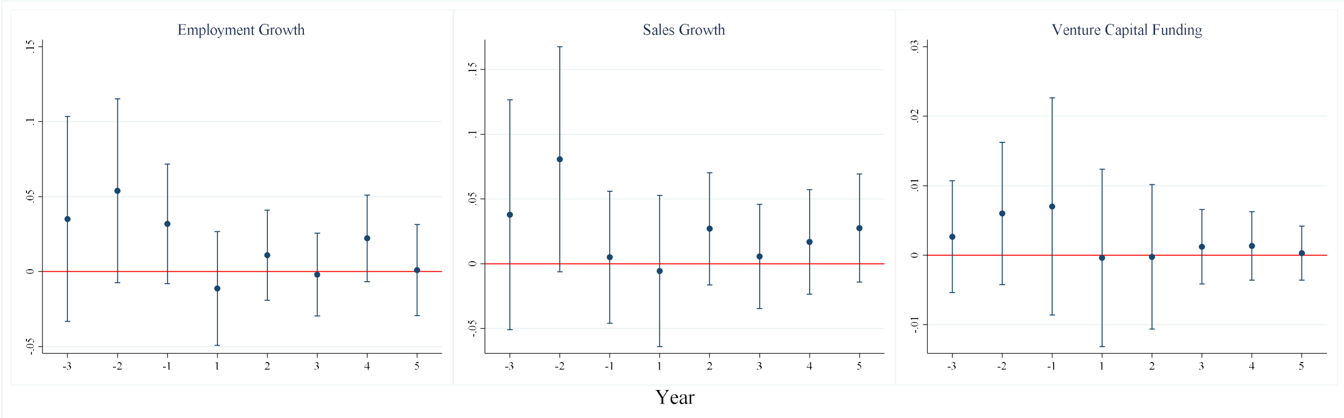


Figure 4. Falsification Test: Effects of Scope and Examination Time on Startup Growth and Funding.
The figure plots the estimated 2SLS effects of patent scope as measured by the count of independent claims (Panel A) and first-action examination time (Panel B) on annual employment growth, annual sales growth, and the annual likelihood of obtaining venture capital funding over the three years before and the five years following the first-action decision on a startup's first patent application, along with 95% confidence intervals.

Panel A. Patent scope.



Panel B. First-action examination time.

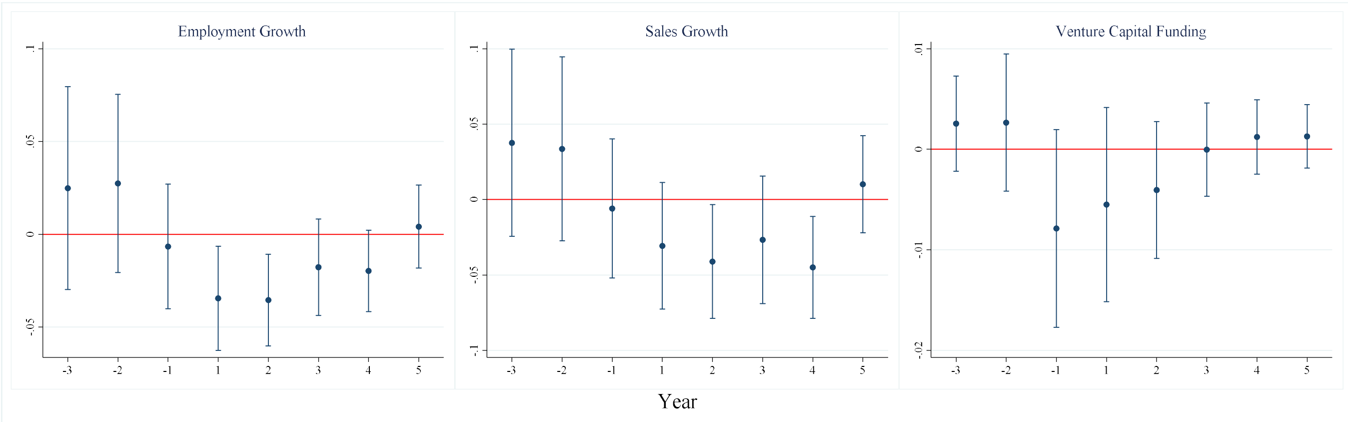


Table 1. Summary Statistics.

The table reports summary statistics for the firms in our sample of first-time patent applicants (or "startups") whose application is approved and that have data regarding patent scope. Data on age, employment, and sales are only available for those startups that can be matched to the National Establishment Times Series (NETS) database. For variable definitions and details of their construction see the Appendix.

No. firms		22,001
Count of independent claims	mean	3.2
	median	3
	st.dev.	*2.6*
First-action examination time (years)	mean	1.6
	median	1.4
	st.dev.	*0.9*
Panel A. Pre-filing characteristics		
Age at first patent filing (years)	median	2
Employees at first-action	mean	28.5
	median	8
	st.dev.	*59.8*
Sales at first-action ($ million)	mean	4.3
	median	0.8
	st.dev.	*10.2*
Pre-patent-filing employment growth (%)	mean	15.4
	st.dev.	*63.9*
Pre-patent-filing sales growth (%)	mean	19.9
	st.dev.	*84.5*
Panel B. Subsequent growth in employment and sales (%)		
… 1 year	mean	6.4
	st.dev.	*48.2*
… 3 years	mean	19.6
	st.dev.	*122.0*
… 5 years	mean	21.1
	st.dev.	*155.9*
… 1 year	mean	11.0
	st.dev.	*70.7*
… 3 years	mean	34.4
	st.dev.	*180.0*
… 5 years	mean	44.4
	st.dev.	*244.3*
Panel C. Subsequent patenting: patent applications filed after first-action decision		
No. subsequent patent applications	mean	3.8
	st.dev.	*16.0*
No. subsequent approved patents	mean	2.6
	st.dev.	*12.1*
Approval rate of subsequent patent applications (%)		33.5%
Total citations to all subsequent patent applications	mean	19.9
	st.dev.	*170.7*
Average citations-per-patent to subsequent patent applications	mean	1.5
	st.dev.	*4.1*
Panel D. Subsequent VC funding and IPOs		
% of startups that raise VC funding after first-action		9.4
% of startups that go public after first-action		0.8

Table 2, Panel A. First-stage Results: Patent Scope.

The table reports the results of estimating various versions of the first-stage eq. (4) of our 2SLS analysis considering patent scope. The first stage uses the scope leniency of the patent examiner in charge of reviewing a startup's first patent application to predict the scope of the granted patent. Identification assumes that applications are assigned to examiners quasi-randomly within an art unit and year. Accordingly, our baseline specification shown in column 1 includes art-unit-by-year fixed effects. Columns 2 through 5 consider threats to identification arising from potential violations of quasi-random assignment. Columns 2 and 3 investigate the possibility of quality-based assignment, using characteristics of the applicant to proxy for quality. Columns 4 and 5 investigate the possibility of assignment based on examiner characteristics, controlling for examiner specialization by including technology-subclass-by-year fixed effects (in columns 4 and 5) and proxies for examiner experience and seniority (in column 5). The number of observations varies depending on data availability (e.g., sales and employment data are only available for startups that can be matched to NETS) and due to a varying number of singletons. All specifications are estimated using least squares. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Patent scope				
	(1)	(2)	(3)	(4)	(5)
IV: examiner scope leniency	0.522***	0.535***	0.546***	0.490***	0.498***
	0.058	*0.065*	*0.077*	*0.066*	*0.066*
examiner review speed +	-0.015	0.010	0.022	-0.031	0.005
docket date lag	*0.036*	*0.039*	*0.046*	*0.062*	*0.066*
Applicant characteristics					
ln(employees at first-action)		0.036			
		0.034			
ln(1 + sales at first-action)		-0.012			
		0.026			
age at application		-0.002			
		0.002			
employment growth			0.084		
at first action			*0.063*		
sales growth at first action			-0.012		
			0.041		
Examiner characteristics					
ln(examiner experience)					0.181***
					0.048
examiner grade GS-9					-0.010
					0.121
examiner grade GS-11					-0.177
					0.141
examiner grade GS-12					-0.291*
					0.153
examiner grade GS-13					-0.265*
					0.149
examiner grade GS-14					-0.306*
					0.185
examiner grade GS-15					-0.239
					0.237
Fixed effects					
art unit × year	Yes	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes	Yes
tech subclass × year	No	No	No	Yes	Yes
Diagnostics					
R^2	16.1%	19.1%	20.6%	35.6%	35.7%
F-test: IV = 0	80.7***	68.0***	50.2***	55.9***	56.4***
No. of observations (firms)	21,518	14,052	11,306	16,246	16,240

Table 2, Panel B. First-stage Results: First-Action Examination Time.

The table reports the results of estimating various versions of the first-stage eq. (5) of our 2SLS analysis considering examination time. The first stage uses examiner review speed plus the docket date lag (i.e., the application-specific time between application date and docket date in years) to predict the first-action examination time for a granted patent application. Identification assumes that applications are assigned to examiners quasi-randomly within an art unit and year. Accordingly, our baseline specification shown in column 1 includes art-unit-by-year fixed effects. Columns 2 to 5 consider threats to identification arising from potential violations of quasi-random assignment. Columns 2 and 3 investigate the possibility of quality-based assignment, using applicant characteristics to proxy for quality. Columns 4 and 5 investigate the possibility of assignment based on examiner characteristics, controlling for examiner specialization by including technology-subclass-by-year fixed effects (in columns 4 and 5) and proxies for examiner experience and seniority (in column 5). The number of observations varies depending on data availability and due to a varying number of singletons. All specifications are estimated using least squares. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	First-action examination time				
	(1)	(2)	(3)	(4)	(5)
IV: examiner average review speed	0.528***	0.523***	0.532***	0.515***	0.529***
+ docket date lag	*0.014*	*0.015*	*0.016*	*0.017*	*0.018*
examiner scope leniency	-0.055***	-0.049**	-0.053**	-0.043**	-0.042**
	0.017	*0.019*	*0.021*	*0.018*	*0.018*
Applicant characteristics					
ln(employees at first-action)		0.000			
		0.007			
ln(1 + sales at first-action)		-0.009			
		0.006			
age at application		0.000			
		0.000			
employment growth			-0.012		
at first action			*0.016*		
sales growth at first action			0.002		
			0.013		
Examiner characteristics					
ln(examiner experience)					0.044***
					0.012
examiner grade GS-9					-0.060*
					0.034
examiner grade GS-11					-0.077**
					0.036
examiner grade GS-12					-0.142***
					0.040
examiner grade GS-13					-0.140***
					0.039
examiner grade GS-14					-0.077*
					0.045
examiner grade GS-15					-0.200***
					0.064
Fixed effects					
art unit × year	Yes	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes	Yes
tech subclass × year	No	No	No	Yes	Yes
Diagnostics					
R^2	62.3%	64.0%	64.8%	73.8%	74.0%
F-test: IV = 0	1,343.9***	1,251.6***	1,134.2***	874.3***	885.2***
No. of observations (firms)	21,695	14,167	11,402	16,396	16,390

Table 3, Panel A. Instrument Validity: Examiner Scope Leniency.

The table reports the results of regressing the scope leniency of the examiner reviewing each firm's first patent application on the characteristics of the applicant and the application. The number of observations varies depending on data availability (e.g., sales and employment data are only available for startups that can be matched to NETS) and due to a varying number of singletons. In columns 3 and 4, the sample is restricted to patent applications that are also filed with the European and Japanese patent offices, respectively. All specifications are estimated using least squares. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use *** and ** to denote significance at the 1% and 5% level respectively.

	IV: Examiner scope leniency				
	(1)	(2)	(3)	(4)	(5)
Applicant characteristics					
ln(employees at filing date)	0.004				
	0.005				
ln(1 + sales at filing date)	-0.003				
	0.003				
age at application	0.000				
	0.000				
employment growth during year prior to filing date		0.001			
		0.010			
sales growth during year prior to filing date		0.002			
		0.007			
Application characteristics					
Claim count at publication			0.001		
			0.002		
Average claim word count			0.000		
			0.000		
Count of backwards citations			0.000		
			0.000		
Count of non-patent literature citations			0.000		
			0.000		
Approval by foreign patent office					
European Patent Office				0.022	
				0.015	
Japanese Patent Office					0.014
					0.020
Fixed effects					
art unit × year	Yes	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes	Yes
tech subclass × year	No	No	Yes	No	No
Diagnostics					
R^2	62.1%	63.4%	78.7%	69.7%	75.0%
No. of observations (firms)	20,314	17,684	11,671	5,294	2,698

Table 3, Panel B. Instrument Validity: First-Action Examination Time.

The table reports the results of regressing examiner review speed plus the application-specific time between application date and docket date in years on the characteristics of the applicant and the application. The number of observations varies depending on data availability (e.g., sales and employment data are only available for startups that can be matched to NETS) and due to a varying number of singletons. In columns 3 and 4, the sample is restricted to patent applications that are also filed with the European and Japanese patent offices, respectively. All specifications are estimated using least squares. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use *** and ** to denote significance at the 1% and 5% level respectively.

	IV: Examiner average review speed + docket date lag				
	(1)	(2)	(3)	(4)	(5)
Applicant characteristics					
ln(employees at filing date)	-0.004				
	0.006				
ln(1 + sales at filing date)	0.001				
	0.004				
age at application	0.000				
	0.000				
employment growth during year		0.000			
prior to filing date		*0.013*			
sales growth during year prior		0.005			
to filing date		*0.010*			
Application characteristics					
Claim count at publication			0.002		
			0.003		
Average claim word count			0.000		
			0.000		
Count of backwards citations			0.000		
			0.000		
Count of non-patent literature citations			0.001		
			0.001		
Approval by foreign patent office					
European Patent Office				-0.030	
				0.020	
Japanese Patent Office					-0.042
					0.027
Fixed effects					
art unit × year	Yes	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes	Yes
tech subclass × year	No	No	Yes	No	No
Diagnostics					
R^2	62.2%	62.6%	73.6%	64.4%	65.2%
No. of observations (firms)	20,447	17,801	11,706	5,339	2,722

Table 4. Effects of Scope and Examination Time on Growth and Survival.

Panels A and B report the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. (Table 5 shows robustness to excluding these observations instead.) Panel C reports the results of linear probability models of firm survival. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panels A and C control for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.011	0.014	-0.004	0.056	0.079
	0.019	*0.031*	*0.039*	*0.049*	*0.056*
First-action examination time	-0.035**	-0.084***	-0.105***	-0.121***	-0.128***
	0.014	*0.028*	*0.039*	*0.043*	*0.049*
Diagnostics					
Weak-instrument test	38.0***	38.0***	38.0***	38.0***	38.0***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	-0.006	0.044	0.023	0.108	0.125
	0.030	*0.049*	*0.061*	*0.073*	*0.087*
First-action examination time	-0.031	-0.083*	-0.120**	-0.171**	-0.204***
	0.021	*0.044*	*0.061*	*0.068*	*0.078*
Diagnostics					
Weak-instrument test	38.0***	38.0***	38.0***	38.0***	38.0***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.008	-0.003	-0.012	-0.014	-0.027*
	0.007	*0.010*	*0.012*	*0.014*	*0.016*
First-action examination time	-0.014***	-0.031***	-0.036***	-0.041***	-0.030**
	0.005	*0.009*	*0.009*	*0.011*	*0.013*
Diagnostics					
Weak-instrument test	38.0***	38.0***	38.0***	38.0***	38.0***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table 5. Effects of Scope and Examination Time on Startup Growth: Growth Conditional on Survival.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we restrict the sample to those startups that survive for the requisite number of years following the first-action date. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. All specifications include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	0.000	0.025	0.020	0.114*	0.194***
	0.018	*0.032*	*0.044*	*0.059*	*0.071*
First-action examination time	-0.020	-0.056**	-0.069*	-0.091*	-0.111**
	0.014	*0.027*	*0.040*	*0.049*	*0.057*
Diagnostics					
Weak-instrument test	36.9***	32.3***	28.6***	26.7***	23.1***
Mean of dep. variable	9.8%	22.7%	33.8%	43.0%	50.5%
No. of observations (firms)	13,231	12,742	12,155	11,559	10,874
Panel B. Sales growth					
Count of independent claims	0.008	0.061	0.057	0.176*	0.267**
	0.029	*0.051*	*0.069*	*0.090*	*0.111*
First-action examination time	-0.014	-0.052	-0.072	-0.123	-0.199**
	0.022	*0.046*	*0.066*	*0.081*	*0.095*
Diagnostics					
Weak-instrument test	36.8***	32.2***	28.5***	26.6***	22.9***
Mean of dep. variable	14.5%	33.0%	50.4%	65.8%	79.4%
No. of observations (firms)	13,231	12,742	12,155	11,559	10,874

Table 6. Effects of Scope and Examination Time on Startup Access to VC Funding and the IPO Market.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first patent application grant affects the startup's ability to raise funding from a VC or in the IPO market. The dependent variable in columns 1 through 5 is an indicator set equal to one if the startup raises VC funding at some point in the 1…5 years following the first-action decision, respectively. The dependent variable in column 6 is an indicator set equal to one if the startup goes public after the first-action decision on its first patent application, and zero otherwise. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Following the first-action decision on its first patent application, does the startup …					
	raise VC funding in the next 1 year?	raise VC funding in the next 2 years?	raise VC funding in the next 3 years?	raise VC funding in the next 4 years?	raise VC funding in the next 5 years?	raise capital in the IPO market?
	(1)	(2)	(3)	(4)	(5)	(6)
Count of independent claims	0.000	0.000	0.002	0.003	0.004	0.008**
	0.006	*0.007*	*0.007*	*0.008*	*0.008*	*0.003*
First-action examination time	-0.005	-0.010*	-0.010*	-0.009	-0.007	-0.004*
	0.005	*0.005*	*0.005*	*0.006*	*0.006*	*0.002*
Log (1 + no. prior VC rounds)	0.283***	0.397***	0.436***	0.448***	0.455***	0.040***
	0.010	*0.011*	*0.010*	*0.011*	*0.011*	*0.005*
Diagnostics						
Weak-instrument test	38.1***	38.4***	38.1***	38.1***	38.0***	38.1***
Mean of dep. variable	4.6%	6.8%	7.6%	8.2%	8.5%	0.79%
No. of observations (firms)	21,483	21,440	21,399	21,372	21,353	21,518

Table 7. Effects of Scope and Examination Time on Follow-on Innovation.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affects the startup's follow-on innovation. Data on subsequent applications come from the PTO internal databases and include all applications that receive a final decision through December 31, 2016. Column 3 includes only startups filing at least one patent application after the first-action decision on the startup's first patent application and for which we can measure the approval rate of subsequent applications. Column 5 includes only those startups with at least one subsequent patent approval and for which we can measure the average number of citations-per-patent to subsequently approved patents. We measure citations over the five years following each patent application's public disclosure date, which is typically 18 months after the application's filing date. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Follow-on innovation				
	Log (1 + subsequent patent applications)	Log (1 + subsequent approved patents)	Approval rate of subsequent patent applications	Log (1 + total citations to subsequent patent applications)	Log (1 + avg. citations to subsequent patent applications)
	(1)	(2)	(3)	(4)	(5)
Count of independent claims	0.057*	0.057**	0.010	0.120**	0.058**
	0.030	*0.028*	*0.014*	*0.047*	*0.026*
First-action examination time	-0.088***	-0.088***	-0.030***	-0.129***	-0.054**
	0.022	*0.020*	*0.011*	*0.038*	*0.022*
Diagnostics					
Weak-instrument test	43.6***	43.6***	43.6***	45.1***	45.1***
Mean of non-logged dep. var.	3.8	2.6	34.6%	19.9	1.5
No. of observations (firms)	21,061	21,061	21,061	20,545	20,545

Table 8. Effects of Scope and Examination Time on Industry Growth and Survival.

Panels A and B report the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect subsequent growth in employment and sales in its industry over the one to five years following the focal startup's first-action date. Panel C reports the fraction of startups in the industry that survive. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. Sales and employment growth are calculated based on the aggregate sales and employment of sample startups that apply in the same PTO technology subclass as the focal firm; the focal firm is excluded in this calculation. The variables of interest in each panel are patent scope and first-action examination time for the focal firm's granted patent application. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time. In addition, we include art-unit-by-year and subclass fixed effects. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the subclass level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.003	0.003	-0.030*	-0.045**	-0.054**
	0.008	*0.012*	*0.016*	*0.021*	*0.024*
First-action examination time	-0.008	-0.026**	-0.024	-0.032	-0.033
	0.007	*0.011*	*0.016*	*0.020*	*0.023*
Diagnostics					
Weak-instrument test	51.9***	51.9***	51.9***	51.9***	51.9***
Mean of dep. variable	4.7%	9.1%	12.5%	15.4%	16.8%
No. of observations	15,826	15,826	15,826	15,826	15,826
Panel B. Sales growth					
Count of independent claims	-0.008	0.000	-0.024	-0.029	-0.067**
	0.010	*0.016*	*0.021*	*0.027*	*0.030*
First-action examination time	-0.017*	-0.047***	-0.065***	-0.059**	-0.057**
	0.010	*0.015*	*0.022*	*0.027*	*0.029*
Diagnostics					
Weak-instrument test	51.9***	51.9***	51.9***	51.9***	51.9***
Mean of dep. variable	6.5%	12.6%	17.8%	22.5%	25.0%
No. of observations	15,826	15,826	15,826	15,826	15,826
Panel C. Survival					
Count of independent claims	0.001	0.001	-0.002	-0.004	-0.002
	0.002	*0.002*	*0.003*	*0.003*	*0.003*
First-action examination time	-0.011***	-0.019***	-0.025***	-0.034***	-0.037***
	0.002	*0.003*	*0.003*	*0.003*	*0.003*
Diagnostics					
Weak-instrument test	51.9***	51.9***	51.9***	51.9***	51.9***
Mean of dep. variable	96.5%	92.7%	88.8%	84.6%	80.1%
No. of observations	15,826	15,826	15,826	15,826	15,826

Table 9. Effects of Scope and Examination Time on Access to VC Funding and the IPO Market in the Industry.

The table reports the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect the ability of other startups in the same industry to raise funding from a VC or in the IPO market. The dependent variable in columns 1 through 5 is the fraction of sample startups with a first patent application filed in the same PTO technology subclass that raise VC funding in the 1…5 years following the first-action decision on the focal patent; the focal startup is excluded in this calculation. The dependent variable in column 6 is the fraction of sample startups with a first patent application filed in the same PTO technology subclass that go public after the first-action decision on the focal patent. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time. In addition, we include art-unit-by-year and subclass fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the subclass level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Fraction of startups in the focal firm's technology subclass that …					
	raise VC funding in the next 1 year (1)	raise VC funding in the next 2 years (2)	raise VC funding in the next 3 years (3)	raise VC funding in the next 4 years (4)	raise VC funding in the next 5 years (5)	raise capital in the IPO market (6)
Count of independent claims	0.0001	0.0003	-0.0001	-0.0006	-0.0007	0.0001
	0.0011	*0.0013*	*0.0015*	*0.0015*	*0.0015*	*0.0002*
First-action examination time	0.0000	-0.0025**	-0.0041***	-0.0064***	-0.0081***	-0.0003*
	0.0011	*0.0013*	*0.0013*	*0.0012*	*0.0012*	*0.0002*
Diagnostics						
Weak-instrument test	52.6***	52.6***	52.6***	52.6***	52.6***	52.6***
Mean of dep. variable	3.3%	5.0%	6.0%	6.7%	7.2%	0.61%
No. of observations	15,887	15,887	15,887	15,887	15,887	15,887

Table 10. Effects of Scope and Examination Time on Follow-on Innovation in the Industry.

The table reports the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect the ability of other startups in the same industry to innovate. Data on subsequent applications come from the PTO internal databases and include all applications that receive a final decision through December 31, 2016. Column 3 includes only startups filing at least one patent application after the first-action decision on the focal startup's first patent application and for which we can measure the approval rate of subsequent applications. Column 5 includes only those startups with at least one subsequent patent approval and for which we can measure the average number of citations-per-patent to subsequently approved patents. We measure citations over the five years following each patent application's public disclosure date, which is typically 18 months after the application's filing date. Dependent variables are calculated as the aggregate value of each measure for sample startups with a first patent application filed in the same PTO technology subclass as the focal patent; the focal startup is excluded in this calculation. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time. In addition, we include art-unit-by-year and subclass fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the subclass level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Follow-on innovation in the technology subclass				
	Log (1 + subsequent patent applications) (1)	Log (1 + subsequent approved patents) (2)	Approval rate of subsequent patent applications (3)	Log (1 + total citations to subsequent patent applications) (4)	Log (1 + avg. citations-per-patent to subsequent patent applications) (5)
Count of independent claims	-0.001	-0.004	-0.001	-0.027	-0.017*
	0.010	*0.010*	*0.003*	*0.018*	*0.009*
First-action examination time	-0.176***	-0.168***	0.006*	-0.155***	0.011
	0.011	*0.011*	*0.003*	*0.019*	*0.009*
Diagnostics					
Weak-instrument test	41.7***	41.7***	41.7***	40.1***	40.1***
Mean of non-logged dep. var.	207.6	128.5	62.6%	1,040.4	4.0
No. of observations	8,902	8,902	8,902	8,204	8,204

INTERNET APPENDIX

for

Quick or Broad Patents? Evidence from U.S. Startups [†]

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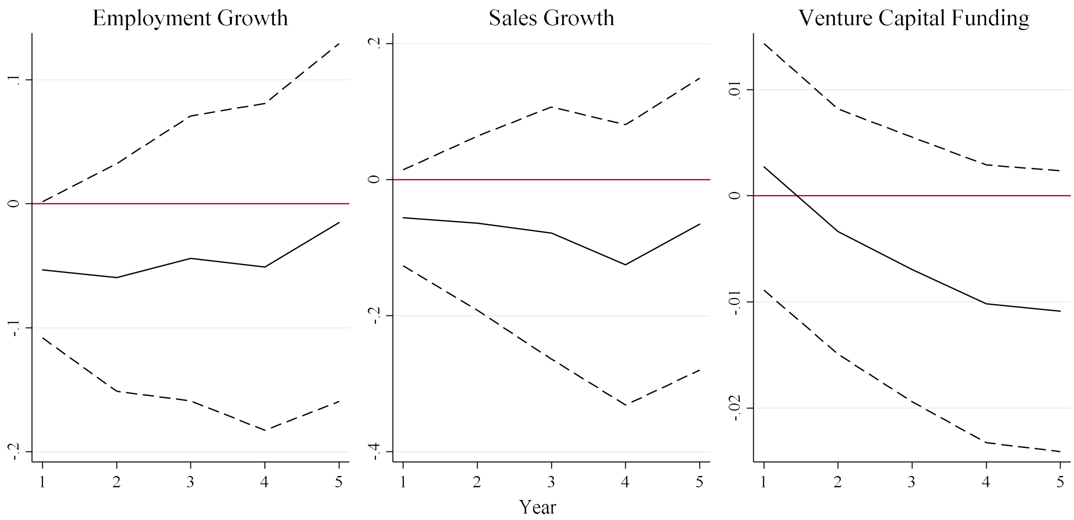
Figure IA.1. Effects of Examination Time for Rejected Applications.

The figure plots the estimated effects of first-action examination time for patents that are ultimately rejected on follow-on innovation measures. Solid lines show point estimates. Dashed lines represent 95% confidence intervals. The 2SLS estimation results underlying these graphs are reported in Tables IA.10 through IA.12.

Panel A. Employment Growth, Sales Growth, and VC Funding.



Panel B. IPO filing and follow-on innovation.

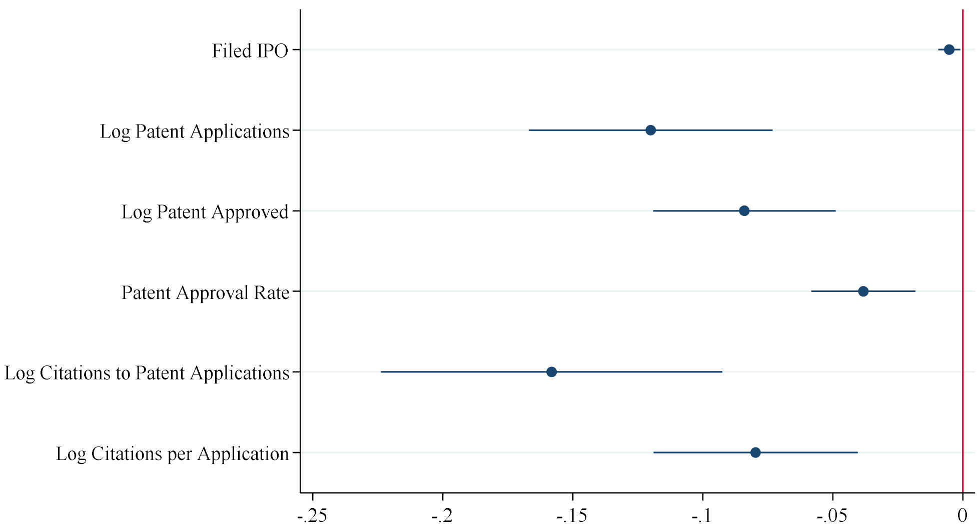


Table IA.1. Effects of Scope and Examination Time on Growth and Survival: OLS Results.
The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	0.004	0.009**	0.013**	0.016***	0.016**
	0.003	*0.004*	*0.005*	*0.006*	*0.007*
First-action examination time	-0.020***	-0.060***	-0.092***	-0.104***	-0.119***
	0.007	*0.014*	*0.020*	*0.022*	*0.026*
Diagnostics					
R^2	16.3%	17.2%	17.6%	18.2%	17.9%
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	0.005	0.008	0.013*	0.019*	0.020*
	0.003	*0.005*	*0.007*	*0.010*	*0.012*
First-action examination time	-0.019**	-0.051**	-0.080***	-0.122***	-0.167***
	0.010	*0.020*	*0.027*	*0.030*	*0.037*
Diagnostics					
R^2	15.9%	17.1%	17.7%	18.0%	17.8%
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.001*	-0.002*	-0.002	-0.001	-0.002
	0.001	*0.001*	*0.001*	*0.001*	*0.002*
First-action examination time	-0.005**	-0.011***	-0.008*	-0.005	-0.003
	0.003	*0.004*	*0.005*	*0.005*	*0.006*
Diagnostics					
R^2	15.8%	16.2%	17.1%	18.1%	18.2%
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.2. Effects of Scope and Examination Time on Growth and Survival.

This table repeats the analysis reported in Table 4, with the addition of the examiner's grant leniency in both the first- and the second-stage regressions. Grant leniency is measured as in Farre-Mensa, Hegde, and Ljungqvist (2020). Panels A and B report the effects of scope and timing of a startup's first granted patent on the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. Panel C reports the results of linear probability models of firm survival. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panels A and C control for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.011	0.007	-0.024	0.039	0.073
	0.023	*0.037*	*0.047*	*0.060*	*0.067*
First-action examination time	-0.035**	-0.080***	-0.091**	-0.109**	-0.123**
	0.016	*0.030*	*0.041*	*0.046*	*0.051*
Grant leniency	-0.001	0.043	0.139	0.116	0.046
	0.045	*0.073*	*0.102*	*0.128*	*0.131*
Diagnostics					
R^2	29.9***	29.9***	29.9***	29.9***	29.9***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	-0.004	0.044	0.000	0.067	0.100
	0.035	*0.058*	*0.073*	*0.087*	*0.104*
First-action examination time	-0.032	-0.084*	-0.104	-0.141**	-0.186**
	0.023	*0.048*	*0.064*	*0.072*	*0.081*
Grant leniency	-0.009	-0.003	0.162	0.281	0.178
	0.067	*0.108*	*0.152*	*0.182*	*0.204*
Diagnostics					
R^2	29.9***	29.9***	29.9***	29.9***	29.9***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.010	0.000	-0.010	-0.011	-0.025
	0.009	*0.011*	*0.014*	*0.016*	*0.018*
First-action examination time	-0.013**	-0.033***	-0.037***	-0.043***	-0.032**
	0.006	*0.009*	*0.010*	*0.012*	*0.013*
Grant leniency	0.010	-0.019	-0.014	-0.019	-0.015
	0.017	*0.022*	*0.025*	*0.031*	*0.033*
Diagnostics					
R^2	29.9***	29.9***	29.9***	29.9***	29.9***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.3. Effects of Scope and Examination Time on Growth and Survival.

This table repeats the analysis reported in Table 4, dropping all controls except for the art-unit-by-year fixed effects. Panels A and B report the effects of scope and timing of a startup's first granted patent on the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. Panel C reports the results of linear probability models of firm survival. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.011	0.013	-0.007	0.053	0.077
	0.019	*0.030*	*0.038*	*0.048*	*0.054*
First-action examination time	-0.034**	-0.084***	-0.103***	-0.118***	-0.123**
	0.014	*0.028*	*0.039*	*0.043*	*0.049*
Diagnostics					
R^2	37.2***	37.2***	37.2***	37.2***	37.2***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	-0.003	0.046	0.026	0.112	0.134
	0.029	*0.048*	*0.060*	*0.073*	*0.086*
First-action examination time	-0.031	-0.084*	-0.120**	-0.170**	-0.202**
	0.021	*0.045*	*0.061*	*0.069*	*0.079*
Diagnostics					
R^2	37.2***	37.2***	37.2***	37.2***	37.2***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.008	-0.004	-0.012	-0.014	-0.026*
	0.007	*0.010*	*0.012*	*0.014*	*0.016*
First-action examination time	-0.014***	-0.031***	-0.036***	-0.041***	-0.030**
	0.005	*0.009*	*0.009*	*0.011*	*0.013*
Diagnostics					
R^2	37.2***	37.2***	37.2***	37.2***	37.2***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.4. Effects of Scope and Examination Time on Growth and Survival.

This table repeats the analysis reported in Table 4, with the addition of the number of claims filed in the initial application (initial application scope) as a control. Panels A and B report the effects of scope and timing of a startup's first granted patent on the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. Panel C reports the results of linear probability models of firm survival. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panels A and C control for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.015	0.014	-0.009	0.061	0.089
	0.023	*0.038*	*0.047*	*0.058*	*0.067*
First-action examination time	-0.038***	-0.084***	-0.111***	-0.119***	-0.122**
	0.014	*0.028*	*0.039*	*0.044*	*0.050*
Initial application scope	0.008	-0.001	0.008	-0.012	-0.020
	0.008	*0.013*	*0.016*	*0.019*	*0.022*
Diagnostics					
R^2	32.1***	32.1***	32.1***	32.1***	32.1***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	-0.009	0.050	0.024	0.122	0.145
	0.036	*0.058*	*0.073*	*0.087*	*0.104*
First-action examination time	-0.033	-0.078*	-0.120*	-0.160**	-0.191**
	0.021	*0.045*	*0.062*	*0.070*	*0.080*
Initial application scope	0.007	-0.012	-0.002	-0.029	-0.039
	0.012	*0.019*	*0.024*	*0.029*	*0.034*
Diagnostics					
R^2	32.2***	32.2***	32.2***	32.2***	32.2***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.009	-0.003	-0.014	-0.016	-0.031
	0.009	*0.012*	*0.015*	*0.016*	*0.019*
First-action examination time	-0.014***	-0.030***	-0.036***	-0.042***	-0.033**
	0.005	*0.009*	*0.010*	*0.011*	*0.013*
Initial application scope	0.002	0.000	0.004	0.005	0.008
	0.003	*0.004*	*0.005*	*0.005*	*0.007*
Diagnostics					
R^2	32.1***	32.1***	32.1***	32.1***	32.1***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.5. Effects of Scope and Examination Time on Startup Growth: Count of Independent and Dependent Claims.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we measure scope as the count of independent and dependent claims in the patent. All columns report 2SLS, with the instrument for examiner scope leniency suitably redefined. All specifications include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent	-0.001	0.005	0.001	0.015	0.012
and dependent claims	*0.005*	*0.009*	*0.011*	*0.013*	*0.013*
First-action examination time	-0.034**	-0.086***	-0.106***	-0.126***	-0.131***
	0.015	*0.028*	*0.040*	*0.044*	*0.049*
Diagnostics					
Weak-instrument test	17.3***	17.3***	17.3***	17.3***	17.3***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent	0.002	0.018	0.010	0.021	0.005
and dependent claims	*0.007*	*0.013*	*0.016*	*0.019*	*0.021*
First-action examination time	-0.032	-0.090**	-0.124**	-0.177***	-0.204***
	0.022	*0.046*	*0.062*	*0.068*	*0.078*
Diagnostics					
Weak-instrument test	17.3***	17.3***	17.3***	17.3***	17.3***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent	-0.004	0.015	0.002	-0.001	-0.010
and dependent claims	*0.011*	*0.016*	*0.019*	*0.020*	*0.023*
First-action examination time	-0.014***	-0.031***	-0.036***	-0.041***	-0.030**
	0.005	*0.009*	*0.009*	*0.011*	*0.013*
Diagnostics					
Weak-instrument test	18.0***	18.0***	18.0***	18.0***	18.0***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.6. Effects of Scope and Examination Time on Startup Growth: The Kuhn-Thompson Measure.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we use Kuhn and Thompson's (2019) measure of scope, the patent scope z-score within an art-unit based on the count of words in the first claim of a patent. All specifications are estimated by 2SLS using the Kuhn-Thompson measure of examiner scope toughness as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. All specifications include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Patent scope (Kuhn-Thompson Measure)	-0.042	-0.020	-0.101	-0.135	-0.074
	0.039	*0.075*	*0.101*	*0.113*	*0.121*
First-action examination time	-0.046*	-0.097*	-0.118*	-0.157**	-0.152
	0.025	*0.049*	*0.067*	*0.078*	*0.093*
Diagnostics					
Weak-instrument test	49.3***	49.3***	49.3***	49.3***	49.3***
Mean of dep. variable	6.1%	14.6%	20.3%	21.9%	20.5%
No. of observations (firms)	6,318	6,318	6,318	6,318	6,318
Panel B. Sales growth					
Patent scope (Kuhn-Thompson Measure)	-0.032	0.037	-0.047	-0.040	-0.065
	0.058	*0.104*	*0.141*	*0.162*	*0.183*
First-action examination time	-0.032	-0.059	-0.095	-0.172	-0.192
	0.036	*0.076*	*0.105*	*0.123*	*0.140*
Diagnostics					
Weak-instrument test	49.3***	49.3***	49.3***	49.3***	49.3***
Mean of dep. variable	10.6%	23.2%	34.1%	40.2%	42.3%
No. of observations (firms)	6,318	6,318	6,318	6,318	6,318
Panel C. Survival					
Patent scope (Kuhn-Thompson Measure)	-0.001	-0.003	-0.020	-0.042	-0.006
	0.015	*0.023*	*0.027*	*0.031*	*0.033*
First-action examination time	-0.025***	-0.048***	-0.051***	-0.065***	-0.047**
	0.010	*0.016*	*0.017*	*0.020*	*0.023*
Diagnostics					
Weak-instrument test	49.3***	49.3***	49.3***	49.3***	49.3***
Mean of dep. variable	96.6%	93.2%	89.3%	84.8%	79.5%
No. of observations (firms)	6,318	6,318	6,318	6,318	6,318

Table IA.7. Effects of Scope and Examination Time on Growth and Survival.
This table repeats the analysis reported in Table 4, but changing the instrument for patent scope. Panels A and B report the effects of scope and timing of a startup's first granted patent on the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. Panel C reports the results of linear probability models of firm survival. We code a startup as being alive in year *t* if it continues to be included in the NETS database that year. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. All specifications are estimated by 2SLS using claims reduction (the examiner's average percentage difference between the final and initial number of claims in her previous applications) as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.078	-0.077	-0.064	0.044	0.167
	0.062	*0.101*	*0.126*	*0.165*	*0.170*
First-action examination time	-0.033**	-0.083***	-0.104***	-0.121***	-0.129***
	0.015	*0.029*	*0.039*	*0.043*	*0.050*
Diagnostics					
R^2	8.9	8.9	8.9	8.9	8.9
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims	-0.121	-0.087	-0.125	0.103	0.115
	0.090	*0.160*	*0.220*	*0.210*	*0.205*
First-action examination time	-0.029	-0.081*	-0.118*	-0.170**	-0.204***
	0.023	*0.045*	*0.061*	*0.068*	*0.077*
Diagnostics					
R^2	8.9	8.9	8.9	8.9	8.9
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel C. Survival					
Count of independent claims	-0.036*	-0.017	-0.024	-0.028	-0.022
	0.019	*0.022*	*0.027*	*0.031*	*0.034*
First-action examination time	-0.014**	-0.031***	-0.036***	-0.041***	-0.030**
	0.006	*0.009*	*0.010*	*0.011*	*0.013*
Diagnostics					
R^2	8.9	8.9	8.9	8.9	8.9
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.8. Effects of Scope and Examination Time on Growth Including Subclass-Year Fixed Effects.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we include subclass-year fixed effects in addition to the art-unit-by-year and headquarter-state fixed effects. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	0.009	0.030	-0.011	0.017	0.008
	0.026	*0.052*	*0.066*	*0.076*	*0.090*
First-action examination time	-0.056**	-0.134***	-0.136**	-0.156**	-0.186***
	0.024	*0.045*	*0.058*	*0.067*	*0.072*
Diagnostics					
Weak-instrument test	24.0***	24.0***	24.0***	24.0***	24.0***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	9,136	9,136	9,136	9,136	9,136
Panel B. Sales growth					
Count of independent claims	-0.002	0.040	-0.002	0.080	0.044
	0.041	*0.076*	*0.102*	*0.125*	*0.140*
First-action examination time	-0.055	-0.193***	-0.238***	-0.306***	-0.397***
	0.035	*0.068*	*0.091*	*0.110*	*0.124*
Diagnostics					
Weak-instrument test	24.1***	24.1***	24.1***	24.1***	24.1***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	9,136	9,136	9,136	9,136	9,136
Panel C. Survival					
Count of independent claims	0.001	0.004	-0.006	-0.001	-0.023
	0.011	*0.015*	*0.020*	*0.021*	*0.023*
First-action examination time	-0.011	-0.034**	-0.049***	-0.055***	-0.032*
	0.009	*0.014*	*0.015*	*0.016*	*0.019*
Diagnostics					
Weak-instrument test	24.0***	24.0***	24.0***	24.0***	24.0***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	9,136	9,136	9,136	9,136	9,136

Table IA.9. Effects of Scope and Examination Time on Growth Excluding Applications with a Request for Continued Examination.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we exclude any sample applications that rely upon a request for continued examination (RCE) in their review. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.007	0.033	0.022	0.056	0.065
	0.019	*0.032*	*0.039*	*0.050*	*0.054*
First-action examination time	-0.026	-0.083**	-0.096**	-0.103*	-0.124**
	0.017	*0.033*	*0.046*	*0.054*	*0.059*
Diagnostics					
Weak-instrument test	44.1***	44.1***	44.1***	44.1***	44.1***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	9,965	9,965	9,965	9,965	9,965
Panel B. Sales growth					
Count of independent claims	0.004	0.059	0.041	0.087	0.086
	0.032	*0.052*	*0.065*	*0.075*	*0.084*
First-action examination time	-0.023	-0.081	-0.086	-0.142*	-0.169*
	0.028	*0.054*	*0.071*	*0.083*	*0.093*
Diagnostics					
Weak-instrument test	43.9***	43.9***	43.9***	43.9***	43.9***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	9,965	9,965	9,965	9,965	9,965
Panel C. Survival					
Count of independent claims	-0.004	0.005	-0.006	-0.009	-0.018
	0.007	*0.010*	*0.012*	*0.013*	*0.015*
First-action examination time	-0.013**	-0.036***	-0.037***	-0.045***	-0.033**
	0.006	*0.011*	*0.012*	*0.014*	*0.017*
Diagnostics					
Weak-instrument test	44.1***	44.1***	44.1***	44.1***	44.1***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	9,965	9,965	9,965	9,965	9,965

Table IA.10. Effects of Scope and Examination Time on Growth Excluding Applications that are Continuations of Previously Submitted Applications.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we exclude any sample applications that are continuations of a previously submitted application. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.017	0.000	-0.021	0.032	0.049
	0.022	*0.036*	*0.045*	*0.055*	*0.064*
First-action examination time	-0.039**	-0.096***	-0.129***	-0.155***	-0.151***
	0.017	*0.031*	*0.043*	*0.048*	*0.053*
Diagnostics					
Weak-instrument test	38.2***	38.2***	38.2***	38.2***	38.2***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	11,884	11,884	11,884	11,884	11,884
Panel B. Sales growth					
Count of independent claims	-0.001	0.042	0.023	0.087	0.092
	0.034	*0.055*	*0.069*	*0.081*	*0.095*
First-action examination time	-0.032	-0.117**	-0.176***	-0.246***	-0.273***
	0.025	*0.048*	*0.065*	*0.075*	*0.084*
Diagnostics					
Weak-instrument test	38.2***	38.2***	38.2***	38.2***	38.2***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	11,884	11,884	11,884	11,884	11,884
Panel C. Survival					
Count of independent claims	-0.007	-0.001	-0.007	-0.010	-0.023
	0.008	*0.010*	*0.013*	*0.015*	*0.017*
First-action examination time	-0.016***	-0.033***	-0.043***	-0.051***	-0.043***
	0.006	*0.010*	*0.011*	*0.012*	*0.014*
Diagnostics					
Weak-instrument test	38.2***	38.2***	38.2***	38.2***	38.2***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	11,884	11,884	11,884	11,884	11,884

Table IA.11. Effects of Scope and Examination Time on Growth Including Rejected Applications Spawning a Continuation.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we include observations for firms whose initial application was rejected but spawned a continuation, continuation-in-part, or divisional application that was reviewed by the same examiner and eventually granted. The first-action examination time in this model refers to the first-action time of the first application. The scope is measured using the ultimately granted continuation. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.009	0.015	0.000	0.055	0.082
	0.019	*0.031*	*0.039*	*0.049*	*0.056*
First-action examination time	-0.037***	-0.089***	-0.105***	-0.123***	-0.132***
	0.014	*0.027*	*0.038*	*0.042*	*0.047*
Diagnostics					
Weak-instrument test	37.8***	37.8***	37.8***	37.8***	37.8***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	14,001	14,001	14,001	14,001	14,001
Panel B. Sales growth					
Count of independent claims	-0.006	0.046	0.024	0.101	0.127
	0.029	*0.048*	*0.060*	*0.073*	*0.087*
First-action examination time	-0.033	-0.092**	-0.127**	-0.183***	-0.218***
	0.021	*0.044*	*0.060*	*0.068*	*0.077*
Diagnostics					
Weak-instrument test	37.8***	37.8***	37.8***	37.8***	37.8***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	14,001	14,001	14,001	14,001	14,001
Panel C. Survival					
Count of independent claims	-0.009	-0.004	-0.012	-0.014	-0.025
	0.007	*0.010*	*0.013*	*0.014*	*0.016*
First-action examination time	-0.014***	-0.030***	-0.036***	-0.040***	-0.031**
	0.005	*0.009*	*0.009*	*0.011*	*0.012*
Diagnostics					
Weak-instrument test	37.8***	37.8***	37.8***	37.8***	37.8***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	14,001	14,001	14,001	14,001	14,001

Table IA.12. Effects of Scope and Examination Time on Growth Excluding Continuations in the Instrument Construction.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we modify the scope and timing instruments to exclude any applications reviewed by an examiner that are continuations, continuations-in-part, or divisionals. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.022	0.013	-0.023	0.045	0.053
	0.021	*0.033*	*0.044*	*0.053*	*0.061*
First-action examination time	-0.037**	-0.079***	-0.098**	-0.113**	-0.118**
	0.015	*0.028*	*0.039*	*0.044*	*0.049*
Diagnostics					
Weak-instrument test	31.6***	31.6***	31.6***	31.6***	31.6***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,281	13,281	13,281	13,281	13,281
Panel B. Sales growth					
Count of independent claims	-0.024	0.027	-0.010	0.060	0.068
	0.031	*0.051*	*0.065*	*0.081*	*0.097*
First-action examination time	-0.034	-0.079*	-0.116*	-0.166**	-0.202***
	0.022	*0.045*	*0.060*	*0.069*	*0.077*
Diagnostics					
Weak-instrument test	31.6***	31.6***	31.6***	31.6***	31.6***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,281	13,281	13,281	13,281	13,281
Panel C. Survival					
Count of independent claims	-0.017**	-0.011	-0.023	-0.029*	-0.043**
	0.008	*0.011*	*0.014*	*0.015*	*0.018*
First-action examination time	-0.016***	-0.033***	-0.037***	-0.043***	-0.034***
	0.006	*0.009*	*0.010*	*0.011*	*0.013*
Diagnostics					
Weak-instrument test	31.6***	31.6***	31.6***	31.6***	31.6***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,281	13,281	13,281	13,281	13,281

Table IA.13. Effects of Scope and Examination Time on Growth Excluding Applications with Accelerated Review.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we exclude any sample applications that have a "make special" designation and received an accelerated review. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.012	0.012	-0.006	0.055	0.077
	0.019	*0.031*	*0.039*	*0.049*	*0.056*
First-action examination time	-0.033**	-0.081***	-0.101***	-0.116***	-0.123**
	0.014	*0.028*	*0.039*	*0.043*	*0.049*
Diagnostics					
Weak-instrument test	37.4***	37.4***	37.4***	37.4***	37.4***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,595	13,595	13,595	13,595	13,595
Panel B. Sales growth					
Count of independent claims	-0.006	0.045	0.020	0.106	0.124
	0.030	*0.048*	*0.061*	*0.073*	*0.087*
First-action examination time	-0.030	-0.081*	-0.118*	-0.169**	-0.206***
	0.021	*0.044*	*0.061*	*0.068*	*0.077*
Diagnostics					
Weak-instrument test	37.3***	37.3***	37.3***	37.3***	37.3***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,595	13,595	13,595	13,595	13,595
Panel C. Survival					
Count of independent claims	-0.008	-0.003	-0.012	-0.014	-0.027*
	0.007	*0.010*	*0.012*	*0.014*	*0.016*
First-action examination time	-0.014***	-0.031***	-0.036***	-0.042***	-0.030**
	0.005	*0.009*	*0.009*	*0.011*	*0.013*
Diagnostics					
Weak-instrument test	37.4***	37.4***	37.4***	37.4***	37.4***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	13,595	13,595	13,595	13,595	13,595

Table IA.14. Effects of Scope and Examination Time on Growth Excluding Applications Submitted at the EPO or JPO.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we exclude any sample applications that also were submitted at the EPO or JPO. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	-0.040	-0.020	-0.044	0.011	0.023
	0.026	*0.045*	*0.054*	*0.067*	*0.074*
First-action examination time	-0.037**	-0.097***	-0.112**	-0.135***	-0.125**
	0.016	*0.033*	*0.045*	*0.051*	*0.056*
Diagnostics					
Weak-instrument test	29.5***	29.5***	29.5***	29.5***	29.5***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	10,382	10,382	10,382	10,382	10,382
Panel B. Sales growth					
Count of independent claims	-0.039	-0.015	-0.029	0.109	0.067
	0.044	*0.070*	*0.091*	*0.099*	*0.114*
First-action examination time	-0.033	-0.129**	-0.166**	-0.207**	-0.239***
	0.024	*0.050*	*0.068*	*0.081*	*0.089*
Diagnostics					
Weak-instrument test	29.5***	29.5***	29.5***	29.5***	29.5***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	10,382	10,382	10,382	10,382	10,382
Panel C. Survival					
Count of independent claims	-0.017	-0.018	-0.017	-0.017	-0.030
	0.011	*0.015*	*0.019*	*0.020*	*0.023*
First-action examination time	-0.014*	-0.032***	-0.037***	-0.042***	-0.021
	0.007	*0.011*	*0.012*	*0.014*	*0.015*
Diagnostics					
Weak-instrument test	29.5***	29.5***	29.5***	29.5***	29.5***
Mean of dep. variable	96.9%	93.5%	89.4%	85.3%	80.5%
No. of observations (firms)	10,382	10,382	10,382	10,382	10,382

Table IA.15. Effects of Scope and Examination Time on Growth for Imputed and Non-Imputed Growth.
The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we interact the measures of scope and timing as well as the instruments for scope and timing with an indicator set equal to one if either the initial or ending value of sales or employment taken from the NETS data is imputed for any establishment within the firm. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims and not imputed growth	-0.012	0.014	-0.005	0.051	0.059
	0.019	*0.031*	*0.039*	*0.048*	*0.055*
Count of independent claims and imputed growth	-0.011	0.012	-0.004	0.063	0.106*
	0.021	*0.034*	*0.044*	*0.054*	*0.060*
First-action examination time and not imputed growth	-0.036**	-0.091***	-0.116***	-0.128***	-0.123***
	0.014	*0.027*	*0.039*	*0.043*	*0.046*
First-action examination time and imputed growth	-0.031	-0.066*	-0.077	-0.097	-0.119*
	0.020	*0.039*	*0.054*	*0.062*	*0.071*
Diagnostics					
Weak-instrument test	19.1***	19.1***	19.2***	19.1***	19.2***
Mean of dep. variable	6.4%	14.8%	19.6%	22.0%	21.1%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671
Panel B. Sales growth					
Count of independent claims and not imputed growth	0.023	0.094*	0.098	0.214**	0.165
	0.033	*0.056*	*0.075*	*0.093*	*0.105*
Count of independent claims and imputed growth	-0.008	0.040	0.015	0.099	0.118
	0.030	*0.049*	*0.061*	*0.073*	*0.087*
First-action examination time and not imputed growth	-0.052*	-0.128**	-0.243***	-0.349***	-0.341***
	0.031	*0.062*	*0.082*	*0.093*	*0.100*
First-action examination time and imputed growth	-0.026	-0.076	-0.103	-0.146**	-0.181**
	0.023	*0.046*	*0.064*	*0.071*	*0.080*
Diagnostics					
Weak-instrument test	18.5***	18.6***	18.8***	18.4***	18.5***
Mean of dep. variable	11.0%	24.4%	34.4%	41.4%	44.4%
No. of observations (firms)	13,671	13,671	13,671	13,671	13,671

Table IA.16. Effects of Scope and Examination Time on Startup Access to VC Funding and the IPO Market: OLS Results.
The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affects the startup's ability to raise funding from a VC or in the IPO market. The analysis here is analogous to Table 7, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Following the first-action decision on its first patent application, does the startup …					
	raise VC funding in the next 1 year?	raise VC funding in the next 2 years?	raise VC funding in the next 3 years?	raise VC funding in the next 4 years?	raise VC funding in the next 5 years?	raise capital in the IPO market?
	(1)	(2)	(3)	(4)	(5)	(6)
Count of independent claims	-0.001	0.000	0.000	0.000	0.001	0.000
	0.001	*0.001*	*0.001*	*0.001*	*0.001*	*0.000*
First-action examination time	-0.012***	-0.016***	-0.018***	-0.020***	-0.020***	-0.003***
	0.002	*0.003*	*0.003*	*0.003*	*0.003*	*0.001*
Log (1 + no. prior VC rounds)	0.283***	0.397***	0.437***	0.449***	0.456***	0.041***
	0.010	*0.011*	*0.010*	*0.011*	*0.011*	*0.005*
Diagnostics						
R^2	39.5%	48.3%	50.9%	50.9%	50.8%	19.3%
Mean of dep. variable	4.6%	6.8%	7.6%	8.2%	8.5%	0.79%
No. of observations (firms)	21,483	21,440	21,399	21,372	21,353	21,518

Table IA.17. Effects of Scope and Examination Time on Follow-on Innovation: OLS Results.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's first granted patent affects the startup's follow-on innovation. The analysis here is analogous to Table 6, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Follow-on innovation				
	Log (1 + subsequent patent applications) (1)	Log (1 + subsequent approved patents) (2)	Approval rate of subsequent patent applications (3)	Log (1 + total citations to subsequent patent applications) (4)	Log (1 + avg. citations-per-patent to subsequent patent applications) (5)
Count of independent claims	0.017***	0.016***	0.007***	0.029***	0.015***
	0.004	*0.004*	*0.001*	*0.006*	*0.003*
First-action examination time	-0.128***	-0.109***	-0.032***	-0.163***	-0.062***
	0.014	*0.012*	*0.005*	*0.020*	*0.010*
Diagnostics					
R^2	24.5%	23.6%	13.9%	25.6%	22.1%
Mean of non-logged dep. var.	3.8	2.6	34.6%	19.9	1.5
No. of observations (firms)	21,061	21,061	21,061	20,545	20,545

Table IA.18. Effects of Examination Time of a Rejected Patent Application on Startup Growth.

Panels A and B report the results of estimating eq. (1) to examine how the timing of a rejection of a startup's first patent application affects the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. For startups that die, we set the growth rate to –100% in the year of exit. The variable of interest in each panel is the first-action examination time for a rejected patent application. Panel A controls for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All specifications are estimated by 2SLS using examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. The sample is restricted to firms for which NETS reports non-zero sales and employment for the year of the first-action decision. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
First-action examination time	-0.053*	-0.060	-0.044	-0.051	-0.015
	0.028	*0.047*	*0.058*	*0.067*	*0.073*
Diagnostics					
Weak-instrument test	389.2***	389.2***	389.2***	389.2***	389.2***
Mean of dep. variable	0.0%	1.3%	2.5%	-1.8%	-5.4%
No. of observations (firms)	6,667	6,667	6,667	6,667	6,667
Panel B. Sales growth					
First-action examination time	-0.056	-0.064	-0.079	-0.125	-0.065
	0.036	*0.065*	*0.094*	*0.105*	*0.109*
Diagnostics					
Weak-instrument test	390.4***	390.4***	390.4***	390.4***	390.4***
Mean of dep. variable	2.3%	7.1%	11.4%	10.9%	10.3%
No. of observations (firms)	6,667	6,667	6,667	6,667	6,667
Panel C. Survival					
First-action examination time	-0.043***	-0.040**	-0.033	-0.057**	-0.043*
	0.015	*0.019*	*0.021*	*0.025*	*0.025*
Diagnostics					
Weak-instrument test	389.2***	389.2***	389.2***	389.2***	389.2***
Mean of dep. variable	93.9%	87.7%	82.2%	75.8%	69.6%
No. of observations (firms)	6,667	6,667	6,667	6,667	6,667

Table IA.19. Effects of Examination Time of a Rejected Patent Application on Access to VC Funding and the IPO Market.
The table reports the results of estimating eq. (1) to examine how timing of the rejection of a startup's first patent application grant affects the startup's ability to raise funding from a VC or in the IPO market. The dependent variable in columns 1 through 5 is an indicator set equal to one if the startup raises VC funding at some point in the 1…5 years following the first-action decision, respectively. The dependent variable in column 6 is an indicator set equal to one if the startup goes public after the first-action decision on its first patent application, and zero otherwise. All specifications are estimated by 2SLS using examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Following the first-action decision on its first patent application, does the startup …					
	raise VC funding in the next 1 year?	raise VC funding in the next 2 years?	raise VC funding in the next 3 years?	raise VC funding in the next 4 years?	raise VC funding in the next 5 years?	raise capital in the IPO market?
	(1)	(2)	(3)	(4)	(5)	(6)
First-action examination time	0.003	-0.003	-0.007	-0.010	-0.011	-0.005**
	0.006	*0.006*	*0.006*	*0.007*	*0.007*	*0.002*
Log (1 + no. prior VC rounds)	0.217***	0.295***	0.315***	0.320***	0.323***	0.027***
	0.013	*0.014*	*0.014*	*0.014*	*0.014*	*0.006*
Diagnostics						
Weak-instrument test	505.6***	511.1***	511.6***	510.0***	508.7***	516.1***
Mean of dep. variable	3.4%	4.8%	5.4%	5.7%	5.9%	0.47%
No. of observations (firms)	11,613	11,600	11,590	11,581	11,571	11,235

Table IA.20. Effects of Examination Time of a Rejected Patent Application on Follow-on Innovation.

The table reports the results of estimating eq. (1) to examine how timing of a rejection of a startup's first patent application affects the startup's follow-on innovation. Data on subsequent applications come from the PTO internal databases and include all applications that receive a final decision through December 31, 2016. Column 3 includes only startups filing at least one patent application after the first-action decision on the startup's first patent application and for which we can measure the approval rate of subsequent applications. Column 5 includes only those startups with at least one subsequent patent approval and for which we can measure the average number of citations-per-patent to subsequently approved patents. We measure citations over the five years following each patent application's public disclosure date, which is typically 18 months after the application's filing date. All specifications are estimated by 2SLS using examiner review speed plus the application-specific time between application date and docket date as an instrument for first-action examination time; they include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Follow-on innovation				
	Log (1 + subsequent patent applications) (1)	Log (1 + subsequent approved patents) (2)	Approval rate of subsequent patent applications (3)	Log (1 + total citations to subsequent patent applications) (4)	Log (1 + avg. citations-per-patent to subsequent patent applications) (5)
First-action examination time	-0.120***	-0.084***	-0.038***	-0.158***	-0.080***
	0.024	*0.018*	*0.010*	*0.033*	*0.020*
Diagnostics					
Weak-instrument test	521.1***	521.1***	521.1***	518.9***	518.9***
Mean of non-logged dep. var.	1.4	0.8	12.0%	6.5	0.6
No. of observations (firms)	11,235	11,235	11,235	11,183	11,183

Table IA.21. Effects of Scope and Examination Time in a Second Patent Application on Startup Growth.

The table reports the results of estimating eq. (1) to examine how the scope and timing of a startup's second patent application affect the startup's subsequent growth in employment and sales, respectively, over the one to five years following the first-action date. The analysis here is analogous to Table 4, except that we focus on a startup's second patent application. All specifications are estimated by 2SLS using examiner scope leniency as an instrument for patent scope and examiner review speed plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. All specifications include art-unit-by-year and headquarter-state fixed effects. For variable definitions and details of their construction see the Appendix. The weak-instrument test uses the Kleibergen-Paap *rk* Wald *F* statistic. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	0.027	0.043	0.068	0.042	0.051
	0.029	*0.047*	*0.068*	*0.085*	*0.095*
First-action examination time	-0.039*	-0.073*	-0.077	-0.107*	-0.075
	0.023	*0.040*	*0.047*	*0.055*	*0.056*
Diagnostics					
Weak-instrument test	30.8***	30.8***	30.8***	30.8***	30.8***
Mean of dep. variable	7.9%	16.0%	21.0%	22.0%	19.4%
No. of observations (firms)	5,682	5,682	5,682	5,682	5,682
Panel B. Sales growth					
Count of independent claims	0.113**	0.142*	0.143	0.236*	0.202
	0.054	*0.080*	*0.114*	*0.136*	*0.145*
First-action examination time	-0.065**	-0.118**	-0.123*	-0.152*	-0.119
	0.031	*0.056*	*0.074*	*0.083*	*0.094*
Diagnostics					
Weak-instrument test	31.1***	31.1***	31.1***	31.1***	31.1***
Mean of dep. variable	14.2%	29.6%	42.1%	46.6%	51.1%
No. of observations (firms)	5,682	5,682	5,682	5,682	5,682
Panel C. Survival					
Count of independent claims	0.024**	0.009	0.010	-0.006	-0.011
	0.011	*0.014*	*0.017*	*0.021*	*0.025*
First-action examination time	-0.015*	-0.030***	-0.026**	-0.030**	-0.029*
	0.007	*0.010*	*0.012*	*0.014*	*0.015*
Diagnostics					
Weak-instrument test	30.8***	30.8***	30.8***	30.8***	30.8***
Mean of dep. variable	96.4%	92.0%	87.8%	82.7%	77.1%
No. of observations (firms)	5,682	5,682	5,682	5,682	5,682

Table IA.22. Effects of Scope and Examination Time on Industry Growth and Survival: OLS Results.

Panels A and B report the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect subsequent growth in employment and sales in its industry over the one to five years following the focal startup's first-action date. Panel C reports the fraction of startups in the industry that survive. The analysis here is analogous to Table 8, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
Panel A. Employment growth					
Count of independent claims	0.000	0.002	0.004**	0.006**	0.006**
	0.001	*0.001*	*0.002*	*0.003*	*0.003*
First-action examination time	-0.015***	-0.034***	-0.045***	-0.049***	-0.057***
	0.004	*0.006*	*0.009*	*0.011*	*0.013*
Diagnostics					
R^2	37.2%	46.0%	52.0%	54.0%	55.9%
Mean of dep. variable	4.7%	9.1%	12.5%	15.4%	16.8%
No. of observations (firms)	15,826	15,826	15,826	15,826	15,826
Panel B. Sales growth					
Count of independent claims	0.000	0.003*	0.004*	0.006*	0.005
	0.001	*0.002*	*0.002*	*0.003*	*0.004*
First-action examination time	-0.029***	-0.058***	-0.075***	-0.087***	-0.078***
	0.005	*0.008*	*0.011*	*0.014*	*0.018*
Diagnostics					
R^2	37.4%	47.5%	52.7%	52.8%	55.6%
Mean of dep. variable	6.5%	12.6%	17.8%	22.5%	25.0%
No. of observations (firms)	15,826	15,826	15,826	15,826	15,826
Panel C. Survival					
Count of independent claims	0.0001	0.0005*	0.0005	0.0003	0.0005
	0.0002	*0.0003*	*0.0003*	*0.0003*	*0.0003*
First-action examination time	-0.0086***	-0.0169***	-0.0233***	-0.0299***	-0.0335***
	0.0008	*0.0011*	*0.0013*	*0.0014*	*0.0015*
Diagnostics					
R^2	47.9%	55.5%	61.5%	65.7%	68.8%
Mean of dep. variable	96.5%	92.7%	88.8%	84.6%	80.1%
No. of observations (firms)	15,826	15,826	15,826	15,826	15,826

Table IA.23. Effects of Scope and Examination Time on Access to VC Funding and the IPO Market in the Industry. OLS Results

The table reports the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect the ability of other startups in the same industry to raise funding from a VC or in the IPO market. The analysis here is analogous to Table 9, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Following the first-action decision on its first patent application, does the startup …					
	raise VC funding in the next 1 year?	raise VC funding in the next 2 years?	raise VC funding in the next 3 years?	raise VC funding in the next 4 years?	raise VC funding in the next 5 years?	raise capital in the IPO market?
	(1)	(2)	(3)	(4)	(5)	(6)
Count of independent claims	0.0000	-0.0001	-0.0002	-0.0004*	-0.0003*	0.0000
	0.0002	*0.0002*	*0.0002*	*0.0002*	*0.0002*	*0.0000*
First-action examination time	0.0001	-0.0011*	-0.0023***	-0.0039***	-0.0056***	-0.0004***
	0.0005	*0.0006*	*0.0006*	*0.0006*	*0.0006*	*0.0001*
Diagnostics						
R^2	62.7%	68.4%	72.3%	76.3%	77.4%	82.8%
Mean of dep. variable	3.3%	5.0%	6.0%	6.7%	7.2%	0.61%
No. of observations (firms)	15,887	15,887	15,887	15,887	15,887	15,887

Table IA.24. Effects of Scope and Examination Time on Follow-on Innovation in the Industry. OLS Results

The table reports the results of estimating a revised version of eq. (1) to examine how the scope and timing of a startup's first granted patent affect the ability of other startups in the same industry to innovate. The analysis here is analogous to Table 10, except that we use OLS instead of 2SLS. For variable definitions and details of their construction see the Appendix. Heteroskedasticity-consistent standard errors clustered at the art unit level are shown in italics underneath the coefficient estimates. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level, respectively.

	Follow-on innovation				
	Log (1 + subsequent patent applications) (1)	Log (1 + subsequent approved patents) (2)	Approval rate of subsequent patent applications (3)	Log (1 + total citations to subsequent patent applications) (4)	Log (1 + avg. citations-per-patent to subsequent patent applications) (5)
Count of independent claims	-0.002	-0.001	0.001*	-0.003	-0.001
	0.001	*0.001*	*0.000*	*0.002*	*0.001*
First-action examination time	-0.174***	-0.172***	0.000	-0.152***	0.017***
	0.006	*0.006*	*0.002*	*0.010*	*0.005*
Diagnostics					
R^2	97.7%	97.3%	76.3%	96.3%	89.6%
Mean of non-logged dep. var.	207.6	128.5	62.6%	1,040.4	4.0
No. of observations (firms)	8,902	8,902	8,902	8,204	8,204