Quick and Dirty Patents

Deepak Hegde[†]
New York University

Alexander Ljungqvist
Stockholm School of Economics,
Swedish House of Finance,
and CEPR

Manav Raj
New York University

January 5, 2020

Abstract

The scope and timing of patents determine the size of economic rewards to inventors. We provide causal evidence on the effects of scope and timing on startups and externalities on their rivals, by leveraging the quasi-random assignment of patent applications to examiners. Using unique data on all first-time applications filed at the U.S. Patent and Trademark Office since 2001, we find that patent grant delays are harmful to the inventor, in terms of reduced growth in employment and sales and a reduced quantity and quality of follow-on innovation. In addition, delays are harmful to both the inventor and its rivals in terms of access to external capital. Broader scope, on the other hand, tends to benefit the inventor while harming rivals, in terms of follow-on innovation. Our findings suggest that quick and dirty, rather than slow and thorough, patents maximize both inventor rewards and positive externalities to rivals.

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

JEL Classification: D23, G24, L26, O34

[†] Author addresses: dhegde@stern.nyu.edu. alexander.ljungqvist@hhs.se, and mraj@stern.nyu.edu.

Patent systems reward inventors with monopoly rights over their inventions. 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 downstream inventors. In prosecuting their patent applications, inventors face a tradeoff between scope and timing: the patent examination process is often characterized as a negotiation, with inventors holding out for broad patents and patent examiners seeking to narrow down claims, forcing inventors to choose between quick and broad patents (Cohen and Lemley 2001, Marco et al. 2019). Figure 1 illustrates this tradeoff with data on successful U.S. patent applications by startups granted between 2001 and 2013: patents that issue with a larger number of claims (the most commonly used measure of scope) take longer to issue. Not surprisingly, then, economists and policymakers have focused on timing and breadth as the most important determinants of patent value (Gilbert and Shapiro 1990, Klemperer 1990, Chang 1995).

Despite the importance of patent timing and scope, most empirical studies treat patenting as a binary outcome (e.g., Hsu and Ziedonis 2013, Galasso and Schankerman 2015, Sampat and Williams 2019, Kline et al. 2019, Farre□Mensa et al. 2019). Further, despite the close relation between patent timing and scope evident in Figure 1, what little existing empirical work there is on timing and scope studies their effects in isolation (Kuhn and Thompson 2019, Lerner 1994, Lerner and Merges 1997). Finally, no work that we are aware of considers the externality effects of timing and scope. As a result, we know little about the causal effects on patent holders and their rivals of the two most fundamental levers of the patent system.

[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.

How do patent timing and scope affect the value of patents to their holders on the one hand and their rivals on the other? We answer these questions by estimating the value of faster and broader patents for U.S. startups that filed their first patent applications after 2001 and received a final decision by December 31, 2013. Focusing on a startup's first patent application offers several conceptual and practical advantages. Most importantly, this focus allows us to assess the value of timing and scope on a subset of applicants for whom patents, and their characteristics, may be most salient (Farre□Mensa et al. 2019). 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 filed applications.

Estimating the effects of patent timing and scope is empirically challenging. Consider patent scope. 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 (USPTO) 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, and 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

approval 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 USPTO. First, the USPTO 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 approval to study the effects of patent grant on startup growth (Farre□Mensa et al. 2019), 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 examination speeds and their leniency with regards to patent scope.

We utilize a rich data set that combines data from the USPTO's internal databases, which cover the population of granted and rejected applications,[2] with data on firm-level outcomes from a variety of sources. We assemble data on four types of firm-level outcomes: (i) growth in sales and employment (from Dun & Bradstreet's National Establishment Time Series or NETS database); (ii) follow-on patenting and patent citations (from the USPTO's patent 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 34,215 first-time patent applications filed by U.S. startups at the USPTO since 2001 that received a final decision by December 31, 2013. For our main results considering the effects of patent scope and evaluation timing on granted patents, we focus on the 22,050 of these patent applications that are ultimately granted.

[2] Access to the USPTO's internal databases was granted to one of the authors through the agency's Thomas Alva Edison Scholars program.

Our estimates suggest that patent grant delays have a large and significant negative effect on startup growth, with a one-year increase in examination time reducing the average startup's employment growth and sales growth by 25.8 and 39.9 percentage points over five years, respectively. For the median startup in our sample, these estimates imply that an exogenous one-year increase in examination time results in 5.8 fewer person-years of employment and a cumulative loss in sales of $860,000 over five years. A one-year increase in examination time also reduces the likelihood of raising venture capital funding by one-sixth over the next five years and the likelihood of raising capital via an IPO on the stock market by a striking three-quarters.

In contrast, patent scope has no meaningful effect on startup performance as measured by sales growth, employment growth, or the likelihood of raising VC funding, though it does increase the likelihood of the startup subsequently raising IPO capital: each granted claim increases the likelihood of an IPO by 0.2 percentage points, equivalent to a 25.3% increase relative to the unconditional sample mean.

We find that both broader scope and speedier examination spur follow-on innovation. Startups that receive broader patents subsequently innovate more and produce higher-quality inventions. An additional granted claim in its first patent application leads to a 2.6% increase in the number of patents a startup subsequently applies for, a 2.2% increase in the number of patents it is subsequently granted, a 3.1% increase in the total number of citations to subsequent patents, and a 2.1% increase in per-patent citations to subsequent patents. Patent grant delays have a negative effect on follow-on innovation. A one-year increase in examination time reduces the number of subsequent patent applications and granted patents by 14.9% and 14.8%, respectively, the approval rate of subsequent applications by 3.5 percentage points, and the

number of citations to subsequent patents by 22.3% in total and by 9.5% on average. The negative effects of delays on performance extend to a startup's second patent.[3]

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 technological area and thus can plausibly be considered rivals. We find evidence that broader scope imposes negative externalities on both the quantity and quality of rivals' follow-on innovation: broader patents granted to a focal startup result in reductions in the number of patents its rivals receive, their approval rate, and their future citations. Timely examination, on the other hand, imposes positive externalities on rivals: the faster a startup's application is reviewed, the greater their chance of raising VC funding for other startups in the same industry. These positive externalities are large: a one-year reduction in examination time for the focal startup increases the likelihood that a rival obtains VC funding in the next five years by 7.9%.

Our study makes the following contributions to the literatures on innovation policy and entrepreneurship. We provide the first causal estimates of the effects of two key determinants of patent value: timing and scope. 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. Since scope has a positive effect on measures of performance in some of our OLS estimates (but not once we instrument it), it is possible that Lerner's findings capture the positive effects of not only patent scope but also the breadth of the underlying technology. Our identification strategy disentangles the two and shows that the positive effect of scope (in our sample) is limited to the patent-holder's follow-on innovation and

[3] Longer waits in ultimately rejected patent applications also have a negative effect on follow-on innovation, though not on growth.

the likelihood that a startup pursues an IPO, while hurting the startup's industry rivals.

Timeliness of patent grant, which has received little attention from scholars, has substantial positive effects on both the applicant and the applicant's industry. Patent policy is typically characterized as striking a fine balance between rewarding inventors and limiting the negative externalities of exclusionary rights. Our results suggest that speedy patent grants (or "quick and dirty" patents) unambiguously improve inventor rewards and may also increase overall industry welfare, through at least two mechanisms: by conferring a longer stream of monopoly rents on the holder (since patents are valid for a maximum of 20 years from the application date but can only be effectively enforced after grant), and by allowing the holder to gain a competitive edge over rivals as modeled in the "patent race" literature (Reinganum 1982, Gilbert and Newbery 1982, Fudenberg et al. 1983). Our finding that timely grants are particularly valuable to information-technology startups, whose products often become obsolete well before the end of the 20-year patent term, suggests that delays hamper growth at least in part through a competition channel.

Finally, our identification strategy, based on quasi-random assignment of applications to patent examiners of varying propensities with respect to speed and leniency, highlights the profound impact the luck of the draw can have in determining startups' fortunes through the characteristics of their patent rights. Relatedly, previous empirical tests of the Schumpeterian hypothesis linking innovation to economic growth report large positive effects of patented inventions on firm growth and productivity (Kogan et al. 2017). Our findings raise the possibility that at least some of these positive effects are shaped by the characteristics of patent rights rather than of the underlying inventions.

I. Institutional setting and data

A. The patent examination process

Upon receipt of a patent application, the USPTO assigns the application to the relevant "art unit" for review. An art unit is a working unit responsible for a cluster of related patent applications. Each art unit consists of a set of patent examiners who specialize in the same narrowly defined technology field. During our sample period, the USPTO 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 below, the assignment of an application to 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 USPTO's internal research databases, which contain

records of all patent applications, both approved and rejected, from 1976 to the present.[4] Our sample starts in 2001, though we use data from previous years in the construction of our instruments for patent scope and examination time.

Because the USPTO does not tag whether an applicant is a startup, we follow Farre-Mensa, Hegde, and Ljungqvist (2019) and code startups as follows. First, we restrict the sample to applications submitted by incorporated applicants based in the United States. Second, we remove not-for-profit organizations such as universities, government research labs, or charities. Third, we manually screen out applicants that are or have been listed on a stock market at the time of the application, are a subsidiary of another firm at the time of the application, or 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). These steps leave us with a set of patent applications filed by stand-alone for-profit U.S.-based firms.

Not all these firms are startups. We apply two further filters to obtain our sample of startups. First, we only include filers that qualify and obtain reduced fees at the USPTO by satisfying the criteria defining a "small business entity" under Section 3 of the Small Business Act. Second, we only include applicants without a history of patenting by screening for firms that have filed at least one application on or after January 1, 2001 and no applications in the previous 25 years. This step requires identifying each patent's original applicant (since a large number of patents are reassigned over time) and also requires us to standardize applicant names and account for name changes. Because scope is a feature of a *granted* patent, we focus on applicants whose first patent application was approved.

[4] Unlike the internal databases we have access to, the USPTO'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.

Our analysis focuses on how scope and timing affect a startup's ability to grow, fundraise, and innovate over the long-term. Accordingly, we require a sufficient amount of time from the evaluation of an application to measure firm outcomes. Given the limitations on our firm-level growth data described below, we require firms to receive a first-action decision on their first application by the end of 2009 and a final decision by the end of 2013.[5]

Our final sample consists of 22,050 first-time patent applicants (hereafter referred to as startups). Of these, 33.8% operate in the electronics, computers, and communications industries (hereafter, IT); 16.9% are active in the pharmaceutical and biochemical sectors (hereafter, biochemistry); and the remaining 49.3% operate in "other" industries including transportation, construction, mechanical engineering, and manufacturing.

C. Timing considerations

Firm outcomes could be measured from three different starting points: the application filing date, the first-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 a startup's application.[6] After first-action, the applicant can take actions that endogenously affect the remaining time it takes the examiner to come to a final determination.[7] Resolution of uncertainty is a necessary but not sufficient condition for a patent application to affect firm outcomes, while the endogenous timing of the final approval decision could confound our estimates.

[5] The "first application" is classified as the first application the USPTO rules on. In 8% of cases, the first ruling a firm receives is not for its first application submitted to the USPTO, but for a later one.
[6] 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 USPTO to the applicant regarding the merits of an application, there can be no resolution of uncertainty before the first-action date.
[7] In particular, the length of time it takes the applicant to respond to concerns raised by the examiner is likely endogenous to the applicant's resources and may reflect its private information regarding the value of greater scope and a faster decision.

D. Measuring scope and examination time

To measure the scope of a patent, we count the number of claims in a granted patent. The intellectual property protected by a patent is defined by a set of claims made in the patent application. The broadest of these claims are referred to as "independent claims." Independent claims 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. Following previous literature, we measure scope using the total number of claims in a granted patent application (Lanjouw and Schankerman 1997, 2004, Mann and Underweiser 2012). In robustness tests, we consider alternative measures based on the independent claim count in a granted patent (Marco et al. 2019) and Kuhn and Thompson's (2019) measure constructed using the word count of a patent's first claim.

To measure examination time, we use the time from application filing date to first-action date. As mentioned earlier, timing delays past the first-action date are inherently endogenous, as applicants' actions in response to the first-action letter will 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.

- *Dun and Bradstreet's National Establishment Time Series (NETS) database.* NETS is similar to the U.S. Census Bureau's Longitudinal Business Database (LBD) 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. Our version of the NETS data end in December 2011 and is

prohibitively expensive to extend. To match patent assignees to NETS, we utilize a "fuzzy" matching algorithm (with each potential match manually verified) based on firm names and locations, in conjunction with information on name changes and location moves obtained from Capital IQ and the USPTO's firm name and address register. We match 80.01% of sample startups to firms in NETS—a higher match rate than that achieved by studies using Census Bureau data.[8]

- *The USPTO's patent database*. This database provides information on each sample company's subsequent patent applications as well as citations to each sample company's patents.
- *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.
- *The Thomson Reuter's 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.

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 USPTO's first-action decision, the average startup experiences 24.8% growth in employment and 50.4% growth in sales over five years (Panel B) and produces 1.8 subsequently approved patents (Panel C). In the five years following first-action, 8.1% of startups raise VC funding and 0.8% of startups complete an IPO.

[8] Using the Census Bureau's Business Register data, often considered the "gold standard" for its coverage of the population of U.S.-based business establishments with paid employees filing taxes with the Internal Revenue Service, 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%.

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 real effects of patent scope and examination time on U.S. startups.

A. Empirical setup

We estimate panel regressions of the following general form:

$$\begin{aligned} Firm\ outcome_{ijat+k} = {} & \beta_1 E[Patent\ scope|First\text{-}action\ decision]_{ijat} \\ & + \beta_2 E[Examination\ \ time|First\text{-}action\ decision]_{ijat} \\ & + \Phi X_{ijat} + \nu_{a\tau} + \varepsilon_{ijat+k} \end{aligned} \quad (1)$$

where *i* indexes startups, *j* examiners, *a* art units, and τ application years. As discussed above, outcomes are measured over up to five years following the first-action decision the startup receives in year *t*.[9] X_{ijat} includes headquarter-state fixed effects to control for the confounding effects of geographical differences (Lerner and Seru 2017); the average word count across patent claims to control for any differences in the complexity or size of the average claim; 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 technology-related shocks that could affect both

[9] While we do not observe the contents of the first-action letter, as noted earlier, first-action letters are highly predictive of final patent application evaluation outcomes.

applications and outcomes.[10,11] 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.

We include both patent scope and examination time in equation (1) 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. We find evidence of this in our sample as well. Figure 1 presents binned scatter plots of patent scope against examination time. Whether or not we include art-unit-by-application-year fixed effects, there is a strong positive correlation between the scope of a patent and the time from application filing to first-action.

B. Identification strategy and identifying assumptions

The coefficients of interest in equation (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 any differences in patent scope and evaluation time 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

[10] For example, a technological breakthrough could increase the number of patent applications in an area, affecting the timing of patent application evaluation while also affecting the growth rate of firms in that area.

[11] Art units are narrowly defined (they span 495 different technology fields in our sample). The inclusion of art unit fixed effects allow us to control for time-varying demand and technological changes at a fine level and ensures that unobserved industry-level shocks do not confound our findings.

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 USPTO's review process that have been exploited in previous research:[12] 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 (Farre□Mensa et al. 2019, Sampat and Williams 2019). 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 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.[13]

We measure examiner leniency with respect to scope as the average claim count granted by examiner *j* belonging to art unit *a* assigned to review startup *i*'s patent application submitted at time τ:

$$Examiner\ leniency\ with\ respect\ to\ scope_{ija\tau} = \frac{n_{\text{claims granted}_{ja\tau}}}{n_{\text{patents granted}_{ja\tau}}}, \quad (2)$$

where $n_{\text{claims granted}_{ja\tau}}$ is the total number of claims across all granted patents examiner *j* has reviewed prior to the application date τ, and $n_{\text{patents granted}_{ja\tau}}$ is the number of patents examiner

[12] Examples include Cockburn, Kortum, and Stern (2002), Lichtman (2004), Sampat and Lemley (2010), Lemley and Sampat (2012), Gaule (2018), Sampat and Williams (2019), and Farre-Mensa, Hegde, and Ljungqvist (2019).
[13] Kuhn and Thompson (2019) similarly construct an instrument for examiner leniency with respect to scope based on previous examination outcomes. Their instrument differs from ours in that it relies on the word count in the first claim of a patent. As we show in Section III.G, our results are robust to following their approach.

j has granted prior to the application date τ.[14]

Our instrument for examination time has two components. The first is the average first-action time in years for all patents reviewed by examiner *j* belonging to art unit *a* assigned to review startup *i*'s patent application submitted at time τ:

$$Examiner\ average\ first\text{-}action\ time_{ija\tau} = \frac{n_{\text{first-action time}_{ja\tau}}}{n_{\text{patents reviewed}_{ja\tau}}}, \quad (3)$$

where $n_{\text{first-action time}_{ja\tau}}$ is the total first-action time across all patents examiner *j* has reviewed prior to the application date τ, and $n_{\text{patents reviewed}_{ja\tau}}$ is the number of patents examiner *j* has reviewed prior to the application date τ.[15] The second component, which we add to the examiner's average first-action time, is the application-specific administrative lag from the time the application is filed at the USPTO to the time it is docketed with a specific examiner.

Figures 2 and 3 show the distributions of examiner leniency with respect to scope and examiner average first-action time across our sample. These figures show that, even accounting for art unit and application year, examiner leniency with respect to scope and average first-action time vary substantially across examiners. To illustrate, compare an examiner at the 25th percentile to an examiner at the 75th percentile. This corresponds to a difference of 2.6 claims (a 14.4% difference considering the median number of claims in our sample) and 6.5 months to first-action.

C. First-stage estimates

Since we have two endogenous variables, patent scope and examination time, our 2SLS model has the following two first-stage regressions:

[14] Neither the numerator nor the denominator in equation (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.
[15] Again, neither the numerator nor the denominator in equation (3) includes application *i*, as it has not been reviewed prior to date τ.

$$Total\ claims_{ijat} = \theta\ Examiner\ leniency\ with\ respect\ to\ scope_{ijat\tau} + \Pi X_{ijat} + \nu_{a\tau} + u_{ijat} \quad (4)$$

$$First\text{-}action\ examination\ time_{ijat} = \delta(Examiner\ average\ first\text{-}action\ time + docket\ date\ lag)_{ijat\tau} + \Gamma X_{ijat} + \nu_{a\tau} + \zeta_{ijat} \quad (5)$$

The first-stage estimates of equations (4) and (5) are reported in Table 2, Panels A and B, respectively. Both first stages 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 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 claim leads to a 0.35 increase in the number of claims in the patent granted to the startup (p<0.001). Similarly, a one-year increase in the examiner's average first-action time in Panel B leads to an increase of 0.53 years (6.4 months) in first-action examination time.

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 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 an instrument have no direct effect on the outcome except through the treatment. In this case, conditional on the quasi-random assignment of patent applications to patent examiners, the exclusion restriction is plausibly justified. It is difficult to imagine how an examiner's past scope leniency or review speed would affect a

startup's future performance directly, other than through its effect on the evaluation of the startup's patent application.[16]

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 examination characteristics correlate with observable characteristics of the applicant or the application.

As noted above, a large body of literature argues that the USPTO assigns applications to examiners quasi-randomly. The precise details and procedures of the assignment process vary across art units,[17] but what they have in common is that they are consistent with our identifying assumption that applications are assigned to examiners 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 hypothesis of quasi-random assignment, the first-stage coefficient estimates of θ and δ in equations (4) and (5)

[16] One plausible exception would be if investors were able to back out patent examiners' scope leniency or review speed during their due diligence process. This is unlikely during out sample period, particularly given that public data on rejected applications are only available for applications filed since late 2000. However, it is possible that this kind of due diligence may become more common in the future.

[17] For example, some art units assign applications based on the last digit of the randomly assigned application serial number (Lemley and Sampat 2012). Other art units use a "first-in-first-out" rule, whereby the application with the earliest application filing data is assigned to the first available examiner.

should be invariant to the characteristics of the startup, application, or examiner. Accordingly, we add further controls to our first-stage regressions shown in Table 2 and observe what happens to the coefficient estimates of θ and δ. Specifically, we use 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 technological subclass-by-year fixed effects to investigate the possibility of assignment based on technological specialization (column 4),[18] and examiner tenure and seniority to investigate the possibility of assignment based on examiner experience (column 5).[19]

Adding these additional controls makes little difference to the first-stage coefficient estimates of θ and δ. In Table 2, Panel A, the coefficient estimates for patent scope vary between 0.31 to 0.39. In Table 2, Panel B, the coefficient estimates for review speed vary even less, ranging from 0.52 to 0.53. These results indicate that both instruments pass Righi and Simcoe's (2019) validation test.[20]

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. Columns 1 and 2 in each panel show that the applicant's characteristics do not predict the type of examiner who is assigned, as regards scope leniency or review speed. Columns 3 and 4 report a placebo test which exploits the fact that a subset of startups file for patent protection not just in the United States, but also in the European Union and/or Japan.

[18] As suggested by Righi and Simcoe (2019).
[19] Data on examiner tenure and seniority are obtained from the USPTO pursuant to a Freedom of Information Act (FOIA) request.
[20] The control variables are worth a brief discussion. None of our measures of applicant quality predicts the scope of a patent or the length of first-action examination time. Examiner tenure and seniority, on the other hand, do appear to correlate with patent scope and first-action examination time. Specifically, examiners with longer tenure grant broader patents, and more senior examiners reach first-action decisions more quickly (consistent with the findings of Frakes and Wasserman 2017). However, this does not undermine identification, given random assignment.

Using foreign patent *grants* as a measure of the quality of the applicant or the underlying invention, we validate the quasi-random-assignment assumption by testing whether applications granted by a foreign patent office are more likely to have been assigned to more lenient U.S. examiners. Consistent with quasi-random assignment, we find no such evidence.

III. The real 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 first-action examination time on a startup's subsequent employment and sales growth and its survival.[21] Panel A reports results for employment growth. Patent scope has no meaningful effect on employment growth over a one- to five-year horizon. In contrast, longer examination time leads to substantial reductions in employment growth in the years following first-action. An additional year of examination time reduces a startup's employment growth rate by 3.8 percentage points (p=0.013) in the first year after first-action. Over time, the negative effect of longer reviews increases: an additional year of examination time reduces cumulative employment growth by 10.6 percentage points over two years, 13.0 percentage points over three years, 18.9 percentage points over four years, and 25.8 percentage points over five years. Figure 4 visualizes these estimates over time.

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 the startup having 2.1 (= 8 × 0.258) fewer employees five years after first-action. Summed over five years, an additional year of examination time results in a decrease of 5.8 person-years of employment at the median startup. Considering the average startup in our sample rather than the

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

median, a one-year increase in examination time results in 7.6 fewer employees five years after first-action and a cumulative decrease of 21.3 person-years of employment.

Table 4, Panel B shows a similar pattern for sales growth: patent scope has no meaningful effect on sales growth, while longer examination times hamper sales growth. On average, a one-year increase in examination time reduces sales growth by a cumulative 4.5 (p=0.048), 10.8 (p=0.018), 15.6 (p=0.062), 36.7 (p=0.003), and 39.9 percentage points (p=0.005) over the next one, two, three, four, and five years, respectively. Figure 4 visualizes these estimates. For the median startup in our sample, with sales of $0.8 million at first-action, an additional year of examination time reduces annual sales by $319,200 (= 0.8 × 0.399) in year 5 and cumulative sales over the five years by $860,000. Considering the average startup in our sample rather than the median, the corresponding figures are $1.7 million and $4.6 million. In short, longer waits appear to be costly to startups.

Table 4, Panel C reports the effects of patent scope and examination time on survival.[22] We find no evidence of a meaningful effect of patent scope on survival over any timeframe. In contrast, 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 1.5 percentage points. The magnitude of this negative effect more than doubles over two- to four-year survival windows (all significant at p<0.01); over five years, it measures 3.8 percentage points (p=0.056).

B. Fundraising in the VC and IPO markets

Patent examination decisions can also have a sizable impact on a startup's ability to raise capital via the VC and IPO markets (Farre□Mensa et al. 2019). We next consider whether patent

[22] We code a startup as being alive in year $t + k$ if it continues to be included in the NETS database in that year. Dun & Bradstreet, the source of the NETS database, carefully identify firm deaths and distinguish them from relocations. Neumark, Zhang, and Wall (2005) contains a comprehensive account of their methodology. We spot-check firm deaths according to NETS using information from Capital IQ.

scope and examination time affect a startup's ability to raise external capital. Table 5 shows that patent scope has no meaningful effect on a startup's likelihood of obtaining VC funding over a five-year horizon.[23] Faster examinations, on the other hand, increase the likelihood of raising VC funding, significantly so over a two- to five-year horizon. An additional year of examination time reduces the likelihood of obtaining VC funding by 1.2 percentage points over two years (p=0.033), 1.4 percentage points over three years (p=0.017), 1.5 percentage points over four years (p=0.012), and 1.3 percentage points over five years (p=0.026). Figure 4 visualizes these estimates. Economically, the effects are sizeable. For example, the five-year estimate in column 5 represents a 16.7% reduction from the 7.8% 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. This is the one place so far that we find patent scope to make a difference. Each additional claim allowed in a granted patent increases the likelihood of an IPO by 0.2 percentage points (p=0.028), or a quarter of the unconditional IPO probability. Apparently, broader claims in a startup's first patent ease access to the stock market. As before, delays are costly. An additional year of examination time reduces the likelihood of an IPO by 0.6 percentage points (p=0.006), equivalent to three-quarters of the unconditional IPO probability.

C. 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 (2019), we measure follow-

[23] This result may appear surprising considering Lerner's (1994) finding that patent scope is positively associated with the likelihood of obtaining VC funding in his sample. Methodologically, the main difference between our approach and Lerner's is that we use an instrument to remove the potentially confounding effects of the quality of the underlying invention while he reports OLS regressions. We report OLS regressions in Table IA.2 in the Internet Appendix. We find a small positive and statistically significant effect of patent scope on the likelihood of raising VC funding, similar to Lerner's finding. This suggests that OLS estimates of patent scope partly capture the confounding effects of unobserved quality aspects of the underlying inventions.

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 approved patent.

Table 6, 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 2.6% ($= e^{0.026} - 1$) increase in the number of patents a startup subsequently applies for and a 2.2% increase in the number of patents it is subsequently granted. Examination time, meanwhile, has a negative effect. An additional year of waiting for a first-action decision reduces the number of subsequent patent applications and granted patents by 14.9% and 14.8% respectively. (All effects are significant at $p<0.01$.) While patent scope has no significant effect on the approval rate of subsequent applications, examination time has a negative effect, reducing the approval rate of subsequent applications by 3.5 percentage points ($p=0.030$).

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 per approved patent (column 5). One additional claim granted in the first patent leads to a 3.1% increase in the total count of citations in subsequent patents ($p=0.006$) and a 2.1% increase in per-patent citations for subsequent approved patents ($p=0.035$). Longer examination times, on the other hand, lead to less impactful subsequent patents. An additional year of examination time reduces the number of citations to subsequent patents by 22.3% in total and by 9.5% on average (both significant at $p<0.01$).

D. Heterogeneity across industries

Patent scope and examination time may affect firms in different industries differently, for example depending on the extent to which patents are used to deter entry or time-to-market considerations. We explore heterogeneity across industries by splitting the sample into information technology (IT) firms, biotech firms, and other firms. To conserve space, the results are reported graphically in Figures 6 through 8, with the underlying tables available in the Internet Appendix.

The key insight to emerge from the industry analysis is that IT firms are particularly sensitive to longer examination times: longer waits for a first-action decision significantly reduce growth in employment and sales, the chances of raising VC funding, and the quantity and quality of follow-on innovation. This finding is unexpected in light of prior survey evidence suggesting that IT firms consider patents the least effective way to protect their R&D investments (Cohen et al. 2000, Levin et al. 1987). Instead, IT firms rely on trade secrets, first-mover advantages, lead time, and design and manufacturing capabilities to appropriate gains from their innovations. A possible explanation for our apparently diverging empirical results is that the intense competition and rapid innovation which characterize the IT industry (Harter et al. 2000) make delays particularly costly for those IT startups that choose to protect their intellectual property through patents rather than some other means.

E. Rejected patents

We briefly consider whether the adverse effects of slower patent reviews depend on whether the application was ultimately rejected or granted.[24] While employment and sales growth and the likelihood of obtaining VC funding within five years of first-action seem unaffected by how long

[24] Scope is a feature of granted patents only and is therefore not considered in this section.

it takes the USPTO to issue a first-action on an ultimately rejected application (see Figure 9, Panel A), we find that slower reviews significantly reduce a startup's chances of going public as well as the quantity and quality of its follow-on innovation (see Figure 9, Panel B).

These results are striking and have important implications. They suggest that longer examination times have meaningful consequences for firms, whether the patent application is ultimately granted or rejected. One plausible explanation is that a faster first-action rejection benefits startups by more quickly resolving uncertainty around their intellectual property rights, allowing startups to more quickly pivot to alternative IP strategies or pursue different means of appropriating the gains from their inventions.

E. Subsequent patents

Farre-Mensa, Hegde, and Ljungqvist (2019) argue that a startup's first patent grant is special, in that it helps the startup to obtain external funding (perhaps because it helps signal the startup's quality) and thereby contributes to a substantial boost to growth and follow-on innovation. Once on this initial high-growth trajectory, subsequent patents appear less important. In this section, we investigate whether broader scope and shorter examination times are particularly valuable in a startup's first patent application by considering second applications.[25] Tables 7 and 8 report the results for growth and follow-on innovation, respectively.

Firms grow no faster if granted a broader patent in their second application, mirroring the null result for first patents. They do grow significantly more slowly in the first two years following the first-action decision on their second application, the longer they had to wait for the decision. Unexpectedly, for sales growth, the adverse effects of longer waits are economically a good deal larger in second applications than in first applications. Specifically, a one-year

[25] Note that this includes both startups whose first patent application was granted and those whose first patent application was ultimately rejected.

increase in the wait time for a first-action decision on a second application reduces sales growth by 22 percentage points (p=0.008) and 42 percentage points (p=0.020) over one and two years, respectively. The corresponding point estimates for a first application are 4.5 and 10.8 percentage points (see Table 4). Beyond two years, longer examination times continue to have large negative effects on growth, but these are more noisily estimated and not statistically significant as the sample size decreases and we appear to lose power.[26]

As for follow-on innovation, we do find some evidence that first patent applications are special. In stark contrast to the strongly negative effects of longer waits on follow-on innovation after a first application reported in Table 6, we find no evidence in Table 8 that longer waits have significant effects after second applications. In part, this may be a power issue – the coefficients are consistently negative in both cases – but comparing coefficient estimates across the two tables suggests that the effects are consistently smaller for second applications than for first ones. Scope, on the other hand, behaves roughly similarly. Increasing the scope of a second patent application by one claim leads to a 2.9% (= $e^{0.029} - 1$) increase in subsequent patent applications (p=0.092), a 2.6% increase in subsequent patent grants (p=0.062), and a 4.7% increase in total citations to subsequent patent applications (p=0.040). Economically, these point estimates are similar in magnitude to those reported in Table 6 for first applications.

Taken together, our results add nuance to Farre-Mensa, Hegde, and Ljungqvist's (2019) conclusion that a startup's first patent *grant* is special: broader scope and faster decisions have positive effects on startups even beyond the first patent. Specifically, broader scope has a consistent positive effect on follow-on innovation across applications, and shorter examination

[26] Limiting our sample to startups whose first patent application was granted yields qualitatively similar results (see Table IA.18). In particular, we find no evidence of an effect of patent scope on growth and economically large but noisily estimated effects of examination time on growth. The number of startups whose first application was rejected and whose second application was approved is too small for a meaningful analysis.

times boost growth and follow-on innovation for both first and second applications.

G. Alternative measures of patent scope

Given our perhaps unexpected finding that patent scope has no meaningful effect on startup employment or sales growth, we investigate robustness to alternative measures of scope. Specifically, we use the count of independent claims at the time of grant (instrumented by the average number of independent claims allowed in prior granted patents by the examiner reviewing an application) and Kuhn and Thompson's (2019) measure of scope based on the count of words in the first independent claim (instrumented by Kuhn and Thompson's measure of examiner leniency with respect to scope). For either measure, we continue to find that startup growth is unaffected by patent scope (see Tables IA.19 and IA.20 in the Internet Appendix).

IV. Scope and timing externalities

Our analysis shows that patent scope and especially examination time have clear effects on the innovating firm. We next ask whether 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 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 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 USPTO's classification system, allowing us to capture firms that are likely closely related. We adapt equation (1) to consider the effects of the scope and timing of startup i's patent decision on not itself but on 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.

Table 9 reports the results for employment growth (Panel A), sales growth (Panel B), and survival (Panel C). We find that the scope and examination time of a startup's first patent has no significant externalities on its rivals' growth or survival. The results in Table 4 in contrast to Table 9 suggests that the more timely resolution of uncertainty at the USPTO has beneficial effects for the applicant but does not seem to have large externality effects on growth across the industry.

Table 10 reports our estimates of externalities on external fundraising. Scope – again – does not give rise to externalities. Examination time, on the other hand, appears to have a large and meaningful effect on the likelihood that others in the industry obtain VC funding. Each additional year of examination time reduces the fraction of startups in the technology subclass that obtain VC funding by 0.3 percentage points over one year, 0.4 percentage points over two years, 0.4 percentage points over three years, 0.5 percentage points over four years, and 0.5 percentage points over five years (all significant at $p<0.01$). Economically, the externality effects are sizeable. For example, the five-year estimate in column 5 represents a 7.9% reduction in the fraction of VC-funded startups from the unconditional sample mean of 6.3%.

Table 11 considers externalities on follow-on innovation in the subclass. Here, we find evidence that broader scope imposes negative externalities on both the quantity and quality of

rivals' follow-on innovation: broader patents granted to a focal startup result in reductions in the number of patents its subclass peers receive, in their success rate at the USPTO, and in the number of citations to their patents. To illustrate, each additional claim the focal startup manages to secure for itself at the USPTO reduces the number of subsequent approved patents among its subclass peers by half a percent (p=0.010), the approval rate in its subclass peers' subsequent applications by 0.2 percentage points (p=0.002), the number of citations to its subclass peers' subsequent patents by 1% (p=0.014), and the average number of per-patent citations for its subclass peers by 0.4% (p=0.019). Timing, on the other hand, has no effect except on approval rates: a one-year increase in the focal startup's examination time increases its subclass peers' approval rate in their subsequent applications by 1.2 percentage points (p=0.006), equivalent to a 2.2% increase when scaled by the unconditional industry approval rate in our sample.

In sum, we find evidence that one firms' patent scope and timing impose externalities on its peer firms, at least among startups with regards to follow-on innovation and access to VC funding. A broader patent hampers follow-on innovation across the inventor's industry, consistent with one firm's property rights limiting its rivals' ability to stake legal claims to related inventions. Longer examination times also hamper rivals' access to venture capital funding, consistent with investors taking wider trends in patenting across a narrowly defined technology area into account in their investment decisions.

V. Concluding thoughts

We investigate the trade-off that inventors face between pursuing broader patents that are likely to take longer to be granted and narrower patents that may move through the evaluation process more quickly. 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 patent and the externalities the scope and timing of their patents impose on their technology rivals. 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 examiners who differ in their propensity to grant narrow patents and their review speed.

Our results show that patent scope has little effect on growth in sales or employment or the likelihood of raising VC funding, for either the inventor or its close technology rivals. Broader scope does, however, boost the inventor's follow-on innovation while hampering that of its rivals. Faster review times at the USPTO, on the other hand, have substantial positive effects on both inventors and their rivals. Faster reviews allow inventors to create more jobs, generate higher sales, and innovate more successfully, and it enables both inventors and rivals to more readily access VC funding.

Considered in conjunction with prior work studying the effects of the patent system on inventors and spillover effects on others (see Heller and Eisenberg 1998, Galasso and Schankerman 2015, Sampat and Williams 2019, Farre□Mensa et al. 2019, among many others), our findings provide nuance on the effects of patents on their holders and others by causally estimating the effects of scope and timing of a patent grant. Our results suggest that the speed of patent evaluation has large and meaningful effects not just for the inventor, but for others in its industry as well. This finding has meaningful implications for the patent system and should be considered by policymakers and the USPTO in any reforms of the patent evaluation process.

References

Angrist JD, Pischke JS (2009) *Mostly Harmless Econometrics: an Empiricist's Companion* (Princeton University Press, Princeton).

Balasubramanian N, Sivadasan J (2011) What Happens When Firms Patent? New Evidence from U.S. Economic Census Data. *The Review of Economics and Statistics* 93(1):126–146.

Carley M, Hegde D, Marco A (2015) What is the Probability of Receiving a U.S. Patent? *Yale Journal of Law and Technology* 17(1):23.

Chang HF (1995) Patent Scope, Antitrust Policy, and Cumulative Innovation. *The RAND Journal of Economics* 26(1):34–57.

Cockburn IM, Kortum S, Stern S (2002) *Are All Patent Examiners Equal? The Impact of Examiner Characteristics* (National Bureau of Economic Research).

Cohen J, Lemley M (2001) Patent Scope and Innovation in the Software Industry. *California Law Review* 89(1):1.

Cohen W, Nelson R, Walsh J (2000) *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* (National Bureau of Economic Research, Cambridge, MA).

Farre□Mensa J, Hegde D, Ljungqvist A (2019) What Is a Patent Worth? Evidence from the U.S. Patent "Lottery." *The Journal of Finance*.

Frakes MD, Wasserman MF (2017) Is the Time Allocated to Review Patent Applications Inducing Examiners to Grant Invalid Patents? Evidence from Microlevel Application Data. *The Review of Economics and Statistics* 99(3):550–563.

Fudenberg, Drew, Gilbert R, Stiglitz J, and Tirole, J. (1983) Preemption, leapfrogging and competition in patent races, *European Economic Review*, 22 (1983), 3-31.

Galasso A, Schankerman M (2015) Patents and Cumulative Innovation: Causal Evidence from the Courts *. *The Quarterly Journal of Economics* 130(1):317–369.

Gaulé P (2018) Patents and the Success of Venture-Capital Backed Startups: Using Examiner Assignment to Estimate Causal Effects. *The Journal of Industrial Economics* 66(2):350–376.

Gilbert, R.J., and Newbery MGD (1982) Preemptive patenting and the persistence of monopoly, *The American Economic Review*, (1982), 514-526.

Gilbert R, Shapiro C (1990) Optimal Patent Length and Breadth. *The RAND Journal of Economics* 21(1):106–112.

Harhoff D (2016) Patent Quality and Examination in Europe. *American Economic Review* 106(5):193–197.

Harter DE, Krishnan MS, Slaughter SA (2000) Effects of Process Maturity on Quality, Cycle Time, and Effort in Software Product Development. *Management Science* 46(4):451–466.

Heller MA, Eisenberg RS (1998) Can Patents Deter Innovation? The Anticommons in Biomedical Research. *Science* 280(5364):698–701.

Hsu DH, Ziedonis RH (2013) Resources as dual sources of advantage: Implications for valuing entrepreneurial-firm patents. *Strategic Management Journal* 34(7):761–781.

Kerr W, Fu S (2008) The survey of industrial R&D—patent database link project. *The Journal of Technology Transfer* 33(2):173–186.

Klemperer P (1990) How Broad Should the Scope of Patent Protection Be? *RAND Journal of Economics* 21(1):113–130.

Kline, P, Petkova N, Williams H, and Zidar O. (2019). "Who Profits from Patents? Rent-sharing at Innovative Firms." *The Quarterly Journal of Economics*, vol 134(3), pages 1343-1404
Kogan L, Papanikolaou D, Seru A, Stoffman N (2017) Technological Innovation, Resource Allocation, and Growth. *Q J Econ* 132(2):665–712.
Kuhn JM, Thompson NC (2019) How to Measure and Draw Causal Inferences with Patent Scope. *International Journal of the Economics of Business* 26(1):5–38.
Lanjouw JO, Schankerman M (1997) *Stylized Facts of Patent Litigation: Value, Scope and Ownership* (National Bureau of Economic Research).
Lanjouw JO, Schankerman M (2004) Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators. *The Economic Journal* 114(495):441–465.
Lemley MA, Sampat B (2012) Examiner Characteristics and Patent Office Outcomes. *The Review of Economics and Statistics* 94(3):817–827.
Lerner J (1994) The Importance of Patent Scope: An Empirical Analysis. *The RAND Journal of Economics* 25(2):319–333.
Lerner J, Merges RP (1997) Patent Scope and Emerging Industries: Biotechnology, Software, and Beyond.
Lerner J, Seru A (2017) *The Use and Misuse of Patent Data: Issues for Corporate Finance and Beyond* (National Bureau of Economic Research).
Levin RC, Klevorick AK, Nelson R, Winter S (1987) Appropriating the Returns from Industrial Research and Development. *Brookings Papers on Economic Activity* 18(3, Special Issue on Microeconomics):783–832.
Lichtman D (2004) Rethinking Prosecution History Estoppel. *University of Chicago Law Review* 71.
Mann RJ, Underweiser M (2012) A New Look at Patent Quality: Relating Patent Prosecution to Validity. *Journal of Empirical Legal Studies* 9(1):1–32.
Marco AC, Sarnoff JD, deGrazia CAW (2019) Patent claims and patent scope. *Research Policy* 48(9):103790.
Neumark D, Zhang J, Wall B (2005) *Employment Dynamics and Business Relocation: New Evidence from the National Establishment Time Series* (National Bureau of Economic Research).
Reinganum, JF, (1982) A dynamic game of R and D: Patent protection and competitive behavior, *Econometrica*: Journal of the Econometric Society, 50 (1982), 671-688
Righi C, Simcoe T (2019) Patent examiner specialization. *Research Policy* 48(1):137–148.
Sampat B, Williams HL (2019) How Do Patents Affect Follow-On Innovation? Evidence from the Human Genome. *American Economic Review* 109(1):203–236.
Sampat BN, Lemley MA (2010) Examining Patent Examination. *Stanford Technology Law Review*.

Appendix. Variable definitions

Count of claims is a count variable that indicates the number of independent and dependent claims allowed for a granted patent application.

First-action examination time measures the time between the filing date and the first-action date of a patent application, in years.

Examiner leniency with respect to scope is the average count of total claims in patents previously allowed by an examiner. Examiner leniency with respect to scope is calculated based on the patent application date.

Examiner average first-action examination time is the average first-action examination time in years for patents previously examined by an examiner. Examiner average first-action examination time is calculated based on the patent application date.

Firm survival during year t after the first-action decision on a firm's first patent application is set to 1 if the firm is matched with the NETS sample and employment (or sales) data are available either for the year t or for any year after t. The variable is set to zero if the firm is matched with the NETS sample and employment (or sales) data are not available for the year t or for any year after t.

Employment growth after the first-action decision on a firm's first (or second) patent application is $\text{employment}_{t+k}/\text{employment}_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. If a firm dies and thus does not appear in NETS in year $t+k$, where $t+k \leq 2011$ (the last year for which we have NETS data), we set $\text{employment}_{t+k} = 0$.

Sales growth after the first-action decision on a firm's first (or second) patent application is $\text{sales}_{t+k}/\text{sales}_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. If a firm dies and thus does not appear in NETS in year $t+k$, where $t+k \leq 2011$ (the last year for which we have NETS data), we set $\text{sales}_{t+k} = 0$.

Pre-patent-filing employment growth is $\text{employment}_t / \text{employment}_{t-1} - 1$, where t is the year that a firm's first patent application is filed.

Pre-patent-filing sales growth is $\text{sales}_t / \text{sales}_{t-1} - 1$, where t is the year that a firm's first 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 a firm's first (or second) 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 a firm's first (or second) application.

Approval rate of subsequent patent applications is defined as (no. subsequent approved patents) / (no. subsequent patent applications) for the focal firm. It is only defined for firms with at least one subsequent patent application.

Total citations to all subsequent patent applications is the number of citations received by all subsequent patent applications by the focal firm combined. (This number 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.

Average citations-per-patent to subsequent approved patents is the average number of citations received by those subsequent patent applications by the focal firm that are approved. It is only defined for firms with at least one subsequent approved patent.

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

Examiner grade is the examiner's grade according 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 when 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.

Industry classification. IT startups are those whose first patent application is reviewed by an examiner belonging to an art unit in one of the following USPTO technology centers: 21 (computer architecture, software, and information security); 24 (computer networks, multiplex communication, video distribution, and security); 26 (communications); or 28 (semiconductors, electrical and optical systems and components). Biochemistry startups are those whose first patent application is reviewed by one of the following technology centers: 16 (biotechnology and organic chemistry); or 17 (chemical and materials engineering). Startups belonging to other industries are those whose first patent application is reviewed by one of the following technology centers: 36 (transportation, construction, electronic commerce, agriculture, national security and license & review); or 37 (mechanical engineering, manufacturing, products).

Subclass classification. The technology subclass classification for the first patent application of a startup. The subclass represents the most granular division of technological subject matter within the USPTO. The subclass classification is used to assign firms to specific product market areas.

Subclass-level employment growth after the first-action decision on a firm's first patent application is industry employment_{t+k}/industry $\text{employment}_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. Industry employment includes the total employment of all firms within the same subclass classification excluding the focal firm.

Subclass-level sales growth after the first-action decision on a firm's first patent application is industry sales_{+k}/ industry $\text{sales}_t - 1$, where t is the first-action year and $k = 1 \ldots 5$. Industry sales includes the total employment of all firms within the same subclass classification excluding the focal firm.

Subclass-level survival is the proportion of firms still alive in year t within the subclass. Firm survival during year t after the first-action decision on a firm's first patent application is set to 1 if the firm is matched with the NETS sample and employment (or sales) data are available either for the year t or for any year after t. The focal firm is not included in calculations of subclass-level survival.

Subclass-level no. subsequent patent applications is the number of applications in our sample with the same subclass classification with a filing date greater than the first-action date of a firm's first application excluding applications by the focal firm.

No. subsequent approved patents is the number of approved applications in our sample with the same subclass classification with a filing date greater than the first-action date of a firm's first (or second) application excluding applications by the focal firm.

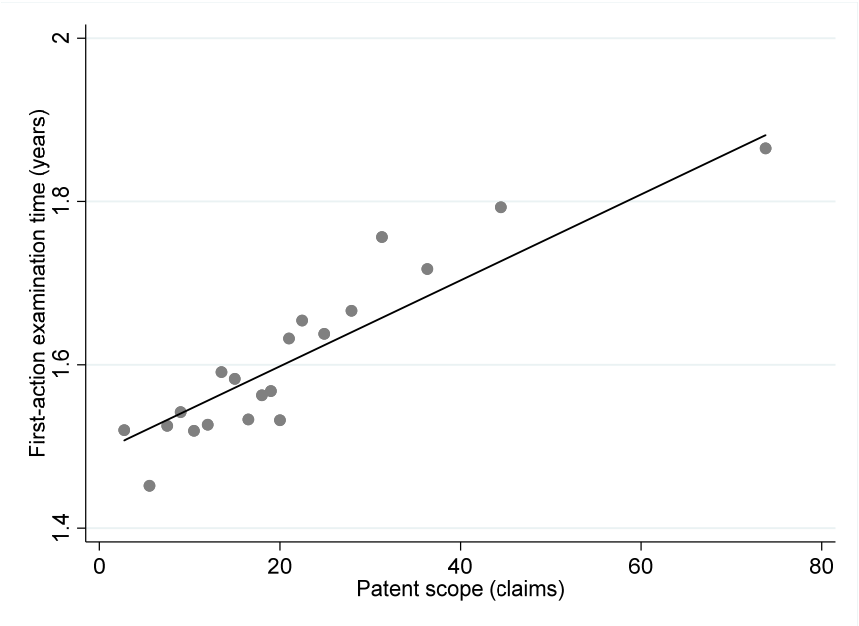
Approval rate of subsequent patent applications is defined as (no. subsequent approved patents)/(no. subsequent patent applications) for all applications in our sample with the same subclass designation excluding applications by the focal firm.

Total citations to all subsequent patent applications is the number of citations received by all subsequent patent applications in our sample with the same subclass classification combined. 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.

Average citations-per-patent to subsequent approved patents is the average number of citations received by those subsequent patent applications in our sample with the same subclass classification that are approved.

Figure 1. Binned Scatter Plots of Count of Claims and First-Action Examination Time.
The figure shows binned scatter plots of count of claims and first-action examination time. Data points are grouped into twenty equally-sized bins and an aggregate statistic is used to summarize each bin.

Panel A. Binned scatter plot.



Panel B. Binned scatter plot with art-unit-by-application-year fixed effects.

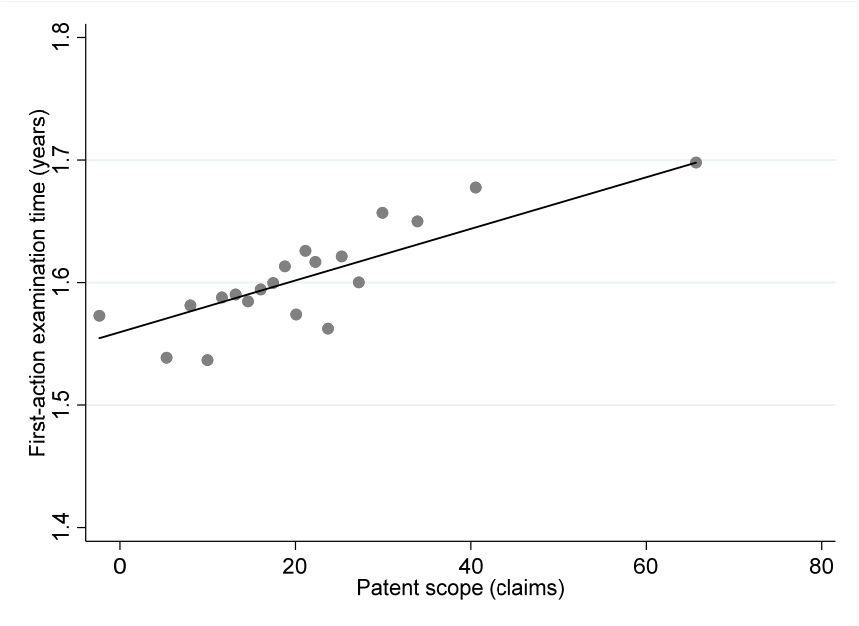


Figure 2. Distribution of Examiner Leniency with Respect to Patent Scope.
The figure shows the sample distribution of examiner leniency with respect to scope, defined as in equation (2), estimated within an art unit and year using a regression of patent scope on a full set of art-unit-by-application-year fixed effects. Histogram is truncated at the positive residual value of 20.

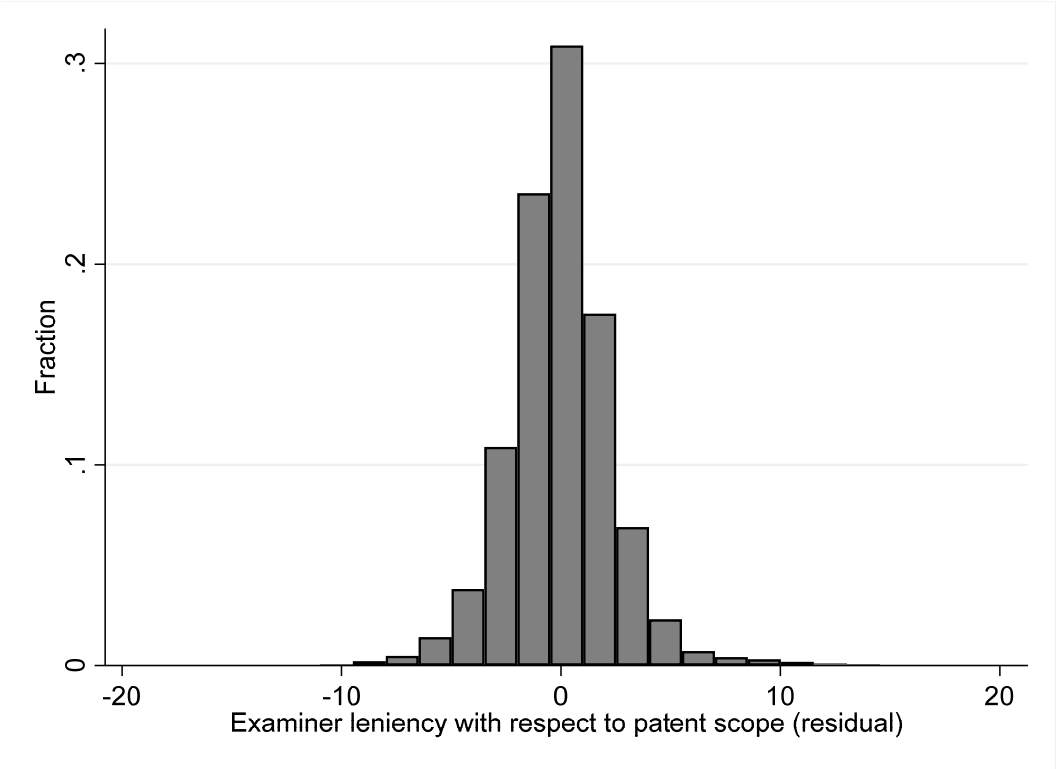


Figure 3. Distribution of Examiner Average First-Action Examination Time.
The figure shows the sample distribution of patent examiners' average time from application date to first-action date in years, defined as in equation (3), estimated within an art unit and year using a regression of first-action examination time on a full set of art-unit-by-application-year fixed effects for allowed patents.

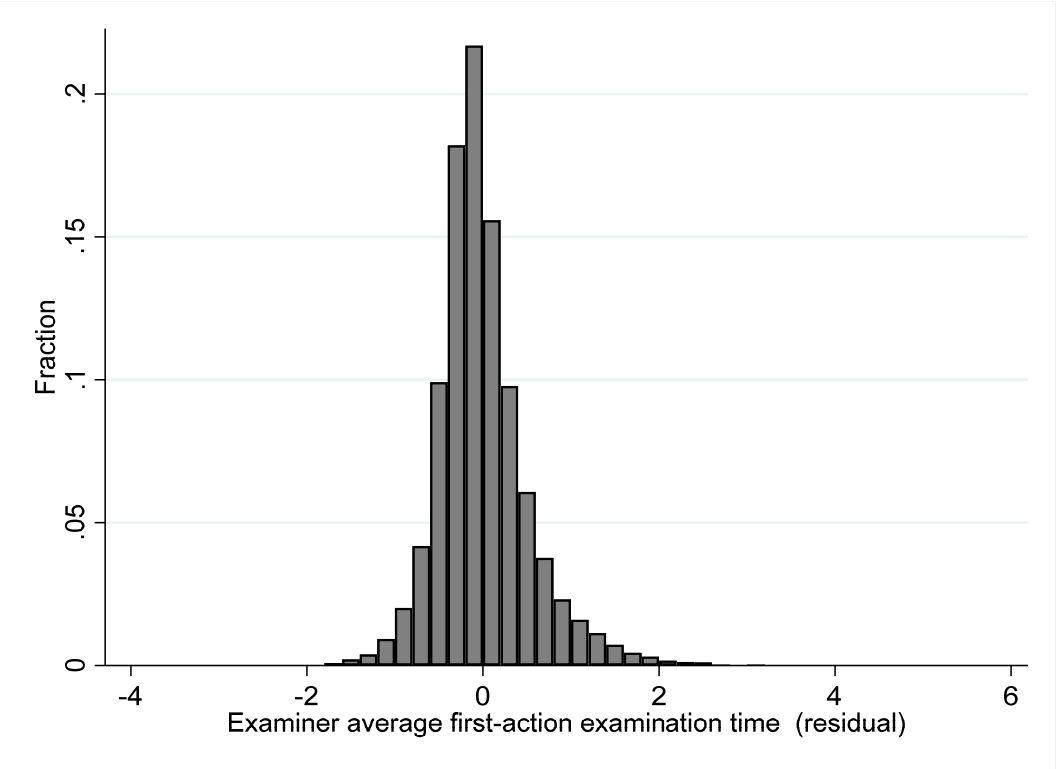
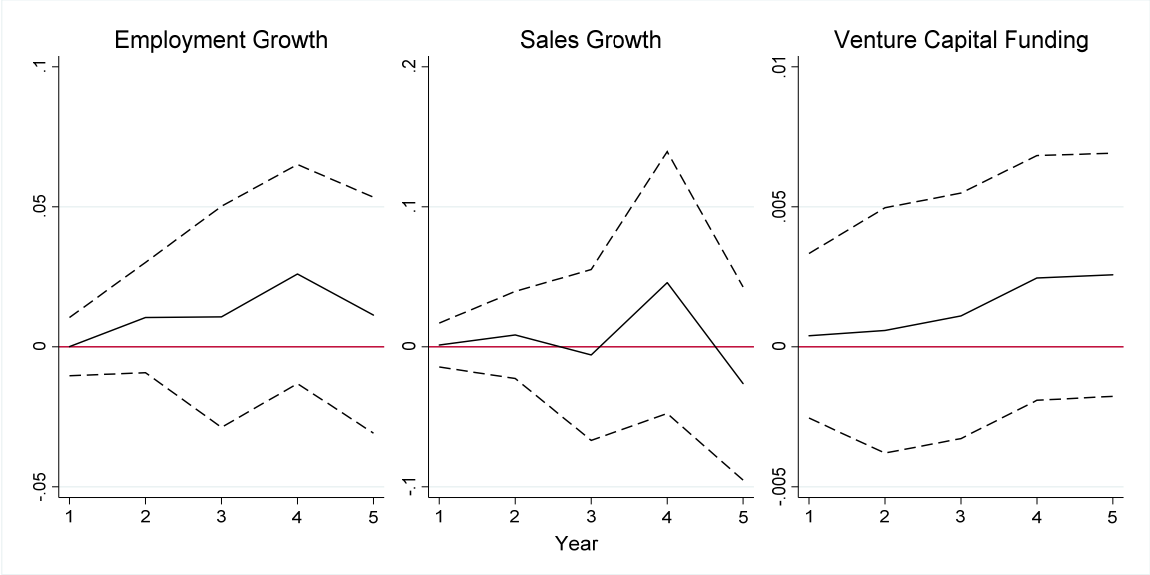


Figure 4. Effects of Patent Scope and Examination Time on Startup Growth and Funding.
The figure plots the estimated effect of patent scope as measured by count of claims (Panel A) and first-action examination time (Panel B) on employment growth, sales growth, and the likelihood of obtaining venture capital funding over the five years following the first-action decision on a startup's first patent application. Specifically, the solid line shows the estimated patent scope effect obtained by estimating equation (1) for by 2SLS separately over horizons from one to five years after the first-action date. We use examiner leniency with respect to scope of the examiner reviewing each patent application as an instrument for patent scope. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for an application's first-action examination time. The dashed lines show 95% confidence intervals. The results underlying these figures are presented in Table 4.

Panel A. Patent scope.



Panel B. First-action examination time.

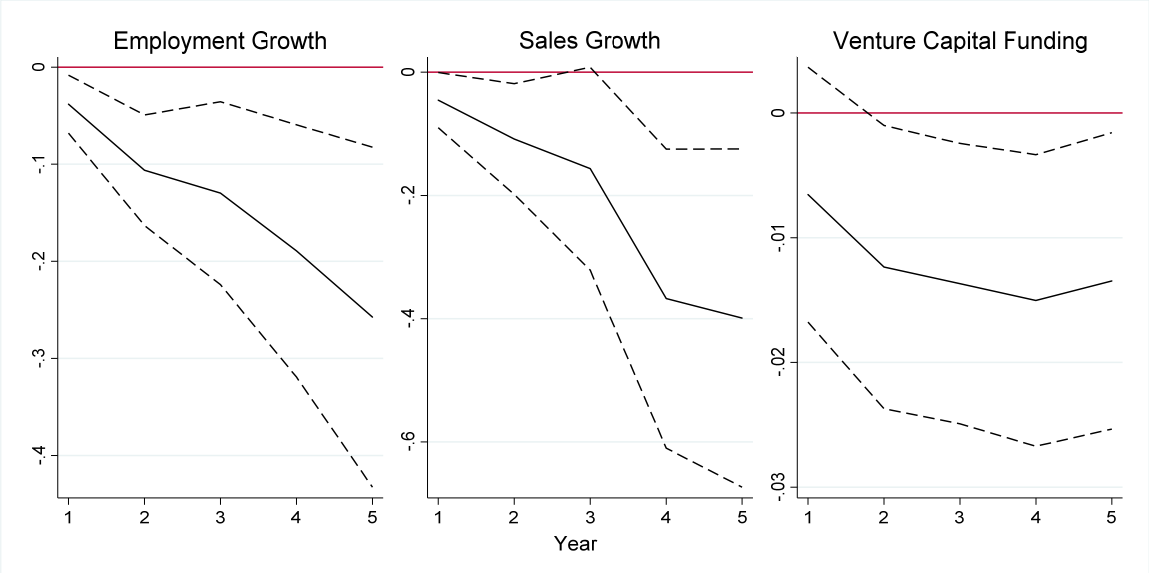


Figure 5. Time Lag between First-Action and VC Investment.
The figure shows the distribution of the time (in months) between the first-action date and the VC investment date for successful first-time patent applicants for which we have data on application scope that go on to raise funding from a VC. VC funding events that take place more than five years after the first-action decision are not shown.

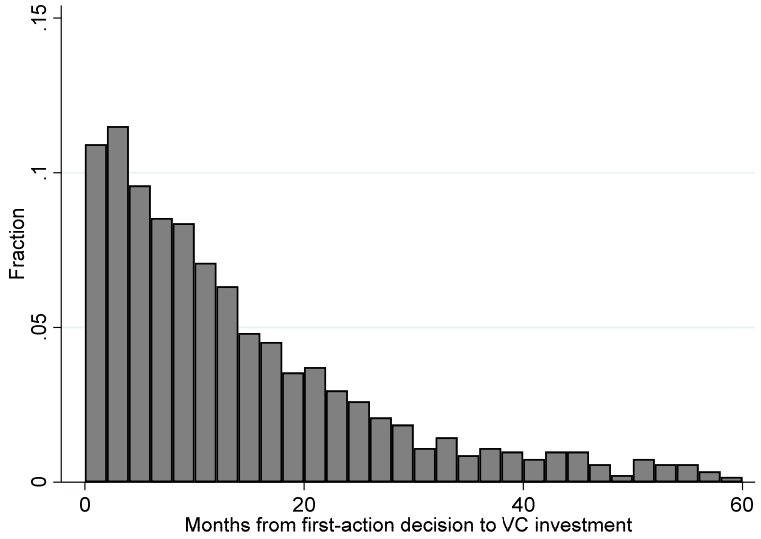
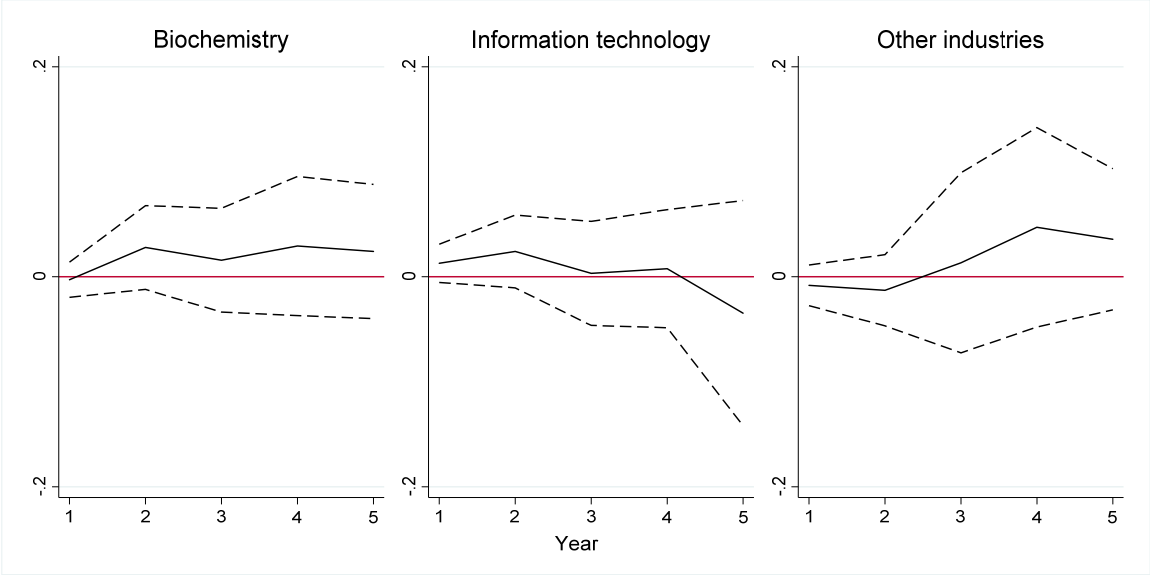


Figure 6. Effects of Patent Scope on Startup Growth and Funding by Industry.
The figure plots the estimated effects of patent scope as measured by count of claims on employment growth (Panel A), sales growth (Panel B), and venture capital funding (Panel C) over the five years following the first-action decision on a startup's first patent application. Specifically, the solid line shows the estimated patent scope effect obtained by estimating equation (1) by 2SLS separately over horizons from one to five years after the first-action date. We use examiner leniency with respect to scope of the examiner reviewing each patent application as an instrument for patent scope. Patents are grouped into industries based on assignment to USPTO technology centers. Biochemistry patents are classified as patents assigned to technology centers 16 or 17, while information technology patents are classified as patents assigned to technology centers 21, 24, 26, and 28. The dashed lines show 95% confidence intervals. The results underlying these figures are presented in Tables IA.6-IA.11.

Panel A. Employment growth.



Panel B. Sales growth.

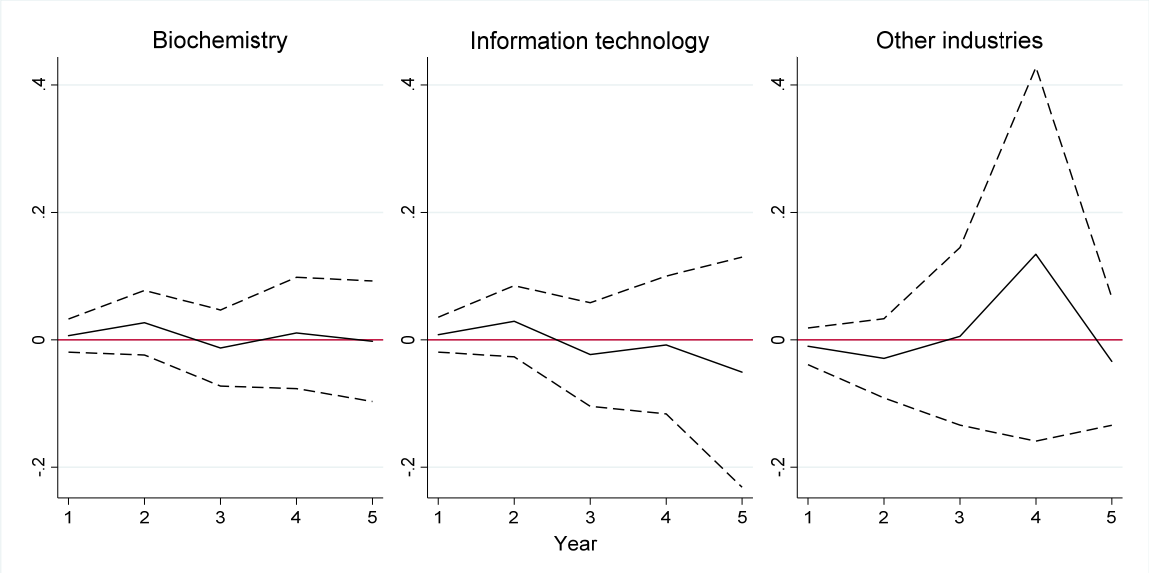


Figure 6 (cont.)

Panel C. Venture capital funding.

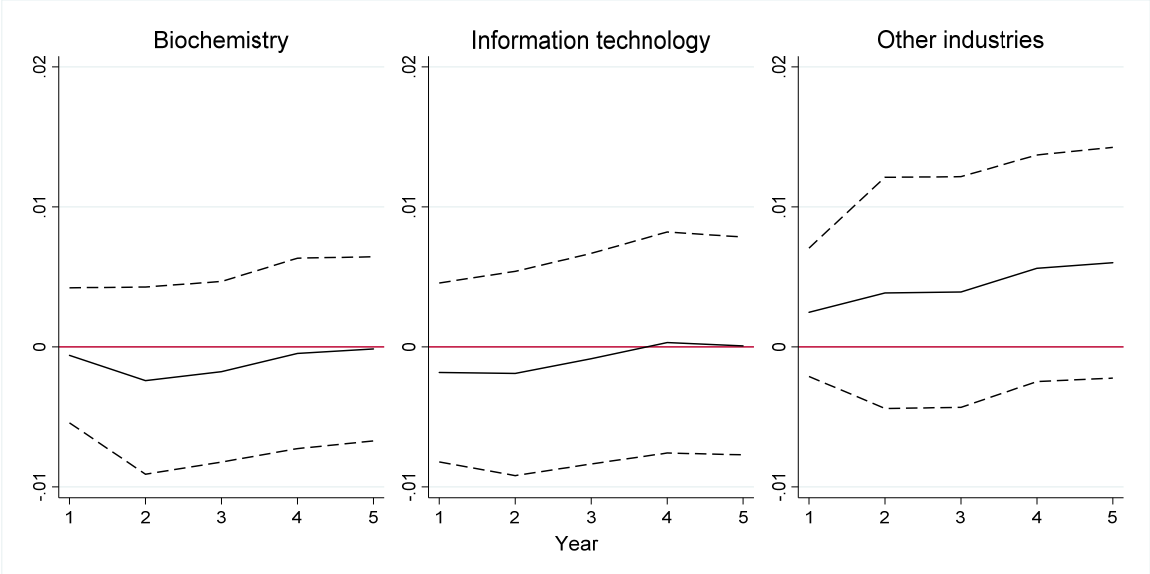
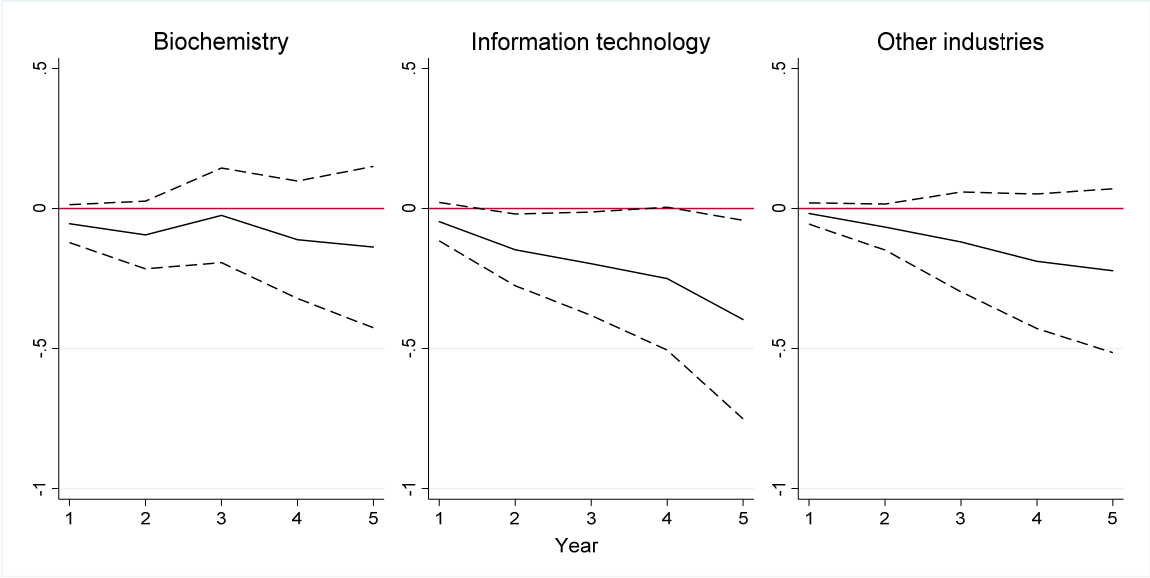


Figure 7. Effects of Examination Time on Startup Growth and Funding by Industry.
The figure plots the estimated effects of patent scope as measured by count of claims on employment growth (Panel A), sales growth (Panel B), and venture capital funding (Panel C) over the five years following the first-action decision on a startup's first patent application. Specifically, the solid line shows the estimated first-action examination effect obtained by estimating equation (1) by 2SLS separately over horizons from one to five years after the first-action date. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. Patents are grouped into industries based on assignment to USPTO technology centers. Biochemistry patents are classified as patents assigned to technology centers 16 or 17, while information technology patents are classified as patents assigned to technology centers 21, 24, 26, and 28. The dashed lines show 95% confidence intervals. The results underlying these figures are presented in Tables IA.6-IA.11.

Panel A. Employment growth.



Panel B. Sales growth.

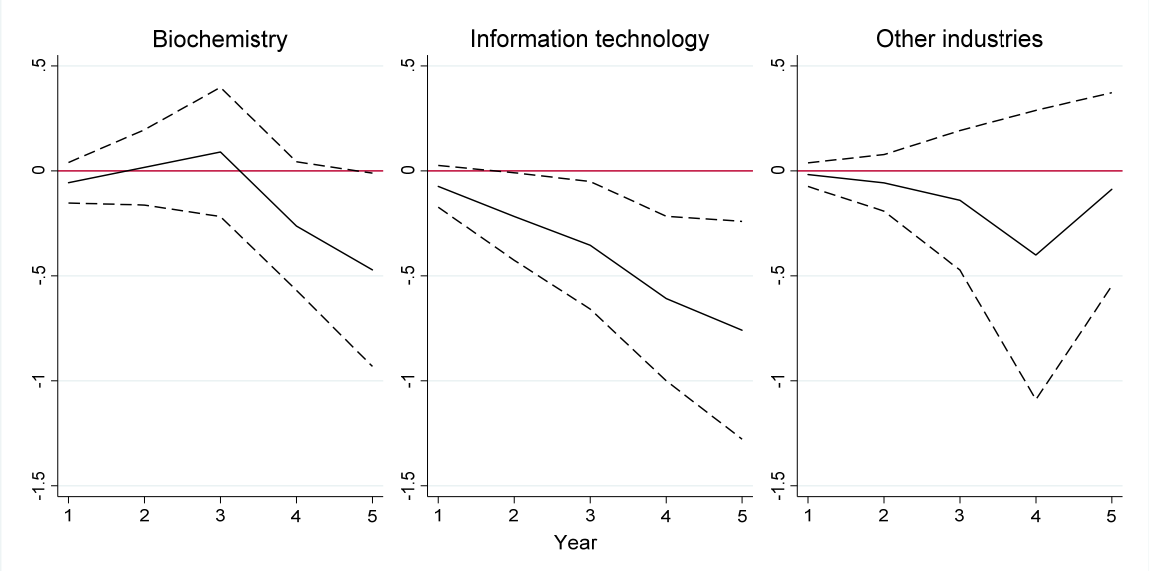


Figure 7 (cont.)

Panel C. Venture capital funding.

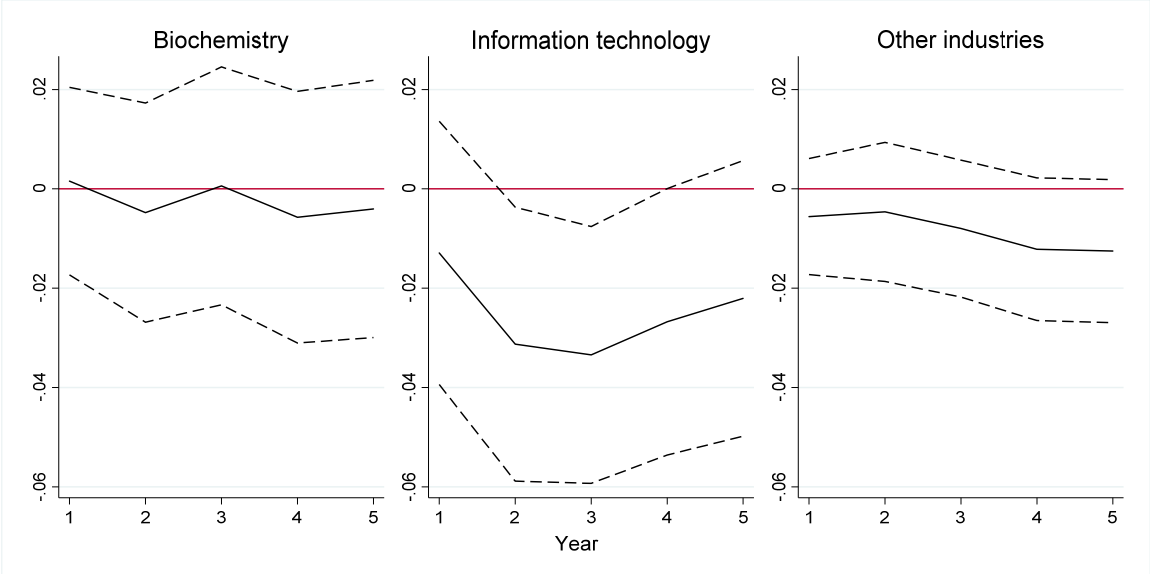


Figure 8. Effects of Scope and Examination Time on Follow-On Innovation by Industry.
The figure plots the estimated effects of patent scope as measured by count of claims and first-action examination time on follow-on innovation measures by industry. Specifically, the markers show point estimates for the effect of first-action examination time and patent scope and the lines represent 95% confidence intervals. Estimates are obtained by estimating equation (1) by 2SLS for a number of measures of follow-on innovation. We use examiner leniency with respect to scope of the examiner reviewing each patent application as an instrument for patent scope. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for an application's first-action examination time. Patents are grouped into industries based on assignment to USPTO technology centers. Biochemistry patents are classified as patents assigned to technology centers 16 or 17, while information technology patents are classified as patents assigned to technology centers 21, 24, 26, and 28. Markers show point estimates and lines show 95% confidence intervals. The results underlying these figures are presented in Tables IA.12-IA.14.

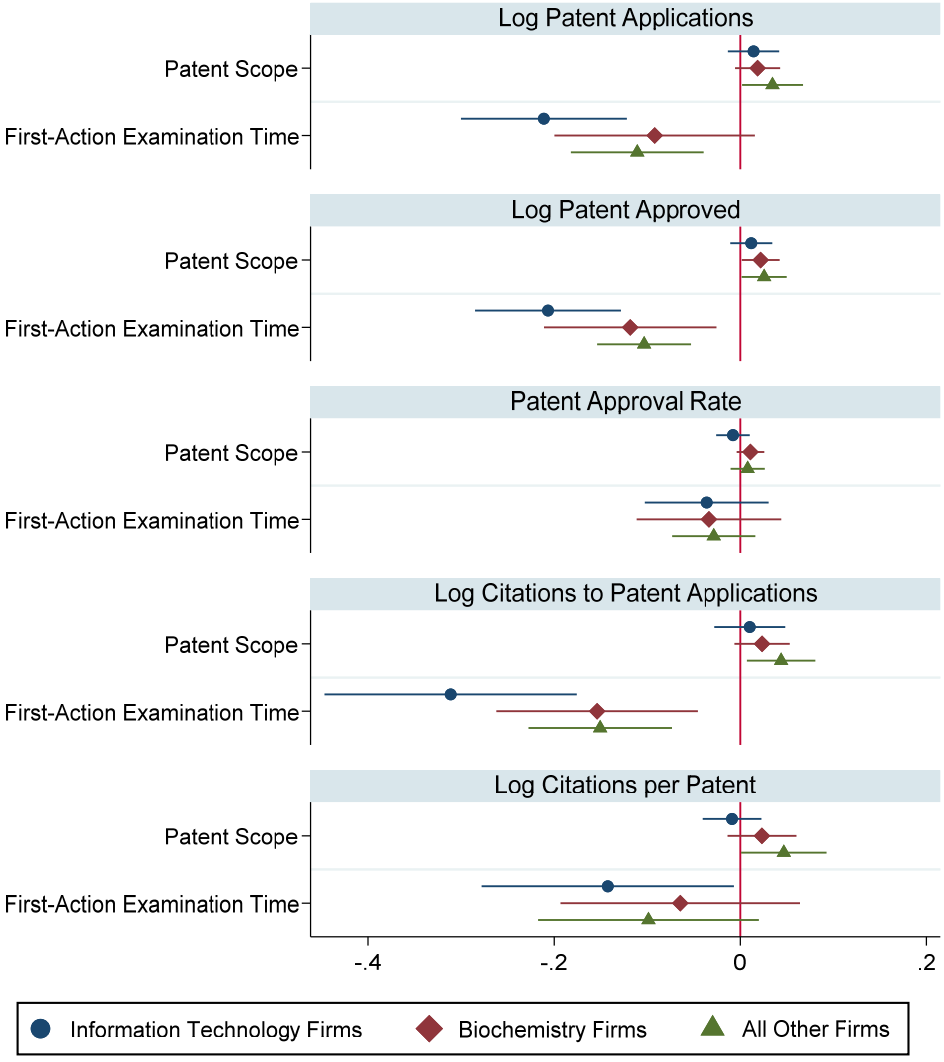
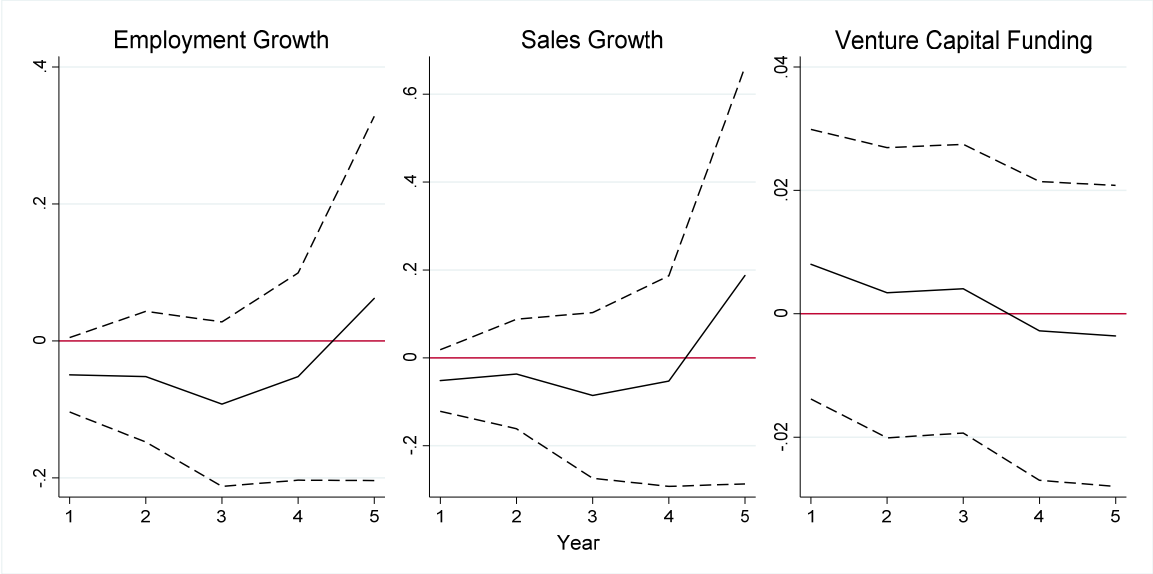


Figure 9. Effects of Examination Time for Rejected Applications on Growth, Funding, and Follow-on Innovation

The figure plots the estimated effects of first-action examination time for patents that are ultimately rejected on follow-on innovation measures. Specifically, the markers show point estimates for the effect of first-action examination time and the lines represent 95% confidence intervals. Estimates are obtained by estimating equation (1) by 2SLS for a number of measures of follow-on innovation. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for an application's first-action examination time. Markers show point estimates and lines show 95% confidence intervals. The results underlying these figures are presented Tables IA.15-17.

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



Panel B. IPO filing and follow-on innovation.

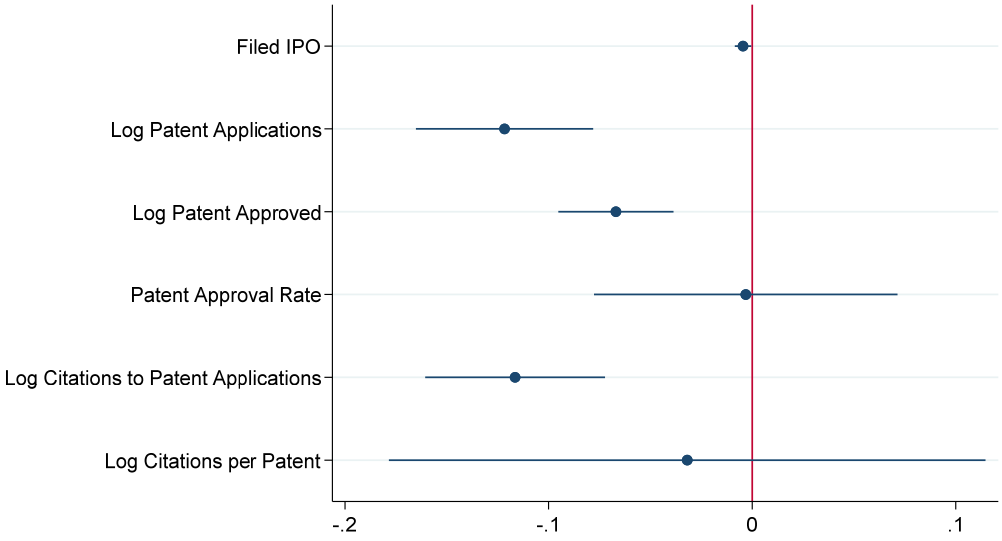


Table 1. Summary Statistics.

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		22,050
Count of claims	mean	21.1
	median	18
	st.dev.	*17.6*
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	29.5
	median	8
	st.dev.	*61.8*
Sales at first-action ($ million)	mean	4.3
	median	0.8
	st.dev.	*9.9*
Pre-patent-filing employment growth (%)	mean	16.2
	st.dev.	*68.8*
Pre-patent-filing sales growth (%)	mean	20.1
	st.dev.	*88*
Panel B. Subsequent growth in employment and sales (%)		
… 1 year	mean	6.6
	st.dev.	*50.1*
… 3 years	mean	19.3
	st.dev.	*122.5*
… 5 years	mean	24.8
	st.dev.	*159.9*
… 1 year	mean	11.2
	st.dev.	*74.2*
… 3 years	mean	34.4
	st.dev.	*184.8*
… 5 years	mean	50.4
	st.dev.	*257.1*
Panel C. Subsequent patenting: patent applications filed after first-action decision		
No. subsequent patent applications	mean	3.1
	st.dev.	*11.9*
No. subsequent approved patents	mean	1.8
	st.dev.	*7.6*
Approval rate of subsequent patent applications (%)		70.5
Total citations to all subsequent patent applications	mean	8.4
	st.dev.	*78*
Average citations-per-patent to subsequent approved patents	mean	2
	st.dev.	*3.8*
Panel D. Subsequent VC funding and IPOs		
% of startups that raise VC funding after first-action		8.1
% 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 equation (4) of our 2SLS analysis considering patent scope. The first stage uses the leniency with respect to patent scope 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 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. 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.

	Count of claims				
	(1)	(2)	(3)	(4)	(5)
IV: examiner leniency w.r.t. scope	0.347***	0.310***	0.347***	0.317***	0.386***
	0.053	*0.059*	*0.064*	*0.082*	*0.087*
Applicant characteristics					
ln(employees at first-action)		-0.200			
		0.180			
ln(1 + sales at first-action)		0.018			
		0.137			
employment growth at first action			-0.243		
			0.425		
sales growth at first action			0.426		
			0.343		
Examiner characteristics					
ln(examiner experience)					0.846***
					0.321
examiner grade GS-9					0.277
					0.952
examiner grade GS-11					-0.480
					0.934
examiner grade GS-12					-0.179
					1.160
examiner grade GS-13					-0.279
					0.989
examiner grade GS-14					0.167
					1.154
examiner grade GS-15					-0.043
					1.731
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	16.5%	20.7%	23.3%	35.2%	35.3%
F-test: IV = 0	43.6***	27.6***	28.2***	15.0***	20.0***
No. of observations (firms)	21,580	13,825	11,116	16,306	16,300

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

The table reports the results of estimating various versions of the first-stage equation (5) of our 2SLS analysis considering examination time. The first stage uses the examiner average first-action examination time plus 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 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 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. 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 first-action time + docket date lag	0.527***	0.522***	0.532***	0.516***	0.530***
	0.014	*0.015*	*0.016*	*0.017*	*0.018*
Applicant characteristics					
ln(employees at first-action)		-0.000			
		0.007			
ln(1 + sales at first-action)		-0.007			
		0.006			
employment growth at first action			-0.011		
			0.016		
sales growth at first action			0.005		
			0.013		
Examiner characteristics					
ln(examiner experience)					0.044***
					0.013
examiner grade GS-9					-0.072**
					0.034
examiner grade GS-11					-0.089**
					0.036
examiner grade GS-12					-0.162***
					0.040
examiner grade GS-13					-0.162***
					0.039
examiner grade GS-14					-0.094**
					0.045
examiner grade GS-15					-0.198***
					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%	64.3%	64.9%	73.8%	74.0%
F-test: IV = 0	1344.3***	1228.1***	1132.4***	873.7***	881.8***
No. of observations (firms)	21,799	13,967	11,232	16,497	16,491

Table 3, Panel A. Instrument Validity: Examiner Leniency with Respect to Patent Scope.

The table reports the results of regressing the leniency with respect to scope 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. 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 (two-sided), respectively.

	IV: Examiner leniency with respect to scope			
	(1)	(2)	(3)	(4)
Applicant characteristics				
ln(employees at filing date)	0.035			
	0.032			
ln(1 + sales at filing date)	-0.049			
	0.025			
employment growth during year prior to filing date		-0.058		
		0.085		
sales growth during year prior to filing date		0.023		
		0.072		
Approval by foreign patent office				
European Patent Office			-0.034	
			0.103	
Japanese Patent Office				0.049
				0.143
Fixed effects				
art unit × year	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes
Diagnostics				
R^2	59.9%	60.5%	61.6%	63.5%
No. of observations (firms)	20,011	17,426	5,324	2,720

Table 3, Panel B. Instrument Validity: Examiner Average Application Lag.

The table reports the results of regressing the examiner average first-action examination time 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. 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 (two-sided), respectively.

	IV: Examiner average first-action time + docket date lag			
	(1)	(2)	(3)	(4)
Applicant characteristics				
ln(employees at filing date)	-0.005			
	0.005			
ln(1 + sales at filing date)	0.001			
	0.005			
employment growth during year		-0.001		
prior to filing date		*0.012*		
sales growth during year prior		0.003		
to filing date		*0.010*		
Approval by foreign patent office				
European Patent Office			-0.030	
			0.020	
Japanese Patent Office				-0.045
				0.027
Fixed effects				
art unit × year	Yes	Yes	Yes	Yes
HQ state	Yes	Yes	Yes	Yes
Diagnostics				
R^2	63.7%	64.2%	65.7%	66.0%
No. of observations (firms)	20,121	17,522	5,350	2,729

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

Panels A and B report the results of estimating equation (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. 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 columns report 2SLS results using examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. NETS data are available through 2011, resulting in reduced sample sizes as we widen the window from one to five years. (Specifically, the one- and two-year estimates are available for all startups matched to NETS, while the three-, four-, and five-year estimates are only available for firms that received a first-action decision by the end of 2008, 2007, and 2006, respectively.) 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. All specifications include art-unit-by-year and headquarter-state fixed effects and a control for the average word count per claim in the granted patent. 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 claims	0.000	0.010	0.011	0.026	0.011
	0.005	*0.010*	*0.020*	*0.020*	*0.021*
First-action examination time	-0.038**	-0.106***	-0.130***	-0.189***	-0.258***
	0.015	*0.029*	*0.048*	*0.066*	*0.089*
Diagnostics					
Underidentification test	25.6***	25.6***	19.1***	18.3***	12.1***
Unconditional mean of dep. variable	6.6%	14.9%	19.3%	23.6%	24.8%
No. of observations (firms)	13,628	13,628	12,108	10,390	8,810
Panel B. Sales growth					
Count of claims	0.001	0.008	-0.006	0.046	-0.026
	0.008	*0.016*	*0.031*	*0.048*	*0.035*
First-action examination time	-0.045**	-0.108**	-0.156*	-0.367***	-0.399***
	0.023	*0.046*	*0.084*	*0.123*	*0.140*
Diagnostics					
Underidentification test	25.1***	25.1***	18.7***	18.1***	12.0***
Unconditional mean of dep. variable	11.2%	24.1%	34.4%	45.0%	50.4%
No. of observations (firms)	13,606	13,608	12,097	10,387	8,808
Panel C. Survival					
Count of claims	0.000	0.003	0.000	0.002	0.003
	0.002	*0.003*	*0.004*	*0.004*	*0.006*
First-action examination time	-0.015***	-0.036***	-0.040***	-0.041***	-0.038*
	0.006	*0.010*	*0.012*	*0.016*	*0.020*
Diagnostics					
Underidentification test	25.6***	25.6***	19.1***	18.3***	12.1***
Unconditional mean of dep. variable	95.6%	90.9%	86.6%	83.5%	79.6%
No. of observations (firms)	13,628	13,628	12,108	10,390	8,810

Table 5. Effects of Patent Scope and Examination Time On Startup Access to VC Funding and the IPO Market.

The table reports the results of estimating equation (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 and include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. We use examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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? (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 claims	0.000	0.001	0.001	0.002	0.003	0.002**
	0.001	*0.002*	*0.002*	*0.002*	*0.002*	*0.001*
First-action examination time	-0.007	-0.012**	-0.014**	-0.015**	-0.013**	-0.006***
	0.005	*0.006*	*0.006*	*0.006*	*0.006*	*0.002*
Log (1 + no. prior VC rounds)	0.300***	0.426***	0.471***	0.482***	0.487***	0.043***
	0.012	*0.012*	*0.012*	*0.012*	*0.012*	*0.006*
Diagnostics						
Underidentification test	38.2***	38.2***	38.2***	38.1***	38.0***	37.1***
Mean of dep. variable	4.4%	6.4%	7.2%	7.6%	7.8%	0.79%
Median no. months from first-action to VC round or IPO for successful applicants	5.5	9.2	11.3	13.0	14.1	62.6
No. of observations (firms)	21,530	21,487	21,445	21,413	21,391	21,569

Table 6. Effects of Patent Scope and Examination Time On Follow-on Innovation.

The table reports the results of estimating equation (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 USPTO internal databases and include all applications that receive a final decision through December 31, 2013. 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. For variable definitions and further details of their construction see the Appendix. All specifications are estimated by 2SLS and include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. We use examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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 approved patents) (5)
Count of claims	0.026***	0.022***	0.005	0.031***	0.021**
	0.009	*0.007*	*0.005*	*0.011*	*0.010*
First-action examination time	-0.139***	-0.138***	-0.035**	-0.201***	-0.097***
	0.025	*0.020*	*0.016*	*0.031*	*0.035*
Diagnostics					
Underidentification test	37.0***	37.0***	22.5***	37.0***	21.4***
Uncond. mean of non-logged dep. var.	3.1	1.8	70.5%	8.4	2.0
No. of observations (firms)	21,569	21,569	9,688	21,569	7,980

Table 7. Effects of Patent Scope and Examination Time in a Second Patent Application On Startup Growth.

Panels A and B report the results of estimating equation (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. For startups that die, we set the growth rate to –100% in the year of exit. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panel A controls for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All columns report 2SLS results using examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. NETS data are available through 2011, resulting in reduced sample sizes as we widen the window from one to five years. (Specifically, the one- and two-year estimates are available for all startups matched to NETS, while the three-, four-, and five-year estimates are only available for firms that received a first-action decision by the end of 2008, 2007, and 2006, respectively.) 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. All specifications include art-unit-by-year and headquarter-state fixed effects and a control for the average word count per claim in the granted patent. 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 claims	-0.003	0.016	0.019	0.022	0.031
	0.007	*0.025*	*0.030*	*0.031*	*0.044*
First-action examination time	-0.104*	-0.180*	-0.177	-0.384	-0.136
	0.058	*0.104*	*0.199*	*0.242*	*0.408*
Diagnostics					
Underidentification test	14.3***	14.3***	11.1***	16.0***	10.0***
Unconditional mean of dep. variable	8.2%	16.5%	22.0%	25.2%	24.7%
No. of observations (firms)	5,316	5,316	4,507	3,628	2,832
Panel B. Sales growth					
Count of claims	0.003	0.028	0.025	0.055	0.084
	0.013	*0.031*	*0.044*	*0.046*	*0.069*
First-action examination time	-0.220***	-0.420**	-0.396	-0.715	0.019
	0.082	*0.179*	*0.385*	*0.482*	*0.880*
Diagnostics					
Underidentification test	15.9***	15.9***	11.1***	15.9***	9.7***
Unconditional mean of dep. variable	15.0%	32.7%	49.4%	58.5%	68.5%
No. of observations (firms)	5,305	5,306	4,502	3,627	2,831

Table 8. Effects of Patent Scope and Examination Time in a Second Patent Application on Follow-on Innovation.

The table reports the results of estimating equation (1) to examine how the scope and timing of a startup's second patent application affects the startup's follow-on innovation. Data on subsequent applications come from the USPTO internal databases and include all applications that receive a final decision through December 31, 2013. 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. For variable definitions and further details of their construction see the Appendix. All specifications are estimated by 2SLS and include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. We use examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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 approved patents) (5)
Count of claims	0.029*	0.026*	0.002	0.046**	0.023
	0.017	*0.014*	*0.006*	*0.022*	*0.019*
First-action examination time	-0.096	-0.108	0.017	-0.148	-0.070
	0.089	*0.077*	*0.036*	*0.122*	*0.090*
Diagnostics					
Underidentification test	13.3***	13.3***	5.8**	13.3***	4.0**
Uncond. mean of non-logged dep. var.	1.8	0.9	66.6%	4.7	2.1
No. of observations (firms)	7,770	7,770	4,362	7,770	3,682

Table 9. Effects of Patent Scope and Examination Time on Industry Growth and Survival.

Panels A and B report the results of estimating a revised version of equation (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 USPTO 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 columns report 2SLS results using examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. All specifications include art-unit-by-year and headquarter-state fixed effects and a control for the average word count per claim in the granted patent. In addition, we include fixed effects for subclass and the year of first-action. 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 claims	-0.001	-0.001	-0.002	-0.002	-0.001
	0.001	*0.001*	*0.002*	*0.002*	*0.002*
First-action examination time	-0.003	-0.007	0.005	0.006	0.002
	0.007	*0.009*	*0.014*	*0.017*	*0.018*
Diagnostics					
Underidentification test	61.0***	61.0***	53.0***	61.3***	63.1***
Unconditional mean of dep. variable	3.4%	6.6%	10.2%	14.8%	18.4%
No. of observations	12,903	12,903	11,440	9,713	8,151
Panel B. Sales growth					
Count of claims	0.001	0.001	-0.001	-0.001	-0.001
	0.001	*0.002*	*0.002*	*0.003*	*0.003*
First-action examination time	-0.010	-0.019	-0.002	-0.015	-0.018
	0.008	*0.012*	*0.017*	*0.021*	*0.024*
Diagnostics					
Underidentification test	61.0***	61.0***	53.0***	61.3***	63.1***
Unconditional mean of dep. variable	4.8%	9.3%	15.5%	22.6%	29.1%
No. of observations	12,903	12,903	11,440	9,713	8,151
Panel C. Survival					
Count of claims	0.000	0.000	0.000	-0.000	0.000
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
First-action examination time	0.001	0.000	0.001	0.000	0.000
	0.001	*0.002*	*0.003*	*0.003*	*0.003*
Diagnostics					
Underidentification test	61.4***	61.4***	53.3***	61.9***	63.3***
Unconditional mean of dep. variable	95.9%	91.3%	87.6%	85.5%	82.8%
No. of observations	12,758	12,758	11,325	9,643	8,106

Table 10. Effects of Patent 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 equation (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 USPTO 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 USPTO technology subclass that go public after the first-action decision on the focal patent. All specifications are estimated by 2SLS and include fixed effects for subclass and the year of first-action. We use examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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 claims	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
First-action examination time	-0.003***	-0.004***	-0.004***	-0.005***	-0.005***	0.000
	0.001	*0.001*	*0.001*	*0.001*	*0.001*	*0.000*
Diagnostics						
Underidentification test	61.0***	61.0***	61.0***	61.0***	61.0***	61.0***
Mean of dep. variable	3.4%	5.0%	5.7%	6.1%	6.3%	0.65%
No. of observations	12,780	12,780	12,780	12,780	12,780	12,780

Table 11. Effects of Patent Scope and Examination Time On Follow-on Innovation in the Industry.

The table reports the results of estimating a revised version of equation (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 USPTO internal databases and include all applications that receive a final decision through December 31, 2013. 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 USPTO technology subclass as the focal patent; the focal startup is excluded in this calculation. All specifications are estimated by 2SLS and include fixed effects for subclass and the year of first-action. We use examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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 approved patents) (5)
Count of claims	-0.003	-0.005***	-0.002***	-0.010**	-0.004**
	0.002	*0.002*	*0.001*	*0.004*	*0.002*
First-action examination time	0.000	0.012	0.012***	-0.021	-0.008
	0.013	*0.015*	*0.004*	*0.032*	*0.015*
Diagnostics					
Underidentification test	53.1***	53.1***	53.9***	58.1***	58.2***
Uncond. mean of non-logged dep. var.	137.6	70.1	53.4%	249.1	2.8
No. of observations	7,454	7,454	7,334	6,055	5,910

INTERNET APPENDIX

for

Quick and Dirty Patents

Deepak Hegde[†]
New York University

Alexander Ljungqvist
Stockholm School of Economics, Swedish House of Finance, and CEPR

Manav Raj
New York University

January 05, 2020

(NOT INTENDED FOR PUBLICATION)

[†] Author addresses: dhegde@stern.nyu.edu. alexander.ljungqvist@hhs.se, and mraj@stern.nyu.edu.

Table IA.1. Effects of Patent Scope and Examination Time on Growth and Survival: OLS Results.

The table reports the results of estimating equation (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, with the only difference being that we use OLS instead of 2SLS. 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 claims	0.000	0.001	0.001	0.002**	0.003**
	0.000	*0.001*	*0.001*	*0.001*	*0.001*
First-action examination time	-0.024***	-0.078***	-0.123***	-0.146***	-0.153***
	0.007	*0.013*	*0.022*	*0.027*	*0.038*
Diagnostics					
R^2	16.5%	17.7%	18.1%	19.0%	18.6%
Unconditional mean of dep. variable	6.6%	14.9%	19.3%	23.6%	24.8%
No. of observations (firms)	13,628	13,628	12,108	10,390	8,810
Panel B. Sales growth					
Count of claims	0.000	0.001	0.001	0.004**	0.004**
	0.000	*0.001*	*0.001*	*0.002*	*0.002*
First-action examination time	-0.028***	-0.065***	-0.118***	-0.173***	-0.218***
	0.010	*0.018*	*0.030*	*0.039*	*0.055*
Diagnostics					
R^2	15.8%	17.5%	18.7%	18.0%	18.4%
Unconditional mean of dep. variable	11.2%	24.1%	34.4%	45.0%	50.4%
No. of observations (firms)	13,606	13,608	12,097	10,387	8,808
Panel C. Survival					
Count of claims	-0.000	-0.000*	-0.000*	0.000	-0.000
	0.000	*0.000*	*0.000*	*0.000*	*0.000*
First-action examination time	-0.005**	-0.014***	-0.012**	-0.002	0.002
	0.003	*0.004*	*0.005*	*0.007*	*0.009*
Diagnostics					
R^2	16.7%	16.9%	17.6%	17.7%	17.2%
Unconditional mean of dep. variable	95.6%	90.9%	86.6%	83.5%	79.6%
No. of observations (firms)	13,687	13,687	12,163	10,437	8,848

Table IA.2. Effects of Patent Scope and Examination Time On Startup Access to VC Funding and the IPO Market. OLS Results

The table reports the results of estimating equation (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 6, with the only difference being that we use OLS instead of 2SLS. 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? (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 claims	-0.000	0.000*	0.000***	0.000***	0.000***	0.000
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
First-action examination time	-0.012***	-0.016***	-0.018***	-0.021***	-0.020***	-0.003***
	0.002	*0.002*	*0.003*	*0.003*	*0.003*	*0.001*
Log (1 + no. prior VC rounds)	0.301***	0.427***	0.472***	0.485***	0.491***	0.046***
	0.011	*0.012*	*0.011*	*0.011*	*0.011*	*0.006*
Diagnostics						
R^2	40.2%	49.8%	52.9%	53.1%	52.8%	19.3%
Mean of dep. variable	4.4%	6.4%	7.2%	7.6%	7.8%	0.79%
Median no. months from first-action to VC round or IPO for successful applicants	5.5	9.2	11.3	13.0	14.1	62.6
No. of observations (firms)	21,530	21,487	21,445	21,413	21,391	21,569

Table IA.3. Effects of Patent Scope and Examination Time On Follow-on Innovation. OLS Results

The table reports the results of estimating equation (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 5, with the only difference being that we use OLS instead of 2SLS. 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 approved patents) (5)
Count of claims	0.005***	0.004***	0.000*	0.006***	0.003***
	0.000	*0.000*	*0.000*	*0.001*	*0.001*
First-action examination time	-0.153***	-0.134***	0.005	-0.218***	-0.115***
	0.013	*0.011*	*0.007*	*0.016*	*0.015*
Diagnostics					
R^2	22.1%	21.1%	19.4%	24.1%	32.2%
Uncond. mean of non-logged dep. var.	3.1	1.8	70.5%	8.4	2.0
No. of observations (firms)	21,648	21,648	9,729	21,647	8,011

Table IA.4. Effects of Patent Scope and Examination Time On Startup Growth Conditional on Survival.

Panels A and B report the results of estimating equation (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 conditional on the survival of the firm. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panel A controls for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All columns report 2SLS results using examiner leniency with respect to scope as an instrument for the total count of allowed independent and dependent claims and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. NETS data are available through 2011, resulting in reduced sample sizes as we widen the window from one to five years. (Specifically, the one- and two-year estimates are available for all startups matched to NETS, while the three-, four-, and five-year estimates are only available for firms that received a first-action decision by the end of 2008, 2007, and 2006, respectively.) 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. All specifications include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. 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 claims	-0.000	0.006	0.011	0.027	0.013
	0.006	*0.010*	*0.020*	*0.019*	*0.019*
First-action examination time	-0.021	-0.071**	-0.094*	-0.187**	-0.241**
	0.015	*0.030*	*0.050*	*0.074*	*0.104*
Diagnostics					
Underidentification test	24.9***	27.3***	19.8***	18.8***	14.7***
Unconditional mean of dep. variable	10.1%	23.5%	34.0%	44.0%	52.4%
No. of observations (firms)	13,157	12,626	10,704	8,862	7,152
Panel B. Sales growth					
Count of claims	0.001	0.002	-0.007	0.042	-0.027
	0.009	*0.016*	*0.033*	*0.048*	*0.033*
First-action examination time	-0.026	-0.069	-0.095	-0.362**	-0.384**
	0.024	*0.049*	*0.092*	*0.142*	*0.172*
Diagnostics					
Underidentification test	24.3***	26.6***	19.3***	18.4***	14.5***
Unconditional mean of dep. variable	14.9%	33.4%	51.0%	68.8%	83.7%
No. of observations (firms)	13,135	12,605	10,691	8,859	7,150

Table IA.5. Effects of Patent Scope and Examination Time On Startup Growth Conditional on Survival. OLS Results

The table reports the results of estimating equation (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 conditional on the survival of the firm. The analysis here is analogous to Table IA.4, with the only difference being that we use OLS instead of 2SLS. 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 claims	0.000	0.001*	0.001	0.002**	0.003**
	0.000	*0.001*	*0.001*	*0.001*	*0.001*
First-action examination time	-0.017***	-0.061***	-0.119***	-0.167***	-0.177***
	0.007	*0.014*	*0.023*	*0.030*	*0.042*
Diagnostics					
R^2	16.9%	19.1%	20.6%	22.5%	23.2%
Unconditional mean of dep. variable	10.1%	23.5%	34.0%	44.0%	52.4%
No. of observations (firms)	13,214	12,682	10,749	8,900	7,179
Panel B. Sales growth					
Count of claims	0.000	0.001	0.001	0.004**	0.004**
	0.000	*0.001*	*0.001*	*0.002*	*0.002*
First-action examination time	-0.023**	-0.047**	-0.112***	-0.195***	-0.257***
	0.010	*0.020*	*0.032*	*0.045*	*0.062*
Diagnostics					
R^2	15.9%	18.9%	21.3%	21.4%	22.5%
Unconditional mean of dep. variable	14.9%	33.4%	51.0%	68.8%	83.7%
No. of observations (firms)	13,191	12,661	10,736	8,897	7,177

Table IA.6. Effects of Patent Scope and Examination Time on Startup Growth: IT Firms.

The table reports the results of estimating equation (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 information technology firms (classified based on patent applications to the USPTO technology centers 21, 24, 26, and 28). The analysis here is analogous to Table 4, with the only difference being that we use a sample of IT firms. 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 claims	0.013	0.024	0.003	0.008	-0.035
	0.009	*0.018*	*0.025*	*0.029*	*0.054*
First-action examination time	-0.047	-0.148**	-0.197**	-0.251*	-0.397**
	0.035	*0.065*	*0.094*	*0.129*	*0.180*
Diagnostics					
Underidentification test	12.6***	12.6***	7.7***	9.8***	3.5*
Unconditional mean of dep. variable	7.8%	17.3%	22.3%	27.2%	28.0%
No. of observations (firms)	4,762	4,762	4,237	3,578	2,985
Panel B. Sales growth					
Count of claims	0.008	0.029	-0.023	-0.008	-0.051
	0.014	*0.028*	*0.041*	*0.055*	*0.092*
First-action examination time	-0.074	-0.217**	-0.354**	-0.608***	-0.759***
	0.050	*0.106*	*0.154*	*0.198*	*0.263*
Diagnostics					
Underidentification test	12.2***	12.2***	7.4***	9.5***	3.3*
Unconditional mean of dep. variable	12.7%	27.3%	38.3%	50.1%	58.4%
No. of observations (firms)	4,756	4,756	4,233	3,576	2,984

Table IA.7. Effects of Patent Scope and Examination Time on Startup Growth: Biochemistry Firms.

The table reports the results of estimating equation (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 biochemistry firms (classified based on patent applications to the USPTO technology centers 16 and 17). The analysis here is analogous to Table 4, with the only difference being that we use a sample of biochemistry firms. 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 claims	-0.003	0.028	0.016	0.029	0.024
	0.008	*0.020*	*0.025*	*0.033*	*0.032*
First-action examination time	-0.054	-0.095	-0.025	-0.112	-0.138
	0.034	*0.061*	*0.085*	*0.105*	*0.145*
Diagnostics					
Underidentification test	8.4***	8.4***	7.9***	5.6**	3.9**
Unconditional mean of dep. variable	8.4%	18.5%	22.2%	28.1%	28.3%
No. of observations (firms)	2,339	2,339	2,071	1,807	1,563
Panel B. Sales growth					
Count of claims	0.007	0.027	-0.013	0.011	-0.002
	0.013	*0.026*	*0.030*	*0.044*	*0.047*
First-action examination time	-0.057	0.016	0.090	-0.263*	-0.471**
	0.049	*0.090*	*0.155*	*0.154*	*0.231*
Diagnostics					
Underidentification test	8.3***	8.3***	7.9***	5.5**	3.9**
Unconditional mean of dep. variable	13.3%	26.0%	35.1%	45.1%	52.1%
No. of observations (firms)	2,337	2,337	2,070	1,807	1,563

Table IA.8. Effects of Patent Scope and Examination Time on Startup Growth: Other Firms.

The table reports the results of estimating equation (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 all other firms (classified based on patent applications to the USPTO technology centers 36 and 37). The analysis here is analogous to Table 4, with the only difference being that we use a sample of other firms. 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 claims	-0.008	-0.013	0.013	0.047	0.036
	0.010	*0.017*	*0.043*	*0.048*	*0.034*
First-action examination time	-0.018	-0.066	-0.119	-0.189	-0.222
	0.019	*0.041*	*0.090*	*0.121*	*0.148*
Diagnostics					
Underidentification test	6.9***	6.9***	5.1**	4.2**	5.1**
Unconditional mean of dep. variable	4.9%	11.7%	15.9%	19.2%	21.0%
No. of observations (firms)	6,526	6,526	5,798	5,002	4,258
Panel B. Sales growth					
Count of claims	-0.010	-0.029	0.005	0.134	-0.034
	0.015	*0.031*	*0.070*	*0.148*	*0.051*
First-action examination time	-0.018	-0.057	-0.140	-0.401	-0.088
	0.028	*0.068*	*0.168*	*0.347*	*0.232*
Diagnostics					
Underidentification test	6.7***	6.7***	5.0**	4.2**	5.1**
Unconditional mean of dep. variable	9.3%	20.8%	31.1%	41.0%	43.8%
No. of observations (firms)	6,512	6,514	5,792	5,001	4,257

Table IA.9. Effects of Patent Scope and Examination Time on Access to VC Funding and the IPO Market: IT Firms.

The table reports the results of estimating equation (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 for information technology firms (classified based on patent applications to the USPTO technology centers 21, 24, 26, and 28). The analysis here is analogous to Table 5, with the only difference being that we use a sample of IT firms. 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? (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 claims	-0.002	-0.002	-0.001	0.000	0.000	0.001
	0.003	*0.004*	*0.004*	*0.004*	*0.004*	*0.001*
First-action examination time	-0.013	-0.031**	-0.033**	-0.027*	-0.022	-0.006
	0.013	*0.014*	*0.013*	*0.014*	*0.014*	*0.005*
Log (1 + no. prior VC rounds)	0.308***	0.430***	0.469***	0.479***	0.487***	0.029***
	0.016	*0.016*	*0.015*	*0.015*	*0.015*	*0.006*
Diagnostics						
Underidentification test	14.4***	14.4***	14.0***	13.9***	14.1***	14.3***
Mean of dep. variable	8.1%	11.3%	12.6%	13.1%	13.4%	0.91%
Median no. months from first-action to VC round or IPO for successful applicants	5.0	7.2	8.3	8.8	9.1	51.6
No. of observations (firms)	7,170	7,151	7,124	7,110	7,101	7,194

Table IA.10. Effects of Patent Scope and Examination Time on Access to VC Funding and the IPO Market: Biochemistry Firms.

The table reports the results of estimating equation (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 for biochemistry firms (classified based on patent applications to the USPTO technology centers 16 and 17). The analysis here is analogous to Table 5, with the only difference being that we use a sample of biochemistry firms. 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? (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 claims	-0.001	-0.002	-0.002	-0.000	-0.000	0.004**
	0.002	*0.003*	*0.003*	*0.003*	*0.003*	*0.002*
First-action examination time	0.002	-0.005	0.001	-0.006	-0.004	-0.012
	0.010	*0.011*	*0.012*	*0.013*	*0.013*	*0.008*
Log (1 + no. prior VC rounds)	0.304***	0.424***	0.480***	0.488***	0.496***	0.089***
	0.025	*0.029*	*0.030*	*0.029*	*0.030*	*0.020*
Diagnostics						
Underidentification test	12.3***	12.3***	12.7***	12.6***	12.6***	12.0***
Mean of dep. variable	4.3%	6.5%	7.3%	7.8%	8.2%	1.8%
Median no. months from first-action to VC round or IPO for successful applicants	5.5	8.6	10.0	10.5	11.4	69.4
No. of observations (firms)	3,608	3,597	3,592	3,583	3,579	3,613

Table IA.11. Effects of Patent Scope and Examination Time on Access to VC Funding and the IPO Market: Other Firms.

The table reports the results of estimating equation (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 for all other firms (classified based on patent applications to the USPTO technology centers 36 and 37). The analysis here is analogous to Table 5, with the only difference being that we use a sample of other firms. 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? (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 claims	0.002	0.004	0.004	0.006	0.006	-0.000
	0.002	*0.004*	*0.004*	*0.004*	*0.004*	*0.001*
First-action examination time	-0.006	-0.005	-0.008	-0.012*	-0.013*	-0.004**
	0.006	*0.007*	*0.007*	*0.007*	*0.007*	*0.002*
Log (1 + no. prior VC rounds)	0.275***	0.415***	0.467***	0.483***	0.480***	0.052***
	0.024	*0.028*	*0.027*	*0.028*	*0.028*	*0.012*
Diagnostics						
Underidentification test	12.6***	12.6***	12.6***	12.5***	12.3***	12.1***
Mean of dep. variable	1.9%	3.0%	3.5%	3.7%	3.8%	0.37%
Median no. months from first-action to VC round or IPO for successful applicants	5.8	9.5	10.8	12.0	12.5	49.4
No. of observations (firms)	10,751	10,738	10,728	10,719	10,710	10,761

Table IA.12. Effects of Patent Scope and Examination Time on Follow-on Innovation: IT Firms.

The table reports the results of estimating equation (1) to examine how the scope and timing of a startup's first granted patent examine how the scope and timing of a startup's first granted patent affects the startup's follow-on innovation for information technology firms (classified based on patent applications to the USPTO technology centers 21, 24, 26, and 28). The analysis here is analogous to Table 6, with the only difference being that we use a sample of IT firms. 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 approved patents) (5)
Count of claims	0.014	0.012	-0.008	0.010	-0.009
	0.014	*0.011*	*0.009*	*0.019*	*0.016*
First-action examination time	-0.211***	-0.207***	-0.036	-0.311***	-0.142**
	0.045	*0.040*	*0.034*	*0.069*	*0.069*
Diagnostics					
Underidentification test	14.1***	14.1***	9.2***	14.1***	12.0***
Uncond. mean of non-logged dep. var.	4.1	2.5	75.3%	13.7	2.8
No. of observations (firms)	7,194	7,194	3,463	7,194	2,978

Table IA.13. Effects of Patent Scope and Examination Time on Follow-on Innovation: Biochemistry Firms.

The table reports the results of estimating equation (1) to examine how the scope and timing of a startup's first granted patent examine how the scope and timing of a startup's first granted patent affects the startup's follow-on innovation for biochemistry firms (classified based on patent applications to the USPTO technology centers 16 and 17). The analysis here is analogous to Table 6, with the only difference being that we use a sample of biochemistry firms. 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 approved patents) (5)
Count of claims	0.019	0.022**	0.011	0.023	0.023
	0.012	*0.010*	*0.007*	*0.015*	*0.019*
First-action examination time	-0.092*	-0.118**	-0.034	-0.154***	-0.064
	0.054	*0.047*	*0.039*	*0.055*	*0.065*
Diagnostics					
Underidentification test	12.0***	12.0***	6.3**	12.0***	4.3**
Uncond. mean of non-logged dep. var.	3.9	1.9	62.5%	7.4	1.2
No. of observations (firms)	3,613	3,613	1,862	3,613	1,444

Table IA.14. Effects of Patent Scope and Examination Time on Follow-on Innovation: Other Firms.

The table reports the results of estimating equation (1) to examine how the scope and timing of a startup's first granted patent examine how the scope and timing of a startup's first granted patent affects the startup's follow-on innovation for all other firms (classified based on patent applications to the USPTO technology centers 36 and 37). The analysis here is analogous to Table 6, with the only difference being that we use a sample of other firms. 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 approved patents) (5)
Count of claims	0.035**	0.026**	0.008	0.044**	0.047**
	0.017	*0.012*	*0.009*	*0.019*	*0.023*
First-action examination time	-0.111***	-0.103***	-0.028	-0.151***	-0.099
	0.036	*0.026*	*0.023*	*0.039*	*0.060*
Diagnostics					
Underidentification test	12.2***	12.2***	8.5***	12.2***	7.1***
Uncond. mean of non-logged dep. var.	2.2	1.2	70.0%	5.1	1.7
No. of observations (firms)	10,761	10,761	4,363	10,761	3,557

Table IA.15. Effects of Examination Time of a Rejected Patent Application on Startup Growth.

Panels A and B report the results of estimating equation (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 variables of interest in each panel is first-action examination time for a granted patent application. Panel A controls for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All columns report 2SLS results using the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. NETS data are available through 2011, resulting in reduced sample sizes as we widen the window from one to five years. (Specifically, the one- and two-year estimates are available for all startups matched to NETS, while the three-, four-, and five-year estimates are only available for firms that received a first-action decision by the end of 2008, 2007, and 2006, respectively.) 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. All specifications include art-unit-by-year and headquarter-state fixed effects and a control for the average word count per claim in the granted patent. 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	-0.049*	-0.052	-0.092	-0.052	0.062
	0.028	*0.049*	*0.061*	*0.077*	*0.135*
Diagnostics					
Underidentification test	79.5***	79.5***	69.2***	60.7***	51.0***
Unconditional mean of dep. variable	0.0%	1.5%	2.4%	1.4%	-1.8%
No. of observations (firms)	6,689	6,689	5,536	4,066	3,026
Panel B. Sales growth					
First-action examination time	-0.052	-0.037	-0.085	-0.053	0.187
	0.036	*0.063*	*0.096*	*0.122*	*0.241*
Diagnostics					
Underidentification test	79.5***	79.5***	69.0***	60.7***	50.7***
Unconditional mean of dep. variable	2.4%	7.4%	12.0%	15.9%	15.7%
No. of observations (firms)	6,674	6,679	5,528	4,061	3,024

Table IA.16. 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 equation (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 and include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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? (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)
First-action examination time	0.003	-0.002	-0.004	-0.005	-0.006	-0.006***
	0.006	*0.005*	*0.005*	*0.006*	*0.006*	*0.002*
Log (1 + no. prior VC rounds)	0.226***	0.308***	0.327***	0.330***	0.332***	0.027***
	0.013	*0.014*	*0.014*	*0.014*	*0.014*	*0.006*
Diagnostics						
Underidentification test	92.7***	93.1***	93.2***	93.0***	92.6***	92.8***
Mean of dep. variable	3.2%	4.5%	5.1%	5.4%	5.5%	0.47%
Median no. months from first-action to VC round or IPO for successful applicants	4.9	7.4	8.5	9.1	9.4	52.8
No. of observations (firms)	11,632	11,619	11,609	11,600	11,589	11,643

Table IA.17. Effects of Examination Time of a Rejected Patent Application on Follow-on Innovation.

The table reports the results of estimating equation (1) to examine how timing of a rejection of a startup's first patent application affects the startup's follow-on innovation. 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. For variable definitions and further details of their construction see the Appendix. All specifications are estimated by 2SLS and include art-unit-by-year and headquarter-state fixed effects as well as a control for the average word count per claim in the granted patent. We use the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM 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 approved patents) (5)
First-action examination time	-0.122***	-0.067***	-0.003	-0.116***	-0.032
	0.022	*0.014*	*0.038*	*0.022*	*0.075*
Diagnostics					
Underidentification test	93.0***	93.0***	62.2***	93.0***	31.6***
Uncond. mean of non-logged dep. var.	1.1	0.5	47.8%	2.1	1.5
No. of observations (firms)	11,643	11,643	1,998	11,643	1,011

Table IA.18. Effects of Patent Scope and Examination Time of a Second Patent Application on Growth when the First Application was Granted.

Panels A and B report the results of estimating equation (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. This analysis only includes startups whose first application was approved. For startups that die, we set the growth rate to –100% in the year of exit. The variables of interest in each panel are patent scope and first-action examination time for a granted patent application. Panel A controls for log employment at first-action, while Panel B controls for log sales at first-action (not shown). All columns report 2SLS results using examiner leniency with respect to scope as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. The underidentification test uses the Kleibergen-Paap *rk* LM statistic. Employment and sales data come from NETS; thus, startups that cannot be matched to NETS are excluded. NETS data are available through 2011, resulting in reduced sample sizes as we widen the window from one to five years. (Specifically, the one- and two-year estimates are available for all startups matched to NETS, while the three-, four-, and five-year estimates are only available for firms that received a first-action decision by the end of 2008, 2007, and 2006, respectively.) 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. All specifications include art-unit-by-year and headquarter-state fixed effects and a control for the average word count per claim in the granted patent. 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 claims	-0.005	0.027	0.044	0.040	0.044
	0.008	*0.032*	*0.041*	*0.039*	*0.048*
First-action examination time	-0.085	-0.136	-0.154	-0.279	0.165
	0.064	*0.114*	*0.227*	*0.287*	*0.510*
Diagnostics					
Underidentification test	14.3***	14.3***	11.1***	16.0***	10.0***
Unconditional mean of dep. variable	8.3%	17.3%	23.2%	26.6%	27.1%
No. of observations (firms)	4,405	4,405	3,774	3,053	2,413
Panel B. Sales growth					
Count of claims	0.005	0.052	0.068	0.077	0.114
	0.016	*0.040*	*0.057*	*0.055*	*0.079*
First-action examination time	-0.139	-0.322	-0.387	-0.429	0.746
	0.091	*0.204*	*0.427*	*0.548*	*0.965*
Diagnostics					
Underidentification test	15.9***	15.9***	11.1***	15.9***	9.7***
Unconditional mean of dep. variable	15.2%	33.3%	50.4%	61.4%	73.0%
No. of observations (firms)	4,395	4,397	3,770	3,053	2,413

Table IA.19. Effects of Patent Scope and Examination Time On Startup Growth Using the Kuhn-Thompson Measure.

The table reports the results of estimating equation (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, with the only difference being that we use a measure of scope from Kuhn and Thompson (2019) based on the count of words in the first claim of a patent. In this specification patent scope is measured using the Kuhn-Thompson patent scope z-score within an art-unit. All columns report 2SLS results using the Kuhn-Thompson measure of examiner scope toughness as an instrument for patent scope and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. 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 claims	-0.430	-0.118	-0.571	-1.684	-0.084
	0.411	*0.750*	*0.856*	*1.186*	*1.325*
First-action examination time	-0.050*	-0.116**	-0.144*	-0.280**	-0.395**
	0.026	*0.055*	*0.082*	*0.136*	*0.174*
Diagnostics					
Underidentification test	13.6***	13.6***	15.8***	11.0***	11.3***
Unconditional mean of dep. variable	11.9%	22.1%	19.9%	8.7%	25.3%
No. of observations (firms)	6,307	6,307	5,362	4,273	3,286
Panel B. Sales growth					
Count of claims	-0.520	0.196	-0.179	-0.587	0.391
	0.552	*1.007*	*1.221*	*1.639*	*1.882*
First-action examination time	-0.049	-0.082	-0.159	-0.451**	-0.443*
	0.038	*0.082*	*0.137*	*0.197*	*0.262*
Diagnostics					
Underidentification test	13.4***	13.4***	15.6***	11.1***	11.5***
Unconditional mean of dep. variable	14.2%	20.7%	21.8%	22.9%	25.0%
No. of observations (firms)	6,298	6,298	5,357	4,270	3,284

Table IA.20. Effects of Patent Scope and Examination Time On Startup Growth Using Independent Claims.

The table reports the results of estimating equation (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, with the only difference being that the measure of scope is the count of independent claims in the patent. All columns report 2SLS results using examiner leniency with respect to scope as an instrument for the total count of allowed independent claims and the examiner average first-action examination time plus the application-specific time between application date and docket date in years as an instrument for first-action examination time. 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 claims	0.008	0.054	-0.008	0.085	0.027
	0.023	*0.040*	*0.054*	*0.069*	*0.070*
First-action examination time	-0.038***	-0.099***	-0.118***	-0.173***	-0.249***
	0.014	*0.027*	*0.043*	*0.062*	*0.084*
Diagnostics					
Underidentification test	53.8***	53.8***	47.5***	39.2***	29.4***
Unconditional mean of dep. variable	11.9%	22.1%	19.9%	8.7%	25.3%
No. of observations (firms)	13,628	13,628	12,108	10,390	8,810
Panel B. Sales growth					
Count of claims	0.026	0.063	0.005	0.145	-0.029
	0.035	*0.062*	*0.091*	*0.121*	*0.114*
First-action examination time	-0.045**	-0.104**	-0.163**	-0.338***	-0.427***
	0.021	*0.044*	*0.072*	*0.102*	*0.130*
Diagnostics					
Underidentification test	53.6***	53.6***	47.7***	39.3***	29.5***
Unconditional mean of dep. variable	14.2%	20.7%	21.8%	22.9%	25.0%
No. of observations (firms)	7,170	7,151	7,124	7,110	7,101