When the Clock Starts Ticking: Measuring Strategic Responses to TRIPS's Patent Term Change

Jorge Lemus* Guillermo Marshall†

February 10, 2018

Abstract

As a consequence of the patent term harmonization introduced by TRIPS, the term of U.S. patents became contingent on how quickly the patents are granted. We find that patent applicants strategically responded to this change in incentives. In the pharmaceutical industry, narrower patents with less detailed descriptions allowed applicants to reduce the approval time by 10.8% (170 days). Also consistent with a ticking clock, we find a reduction in the use of continuations across all industries. Our results suggest that the patent term change created long-lasting efficiencies in the patent office.

JEL codes: D9, L5, O3, K0.

Keywords: TRIPS, patents, length, breadth, disclosure, continuations

1 Introduction

We examine the response of patent applicants in the U.S. to the patent term harmonization induced by the Trade-Related Aspects of Intellectual Property Rights (TRIPS)

*Department of Economics, University of Illinois at Urbana-Champaign, 214 David Kinley Hall, 1407 W Gregory St, Urbana, IL 61801. email: jalemus@illinois.edu

†Department of Economics, University of Illinois at Urbana-Champaign, 214 David Kinley Hall, 1407 W Gregory St, Urbana, IL 61801. email: gmarshll@illinois.edu

agreement in 1995. Prior to TRIPS, a patentee was granted a fixed term of 17 years of protection starting from the *issue* date of the patent. Since June 8, 1995, patent protection expires 20 years after the *filing* date,[1] regardless of the patent issue date.

This change in patent law allowed patent applicants to increase the effective length of protection by strategically choosing actions to shorten the prosecution time—i.e., the time elapsed between the filing and issue dates. Applicants choose the number of independent and dependent claims (breadth); the number of figures and words used to describe the patented invention (disclosure); how many and what type of continuations are used;[2] the number of continuations *after* allowance (a proxy for submarine patents); how promptly they respond to USPTO communications (applicant promptness); and how much effort to exert to perfect their applications (polishedness). By constructing a comprehensive dataset that includes application history and observable patent characteristics for all issued patents filed between 1991 and 1998, we study how applicants' choices changed in response to the patent term harmonization.

The TRIPS agreement was ratified by the U.S. Congress in December 8, 1994, and came into force on June 8, 1995.[3] To gauge the impact of the patent term change on applicants' behavior, Figure 1 shows the average prosecution time of successful patent applications filed between 1992 and 1998. The figure displays two salient features. First, there is a downward shift in average prosecution time after June 8, 1995, suggesting permanent efficiency gains in applicant behavior in response to the new incentives to shorten the prosecution time.[4] Second, there is anticipation: the average prosecution time increased by almost 50% days before June 8, 1995, suggesting that before TRIPS came into effect applicants filed applications that they expected would take longer to prosecute.

Figure 1 raises an economic puzzle since there are many strategic decisions made by patent applicants that affect prosecution time. By analyzing each one of the variables

[1] For continuation applications, the patent term ends 20 years from the filing date of the earliest parent application referenced in the application. For more details visit: http://www.uspto.gov/web/offices/pac/mpep/s201.html

[2] "Continuations" prolong or restart the examination of a rejected or even an allowed application.

[3] For patent applications filed between December 8, 1994 and June 8, 1995, the patent length was the maximum between 17 years from grant date and 20 years from the filing date. This transition period offered the "best of both worlds," providing incentives to submit applications instead of waiting for the new system to be in place.

[4] Alternatively, TRIPS could have generated a structural break and a change in the slope of the time trend of the average prosecution time. Had the slope increased after TRIPS, the efficiency gains would have been only temporal. From Figure 1, however, we see that the slope flattened slightly after TRIPS came into force. This evidence suggests that TRIPS caused permanent efficiency gains in prosecution time.

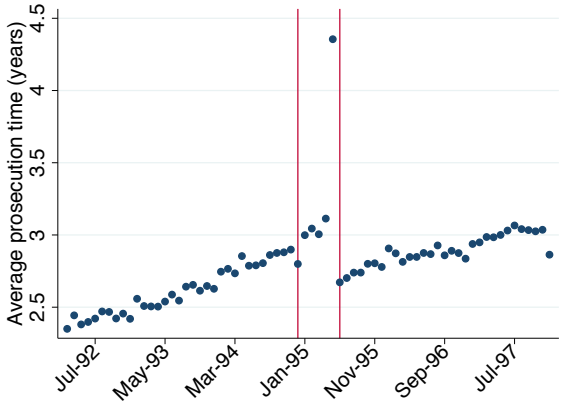


Figure 1: Average prosecution time of patent applications filed between 1992 and 1998. The vertical lines indicate the beginning and the end of the transition period, December 8, 1994 and June 8, 1995, respectively.

that contribute to the prosecution time, we can understand what actions and which applicants are responsible for this drop in the average prosecution time. More broadly, this analysis sheds light on how the incentives of patent applicants are shaped by the patent system.

Our main source of identification is the change in incentives after June 8, 1995: the patent term became dependent on the prosecution time. We argue that the patents filed before TRIPS came into force (in particular, those filed some months before June 1995) are a good counterfactual for the patents filed after TRIPS, as the trends of patent observables evolved similarly before and after TRIPS (see Figure 1 for an example). We use (time adjusted) differences between these groups of patents to identify the effect of TRIPS's patent term change on the outcomes of interest. A potential identification threat is that the USPTO could have taken actions concurrent to TRIPS to deal with the policy change, which may explain the structural break in Figure 1. Two facts minimize this threat. First, the USPTO was subject to the Federal Workforce Restructuring Act of 1994, which limited the USPTO's ability to hire new employees in the fiscal year of 1995.[5] Second, the number of patents that were allowed did not experience a structural break when TRIPS came into effect, suggesting no change in the patent examination criteria.

We find that the prosecution time (shown in Figure 1) fell on average by 44 days

[5]As noted by the commissioner of patents in the 1995 USPTO annual report: "Government-wide restrictions on personnel ceilings prohibited additional hiring to address the new work." See http://www.uspto.gov/sites/default/files/about/stratplan/ar/1995annualreport.pdf (page 43).

after the patent term change. We decompose this change by size of the applicant (small or large) and by industry (using the NBER industry classification in Hall and Adam 2002). In the pharmaceutical industry,[6] large entities experienced the largest reduction in prosecution time, falling on average by 10.8% or 170 days. We then explore what actions led to shorter prosecution time and we find heterogeneous responses by firm size and industry. For instance, after TRIPS came into force, large entities in the pharmaceutical industry decreased the use of words and figures by 11.67% and 10.72%, respectively; they also decreased the number of independent claims by 7.5%. In the computer industry,[7] we find a 43% decrease in our measure of "submarine" patents—those kept secret and issued strategically after a long period of prosecution—after TRIPS came into effect (Graham and Mowrey, 2004).

We also find two strategic responses to TRIPS's patent term change that are consistent across industries and firm size: a permanent reduction in the use of continuations and an increase in application polishedness. Since most continuations restart the prosecution process without restarting the prosecution time clock, patent applicants had strong incentives to avoid them after TRIPS came into effect, because filing them directly shortens the patent term. On average, we find that large entities reduced the total number of continuations by 47.89% after TRIPS, while small entities by 28.48%. Our estimates show that the reduction of continuations caused by the patent term change saved the USPTO about 263,186 hours of examination during the 1995-1996 period. Back of the envelope calculations suggest that these savings are approximately $6.43 millions in 1995 dollars, which was roughly 1.6% of the USPTO's revenues in 1995.[8] This calculation is a conservative lower bound because it does not consider the benefits for the USPTO of examining more polished applications, which could have saved hours of examination.

Our findings suggest that TRIPS's patent term change caused permanent changes in the patent system along different dimensions, i.e., the impact of the policy change was far beyond a simple change in the statutory length of patents. TRIPS overall injected efficiency into the patent examination process through different channels: fewer continuations (i.e., less congestion), narrower patents (i.e., reduced entry costs, which promote competition), faster applicant responses (i.e., increased efficiency in the prose-

[6]We use 'pharmaceutical industry' for the NBER category 'Drugs and Medical'.

[7]We use 'computer industry' for the NBER category 'Computers and Communications'

[8]Using our regression estimates we calculate an expected reduction in continuations of 13,694 per year due to TRIPS's patent term change. We assume that applications were examined on average for 19 hours (Frakes and Wasserman, 2017). Patent Examiners make about $80,000 per year, which is equivalent to an hourly wage of $38.46 (or $24.61 in 1995 dollars after adjusting for inflation).

cution process), and fewer submarine patents. Also, pharmaceutical patents are shorter (fewer words and figures) after TRIPS, which may allow for faster examination. However, we cannot measure whether fewer words and figures reflects a more efficient use of words to describe the invention or a less detailed description of the invention, the latter of which could negatively affect the disclosure of the invention. Finally, our results may shed light on how to address the use of 'Request for Continuing Examination' (RCEs), a recent and prominent issue affecting the USPTO (Tu, 2015).

The paper is organized as follows. In Section 2, we review the literature. In Section 3, we describe our data and define the key variables of interest. Section 4 describes our empirical framework and discusses identification. In Section 5 we present our results, which are supported by tables and figures in the main text as well as in the Supplementary Material. Finally, in Section 6, we summarize and discuss our findings.

2 Literature Review

Jaffe (2000) discusses major changes to the U.S. patent system from 1980 to 2000. These include the creation of the U.S. Court of Appeal for the Federal Circuit (CAFC), the Bayh-Dole act, the expansion of patentability of software, and the TRIPS agreement. The creation of the CAFC, which according to Jaffe and Lerner (2011) weakened the patent system overall, affected the incentives to appeal patent-invalidity decisions (Henry and Turner, 2006). The Bayh-Dole act changed incentives to file patents (see, e.g., Mowery et al. (2002) and Thursby and Thursby (2003)). Bessen and Hunt (2007) study the incentives for public firms to patent software-related inventions. Katznelson (2007) discusses the effect of the creation of the CAFC and the TRIPS agreement on patenting behavior. Closer to our analysis, Abrams (2009) studies the effect of TRIPS on patent counts and citations,[9] and Sukhatme and Cramer (2014) argues that TRIPS caused a short-run change in the response time of applicants to USPTO notices.[10]

A distinctive feature of the U.S. patent system, described in detail in Lemley and Moore (2004) and Hegde et al. (2009), is the possibility of filing "continuation" applications that enable the applicant to continue the examination process. Higgins (2001) and

[9] In this analysis, it is assumed that applications pre-TRIPS and post-TRIPS have similar prosecution times. This assumption is problematic since, as we will show in Section 4, patent applicants endogenously changed their behavior after TRIPS and they also anticipated the change.

[10] After dealing with anticipation effects, we find much weaker results. We do not find a significant drop in the applicants' response time in the computer industry, and find only a small drop for the pharmaceutical industry (around 6%).

Graham and Mowrey (2004) discuss the use of continuations to file submarine patents. Cotropia et al. (2013) shows that the number of re-filed applications since 1996 have increased over time. Quillen Jr and Webster (2009) study the use of continuations and request for continued examination (RCEs) and compute the USPTO's grant rates adjusting for the use continuing examination. Tu (2015) studies the burden that RCEs put on the U.S. patent system.

Determinants of the prosecution time have been investigated, among others, by Popp et al. (2004), Régibeau and Rockett (2007), and Harhoff and Wagner (2009), finding that more valuable patents are processed faster. Carley et al. (2015), using data from 1996-2005, compute patent allowance rates at the USPTO at different stages of the examination process.

Our paper also relates to information disclosure, breadth and length. A patent grants a temporary monopoly in exchange for information disclosure which allows for the diffusion of knowledge (Scotchmer and Green, 1990). As Gilbert and Shapiro (1990) note, patent breadth and patent length are two appropriability instruments and the optimal patent policy should balance their scope. Lerner (1994) empirically examines the effect of patent breadth on firm value.

3 Data and Methodology

3.1 Data

We combined data from the USPTO Historical Patent Data files (Marco et al., 2015), USPTO bulk downloads, and Patexia.[11] From Marco et al. (2015) we gathered a list of all issued patents filed between 1991-1998, with their respective filing dates and NBER industry classifications (Hall and Adam, 2002). The number of figures and words in the patent description, and the number of independent and dependent claims of each patent were collected from Patexia. Finally, we used the USPTO bulk downloads (PAIR) to reconstruct both the continuation and the transaction history of each patent in our sample, from which we computed the priority date of each patent and constructed measures of continuation use and applicant promptness.

[Figure 2 about here]

[11] https://www.patexia.com/ (Visited on October, 2016)

Table 1 shows the number of patents in our data decomposed by NBER classification. Figure 2 (Panel A) shows the number of applications over time (both issued and never issued). The *anticipation effect*—the spike in the number of applications immediately before TRIPS came into force—reflects the incentive to capture the benefits of obtaining no less than 17 years of patent protection (see Footnote 3).

Figure 2 (Panel B) shows the number of applications that were issued each month. The absence of a structural break in the number of allowed patents when TRIPS came into force suggests that there were no concurrent changes in the USPTO's allowance policy. This fact is key for the validity of our identification strategy. In this time period, about 86 percent of all applications were eventually allowed, which minimizes concerns arising from the fact that our data only include issued patents.

[Table 1 about here]

Next, we describe the set of patent observables grouped in five categories: prosecution time, disclosure, scope, use of continuations, and applicant promptness. Summary statistics and definitions for these sets of variables are reported in Table 2.

[Table 2 about here]

3.1.1 Patent Prosecution Time

We measure prosecution time as the time elapsed between a patent's priority date and the issue date. The priority date coincides with the filing date for the vast majority of patents, but it does not coincide for applications that are continuation applications. In this latter case, a patent's priority date is the filing date of the earliest application (in the chain of continuations) that is made reference to in the application document. For instance, if application X (filed at time t) is a continuation of both application Y (filed at time t') and application Z (filed at time t''), then application X's priority date is the earlier date between t' and t''.[12] By using the priority date, as opposed to the filing date, we can capture changes in prosecution time after TRIPS that result from changes in the use of continuations. On average, a patent is prosecuted for 2.78 years as shown in Table 2 (Panel A).[13]

[12] An exception to this rule applies for continuations-in-part (see Section 3.4), where material that was not included in earlier applications may not inherit the priority date of those earlier applications. See Lemley and Moore (2004) for a detailed discussion.

[13] There are patents issued after more than 40 years of prosecution (e.g., US7038290B1).

3.1.2 Description and Disclosure

We measure the length of the description of an invention by the number of words and figures used. Table 2 (Panel C) presents summary statistics for these variables. On average, a patent in our sample includes 10.09 figures and 5,890 words in the patent description. These variables present high variance, with some patents having as little as zero figures while others as many as several thousand figures (e.g., see US6278698B1). Both measures of disclosure have a coefficient of correlation of 0.41, suggesting that patents with more figures are also patents with more words.

3.1.3 Patent Breadth

We use the number of independent and dependent claims as well as the number of dependent claims per independent claim as our measures of patent breadth (Lerner, 1994). We consider a patent with more independent claims as broader (all else equal), while a patent with more dependent claims per independent claim, as narrower. Table 2 (Panel D) shows that patents on average include 2.85 independent claims and 12.18 dependent claims. Again, the variation across patents is extensive, with some patents including more than 200 independent claims (e.g., US8060169B1).

3.1.4 Continuations

At the time TRIPS came into force, applicants could choose to delay their patent prosecution by employing continuations of three kinds: continuations, continuations-in-part, and divisional continuations. Continuation applications allow for further examination of the original patent application. Continuations-in-part allow the applicant to continue the examination while adding new subject matter to the original application. A divisional application divides the patent application into several different applications that could potentially lead to different patents. The latter type of continuation may be required by the USPTO if the original application included more than one invention (Hegde et al., 2009).

To measure the use of continuations, we use indicator variables for whether an application is a continuation application, a continuation-in-part, or a divisional application. We also use the number of earlier applications (in a chain of continuations) that are referenced in each application to measure the total number of continuations that precede

each application. Table 2 (Panel B) shows that an average of 22 percent of applications are a continuation and that a given application can be as much as the 99th application in a sequence of continuations (e.g., see US6420526B1).

We incorporate a novel measure of "submarine patents," which are applications issued only after a *deliberately* long prosecution. An applicant may delay the patent issue date to wait for the uncertainty of an industry to be resolved to then determine targets for patent infringement lawsuits. Before 1999, patent applications remained secret until issued so inventors could "submarine" their applications.[14] One of the tools used by applicants when submerging their patents is the use continuations. Continuations filed after an earlier application was allowed is a reasonable proxy for submarine patents, since the applicants' ultimate objective should be to get their applications approved. For this reason, we use the number of references (in a chain of continuations) to earlier applications that had been abandoned after being allowed as our measure of submarine patents. Table 2 (Panel B) shows that an average of 2 percent of applications make reference to an application that was abandoned after allowed and that there are patents with as many as 7 applications made reference to that were abandoned after allowance.

3.1.5 Applicant Promptness

As a proxy to an applicant's promptness, we use the response time to the first (non-final) rejection notice sent by USPTO. As a measure of patent application's polishedness we use the number of non-final rejection notices received from USPTO and an indicator for allowance without having received a rejection notice. The argument for using rejections as a measure of polishedness is that applications with fewer rejections are likelier to be more complete and polished than ones with a larger number of rejections. Table 2 (Panel E) shows that applicant's took an average of 112.65 days to reply to the USPTO after receiving a first rejection notice. The table also shows that 19 percent of all patents were issued without having been rejected and patents received an average of 1.32 rejections in the application process before being issued.

[14] American Inventors Protection in 1999 required patent applications be published after 18-months of the filing date.

4 Empirical Framework

To visualize the effect of TRIPS on disclosure, patent breadth, the use of continuations, and applicant delays, we run OLS regressions with flexible time fixed-effects for several versions of the model

$$y_{ijt} = \alpha + \text{small}_i\pi + \lambda_j + \gamma_t + \varepsilon_{ijt}, \tag{1}$$

where i corresponds to an issued patent,[15] j the NBER industry classification of the patent, and t is the month–year when the patent application was filed. y_{ijt} is the outcome variable of interest, which in our analysis includes measures of patent breadth (e.g., number of independent claims), information disclosure (e.g., number of words), use of continuations, and applicant delays (e.g., response time to USPTO notices). small_i is a firm-size indicator and λ_j are industry fixed effects, which capture systematic differences across small and large entities as well as across industries. γ_t is a month–year of application effect, with which we measure (in a flexible way) how the outcomes of interest changed once TRIPS came into force (i.e., after June 1995). Finally, ε_{ijt} is an error term clustered at the NBER industry level.

We complement the above analysis by running several versions of the model

$$y_{ijt} = \alpha + \text{small}_i\pi_0 + 1\{\text{Post TRIPS}\}\pi_1 + \text{small}_i \cdot 1\{\text{Post TRIPS}\}\pi_2 + \lambda_j + \gamma \cdot t + \varepsilon_{ijt}, \tag{2}$$

where $1\{\text{Post TRIPS}\}$ is an indicator for applications filed after June 1995. All other variables are defined as above. An important difference between equations (1) and (2) is that in equation (2) we include $1\{\text{Post TRIPS}\}$ as well as a linear time trend instead of month–year of application fixed effects. With $1\{\text{Post TRIPS}\}$, we are able to capture post TRIPS changes in the conditional expectation of outcomes of interest, while controlling for industry effects and a linear time trend. The coefficients of interest are then π_1 and π_2, which measure the impact of TRIPS on outcomes of interest for both large and small entities.[16]

[15] Unfortunately, our measures for breadth, disclosure, applicant delays, and continuation use are not available for patent applications that are never issued. However, a vast majority of applications are allowed to become patents. Towards the end of our period of study, the share of applications that are issued exceeds 90 percent. See Figure 2 for details.

[16] Figure 3 plots γ_t in equation (1), whereas all the tables are generated using equation (2).

4.1 Identification

Our identification strategy is based on the incentives to achieve a lower prosecution time after TRIPS's patent term adjustment. Patents filed before TRIPS (in particular, those filed some months before June 1995) are a good counterfactual for the patents filed after TRIPS came into force, as the trends for observables evolved similarly before and after June 1995 (see Figure 1), which is confirmed by the estimates for equation (1). As a consequence, we use (time adjusted) differences between these groups of patents to identify the effect of TRIPS's patent term change on the outcomes of interest. To minimize differences in the trends of observables, we estimate equation (2) with all the patents filed between January 1994 and December 1996, excluding those filed shortly before June 8, 1995 (see discussion below). For robustness, we also present estimates using the full set of patents filed between 1991 and 1998 (again, excluding those filed shortly before TRIPS came into force).

A potential issue with estimating equation (2) is that, as shown in Figure 1, applicants anticipated the policy change by submitting applications with a long expected prosecution time, creating selection that may compromise the causal interpretation of the coefficients π_1 and π_2. However, not all applicants who would otherwise file their applications after TRIPS are *able* to file before TRIPS, as coming up with innovations and writing patent applications can only be advanced in time so much. In fact, Figure 1 shows that the anticipation effect is short lived, in the sense that the prosecution time returns to its pre-TRIPS trend shortly after TRIPS came into force. To address the issue of this anticipation effect, we exclude the applications filed in the period between December 1994 and September 1995 when estimating equation (2). Given that the anticipation effects are short lived, we consider that this sample restriction is sufficient to alleviate any concerns that arise along this dimension.[17]

Another concern is that our results might be affected by policy or organizational changes in the USPTO that are concurrent with TRIPS. Two facts minimize this concern. First, as shown in Figure 2 (Panel B), there was no discontinuous change in the number of allowed patents after TRIPS, suggesting that there was no change in the USPTO patent examination criteria concurrent with TRIPS. Second, the USPTO at the time was subject to the Federal Workforce Restructuring Act of 1994, which limited the USPTO's ability to hire new employees. The fact that the USPTO was unable to respond to the surge in applications caused by TRIPS is reflected in the following quote from the USPTO's 1995 annual report:"In fiscal year 1995, patent

[17]For robustness, we repeated the analysis using an alternative sample restriction.

applications exceeded plan by approximately 28,000 cases and for trademarks, applications exceeded plan by approximately 18,000 applications. In the patent area, the PTO received an unexpected surge of patent applications due to enactment of pending legislation. Unfortunately, the PTO could not respond immediately to these fluctuations. For example, not only is recruitment of patent examiners and trademark attorneys cumbersome but Government-wide restrictions on personnel ceilings prohibited additional hiring to address the new work."[18]

5 Results

In our analysis, we first estimate equation (1) for the full set of dependent variables described in Section 3. We present these results by plotting estimates for the month–year of application fixed effects (i.e., γ_t in equation (1)), which allows us to flexibly study the impact of TRIPS on the outcomes of interest, as well as document any potential anticipation effects. These results are mostly reported in the Supplementary Material. We then estimate equation (2) to capture the effect of TRIPS on the same set of dependent variables, controlling for both industry effects and a time trend.

A summary of the impact of TRIPS on all the outcomes of interest, separated by small and large firms, can be found in Table A1 in the Supplementary Material. A summary of the systematic differences between small and large firms can be found in Table A2 in the Supplementary Material. In what follows we discuss these results in detail.

5.1 Patent Prosecution Time

Figure 1 shows a structural break in prosecution time after TRIPS came into effect. Figure 3 shows estimates of equation (1) using prosecution time as the dependent variable, and shows that the pattern in Figure 1 is robust to controlling for both industry and entity size fixed effects.

[Figure 3 about here]

Table 3 reports estimates of equation (2) using the subset of patents filed between January 1994 and December 1996. The first column of Table 3, which includes patents

[18] http://www.uspto.gov/sites/default/files/about/stratplan/ar/1995annualreport.pdf

from all NBER categories, shows that large entities, on average, reduced their prosecution times by 0.121 years (44.17 days or 4.25%) as a consequence of TRIPS. The effect for small entities is negative but statistically insignificant, suggesting that it was large firms who had a stronger response to the change in incentives created by TRIPS. Also noteworthy is that the prosecution times for small entities were on average 6.44% shorter than for large entities.[19]

[Table 3 about here]

We decompose our estimates for equation (2) by NBER category to assess heterogeneity (Columns 2 to 7 in Table 3). The table shows that decline in prosecution time was mostly driven by large entities in three NBER categories: 'Chemical', 'Computers and Communication', and 'Drugs and Medical,' which on average reduced their prosecution times by 6.57%, 3.88%, and 10.8%, respectively. We only find a statistically significant decrease in prosecution time for small entities in the pharmaceutical industry (a reduction of 3.4% in prosecution time). The fact that the pharmaceutical industry had the strongest reduction in prosecution time after TRIPS came into force is not surprising given that the pharmaceutical industry relies heavily on patent protection.

5.2 Description and Disclosure

Under the hypothesis that more information takes patent examiners longer to review, we expect that patent applicants who were worried about prosecution time would have shortened their applications in order to gain a longer patent protection. Thus, we expect to find shorter applications after TRIPS, especially in the pharmaceutical industry where the marginal benefit of a longer protection is higher.

Table 4 (Panel A) shows a negative, though statistically insignificant, effect of TRIPS on the number of words and figures for large firms. For small entities, however, we find that TRIPS caused a statistically significant reduction in the number of words (on average 276 fewer words in the patent description).

[19] In Table A9 in the Supplementary Material we repeat this exercise using all patents filed between 1991 and 1998 (excluding those filed between December 1994 and September 1995). As can be seen, the post TRIPS estimated effects are qualitatively identical, though larger in magnitude, when compared to the estimates in Table 3. The increased magnitude of the estimates may be due to the pre-TRIPS period being a worse counterfactual for the post-TRIPS period when including both earlier and later patents into the estimation. For this reason, we prefer the results in Table 3.

[Table 4 about here]

We also perform the previous analysis by NBER category.[20] Following June 8, 1995, small entities in the categories 'Computers and Communications' and 'Drugs and Medical' (Panel A, Column 2 in Tables A4 and A5 in the Supplementary Material, respectively) on average reduced the number of words in the description. In the former case, small entities reduced the number of words by 9.06%, while in the latter by 14.56%. However, small entities on average did not change the number of figures after TRIPS. We find either no effect or weak effects for large firms with the exception of 'Drugs and Medical'—where we find a 11.67% and 10.72% decrease in words and figures, respectively—and 'Mechanical', where we find a 5.2% decrease in the number of words in the description of the invention.

Fewer words and figures indicate two distinct effects. First, firms may use words and figures more efficiently, disclosing the same amount of information in a more concise and effective way. Alternatively, shorter descriptions may suggest that applicants are omitting details which stand in the way of information disclosure. We leave the question of which of these two effects drives the decrease in words and figures for future research.

5.3 Patent Breadth

The claims of a patent define its breadth of protection. Independent claims are statements that increase the breadth of protection, while dependent claims narrow the breadth within independent claims.[21] Under the hypothesis that broader patents take longer to prosecute—as it is likely costlier for an applicant to convince a patent examiner to allow an application with broad claims—we expect that applicants reduced the breadth of their applications after TRIPS came into effect.

In Table 4 (Panel B) first, we find weak effects of TRIPS on patent breadth for both small and large entities. The number of dependent claims on average increased by 2.4% for large entities, while for small entities we did not find statistically significant changes. The effect on dependent claims in large firms is in line with our hypothesis that applicants would tend to reduce patent breadth once TRIPS came into effect.

Decomposing these results by NBER categories, we observe heterogeneous responses

[20] See Panel A in Tables A3-A8 in the Supplementary Material.

[21] A good discussion about patent claims can be found in:
http://www.ipwatchdog.com/2014/07/12/understanding-patent-claims/id=50349/

by industry.[22] First, we find similar effects of TRIPS on dependent claims for most NBER categories though the estimates are noisier. We also observe, in the 'Drugs and Medical' category (Table A5 (Panel B) in the Supplementary Material), that the average number of independent claims in patents issued to large entities decreased by 7.6% after the patent term change. Again, these results suggest that large entities, in particular those in the pharmaceutical industry, began to apply for narrower patents after TRIPS, with the goal of speeding up prosecution time.

5.4 Applicant Promptness

When a patent application is reviewed by the USPTO, there is back-and-forth communication between the patent office and the applicant (e.g., non-final rejections). Minimizing these interactions may help reduce the prosecution time. As a consequence, preparing polished patent applications and replying quickly to USPTO notices are straightforward ways for an applicant to gain more patent protection. For this reason, we expect that applicants prepare more polished applications and reply quicker to USPTO communications after TRIPS. We use the number of rejections throughout the prosecution process and whether the application was allowed without rejections as measures of application polishedness, while we use the response time to the first USPTO communication as a measure of promptness.

Table 4 (Panel D) shows the regression coefficients of equation (2) for the measures of applicant promptness. The number of rejections declined on average by 4.3% for large entities and by 6.45% for small entities after the patent term harmonization. However, we do not find a significant change in patents issued without rejections after TRIPS. In terms of promptness, we find a 1.4% decrease in response time to USPTO notices for large firms though the effect is marginally significant. These results provide evidence in favor of both applications becoming more polished and large entities becoming more prompt after TRIPS came into effect.

In our heterogeneity analysis, we find that TRIPS caused a significant reduction in the number of rejections for small entities in 'Chemicals' (8.6% reduction), 'Drugs and Medical' (8.24% reduction), and 'Electrical and Electronic' (10.22% reduction).[23] For large entities, we find a significant change after TRIPS in 'Chemicals' (11.48% reduction in rejections) and in 'Others' (4.17% reduction in delay of response).

[22] See Panel B in Tables A3-A8 in the Supplementary Material.

[23] See Panel D in Tables A3, A5, and A6 in the Supplementary Material.

In summary, we find some evidence suggesting that both applications became more polished and large entity applicants became more prompt after TRIPS came into force. It is perhaps surprising that small entities did not speed up their responses to USPTO communications after TRIPS. However, it is plausible that these applicants had already optimized their response times even before TRIPS came into force.

5.5 Use of Continuations

Hegde et al. (2009) analyzes the use of different types of continuations across industries using patent data linked to Compustat.[24] Although the authors do not explicitly deal with the anticipation effect caused by TRIPS, their results show that the use continuations declined after June 8, 1995. We analyze how continuation use changed after TRIPS while dealing with the anticipation effect. We perform a separate analysis for total continuations, continuation applications, divisional applications, and continuations-in-part. In general, continuations restart the prosecution without restarting the prosecution time clock. Hence, we expect to see a decline in the use of continuations after TRIPS came into effect.

5.5.1 Total Continuations

Total continuations is the number of earlier applications (in a chain of continuations) that referenced in the application document. That is, if application X is a continuation of both applications Y and Z, then total continuations is 2 for application X. This measure captures the repeated use of continuations by applicants. Figure A4 (Panel A) in the Supplementary Material plots estimates for the month–year of application fixed effects in equation (1) using the total number of continuations as the dependent variable. As we can see in the figure, there was an evident drop in the number of continuations after June 8, 1995, suggesting that the new incentives from TRIPS made continuations less attractive. Apart from this drop in the number of continuations, the figure shows a noticeable anticipation effect. The first column of Panel C in Table 4 shows the regression results for equation (2) using the same dependent variable. Aggregating over all patent categories, we find that large entities on average reduced the total number of continuations by 47.89% after TRIPS, while small entities by 28.48%.

[24] While their matched data consist of 38% of all patents assigned to U.S. business between 1981 and 2004, we use the full set of patents granted between 1991 and 1998.

With the exception of small entities in 'Computers and Communications,' all NBER categories exhibited a significant reduction in the total number of continuations. We find a larger reduction in the total number of continuations for large entities when compared to small entities.

5.5.2 Continuation Applications

Figure A4 (Panel B) in the Supplementary Material plots estimates for the month–year of application fixed effects in equation (1) using continuation application (CAP) as the dependent variable. We see a significant drop in the likelihood of an application being a continuation application after TRIPS came into force. The second column of Panel C in Table 4 shows the regression results for equation (2) using the same dependent variable. The coefficients that capture the impact of TRIPS on the use of continuation applications for small and large entities are negative and significant. For large entities, there was a reduction in continuation applications of 50.39%, while a reduction of 23.64% for small entities.[25] We find similar results across industries when decomposing the analysis by NBER category. The largest reduction in the use of continuation applications, however, was by large entities in the category 'Drugs and Medical,' where we see a 67.6% decline in the number of continuation applications.

5.5.3 Divisional Continuations

The third column of Panel C in Table 4 shows the regression results for equation (2) using the indicator for divisional continuation as the dependent variable. The coefficient on the effect of TRIPS for large entities is negative and implies an average reduction in the use of divisional continuations of 16.07%, although this is only marginally significant. Small entities did not change the number of divisional continuations in a significant way. 'Electrical and Electronic' is the only category where there was a significant decline in the use of divisional continuations. For this category, large entities on average reduced the number of divisional continuations by 38% after TRIPS.

[25] In 1997 there was another change that caused a large decrease in the use of continuations. However, this change does not affect our estimates in Table 4. http://www.uspto.gov/web/offices/com/sol/notices/aa97.html

5.5.4 Continuations-In-Part

Figure A4 (Panel D) in the Supplementary Material plots estimates for the month–year of application fixed effects in equation (1), using whether an application is a continuation-in-part as the dependent variable. We observe a small permanent decrease in continuations-in-part after TRIPS as well as a small anticipation effect. The fourth column of Panel C in Table 4 shows the regression results for equation (2) for the same dependent variable. The coefficient capturing the effect of TRIPS on the use of continuations-in-part is negative though insignificant.

Decomposing by NBER category, we find that the use of continuations-in-part increased by 30% for large entities in 'Drugs and Medical', decreased by 33% for small and large entities in 'Electrical and Electronic', and decreased by 23% and 44.44% for large and small entities in 'Mechanical', respectively.

5.5.5 Proxy for Submarine Patents

Table 4 shows the regression results for equation (2) using the number of parent applications that were allowed and later abandoned as the dependent variable. Following TRIPS, large entities on average reduced the number of allowed-abandoned applications by 34.78%, while small entities did not significantly change their behavior. Interestingly, the reduction in the number of allowed-abandoned applications among large entities was driven by 'Computers and Communications,' an industry associated with the use of submarine patents, where the number of allowed-abandoned applications dropped by 65.17% after TRIPS came into effect (Graham and Mowrey, 2004).

5.6 Robustness

We perform two robustness checks. First, we include the full set of patents in our data—i.e., those filed between 1991 and 1998—when estimating equation (2). Second, we estimate equation (2) excluding patents filed between December 1994 and October 1995, as an alternative way of addressing the anticipation effect.

Tables A9 and A10 in the Supplementary Material present the results for the first exercise. As the tables show, the results remain qualitatively unchanged though, they generally increase in (absolute) magnitude. This may indicate that there was a learning process for how to best respond to the change in incentives. However, we cannot rule

out that by making the period of study longer, the set of patents filed before TRIPS becomes a worse counterfactual for the set of patents filed after June 8, 1995. Despite the fact that the trends of patent observables generally remain parallel even for this extended period, we prefer the results presented in Tables 3 and 4, as they are more conservative. Finally, Tables A11 and A12 in the Supplementary Material present the results for the second exercise. The tables show that changing the sample restriction criterion to address the anticipation effect does not change the results in a meaningful way.

6 Discussion

We analyze how the patent term adjustment caused by TRIPS affected patent applicant's strategies. We find heterogeneous responses across industries and firm size on description of the inventions, breadth, promptness of response, and polishedness of applications. However, we find a consistent reduction in the use of continuations in every industry. Compared to other NBER categories, the patent term adjustment affected the category 'Drugs and Medical' in a disproportionate manner. Large entities in this category reduced the number of words in the description of the invention, the number of figures, and the number of independent claims in their patents after the patent term harmonization. This response on disclosure and breadth are not observed for any other NBER category. Other idiosyncratic effects include a 43% decrease in our measure of submarine patents in the NBER category 'Computers and Communications,' which is unsurprising given that the software industry is one where the practice of submarine patenting was prominent at the time (Graham and Mowrey, 2004).

Our findings are consistent with a strategic response by patent applicants to the increase in the opportunity cost of delaying patent prosecution as a consequence of the patent term change. The response was stronger in the pharmaceutical industry, which is an industry that relies more heavily on patents. Some of the changes in response to TRIPS could have had an ambiguous effect. For example, the reduction on the number of words could reflect either a more efficient description of the invention or a decrease in information disclosed in the patent, which would go against some of the objectives of the patent system. However, most of the consequences of TRIPS were positive: narrower patents after TRIPS—captured by the reduction in independent claims—could have had positive effects on market competition by reducing entry costs (Gallini, 1992); the reduction in the use of continuations is indicative of applicants

partly internalizing the negative externality of congesting the USPTO.

We conclude that the patent term adjustment in 1995 enhanced the efficiency of the patent application process. A conservative back of the envelope calculation shows that the patent office in 1995-1996 saved about 263,186 hours of examination, which is roughly equivalent to $6.43 millions in 1995 dollars or 1.6% of the USPTO's revenues in 1995.

Acknowledgements

We wish to thank Julia González, Fernando Luco, Richard Miller, Álvaro Parra, Andrew Toole, Melissa Wasserman, and conference participants at International Industrial Organization Conference for helpful comments and suggestions. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Abrams, David S (2009) "Did TRIPS spur innovation? An analysis of patent duration and incentives to innovate," *University of Pennsylvania Law Review*, pp. 1613–1647.

Bessen, James and Robert M Hunt (2007) "An empirical look at software patents," *Journal of Economics & Management Strategy*, Vol. 16, pp. 157–189.

Carley, Michael, Deepak Hedge, and Alan Marco (2015) "What is the probability of receiving a US patent," *Yale JL & Tech.*, Vol. 17, p. 203.

Cotropia, Christopher A, Cecil D Quillen Jr, and Ogden H Webster (2013) "Patent Applications and the Performance of the US Patent and Trademark Office," *Fed. Cir. BJ*, Vol. 23, p. 179.

Frakes, Michael D and Melissa F Wasserman (2017) "Is the Time Allocated to Review Patent Applications Inducing Examiners to Grant Invalid Patents? Evidence from Microlevel Application Data," *Review of Economics and Statistics*, Vol. 99, pp. 550–563.

Gallini, Nancy T (1992) "Patent policy and costly imitation," *The RAND Journal of Economics*, pp. 52–63.

Gilbert, Richard and Carl Shapiro (1990) "Optimal patent length and breadth," *The RAND Journal of Economics*, pp. 106–112.

Graham, Stuart JH and David C Mowrey (2004) "Submarines in Software? Continuations in US Software Patenting in the 1980s and 1990s," *Economics of Innovation and New Technology*, Vol. 13, pp. 443–456.

Hall, Bronwyn H and B Adam (2002) "13 The NBER Patent-Citations Data File: Lessons, Insights, and Methodological Tools," *Patents, citations, and innovations: a window on the knowledge economy*, p. 403.

Harhoff, Dietmar and Stefan Wagner (2009) "The duration of patent examination at the European Patent Office," *Management Science*, Vol. 55, pp. 1969–1984.

Hegde, Deepak, David C Mowery, and Stuart JH Graham (2009) "Pioneering inventors or thicket builders: Which US firms use continuations in patenting?" *Management Science*, Vol. 55, pp. 1214–1226.

Henry, Matthew D and John L Turner (2006) "The Court of Appeals for the Federal Circuits impact on patent litigation," *The Journal of Legal Studies*, Vol. 35, pp. 85–117.

Higgins, Brian Wm (2001) "Note, Reiffen and the New Economy: Rethinking the Use of the Written Description Requirement to Curb Submarine Patent Tactics," *Fed. Cir. BJ*, Vol. 11, p. 23.

Jaffe, Adam B (2000) "The US patent system in transition: policy innovation and the innovation process," *Research policy*, Vol. 29, pp. 531–557.

Jaffe, Adam B and Josh Lerner (2011) *Innovation and its discontents: How our broken patent system is endangering innovation and progress, and what to do about it*: Princeton University Press.

Katznelson, Ron D (2007) "Patent Continuations, Product Lifecycle Contraction and the Patent Scope Erosion-A New Insight into Patenting Trends," in *Southern California Law Associations Intellectual Property Spring Seminar*.

Lemley, Mark A and Kimberly A Moore (2004) "Ending abuse of patent continuations," *BUL rev.*, Vol. 84, p. 63.

Lerner, Joshua (1994) "The importance of patent scope: an empirical analysis," *The RAND Journal of Economics*, pp. 319–333.

Marco, Alan C, Michael Carley, Steven Jackson, and Amanda F Myers (2015) "The USPTO Historical Patent Data Files: Two Centuries of Innovation," *Available at SSRN 2616724*.

Mowery, David C, Bhaven N Sampat, and Arvids A Ziedonis (2002) "Learning to patent: Institutional experience, learning, and the characteristics of US university patents after the Bayh-Dole Act, 1981-1992," *Management Science*, Vol. 48, pp. 73–89.

Popp, D, T Juhl, and D Johnson (2004) "Time in purgatory: Determinants of the grant lag for US patent applications.," *Topics in Economic Analysis & Policy*, Vol. 4.

Quillen Jr, Cecil D and Ogden H Webster (2009) "Continuing patent applications and performance of the US Patent and Trademark Office-One more time," *The Federal Circuit Bar Journal*, Vol. 18, pp. 379–404.

Régibeau, Pierre and Katharine Rockett (2007) "Are more important patents approved more slowly and should they be?".

Scotchmer, Suzanne and Jerry Green (1990) "Novelty and disclosure in patent law," *The RAND Journal of Economics*, pp. 131–146.

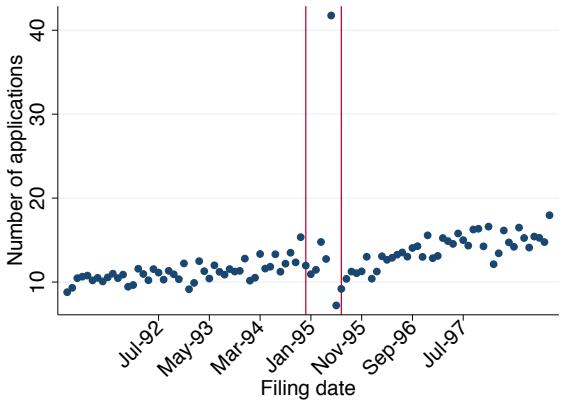
Sukhatme, Neel U and Judd NL Cramer (2014) "Who Cares About Patent Term? Cross-Industry Differences in Term Sensitivity," *Cross-Industry Differences in Term Sensitivity (August 19, 2014)*.

Thursby, Jerry G and Marie C Thursby (2003) "University licensing and the Bayh-Dole act," *Science*, Vol. 301, pp. 1052–1052.

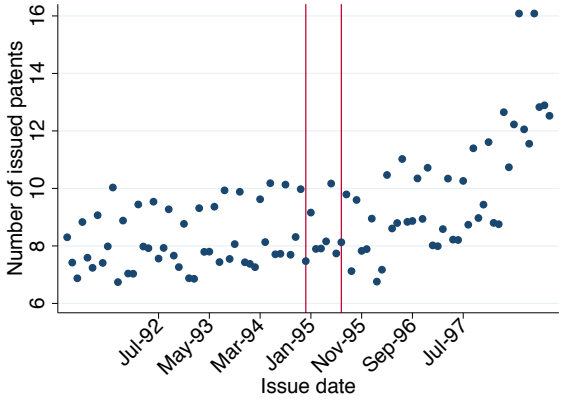
Tu, Shine (2015) "Understanding the Backlog Problems Associated with Requests for Continued Examination Practice," *Duke Law & Technology Review*, Vol. 13, p. 216.

Tables and Figures

Figure 2: Number of applications and issued patents

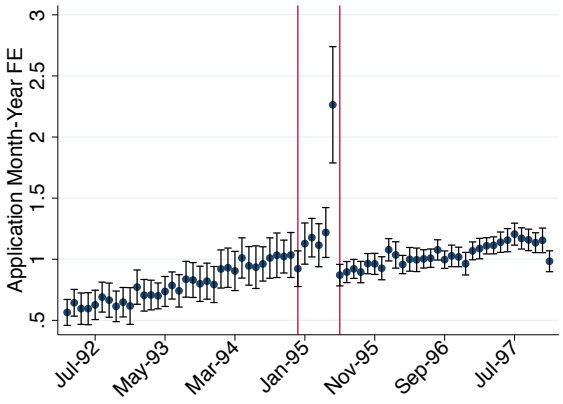


A: Number of applications (in thousands) by filing date



B: Number of issued patents (in thousands) by issue date

Figure 3: Prosecution time: All applications, OLS regressions. The figure plots estimates for the month-year fixed effect in the regression model (1) with prosecution time (in years) as the dependent variable. The vertical line on the left indicates December 8, 1994. The vertical line on the right indicates June 8, 1995.



Notes: 95% confidence intervals based on standard errors clustered at the NBER industry classification level are reported. The number of clusters is 37. The sample includes all issued patents filed between January 1991 and December 1998.

Table 1: Patents with a filing date between 1991 and 1998, by aggregated NBER category

NBER aggregated classification	Classification codes	Number of classifications	Number of patents	Percent of total
Chemical	10-19	6	170,657	16.23
Computers and Communications	20-29	4	196,262	18.67
Drugs and Medical	30-39	4	119,292	11.35
Electrical and Electronic	40-49	7	197,489	18.79
Mechanical	50-59	6	179,701	17.09
Others	60-69	9	187,865	17.87
Total			1,051,266	100.00

Table 2: Summary statistics

Name	Mean	St. Dev.	Min	Max	Definition
Panel A:					
Prosecution time					
Prosecution time	2.78	1.84	0.21	48.02	Prosecution time measured starting priority date (in years)
Panel B:					
Use of continuations					
totcont	0.45	1.00	0.00	98.00	Number of earlier applications made reference to
cont_con	0.10	0.31	0.00	1.00	Indicator for continuation
cont_div	0.06	0.24	0.00	1.00	Indicator for divisional continuation
cont_cip	0.06	0.23	0.00	1.00	Indicator for continuation in part
allowed_abandoned	0.02	0.16	0.00	7.00	Number of applications made reference to abandoned after allowance
Panel C:					
Measures of disclosure					
figures	10.09	15.72	0.00	3,654.00	Number of figures
words1000	5.89	6.61	0.00	318.09	Number of words (in thousands)
Panel D:					
Measures of patent breadth					
ind_claims	2.85	2.52	0.00	248.00	Number of independent claims
dep_claims	12.18	11.32	0.00	886.00	Number of dependent claims
ratio_dep_ind	5.44	5.12	0.00	886.00	Number of dependent claims per independent claim
Panel E:					
Measures of promptness					
rejection	1.32	1.10	0.00	24.00	Number of rejection notices received from USPTO
delay_resp	112.65	65.71	0.00	4,889.00	Response time to first rejection notice (in days)
noreject	0.19	0.39	0.00	1.00	Indicator for allowance without a rejection notice
Observations	1,064,792				

Notes: All patents that were issued between years 1991 and 1998 are included in the sample.

Table 3: Effect of TRIPS on prosecution time: OLS Regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Prosecution time						
	All	Chemical	Computers and Communication	Drugs and Medical	Electrical and Electronic	Mechanical	Others
Post TRIPS * Large	-0.121**	-0.193***	-0.120**	-0.405***	-0.044	0.001	-0.075+
	(0.040)	(0.054)	(0.042)	(0.083)	(0.040)	(0.038)	(0.042)
Post TRIPS * Small	-0.017	-0.100	-0.022	-0.273**	-0.027	0.058	0.018
	(0.048)	(0.066)	(0.063)	(0.086)	(0.054)	(0.042)	(0.041)
Small	-0.183**	0.004	-0.119**	-0.228***	0.064+	-0.158***	-0.384***
	(0.052)	(0.038)	(0.043)	(0.044)	(0.034)	(0.021)	(0.021)
Observations	289,594	45,158	55,316	32,312	53,638	48,611	51,476
R^2	0.085	0.008	0.016	0.075	0.026	0.029	0.028
Dep. variable mean	2.841	2.939	3.091	3.746	2.574	2.462	2.435

Notes: Standard errors clustered at the NBER industry classification level in parentheses in Column 1. The number of clusters is 37. Robust standard errors in parentheses in Columns 2-7. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All Columns include an NBER category FE and a linear time trend. The sample includes all issued patents filed between January 1994 and December 1996 excluding those filed in between December 1994 and September 1995.

Table 4: Effect of TRIPS on outcome variables: OLS Regressions

Panel A: Disclosure					
	figures	words1000			
Post TRIPS * Large	-0.299	-0.141			
	(0.185)	(0.110)			
Post TRIPS * Small	-0.359^{+}	-0.277*			
	(0.184)	(0.133)			
Small	-0.001	-0.844***			
	(0.389)	(0.141)			
Observations	289,031	289,031			
R^2	0.057	0.097			
Dep. variable mean	10.359	5.885			
Panel B: Breadth					
	ind_claims	dep_claims	ratio_dep_ind		
Post TRIPS * Large	-0.002	0.293*	0.098		
	(0.038)	(0.143)	(0.062)		
Post TRIPS * Small	-0.034	0.104	0.123^{+}		
	(0.045)	(0.161)	(0.067)		
Small	-0.122*	-0.519^{+}	-0.357**		
	(0.056)	(0.260)	(0.115)		
Observations	289,031	289,031	285,935		
R^2	0.038	0.017	0.017		
Dep. variable mean	2.874	12.211	5.425		
Panel C: Continuations					
	totcont	cont_con	cont_div	cont_cip	allowed_abandoned
Post TRIPS * Large	-0.227***	-0.064***	-0.009^{+}	-0.004	-0.008***
	(0.023)	(0.009)	(0.005)	(0.005)	(0.002)
Post TRIPS * Small	-0.134***	-0.030**	0.001	-0.007	-0.002
	(0.024)	(0.009)	(0.004)	(0.004)	(0.002)
Small	-0.102***	-0.062***	-0.025***	0.043***	-0.013***
	(0.021)	(0.006)	(0.003)	(0.005)	(0.002)
Observations	289,594	289,594	289,594	289,594	289,594
R^2	0.048	0.022	0.020	0.019	0.003
Dep. variable mean	0.474	0.127	0.056	0.063	0.023
Panel D: Promptness					
	rejection	delay_resp	noreject		
Post TRIPS * Large	-0.056*	-1.560^{+}	0.006		
	(0.022)	(0.918)	(0.007)		
Post TRIPS * Small	-0.084**	-0.606	0.001		
	(0.025)	(1.659)	(0.007)		
Small	-0.037	-3.932**	-0.002		
	(0.023)	(1.355)	(0.006)		
Observations	289,567	216,323	289,594		
R^2	0.031	0.016	0.014		
Dep. variable mean	1.302	112.727	0.191		

Notes: Standard errors clustered at the NBER industry classification level in parentheses. The number of clusters is 37. $+$ $p < 0.1$, $*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$. Sample includes all issued patents filed between January 1994 and December 1996 excluding those filed between December 1994 and September 1995. All regressions include NBER category FE and a linear time trend.