Pre-Grant Patent Oppositions: Evidence from Chile*

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July 5, 2024

Abstract

Pre-grant patent oppositions are challenges filed by third parties against patent applications *during* the examination process. They can prevent the issuance of weak patents but can also cause delays. We investigate the impact of pre-grant oppositions on rejection rates and grant delay using data from the Chilean patent office, where such oppositions are free to file and publicly disclosed. We exploit an exogenous shock to construct an instrumental variable to deal with selection bias. We find that pre-grant oppositions reduce the probability of receiving a patent by 20 percent and delay the examination process by 218 days, on average.

*We are grateful for comments by Bernhard Ganglmair on a preliminary version; we are also grateful for comments and suggestions by participants at the ZEW.

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1 Introduction

Patents are vital in fostering innovation by granting exclusive rights for a limited period, in a given jurisdiction, to inventions that are novel, useful, and non-obvious. Inventors applying for patents must submit applications to the patent office, where experts evaluate whether they meet the patentability criteria. However, this examination process is imperfect because experts can make errors, sometimes resulting in the granting of patents to undeserving applications.

Different jurisdictions have considered various ways to enhance the patent examination process, including allocating more resources to examiners and improving information systems. Additionally, some jurisdictions have allowed third parties to submit a *pre-grant* oppositions against patent applications. These oppositions typically critique the application on the grounds of not meeting the patentability requirements, along with evidence that the examiner of can consider *before* granting a patent. Countries such as India, the United States, New Zealand, Australia, and Chile permit the use of some form of pre-grant oppositions.[1]

In contrast to the literature investigating post-grant oppositions, research on pre-grant oppositions remains quite limited. Our contribution is to empirically investigate the impact of pre-grant oppositions one the examination process. The existing articles on pre-grant oppositions primarily consists of descriptive studies or small-sample analyses. To the best of our knowledge, we are the first article to conduct large-scale econometric analysis of pre-grant oppositions.

The welfare impact of pre-grant oppositions remains a contentious issue. On the one hand, there is a growing concern that the patent examination process, constrained by time and cost, may overlook crucial information and lead to the grant patents to undeserving applications (see, e.g., Harhoff, 2016; Frakes and Wasserman, 2023). In response to this concern, pre-grant oppositions may offer a solution, potentially enhancing welfare, by providing examiners with additional evidence to help weed out undeserving applications. For instance, Ho and Ouellette (2020) conducted a field experiment that provided input from scientific experts' to patent examiners, finding that the additional information led them to reject more low-quality applications and fewer high-quality ones.

On the other hand, the misalignment between social and private incentives can be concerning. Successful oppositions serve as a "public good" because multiple parties benefit from them.

[1] https://www.wipo.int/scp/en/revocation_mechanisms/opposition

As such, the number of oppositions filed by third parties may not be at the socially optimal level because it may be subject to a "free-rider" problem, i.e., third parties lack sufficient incentives to challenge patent applications due to bearing the costs alone while a successful challenge benefits multiple entities (see, e.g., Choi, 2005; Harhoff et al., 2016). Additionally, third parties may seek to block patents for competitive reasons rather than genuine concerns over patentability. The Federal Trade Commission's 2003 report highlights this tension, noting that while third parties can offer valuable expertise in evaluating patent applications, their involvement must be balanced to prevent undue harassment of applicants.[2]

One of the main challenges in identifying the causal effect of pre-grant oppositions is the potential selection bias. Oppositions are the result of a strategic decision rather than a random occurrences, which complicates the task of isolating the impact of pre-grant oppositions on outcomes such as grant rate or delay. Dealing with this bias is important to answer the question of whether pre-grant oppositions have the potential to enhance the examination process or are merely a vehicle to stall a competitor's patent.

To address these issues, we build a novel dataset comprising pre-grant oppositions filed against patent applications submitted to the Chilean patent office from 2009 to 2019. There are at least three institutional features of the Chilean system make it particularly conducive to exploring the impact of pre-grant oppositions on examination outcomes. First, anyone can file an opposition within 45 days of the publication of the application, free of charge. Second, the identity of the opposing party is publicly disclosed. Third, the examination process beginnings only *after* the publication of the application and the submission of any oppositions by third parties.[3]

Another feature that we exploit to our advantage is that, in our setting, the majority of oppositions were historically filed by a single entity, ASILFA, a consortium of generic manufacturers.[4] ASILFA ceased filing oppositions in 2018 due to a strategic shift and funding constraints, thereby creating a shock to the likelihood of an application facing an opposition. We leverage the variation in the number of oppositions filed by ASILFA across fields to construct an instrumental variable that helps mitigate selection biases introduced by the decision to oppose patent applications.

[2] http://www.ftc.gov/os/2003/10/innovationrpt.pdf

[3] The requirements and scope of pre-grant oppositions vary across jurisdictions. Differences include the timeframe for filing an opposition, the required evidentiary threshold, whether the opposing party remains anonymous, the permissible opposition grounds (e.g., novelty), the reviewing body (e.g., an examiner or a specialized opposition board), and the associated fees.

[4] `www.asilfa.cl`

We analyze the effect of pre-grant patent oppositions on three main outcomes: (i) the probability that the application's examination process finishes within 4 years from the application's filing date; (ii) the time it takes for the patent office to terminate a patent (prosecution time); and (iii) the probability of a patent being granted conditional on being terminated within 4 years.

Our results show that pre-grant oppositions increase rejection rates by around 20 percent and also increases the patent prosecution time by around 218 days. Moreover, patent examiners deemed over 80 percent of all oppositions "unfounded," suggesting that only a minority of oppositions may be granting useful information for the examiners.

Although many jurisdictions permit third parties to file a *post*-grant opposition, few have embraced third parties to file pre-grant oppositions, even though they could offer some economic advantages. Unlike post-grant processes, which occur *after* patent granting and involve formalities and delays, pre-grant oppositions enable early challenges by third parties. This can prevent patents from being issued without meeting novelty, utility, or non-obviousness criteria, saving potential costs of litigation or patent invalidation later.

Implementing pre-grant opposition procedures could significantly enhance the quality of granted patents, reduce the burden on judicial systems, and promote a more efficient and reliable patent system. However, policymakers should be mindful of potential delays in the examination process introduced by pre-grant oppositions. Ensuring an efficient handling process that leverages valuable information and swiftly dismisses unfounded pre-grant oppositions, can enhance the examination process.

1.1 Related Literature

Pre-grant oppositions have received attention because of their potential to improve patent quality by identifying weak patents before they are granted. There are many articles highlighting the problem of weak patents (see, e.g., Frakes and Wasserman, 2015). Lemley (2000) argue the patent examination system may provide insufficient incentives to examiners. Weak patents are even issued by experienced examiners (Lemley and Sampat, 2012), or because examiners misallocation (Lei and Wright, 2017). Moreover, ex-post litigation is likely insufficient to correct patent office errors (Farrell and Merges, 2004).

In the United States, the Leahy-Smith America Invents Act (AIA) of 2011 introduced faster and less expensive procedures for challenging patent validity, aiming to enhance patent quality

(Tamimi, 2014). Early advocacy for pre-grant oppositions in the U.S. is noted by Kesan (2002), who supported the concept nearly a decade before the AIA's implementation. Post-AIA discussions on pre-grant oppositions are presented by Aste (2012) and Kapelner et al. (2013), who analyze the effectiveness of these mechanisms in improving patent quality.

The existing literature predominantly focuses on post-grant opposition mechanisms. For example, Rai et al. (2022) examine the impact of the Patent Trial and Appeal Board (PTAB) on patent invalidation, while Chien et al. (2018) compare post-grant opposition systems in the U.S., Europe, and Germany, concluding that Inter Partes Review (IPR) outcomes are consistent with those of other systems. Nagler and Sorg (2020) finds that invalidating marginally valid patents during opposition at the European Patent Office leads affected inventors to subsequently file fewer low-quality patent applications. Harhoff and Reitzig (2004) investigate the determinants of post-grant opposition to biotechnology and pharmaceutical patents granted by the European Patent Office. By contrast, the impact of pre-grant oppositions remains relatively unexplored in the literature.

Several studies discuss opposition systems in specific countries, though many lack rigorous econometric analysis. Puasiri (2013) provides case studies from Thailand without substantial data analysis. Similarly, Buchinski (2010) discusses changes in New Zealand's pre-grant system without empirical support. Correa and Hilty (2022) and Rathod (2022) offer case studies on pre-grant oppositions in various countries, focusing on specific drugs.

Comparative studies highlight differences in opposition systems across countries. Dent (2007) and Weatherall (2009) discuss Australia's system, while Cassier (2013) contrast Brazil and India. Correa and Lamping (2024) provides a comparative analysis of patent laws and regulations across multiple Latin American countries, including Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, and Uruguay.

2 Obtaining a Patent in Chile

Since 2009, the National Institute of Industrial Property (INAPI) manages industrial property services, promotes industrial property protection, and disseminates technological information.[5] It is the Chilean equivalent to the United States Patent and Trademark Office (USPTO) or the European Patent Office (EPO). The Chilean legal framework regarding enforcement is influenced by the entry into force of the TRIPS agreement in 2005, and the

[5] www.inapi.cl

existence of Free Trade Agreements (with Europe and the USA, for example), and the Patent Cooperation Treaty (PCT), which enter into force on June 2, 2009. INAPI also serves as a first-instance court in opposition and nullity procedures.

The process of obtaining a patent in Chile consists of a series of stages.[6] Applicants initiate the process by submitting their applications through the online platform provided by the National Institute of Industrial Property (INAPI). An application must detail the invention's title, prior art, and thorough description, with crucial technical features defined through "claims" that delineate the patent's scope. Following submission, the application undergoes a preliminary review conducted by INAPI to ensure adherence to procedural and documentary standards. If the initial review identifies deficiencies, applicants have 60 (business) days to rectify them. Otherwise, the application is discarded.

Once the application successfully clears the preliminary review, the applicant has 60 days to pay for its publication in the Official Gazette. This public disclosure notifies potential competitors and stakeholders regarding the applicant's intention to obtain a patent. However, the applicant has the option to delay the publication of the application for up to 18 months by submitting a petition explaining that such a delay will safeguard legitimate foreign interests. Failing to adhere to these publication deadlines will render the application abandoned.

After the application's publication in the Official Gazette, there is a 45-day period during which *anybody*, at *zero cost*, can contest it by filing an *opposition*. Following the expert's report regarding the merits of an opposition (if there is one), the application is examined by an INAPI expert, who makes recommendations for acceptance, rejection, or requests for amendments. Applicants can respond to these recommendations, providing clarifications or modifications as warranted. Ultimately, based on the all the available information, INAPI determines whether to grant a patent.

3 Data and Descriptive Evidence

3.1 Data, Empirical Measures and Estimation Sample

Our dataset consists of patent applications filed with the Chilean Patent Office (INAPI) from 2009 to 2019. For each application, we collected information on the applicant, technology fields, filing date, and grant date (if applicable). We supplemented these data with additional

[6] https://www.inapi.cl/patentes/para-informarse.

details scraped from INAPI, including the event history of each application, whether a third party opposed the application and the outcome of each opposition. We also include data on forward citations and priorities obtained from Google Patents. Our dataset contains information on 28,275 patent applications filed with INAPI between January 2009 and December 2019.

Empirical Measures. We identified a set of key dates for our analysis. First, we obtained the 'Filing' date for all applications. Second, we obtained the 'Publication' date for all applications. Applications that were never published were considered 'Abandoned' and were discarded from our analysis. We also obtained the 'Grant' date for all patents granted by the Chilean Patent Office and the 'Rejection' date for applications that were not granted. We defined the 'Termination' date as the Grant date for granted patents and as the Rejection date for rejected applications.

We constructed two variables to measure the duration of patent prosecution. Since the actual examination process at the Chilean Patent Office begins after the application is published in the Official Gazette, we first computed the prosecution time by the time difference (in days) between the Termination and Publication dates. Although this measure naturally assesses the time it takes for the patent office to grant a patent, right censoring in this variable may introduce bias into our analysis. More complex applications, or those with more priorities, may require more time to examine.[7] To address this right censoring issue, we computed a second measure: the probability that the examination process ends within four years.[8] We then generated a dummy variable that takes the value 1 if the patent examination process is terminated in less than four years since the application's filing date ('Terminated in ≤ 4 years'), and 0 otherwise. This measure does not suffer from censoring issues, given that we observed four years since the publication of each application in our data.

Patent applications are not all equal in terms of patentability or quality, which can influence the outcome of a patent application regardless of oppositions. These characteristics may also impact the probability that a patent is opposed, leading to an endogeneity issue. To address this heterogeneity, our analysis includes the number of priorities for each patent application and forward citations for each granted patent, following Hall et al. (2001).[9]

Estimation Sample. We restrict our analysis to patents filed from 2011 onward, due to

[7] In our data, some applications have taken over ten years from publication to grant date.

[8] Our dataset was last updated on June 4, 2024.

[9] A challenge with forward citations is that "older" patents would tend to have more citations, regardless of their technological importance. To mitigate this issue, we limited our analysis to citations within three years after the grant of a patent.

the change in the institutional context described in Section 2. We focus on patents that were granted or rejected, excluding from our main analysis patents that were abandoned (and never examined) or have not been terminated by June 2024. Finally, since we are interested in comparable patents, in our baseline estimations we also exclude patents from one-time applicants, in order to control for applicants' unobserved heterogeneity. We end up with a final sample of 15,027 patents. Table 1 shows descriptive statistics of our final estimation sample.

Table 1: Estimation Sample Descriptive Statistics

	Mean	Median	min	max	st.dev.	Observations
Granted	0.72	1.00	0	1	0.450	15,027
Terminated in $\leq$ 4 years	0.67	1.00	0	1	0.470	15,027
Granted in $\leq$ 4 years	0.66	1.00	0	1	0.475	10,795
Prosecution Time	1272.31	1230.00	0	3896	501.315	15,027
Opposed	0.12	0.00	0	1	0.328	15,027
Number of Priorities	1.19	1.00	0	3	0.715	15,027
Fwd Citations within 3 Years	5.18	2.00	0	984	13.677	15,027

Notes: The table presents the means, medians, minimums, maximums, standard deviations, and valid observations for the main characteristics of the estimation sample. The sample was drawn from the INAPI records and covers terminated patents filed from 2011 to 2019.

3.2 Descriptive Evidence

Figure 1 (left panel) reports the total number of patent applications filed each year. Figure 1 (right panel) reports the total number of patent applications filed in each one of five broad categories of technology.[10]

[10]We define technology sectors and technology fields (subsector) according to the WIPO's definition, https://www.wipo.int/ipstats/en/statistics/patents/xls/ipc_technology.xlsx.

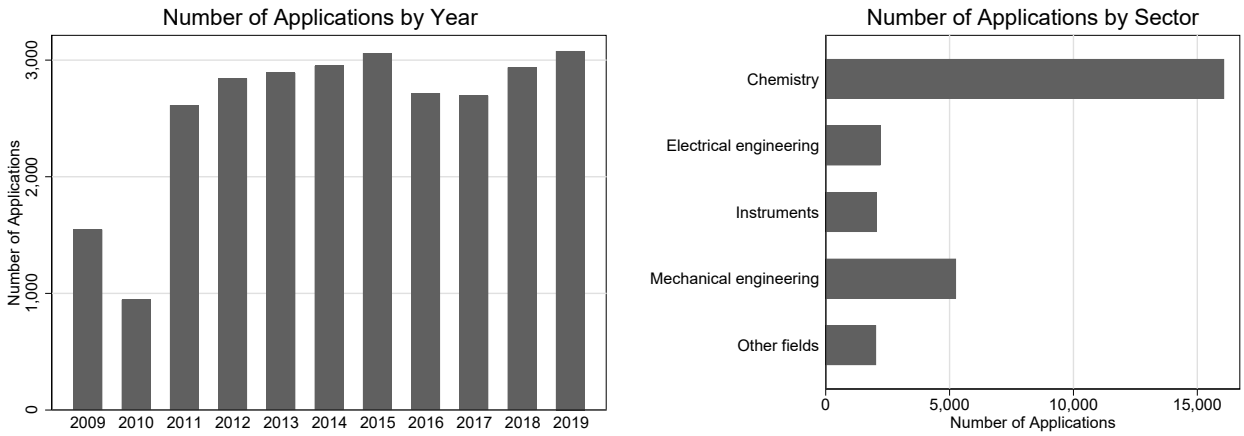

Figure 1: Number of Patent Applications by Filing Year and Technology Sector.

The figure shows that the number of patent applications after 2011 is roughly constant, with a yearly average of 2,496 applications per year. The increase in applications starting in 2011 reflects the period following the initial 18-month window after Chile's joined to the PCT, during which international applicants began to include Chile in their patent filing strategies. In terms of technology sectors, "Chemistry" is the most popular technology class, comprising almost sixty percent of all patent applications. Figure A.1 (in the Appendix) reports the number of applications by each field within technology classes. Pharmaceutical patents represent the largest contribution of patent applications within the "Chemistry" sector.

Out of 8,350 unique applicants in our sample, 5,448 (65.25%) submitted a single application, 1,220 (14.61%) submitted two applications, and 1,682 (20.14%) submitted three or more applications. Nestlé (subsidiary Nestec) and Novartis are among the companies with the largest number of patent applications.

We next present descriptive evidence on pre-grant oppositions. In Chile, any third party can file an opposition request explaining why an application does not deserve patent protection. There is no fee to submit an opposition report, but it must be filed within 45 business days from the public disclosure of the application. Figure 2 shows the fraction of third-party oppositions by year (left panel) and by sector (right panel).

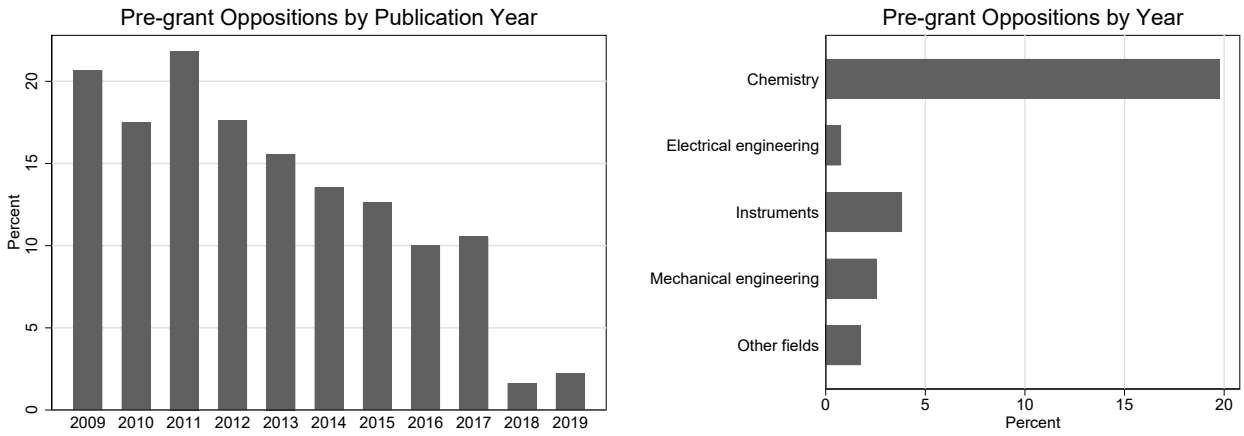

Figure 2: Fraction of Patent Applications Challenged by a Pre-grant Opposition by Filing Year (left panel) and by Sector (right panel).

The figure shows that applications in the 'Chemistry' sector experience the largest likelihood of opposition: about 20 percent of these patents are opposed. Figure A.2 (in the Appendix) breaks down the fraction of oppositions by fields. Within the 'Chemistry' sector, pharmaceutical patents face the highest opposition rate, with around 40 percent of all pharmaceutical patent applications being opposed. Figure 2 (left panel) shows a drastic drop in third-party oppositions after 2017. As we document below, this sharp drop is almost entirely explained by a change in the strategy of the largest filer of oppositions.

Figure 3 (left panel) shows the fraction of oppositions attributed to specific opposition filers. ASILFA, representing domestic labs in the Chilean pharmaceutical industry, accounted for 70.78 percent of all oppositions. RECALCINE, a network of national labs engaged in generics production and R&D, also played a substantial role, filing around 15 percent of all oppositions.

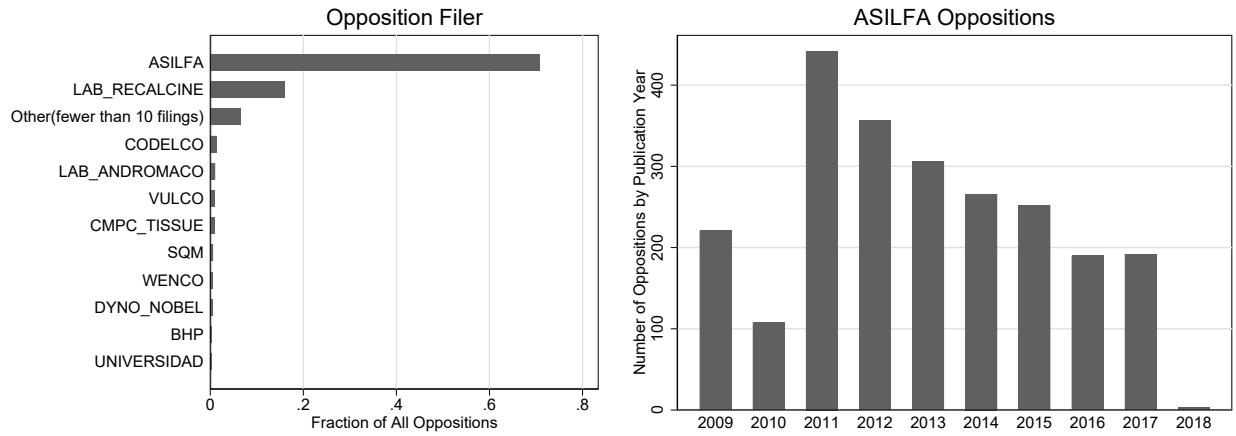

Figure 3: Parties Filing Oppositions. Percent of Oppositions by Party (left panel) and Number of Oppositions by ASILFA by Filing Year of the Opposed Application (right panel).

Figure 3 (right panel) shows the number of oppositions filed by ASILFA each year. The figure shows that ASILFA ceased to file oppositions in 2018, which is explained to various reasons. Initially, their decision hinged on the types of patents being filed by innovative labs in Chile. A former ASILFA contractor, explained to us that their opposition strategy was based on commercial interests related to these products. Until 2017, ASILFA, actively monitored and proposed oppositions based on daily publications, presenting about 15 oppositions per month.

However, ASILFA's influence waned as new associations, such as the National Chamber of Laboratories (CNL) and the Association of Local Medicine Producers (PROLMED), emerged and garnered more members. This shift fragmented ASILFA's resources and member support, leading to the termination of their surveillance and opposition services contract. Consequently, individual laboratories began independently monitoring patents and deciding whether to oppose applications.

Furthermore, ASILFA's strategic focus shifted away from patent oppositions to regulatory matters, particularly concerning health registrations with the ISP. Additionally, the acquisition of major local laboratories by foreign companies, such as Abbott acquiring Recalcine and Grunenthal acquiring Andromaco, also contributed to ASILFA's decreased opposition activities. This consolidation under foreign ownership likely altered strategic priorities and reduced the volume of oppositions ASILFA previously sponsored and funded.

The drastic impact on the number of oppositions in 2018 caused by the strategic change in ASILFA will be central for our econometric strategy.

4 Impact of Pre-Grant Oppositions on Outcomes

Pre-grant oppositions can enhance welfare by aiding patent examiners in rejecting low-quality applications. Table 2 shows that opposed applications are rejected at a higher rate (51.81%) compared to unopposed ones (29.01%). Conversely, unopposed applications have a higher grant rate (70.99%) instead of (48.19%).

Table 2: Rate of Rejection conditional on Pre-grant Opposition.

	Pre-Grant Opposition		
Granted	No	Yes	Total
No	5,572	1,315	6,887
	29.01%	51.81%	31.67%
Yes	13,635	1,223	14,858
	70.99%	48.19%	68.33%
Total	19,207	2,538	21,745

As a second descriptive fact, we show that some pre-grant oppositions may contain questionable information. An INAPI's examiner is who ultimately decides whether the evidence in an opposition is sufficiently strong as to be used against an application. If the evidence in the opposition is useful, and the examiner uses it to reject a patent, the opposition is "successful." Otherwise, if the opposition does not have enough merit, it is "unfounded." Even when an opposed application is ultimately rejected, an opposition challenging the application can be unfounded. By reading the outcome of the opposition trial from each one of the files available in the INAPI webpage, we were able to track whether an opposition is successful or found to be unfounded.

Table 3 indicates that only 489 applications (out of a total of 2,538 opposed applications, see, Table 2) are successfully opposed. The table also shows that for only 37 percent of the 1,315 opposed applications that are ultimately rejected, the opposition was successful, i.e., it was considered as part of the reason to reject the application.

This evidence suggests that the majority of pre-grant oppositions are unfounded: 2,049 out of 2,538 (80.73 percent). Thus, only a relatively low number of oppositions may be providing useful information to patent examiners.

Table 3: Rate of Rejection conditional on Pre-grant Opposition.

	Pre-Grant Opposition		
Granted	Unfounded	Successful	Total
No	826	489	1,315
	62.81%	37.19%	100%
Yes	1,223	0	1,223
	100%	0%	100%
Total	2,049	489	2,538
	80.73%	19.27%	100%

Next, we investigate the impact of pre-grant oppositions on prosecution time, focusing the analysis exclusively on granted patents. In Figure 4, we compare the distribution of "grant delay" for opposed and unopposed patent applications. Grant delay is defined as the number of days between the publication of the application and the grant of the patent. Before the application is published in the Official Gazette, there is no substantial examination (only a preliminary review).[11] The figure shows that opposed applications exhibit larger grant delay; the distribution of grant delay for opposed patents first-order stochastically dominates the distribution of of unopposed patents. Opposed applications take on average 690 additional days to be granted than unopposed applications.

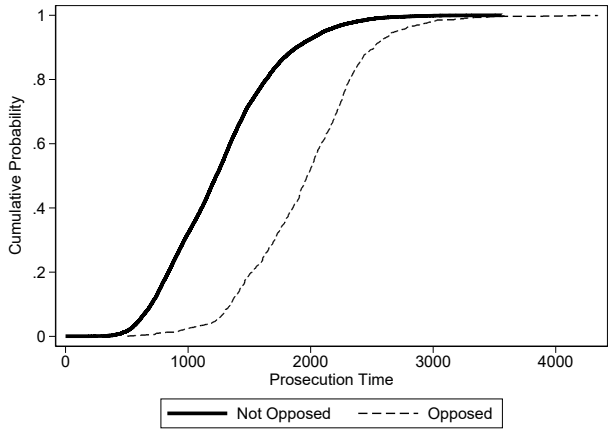

Figure 4: Distribution of "grant delay" for Opposed and Unopposed Patents.

Establishing causality from this descriptive evidence can lead to wrong inferences due to potential selection biases.

[11] In the Chilean Patent Office, the bulk of the examination occurs after the application is published in the Official Gazette and third-parties have been given an opportunity to oppose.

Taking this evidence at face value one might conclude that oppositions *cause* examiners to reject applications more often and delay the examination process. However, one must be careful in making such causal statements. Pre-grant oppositions are the result of a strategic decisions that may correlate with some features of the patent application that also correlate with increasing the probability of rejection. For instance, if low-quality applications are more likely to be opposed, the sample of opposed applications may already predispose them to higher rejection rates. Or if opposition occur more frequently for complex technologies, then complexity rather than the opposition can be responsible for examination delays. Our econometric analysis in the next section addresses the selection issue.

5 Empirical Strategy

5.1 OLS Conditional Correlations

As a starting point, we provide evidence on the correlation between receiving an opposition and three outcomes of interest: the grant probability of an application, as well as the prosecution delay and the probability that the examination process is finished in 4 years or sooner. To that end, we estimate the following equation:

$$Outcome_i = \alpha + \gamma Opposed_i + \beta_1 Priorities_i + \beta_2 Citations_i + \mu_f + \mu_a + \mu_t + \varepsilon_i. \quad (1)$$

The variable *Opposed* is a dummy variable that takes value 1 if patent application i is opposed and 0 otherwise, *Priorities* accounts for the number of priorities the patent application relates to, *Citations* is the number of forward citations patent i received the three after it is granted. The terms μ_f, μ_a, μ_t are a set of fixed effects controlling for unobserved heterogeneity in the field number, applicant, and filing date (month-year). Finally ε_i is the error term of the model.

5.2 Instrumental Variable

Oppositions result from strategic decisions rather than random occurrences; therefore, the OLS estimation of Equation 1 allows us to compute the marginal effect of an opposition on our outcomes of interest, but not their causal effect. While controlling for a wide range of fixed effects controls for some unobserved heterogeneity, ε_i still includes unobserved components

of patent quality or patentability that might correlate with the opposition decision.

To deal with this problem, our empirical strategy exploits the dissolution of ASILFA in 2017 as an exogenous shock to the probability that an application would receive a pre-grant opposition. As explained in Section 2, once ASILFA ceased its coordinating role, the free-riding incentives may prevent each potential plaintiff from filing an opposition, even if the cost of filing such an opposition is small. As a consequence, oppositions may be likely to occur, particularly in technology fields were ASILFA was more active.

We compute the 'ex-ante' probabilities of ASILFA opposing a patent in each IPC field to construct a measure of *exposure to the shock* after the dissolution of ASILFA in 2017. In practice, this measure is calculated by computing the opposition rate by technology field in 2010 and 2011. We use this exposure measure as an instrumental variable (IV), since it affects the probability of receiving an opposition but it does not (directly) affect the patent examination process. Therefore, our identification strategy exploits both the exogeneity of ASILFA's termination and the exogeneity of patents' IPC classification. Using this instrumental variable, we can control for the potential selection of effect that bias standard OLS estimators, allowing us to uncover the causal effect of oppositions on patent examination outcomes.

As explained in Section 3, ASILFA used to oppose patents in specific fields, all related to pharmaceuticals. We use the share of patents opposed by ASILFA in each field in 2010 and 2011 as a measure of exposure intensity within each field. That is, to predict an opposition of patent i, in field f, filed in year t, we construct the following variable:

$$\text{Exposure}_{i(f)} = \frac{\text{Total ASILFA Oppositions}_{f,2010-2011}}{\text{Total Applications}_{f,2010-2011}} \times 1(filingyear(i) > 2017). \quad (2)$$

In this equation, $\text{Total ASILFA Oppositions}_{f,2010-2011}$ is the total number of oppositions presented by ASILFA to patents in field f during 2010-2011, $\text{Total Applications}_{f,2010-2011}$ are the total number of applications in field f during 2010-2011. The dummy variable $1(filingyear(i) > 2017)$ takes the value 1 if a patent application i's filing year is 2018 or 2019, and 0 otherwise. This dummy variable captures the "ASILFA Shock," after this consortium ceased to file oppositions in 2017.

We then leverage the exogeneity of the variable 'Exposure' and use it as an instrument and use it to esimate Equation 1 by instrumental variables.

5.3 Additional Estimation Methods

We present two additional estimation methods: 'Diff-in-Diff' and 'Indirect Least Squares.' We estimate a canonical Difference-in-Difference research design considering patents in the pharmaceutical field as treated and those in fields where ASILFA never presented an opposition as controls. To prevent the mixing of treated and non-treated patents, we exclude applications in fields outside pharmaceutical for which ASILFA opposed at least one application during our sample period.[12] The Diff-in-Diff estimates then account for the reduced-form estimates of the effect of oppositions on patents.

The second method we explore in this section relies on an Indirect Least Squares (ILS) estimator. We compute the ILS estimator by determining the ratio of the reduced-form coefficients on the instrument to the first-stage coefficient.

To that end, we estimate the following equations:

$$Outcome_{i(f,t)} = \eta_0 + \eta_1 Post_t + \eta_2 Treated_f + \eta_3 Post_t * Treated_f + \nu_i \quad (3)$$

$$Opposed_{i(f,t)} = \delta_0 + \delta_1 Post_t * Treated_f + \delta_2 Priorities_i + \delta_3 Citations_i + \mu_f + \mu_a + \mu_t + \mu_c + \varepsilon_i \quad (4)$$

where $Post_t$ is a dummy variable that takes value 1 if patent i is filled in year t after ASILFA cessation in 2017, and 0 otherwise; $Treated_f$ is a dummy variable that takes value 1 if patent i is from the pharmaceutical field and 0 otherwise, as described below. All the remaining variables are defined as in Equation 1. ν_i and ε_i are the error term in the difference in difference and the first stage equations, respectively.

The ILS estimator is derived by calculating the ratio of the reduced form coefficients η_3 on the instrument to the first-stage coefficient δ_1 estimated by OLS in Equation 4.

6 Results

Table 4 reports the OLS estimates associated with Equation 1. Column (1) indicates that an opposed patent has a lower probability of being terminated in 4 years or less (0.45 percentage points lower), Column (2) indicates that its prosecution time is almost 500 days longer, and

[12] Specifically, we identify patents with IPC field number 16 (pharmaceuticals) as treated and exclude those with field numbers 6, 10, 13, 14, 15, 17, 18, 19, 20, 21, 23, and 29.

Column (3) indicates that their granted rate is 0.41 percentage points lower than non-opposed patents. Results also indicates a significant correlation between the number of priorities of a patent and its prosecution time. These results are consistent with the preliminaty descriptive evidence in Section 4.

Table 4: OLS Estimates of Oppositions Effects

	Terminated in $\leq$ 4 years	Prosecution Time	Granted
Opposed	-0.456***	498.551***	-0.413***
	(0.01)	(13.79)	(0.02)
Number of Priorities	-0.010	19.029***	-0.012
	(0.01)	(6.44)	(0.01)
Fwd Citations within 3 Years	-0.000	0.121	-0.000
	(0.00)	(0.38)	(0.00)
Obs.	15027	15027	10470
R-squared	0.427	0.544	0.442

Notes: The Table presents the OLS estimates of Equation 1. Column (1) shows the results for the probability of a patent to be terminated in 4 or less years, Column (2) indicates the results for the prosecution time and Column (3) displays results for a patent granted probability conditional on being terminated in 4 or less years. All specifications include applicant, IPC field, country of the applicant and month-year of filing fixed effects. Robust Standard errors in parentheses. ***significant at the 1% level, **5% level, *10% level.

Next, we turn to deal with endogeneity by using the instrument described in Section 5.2. Table 5 reports the estimates of Equation 1 for the probability a patent to be terminated in 4 or less years and for the prosecution time. Column (1) indicates that the variable 'Exposure' is statistically significant in explaining the probability of a patent being opposed at the 1% level. The t-statistic for the significance test of our instrument, not reported in the table, is -31.60, indicating that 'Exposure' is a robust instrument for predicting the probability of a patent being opposed. Furthermore, column 1 in the table indicates that while the probability of a patent application being opposed is positively and significantly correlated with the application's priorities, it is not correlated with the number of forward citations. Since forward citations are calculated globally, and it is highly probable that a patent application in Chile has already been patented elsewhere, we can use it as a proxy for the importance of the patent even if the application was not successful.

Table 5, columns 2 and 3, show the IV estimates of Equation 1. The results indicate that an opposition reduces the average probability of terminating the application's examination process in 4 years or earlier by 0.38, whereas it increases the average prosecution time by more than 200 days. When comparing these estimates with the OLS estimates presented in Table 4, we find that the correlation and the causal effect estimates are not very different when analyzing the probability of a patent being terminated in 4 years, but they are different when analyzing prosecution time. Specifically, the correlation between a patent being opposed and

its probability of termination in 4 years or less is -0.45, while the causal effect is -0.38, indicating a small selection bias.

Nevertheless, when comparing the correlations and causal effects in the case of prosecution time, we find that the IV estimate is half the OLS estimate. This suggests that while opposition generates a delay in prosecution time of 200 days, this effect is less than half the prosecution time observed for opposed patents (500 days). Given that the estimates in column 3 also show a positive correlation between prosecution time and the number of priorities a patent application has, part of this selection bias might be explained by the fact that patents with more priorities are more likely to be opposed, and it takes longer to prosecute them as well.

Table 5: Oppositions and Patent Termination

	Opposed	Terminated in $\leq$ 4 years	Prosecution Time
Exposition Asilfa	-0.838***		
	(0.03)		
Number of Priorities	0.013***	-0.011*	22.014***
	(0.00)	(0.01)	(6.60)
Fwd Citations within 3 Years	0.000	-0.000	0.104
	(0.00)	(0.00)	(0.39)
Opposed		-0.381***	218.183***
		(0.05)	(51.76)
Obs.	15027	15027	15027
R-squared	0.486	0.086	0.079

Notes: Column 2 and Column 3 of the Table presents the IV estimates of the effect of oppositions on the patent probability of being terminated in 4 or less years, and on prosecution time. and the conditional probability of being granted in 4 yeas. Column 1 show the first stage estimates. All specifications include applicant, IPC field, country of the applicant and month-year of filing fixed effects. Robust Standard errors in parentheses. ***significant at the 1% level, **5% level, *10% level.

Table 6 shows the estimates of Equation 1 for the probability of a patent being granted, conditional on being terminated in 4 years or less. Column (1) displays the first-stage estimates in the reduced sample of patents terminated in 4 years or less (10,470 patents). Regarding the full sample estimations, 'Exposure' is a strong instrument for predicting the probability of a patent opposition. Column 2 indicates that oppositions reduce the average probability of a patent being granted by 0.19. This estimate is almost half of the OLS estimation, suggesting high selection in patent oppositions in terms of their probability of being granted. Apart from the selection bias, oppositions do have a negative effect on the probability of a patent being granted.

Table 6: Oppositions and the Probability of Granted

	Opposed	Granted
Exposition Asilfa	-0.715***	
	(0.03)	
Number of Priorities	0.016***	-0.015*
	(0.01)	(0.01)
Fwd Citations within 3 Years	0.000	-0.000
	(0.00)	(0.00)
Opposed		-0.194***
		(0.07)
Obs.	10470	10470
R-squared	0.431	0.043

Notes: Column (2) of the Table presents the IV estimates of the effect of oppositions on the probability of a patent of being granted conditional of being terminated in 4 or less years. Column (1) show the first stage estimates. All specifications include applicant, IPC field, country of the applicant and month-year of filing fixed effects. Robust Standard errors in parentheses. ***significant at the 1% level, **5% level, *10% level.

Table 7 shows the first-stage and Difference-in-Difference estimates of Equation 3 and Equation 4. Column (1) presents estimates of Equation 4 and indicates that pharmaceutical patents (treated) after ASILFA cessation in 2018 (post period) are a good predictor for patent oppositions. The t-statistic of -29.21 suggests that the interaction term between the treated dummy and the post-ASILFA period is a good predictor of the probability of a patent opposition. Columns (2) and (3) show the Difference-in-Difference estimates of Equation 3. Column (2) indicates that treated patents after the ASILFA shock are, on average, 0.18 more likely to be terminated in 4 years compared to the counterfactual scenario in which ASILFA would have continued being active. Column (3) shows that in the absence of ASILFA, treated patents would have been prosecuted in 95 fewer days, on average.

The causal effect is then computed by dividing the reduced form estimates by the first stage one (ILS estimator). Column(2) and Column(3) indicate that oppositions reduce on average the probability a patent to be terminated in 4 years by 0.443 and increase prosecution time by an average of 232 days. The ILS estimation of the causal effect is consistent and in the same magnitude term than the IV estimates showing robustness of our main results.

Finally, columns 2 and 3 report the p-value of the F test for the parallel trend test. In each of the specifications we fail to reject the null hypothesis of parallel trends. Appendix Figures A.4 and A.5 show graphical evidence of the parallel trend assumption.

Table 7: Difference in Differences Estimates

	Opposed	Terminated in $\leq$ 4 years	Prosecution Time
Treated*Post	-0.409***	0.181***	-95.050***
	(0.01)	(0.02)	(19.98)
Causal Effect (ILS)		-0.443	232.309
P-value Parallel Trends		0.270	0.067
Obs.	8915	8915	8915
R-squared	0.518	0.244	0.370

Notes: The Table presents the first stage and Difference in Difference estimates for the interaction term between the treated dummy, that takes value 1 if it is a pharmaceutical patent and 0 otherwise, and post ASILFA cessation dummy, that takes value 1 for patents filed after 2017 and 0 otherwise. Opposition is a dummy variable that takes value 1 if there was an opposition to the patent and 0 otherwise. The causal effect is computed by dividing reduced form estimates over the first stage one. All specification include controls for number of priorities and forward citations. The first stage specification include applicant, field , country of the applicant and month- year of filing fixed effects. The Difference in Difference specifications include field and filing year fixed effects. Robust Standard errors in parentheses. ***significant at the 1% level, **5% level, *10% level.

7 Conclusion

We examine the impact of pre-grant oppositions on the patent examination process using empirical evidence from Chile. Our findings indicate that pre-grant oppositions can significantly enhance rejection ratios at the expense of longer prosecution time. Oppositions cause a 20 percent increase in rejection rates and an extension in prosecution time by approximately 218 days. These results suggest that pre-grant oppositions help to filter out low-quality patent applications, potentially improving the overall quality of patents granted.

However, the analysis also reveals that most oppositions are deemed unfounded, indicating that the system needs to manage these cases efficiently to avoid unnecessary delays. The free-rider problem and the possibility of strategic opposition for competitive reasons underscore the importance of balanced and well-regulated opposition procedures.

We contribute to the limited literature on pre-grant oppositions and underscore the need for further research in this area. Future studies could explore the long-term effects of pre-grant oppositions on innovation and economic growth, as well as the impact of different opposition mechanisms across jurisdictions. As patent systems continue to evolve, the insights from our research can help inform policies that balance the interests of inventors, competitors, and the broader public, ultimately fostering a more innovative and competitive economy.

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APPENDIX: Additional Figures

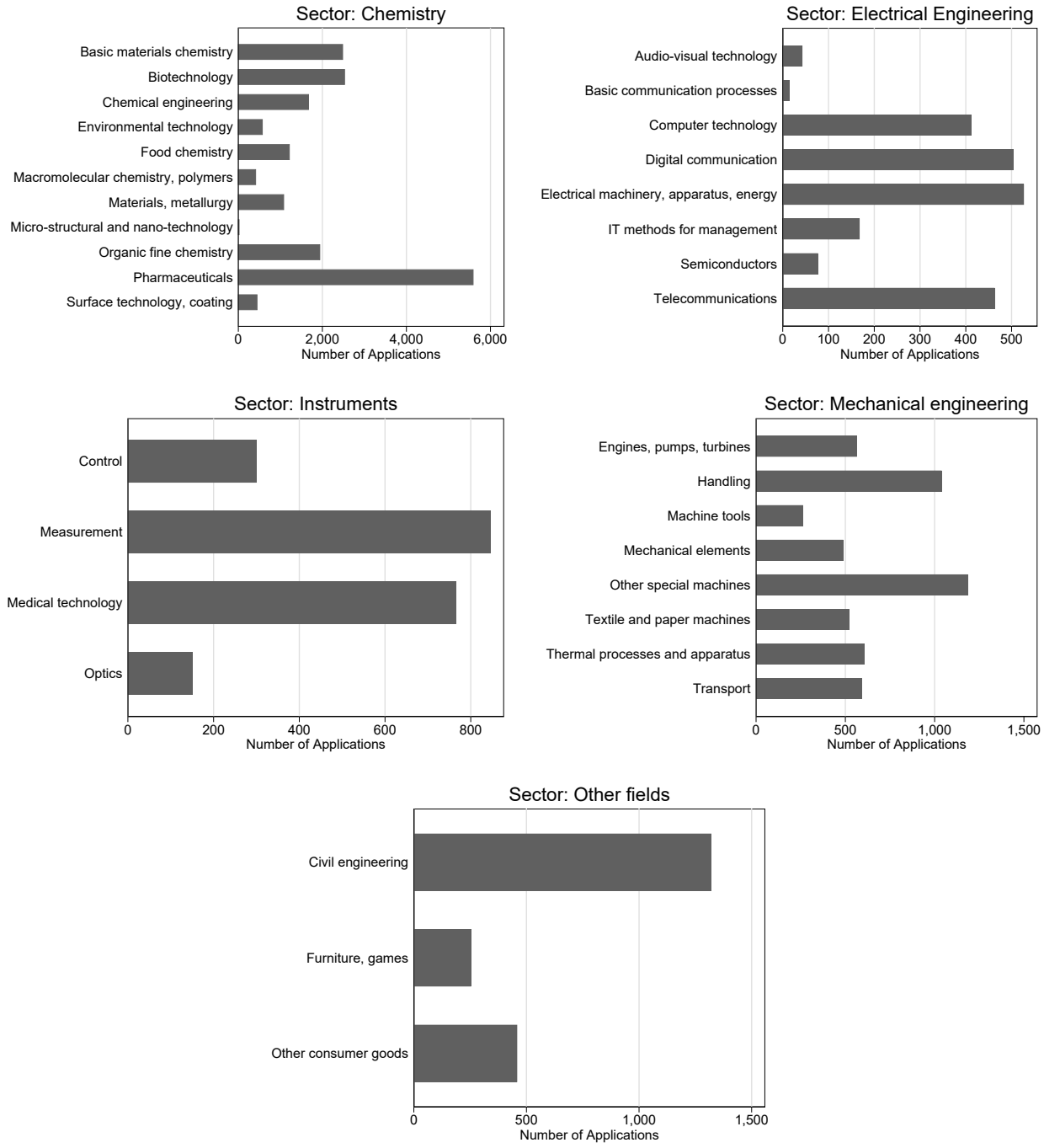

Figure A.1: Applications by technology field within sectors.

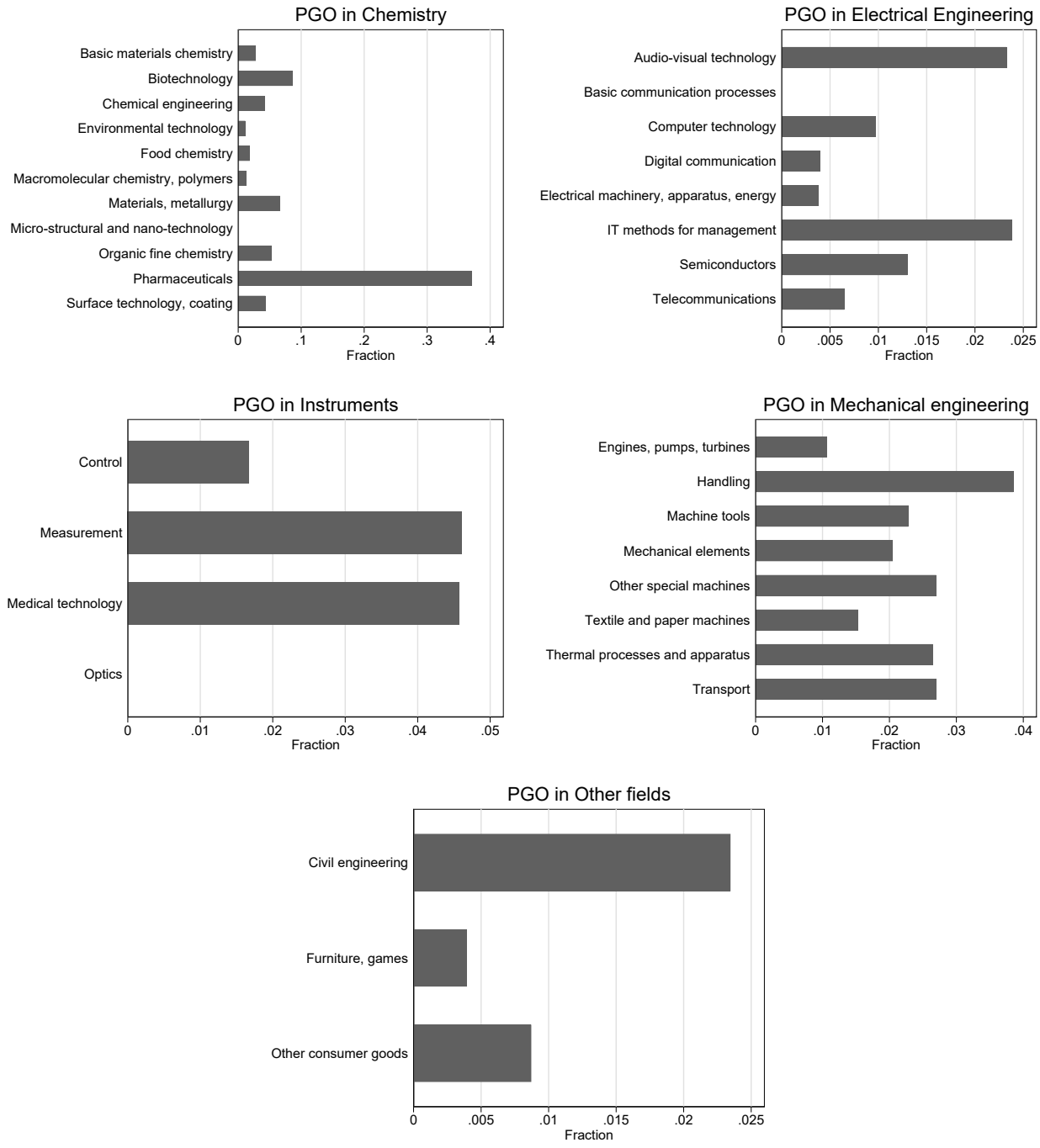

Figure A.2: Fraction of applications opposed by third parties during prosecution by technology field within sectors.

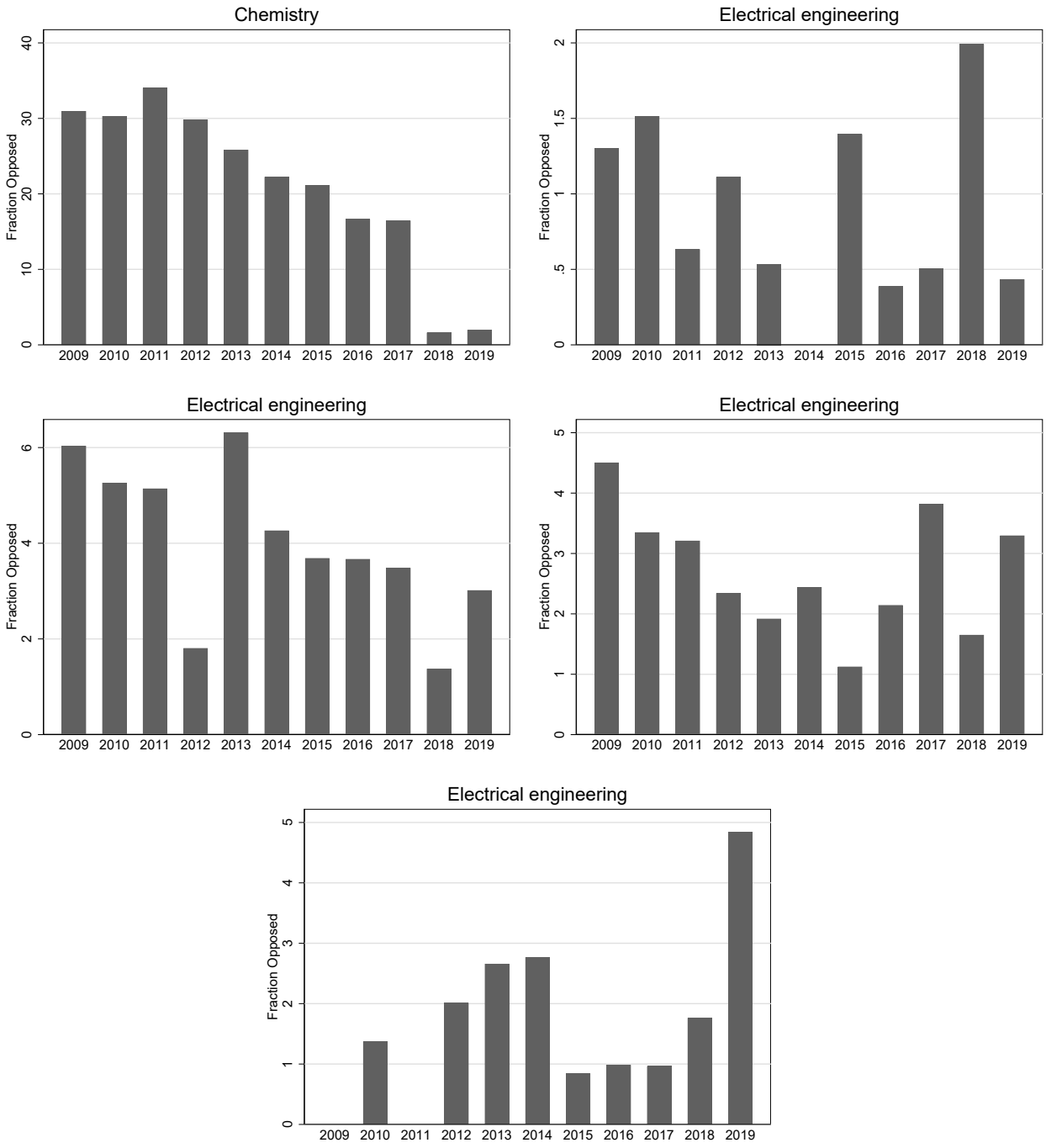

Figure A.3: Fraction of applications opposed by third parties during prosecution over the years by sectors. Note the difference in scale on each figure. Except for Chemistry before 2017, the fraction of opposed patents is below 6 percent per year.

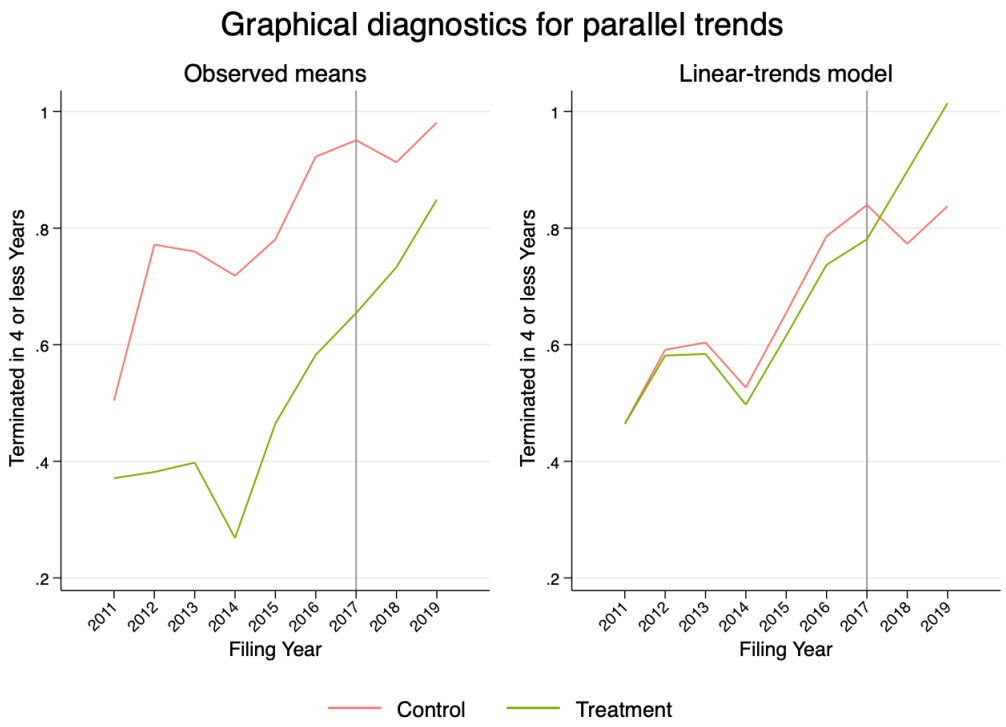

Figure A.4: Termination Probabilities over Time

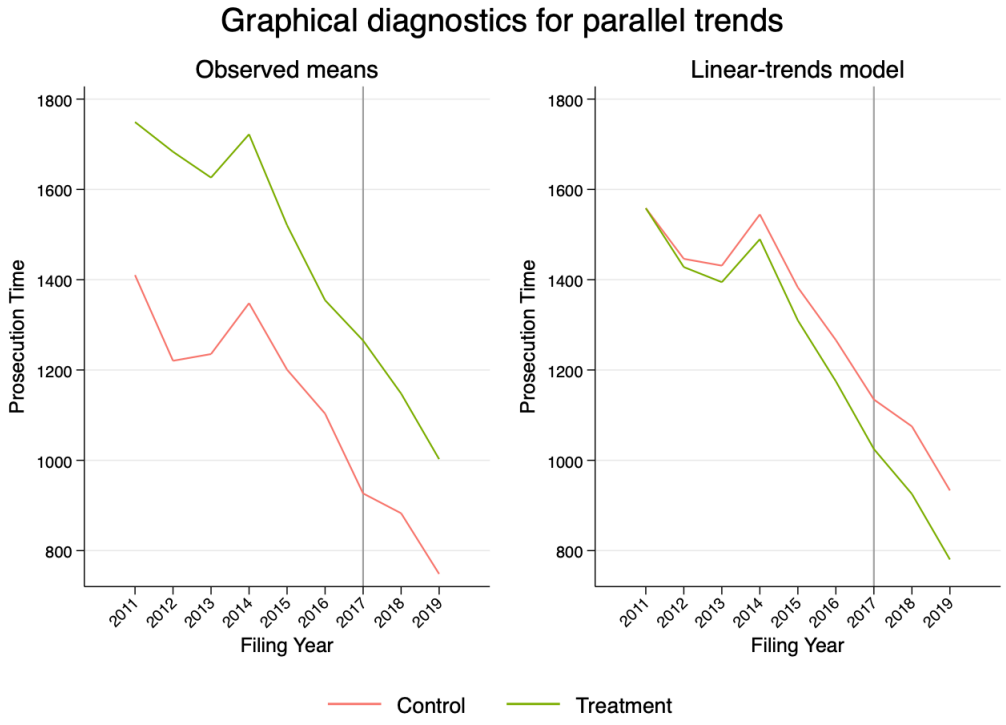

Figure A.5: Prosecution Time over Time