

# Antitrust, Patents, and Cumulative Innovation: Evidence from Bell Labs

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This version: January 24, 2016

## Abstract

How large is the impact of intellectual property on cumulative innovation in electronics, computers and communications? Following an antitrust lawsuit against Western Electric and AT&T, Bell Labs had to license all patents published by 1956 for free. We find that this removal of patent rights increased subsequent citations to Bell's patents by 7%. Patenting in affected patent subclasses increased by 17%. The effect comes from young and small firms in fields in which Bell did not remain commercially active. Placebo regressions support the identification assumption of parallel trends in citations.

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# 1 Introduction

Innovation is a key driver of economic growth. A major tool to foster innovation are patents. Patents correct for the lack of market incentives to create innovation resulting from the public-good nature of ideas (Arrow, 1962; Nelson, 1959). Yet, patents have come under attack because they might reduce the likelihood that a patented innovation is used as the basis for future inventions. This problem could be particularly acute in complex product industries such as electronics, computers and communications, because in these technologies new inventions require a large number of components and thus cumulative innovation is thought to be very important. The concern that patents might impede follow-on innovation in mobile communication technology was raised for example in the public debate on the “Smartphone wars”.<sup>1</sup> Many argued that small entrepreneurial companies might be unwilling to build on current patented mobile technologies if they have to fear diverse patent claims from various incumbent companies. This could eventually prevent market entry and thus innovation.

But is this indeed the case? Up to now our knowledge about the effects of patents on cumulative innovation in electronics, computers and communications is limited. The reason is that there is very little variation in patent rights to learn about the effects. The only variation comes from cases where patents have been invalidated in court (Galasso and Schankerman, 2015b). However, the sample of patents challenged in court is very selective and we do not know whether we can generalize the findings from this sample to the policy-relevant case of large scale patent rights removals.<sup>2</sup> Furthermore, we cannot generalize other findings in the literature because they are often based on discrete product technologies such as pharmaceuticals, biotechnology or chemicals (Moser and Voena, 2012; Williams, 2013). However, we know from surveys that patents work very differently in these discrete product technologies than in complex product technologies (Cohen *et al.*, 2000).

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<sup>1</sup>Refer for example to Eduardo Porter, “Tech Suits Endanger Innovation”, New York Times, May 29, 2012, page B1 or Charles Duhigg and Steve Lohr “The Patent, Used as a Sword”, New York Times, Oct 7, 2012, Page A1

<sup>2</sup>Yet, the sample of patents invalidated in court is a very interesting sample, because the estimated effect is immediately policy relevant and the selection might be based on the value of patents.

In this paper we provide empirical evidence on how the removal of patent rights from Bell Labs, one of the most innovative companies of all times, influenced subsequent innovation. Researchers at Bell Labs were responsible for groundbreaking innovations in the fields of computer electronics and communications, such as the transistor, the laser, information theory and the basis of the cellular phone technology. In the 1950s, Bell Labs, AT&T and Western Electric constituted the Bell System, which had an 85% share in the US telecommunication market. In response to this dominant position, the Federal Communications Commission (FCC) filed an antitrust suit against Western Electric in 1949, suggesting that the Bell System should be broken up and all patents should be licensed for reasonable rates. After some wrangling, Bell agreed in 1954 to the compulsory licensing of their patents in return for the monopoly in the telephone market. This concession was the basis of the consent decree in 1956: all existing patents became freely available to other companies and all future patents had to be licensed for reasonable licensing fees. In addition, Bell Labs was required to provide complementary technical information relating to the compulsorily licensed patents and had to leave all industries unrelated to the telecommunication industry.

At the time, most observers thought of the consent decree as an ineffective antitrust remedy: The magazine *Business Week* wrote that the decree was “hardly more than a slap on the wrist of the world’s biggest company”. In a later investigation the House Subcommittee on Antitrust found that the “cozy” consent decree of the Bell System “failed the purpose of the Sherman Act” and that it was a “blot on the enforcement history of antitrust laws”. Over the years, opinions on the consent decree changed - but mainly because of its effect on other companies: For example, the co-founder of Intel, Gordon Moore, called the consent decree one of the most important developments for the commercial semiconductor industry, which started the growth of the Silicon Valley. David Teece opined in 1997, that “[s]haped by antitrust policy (...) [AT&T’s liberal licensing policy] remains one of the most unheralded contributions to economic development – [it] possibly far exceeds the Marshall plan in terms of wealth generation capability established abroad and in the United States“ (Grindley and Teece, 1997, p.

6).

This paper sheds light on what really happened. In particular, we look at patent citations of other companies to Bell Labs patents published before 1949 and compare them with citations to a control group of patents that are identical with the treated Bell Labs patents in terms of technology class, publication year and number of citations up to 1949. We find that after the consent decree, the number of citations to Bell Labs' patents increased by about 7% or a total of 1,500 citations.<sup>3</sup> The timing of the effect mirrors the timeline of the antitrust suit against Bell: Measured by the application year of the citing patent, the impact is first measurable in 1954, peaks between 1956 and 1959 and reverts to baseline by 1965. The effect is driven by young and small companies outside the technological field of electrical communications. This points to the importance of market entry of entrepreneurial companies for cumulative innovation. The positive effect on citations by other companies is accompanied by an equally large negative effect on self-citations, suggesting Bell changed its research focus in response to the invalidation of their patents. This is in line with recent findings by Galasso and Schankerman (2015a).

The effect is identified under the assumption that the citations to the patents of Bell Labs and to the control patents would have followed a parallel trend in the absence of the consent decree. This seems plausible as citations followed parallel trends from 1949 to 1953 before compulsory licensing became known. In addition, we conduct three more tests of the identification assumption: First, we look at a subsample of citing companies that were explicitly excluded from compulsory licensing in the consent decree: RCA, Westinghouse, General Electric and ITT. Re-doing our analysis with citations of these companies only, we find no effect. This speaks in favor of parallel trends. Second, the assumption of parallel trends might be violated if the FCC anticipated strong follow-up research based on Bell's most important inventions and as a consequence initiated the compulsory licensing. In this case, the effect would be driven by the most important patents affected by the consent decree. We show that our effect is robust to

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<sup>3</sup>In further analysis we show that there is a similar increase of 10% in the total number of patents in patent classes where Bell was active before the consent decree.

dropping the top 5% of Bell’s patents as measured by their citations both before the beginning of the antitrust suit and as measured by their citations before the consent decree became public. Third, we conduct placebo regressions for other companies in the telecommunication sector where Bell preserved its monopoly and thus effectively blocked entry and do not find any effect.

This paper contributes to the growing literature on the effect of intellectual property on cumulative innovation in two important ways. First, we complement the recent literature on the impact of patents on cumulative innovation. Consistent with the findings of Galasso and Schankerman (2015b), our findings suggest that indeed patents prevent knowledge spillovers and follow-up research in the computer and electronics industry.<sup>4</sup> However, with an increase of 7% we find a much smaller impact in citations than they do in their sample of litigated patents: Following the invalidation of a patent in the field of computer and electronics they find an increase of 170 and 200% in the number of patent citations.<sup>5</sup> Second, to arrive at our result we look at variation from a highly policy relevant case, namely the large-scale removal of patent rights following an antitrust lawsuit for one of the largest innovators in US economic history. In a companion paper we look at all consent decrees in US post war history to determine which remedy was most effective.

The rest of this paper is organized as follows. In the next section we look at the history of Bell Labs and the consent decree. Then we describe the data and in section 4 the empirical set-up. In section 5 we discuss our results and their interpretation. Section 6 concludes.

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<sup>4</sup>Patent citations are an often used measure of knowledge flows albeit with known imperfections (Alcacer and Gittelman, 2006; Lemley and Sampat, 2012).

<sup>5</sup>The size of our measured effects appear consistent with Murray and Stern (2007) and Williams (2013), who find an overall impact of patent removal on innovation of about 10-20% in biotech and medical instruments. Moser and Voena (2012) find that domestic patenting increases by 20% after the compulsory licensing of German chemical patents in World War I. Given that the effectiveness of patents is thought to be much stronger in these areas, the smaller magnitudes in our study seem reasonable (Cohen *et al.*, 2000).

## 2 The history of AT&T, Bell Labs and the consent decree<sup>6</sup>

In 1876, Alexander Graham Bell, then a professor for Vocal Physiology and Elocution at Boston University's School of Oratory, was granted a patent for the first telephone device. Shortly afterwards, he founded the "Bell Telephone Company of Massachusetts". 80 years later, this company had developed into the Bell System, the largest US company of its time, providing telephone services to 46 million telephone lines or 85% of the total market.

The Bell System consisted of AT&T, a holding company managing the Bell System, Western Electric, which produced telephone equipment, the Bell Telephone Laboratories, which engaged in basic and applied research and the regional Bell operators, which delivered telephone services in particular regions. In 1955, the operating revenue of the Bell System was around USD 62 Billion (in 2015 Dollars) and it employed 745,000 people.

The most remarkable part of the Bell System were the Bell Laboratories (Bell Labs) in Murray Hill, New Jersey. Bell Labs was arguably the most innovative company of its time, producing pathbreaking basic and applied research. Scientists at Bell are credited for the development of radio astronomy (1932), the transistor (1947), information theory (1948), the cellular telephone technology (1947), the solar cells (1954), the laser (1957), and Unix (1969). Often, these inventions were based on breakthroughs in basic research such as understanding the fundamental nature of semiconductors, of cosmic radiation and the nature of electrons. In total, 8 Nobel Prizes were awarded for work done at Bell. The 1955 staff of Bell Labs alone would go on to win three Nobel Prizes in physics, one Turing Award, five US National Medals of Science and 10 IEEE Medals of Honors for work at Bell Labs. In the late 1960s, Bell Labs employed 15,000 people including 1,200 PhDs.

In January 1949, the government started to move against the monopoly of AT&T

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<sup>6</sup>This history largely follows the final report to the Antitrust Subcommittee of the House on the Bell Consent Decree Program (Celler, 1959).

and filed a 73 page antitrust suit with the aim to break up the Bell System. It charged extensive violations of the Sherman Antitrust Act in the manufacture and sale of telephone equipment beginning in 1900. It proposed three remedies: First, Western Electric should be split into at least three companies. Second, AT&T should be required to buy telephone equipment only under competitive bidding. And third, Bell Labs should be required to license its patents non-discriminatorily for a reasonable royalty rate.

Bell answered in April 1949 to the effect that the allegation were groundless. There was no further contact between the Bell and the government till August 1951, when the government served a request for documents relating to the case to Bell. In early 1952 the Bell System decided to seek a freeze of the antitrust suit due to the Korean war, claiming it would distract key executives from the war efforts. The Department of Defense (DoD) strongly supported Bell with this request and even requested an indefinite postponement. The Attorney General granted a two year freeze in December 1952.

In January 1953 the Republican Dwight D. Eisenhower took office. The Justice Department was now much less keen on going after Bell than the previous Truman administration. In March 1953 the new Attorney General, Herbert Brownell Jr, announced publicly “that he was reviewing the pending antitrust cases in the Department for the purpose of deciding whether any of them should be dismissed.” Under these circumstances, AT&T saw the chance to settle all antitrust claims once and for all.

After several staff meetings, Herbert Brownell and AT&T’s general counsel T. Brooke Price met privately at a judicial conference in White Sulphur Springs, West Virginia on June 27, 1953. Price argued for dismissal of the case. In response, Brownell gave Price the hint that minor concessions would suffice to “get rid of the case”. What is more, Brownell urged the defendant’s counsel to review their practices and instead of seeking dismissal to submit concessions that would cause “no real injury to (A.T. & T.’s) business” in order to settle (Celler, 1959, p.55).

In May 1954 AT&T presented and in June 1954 submitted a checklist of concessions to Herbert Brownell that would be an acceptable basis for a consent decree. The only

suggested major remedy was the compulsory licensing of all Bell patents on reasonable terms. The proposal did not require severance of Western Electric, it did not limit the role of Western Electric as supplier to the Bell System, and it did not require operating companies of the Bell System to purchase under competitive bidding. In the end - after several further interventions of the Department of Defense - this proposal served as general framework for the final decree.

Negotiations continued through 1954 and 1955. Some voices in the DOJ wanted to press for divorcement of Western Electric from the Bell System till they agreed to drop this matter in November 1955. In December 1955 the DOJ communicated with AT&T that it was ready to consider a decree of "general character suggested (by A. T. & T.) in its memorandum (...) dated June 4, 1954" with a few additional constraints (Celler, 1959, p.92). Bell agreed.

On January 24 1956 the final judgement was handed down and the consent decree of 1956 took effect. The decree contained four major provisions affecting Bell: First, Bell had to license all its 8,600 published patents to all applicants royalty free and all future patents at reasonable rates. Second, it had to give technical information to all US companies licensing the patents. Third, it had to get out of all business not directly connected to the communications field. Fourth, it had to introduce uniform cost accounting for Western Electric.

Although hailed as a victory by antitrust officials, posteriority begged to differ: According to Business Week "the consent decree (...) [is] hardly more than a slap on the wrist for the biggest corporation in the world". A Western Electric official said, that the decree "grants a legalized monopoly" and "in effect the decree constitutes an admission for the government that the way we are doing our Bell System job is a legal and proper way (...) - in effect a blessing of the present set-up"(House, 1958, pp.2020). Furthermore, the decree "made no change of any importance as regards Western" outside of the "patents and technical information fields". The permissive nature of the consent decree led to extensive Hearings in Congress on the Consent Decree program in general and on the consent decree of AT&T. It concluded that "the



consent decree entered in the A. T. & T. case revealed as devoid of merit and ineffective as an instrument to accomplish the purposes of the antitrust laws.” Furthermore, it considered the decree as a “blot on the enforcement history of the antitrust laws” (Celler, 1959, pp. 290).

### 3 Data

For our study we use patent data from the “Worldwide Patent Statistical Database” (Patstat) of the European Patent Office (EPO). Patstat contains patent data from more than 100 countries. It was specifically developed for statistical analysis. The data on US patents come from the United States Patent and Trademark Office (USPTO). The coverage for bibliographic data of patents for the US starts in 1920. However, only in 1947 the USPTO started to publish citations of prior art on the patent (Alcacer *et al.*, 2009). As a consequence, Patstat has the citation data starting from this date only.<sup>7 8</sup>

The consent decree affected all “Bell System Patents”, i.e. all patents held by American Telephone and Telegraph Company (AT&T), Western Electric Company (Western) and the Bell Laboratories (Bell Labs). We identify all patents affected by the consent decree with a list of patent numbers published in the “Hearings before the Antitrust Subcommittee” of the US Congress on the consent decree of AT&T in May 1958 (House, 1958).<sup>9</sup> In total, we find 7,720 patents that were affected by the consent decree. 5,421 patents were filed by Bell Labs, 1,957 patents by Western Electric and 342 patents by AT&T. In the following, we use a patent publication as the unit of observation. As more than 80% of all patents are filed in the name of Bell Labs, in the following we use Bell Labs as *pars pro toto* for the Bell System.

Figure 1 shows the share of patent applications filed by the Bell System on all patents filed in the US for the five patent classes (3-digit level IPC) in which it was

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<sup>7</sup>The first patent to include prior art was issued on 4 February 1947. Yet, inventions were evaluated against the prior art already since passage of the Patent Act of 1836. Prior to 1947, however, the prior art was available only from the “file history” of the issued patent, which is not contained in Patstat.

<sup>8</sup>The exact coverage for each country can be found here.

<sup>9</sup>The list is the complete list of all patents owned by the Bell System in January 1956. It also includes patents of Typesetter Corp. which are explicitly excluded from compulsory licensing in Section X of the consent decree. We mark these patents as unaffected.

Table 1: Citations statistics

	Citations	Patents	Cit. per patent	Self-cites	Self-cites [%]	H04-cites	H04-cites [%]
All	3,311,690	1,347,374	2.46	148,665	4.5	54,943	1.7
Control	3,257,565	1,329,568	2.45	141,694	4.3	44,076	1.4
Bell System	53,759	17,700	3.04	6,960	12.9	10,809	20.1
Bell Labs	35,453	8,383	4.23	5,802	16.4	7,429	21.0
AT&T	4,577	2,746	1.67	66	1.4	1,973	43.1
Western Electric	13,823	6,629	2.09	1,096	7.9	1,470	10.6

*Notes:* Data for all US patents published before 1956, both valid and expired. “Control” includes patents whose applicants are not part of the Bell System. A citation is identified as a self-cite if the applicant of cited and citing patent is the same. The IPC class H04 “Electric Communication Technique” was central to AT&T’s business.

most active. In the 1930s and 1940s, Bell virtually dominated electric communications with around 30% of all US patents. In 1956, it filed between 5 and 10% of all patents in “Electric Communication Techniques”, “Basis Electric Elements” and “Basic Electric Circuitry”.

To each patent publication, we link the number of forward citations by other patents. Table 1 shows summary statistics of forward citations for all patents in our dataset. Note that not all of these patents were still under patent protection in 1956 (see table 2). The average patent in our data set receives 2.46 citations per patent and 4.5% of these citations are self-citations. Bell Labs patents receive 4.23 citations and 16.4% of these citations are self-citations.

In this study we use patent citations as a way of measuring how many other patents build on the knowledge of Bell Labs and as the dependent variables in our regressions. This is possible even after the consent decree was implemented as each patent has to state all prior art on which it is based, irrespective of whether the cited patents are still under protection of the patent law or not. Except when explicitly mentioned in the text we correct in all our regressions for self-citations because we are mainly interested to which extend other companies build on Bell Labs patents.

Patent citations are known to have two main drawbacks: First, patent citations capture only follow-up innovations that are patented, i.e. they do not measure flows if the follow-up innovation is held as a trade secret. Second, many citations are added by the patent examiner, which decreases the signal to noise ratio of patent citations (Alcacer and Gittelman, 2006). The main advantage of patent citations is that they

Figure 1: Share of Bell System patents by class and application year

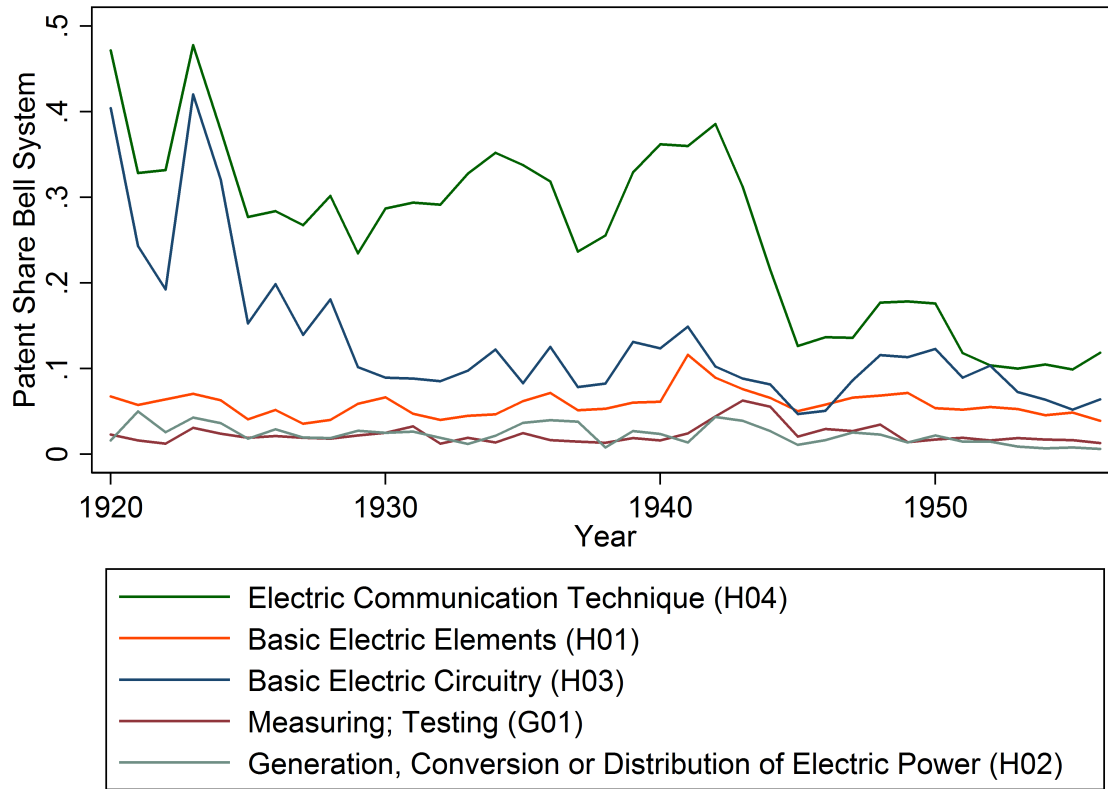


Table 2: Patent protection

	Other patents	Bell System	Bell Labs	AT&T	Western Electric
Patent protection	516,053	7,375	5,152	314	1,926
Expired protection	813,621	10,325	3,231	2,432	4,703
Total	1,329,674	17,700	8,383	2,746	6,629

*Notes:* Patents published before 1956 split by age: Patents published more than 17 years ago had already been expired at the time of the consent decree.

are consistently available for a long time period, they have a clear legal interpretation and they allow - due to their relative high frequency - a precise measurement of effects.

## 4 Identification strategy

Prior to the consent decree the objective of Bell's licensing policy was to use it strategically in order to have "design freedom", i.e. the ability to use all available technology to produce the best product, no matter who owned the intellectual property (Grindley

and Teece, 1997).<sup>10</sup> Bell implemented this strategy by first demanding standardized royalty rates depending on licensed technology in the range from 1% - 6% of net sales price and then shaded these royalties if a cross-license of the licensee patents were agreed upon (House, 1958, p. 2685).<sup>11</sup> Due to its large portfolio of important technologies Bell usually received any grantback it required.<sup>12</sup> After the consent decree royalty rates of patents published before 1956 were reduced to zero and patents published after the consent decree had to be licensed for reasonable royalty rates.<sup>13</sup> The consent decree limited grant-backs to technologies that were connected to common carrier communication.

By ensuring the right of any company to receive a license and technical information for free starting in 1956, the consent decree may or may not have increased the equilibrium rate of subsequent research. Reducing the royalty rate to zero should have increase the demand for its technology by all potential licensees and in particular for companies which did not have a large patent portfolio to bargain for royalty shading with Bell. In addition, by taking away discretion to grant or to not grant a license the agreement potentially reduced ex-post hold up situations between Bell and inventors successfully building on Bell's technology. As a consequence, we should expect that follow-up innovation increases after the consent decree. Yet, Bell already licensed patents to other companies for royalties or reciprocal rights to its patents. This implies that the effect might be zero if licensing worked reasonably smooth prior to the decree.

To evaluate these hypotheses, we must address the fundamental problem of causal inference, namely that we can only observe the realized but not the counterfactual outcomes of the consent decree. Ideally, we would like to compare the realized number

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<sup>10</sup> According to Grindley and Teece (1997) Bell was first company to put this "design freedom" at the heart of its patent strategy.

<sup>11</sup> For example, prior to the decree to get access to the transistor patents each licensee had to pay non-refundable advance payment of \$ 25'000 (around \$ 220'000 in today's Dollar ) which was credited against royalty payments House (1958, p.2957). Royalty payments amounted to 5% percent of the net selling price in 1950 which was reduced to 2% in 1953 Celler (1959, p. 117).

<sup>12</sup> At the time of the judgement Bell had 639 patent license agreements of which 352 contained grant back provisions of which 7.7 were royalty bearing (House, 1958, p. 2664). In total Bell collected \$ 3.5 million in 1955 (\$ 30 Mio. today) which dwindled to 0.3 Million (\$2 Mio today) in 1957.

<sup>13</sup> Reasonable royalty rates were again interpreted to lie between 1%-6%. Indeed Bell changed reduced its standard royalty rates only for 25% of all technologies and increased it for one.

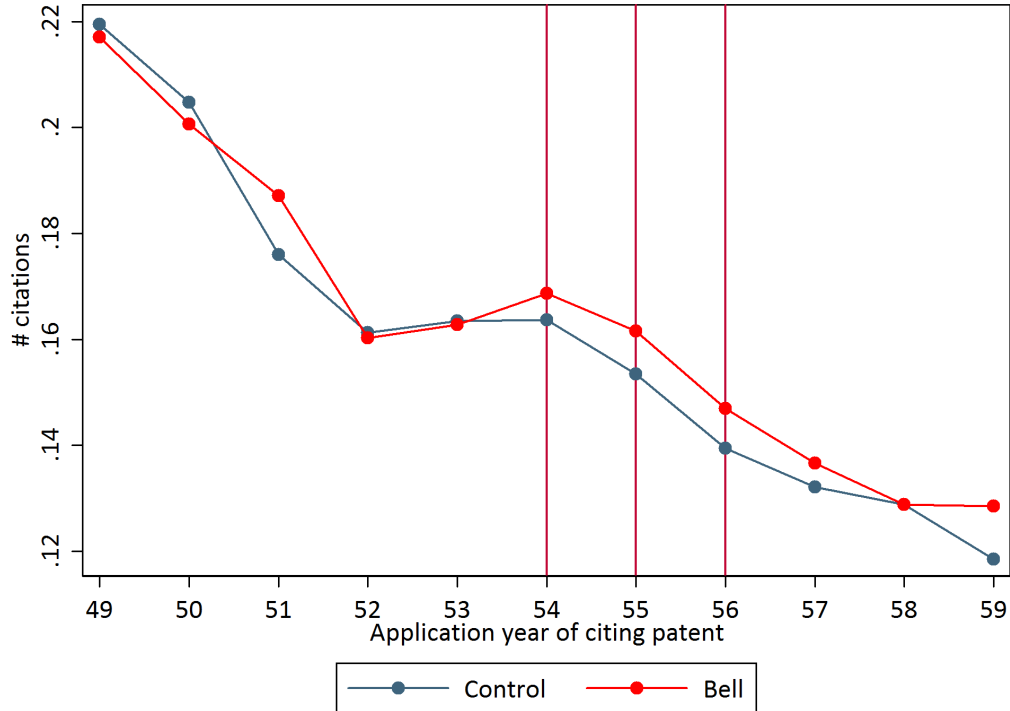
of follow-up innovation based on Bell patents with and without the consent decree. As this is not possible, we need to find a control group whose evolution of follow-up innovation over time is on comparable to the counterfactual evolution of follow-up innovations based on Bell patents in the absence of the consent decree.

Our research design allows us to measure follow-up innovations and to find a suitable control group: The consent decree made Bell patents published before January 1956 freely available in form of a free license to all companies. Yet, although the patents could be freely used, other patents that built on the patented innovations of Bell still had to cite them. Thus we can use patent citations as a measure for follow-up innovation although the patents lost their power to exclude competitors.

The consent decree stated that only patents published before 1956 were to be compulsorily licensed. As a consequence of this cut-off date in publication years, more than 98% of the patents affected by the consent decree were filed before 1953, and 88% in 1949 or earlier. This implies that the characteristics of the majority of the affected patents were fixed before the antitrust department filed its initial plea. To be on the safe side, we use only patents *published* by 1949, the year the lawsuit against Bell started. Thus we can be sure that there is no direct link from the consent decree to the characteristics of the patents under consideration.

In addition, by using patents that were published so early we can observe the evolution of follow-up innovation, measured by citations (corrected for self-citations), in the first 6 years before the consent decree took effect. We can use the information on the counterfactual evolution to choose a control group in the following way: We select patents that have the same total number of citations prior to the start of the lawsuit in 1949, that are published in the same year and in the same technology class. The identifying assumption is that patents that have the same number of follow-up innovations in the first years also have on average the same number of follow-up innovations in the following years. We test this assumption using various falsification tests.

Figure 2: Average number of citations of Bell and control patents published before 1949



## 5 Results

### 5.1 Impact of the consent decree on patent citations

We begin our analysis by graphically comparing the evolution of patent citations of patents published before 1949 in every year after publication of the treated patents and patents in the same publication year and the same four digit technology class in Figure 2. From 1949 to 1953, the average number of citations of treatment and control patents track each other very closely. This implies that there seems to be no effect in the first 4 years after the plea. Furthermore, the the patents appear to be a good control group as they exhibit parallel trends. There is a clear increase of citations to Bell patents in 1954 in both graphs, which converge again in 1961/1962. This is prima facie evidence for an effect from 1954 onwards.

In a second step we use regressions to quantify the effect. Our baseline regression analysis measures the effect of compulsory licensing of Bell Labs' patents on subsequent citations. We use a difference-in-difference estimator that identifies the average

difference between treatment and control patents. Specifically, we use the following equation

$$\#Citations_{i,t} = \alpha + \beta_t \cdot Bell_i + YearFE + \varepsilon_{i,t} \quad (1)$$

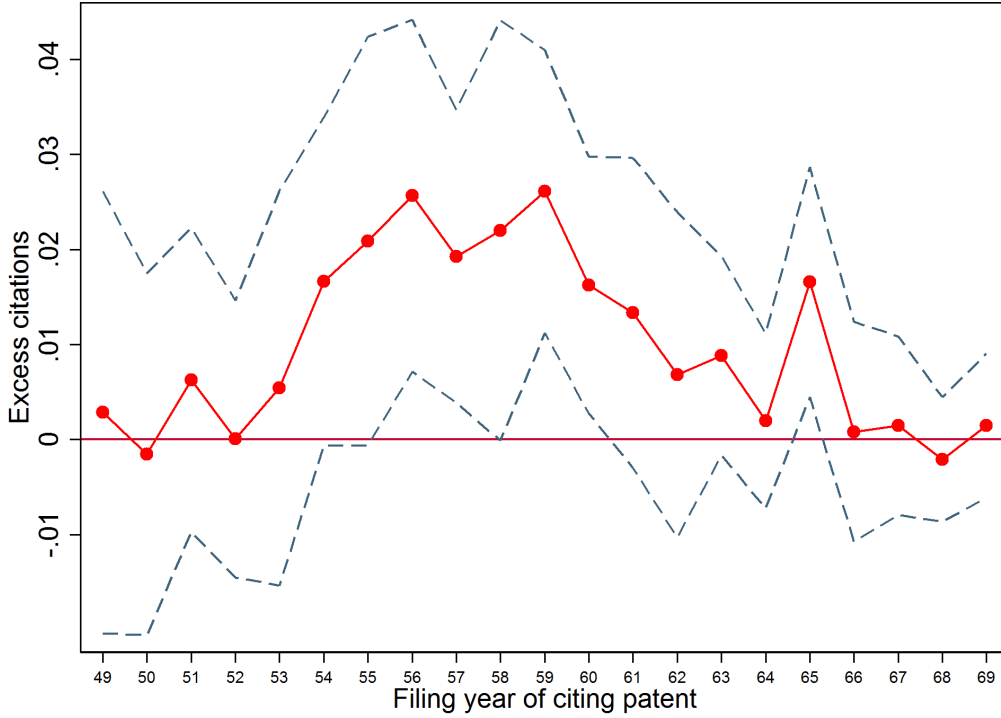
where  $Citations_{i,t}$  is the number of follow-up citations of other companies to the treated and the control patents.  $Bell_i$  is an indicator if the patent is owned by the Bell System and therefore treated. To avoid contamination we use as treated patents only the 4730 patents of Bell published before the antitrust suit was filed in 1949. Control patents belong to the same technology class on the four-digit IPC level, have the same publication year and the same number of citations up to the year 1949. In total we can match 4507 (95%) Bell patents to 55111 control patents. To estimate an average treatment effect on the treated, we use weights from the coarsened exact matching algorithm provided by Iacus *et al.* (2009) in order to adjust for the imbalance in the number of treatment and control patents.

The results for the estimating the time-varying treatment effect,  $\beta_t$  in the Equation (1) is shown in Figure 3. In the years 1949 up to 1953 there is no significant difference between treatment and control group. As in the simple comparisons of means in Figure 2 this implies that in the first four years the patent citations of treatment and control patents exhibit similar trends. In 1954 and 1955, there is an increase to 0.02 excess citations. The coefficients are significantly different from zero on the 10 percent level. Starting in 1956, the year of the consent decree, the increase becomes statistically significant on the 5% level. From 1954 to 1960 the size of the effect is almost constant at 0.02 excess citations per patent per year. Afterwards the year-by-year coefficient converges, with one outlier in 1965 - back to baseline.

In Table 3 we estimate a uniform effect of the consent decree for the years 1949 to 1965, using the following equation

$$\#Citations_{i,t} = \beta_1 \cdot Bell_i + \beta_2 \cdot Bell_i \cdot I[1954 - 1965] + PeriodFE + \varepsilon \quad (2)$$

Figure 3: Effect of compulsory licensing on subsequent citations



where  $I[1954 - 1965]$  is an indicator for the treatment period from 1954 to 1960 and  $PeriodFE$  is a fixed effect for the treatment period. In the first column, we look at the effect of the consent decree in the pre- and post-treatment period with the citations of other companies to Bell patents as dependent variable. There is no significant baseline effect while in the treatment period the effect is 0.015 additional citations relative to the mean of 0.2, an increase of around 7%. The second column looks at self-citations which decrease by 0.011 citations. This points either to a lower propensity to exploit the already existing technology by Bell after the consent decree or to a shift in the patent strategy towards using secrecy as a way to protect its intellectual property. The effect on own citations is large enough to reduce the effect on total citations to statistical insignificance (column 3).

The effect of the consent decree is identified under the assumption that the citations to the Bell Labs and to the control patents would have followed a parallel trend in the absence of the consent decree. This might not be the case for three reasons: First, Bell might have published a different type of patents with different citation patterns in



Table 3: The effect of compulsory licensing on subsequent citations

	(1) Non-Self- Cites	(2) Self- Cites	(3) All Cites	(4) wo Transistor	(5) wo Top 5%	(6) wo Top 20%
Bell	-0.11 (0.58)	1.71*** (0.27)	1.60*** (0.56)	-1.94*** (0.46)	-0.26 (0.43)	-0.23 (0.36)
Bell x I(54- 65)	1.47** (0.63)	-1.06*** (0.23)	0.41 (0.72)	2.26*** (0.53)	1.56*** (0.54)	1.20** (0.52)
Constant	20.88*** (1.58)	1.49*** (0.15)	22.37*** (1.66)	19.45*** (1.12)	17.08*** (0.91)	10.54*** (0.46)
Adj R2	0.01	0.00	0.01	0.01	0.00	0.00
Clusters	262	262	262	262	262	262
Obs.	1446972	1446972	1446972	1446972	1446972	1446972

*Notes:* This table shows the results from a difference-in-difference estimation with years 1949 to 1953 as pre-treatment period and 1953 to 1965 as treatment period. The variable "Bell" is an indicator if a patent is published by a Bell System company before 1949 and therefore treated by the consent decree. As control patents we use all patents which were published in the US matched by publication year, four digit IPC class and the number of citations up to 1949. As dependent we use in the first column all citations by other companies than the filing company, in the second column we use all self-citations and in the third column all citations as dependent. In the fourth column we exclude patents which are connected to the transistor, the most prolific invention of Bell Labs. All coefficients are multiplied by 100 for better readability.

anticipation of the consent decree. This would imply a selection effect. As we are only using patents published before 1949, i.e. seven years before the consent decree took effect, this possibility seems remote. Second, unobserved characteristics of the Bell patents might have caused the consent decree, i.e. there is reverse causality. Third, Bell technologies might have received a positive shock around the date of the consent decree and we are measuring the effect of this independent shock. In the following we address each of these challenges to identification.

### **Dropping the most important patents**

One threat for identification of the effect is that the government singled out AT&T for compulsory licensing because of Bells outstanding inventions. If this is the case, the increased number of citations might have happened in any case - and might have nothing to do with compulsory licensing. To see if this is the case we drop in the following the most important inventions and re-do the analysis. If public officials enacted the consent decree as a reaction to the great inventions of the Bell Labs, the effect of the consent decree should not be observable for patents which were “by chance” part of the consent decree. Bell created many outstanding patents but the majority of patents solved specialized technical problems for communications. Some inventions, such as the transistor, made it to the headline of the New York Times, but most others did not. As a consequence, it seems hard for a public official to know the potential for follow-up research of each and every patent.

At this time, the most celebrated invention of Bell was the transistor in 1947. In Column (4) we drop all patents which are potentially related to the transistor development and re-estimate our main specification. The effects are not significantly different from the effects in the main specification.<sup>14</sup> In the last two columns we drop

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<sup>14</sup>To identify all patents we adopt a three step procedure. We first identify the key patents of transistor development from the description of the history of transistor development. These are among others:

- Patent # 2,524,035 of John Bardeen and Walter H. Brattain with the title "Three-Electrode Circuit Element Utilizing Semiconductive Materials" which was applied for on June 17, 1948, and was granted on October 3, 1950.
- The patents of Texas Instrument, the original inventor of the microchip. Jack St. Clair Kilby applied for the "Miniature Semiconductor Integrated Circuit" patent on May 6, 1959, which

the top 5% and top 20% of all Bell Labs patents measured by their citations up to 1949 and repeat the analysis.<sup>15</sup> Again the measured impact does not change.

### Counterfactual regressions

Our main results are also compatible with a positive shock on the potential for follow-up inventions of Bell but not for control patents around the time of the consent decree. If this is indeed the case, such a shock should positively affect the patenting of all companies building on Bell's technology - no matter if they could license for free from Bell or not.

The 1956 consent decree singled out specifically three companies for not receiving the benefits of free compulsory licensing of Bell patents. These companies were the General Electric Company, Radio Corporation of America and Westinghouse Electric Corporation. The reason was that these companies already had a general cross-licensing agreement in place, the "B2-agreements" dated July 1, 1932. A fourth company, the International Telephone and Telegraph Company was not affected by the decree as it had a patent pool with Bell. In Figure 4 we re-estimated equation (1) using only the citations of the B2-companies as dependent variable. We do not find any effect. As these companies make up in total 10% of all citations to Bell patents, this is not due a lack of measurability.

There were two other groups of companies that were to a lesser degree influenced by the consent decree: foreign companies and companies that already had licensing agreements in place. Foreign companies and companies in US controlled by foreign companies could license for free but did not receive any technical description or assistance from Bell.<sup>16</sup> Companies that licensed already before the consent decree from

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was granted on December 24, 1963 (Patent # 3,115,581).

Then we collect all patents which are cited and are citing these patents. In a last step we also collect the citations to and from these cited/citing patents. With this procedure we identify in 218 transistor patents affected by the consent decree, i.e. held by Bell Labs.

<sup>15</sup>Dropping the top 5% implies that we drop all patents with more than one citation up to 1949. Dropping the top 20% implies dropping all patents with any citation.

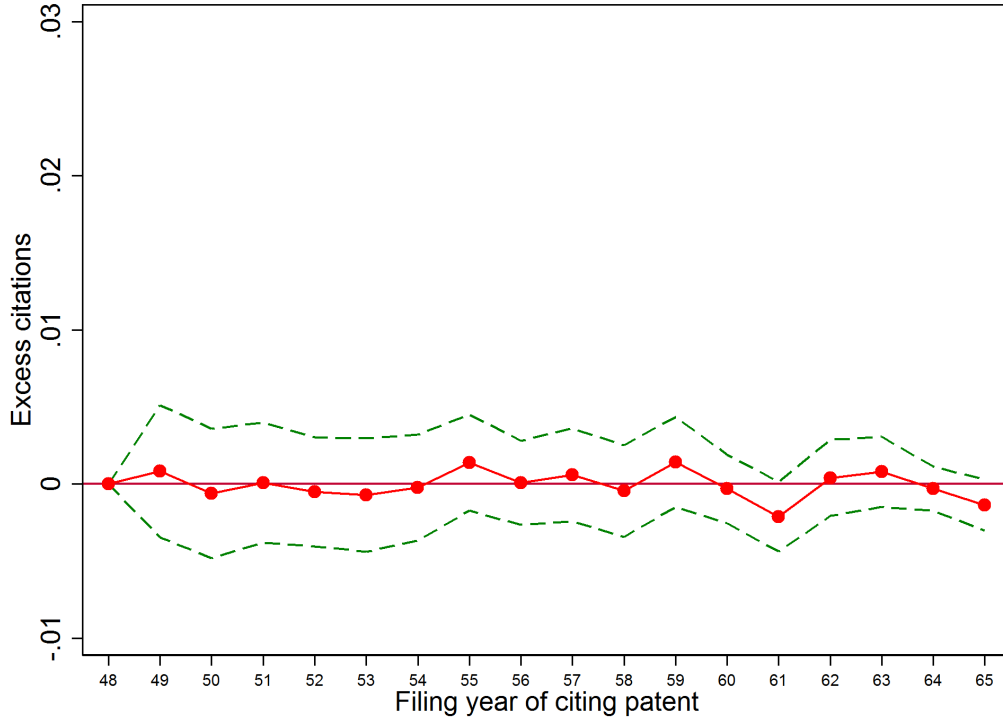
<sup>16</sup>Verbatim in the consent decree "The defendants are each ordered and directed (...) to furnish to any person domiciled in the United States and not controlled by foreign interests (...) technical information relating to equipment (...)".

Table 4: The effect of compulsory licensing on subsequent citations of unaffected companies

	(1) Base- line	(2) Exempt companies	(3) Foreign companies	(4) License	(5) No license
Bell	-0.11 (0.58)	-0.24 (0.18)	-0.05 (0.08)	0.02 (0.08)	0.16 (0.48)
Bell x I(54- 65)	1.47** (0.63)	0.15 (0.14)	0.14 (0.09)	0.10 (0.09)	1.09** (0.53)
Constant	20.88*** (1.58)	2.90*** (0.54)	0.89*** (0.08)	1.01*** (0.16)	16.08*** (0.96)
Adj R2	0.01	0.00	0.00	0.00	0.01
Clusters	262	262	262	262	262
Obs.	1446972	1446972	1446972	1446972	1446972

*Notes:* This table shows the results from a difference-in-difference estimation with years 1949 to 1953 as pre-treatment period and 1953 to 1965 as treatment period. The variable "Bell" is an indicator if a patent is published by a Bell System company before 1949 and therefore treated by the consent decree. As control patents we use all patents which were published in the US matched by publication year, four digit IPC class and the number of citations up to 1949. As dependent we use in the first column all citations by other companies than the filing company, in the second column we use all citations of companies exempt from the consent decree (GE, RCA, Westinghouse & ITT) and in the third column all citations of foreign companies. In the fourth column we use citations of companies which had no licensing agreement with any Bell company prior to the consent decree and in the last column we look at the citation of companies which had a licensing agreement. All coefficients are multiplied by 100 for better readability.

Figure 4: Effect of compulsory licensing on subsequent citations among companies that were exempt from the consent decree



Bell were obviously able to get a license and build on the work of Bell and therefore seem to a lesser degree influenced by compulsory licensing. All companies with a license agreement are listed in the hearing documents (House, 1958, p. 2758). In Table we re-estimate the equation (2) using as dependent the citations from all (column 1), from the exempt B2-companies (column 2), from foreign companies (column 3) and for companies that had a license before the consent decree (column 4). In the last column we use data on all companies that did not have a license from Bell. We do not find an measurable effect for all the different types of non-treated companies and a positive effect for companies which had no license before the consent decree.

### Timing of the effect

The consent decree took effect on January 24, 1956. Yet, the measured effect in Figure (3) starts already in 1954. This is only plausible if companies building on the patents of Bell were already in 1954 aware of the general outline of the upcoming judgement.

From the congress hearings in 1958, we know that on May 28, 1954, Bell suggested

a consent decree including the compulsory licensing of Bell System patents. In the following negotiations which span the years 1954 and 1955, the government tried to impose more severe restrictions, yet the licensing requirement was never contested. As a consequence, starting in May 1954, both the Bell Laboratories and companies building on the patents of Bell could have known that compulsory licensing was in the cards (Celler, 1959).

We can infer from the subsequent behavior of Bell, that the dating from the hearings of the agreement to prior 1955 is accurate: According to the consent decree all patents were compulsory licensed for zero if they were published before January 24, 1956. If they were published after this cut-off date, they were licensed under a reasonable and non-discriminatory basis. So starting from the date when Bell came aware of the clause, it had an incentive to delay the publication of their patent beyond the cut-off date.

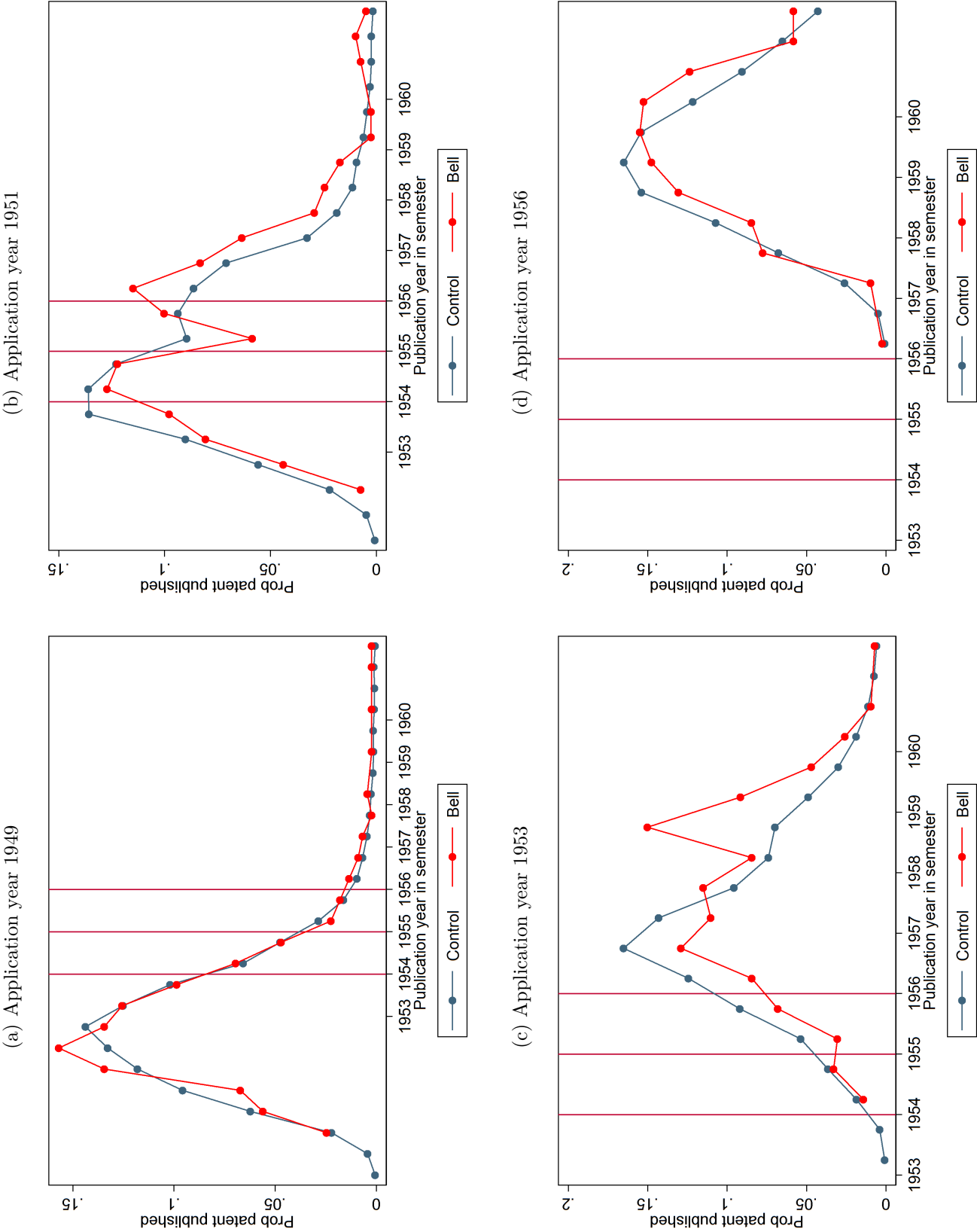
According to the data, Bell started to delay its patents at the patent office beginning in the first half of 1955. To pin down the date we compare for a given filing year the propensity of a Bell patent to be published with the propensity that control patents are published. In Figure 5, we show these hazard rates of publishing for the years 1949, 1951, 1953 and 1956.<sup>17</sup> In 1949 and 1956, the publishing rates per year are very similar for Bell patents and patents from other companies. If at all, Bell patents were published a bit earlier. In 1951 and 1953, this picture is reversed: Starting in the first half of 1955, Bell patents had a significantly lower probability of being published. This is consistent with Bell trying to delay the publications of their patents and having credible information about the general outline of the consent decree in the first half of 1955 the latest.

But when did the public have credible information about the consent decree? The first media mentioning that a consent decree for Bell was about to happen was on May 13 1955 in the New York Times. Public officials confirmed that top level negotiations are ongoing “looking towards a settlement of the AT&T case”. While the terms of settlement are not mentioned, the outline of the widely publicized plea in 1949 which

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<sup>17</sup>All other years are available from the authors on request.

Figure 5: Hazard to publish by filing year



included compulsory licensing was generally known. This should have given companies in the industry the incentive to gather information on what really was about to happen. So in mid 1955, the possibility of a consent decree should have been widely known.

Another way to look at information acquisition is to look at stock returns of AT&T relative to the market. Figure 6 shows cumulative abnormal stock returns of the AT&T Corporation stocks starting in Januar 1948. Up to the Eisenhower election cumulative abnormal return were centered around zero. Afterwards there is a transistion period up to beginning of 1954 when the abnormal returns remain stable at around 9%. The transistion period coincides with the period of negotiations from the freeze at the end of 1952 to the offer of compulsory licensing by AT&T in April/May 1954. In particular the large uptick at the end of Feburary/beginning of March 1954 conincides with meeting on the consent decree of the AT&T on March 3, 1954 (House, 1958, p. 1956).<sup>18</sup> Afterwards there is no persistent positive or negative abnormal return till 1959. Even the consent decree in 1956 did not seem to have any informational value. This pattern of abnormal returns is consistent with traders informed about the consent decree in 1954 the latest. The timing of the effect in our main specification is consistent with this interpretations.

## 5.2 Where does the effect come from?

Our results show that the consent decree increased the number of citations to Bell's patents. But what drives these effects? Understanding the mechanism behind the increase in follow-on innovation is important to be able to tailor policies accordingly. In this section, we document heterogeneities of the effect both with respect to firm characteristics and to the field of the citing patent.

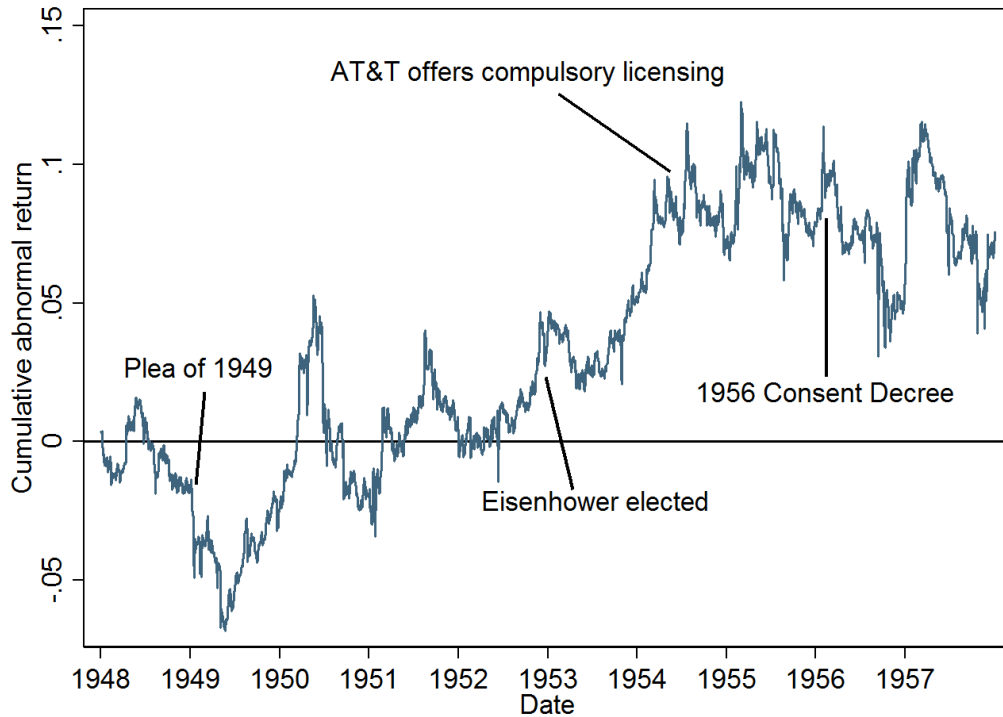
Anecdotal evidence suggests that the consent decree spurred large scale market entry creating whole new industries such as the semiconductor industry. For example, Gordon Moore acknowledged that "There is a direct connection between the liberal licensing policies of Bell Labs and people such as Gordon Teal leaving Bell Labs to

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<sup>18</sup>The content of the meeting could not be cleared up despite intense questioning. In the Appendix in Figure 9 is a transcript of the questions and answers.



Figure 6: Abnormal returns of AT&T stocks



start Texas Instruments and William Shockley doing the same thing (...), Shockley Semiconductors in Palo Alto. This started the growth of Silicon Valley (...)"

To see if indeed the case, in Table 5 we separately analyze the impact of the consent decree on citations of young and old as well as small and large firms. New companies are citing companies for which the citation is their first patent, young companies filed their first patent in the 10 years before they cited the Bell patent and old companies are all others. Small companies are defined as companies with less than 10 patents before 1949. We find that the effect primarily comes from new, young and small companies. The coefficient for old and large companies is not significantly different from zero on conventional levels. Combining citations from small and young firms shows that around 2/3 of the overall increase comes from this type of company.

One provision in the consent decree was that Bell had to exit all industries which were not related to the field of communication. Thus Bell preserved its monopoly in the telecommunication market but ceased to be a player in all other industries. This restriction might have improved the conditions for start-ups in all industries except in

Table 5: The effect of compulsory licensing on subsequent citations of companies by company type

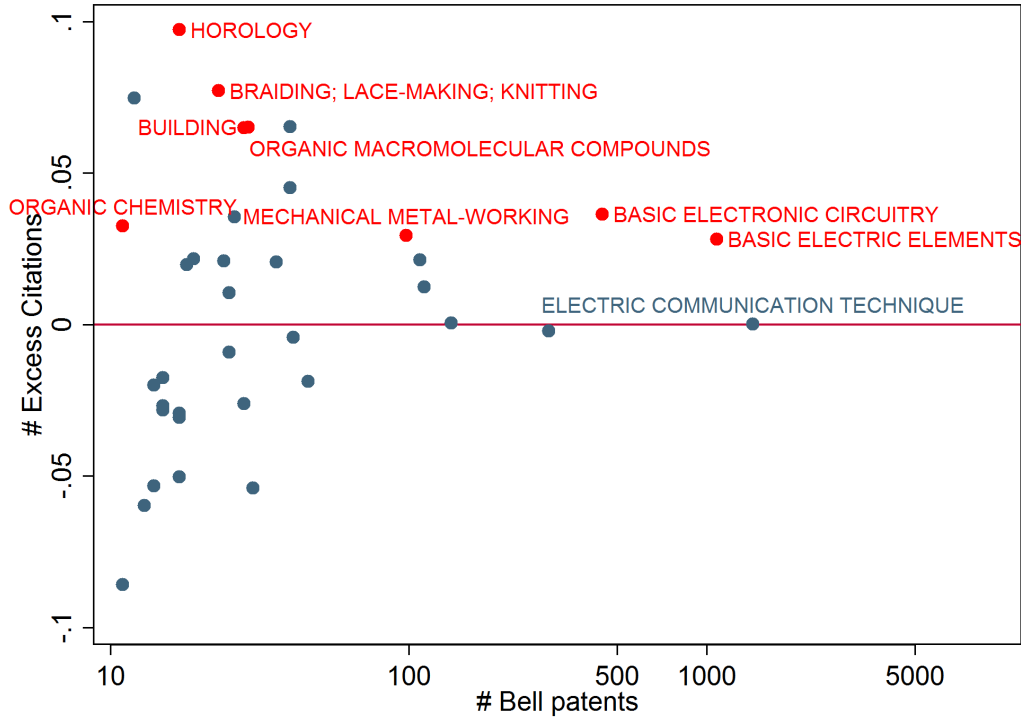
	Base- line	Company type					
		New	Young	Old	Small	Large	Y & S
Bell	-0.11 (0.58)	-0.82*** (0.27)	-0.69* (0.41)	0.63* (0.37)	-0.77* (0.42)	0.71 (0.44)	-0.77* (0.41)
Bell x I(54-65)	1.47** (0.63)	0.86*** (0.22)	1.07*** (0.39)	0.26 (0.38)	1.37*** (0.39)	-0.04 (0.46)	1.16*** (0.37)
Constant	20.88*** (1.58)	3.98*** (0.29)	8.02*** (0.44)	11.97*** (1.30)	7.84*** (0.48)	12.15*** (1.36)	6.66*** (0.43)
Adj R2	0.01	0.00	0.00	0.01	0.00	0.01	0.00
Clusters	262	262	262	262	262	262	262
Obs.	1446972	1446972	1446972	1446972	1446972	1446972	1446972

The dependent variable is the number of subsequent citations of other companies to patents affected by the consent decree in 1956 by citing company characteristics. Small: less than 10 patents. New: first patent. Young: less than 10 years since first patent. The coefficients are multiplied by 100 for better readability. Standard errors in parentheses are adjusted for clustering at IPC4: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

communication were it effectively blocked entry (Gertner, 2012; Celler, 1959, p.108). According to Celler (1959) this conclusion was already apparent during the negotiations: “The patent and technical information requirement have efficacy only so far as they permit independent manufacturer to avail themselves of patents in fields that are unrelated to the common carrier communication business carried on by the Bell System companies, and nothing more.” It was suggested that a liberal licensing policy is “only “good window dressing” but would do no good because Western had already “achieved an exclusive position (...) and liberal licensing would not permit competitors to catch up” in the communication business (Celler, 1959, pp. 108).

To investigate if the measured effects are consistent with a mechanism of firm entry, we repeat our baseline analysis separately along the patent subclass of the citing patents. Figure 7 shows the estimates for our main parameter of interest for all technology classes where Bell had more than 10 patents. In patent subclasses in which Bell substantially contributed to technological progress (above 50-70 patents), the impact of the consent decree on follow-on innovation is positive throughout. Among the subclasses that were important for Bell, the impact seems to be largest for Basic Electronic Circuitry and Basic Electric Elements. Importantly however, the effect is not present

Figure 7: Effect of compulsory licensing on subsequent citations across patent sub-classes



**Note:** This figure shows the coefficient for the impact of the consent decree on citations for patents in all IPC 3 classes where Bell had in more than 10 patents. A red dot signifies that the coefficient is significant on the 10% level.

for Electric Communication Technique, where Bell continued operating. In contrast, AT&T and its subsidiaries had to stop their operations in all other fields.

Our results are therefore consistent with the idea that the effect of compulsory licensing on follow-on innovation to a large degree depends on the entry of new companies.

### 5.3 Scale of innovation

According to the results above, the consent decree increased the number of citations to Bell patents. But is this just because to same number of patents cite Bell patents more frequently after the decree or did the number of patents in the economy increase? Arguably, only the second alternative would speak for a long-lasting effect of Bell's antitrust case on the US economy. To look at this question we follow Moser and Voena (2012) and compare technology subclasses, in which at least one Bell patent was subject

to compulsory licensing to subclasses without such patents. Our sample consists of 201 classes with 2889 subclasses of which 653 are treated.<sup>19</sup>

We estimate the following model

$$\#Patents_{s,t} = \beta \cdot Treatment_i \cdot I[1954 - 1965] + Controls + \varepsilon \quad (3)$$

where the dependent variable is the number of patent applications per subclass in a year.<sup>20</sup> Following the literature we use three different variables as treatment: an indicator which is equal to one if there is at least one affected Bell patent in the subclass, the number of these Bell patents and the number of Bell patents multiplied with the remaining years under patent protection at the time of the decree. As controls we include technology class-year and subclass fixed effects.

Table 6 shows the results for this estimation. The effect of the treatment variables is significant and positive in all regressions. According to column 1, there are on average 3.18 more patent applications per year in treated than in untreated sub-classes. Relative to the average number of applications per year in treated subclasses of 18.6 in 1955, this implies a 17% increase. Column 2 indicates that each additional freely available Bell Labs patent led to 0.13 additional applications per year in the 20 years following the decree. An additional year of patent lifetime of affected Bell Labs patents increases the number of annual applications by 0.03 (column 4). All these results point to an actual increase in the scale of innovation through the consent decree and not just an increased propensity to cite royalty-free patents.

In Figure 8, we show the annual treatment effects using the number of patent applications in a subclass as outcome. The effect starts already in 1953 and shows no sign of abating.

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<sup>19</sup>We exclude subclasses which did not have any patents at all before 1956 and we include only patent classes (4-digit IPC level) which contain subclasses that were treated and subclasses which were not.

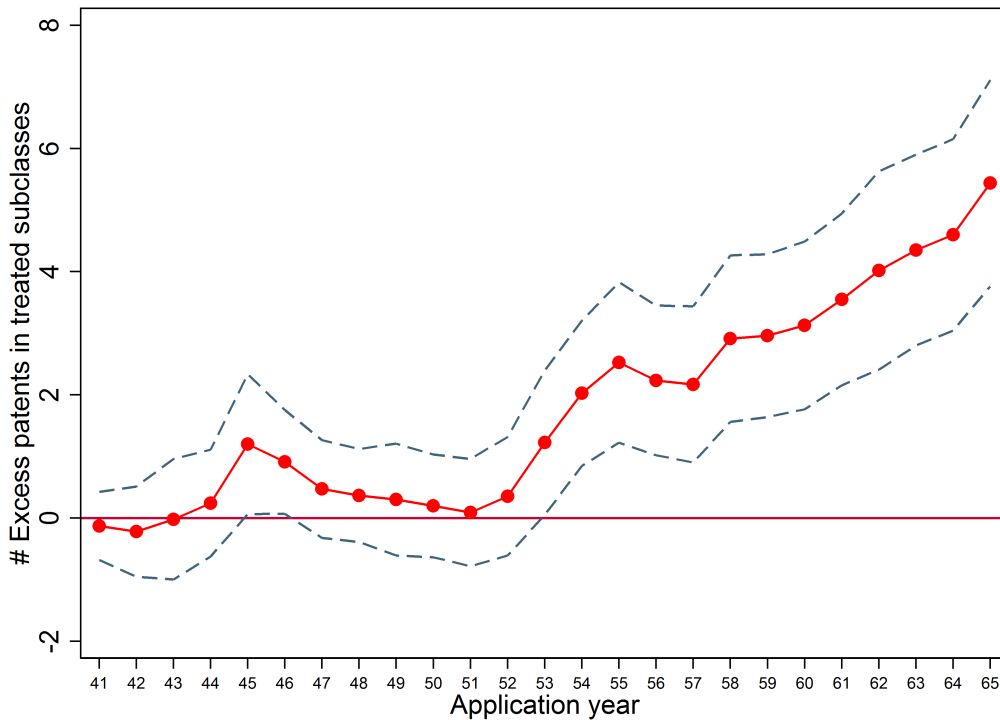
<sup>20</sup>We exclude Bell System patents for the entire sample. Patent applications are weighted according to the number of subclasses they are assigned to. If a patent is assigned to two subclasses, for example, it increases the size of each class by 0.5, such that the total increase is 1 for each patent.

Table 6: OLS Regressions of patent applications per subclass and year to treatment measures (1936-1976)

	Patent applications per year				
	(1)	(2)	(3)	(4)	(5)
I(Bell patents > 0)	3.18*** (0.44)				
#Bell patents		0.13*** (0.05)	0.31*** (0.07)		
#Bell p. squared			-0.00*** (0.00)		
Patent life				0.02*** (0.01)	0.03*** (0.01)
Patent life squared					-0.00*** (0.00)
Subclass FE	Yes	Yes	Yes	Yes	Yes
Class-year FE	Yes	Yes	Yes	Yes	Yes
Observations	132894	132894	132894	132894	132894

*Notes:* The dependent variable is the number of patent applications per subclass (IPC group) per year, excluding Bell System patents. The treatment variables are interacted with an indicator that is 0 before 1956 and 1 after the decree. In column 1 the treatment variable is an indicator that is 1 for subclasses that received at least one Bell patent through the consent decree and 0 otherwise. In columns 2 and 3, the number of Bell Labs patents received through the decree is the treatment measure. For columns 4 and 5, the treatment variable is the number of remaining patent life years the Bell patents available for compulsory licensing have at the time of the decree. All regressions include class-specific time fixed effects and subclass fixed effects. Standard errors are clustered at the class level.

Figure 8: Annual treatment effects on the number of patent applications



## 6 Conclusion

In this paper we study the impact of the 1956 compulsory licensing of Bell Labs' patents on follow-up innovation. Bell was forced to license all its patent as part of a consent decree that settled the antitrust suit of 1949 against its mother company AT&T. This case is particularly interesting as it focuses on one of the largest inventors in US economic history and the biggest inventor in computers and electronics at that time: Bell Labs owned 8,600 patents protecting some of the central inventions in US post-war history such as the transistor. What is more, our study analyzes the policy-relevant case of large scale patent rights removals, assessing the “case against intellectual property” advocated by some researchers (Boldrin and Levine, 2002).

We estimate that the consent decree increased citations to Bell patents by over 7%. Placebo regressions support our identification assumption of parallel counterfactual citation trends between treatment and control group: Most importantly, we show that the effect is not present for firms that were exempt from the consent decree and for foreign firms which did not receive additional technical support.

Our results are in line with recent research on the impact of patents on cumulative innovation. However, the magnitudes stand in contrast to the much larger impacts in computers and electronics found by recent research and suggest that in policy-relevant cases, the impact of patent rights removals on cumulative innovation may be smaller than previously thought (Galasso and Schankerman, 2015b).

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Figure 9: The meeting on March 3, 1954

**Mr. MALETZ.** I notice that the memorandum of your meeting with Mr. Brownell is dated March 3, 1954, notwithstanding that the meeting took place on June 27, 1953, is that correct?

**Mr. PRICE.** Yes. That puzzled me a little, too.

**Mr. MALETZ.** What was the occasion for your preparing on March 3, 1954 a memorandum of a meeting with the Attorney General which took place on June 27, 1953?

**Mr. PRICE.** Well, you know that puzzled me a little and I had to speculate about it. The best I can do is somebody wanted me to write out what I remembered about that talk I had had with Brownell at White Sulphur Springs and I sat down and did it.

**Mr. MALETZ.** Isn't it true that Mr. Dumas had arranged a second meeting with Mr. Brownell for April 1954 and wanted from you a written account of what had transpired at your meeting with Mr. Brownell in White Sulphur Springs in June?

**Mr. PRICE.** That is the best guess I could make of it but I don't know whether it is right or not.

**Mr. MALETZ.** Do you recall now whether that was the occasion of your preparing this memorandum which has just been read into the record?

**Mr. PRICE.** I am afraid it is speculation rather than recollection but certainly that is the best explanation I can give and I think that is what happened.

**The CHAIRMAN.** Well, now we will adjourn and we will meet tomorrow morning at 10 o'clock.