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Defensive Disclosure Under Antitrust Enforcement

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We formulate a simple model of optimal defensive disclosure by a dominant firm facing uncertain antitrust enforcement and test its implications using unique data on defensive disclosures and patents by IBM during 1955-1989. Our results indicate that stronger antitrust enforcement leads to more defensive disclosure, that quality inventions are disclosed defensively, and that defensive disclosure served as an alternative but less successful mechanism to patenting at IBM in appropriating returns from R&D.

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1 Introduction

Patent law provides exclusivity in exchange for knowledge disclosure. Some large firms, however, have for decades disclosed patentable inventions defensively, sacrificing exclusivity. Extant theories conceive of novel mechanisms through which such disclosure helps firms eventually establish exclusivity on a more valuable invention (e.g., Baker and Mezzetti 2005). Such theories assume that much is known to rivals engaged in a patent race about each others' progress. Their implications often concern project-level success, are difficult to test, and arguably do not capture the real motive behind programmatic defensive disclosure. That is, what these theories overlook are the institutional reasons for setting up, scaling up, and shutting down defensive disclosure programs that transcend strategic considerations about project-level outcomes.

We study the life-cycle of a defensive disclosure program, albeit at one firm, in rich detail and uncover a tradeoff between the exclusivity afforded by patent protection and the cost of potential antitrust action. The value of patents is eroded under the threat of antitrust action, which limits a firm's ability to enforce its patents and appropriate returns. Consequently, the threat of antitrust action provides a motive for defensive disclosure of patentable subject matter, which preserves the freedom to use inventions by avoiding holdup due to rivals' patenting, although at the expense of exclusivity.

We study IBM's defensive disclosure program for its significant size, scope, span, the many antitrust cases it faced, the changes to U.S. patent law, the availability of disclosure and patent data, the accessibility of former R&D directors of IBM directly involved in decision making, and the dramatic shifts in IBM's disclosure, patenting, and licensing revenue trends during the period of our study.

We find that IBM embarked on a science-oriented strategy of growth since the first antitrust case in the 1930s; began disclosing many inventions defensively in response to the second antitrust action in the mid 1950s; scaled up the defensive disclosure program when the third antitrust case against IBM began in 1969; and sustained the program through the European Commission's case that began in 1980. IBM rapidly scaled down the disclosure program in the 1990s as the U.S. and E.C. cases against IBM ended.

IBM's internal incentives for rewarding its researchers, setup during the early years of the disclosure program, brought parity between disclosures and patents by rewarding each disclosure with third-of-a-patent points and contributed to the scale of disclosure activity. IBM's inability to appropriate returns from significant R&D expenditures threatened the future of its central research lab and led to significant changes in the management of R&D in 1990 that laid the ground for the company's turnaround. We present a theoretical model to explain patterns of defensive disclosure, patenting, and R&D investment at IBM during 1955-1989.

In the stylized model, a dominant firm’s optimal R&D investment is determined by a tradeoff between the expected value of an invention due to patent protection and the expected loss of value from antitrust action. Consequently, inventions are more likely to be disclosed defensively under the threat of antitrust action and only half of the inventions are patented when the antitrust action is certain to occur, even if the antitrust fine is small. In addition, in the model the quality of invention is unrelated to the probability of patenting, which implies that high-quality inventions are just as likely to be defensively disclosed as low-quality inventions.

In regression models at the firm- and inventor-level, we confirm the theoretical predictions. We show that during the period of the third antitrust action significantly more inventions were disclosed defensively compared to the earlier period. We extend our analysis to include patenting at Xerox and AT&T and find that relative to a comparable set of control firms, IBM, Xerox, and AT&T patented less under antitrust enforcement.

We examine other empirical findings consistent with our theory. Yale and Carnegie Mellon innovation surveys of high-level R&D executives have found patents to be among the least effective mechanisms for appropriating returns from R&D (Levin et al. 1987 and Cohen et al. 2000). We highlight the role played by stronger antitrust enforcement against large R&D intensive firms in the U.S. in rendering patents ineffective until the late 1980s in a quantitative study (see for a descriptive account, Grindley and Teece 1997). We examine one alternative mechanism, namely defensive disclosure, adopted by IBM as a substitute for patenting.

Our study also clarifies why the recent surge in patenting in the U.S. is not accompanied by a commensurate rise in R&D expenditures or innovative activity as IBM substituted away from defensive disclosure toward patenting without raising R&D expenditures (e.g., Jaffe and Lerner 2004, Bessen and Hunt 2007).

The paper is organized as follows. Related literature is reviewed and historical background information related to defensive disclosure programs and the shifts in the antitrust regime in the U.S. are presented in the next section. The case of IBM is developed in the third section. A theoretical model is presented in the fourth section. Its implications are tested in the next section. The article concludes in the final section.

2 Literature Review

2.1 Defensive Disclosure

Defensive disclosures are patentable inventions that firms disclose without seeking patent rights. Such disclosures are short technical descriptions of inventions and hence inexpensive to draft as opposed to patents. They are typically reported in a technical journal targeted at the U.S. Patent Office, which helps accurately establish the date of prior art. Defensive disclosures often do not contain the firm and inventor names (see for example Figure A1).

Prior theoretical literature has proposed several explanations for defensive disclosure by the trailing firm in an innovation race (e.g., Parchomovsky 2000, Lichtman et al. 2000, Baker and Mezzetti 2005, Bar 2006). Since defensive disclosure resets the prior art, it can potentially prolong an innovation race by preventing the leader from reaching the threshold level of patenting. These explanations are not consistent with the fact that defensive disclosure has been a leading-firm phenomenon. Since large R&D intensive firms have primarily maintained defensive disclosure programs, theories of why leading firms disclose have also been proposed (Gill 2008). Disclosure by the leader demonstrates commitment to a research program and can discourage rival's entry. However, firms are increasingly disclosing anonymously making it difficult to infer commitment. Other theories have incorporated into such models of commitment through strategic disclosure, strategic disadvantages of disclosure due to spillovers (Jansen 2006).

A separate theoretical literature has explored the merits of trade secrecy and patenting as recent innovation surveys suggest a rise in the importance of secrecy as a preferred mechanism to appropriate R&D returns (e.g., Horstmann et al. 1985, Anton and Yao 2004, Kultti et al. 2007). However, these models do not consider defensive disclosure as an alternative mechanism to patenting and secrecy.

In the empirical literature, Henkel and Pangrel (2008) collate wide-ranging responses of 44 patent professionals at 37 German industrial firms in an exploratory study of defensive disclosure. One such response is that low quality inventions are disclosed defensively following a cost-benefit analysis. Such propositions have not been weighed against the data.

We depart from the above literature in our emphasis on defensive disclosure programs rather than optimal invention- or project-level disclosure strategies as well as our emphasis on the role of antitrust action in precipitating defensive disclosure. In doing so, we build on a long tradition of research in economics and law examining the tension between patent and antitrust laws. While the patent law grants temporary market power to reward innovation, the antitrust law limits market power afforded by patent protection. Prior literature has focused on the implications of this tension for merger policy as well as for regulating dynamic R&D competition (Carlton and Gertner 2003). Prior work has also examined the impact of uncertain antitrust enforcement on firm behavior such as collusion (e.g., Block et al. 1981). However, we are not aware of empirical studies examining the impact of antitrust enforcement on a firm's incentive to patent or disclose.

We begin by exploring the origins of defensive disclosure programs historically to support our argument that antitrust policy was instrumental in the emergence of corporate research laboratories in the U.S. and the evolution of their patenting and disclosure strategies.

2.2 Antitrust and the Origins of Corporate R&D Labs

During the formative period of the antitrust policy in the United States, from 1890 to 1930, innovation provided a defense for dominant firms against antitrust action (Hart 2001). Corporate research labs were set up during this period: General Electric set up an R&D lab in 1900; Du Pont in 1902; AT&T during 1910-1912; Eastman Kodak in 1910; and Westinghouse in 1916. However, the ascension of Thurman Arnold to the antitrust division in 1938 heralded a new era of aggressive antitrust policy against large firms with patent portfolios and against patent pools, where cases were settled by consent decrees mandating compulsory patent licensing (Usselman 2009). Patenting by corporate labs was viewed as an abuse of power (Hounshell and Smith 1988). The number of antitrust cases in the U.S. increased from 57 during 1935-1939 to 223 in the next five years (Posner 1970). Large firms found it difficult to grow through acquisitions in this era and began to expand internal R&D

as a strategy for growth, which is reflected in the diversification of Du Pont's R&D program in the late 1940s (Hounshell and Smith 1988).

During the early period large R&D intensive firms also began disclosing research results in their own newly created technical journals. General Electric published General Electric Company Review during 1903-1958, AT&T published Bell Labs Technical Journal during 1922-1983, and Westinghouse published Electric Journal since 1904-1939 and Westinghouse Engineer in later decades. In Europe, Philips opened its central lab in 1914 and published Philips Technisch Tijdschrift, during 1936-1989. Such corporate journals fostered an academic environment and helped attract doctorates to join corporate research labs. In response to the changing antitrust climate, by the late 1930s firms began to search for alternatives to patenting. Discussing the shifting trends in industrial research in the U.S. during 1899-1946, Mowery and Rosenberg (1989:73) note:

> "Appropriability concerns, reflected in the drive to strengthen patent positions through internal development or acquisition of innovations, played an important role in the early development of industrial research. With the growth of in-house research, however, patents appear to have declined somewhat in importance within the research strategies of some of the corporate pioneers of industrial research... Both Eastman Kodak and AT&T, for example, which had placed great emphasis on patent strategies in the early years of development of their industrial research strategies, increasingly focused on developing a strong knowledge base through in-house research and gave less weight to patents."

We argue that firms with leading corporate R&D labs began to disclose defensively due to the increased probability of antitrust enforcement. While we do not know historically which firm first began disclosing defensively its patentable inventions, IBM's disclosure program provides an exemplary case of such programs, which we elaborate next.

3 A Case Study of IBM's Disclosure Program

3.1 Antitrust, R&D, and Technical Disclosure Bulletin

IBM faced its first antitrust case in 1932. Soon after, IBM followed many leading firms at the time by adopting a science-oriented strategy of growth. IBM began expanding its in-house R&D by opening a research lab in Endicott, New York, the next year. After the war, IBM created a department of pure science to deepen focus on scientific research. In 1952, the second antitrust case against IBM began, the same year IBM established the San Jose laboratory to focus on less-directed research. Thomas Watson Jr. also initiated an organizational change, which led to a *Research* department directed by a physicist Emanuel Piore (see for a historical treatment, Usselman 2009).

The second case ended in 1956 with a consent decree, which placed restrictions on IBM's patent portfolio. IBM was ordered to "grant to each person making a written application, an unrestricted, nonexclusive license to use any, some, or all of IBM's existing and future patents without any restrictions." In response, IBM adopted a policy of freedom of action, according to which IBM would continue to increase its investment in R&D and disclose inventions to preserve the freedom to use them by preventing others from patenting them in the future. To do so, IBM expanded its R&D investment, opened a new lab in 1956, and began publishing IBM Journal of R&D in 1957. IBM’s R&D expenses doubled during 1952-1956 and increased from 10 to 50 as a percentage of net income during 1948-1960 (Flamm 1988).

IBM’s R&D staff increased from 105 in 1956 to 898 doctorates in 1960 when Emanuel Piore directed the lab (National Research Council 1956-1990). The number of physicists alone increased from one in 1946 to 11 in 1956 and 328 in 1960, the year IBM opened its T.J. Watson Research Center. The number of doctorates at IBM, including some auxiliary staff, increased marginally to 1250 in 1977, 1600 in 1986, and dropped to 1000 in 1990. In 1962, IBM also started awarding its most exceptional researchers the title ‘IBM Fellow.’

These investments in R&D dollars and personnel translated into research output, which began to be disclosed defensively, as one distinguished IBM researcher noted about the development of relational databases (McJones 2009):

> ``Since we were in the research division of IBM, our philosophy of research was to publish our results in the open literature...The project was not a secret and, in fact, we'd been telling everybody about it that would listen.''

IBM proactively pursued open publication policy as elaborated by a former executive, Sarasohn (1973):

> ``Used in a planned and judicious manner, the journal can serve to measure the merit of the work being performed in a laboratory. Its value stems, first of all, from the formulation of a publication strategy as an integral part of each significant technical project. This means that the manager, whether he be a research director, chief engineer, project leader, or department head, must make a conscious and deliberate plan, that takes effect with the start of the work, which implements the expectation of authorship along with other elements that make up the technical undertaking. This strategy should identify the areas of the work for which publication is permissible and expected, and those that must be restricted for valid security, proprietary, or business reasons. Even in the latter case, provision should be made for periodic review to determine when restricted information can be released for publication.''

The third case against IBM was filed during the last days of Lyndon B. Johnson's administration in early 1969, much to Watson Jr.'s surprise and sudden deterioration of his health (Usselman 2009). The case charged IBM of monopolizing the data processing industry and contemplated divorcement, divestiture, reorganization, and other relief measures. Four private suits were also filed in 1969 by IBM's competitors, Control Data, Data Processing Financial & General, Applied Data Research, and Programmatics Research, alleging violation of antitrust laws, which led to the early exit of Watson Jr. from IBM (Usselman 2009). These cases further strengthened IBM disclosure program. The case in the U.S. ended formally in 1982 but the European Commission (E.C.) pursued it formally starting in 1980. IBM and the E.C. reached an understanding in 1984, which required IBM to disclose information necessary for the interoperability of rival products with IBM's products until the next five years.

3.2 IBM Technical Disclosure Bulletin

In 1958, IBM started publishing the 'IBM Technical Disclosure Bulletin' dedicated to defensive disclosures targeted at the U.S. Patent Office. The Technical Disclosure Bulletin became an increasingly attractive venue for the researchers as Technical Disclosures were rewarded with third-of-a-patent points where as scientific publications earned zero points.

Researchers at IBM submitted their inventions to decentralized review committees composed of technical and legal members, which decided whether to patent, disclose defensively, or do nothing.

We collected data from the `Table of Contents' section of the monthly IBM Technical Disclosure Bulletins for the period 1976-1984 and from IP.com, an online repository of such disclosures, for the remaining period of 1958-1998. IBM stopped disclosing the names of researchers since 1985 in the Bulletin but fortuitously IP.com's database constructed in the late 1990s contains these names. Our data contain the names of the inventors and the title and date of invention. We also collected data on IBM patents from the U.S. Patent Office web site for all patents issued after 1975. We identified patents issued earlier using announcements of recently issued IBM patents in the monthly issues of IBM Journal of R&D. We used these patent numbers to obtain current patent classification and issue dates from the U.S. Patent Office web site and appended patent filing dates using Google Patent Search. We used contemporary press accounts to measure patent license revenues.

The time paths of disclosures, patents, and licensing revenues are shown in Figure 1. During 1958, 378 inventions were filed for patenting and 119 inventions were disclosed defensively. The annual number of defensive disclosures rapidly increased more than ten-fold to 1143 in the next decade while the number of patents increased by just 16% to 439. The share of reported inventions disclosed defensively increased from 24% in 1958 to 72% in 1967. Researchers during this period, including those with the most patents, had many disclosures. For instance, Clapper, a top IBM inventor during this period specializing in speech and pattern recognition, produced 45 patents and 33 defensive disclosures.

Insert Figure 1

The number of disclosures continued to rise even more rapidly in subsequent years, particularly since 1970. In contrast, the number of patents remained largely constant until 1989. The number of defensive disclosures peaked in 1990 at 4,229 and declined subsequently. At its peak, IBM patented just one in five reported inventions. The number of patents, however, remained constant across top ten patent classes as shown in figure 2.

Insert Figure 2

We interviewed IBM's former directors of R&D during 1970-1996 and its general counsel during the 1990s and confirmed the validity of these trends and gained further insights.[1] IBM did not enforce its patent rights and seek licensing revenues until the late 1980s despite known cases of infringement against IBM's intellectual property (e.g., IBM's fundamental patent on DRAM assigned to an IBM Fellow, Robert Dennard, in 1968 was reportedly widely infringed). IBM's licensing revenues did increase in the early 1990s from $30 million in 1992 by more than ten-fold to $390 million in 1993, to $646 million in 1995 and $1.5 billion by 2000, reflecting the extent of IBM's foregone licensing revenues in the previous decades.

IBM researchers reached career milestones, known as Plateaus, with only a small fraction of inventions ever being patented and earning points mostly through defensive disclosures. Interviews with former IBM directors of R&D reveal that researchers themselves appear to have preferred disclosures to patents as securing the latter involved a much longer process. These changes in incentives brought about parity between patenting and disclosure, which institutionalized a response specific to the threat of antitrust action.

Overall, IBM continued to invest in R&D but failed to appropriate returns in terms of the number of patents and licensing revenues until its research lab became unsustainable, which precipitated significant organizational changes (see Bhaskarabhatla and Hegde 2012). IBM's research director and the general counsel at the time confirmed that significant changes were made to incentives for patenting and defensive disclosure. They include: (a) the establishment of a team dedicated to increasing the fraction of patented inventions, known as the Patent Factory; and (b) the institution of *ex post* rewards to inventors whose patents brought in licensing revenues. IBM began to dismantle defensive disclosure program since 1990. For these reasons we restrict our attention to the period 1955-1989 and study the impact of the antitrust action on defensive disclosure program.

We formulate a simple model of defensive disclosure under uncertain antitrust enforcement to explain these patterns of patenting and defensive disclosure.

4 Model

Consider a monopolist deciding how much to invest in R&D and subsequently what fraction of inventions to patent. Suppose the monopolist faces the risk of antitrust enforcement with a given level of uncertainty. The monopolist's payoffs from decisions to patent and disclose determine its *ex ante* R&D investment.

The timing of decisions is as follows. In the first stage the firm decides how much to invest in R&D. In the second stage the firm decides which inventions to patent or disclose defensively. In the third stage, uncertainty about antitrust action is resolved and the value of an antitrust fine, if there is antitrust action, is realized. Also payoffs from returns to R&D and patenting are realized. The investment in R&D, probability of antitrust action, and

[1] Those interviewed include R&D Directors Ralph Gomory, John Armstrong, James McGroddy. We also interviewed Marshall Phelps, the General Counsel at IBM, and John Cronin, a leading inventor at IBM who went on to play a significant role in the rise in patenting since 1989. We also interacted with other high-level former executives and scientists at IBM.

expected antitrust fines are endogenously determined by the extent of patenting and disclosure.

We now introduce some notation. Suppose the probability of antitrust action is $a(P)$ where P stands for the fraction of discoveries patented.

$$P = \frac{Patents}{Discoveries}$$

where discoveries include patents and defensive disclosures. In other words, firms with large patent portfolios are more likely to face punitive antitrust action, which is consistent with the experiences of number large R&D intensive firms in the U.S. including those of IBM and Xerox.

In the third stage of the game, if the firm discloses, its payoff is D. If the firm obtains a patent, its payoff is M with probability $a(P)$ and $D - C$ otherwise, where C is the expected value of penalty from a potential antitrust action. Suppose the payoff from disclosure is less than the monopoly profit, $D < M$, and that there is a positive penalty, $C > 0$. The expected payoff is $\left(1 - a(P)\right) * M \; + \; a(P) * (D - C)$ for a firm with a patent and the payoff is D for a firm with a disclosure.

Now, in the second stage of the game the expected payoff for a pool of discoveries, denoted by N, is:

$$E[\pi] \; = \; N * \left\{P\left[\left(1 - a(P)\right) * M \; + \; a(P) * (D - C)\right] + (1 - P) * D\right\} \qquad (1)$$

We assume that $a(P) = zP$ with $0 \leq P \leq 1$ and $z \leq 1$, and maximize the expected payoff with respect to P, which leads to the following expression for the optimal fraction of discoveries to be patented:

$$P^* = \frac{M - D}{2z(M - D + C)} \qquad (2)$$

The percentage of patents (disclosures) over total discoveries increases (decreases) with the markup, decreases with the penalty if antitrust action is undertaken and decreases with the probability that an antitrust action will be undertaken.

The probability of antitrust action, as measured by the number of antitrust cases, significantly decreased after the mid-1980s (Gallo et al. 2000). Consistent with this fact, the model predicts an increase in the relative number of patents. Furthermore, the model shows that even when the antitrust sanction is negligible ($C = 0$) but antitrust action will be undertaken with certainty ($z = 1$) when $P = 1$, the percentage of patents is only fifty. Hence, there is scope for disclosure as to increase the chance of monopoly profit under patent protection.

Next, we derive the optimal level of R&D expenditure in the first stage. Substituting the expression for P^* in equation (1),

$$E[\pi] = N\left[\frac{(M-D)^2}{4z(M-D+C)} + D\right] \quad (3)$$

Now, we assume that N is an increasing and concave function of R&D expenditures, denoted by R. Then, optimal R&D expenditure, R^*, is given by the following equation:

$$N'[R^*] \cdot \left[\frac{(M-D)^2}{4z(M-D+C)} + D\right] = 1 \quad (4)$$

It follows from the above equation that $\frac{\partial R^*}{\partial z} < 0$, or in other words, that optimal R&D expenditures are negatively related to the probability of antitrust action.

As disclosures can be observed at either the firm-level or at the individual researcher-level, the model yields the following related hypotheses:

Hypothesis 1a. Controlling for other factors, the extent of defensive disclosure by IBM is greater during the period of antitrust action than before.

Hypothesis 1b. Controlling for other factors, the extent of defensive disclosure by researchers at IBM is greater during the period of antitrust action than before.

5 Data Analysis

We described the collection of defensive disclosure and patent data in section 3.2. We merged these patent and disclosure data by matching the names of inventors to a high degree of accuracy (more than 77% of the matched names contain two or more initials), which enables us to test the main implication of the model at the inventor level. We also collected IBM's financial data from Compustat for years 1960-1989 and from its annual reports for years 1955-1959. So, our sample period is 1955-1989. We restrict our regression analyses to the period 1958-1982, where the first year corresponds to the beginning of the defensive disclosure program at IBM and last year corresponds to the end of the third antitrust case against IBM in the U.S. In addition, we collected antitrust enforcement data in the U.S. In particular, a number of measures such as the annual number of antitrust cases instituted by the U.S. Department of Justice are collected from Gallo et al. (2000), which is an extension of data contained in Posner (1970).

5.1 The impact of the third antitrust case on disclosures

We expect 1969, the year the third antitrust case began, to be the year in which IBM scales up its defensive disclosure activity. Consistent with the model, Zivot-Andrews test identifies 1970 as the year of structural break in defensive disclosure activity with a minimum t-statistic of -4.94 in that year. In other words, the number of IBM's defensive disclosures increased fundamentally since 1970 compared to the trend in prior years.

We investigate disclosure activity by technology class. Since IBM disclosures are not assigned a patent class, we assign a class based on the patent classes in which authors of these disclosures received patents. For instance, we identify all inventors of disk drive patents in 360 patent class and subsequently identify all their disclosures and classify them as disk drive related disclosures. We underestimate the actual disclosure activity in each technology area as disclosures by researchers who have never patented are not counted. However, we do not expect disclosures by such researchers to change significantly and in the opposite direction after 1969 to confound our results. We separately plot disclosures in hardware and software related classes in figures 3 and 4 as software related inventions began to become patentable since 1982.

Insert Figures 3 and 4

Solidstate and semiconductor device related disclosures spiked in 1970. The number of disclosures in class 438 related to semiconductor manufacturing rose from 54 in 1969 to 201 in 1970, peaked at 247 in 1989. Zivot-Andrews test identifies a structural break in the year 1970 in 438 class with a minimum t-statistic of -6.23 and in 360 class with a minimum t-statistic of -4.51 in that year. In addition, most of the entry in the hard disk drive industry occurred during 1977-1984 when IBM disclosed at a high-level, contrary to some theories that predict the entry-deterrence effect of disclosures.

Disclosure activity increased in software related classes after 1969 but experienced a significant increase after 1982 when software inventions became patentable increasing the threat of holdup for IBM.

5.2 Regression Analyses

We conducted regression analyses on the disclosure and patent data spanning 1958-1982 to test whether the disclosure activity increased since the third antitrust case than previously, both at the organization and individual researcher level.

First, we show that IBM disclosed defensively more intensively since the start of the third antitrust action than previously. We estimate an OLS regression with the annual number of disclosures by IBM as the dependent variable. We also estimate censored Tobit specifications with the annual number of disclosures and the fraction of inventions defensively disclosed as the dependent variables. The key independent variable in these regressions is a dummy variable, ANTITRUST, which is set to zero for the period 1958-1968 and one for the period 1969-1982. The second explanatory variable is the number of employees measured annually, which controls for the scale of disclosure activity. The third explanatory variable is R&D Intensity, which is defined as annual R&D expenditure as a percentage of sales. The fourth explanatory variable is Capital Intensity, which is annual capital expenditure as a percentage of sales. R&D and Capital Intensities control for resources for research, more of which lead to more discoveries and potentially more defensive disclosures. We control for the antitrust enforcement climate in the U.S. by including the average number of `landmark' antitrust cases in a four year period instituted by the U.S. Department of Justice as measured by Sullivan and Hovenkamp, `Landmark Cases (SH),' which is derived from Gallo et al. (2000).

The coefficient estimates of this regression are shown in Table 1. In specification (1), controlling for other factors, IBM was more likely to disclose inventions defensively since the third antitrust case than before as reflected by the large, positive and significant coefficient estimate of ANTITRUST. In addition, an increase in the number of employees by a thousand led to 5.6 more defensive disclosures as reflected by the coefficient estimate of `No. of Employees.' A percentage point increase in R&D Intensity led to 117.3 more defensive disclosures as reflected by the coefficient estimate of `R&D Intensity.'

Insert Table 1

In specification (2) we introduce additional control variables and run censored Tobit regression as our dependent variable is left-censored at zero. Consistent with our model, controlling for other factors, IBM disclosed more inventions defensively during the third antitrust case than previously. The coefficient estimates of `Landmark Cases (SH)' is positive reflecting that greater antitrust enforcement in general as measured by landmark cases led to more disclosures but it is not statistically significant at the 10% level.[2] The coefficient estimate of `Capital Intensity' is also positive but not significant.

In specifications (3) and (4) the dependent variable is the fraction of inventions defensively disclosed and we run a censored Tobit regression as the dependent variable, a fraction, ranges between 0 and 1. In specification (3), the coefficient estimate of ANTITRUST is positive and significant at the 0.01 level reflecting that the fraction of inventions defensively disclosed increased by 19.3% after the start of the third antitrust case, controlling for other factors consistent with hypothesis 1. The result is robust to the inclusion of other control variables in specification (4). The coefficient estimate of `Landmark Cases (SH)' is positive and significant at the 0.05 level reflecting that more landmark cases filed in a given year led to more disclosures.

Second, we test hypothesis 2 that researchers at IBM patented a smaller fraction of inventions defensively since the start of the third antitrust case. We estimate a Pooled OLS regression with year dummies for the period 1958-1982 in specification (1). We then estimate a linear regression on panel data with researcher fixed effects for the period 1955-1982 in specifications (2) and (3). In other words, we control for time-invariant factors at the researcher-level, such as the field of expertise, that explain the researcher's patenting and disclosure preferences. The errors are clustered at the researcher-level. The dependent variable in specifications (1) is the number of defensive disclosures reported in a given year and in specifications (2) and (3) is the fraction of reported inventions disclosed defensively in a given year. The independent variables are as described previously.

Insert Table 2

The coefficient estimates of this regression are shown in Table 2. The coefficient estimates of year dummies in specification (1), shown in Figure 5, show a jump during 1969-1970. The coefficient estimate of ANTITRUST in specifications (2) and (3) is positive in sign and

[2] We also experimented with alternative measures of the annual number of antitrust cases reported in Gallo et al. (2000) for all firms and against Fortune 500 firms but the coefficient estimates were not statistically significant. An ideal measure would be the annual number of cases which mention patent portfolios as an area of concern.

significant at the 0.01 level reflecting that during the period of the antitrust case researchers at IBM on average filed for 10.6% more defensive disclosures than in prior years controlling for other factors consistent with hypothesis 2. The coefficient estimate of `Landmark Cases (SH)' is positive and significant at the 0.01 level reflecting that stronger antitrust enforcement climate led to a greater fraction of defensive disclosures. Similar results are obtained when we ran regressions for the period 1958-1989 instead of 1958-1982 as IBM continued to face the same antitrust case in Europe until the late 1980s.

Insert Figure 5

5.3 Disclosure of Valuable Inventions

The economic value of an invention is difficult to determine *ex ante*, it may depend on whether it is patented and what other related inventions are patented. Deciding which inventions are to be patented is further complicated by the threat of antitrust action under which a firm optimally discloses a large fraction of inventions defensively. The decentralized nature of the decision making process at IBM adds another layer of complexity to the decision making process. In our theoretical model, valuable inventions are just as likely as less valuable inventions to be disclosed defensively in contrast to other theories that predict that only low value inventions are disclosed defensively. We provide evidence consistent with our view in three parts.

First, IBM Fellows, those who received the highest technical honor at IBM, disclosed more inventions defensively between 1970 and 1989 than previously, as shown in Figure 6. Top researchers at IBM were likely to disclose more during the third antitrust case as was observed in the overall sample. In addition, during 1958-1989 top inventors as defined by the total number of awarded points disclosed on average 64% defensively and earned 40% of their points from defensive disclosures as summarized in Table A1 in the Appendix. At the top of the list is JJ Cuomo, a leading researcher in the area of semiconductor manufacturing, with 321 points who disclosed 77% of all his inventions and earned 53% of the points through disclosures.

Insert Figure 6

Second we group inventors with at least one disclosure by the highest number of citations any of their patents received during the period 1963-1999. A small group of 2,420 (9.5%) inventors with at least one very highly cited patent (in the top decile of cited patents) contributed to 17,895 (21.5%) defensive disclosures at an average of 7.4 defensive disclosures per inventor. In contrast, 52.5% of inventors with no patents contributed to 29.5% of defensive disclosures at an average of 1.82 disclosures per inventor. These patterns reflect that during the third antitrust case period top inventors contributed disproportionately more to the defensive disclosure activity, which further supports our view.

Third, we collected data on citations to defensive disclosures in aggregate using the USPTO's non-patent literature citations for the period 1975-1989. We find that the aggregate number of citations to the Technical Disclosure Bulletin by non-IBM patents steadily increased during 1975-1989 from 637 to 2,109 at a rate faster than the rate of increase in defensive disclosures during the period. In addition, citations to the TDB per non-IBM patent increased from 1.25 to 1.41 reflecting the increasing quality of defensive disclosures during this period. The absence of inventor names in TDB citations in the non-patent literature prevents us from investigating if the quality of disclosures increased at the inventor-level after 1969 through a citation analysis.

The concentration of disclosure activity among few top inventors is consistent with a view that the nearly thousand doctorates that IBM employed annually, systematically defensively disclosed inventions relating to IBM's main research programs, which is borne out by the defensive disclosure and patenting trends in semiconductor, disk drives, and software domains. These trends are not consistent with a view that defensive disclosures are primarily inventions unrelated to and thus less valuable to IBM's main research programs and lines of business.

5.4 Other Similar Cases

5.4.1. Xerox: Although we examined only one disclosure program here, our claims apply more broadly. To show this, we elaborate the case of Xerox's defensive disclosure program. Xerox, following its merger with Rank-Xerox, faced a Federal Trade Commission investigation, which alleged that the patent portfolio of the combined entity created barriers to entry into the paper copier market and that Xerox acted in ways to preserve its monopoly power through patents and marketing practices (see Bresnahan 1985). The case ended in 1975 with a consent decree, which required Xerox to license its patents at low or no royalties to its competitors.

Xerox’s management at the time believed that: (a) the weakening of its patent portfolio would not erode its market position given its superior sales force and well-established brand value; (b) refusal settle the FTC case by agreeing to license its patents would not prevent infringement of its patents, particularly by the Japanese competition; and (c) its suits alleging patent infringement would be replied with antitrust countersuits (Kearns and Nadler 1992:62). Xerox, however, quickly lost its dominant position in the copier market as rivals entered and benefited from Xerox's patents and disclosures.

In 1976 Xerox began its defensive disclosure program and disclosed 460 patents and 456 inventions defensively in that year. Xerox identified the names of the inventors in each of its defensive disclosures. In addition, Xerox classified its defensive disclosures according to the U.S. patent classification, leaving little doubt as to what it would have done if it had not faced the threat of antitrust action. Rivette and Kline (2000:37,99) note that the consent decree inhibited Xerox from patenting important inventions:

> “A former Xerox patent attorney says Xerox had even gone so far as to write patent applications for some of its GUI technologies, including everything from pull-down menus to pop-up dialog boxes to scalable windows. But at a critical invention disclosure meeting held at the time, it was decided not to proceed with the filings. Clearly, the 1975 FTC consent decree that forced Xerox to license away its copier patents was still inhibiting the firm’s patenting practices. But Xerox also seriously underestimated the GUI’s significance.”

As shown in Figure 7, the number of patents by filing year declined from 482 in 1975 to 399 in 1976 and 316 in 1977. The number of defensively disclosed inventions increased from zero in 1975 to 456 in 1976 and 300 in 1977. Xerox's patenting remained relatively low until 1986. A leadership change at Xerox and the rising cost of patent infringement by Japanese firms led to a turnaround in patenting (see for similar developments at other firms, Hall 2005). The defensive disclosure program was rapidly scaled down since the mid 1990s and by the year 2000 Xerox disclosed 21 inventions defensively while it filed for 1,028 patents in the same year.

Insert Figure 7

5.4.2. AT&T's Bell Labs: Another large R&D intensive U.S. firms that faced antitrust cases concurrently with IBM was AT&T in 1949. The first case ended in a consent decree in 1956 inhibiting AT&T's patenting practices. The second case started in 1974 and ended in 1982 with the divestiture of AT&T and the creation of regional telephone companies in 1984. At the start of the first case against AT&T in 1949, its vice president, Keith McHugh, stated AT&T's patent policy in Bell Telephone Magazine:

> "It is the Bell System's policy to make available upon reasonable terms to all who desire them non-exclusive licenses under its patents for any use."

Ralph Bown, vice president in charge of research and patents at Bell Labs in 1954, who oversaw the successful patenting and publication strategy following the invention of transistor in 1948, reiterated AT&T's patent policy (Bown 1954):

> "Although our patent system may make it possible for a successful industrial research laboratory to follow a publication policy nearly as free as that of an individual worker in pure science, it is not the only thing necessary. The patent system is available to all, but not all companies permit easy publication. There is always a temptation to hold a new invention back until a pattern of related ideas and alternative inventions can be embroidered about it and all the easy smart alternatives it suggests are covered. Also the advantage of hitting the market with a new product fully developed and ready to deliver in advance of any competition is a powerful motive. A publication policy is a judicious mixture of these influences together with the desire for the reputation which flows from scientific leadership, and with a realization that submission of new ideas to other minds will result in faster over-all progress. The fact that the Bell System wants only freedom to use the best ideas man can produce, and is willing to buy or trade for these when necessary, is a powerful factor in our publication-policy thinking."

In addition, Bell Labs facilitated the diffusion of its newly accumulated semiconductor technology by holding symposia for several U.S. and foreign firms and began licensing its patents at zero rate following the 1956 antitrust settlement (Scherer 1996). We find that firms like AT&T and IBM used the patent system to preserve freedom of action rather than to exclude others from using their inventions. There is further evidence to suggest that IBM learned from other similar firms such as Westinghouse and AT&T in building up its research in the late 1950s, both of which had maintained technical journals (see Hounshell 1996). For instance, Mervin Kelly, a retired chairman of Bell Telephone Laboratories, served as a consultant to Emanuel Piore, the director of IBM R&D during 1956-1960, at the request of

Tom Watson (Pugh 1995). These similarities among large firms in the organization and management of R&D labs suggest that the lessons we learned from the case of IBM apply more generally to other similar firms during this period.

5.5 Extending Regression Analysis

One limitation of our earlier analyses is that the secular trend in aggregate disclosure data may be driven by other factors. We attempt to exclude some industry-level explanations for the trend in the following analysis.

We focus on three of the seven important antitrust cases identified by Scherer (2008) that fall in our study period and show that under the threat of antitrust enforcement AT&T, Xerox, and IBM reduced their patenting relative to a control group of firms in their industry. We estimate patenting propensity for these three firms and 206 control firms chosen from COMPUSTAT that have patents in electronics and semiconductor industry during 1971-1980 as defined by four-digit SIC codes. We control for R&D intensity (R&D divided by sales), Capital intensity, firm age, firm size, and using year dummies all other factors that affect patenting of all firms annually. We interact dummies for AT&T, Xerox, and IBM with year dummies to capture factors specific to these three firms that uniquely explain patenting propensity.

Insert Table 3

The regression results are shown in Table 3. The coefficient estimates of R&D Intensity, Capital Intensity, and Employees are positive reflecting that larger and more R&D intensive firms have a higher propensity to patent. Similarly, firms that do not have any R&D investment have a significantly lower patent propensity as reflected by the negative and significant coefficient of No R&D Dummy. The coefficient estimate of AT&T is not statistically significant reflecting that AT&T did not differ from an average firm in the sample in terms of their propensity to patent. IBM and Xerox, however, have large, positive and significant coefficient estimates reflecting a higher patent propensity relative to an average firm in the sample.

While ATT and IBM were already under a consent decree since 1956, Xerox was not until 1975. Hence, we omit 1975, the year of first consent decree, for Xerox's year-interaction terms. We also omit 1969 for IBM's and 1974 for AT&T's year-interaction terms as those years represent the start of new antitrust cases against these firms, which were already under previous consent decrees. The coefficient estimates of the year dummies and year dummies interacted with AT&T, Xerox, and IBM are plotted in figure 8.

Insert Figure 8

The patenting propensities of both IBM and Xerox decline significantly after 1969 and 1975 respectively as reflected by the declining trend of firm-specific year interaction terms, consistent with our theory. The coefficient estimates of IBM dummy's interaction with year dummies are negative and significant at 0.05 level for all years after 1969 reflecting that IBM's patenting propensity declined relative the control set of firms. Similarly, the coefficient estimates of Xerox dummy's interaction with year dummies are also negative and significant after 1975. AT&T's patenting propensity, however, did not significantly decline in years after 1974.

5.6 Limitations

A number of limitations persist with our study. One set of limitations derive from our research design determined by data availability. Ideally, we would use a 'differences-in-differences' approach to test whether the fraction of inventions defensively disclosed by firms increased after antitrust enforcement 'treatment' relative before and relative to a set of similar control firms. However, data on defensive disclosures are prohibitively expensive to collect for other firms. In addition, patent and scientific publication datasets have very limited coverage for years prior to 1969. For instance, NBER patent data do not identify patent assignees for patents issued prior to January 1969. Similarly, Web of Science's coverage of scientific journals is very limited for years prior to 1973, which prevent us from controlling for publication propensity over time for firms in the US, particularly before and 1969. The lack of citation data disaggregated at the defensive disclosure-level precludes analyses of the quality of individual disclosures although we showed that, in aggregate, IBM disclosure bulletin received more citations over time adjusting for its expansion.

A second set of limitations derive for other contemporaneous events at IBM in 1969 that can plausibly explain the rise in defensive disclosure activity. We argued earlier that the defensive disclosure activity is not limited to a few but spread across several technology classes in which IBM played a dominant role. However, it may be argued that IBM's decision to unbundle software and hardware or IBM's adoption of open architecture explains our results. These changes themselves are triggered by the 1969 antitrust case and they still do not explain the origin of defensive disclosure programs in 1958 at IBM and in 1976 at Xerox (Usselman 2009). We can, however, exclude the explanation that that new product launches in non-patentable areas in 1969 drove disclosure activity as IBM's most successful product, System 360 was launched in 1964 and the rise in disclosure activity in 1969 included patentable and nonpatentable areas such as hardware and software.

6 Discussion

We investigated IBM's defensive disclosure program in rich detail and found several insights. IBM's defensive disclosures were intended neither to slow a leader nor to scare a follower in an innovation race. We argued that IBM started and rapidly expanded its defensive disclosure activity as a coping mechanism in response to the antitrust action taken by the U.S. Department of Justice since the 1950s.

Soon after the second antitrust case against IBM ended in a consent decree, IBM adopted a science-oriented business strategy accompanied by a policy of `freedom of action,' which involved large investments in corporate research and open disclosure of scientific results and technical inventions. IBM hoped to preserve the freedom to use its inventions without applying for costly patents given its limited ability to enforce patents and extract licensing revenues. Consistent with this policy, IBM began defensively disclosing inventions after the consent decree in 1956 and scaled up the disclosure program since 1969 when it faced the imminent threat of antitrust action.

We find evidence that researchers at IBM patented an increasingly smaller fraction of their inventions since 1958, when the Bulletin began. During the third antitrust case, IBM continued to patent a smaller fraction of its inventions. A small group of top IBM researchers contributed disproportionately more defensive disclosures compared to other IBM employees, which reflects that the defensive disclosures were not necessarily low value inventions unrelated to IBM's main lines of business. IBM reached a crisis in the late 1980s as its investment in research failed to translate into competitive advantage. IBM finally down-shifted its defensive disclosure program and began patenting aggressively. The case of Xerox disclosure program, which resembles IBM's program in several aspects, further supports our view.

The policy of defensive disclosure at IBM persisted even after the third antitrust case ended in the U.S. because the E.C. continued to pursue the same case until the late 1980s. The institutionalization of the defensive disclosure program and the creation of incentives for defensive disclosure was another contributing factor. While Xerox down-shifted its defensive disclosure program in 1986, IBM's program lasted longer until changes were made to researcher incentives for disclosure and patenting, and the E.C. case came to a close (Bhaskarabhatla and Hegde 2012).

The nature and extent of the defensive disclosure program by IBM have not been previously characterized. As a result, the business history of IBM, the evolution of industries in which it participated, and the lessons from its turnaround should be revisited (e.g., Lerner 1997). IBM's generous disclosure and limited patenting, we argue, created room for several firms in component markets to enter, grow, and eventually compete with IBM in software, storage, and semiconductors manufacturing markets.

Our characterization of IBM's disclosure program sheds new light on the variation in the effectiveness of patents across industries as reflected in innovation surveys by highlighting the role of antitrust enforcement against dominant firms in some industries (Levin et al. 1987). In addition, our results provide a better context to the `patent paradox' observed in innovation surveys, where firms report deriving a modest return from patents but patenting in large scale nonetheless since the mid-1980s (Cohen et al. 2000). Several explanations exists to explain the patent paradox (e.g., Hall and Ziedonis 2001; Arora and Gambardella 1994; Rosenbloom and Spencer 1996; Kortum and Lerner 1998).

Hall and Ziedonis (2001) study the semiconductor industry and suggest that the surge in patenting in the U.S. following the establishment of the Court of Appeals for the Federal Circuit (CAFC) in 1982 is driven by the aggressive patenting by capital intensive firms as a defensive mechanism against the problem of hold-up caused by the patenting by small rival firms. While they attribute the shift in `defensive' patenting to the strengthening of the patent rights since the 1980s, we offer an explanation rooted in the history of antitrust action in the U.S. Patent reforms under the threat of antitrust action against large firms will cause, in relative terms, more defensive disclosure rather than patenting as observed in the case of software sector at IBM after 1982. The subsequent increase in patenting by large firms, with IBM at the top, suggests a fundamental change in the way the U.S. Department of Justice dealt with patent portfolios of some large firms and a shift in the political economy of antitrust enforcement in the U.S. in the 1980s (Ghosal 2011). The case of IBM's disclosure program also clarifies how patenting surged despite reductions in R&D as IBM substituted away from defensive disclosures to patents in the 1990s.

Since the rise of industrial research in the early 20th century, large R&D intensive firms have driven technological and economic progress and IBM's role has been well-recognized (Reich 1985, Mowery and Rosenberg 1989, Bresnahan and Malerba 1997). Empirical studies have shown a positive relationship between firm size and process R&D (Cohen and Klepper 1996a, 1996b). More recently, however, the usefulness and sustainability of centralized corporate research labs has been questioned as pioneering R&D firms have significantly shrunk their R&D investments (Rosenbloom and Spencer 1996). We argued that such firms had to balance science-oriented strategy of growth with concerns of appropriability and punitive antitrust action. This tension between intellectual property laws and antitrust laws is well-noted (Carlton and Gertner 2003). The case of IBM has provided an unusual opportunity to study the impact of this tension on an innovative monopolist's ability to stay competitive in dynamic markets it first pioneered, raising questions about the efficacy of antitrust laws to regulate dynamic R&D competition in the hope of promoting incentives for innovation.

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Figures and Tables

Figure 1: IBM R&D Expenditure, Disclosures, Patents, and Licensing Revenues

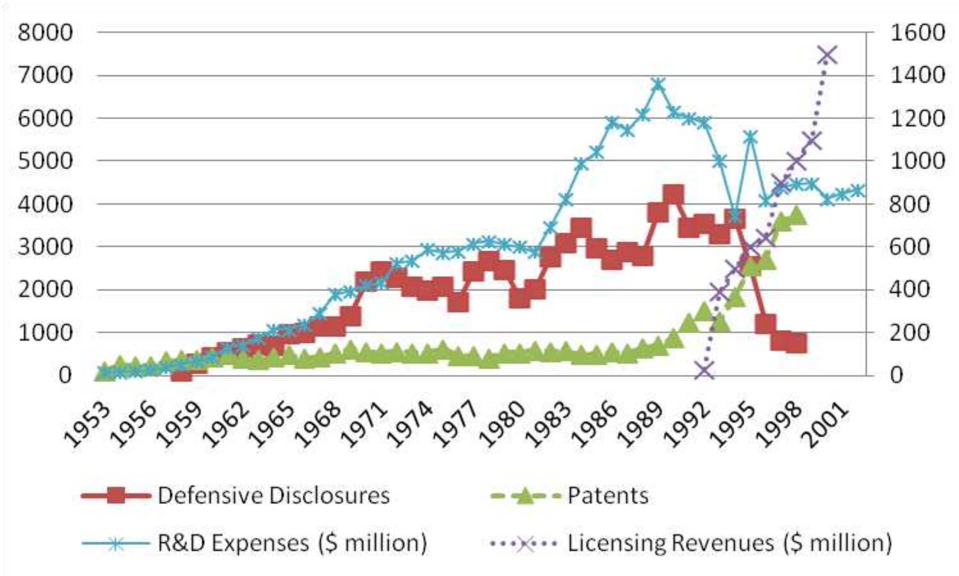

FIGURE 1 NOTES: Figure shows the time path of IBM's R&D Expenditures, Defensive Disclosures, Successful US Patent Applications, and Licensing Revenues. Licensing revenues, in $ million, are shown on the secondary Y-axis.

Figure 2: IBM patents in top IBM three-digit patent classes

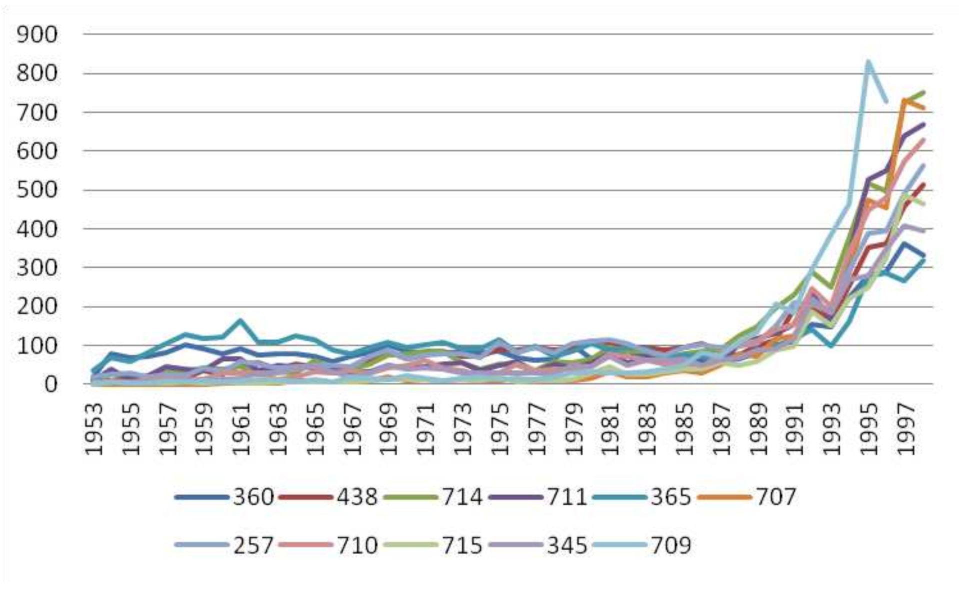

FIGURE 2 NOTES: US patent class 360 refers to dynamic information storage and retrieval, 438 semiconductor manufacturing, 365 static information storage and retrieval, 257 active solid state devices, 714 error detection/correction & fault detection/recovery, 711 electrical computers & digital processing systems: memory, 707 data processing: database & file management or data structures, 710 electrical computers & digital processing systems: input output, 715 data processing: presentation processing of document, operator interface processing, and screen saver display processing, 709 multicomputer data transferring, 345 computer graphics processing and selective visual display systems.

Figure 3: Disclosures by IBM inventors with patents in top hardware-related IBM patent classes

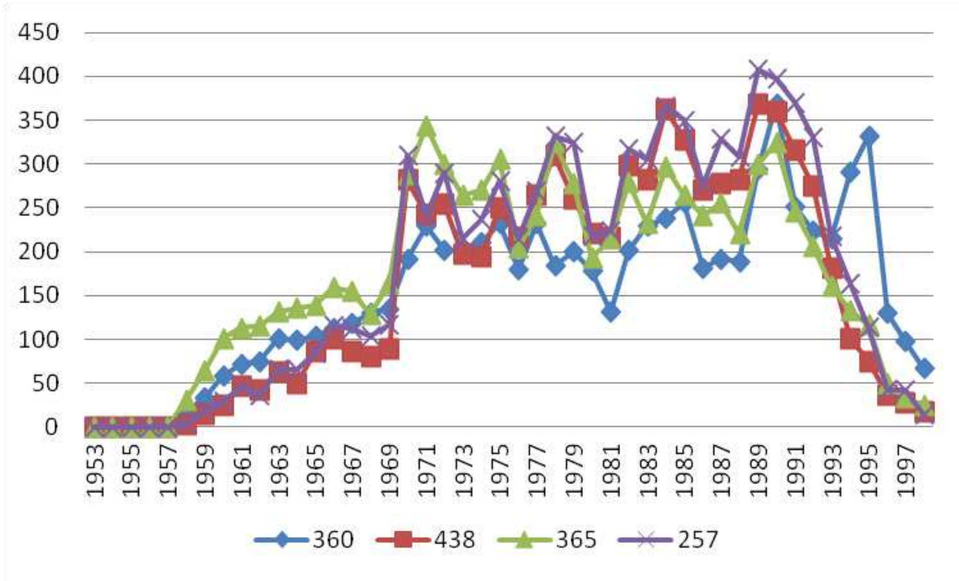

FIGURE 3 NOTES: US patent class 360 refers to dynamic information storage and retrieval, 438 semiconductor manufacturing, 365 static information storage and retrieval, and 257 active solid state devices.

Figure 4: Disclosures by IBM inventors with patents in top software-related IBM patent classes

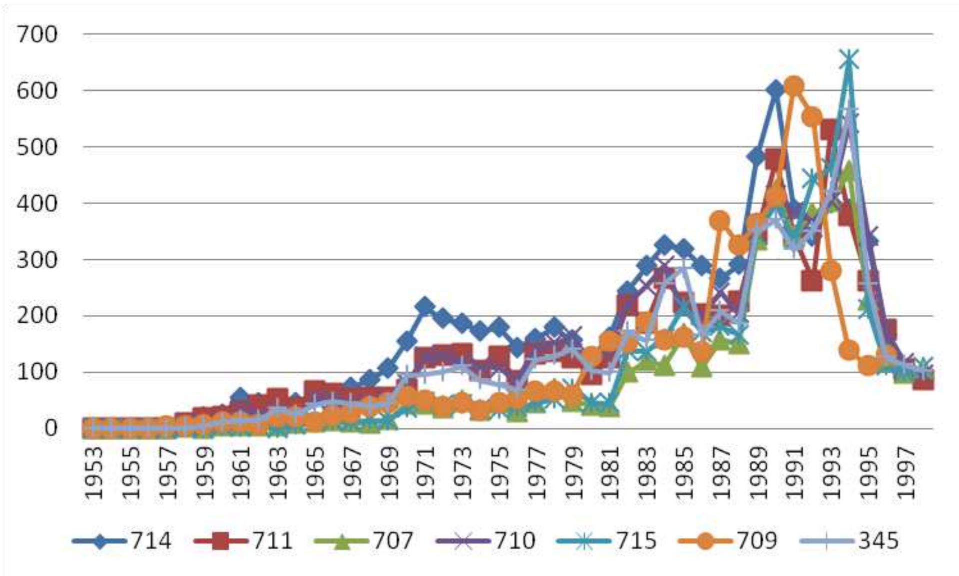

FIGURE 4 NOTES: US patent class 714 refers to error detection/correction and fault detection/recovery, 711 electrical computers and digital processing systems: memory, 707 data processing: database and file management or data structures, 710 electrical computers and digital processing systems: input output, 715 data processing: presentation processing of document, operator interface processing, and screen saver display processing, 709 electrical computers and digital processing systems: multicomputer data transferring, 345 computer graphics processing and selective visual display systems.

Figure 5: Increase in the fraction of disclosed inventions since 1969

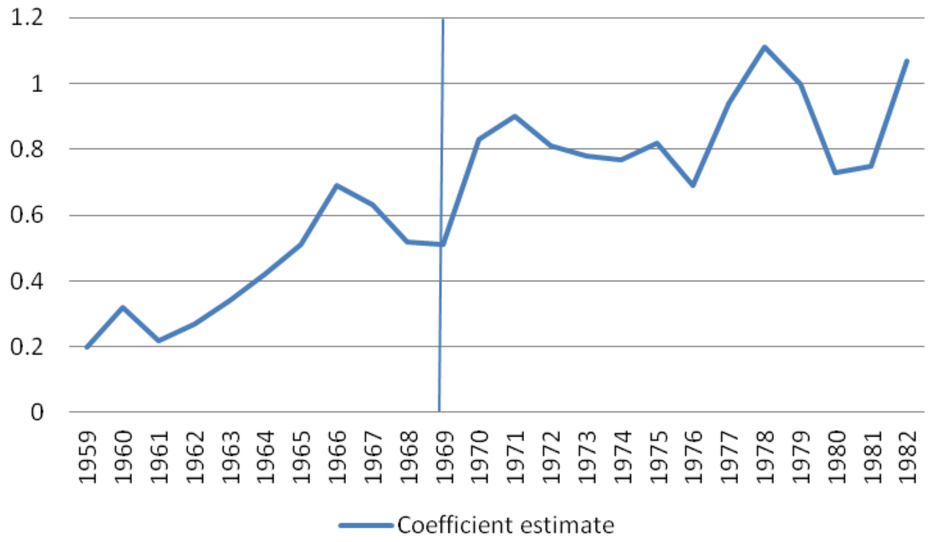

FIGURE 5 NOTES: Coefficient estimates of year dummies from specification (1) of table 2 are plotted here. 1969 represents the year in which antitrust case against IBM was initiated.

Figure 6: Disclosure and Patenting by IBM Fellows

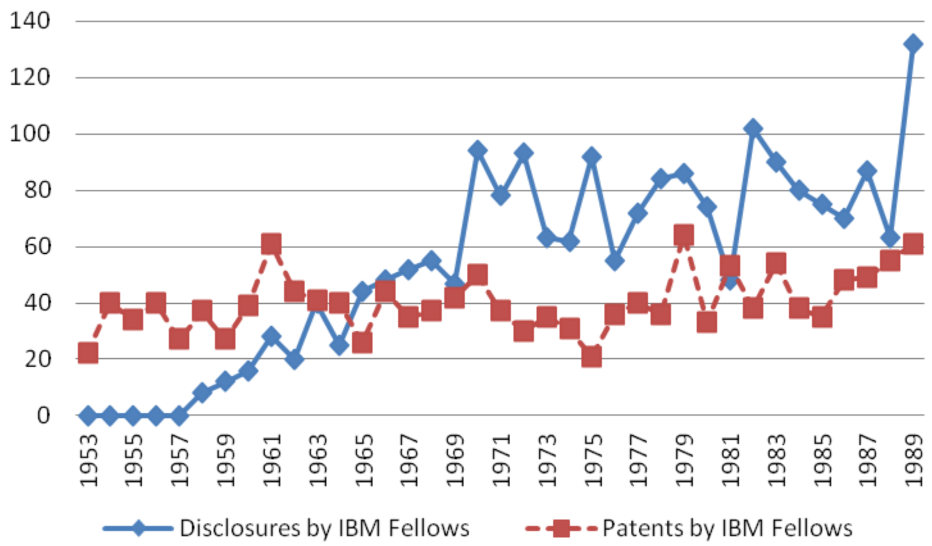

FIGURE 6 NOTES: The figure plots aggregate disclosure and patenting activity by a group of researchers that receive IBM Fellow title during their career at IBM.

Figure 7: Disclosure and Patenting by Xerox

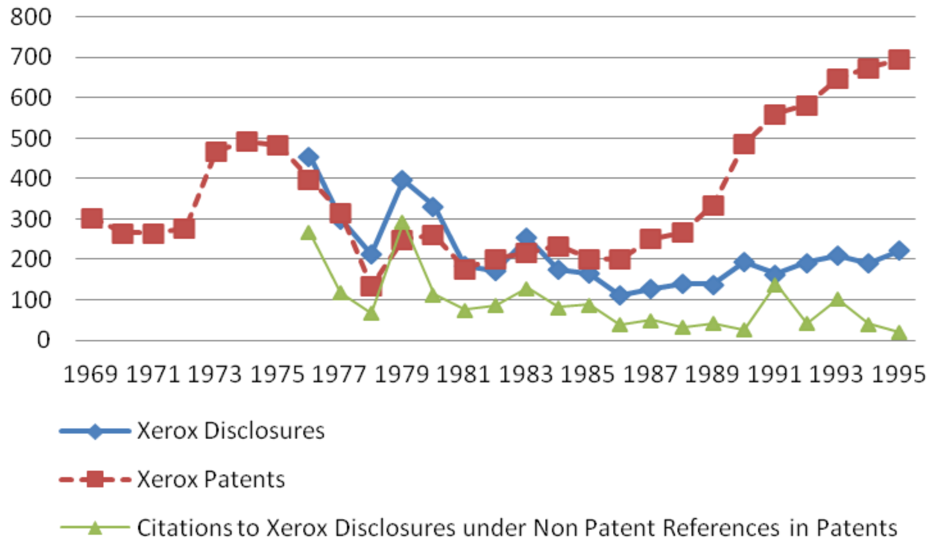

FIGURE 7 NOTES: The figure plots the number of patents by application year and the number of Xerox disclosure articles by publication year.

Figure 8: Patent propensity of ATT, Xerox, and IBM relative to a control set of firms

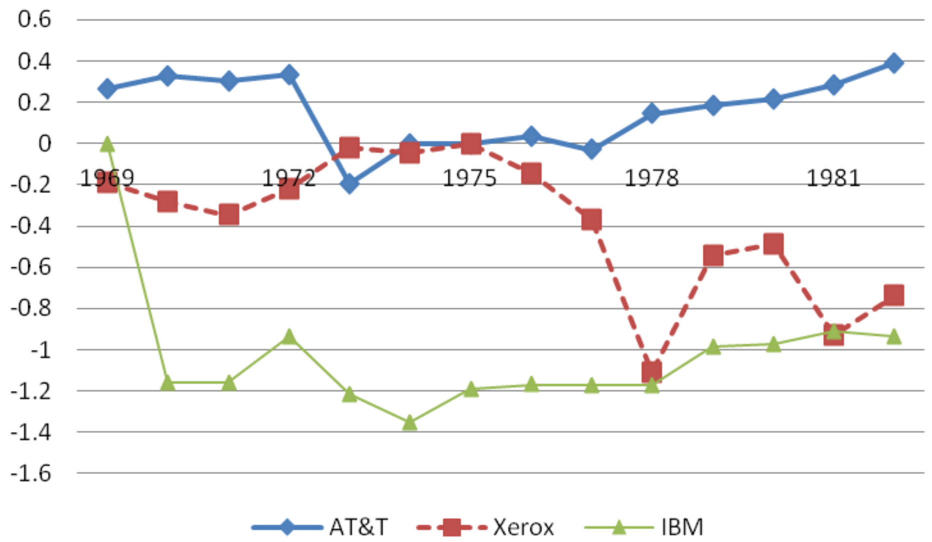

FIGURE 8 NOTES: The figure plots the coefficient estimates of year dummies interacted with ATT, Xerox, and IBM dummies in table 3.

Table 1: Impact of Antitrust Case on Disclosures at the Firm Level

	(1)	(2)	(3)	(4)
	OLS	Censored Tobit		
D.V.=	N of Disclosures	N of Disclosures	Fraction Disclosed	Fraction Disclosed
ANTITRUST	565.82**	666.40**	0.19**	0.21**
	[195.73]	[194.33]	[0.03]	[0.03]
Employees (thousands)	5.61**	5.16**		
	[1.12]	[0.89]		
R&D Intensity	117.37**	133.29*	0.06+	0.07*
	[41.25]	[48.17]	[0.03]	[0.03]
Capital Intensity		5.81		0
		[8.37]		[0.00]
Landmark Cases (SH)		44.6		0.04*
		[70.27]		[0.01]
Constant	-834.81**	-1,272.08+	0.22	-0.1
	[220.74]	[662.83]	[0.22]	[0.33]
Sigma		245.99**	0.09**	0.08**
		[37.21]	[0.01]	[0.01]
Observations	25	25	25	25
R-squared	0.904			
S.E. in brackets; ** p<0.01, * p<0.05, + p<0.1				

TABLE 1 NOTES: Method of estimation is OLS for specification (1) and censored Tobit for (2) to (4).

Table 2: Impact of Antitrust Case on Disclosures at the Inventor Level

	(1)	(2)	(3)
	OLS	Fixed Effects	
D.V.=	N of Disclosures	Fraction Disclosed	Fraction Disclosed
Year Dummies (1959-1982)	YES	NO	NO
ANTITRUST		0.10**	0.11**
		[0.01]	[0.01]
R&D Intensity	0.08**	0.05**	0.06**
	[0.01]	[0.00]	[0.00]
Capital Intensity			0.00**
			[0.00]
Landmark Cases (SH)			0.01**
			[0.00]
Constant		0.30**	0.15**
		[0.03]	[0.04]
Inventor Fixed Effects	NO	YES	YES
Observations	37,894	37,894	37,894
R-squared	0.498	0.015	0.016
N of Clusters		8,760	8,760

Inventor-Clustered S.E. in brackets; ** p<0.01, * p<0.05, + p<0.1

TABLE 2 NOTES: Method of estimation is OLS for specification (1) and fixed-effects GLS for (2) and (3).

Table 3: Impact of Antitrust Cases on Patent Propensity

D.V.=	Patent Count
log (R&D/Sales)	0.33**
	[0.08]
log (Capital Expenditure/Sales)	0.28+
	[0.16]
log (Employees)	0.71**
	[0.06]
log (Age)	-0.07
	[0.12]
No R&D Dummy	-1.04**
	[0.33]
ATT	0
	[0.47]
XEROX	1.21**
	[0.25]
IBM	1.59**
	[0.47]
ATT x Year Dummies	YES
XEROX x Year Dummies	YES
IBM x Year Dummies	YES
Constant	0.22**
	[0.09]
Observations	1,482
N of Clusters	290
Log likelihood	-5203.28
Firm-Clustered S.E. in brackets; ** p<0.01, * p<0.05, + p<0.1	

TABLE 3 NOTES: Method of estimation is Maximum Likelihood for Negative Binomial. The dependent variable is the number of successful patent applications for each firm-year. Time-period of analysis is 1969-1982 containing 290 firms, each with annual Compustat records and at least one successful patent application IBM's industry (electronics and semiconductors) defined based on four-digit SIC codes. Logged values of R&D/Sales and Plant & Equipment/Sales and Employees are used. Employees are in 1000's.

Table A1. IBM Inventors with more than 100 points obtained through patents and disclosures

Name	Pats	Discs	%	Pts*
Cuomo JJ	50	171	77	321
Woodall JM	60	106	64	286
Wiedmann SK	51	88	63	241
Romankiw LT	39	101	72	218
Riseman J	55	51	48	216
Clapper GL	53	55	51	214
Marinace JC	43	61	59	190
Vinal AW	57	19	25	190
Pricer WD	44	46	51	178
Barker BA	23	107	82	176
Ahn KY	22	104	83	170
Reisman A	42	42	50	168
Pennington K	31	73	70	166
Pomerene JH	20	103	84	163
Malaviya SD	32	58	64	154
Patel AM	38	40	51	154
Briska M	26	73	74	151
Sincerbox GT	31	55	64	148
Hunt RE	30	57	66	147
Pennebaker WB	39	28	42	145
Weinberger A	23	74	76	143
Chu RC	19	85	82	142
Beausoleil WF	34	39	53	141
Howard JK	35	36	51	141
Anantha NG	26	62	70	140
Bhatia H	23	71	76	140
Rechtschaffen RN	14	98	88	140
Magdo IE	42	13	24	139
Sparacio FJ	19	82	81	139
Uberbacher EC	22	73	77	139
Jambotkar CG	21	73	78	136
Sambucetti CJ	20	76	79	136
Chang H	26	57	69	135
Maley GA	32	38	54	134
Walsh JL	34	32	48	134
Keefe GE	28	49	64	133
Lean EGH	23	62	73	131
Schaefer JO	33	32	49	131
Fang FF	25	54	68	129
Matyas SM	25	54	68	129
Voegeli O	36	20	36	128
Ho IT	31	34	52	127

Name	Pats	Discs	%	Pts*
Dorler JA	18	71	80	125
Gambino RJ	18	71	80	125
Harris TJ	34	23	40	125
Grebe KR	25	49	66	124
Hinkel H	15	79	84	124
Irwin JW	24	52	68	124
Thompson DA	25	47	65	122
Hernandez IH	15	76	84	121
Poponiak MR	19	63	77	120
Stuckert PE	29	32	52	119
Garwin RL	30	27	47	117
Greschner J	26	39	60	117
Nassimbene EG	18	63	78	117
Schmeckenbecher AF	20	56	74	116
Lin Y	16	67	81	115
Roth JP	7	94	93	115
Rutz RF	30	23	43	113
Fleisher H	31	19	38	112
Pawletko JP	22	46	68	112
Galand CR	24	39	62	111
Helinski EF	15	65	81	110
Magdo S	28	25	47	109
Queener CA	27	27	50	108
Criscimagna TN	21	44	68	107
Esaki L	23	38	62	107
Torres RJ	6	89	94	107
Brownlow JM	24	34	59	106
Tummala RR	24	33	58	105
Bohg A	17	53	76	104
Gersbach JE	14	62	82	104
Najmann K	12	68	85	104
Schettler H	14	62	82	104
Terman LM	19	47	71	104
Cronin JE	8	79	91	103
Edel TR	10	73	88	103
Hoffman H	20	43	68	103
Max E	27	22	45	103
Aviram A	19	45	70	102
Hodgson RT	13	62	83	101
Hovel HJ	19	44	70	101
Kollar EP	24	29	55	101
Meyer CH	18	47	72	101

Notes: * Points=3xPatents+Disclosures; % denotes % of inventions disclosed defensively

Figure A1. Sample Defensive Disclosure

XEROX DISCLOSURE JOURNAL

NEXT GENERATION PAPER FEEDER
Denis J. Stemmle

Proposed Classification
U. S. Cl. 399/383
Int. Cl. G03g 15/00

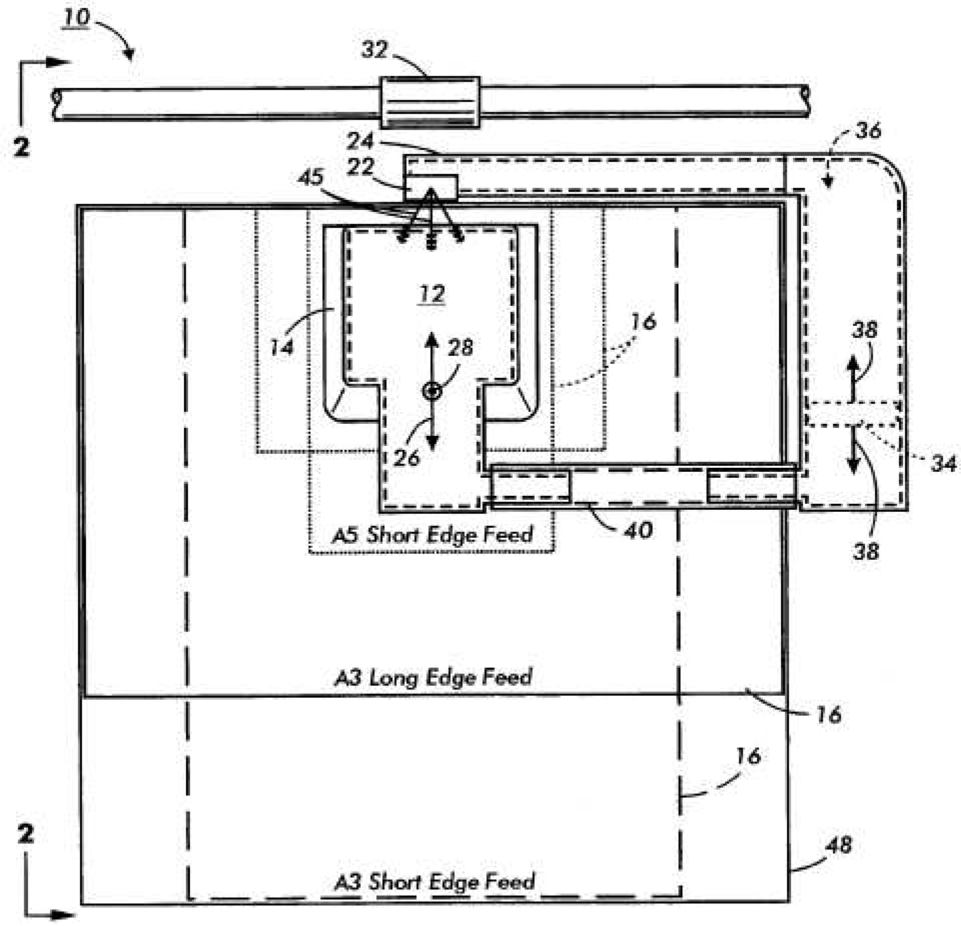

FIG. 1

FIGURE A1 NOTES: The figure shows a page from a sample defensive disclosure from Xerox Disclosure Journal. The page contains the title of the invention, the name of the inventor, proposed US and International Patent Classifications, and a rendering of invention-specific apparatus.