The Use of Voluntary Public Disclosure and Patent Strategies to Capture Value from Product Innovation

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Firms make tradeoffs in voluntarily and publicly disclosing R&D information. Disclosure can deter competition by signaling a technological advantage. However, such disclosures might signal technological opportunity and encourage competitors to develop competing innovations. This study investigates the effect of industry- and firm-specific advantages on the influence of voluntary public disclosure on competitors' patenting in the same technology space. Theoretical predictions are tested on a sample of 322 publicly traded firms between 1991 and 2004. The results are consistent with industry and firm-specific advantages moderating the effectiveness of disclosure along with patents as a strategy for capturing value from product innovation.

INTRODUCTION

Publicly traded firms face a dilemma in publicly disclosing qualitative information about their R&D accomplishments. On the one hand, firms might disclose such information because they need financing and seek to reduce their cost of capital (Botosan, 1997; Botosan & Plumlee, 2002; Dedman, Lin, Prakash, & Chang, 2008; Jones, 2007). By reducing uncertainty of innovation outcomes, disclosure helps investors to make better estimates of future profits from innovation. As a result, greater disclosure reduces a firm's cost of capital. On the other hand, disclosing such information may expose a firm to greater risk of competitive entry that reduces its competitive advantage (Davis, 2001; James, Leiblein, & Lu, 2013). As such, some firms may have strategic motivations to withhold information about their innovative efforts (Hemphill, 2004; Kale & Little, 2007). Given this paradox of disclosure (Arrow, 1962), the influence of disclosure on a firm's competitive advantage and ability to capture value from product innovation (James et al., 2013) is an important consideration for top managers who establish and implement disclosure strategies on behalf of the firm. Yet little work has been done regarding the intentional use of public disclosure (versus secrecy) and patents as a strategy for capturing value from innovation. This study addresses this gap in the literature in an investigation of the conditions under which public disclosure along with patents can be an effective value capture strategy in the context of competitive patenting in the same technology space.

For some firms, disclosing proprietary information about product innovations may make their strategies more transparent and reduce profits from innovation (Cohen, Nelson, & Walsh, 2000; Levin, Klevorick, Nelson, & Winter, 1987; Winter, 2000). In such cases, disclosure might help competitors benefit from lower innovation costs or the time to develop and patent a product innovation (Bhattacharya & Ritter, 1983; Choi, 1991; De Fraja, 1993). The net result is that disclosure can reduce a firm's technological advantage in a race to patent an innovation ahead of rivals. Therefore, some firms may have

strategic motivations to withhold information about product innovation activities (Arundel, 2001; Katila, Rosenberger, & Eisenhardt, 2008).

However, for firms that have technological capabilities that reduce the risk of preemptive patenting by competitors, the tradeoffs managers face in publicly disclosing proprietary information will be lower for three reasons. One, for such firms disclosing their technological strengths will likely not enable competitors to replicate their R&D strategies or leapfrog their efforts to patent innovations (Dierickx & Cool, 1989; Ethiraj & Zhu, 2008). Two, for firms that have significant learning or lead-time advantages, disclosing their advantages may deter competitors from entering the same technology space (Polidoro Jr. & Theeke, 2012). Three, for firms that face a more competitive technology environment, broadcasting their R&D accomplishments might expand profit opportunities via cross-licensing or other cooperative arrangements (Harhoff, Henkel, & von Hippel, 2003). This study examines these potential deterrence and attraction effects of voluntary public disclosure on a sample of 322 firms in the pharmaceutical and communications equipment industries. The focus is on the impact of voluntary public R&D disclosures during the early stages of R&D before a firm would have filed for a patent on a given innovation and in the period during which managers would likely be more concerned with competitive patenting in the same technology space. Patent applications are used as a competitive outcome of interest because prior research has shown that a firm's patent stock is considered to be an important source of competitive market advantage (Gans & Stern, 2003; Jaffe, 1986; Lerner, 1994; Somaya, 2012). The results are consistent with industry and firm-specific advantages moderating the effective use of disclosure, along with patents, to deter competitive imitation.

This work contributes to literature on how firms capture value from competitive advantages, in general, and firms' technological advantages, in particular. Disclosure is empirically examined as a value capture mechanism in the context of high-tech firms where firms' efforts to protect their innovative ideas can be costly (Liebeskind, 1997), yet such efforts are necessary in industry contexts where owning patents are necessary but not sufficient conditions for capturing value from innovation (Gehl Sampath, 2007; James et al., 2013; Thumm, 2004). For firms that have technological advantages, strategically disclosing information signaling these strengths may deter competitors from patenting in the same technology space (Polidoro Jr. & Theeke, 2012). However, for firms lacking these advantages secrecy may be a more effective mechanism for preventing competitive imitation (Cohen et al., 2000; Hemphill, 2004). The remainder of the paper proceeds as follows. The next section reviews literature on the use of disclosure as a value capture mechanism and develops hypotheses on industry and firm-specific advantages as moderators of the deterrence effects of this value capture mechanism. This is followed by empirical analysis of theoretical predictions. The paper concludes with a discussion of the implications for firms' ability to effectively use intentional information disclosure along with patents as a value capture strategy.

VOLUNTARY PUBLIC DISCLOSURE AND PATENTING

Prior research suggests that credible R&D disclosures may help firms achieve a sustainable competitive advantage in developing and profiting from cutting edge technologies (Harhoff, 1996; Harhoff et al., 2003). An important implication of this research is if disclosure influences competitors' R&D activities in the same technology space, a firm that credibly signals a technological advantage may reduce rivals' development and patenting of competing product innovations. However, few studies have explored this possibility.

A recent study investigated plausible motivations for voluntary public R&D disclosures outside of the patent system (James & Shaver, 2014). The results are consistent with firms that have a technological advantage having strategic motivations to disclose and highlight the need for more research on the competitive implications of such disclosure.

Some firms might disclose their advantages to deter competition in strategic factor and product markets. Other firms may disclose to encourage development of complementary product innovations or to attract cross-licensing partners that control capabilities they need to profit from a product innovation. If R&D disclosures are indeed strategic and have the intended effect on competitors' product innovation

activities, then we would expect to observe competitive outcomes that are favorable to the disclosing firm. The following discussion outlines the effects of industry and firm-specific advantages on competitors' patenting in the same technology space.

Industry Intellectual Property Regime Strength

The characteristics of the industry in which a firm operates may dictate the effect of voluntary public disclosures on competitors' patenting efforts. One important factor is whether the disclosing firm's industry has strong inherent patent protection. An industry has a relatively strong IP regime when owning patents inherently provides a stronger defense against imitation or legal challenges from competitors. For example, in discrete product industries such as the pharmaceutical industry one patent tends to map into a given product innovation, and owning that patent provides a relatively strong intellectual property right to the owner, all other things equal. However, in complex product industries, such as communications equipment, a product innovation tends to consist of many patents, some of which may not be owned by the firm (Cohen, Goto, Nagata, Nelson, & Walsh, 2002; Cohen et al., 2000). Consequently, a given patent provides relatively weak IP protection for two reasons. First, it may be more difficult for a firm to make a broader claim of novelty for a patented technology and as a result that technology may be easier to invent around. Second, absent a cross-licensing agreement, other firms that own patents on similar technologies may make a claim of infringement against the firm. For instance, in 2000 NTP, Inc. filed a lawsuit against Research in Motion (RIM) for infringement against NTP's patents on technologies similar to RIM's patented technologies in the Blackberry® wireless email system. After an appeal of NTP's claims, in 2006 Research in Motion paid NTP $612.5 million to settle the dispute[1].

In sum, the inherent strength of legal protection within an industry influences the strength of a firm's patents and thus its technological advantage over rivals. It follows then that the strength of patent protection within an industry likely influences whether public disclosures will deter competitor's subsequent patenting in the same technology space. For firms in industries with relatively strong patent protection, disclosures are more likely to result in competitors patenting fewer similar product innovations. Because firms in such industries have a stronger defense against potential legal challenges of their patents and are more likely to prevail in patent infringement disputes, disclosing technological advantages will likely deter competitive entry. In contrast, firms that operate in industries characterized by relatively weak patent protection would likely face greater competition after publicly disclosing proprietary information. Because firms in these industries have a relatively weak defense against potential legal challenges and are less likely to prevail against patent infringement claims, disclosures that signal technological opportunities to competitors that have a similar technology profile are less likely to deter entry. The foregoing logic leads to the following:

> *Hypothesis 1a: For firms that operate in industries characterized by a relatively strong intellectual property regime, R&D disclosures decrease patent applications by competitors in the same technology areas.*
>
> *Hypothesis 1b: For firms that operate in industries characterized by a relatively weak intellectual property regime, R&D disclosures increase patent applications by competitors in the same technology areas.*

Firm-Specific Advantages and Competitive Patenting

Firms may be motivated to disclose proprietary R&D information because they have internally developed a strong defense against competitive entry into the same technology space. This firm-specific appropriability may stem from lead time and learning curve advantages that help firms to patent around core technology areas to wall off those areas (Denicolò & Alberto Franzoni, 2004). Such defensive patenting makes it more difficulty or costly for competitors to replicate the firm's R&D strategies. To the extent that a firm has internally developed a strong defense against competitive entry, voluntary public

R&D disclosures will likely deter competitors from developing and patenting innovations in the same technology space.

The deterrence effect of disclosure will be more prominent in cases where a lead-time advantage is an important mechanism for profiting from innovation, and accelerating R&D spending over a shorter time period does not achieve the same R&D output as maintaining a given rate of R&D spending over a longer time period. These time compression diseconomies make it unprofitable for rivals to redirect R&D spending into more promising areas highlighted by disclosures from firms that have lead-time advantages (Dierickx & Cool, 1989). Under these conditions, rivals are less likely to engage in direct competition with the disclosing firm. However, for firms that do not have internal capabilities that make competitive entry into the same technology space more difficult disclosure will likely have an unintended negative competitive effect.

Another possibility is firms might disclose to broadcast their capabilities and attract trading partners with the ultimate goal of increasing profit opportunities. This motivation is likely in cases where firms face a more competitive landscape where other firms control complementary technologies or other capabilities (i.e., specialized manufacturing, sales, or service capabilities) that are necessary to commercialize an innovation. In such cases, disclosing technological accomplishments may help the firm to accelerate the commercialization of an innovation. Firms may also disclose early technological breakthroughs to lead the development of a new technological standard or to develop a new customer base for a breakthrough product innovation (Harhoff et al., 2003; Spencer, 2003). Thus, I hypothesize:

> *Hypothesis 2: Technological capabilities indicating firm-specific appropriability strength will have a negative association with patent applications by competitors in the same technology areas.*

The foregoing discussion leads to the following conjectures about the effect of voluntary public disclosure on competitors' patenting in the same technology space. One, for firms that operate in industries characterized by relatively strong patent protection, R&D disclosures decrease patent applications by competitors in the same technology areas. However, for firms that operate in an industry with relatively weak patent protection, we would expect the opposite effect. By disclosing their R&D strategies, firms in such industries would make it easier for competitors to develop and patent innovations in the same technology space. Therefore, absent other motivations to disclose such as to attract licensing or alliance partners, for firms in an industry with relatively weak patent protection secrecy would be a more effective mechanism for protecting profits from innovation. Two, holding industry level appropriability constant, firms that have a strong internal defense against competitive imitation might also deter competition by disclosing. By developing and patenting innovations around core technology areas, such firms can make it more costly for others to replicate their R&D strategies without adequate compensation. For firms that do not have this strong technology position, disclosing proprietary information about technological opportunities would likely attract competitive entry. The next section empirically examines these effect of industry and firm-specific appropriability on competitive patenting in the same technology space.

EMPIRICAL ANALYSIS

Data and Sample

The research setting is all firms that operate in the global communications equipment (SIC codes 3661, 3663, and 3669) and pharmaceutical preparation (SIC 2834) industries and trade stocks on a US exchange over the period 1990 to 2004. These industries are investigated because they differ significantly in the inherent strength of patent protection. This distinction stems from the tendency of products in the pharmaceutical industry to consist of relatively few patentable elements (i.e., discrete product technologies) compared to firms in the communications equipment industry where products tend to

consist of a much larger number of patentable elements (i.e., complex product technologies), some of which the firm may not control.

Invoking variance in the strength of industry level patent protection allows us to distinguish between industry and firm-specific factors that drive the competitive effects of disclosure. Specifically, if the analysis shows that disclosure has opposite effects from those implied by prior research, then firm-specific factors might better explain the competitive implications of disclosing proprietary information. Alternatively, if the empirical analysis demonstrates the expected effects then industry factors likely have a strong influence on competitive patenting in the same technology space.

The sample includes all firms that have R&D expenditures at any point in the sample period and financial statement data available. Because most of the independent variables have one-period lags, this sampling process yields an initial sample of 2,790 firm year observations for 322 firms from 1991-2004. Disclosure data are drawn from all press releases issued by a firm or by others on behalf of the firm to major news wires (i.e., PR Newswire, Business Wire). Patent data are drawn from the National Bureau of Economic Research Patent Data file and the USPTO. The Compustat Industrial Annual database provides financial data.

Dependent Variable

Patent counts have been used to measure innovativeness in prior technology and innovation research. I utilize patent applications as an outcome of a firm's technological advantage for two reasons. First, recent theoretical and empirical work suggests that internal attributes of a firm that increase their ability to capture value from innovation are more likely to generate a competitive advantage and superior performance compared to external factors such as industry patent protection. Second, owning more patents can strengthen a firm's bargaining position when negotiating technology licensing arrangements.

Competitors' patent applications are the number of patent applications from firms in the same technology classes as the focal firm in a given firm year. Technology classes for each patent owned by firms in the sample were drawn from USPTO raw patent data.

The data indicate heterogeneity across firms and across industries in the incidence of R&D disclosures. Table 1 presents a frequency distribution of R&D disclosure over the sample period 1991-2004. Panel A includes the distribution for pharmaceutical firms. Panel B shows the frequency of disclosures for communications equipment firms. Interestingly, pharmaceutical firms have more years with disclosures and larger numbers of disclosures than communications equipment firms. In contrast, communications equipment firms have more years with no disclosure (93%) compared to pharmaceutical firms (56%). Thus, although many firms never publicly disclose R&D information, such disclosure is not rare as some firms disclose regularly.

TABLE 1
FREQUENCY DISTRIBUTION OF DISCLOSURES BY FIRM-YEAR

Panel A: Pharmaceuticals

Value of Disclosures	Frequency	Percent of all observations
0	813	55.99
1	240	16.53
2	148	10.19
3	86	5.92
4	59	4.06
5	32	2.2
6	23	1.58
7	14	0.96
8	10	0.69
9	8	0.55
10	2	0.14
11	4	0.28
12	2	0.14
13	2	0.14
14	5	0.34
15	1	0.07
16	1	0.07
19	1	0.07
22	1	0.07

n=1452, 166 firms

Panel B: Communications Equipment

Value of Disclosures	Frequency	Percent of all observations
0	1,244	92.97
1	65	4.86
2	12	0.9
3	8	0.6
4	3	0.22
5	2	0.15
6	2	0.15
7	1	0.07
10	1	0.07

n=1338, 156 firms

Independent Variables

R&D Disclosure

R&D disclosures in a given firm year are equal to the count of all press releases containing R&D information, as discussed previously, which are coded "1". R&D disclosures that include information about projects in the initial research phase of the innovation process and before the development or testing of a product innovation measure a firm's 'early-stage' disclosures (Early-stage R&D Disclosures).

R&D disclosures about projects in the initiation research phase that exclude all references to patent applications measure a firm's research disclosures (Research R&D Disclosures).

Early-stage R&D Disclosures and Research R&D Disclosures are included as more robust measures of R&D disclosure to control for the possibility that total R&D disclosures might include information previously disclosed to the FDA or the USPTO.

Industry IP Regime Strength

To measure the effect of industry level patent protection on competitors' patenting activities, the empirical analysis is conducted on split industry subsamples. As discussed previously, prior research has shown that industries differ in the extent to which they seek to patent innovations and the effectiveness of this mechanism for capturing value from R&D.

Firm-Specific Appropriability Strength

Self-citation Ratio and Patent Applications are used as measures of firm-specific appropriability or technological strength. Self-citation Ratio, measured as total self-citations divided by total citations to a firm's patents in a given firm year, is included as a measure of a firm's internal intellectual property protection. Self-citation ratio is an indicator of the extent to which firms build on the stock of owned technologies in developing product innovations. Despite the limitations and criticisms of patent citations, self-citation ratio represents the extent to which a firm retains the value of R&D within internal boundaries. Firms that develop and patent innovations around core technology areas (i.e., patent thickets) have a stronger internal defense against patent infringements by competitors. Self-citation Ratio is also used in sensitivity analyses to distinguish the effects of firm-specific technological advantage from an industry advantage. Patent Applications are measured as the count of all patent filings by the focal firm. This variable is a measure of a firm's stock of technological capabilities.

Control Variables

Publication R&D disclosures are the count of press releases that highlight publication of R&D outcomes in scientific journals. I include this measure to distinguish disclosures directly to the public from scientific publications which are not necessarily widely disseminated.

Also included are controls for important firm attributes found in previous research to have a positive relationship with disclosure – secondary offerings, R&D spending, self-citation ratio, and patent applications. Secondary Offerings measure a firm's need for financing in public capital markets. Measured in millions of dollars, this variable is the value of secondary offerings of debt and equity securities. These data were collected from the Securities Data Corporation database of new issues. R&D Spending indicates the extent to which firms have different levels of R&D inputs which likely influences disclosure. Self-citation Ratio and Patent Applications are included in models estimating the effect of Industry IP strength on competitors' patenting behavior. Both variables are defined in the previous section.

All models include the dummy variable post1995 to control for unobserved temporal effects, such as changes in disclosure requirements on firms' patenting efforts. In 1995, the Securities & Exchange Commission increased disclosure requirements that likely influence a firm's propensity to disclose R&D information. Table 2 presents descriptive statistics and correlations among the variables. Panel A includes data for the 1,452 firm-years for 166 pharmaceutical firms in the sample. Panel B provides statistics for the 1,338 firm-years for 156 communications equipment firms in the sample.

TABLE 2
DESCRIPTIVE STATISTICS AND CORRELATIONS

Panel A: Pharmaceutical Firms

		Mean	Std. Dev.	Min	Max
1	Competitors' Patent Applications	45.01	116.08	0	942
2	R&D Disclosures$_{t-1}$	1.32	2.26	0	22
3	Early-stage R&D Disclosures$_{t-1}$	0.47	1.11	0	11
4	Research R&D Disclosures$_{t-1}$	0.31	0.84	0	11
5	Publication R&D Disclosures$_{t-1}$	0.06	0.38	0	6
6	Secondary Offerings$_{t-1}$	8.42	56.34	0	1340
7	Self-citation Ratio$_{t-1}$	0.23	0.32	0	1
8	R&D Spending$_{t-1}$	252.88	726.90	0	12183
9	Patent Applications$_{t-1}$	20.97	54.89	0	415

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1								
2	0.004	1							
3	0.054*	0.768*	1						
4	0.054*	0.698*	0.878*	1					
5	0.012	0.542*	0.639*	0.587*	1				
6	0.049	-0.017	0.017	-0.004	-0.015	1			
7	0.306*	0.075*	0.090*	0.049	0.062*	0.005	1		
8	0.441*	0.023	0.009	0.045	-0.042	0.033	0.213*	1	
9	0.732*	0.005	0.054*	0.074*	0.002	0.010	0.308*	0.576*	1

n=1452, 166 firms * $p<0.05$

Panel B: Communications Equipment Firms

		Mean	Std. Dev.	Min	Max
1	Competitors' Patent Applications	18.97	97.00	0	938
2	R&D Disclosures$_{t-1}$	0.12	0.61	0	10
3	Early-stage R&D Disclosures$_{t-1}$	0.08	0.50	0	8
4	Research R&D Disclosures$_{t-1}$	0.04	0.28	0	4
5	Publication R&D Disclosures$_{t-1}$	0.001	0.04	0	1
6	Secondary Offering$_{t-1}$	19.59	147.35	0	3275
7	Self-citation Ratio$_{t-1}$	0.07	0.14	0	1
8	R&D Spending$_{t-1}$	131.84	546.32	0	5152
9	Patent Applications$_{t-1}$	20.89	111.29	0	1400

	1	2	3	4	5	6	7	8	9
1	1								
2	0.510*	1							
3	0.484*	0.928*	1						
4	0.410*	0.794*	0.877*	1					
5	-0.006	0.279*	0.267*	0.271*	1				
6	0.159*	0.322*	0.320*	0.159*	-0.005	1			
7	0.236*	0.146*	0.149*	0.135*	0.004	0.143*	1		
8	0.576*	0.674*	0.654*	0.547*	0.259*	0.370*	0.234*	1	
9	0.754*	0.512*	0.487*	0.409*	0.054*	0.342*	0.193*	0.654*	1

n=1338, 156 firms * p<0.05

Looking at the raw correlations for pharmaceutical firms in Panel A, with the exception of total R&D Disclosures, Publication R&D Disclosures, and Secondary Offerings, have significant positive correlations with Competitors' Patent Applications. In addition, all of the significant variables have a positive sign, which is contrary to what theories of strategic disclosure suggest. Similarly, the descriptive statistics for communications equipment firms in Panel B show that all variables have positive and significant correlations with the dependent variable except for Publication R&D Disclosures. The empirical analysis that follows further explores what might be driving these surprising descriptive results.

Other noteworthy descriptive results include positive correlations between important firm attributes and R&D Disclosure for firms in both industries. In the pharmaceutical subsample, Self-citation Ratio has a positive and significant correlation with total R&D disclosures and Early-stage disclosures. Patent Applications have a significant positive correlation with Early-stage R&D Disclosures and Research R&D Disclosures. In the communications equipment firm subsample, Self-citation Ratio has a significant positive correlation with total R&D Disclosures and Early-stage R&D Disclosures. Patent Applications have a significant positive correlation with all types of R&D disclosures.

Analysis

The econometric approach used to test the hypotheses regresses Competitors' Patent Applications on the independent variables and controls. A Poisson or negative binomial regression model with fixed effects is recommended to deal with dependent count variables of this sort (Cameron & Trivedi, 1998; Greene, 1994; Hausman, Hall, & Griliches, 1984). The variance in the dependent variable is significantly larger than the mean which indicates over-dispersion. The negative binomial specification allows us to control for this over-dispersion. However, critics argue that the fixed effects negative binomial is not a true fixed effects estimator. This specification estimates the conditional mean using a fixed parameter to account for over-dispersion in the variance, rather than include fixed effects in the model estimating the dependent variable (Allison & Waterman, 2002; Greene, 1994).

Thus, to test the hypotheses I use a fixed-effects Poisson estimator for the following reasons. As demonstrated by Hausman, Hall, and Griliches (1984), this specification includes true firm fixed effects which controls for unobservable factors. In addition, 'the fixed-effect Poison estimator has very strong robustness properties for estimating the parameters in the conditional mean' (see Wooldridge, 2002, pages 674-675) . Specifically, this method allows for over-dispersion or under-dispersion in the variance of the dependent variable and thus addresses the limitations of the negative binomial estimator.

Because the fixed effects Poisson regression excludes all firms that have zero observations for the dependent variable across all firm years in the sample, the analysis is based on a usable sample of 1,283

firm-years for 139 pharmaceutical firms and 847 firm years for 96 communications equipment firms. Two different models are estimated for the pharmaceutical subsample and the communications equipment subsample, respectively. Models Pharma1 and Comm1 include Early-stage R&D Disclosures and the control variables. Pharma2 and Comm2 replace Early-stage R&D disclosures with Research-stage R&D Disclosures.

Results

Table 3 presents the results of fixed effects Poisson regressions on competitors' patent applications in the same technology classes in a given year as the dependent variable.

TABLE 3
FIXED EFFECTS POISSON REGRESSION RESULTS BY INDUSTRY
(ROBUST STANDARD ERRORS IN PARENTHESES)

Dependent Variable: Competitors' Patent Applications

	Pharma1	Comm1	Pharma2	Comm2	Pharma3	Comm3
R&D Disclosures$_{t-1}$	-0.07***	0.16***				
	(0.003)	(0.004)				
Early-stage R&D Disclosures$_{t-1}$			-0.04***	0.15***		
			(0.005)	(0.005)		
Research R&D Disclosures$_{t-1}$					-0.11***	0.16***
					(0.006)	(0.008)
Publication R&D Disclosures$_{t-1}$	0.11***	-2.43***	0.08***	-2.45***	0.08***	-2.36***
	(0.02)	(0.32)	(0.02)	(0.32)	(0.02)	(0.32)
Secondary Offering$_{t-1}$	0.0004***	-0.0003***	0.0003***	-0.0003***	0.0003***	-0.0002***
	(0.00004)	(0.00003)	(0.00004)	(0.00003)	(0.00004)	(0.00002)
Self-citation Ratio$_{t-1}$	0.65***	0.94***	0.65***	0.92***	0.65***	0.83***
	(0.02)	(0.06)	(0.02)	(0.06)	(0.02)	(0.06)
R&D Spending$_{t-1}$	-0.0002***	-0.0005***	-0.0002***	-0.0004***	-0.0002***	-0.0004***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Patent Applications$_{t-1}$	0.005***	0.002***	0.006***	0.002***	0.005***	0.002***
	(0.0001)	(0.00004)	(0.0001)	(0.00004)	(0.0001)	(0.00004)
Post1995	0.04***	1.40***	0.001	1.37***	0.02+	1.41***
	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)
Log Likelihood	-25367.99	-7118.74	-25589.95	-7331.77	-25469.96	-7624.82
$X^2(7)$ for covariates	9362.45***	12367.03***	9030.24***	12070.55***	9294.19***	11458.32***

1,283 pharmaceutical firm years, 139 firms, 847 communications equipment firm years, 96 firms
+ p<.10, ** p<.05, *** p<.01

Hypothesis 1a argued that firms operating in a strong industry IP regime would show a negative association between R&D disclosures and competitors' patent applications in the same technology areas as the focal firm. Hypothesis 1b argued the opposite effect for firms operating in a weak industry IP regime: a positive association between R&D disclosures and competitors' patent applications. The results

for pharmaceutical firms show that the coefficients for all types of R&D disclosures are negative and significant. In contrast, communications equipment firms show positive and significant results for all types of R&D disclosures. Table 4 includes t-tests comparing the results for pharmaceutical firms with those for communications equipment firms, demonstrating that the findings are significantly different from zero. Taken together, the analysis in Table 3 and Table 4 provide strong support for hypothesis 1a and hypothesis 1b.

TABLE 4
COMPARISON OF FIXED-EFFECTS POISSON REGRESSION COEFFICIENTS BY INDUSTRY

	(1) Pharmaceutical		(2) Communications Equip.		t-test	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.	Mean	*p*-value
R&D Disclosure$_{t-1}$	-0.07***	0.11	0.16***	0.12	(1)-(2)≠0	0.0000
Early-stage R&D Disclosure$_{t-1}$	-0.04***	0.18	0.15***	0.15	(1)-(2)≠0	0.0000
Research R&D Disclosure$_{t-1}$	-0.11***	0.21	0.16***	0.23	(1)-(2)≠0	0.0000

(1) 1,283 firm years, 139 firms
(2) 847 firm years, 96 firms

Overall, these results are consistent with firms in an industry with strong patent protection having greater strategic incentives to disclose technological advantages as these firms face lower risk of competitive imitation. Accordingly, competitors are less likely to develop and patent innovations in the same technology areas. However, in an industry with relatively weak patent protection competitors are more likely to engage in head to head competition as imitation costs (i.e., stemming from legal penalties associated with replicating a firm's technologies) would be lower in this context.

To test hypothesis 2, the moderating effect of firm-specific technological strength on competitors' patent applications in the same technology space is estimated in two ways: self-citation ratio and patent applications, respectively, as measures of firm-specific appropriability to assess whether firms with stronger technological capabilities exhibit differential effects of R&D disclosure on competitors' patenting efforts from firms with relative weaker capabilities. First, the sample was split into two groups based on firms' own patenting efforts: (1) firms that actively file new patent applications and (2) firms that do not file patent applications. Second, additional analyses were conducted based on firms' citing of their owned patents: (1) firms that cite their owned patents in patent applications and (2) firms that do not cite their owned patents. Table 5 presents these results for pharmaceutical firms. Panel A presents results comparing subsamples based on pharmaceutical firms' own patenting efforts versus firms that do not have patent applications. Panel B replicates this analysis for subsamples of pharmaceutical firms that cite their owned patents versus firms that do not. Table 6 replicates the analysis in Table 5 on communications equipment firms.

TABLE 5
PHARMACEUTICAL INDUSTRY COMPARISON OF FIXED-EFFECTS POISSON REGRESSION COEFFICIENTS

Panel A – By Number of Patent Applications

	(1) Patent Applications>0		(2) Patent Applications=0		t-test	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.	Mean	*p*-value
R&D Disclosure$_{t-1}$	-0.09***	0.08	-0.03	0.61	(1)-(2)≠0	0.0937
Early-stage R&D Disclosure$_{t-1}$	-0.07***	0.14	0.89***	1.64	(1)-(2)≠0	0.0000
Research R&D Disclosure$_{t-1}$	-0.17***	0.18	1.25***	1.80	(1)-(2)≠0	0.0000

(1) 866 firm years, 121 firms
(2) 294 firm years, 59 firms

Panel B – By Self-citation Ratio

	(1) Self-citation Ratio>0		(2) Self-citation Ratio=0		t-test	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.	Mean	*p*-value
R&D Disclosure$_{t-1}$	-0.05***	0.07	-0.16***	0.36	(1)-(2)≠0	0.0000
Early-stage R&D Disclosure$_{t-1}$	-0.06***	0.12	0.25***	0.61	(1)-(2)≠0	0.0000
Research R&D Disclosure$_{t-1}$	-0.11***	0.14	0.11***	0.78	(1)-(2)≠0	0.0000

(1) 567 firm years, 87 firms
(2) 629 firm years, 105 firm

TABLE 6
COMMUNICATIONS EQUIPMENT INDUSTRY COMPARISON OF FIXED-EFFECTS POISSON REGRESSION COEFFICIENTS

Panel A – By Number of Patent Applications

	(1) Patent Applications>0		(2) Patent Applications=0		t-test	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.	Mean	*p*-value
R&D Disclosure$_{t-1}$	0.10***	0.08	-1.59***	9.51	(1)-(2)≠0	0.0061
Early-stage R&D Disclosure$_{t-1}$	0.09***	0.09	-11.88	5774.44	(1)-(2)≠0	0.9743
Research R&D Disclosure$_{t-1}$	0.09***	0.16	-12.58	13076.83	(1)-(2)≠0	0.9880

(1) 477 firm years, 72 firms
(2) 242 firm years, 44 firms

Panel B – By Self-citation Ratio

	(1) Self-citation Ratio>0		(2) Self-citation Ratio=0		t-test	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.	Mean	*p*-value
R&D Disclosure$_{t-1}$	0.10***	0.06	-0.20	4.10	(1)-(2)≠0	0.1247
Early-stage R&D Disclosure$_{t-1}$	0.10***	0.07	0.46	10.81	(1)-(2)≠0	0.4842
Research R&D Disclosure$_{t-1}$	0.12***	0.13	-0.89	16.11	(1)-(2)≠0	0.1882

(1) 315 firm years, 59 firms
(2) 442 firm years, 66 firm

Turning to the results for pharmaceutical firms in Table 5, panel A shows firms that actively file patent applications indicate a negative association between different types of R&D disclosure and competitors' patenting in the same technology areas. However, for firms that have no patent applications, we observe a positive association between disclosure and competitors' patenting. Taken together, these results are consistent with firm-specific technological strength driving this relationship. Similarly, the analysis in panel B contrasting pharmaceutical firms that cite their owned patents with those that do not yields consistent results. The results of t-test indicate that the coefficients on different types of R&D disclosures are significantly different from zero, providing strong support for hypothesis 2.

The results for communications equipment firms are notably different from pharmaceutical firms. Panel A in Table 6 compares the results for firms actively file patent applications with those that do not. The results for firms with patent applications greater than zero indicate a positive association between R&D disclosure and competitors' patent applications. Panel B replicates this analysis of firms that cite their owned patents versus firms that do not and yields similar results. These results are consistent with arguments supporting a weak industry IP regime making disclosing firms more vulnerable to competitors' patenting even in the presence of firm-specific technological strength. Interestingly, for firms that do not have patent applications or do not cite their owned patents, the results are not significant. The next section discusses the implications of these findings.

DISCUSSION AND CONCLUSION

This study investigates the influence of voluntary public R&D disclosures on competitors' patenting in the same technology areas. The results show that R&D disclosures by pharmaceutical firms have a negative association with competitive patenting while disclosures from communications equipment firms have a positive association. These findings are consistent with industry IP strength driving the negative association between R&D disclosure and competitors' patenting strategies. Further analysis of how firm-specific technological capabilities moderate the effect of disclosure on competitors' patenting demonstrates evidence of firm-specific advantages negatively influencing competitors' patenting efforts. Overall, the results for pharmaceutical firms demonstrate that firm technological capabilities are an important influence on competitors' efforts to innovate in the same technology space. Further, the results demonstrate that these firm-specific advantages are distinct from industry advantages. Otherwise, if industry advantage was driving the association between disclosure and competitive patenting, we would expect to find a consistent negative effect of disclosure across all subsamples of pharmaceutical firms.

In the communications equipment subsample, the results for firms that cite their owned patents show a positive and significant association between disclosure and competitors' patenting, suggesting that industry advantages moderate this relationship. The non-significant results in the subsample of firms that do not cite their owned patents provide inconclusive evidence of industry level effects. On the one hand,

if weak industry patent protection was driving the association between disclosure and competitive patenting, then we would expect to observe a consistent significant positive effect of disclosure on competitors' patenting activity. On the other hand, the non-significant results in the subsample of firms that do not have patent applications or cite their owned patents might lead us to conclude that public disclosures have no effect at all on competitors' patenting strategies.

One alternative explanation might be that in industries with relatively weak IP regimes firms tend to defensively patent innovations for future use as bargaining chips in cross-licensing or other cooperative negotiations (Cohen et al., 2000; Grindley & Teece, 1997; Rothaermel, 2001). Another alternative is firms disclose their R&D accomplishments to encourage other firms to patent complementary technologies which are necessary to commercialize innovations (Harhoff et al., 2003; Spencer, 2003). Taken together, the results of this study highlight the importance of both industry and firm-specific appropriability advantages. These findings have important implications for technology strategy literature, which examines mechanisms firm use to capture value from their innovations (Cohen et al., 2002; Cohen et al., 2000; James et al., 2013; Levin et al., 1987) as well as work on new product development (insert cites).

This work contributes to strategy research on how firms achieve and sustain competitive advantages (Barney, 1991; Peteraf, 1993; Porter, 1985), in general, and how firms capture value from their technological competitive advantages (James et al., 2013; Somaya, 2012), in particular. The extent to which firms have costly-to-imitate resources depends on rivals' ability to develop these resources internally or to acquire them in strategic factor markets, and information acquisition costs influence this ability (Makadok & Barney, 2001). Voluntary public disclosures reduce information uncertainty and as a result lower competitors' information acquisition costs. The current study complements this research by demonstrating that firms can not only increase their competitive advantage by developing costly-to-imitate product innovations, but also by deterring competitors from patenting similar product innovations in the same technology space (Polidoro Jr. & Theeke, 2012; Polidoro Jr. & Toh, 2011). Future studies that explore other competitive effects of disclosure will provide further insights on how firms can effectively manage the tradeoff between secrecy and disclosure in different contexts to capture value from innovation.

Managerial Implications

This study offers important insights for strategic managers. For managers in firms that have a strong technological advantage, publicly disclosing R&D successes may increase their ability to profit from product innovations while also mitigating imitation risk. This insight is contrary to conventional wisdom within some firms that never publicly disclose ahead of commercializing an innovation despite their competitive advantages. The results of this study suggest that in some cases strategic public disclosure of a firm's technological strengths might deter competitive entry into the same technology space.

For managers in firms that do not possess technological advantages, this study confirms that keeping intermediate R&D successes secret may be a more effective mechanism for protecting profits from innovation. In such cases, the profit-maximizing strategy is to disclose product innovations only around the timing of launching new products in order to capture value innovations without enabling competitors to appropriate this value (Bayus, Jain, & Rao, 2001; Dranove & Gandal, 2003; Haan, 2003).

ENDNOTE

1. Research in Motion corporate press release dated March 3, 2006. http://press.rim.com/release.jsp?id=981

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