Deterrent Disclosure

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ABSTRACT: We examine how product market competition affects the disclosure of innovation. Theory posits that product market competition can cause firms to increase their disclosure of innovation to deter competitors. Consistent with this reasoning, we find that patent applicants in more competitive industries voluntarily accelerate their patent disclosures, which are credibly disclosed via the United States Patent and Trademark Office. Our inferences are robust to using changes in industry-level import tariffs as sources of plausibly exogenous variation in product market competition in a differences-in-differences design. Consistent with patent disclosures successfully deterring product market competitors, we find that timelier patent disclosures are more strongly associated with declines in the similarity of competitors' products than are less timely patent disclosures. In total, our results suggest that product market competition increases patent disclosure, which is consistent with firms using the disclosure of innovation to deter product market competition.

Keywords: Voluntary disclosure, innovation, patents, competition

JEL classification: D23, G38, O30, O31, O33, O34, O38

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1. Introduction

We examine how product market competition affects the voluntary disclosure of innovation. Prior work posits that product market competition discourages the voluntary disclosure of good news because disclosure can reveal proprietary information to competitors.[1] However, such reasoning may not apply to the disclosure of partially excludable innovations. Innovations provide firms with an efficiency or product market advantage over their product market competitors, and partial excludability allows them to protect this advantage. Consequently, theory posits that product market competition can increase, rather than decrease, the disclosure of innovation.[2] Therefore, our goal is not to examine the standard predictions about competition and disclosure through the lens of innovation. Instead, our goal is to examine a distinct theoretical prediction about the effect of product market competition on the disclosure of innovation.

To do so, we examine 206,636 successful patent applications filed by public firms with the U.S. Patent and Trademark Office (USPTO). All patent applications filed with the USPTO include a detailed description of how to recreate the innovation independently of the inventor. The USPTO publishes patent applications after a deadline of 18 months or more. However, applicants can choose to have their applications published by the USPTO prior to the publication deadline, credibly disclosing their innovation on a centralized repository monitored by competitors and investors.[3] We examine how product market competition affects this timing choice by comparing

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[1] Analytical studies include Verrecchia, 1983; Dye, 1985; Dye, 1986; Wagenhofer, 1990; Feltham, Gigler, and Hughes, 1992; and Feltham and Xie, 1992. Empirical studies include Harris, 1998; Botosan and Stanford, 2005; Rogers and Stocken, 2005; Verrecchia and Weber, 2006; Dedman and Lennox, 2009; Li, 2010; Bens, Berger, and Monahan, 2011; Ellis, Fee, and Thomas, 2012; Ali, Klasa, and Yeung, 2014; Huang, Jennings, and Yu, 2017; and Christensen, Liu, and Maffett, 2019.

[2] Smiley, 1988; Baker and Mezzetti, 2005; Jansen, 2005, 2011; Hughes and Pae, 2015.

[3] See, for example, Brown and Arshem (1993), Boulakia (2001), Kogan et al. (2017), and Martens (2019). Brown and Arshem (1993) finds that 17% of visitors to Patent and Trademark Depository Libraries from 1991-92 used the patent information for legal, product, and market research, while 6% used the information for economic research. Boulakia (2001) describes the process of patent mapping by companies such as AT&T, IBM, and Lucent. Patent mapping allows

applications filed by applicants facing different levels of product market competition (i.e., the unit of analysis is the patent application). Our focus on the timing of disclosure mirrors prior studies that examine manager earnings forecasts, which accelerate the disclosure of earnings information from the 10-K release date to the disclosure date.

Patent applications have several advantages as a setting to examine our research question. First, our data include the application date, the disclosure date, and the mandatory disclosure deadline for all patent applications. Because this information is revealed *ex post,* we are able to observe in-process applications that were not publicly disclosed at the time. This permits us to compare disclosing and nondisclosing applicants when assessing the costs and benefits of disclosure. Second, each observation in our sample is a *successful* patent application, meaning that every applicant in our sample has successfully innovated and chosen to protect that innovation with a patent. Therefore, we are able to isolate applicants' disclosure decisions from the underlying economics of successfully innovating and choosing to protect that innovation with a patent. Third, patent examiners review patent applications for novelty and accuracy, and patent protections extend only to information disclosed in the application. When disclosed, patent applications are published by the USPTO on the USPTO website. Consequently, patent disclosures represent highly credible disclosures (Long, 2002). Fourth, patents provide the right to exclude others from using the innovation. Therefore, patents match the theoretical assumption of excludability.

The final benefit of examining patenting applications is that doing so allows us to separate technological competition, or knowledge spillovers, from product market competition. Although technological and product market competition are correlated, they are distinct concepts.[4] Whereas

the CEOs and VPs of these companies to "identify…future competitive threats" and "competitors that [they] didn't know existed yet."

[4] Bloom, Schankerman, and Van Reenen, 2013; Cao, Ma, Tucker, and Wan, 2018; Bloom, Lucking, and Van Reenen, 2018; Ettredge, Guo, Lisic, and Tseng, 2019.

technological competition is the competitive pursuit of new ideas and ways of doing things, product market competition is the competitive pursuit of users or consumer spending. For example, Apple and Intel are technological competitors as evidenced by their similar patenting activity, but are not product market competitors because Apple does not compete with Intel in the semiconductor product market. In contrast, Apple and Nokia are product market competitors in the smartphone product market. Theory suggests that product market competition will increase the disclosure of innovation, but technological competition will decrease the disclosure of competition.

We use several features of the patent application setting to separate the effects of technological competition from the effects of product market competition. First, we follow Bloom et al. (2013) and Bloom et al. (2018) to construct a measure of technological competition based on competitors' total R&D spending and comparative patenting activity across patent classes. Second, we construct a vector of patent class-by-year fixed effects as a control for spillovers within patent classes. Third, we directly measure realized knowledge spillovers using the citations a patent receives. We include these fixed effects and measures of technological competition as controls throughout our analyses. Although our focus is on the effects of product market competition, we anticipate and find that patent disclosure timeliness is decreasing in the degree of technological competition. The negative relation between patent disclosure timeliness and technological competition is consistent with a cost of patent disclosure being the risk of revealing enabling information to technological competitors.[5]

[5] Cao et al., 2018; Kim, 2018; and Valentine, 2018. James (2014) finds that public R&D disclosures by communications equipment firms positively relate to competitors' patenting activity and that public R&D disclosures by pharmaceutical firms negatively relate to competitors' patenting activity.

In our first set of analyses, we measure product market competition using industry concentration (U.S. Department of Justice and Federal Trade Commission, 1993).[6] We find that firms in less concentrated industries accelerate their patent disclosures by more, consistent with product market competition encouraging the disclosure of innovation. The elasticity of disclosure delays to industry concentration is 0.26%. This elasticity is economically significant; it implies that a one standard deviation increase from the mean of industry concentration results in slightly more than three additional months until patent disclosure. However, we note an important caveat to these findings. The models that motivate our analysis suggest that firms use patent disclosures to affect product market competition, implying the correlation between the two is potentially endogenous. To address this potential endogeneity, we examine the effects of lagged product market competition in our analyses.

We further address the potential endogeneity of the relation between product market competition and patent disclosure by using changes in import tariffs across different industries at different times as a source of variation in product market competition in a differences-in-differences design (e.g., Fresard, 2010; Huang, Jennings, and Yu, 2017). The intuition for this approach is that increases (decreases) in the tariff rate represent decreases (increases) in competition from foreign competitors that is otherwise plausibly exogenous with respect to patent disclosure. Consistent with our predictions, we find that changes in tariff rates are negatively related to changes in patent disclosure timeliness (e.g., increases in tariff rates lead to longer delays until the publication of a patent application). Because tariff rate changes reflect a dimension of product market competition distinct from industry concentration, these findings also increase

[6] Studies of voluntary disclosure that use industry concentration to measure product market competition include Bamber and Cheon, 1998; Botosan and Stanford, 2005; Verrecchia and Weber, 2006; and Berger and Hann, 2007.

confidence that our inferences are not due to any one dimension of product market competition (e.g., Ali et al., 2014; Lang and Sul, 2014).

We conduct two additional tests to assess the validity of the inferences we draw from our differences-in-differences design. First, we conduct a parallel trends test by examining whether firms affected by changes in tariff rates differentially change their disclosure behavior prior to the change in tariff rates. We find no evidence that firms respond to changes in tariff rates prior to the change, i.e., "treatment" and "control" firms exhibit parallel pre-treatment trends. Second, we separately examine tariff rate increases and decreases. If firm lobbying drives our results, we expect our findings to be solely attributable to tariff increases because firms are unlikely to lobby for decreased tariffs on foreign competition in the same industry. We find that both increases and decreases in the tariff rate affect firm disclosure and to approximately the same degree, which suggests that lobbying is not the source of our findings. Collectively, our differences-in-differences results suggest that changes in product market competition cause changes in the disclosure of innovation.

Next, we examine the relation between an alternative text-based measure of product market competition and the disclosure of innovation. We measure competition using managers' perceptions of competition, as measured by Li, Lundholm, and Minnis (2012), and find that this measure is also negatively related to patent disclosure delays. In total, we find evidence that product market competition leads to timelier patent disclosure across multiple distinct measures of product market competition.

We acknowledge that firms might respond to product market competition by providing timelier disclosure of innovation for reasons other than a desire to deter product market competitors. In particular, firms may wish to license their innovations to product market competitors, and use patent disclosures to advertise ("royalty seeking"). Royalty seeking represents an alternative mechanism through which product market competition could affect patent disclosure, but does not alter our main finding of a positive relation between product market competition and patent disclosure. Nonetheless, we conduct a test to determine whether deterrence or royalty seeking is primarily responsible for the positive relation between product market competition and patent disclosure.

We anticipate that royalty seeking will result in firms licensing their innovations to their competitors, leading to increased similarity between the firm's products and those of their competitors. In contrast, deterrence will cause competitors to avoid the firm's product space, leading to decreased similarity between the firm's products and those of their competitors. Consistent with deterrence primarily causing the positive relation between product market competition and patent disclosure, we find that timelier patent disclosure is associated with decreases in the similarity between the firm's products and those of their competitors (Hoberg and Phillips, 2010, 2016).

We also extend our main results by examining several auxiliary predictions. We predict that firms will rely less on costly patent disclosures when other methods of communicating a forthcoming product market advantage are more credible. Consistent with this prediction, we find that the relation between product market competition and patent disclosure timeliness is stronger when the firm's information environment is lower quality. We also show that our inferences are robust to excluding industries potentially regulated by the Food and Drug Administration (FDA).

Our work contributes to the literature on voluntary disclosure by documenting evidence that product market competition is associated with an increase in the timeliness of patent disclosure. In this regard, we also build on the literature that examines how firms respond to the threat of product market predation. For example, Bernard (2016) finds that firms avoid disclosures that could invite predation by product market rivals. In contrast, we find that firms use patent disclosures to discourage competition from product market rivals, which is consistent with firms "weaponizing" the disclosure of innovation in the face of competition (Ordover and Willig, 1981; Bloomfield, 2018; Bloomfield and Tuijn, 2018). Therefore, whereas Bernard (2016) finds evidence that certain disclosures represent a liability in the face of competition, we document the opposite for patent disclosures. Our focus on patent disclosures also answers the call of Leuz and Wysocki (2016) for more research on nontraditional disclosures.

We also contribute to a growing literature that examines how firms trade off different types of disclosures (e.g., Glaeser, 2018; Heinle, Samuels, and Taylor, 2018). In this regard, prior work that documents a positive effect of competition on voluntary disclosure, in particular Huang et al. (2016), is important. Huang et al. (2016) finds that product market competition, as measured by tariff changes, decreases the quantity of voluntary earnings forecasts. In contrast, we find that product market competition, as measured by tariff changes, increases the timeliness of patent disclosure. Together, our results highlight how the same economic force can affect different disclosures in very different ways, and suggest that both competition and disclosure are multidimensional constructs (Bloom et al., 2013; Cao et al., 2018).

Our finding that firms accelerate patent disclosures in the face of product market competition also has potential policy implications. Most international patent offices enforce a patent application disclosure deadline of 18-months after initial filing. The USPTO enforces a deadline of 18-months for applications seeking foreign protection and publishes all other applications on the decision date (an average of 34 months after initial filing in our sample). The Tegernsee Heads, which consists of the heads of offices of and experts from the USPTO, the Japan

Patent Office, the European Patent Office, and the patent offices of the UK, Denmark, Germany and France, describe the policy considerations underlying the 18-month deadline for patent disclosure:

> "There are many policy considerations that underlie this balance. One such policy is to ensure that third party competitors have timely notice of new developments, so they can make informed decisions about, e.g., whether to continue pursuing a similar technology, or designing around the subject matter disclosed in the application. This, in turn, promotes a more effective allocation of research investments and a corresponding reduction in costly and time consuming litigation. Another underlying policy is to allow the inventor to make a suitably informed decision whether to continue seeking patent protection or to keep the information as a possible trade secret. 18-month publication also increases the efficiency of allocating patent rights by enabling an early assessment of prior art with respect to conflicting applications."
> -Tegernsee Experts Group study on 18-month Publication (2012).

The Tegernsee Experts Group's discussion suggests that regulators balance the cost to individual inventors of revealing enabling information against the positive externalities of patent disclosure when setting patent disclosure deadlines. Our work can help inform regulators' calculus by shedding light on when and why firms voluntarily accelerate their patent disclosures. This calculus has efficiency implications; the positive externalities of disclosed innovations are the central driver of growth in developed economies (e.g., Solow, 1957; Romer, 1990; Hall, Mairesse, and Mohnen, 2010). The positive externalities of disclosed innovations suggests our focus on patent disclosures also answers the call of Leuz and Wysocki (2016) for more research examining nontraditional reporting settings that involve real effects of disclosure.

We organize the rest of the paper as follows. We provide background information on patenting, disclosure theory, and prior work in Section 2. We describe our research design in Section 3 and discuss our sample, data sources, and variable measurement in Section 4. We present results in Section 5 and provide concluding remarks in Section 6.

2. Background and theoretical predictions

2.1 Patenting and patent disclosure

Patents provide the right to exclude others from the production or use of a novel device, process, apparatus, formula, or algorithm for a specified period.[7] Patent offices issue patents to inventors after a patent examiner verifies the novelty and potential utility of the claimed item. Patent examiners frequently make requests to amend or revise the application, to which the applicant must either comply or object within six months. The applicant may also revise their beliefs about the application's odds of success based on communication with the examiner. Patent examinations can be quite lengthy: an average of 34 months in our sample, with the longest examination lasting almost ten years.

The inventor can transfer or license the right embedded in the patent, usually to their employer, and can enforce the right only by the threat of, or an actual suit for, infringement damages or an injunction. The stated purpose of the patent system is to encourage invention and economic progress by providing inventors temporary monopoly rights in exchange for a public disclosure of how to recreate the innovation (e.g., Article 1, Section 8, Clause 8 of the U.S. Constitution).[8] The USPTO requires applicants to publish their application within 18-months of filing if they also file overseas and by the decision date otherwise. Publication does not leave the inventor exposed without recourse. Inventors can seek reasonable royalties for infringement that occurred between publication and grant if the application is successful (35 U.S.C. § 154(d)).[9]

[7] This period is 20 years from the application filing date for U.S. utility patents and 14 years from the grant date for U.S. design patents.

[8] "[The Congress shall have power] to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

[9] However, we note that such rights are "rarely asserted or granted" (Dowd and Crotty, 2016) and "highly unusual" (Millemann, 2016).

When inventors disclose their proprietary knowledge has efficiency implications. Innovation is the central driver of growth in developed economies (e.g., Solow, 1957). Innovation contributes to growth because innovations are non-rival and produce technological spillovers, which increase the productivity and innovative ability of others (e.g., Romer, 1990; Bloom et al., 2013). More timely disclosure increases the speed of technological progress by allowing others to begin building on the inventor's discovery sooner. Similarly, more timely disclosure reduces the potential for inefficient duplication of research efforts. However, disclosure is costly for the innovator because other inventors can use the disclosed information in conjunction with their own research efforts to surpass the patented innovation in quality, or to invent around the patent.[10] Consequently, some inventors view patent disclosures as the "greatest constraint on the effectiveness of patents" (Harabi, 1995).

2.2 Competition and disclosure theory

Early models of voluntary disclosure posit that informed managers voluntarily reveal their private information to avoid investors assuming the worst about the firm's prospects (Grossman and Hart, 1980; Grossman, 1981; and Milgrom, 1981). Verrecchia (1983) observes that full disclosure is rare, and shows that disclosure costs can theoretically prevent full disclosure. Verrecchia (1983) contends that one such disclosure cost is the cost of revealing proprietary information to competitors. Subsequent authors extend this line of reasoning in various directions, and generally find that competition impedes voluntary disclosure (see Verrecchia, 2001 for a review). However, Hughes and Pae (2015) suggests that this finding does not necessarily extend to the disclosure of innovation.

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[10] See, e.g., Horstmann, MacDonald, and Slivinski, 1985; Grossman and Helpman, 1991; Scotchmer, 1991; O'Donoghue, 1998; Anton and Yao, 2004; Saidi and Zaldokas, 2017; Glaeser, 2018; Glaeser, Michels, and Verrecchia, 2018.

Hughes and Pae (2015) presents a model in which an innovating firm has a choice of whether to disclose its innovation. Disclosing is costly because doing so creates knowledge spillovers that can allow technological competitors to partially free ride. However, disclosing can also be beneficial because communicating the innovating firm's advantage affects its product market competitors' pricing or production decisions. Conceptually, this deterrence can occur because the product market competitor knows they cannot replicate a patented product innovation or because they know a patented process innovation provides the disclosing firm a lower cost of production.

We illustrate the theoretical relation between technological competition and the disclosure of innovation and between product market competition and the disclosure of innovation in Figure 1. Other things equal, the greater the intensity of product market competition, the greater the benefit of communicating the innovating firm's advantage. In our empirical analysis, we hold the effect of technological competition fixed. Consequently, we expect the equilibrium degree of disclosure of innovation to increase in the intensity of product market competition (see also Baker and Mezzetti, 2005; Jansen 2005, 2011).

2.3 Case study

The case study of Henry Ford and the moving assembly line illustrates the notion that innovators may disclose their innovations to discourage competition.[11] The assembly line was an innovation that reduced the build time of Model T components by almost 90%. Traditional information economics and disclosure theory suggests that Ford would have kept the development

[11] Other examples include Microsoft's product preannouncements (e.g., United States v. Microsoft, Civil Action 94-1564) and IBM's disclosure of copper-dependent process in producing semi-conductors in place of aluminum (Harhoff, Henkel, and Hippel, 2003). Deterrent disclosure even occurs in the natural world: Thomson's gazelles use stotting as a credible, but costly, disclosure of their physical condition to deter predators (Fitzgibbon and Fanshawe, 1988).

of the assembly line a secret from competitors (e.g., Verrecchia, 2001; Hall, Helmers, Rogers, and Sena, 2014). Surprisingly, Ford instead aggressively informed competitors about the existence and efficiency of the assembly line (Arnold, 1914). Ford chose to do so, at least partially, to discourage competition by making competitors aware of his tremendous cost advantage.[12]

However, Ford was also cognizant of the potential costs of knowledge spillovers:

> "Henry Ford's contemporaries, many of whom were competitors, closely watched the doings at Highland Park, attempting to understand and emulate the revolutionary developments. Henry Ford encouraged their interest. Unlike the Singer Manufacturing Company, the Ford company was completely open about its organizational structure, its sales, and its production methods—at least after Henry Ford was satisfied that his company was on the road to mass production."
> -Hounshell (1985, pp. 260).

As technical journalist and Ford contemporary Fred H. Colvin wrote, "I was not permitted to write a line about the new shop until Ford was ready for it to be described in detail." Ford was likely unwilling to disclose the assembly line until he was sure that he could exclude competitors from his product market using a combination of lead-time and secrecy (Hall et al., 2014). Indeed, even over a decade later the closest price competitor to Ford was still almost 30% more expensive (Dalton, 1926).

In other words, a key feature of Ford's disclosure, and an implicit assumption of Jansen (2005) and Hughes and Pae (2015), is the presence of partial excludability in the form of lead-time, secrecy, or patent protections that prevents competitors from fully appropriating the innovation. A benefit of examining patent disclosures is that the excludability mechanism is apparent: patent protections legally preclude competitors from fully appropriating the innovation. An additional benefit of examining patent disclosures is that the costs of potentially revealing enabling information to technological competitors explains why all firms do not disclose, despite the potential benefits of disclosure.

[12] See Nevins and Hill, 1954; Hounshell, 1985; Anton and Yao, 2004; Hall et al., 2014.

2.4 *Prior empirical work*

A small, but nascent literature within accounting examines the disclosure of innovation. Guo, Lev, and Zhou (2004) examines the disclosure of information about 265 pharmaceutical products developed by 49 biotech companies issuing initial public offerings from 1995 to 1997. The study finds firms disclose more information about patentable products and when backed by venture capital. Using R&D disclosures for a sample of 117 firms in a single year, Jones (2007) finds that firms with lower historical performance disclose less about their R&D projects. Merkley (2014) finds that current earnings performance is negatively related to the quantity of narrative R&D disclosure. Plumlee, Xie, Yan, and Yu (2015) finds evidence that borrowers communicate private information about patent approvals to banks to obtain better loan terms. Cao et al. (2018) finds that technological competition is negatively related to product-development press releases. Glaeser (2018) finds that trade secrecy causes firms to redact proprietary information from their SEC filings. Chen, Tian, and Yu (2019) find that that trade secrecy by customers causes suppliers to redact information from their material contracts. Huang, Ng, Ranasinghe, and Zhang (2019) find that innovative firms release more voluntary manager earnings forecasts. We build on this literature by examining how product market competition affects patent disclosure.

In this regard, we also build on prior empirical studies that examine the relation between product market competition and disclosure. Broadly, this literature finds evidence of a negative relation or no relation between product market competition and disclosure (see Beyer, Cohen, Walther, and Lys, 2010 for a review). The weight of the evidence from this literature is consistent with product market competition discouraging disclosures that carry high proprietary costs with respect to competitors' actions (e.g., competition discourages good news earnings forecasts that might encourage competitors to increase production). However, this prior work does not examine the relation between product market competition and the disclosure of innovation.

Importantly, the relation between product market competition and the disclosure of innovation is theoretically distinct from the relation between product market competition and other disclosures (Hughes and Pae, 2015). Therefore, our goal is not to examine the standard predictions about disclosure and competition through the lens of patent disclosures. Instead, our goal is to examine a distinct theoretical prediction. Indeed, we find that product market competition causes an increase, rather than a decrease, in patent disclosure, as reflected by more timely voluntary disclosure. In this regard, our work is related to the literature that finds that product competition encourages the disclosure of bad news (e.g., Li, 2010; Burks, Cuny, Gerakos, and Granja, 2017; Tomy, 2018). Our study differs because we study a good news disclosure that discourages entry by signaling forthcoming product market strength, whereas this prior work studies bad news disclosures that discourage entry by signaling poor product market conditions.

The study most closely related to our own is a concurrent working paper, Bloomfield and Tuijn (2018), which finds product market competition encourages voluntary capacity expansion disclosures. The primary difference between Bloomfield and Tuijn (2018) and our work is that we study the disclosure of innovation, while Bloomfield and Tuijn (2018) studies capacity expansion disclosures. Whereas capacity expansion disclosures represent a credible commitment to aggressive production schedules, the disclosure of innovation represents a credible signal of forthcoming product market strength.

Our study is also conceptually related to the large literature on the determinants of innovation.[13] We differ from this literature in that we study determinants of *disclosing* innovation,

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[13] See, e.g., Aghion, Bloom, Blundell, Griffith, and Howitt, 2005; Lerner, Sorenson, and Stromberg, 2011; Hirshleifer, Low, and Teoh, 2012; Aghion, Van Reenen, and Zingales, 2013; Atanassov, 2013; He and Tian, 2013; Baranchuk,

conditional on the existence of innovation, whereas this literature studies the determinants of successfully innovating. Prior work posits that innovation produces positive externalities that drive growth (e.g., Solow, 1957; Romer, 1990; Hall et al., 2010). These externalities occur because the disclosure of innovation allows others to begin building on the innovation and because public (i.e., disclosed) knowledge is nonrival (Romer, 1990). Consequently, understanding both what determines the creation of innovation, and what determines the disclosure of those innovations, are jointly important to gaining a full understanding of the role innovation plays in growth.

3. Research design

3.1 Baseline model

Our baseline model compares the timing of voluntary disclosure by patent applicants facing different levels of product market competition:

$$\begin{aligned} \textit{Patent Disclosure Delay}_{i,j,t} = {} & \beta_{0,\mathrm{it}} + \beta_1 \textit{Product Market Competition}_{i,t\text{-}1} + \gamma' X_{i,t\text{-}d} + \eta' Y_{j,t} \\ & + \textit{IndustryFE} + \textit{FiscalYearFE} \\ & + \textit{PatentClass*ApplicationYearFE} + \varepsilon_{i,j,t}\,, \qquad (1) \end{aligned}$$

where *i* indexes patent applicants (i.e., *i* indexes individual firms), *j* indexes patent applications, and *t* indexes application years. All patent applicant variables are measured as of the most recent fiscal year prior to the patent application filing (the *t-d* subscript refers to the applicants' most recent fiscal year end prior to the patent filing). For example, for a firm with a December fiscal year-end filing an application on April 3, 2003, the patent applicant variables are measured as of December 31, 2002. *Patent Disclosure Delay* is one of two measures of the length of time the

Kieschnick, and Moussawi, 2014; Chemmanur, Loutskina, and Tian, 2014; Fang, Tian, and Tice, 2014; Hsu, Tian, and Xu, 2014; Seru, 2014; Tian and Wang, 2014; Cornaggia, Mao, Tian, and Wolfe, 2015; Brav, Jiang, Hsu, and Xi, 2016; Acharya and Xu, 2017; Agarwal, Vashishtha, and Venkatachalam, 2017; Balsmeier, Fleming, and Manso, 2017; Breuer, Leuz, and Vanhaverbeke, 2019; and Tsang, Wang, and Zhu, 2019.

applicant delays disclosure, which we describe in section 4. *Product Market Competition* is one of several measures of product market competition, which we also describe in section 4. Based on our discussion in section 2.2, we predict that product market competition will lead to more timely patent disclosure ($\beta_1 < 0$).

X is a vector of the following time-varying patent applicant controls. *External Capital Dependence* is capital expenditures plus R&D expenditures minus operating activities net cash flow, divided by capital expenditures plus R&D expenditures (Rajan and Zingales, 1998). We expect firms more reliant on external capital to delay their patent disclosures by less, because credibly disclosing that the firm has an innovation in the patent process can reduce the cost of external capital (Balakrishnan, Billings, Kelly, and Ljungqvist, 2014). *Blockholders* is the number of shareholders listed on Thomson-Reuters with 5% or more ownership of the firm. We expect firms with more blockholders to delay patent disclosure to a greater degree because blockholders can communicate privately with managers. Consequently, managers can communicate patent applications privately to blockholders without having to rely on public disclosure.

We also include the following patent applicant controls drawn from the prior literature on innovation and disclosure (e.g., Glaeser, 2018). *Leverage* is the book value of total debt, divided by the book value of total assets plus the book value of total debt. Ln(*Equity Market Value*) is the natural logarithm of the market value of the firm's equity. *Loss* is an indicator equal to one if net income is negative. *Market to Book* is the ratio of the market value of assets to the book value of assets. *R&D* is R&D expenditures scaled by total assets. Missing values of R&D are replaced with zeroes. *Missing R&D* is an indicator set equal to one if data on R&D expenditures is missing (Koh and Reeb, 2015). *Return* is buy and hold return over the prior fiscal year. *Return on Assets* is income before extraordinary items scaled by the book value of assets. Sigma*(Returns*) is the standard deviation of monthly returns. We make no predictions regarding the coefficients on these control variables.

We include several variables as controls for technological competition to isolate the effect of product market competition. First, we include actual knowledge spillovers, ln(*Technological Competition 1*), in the vector of patent application controls, *Y*. Ln(*Technological Competition 1*) is the natural logarithm of one plus the number of citations the patent receives. We exclude applications filed in the last three years of the patent database and include time-period fixed effects in all tests to address potential truncation bias in patent citations (Hall, Jaffe, Trajtenberg, 2001).[14]

Second, we include *Technological Competition 2* in the vector *X*. Bloom et al. (2018) calculates *Technological Competition 2* as the potential knowledge spillovers from patenting activity.[15] Bloom et al. (2018) first calculates the Jaffe (1986) measure of technological proximity:

$$Technological\ Proximity_{i,j} = \frac{(T_i T_j')}{(T_i T_i')^{1/2}(T_j T_j')^{1/2}},$$

where T is the vector of firm i or j's share of patenting activity across each of the 426 patent classes over the period 1970 to 2006. *Technological Proximity* measures the degree of technological overlap between two firms and ranges from 0 to 1. *Technological Competition 2* is the pool of potential knowledge spillovers for firm i in year t:

$$Technological\ Competition_{i,t} = \sum_{j \neq i} Technological\ Proximity_{i,j} \times R\&D\ Stock_{j,t}$$

[14] Patent citations involve potential truncation bias because they are a forward-looking measure (e.g., a patent filed in the final year of the database will have received relatively few citations). Hall et al. (2001) find that most citations are received in the first three years of the patent's life and recommend excluding the final three years of the patent database to address potential truncation bias.
[15] We thank the authors of Bloom et al. (2013) and Bloom et al. (2018) for making the data publicly available on Nicholas Bloom's website: https://people.stanford.edu/nbloom/.

R&D Stock is calculated from current and historical R&D spending using the perpetual inventory method assuming a 15% depreciation rate (Hall, Jaffe, Trajtenberg, 2005). We divide *Technological Competition 2* by 100,000 to ease interpretation.

We expect firms to delay their patent disclosures more when technological competition is more intense, i.e., we predict a positive relation between *Patent Disclosure Delay* and both *Technological Competition 2* and ln(*Technological Competition 1*). Second, we include a vector of indicators for each patent class in each application year (*PatentClass*ApplicationYearFE*). Consequently, our tests compare patent applications filed in the same patent class in the same year. Therefore, these indicators act as controls for all knowledge spillovers that are common within patent classes.

Finally, we include *Foreign Protection* in the vector *Y*. *Foreign Protection* is an indicator that equals one if the applicant also applies for patent protections overseas, as identified by the OECD patent family database.[16] We make no prediction regarding the coefficient on this control variable. We cluster standard errors in all analyses by date to mitigate potential cross sectional dependence, and by industry to mitigate potential serial dependence within industries and firms.

3.2 Differences-in-differences model

Eq. (1) measures the relation between competition in the most recent prior fiscal year and patent disclosure delays. A potential concern with interpreting the delay in patent disclosure as the causal effect of product market competition is that Hughes and Pae (2015) contend firms use patent disclosure to affect competition. Hence, the relation between the two may be endogenous. We attempt to address this concern directly in Eq. (1) by using measures of competition that precede firms' disclosure choices. Nonetheless, we use an additional approach to address potential

[16] https://data.oecd.org/rd/triadic-patent-families.htm. The database includes triadic patent families (i.e., patents filed with the USPTO, European Patent Office, and Japanese Patent Office).

endogeneity concerns. Specifically, we estimate the following generalized differences-in-differences specification:

$$Patent\ Disclosure\ Delay_{i,j,t} = \beta_{0,it} + \beta_1 \ln(1\text{-}Tariff\ Rate_{i,t}) + \gamma' X_{i,t-d} + \eta' Y_{j,t} + FirmFE + FiscalYearFE + PatentClass{*}ApplicationYearFE + \varepsilon_{i,j,t} \quad (2)$$

Eq. (2) is identical to Eq. (1), except that we replace *IndustryFE* with *FirmFE* and replace *Product Market Competition* with ln(*1-Tariff Rate*).

Tariff Rate corresponds to the fraction of the pre-tariff value of goods that importers retain. We examine *1-Tariff Rate*, rather than *Tariff Rate* so that we can take the natural logarithm. The inclusion of *FirmFE*s mean that Eq. (2) effectively estimates the relation between changes in ln(*1-Tariff Rate*) and changes in *Patent Disclosure Delay*. We follow Fresard (2010) and Huang et al. (2016) and interpret changes in tariff rates as a source of variation in product market competition that is plausibly exogenous with respect to patent disclosure delays.[17] The intuition for this approach is that tariffs are a significant trade barrier that reduce foreign competitors' potential profits in the domestic market. Because tariffs are levied on the value of the good, and not the profit on the good, even seemingly small increases in tariffs significantly discourage foreign competitors (Fresard, 2010).

The effect of changes in tariff rates can identify the *effect* of changes in competition only if the differences-in-differences assumptions, particularly the parallel trends assumption, are satisfied. Fresard (2010) and Huang et al. (2016) present logical reasons and statistical tests to support the parallel trends assumption. In addition, we explicitly test for evidence of pre-existing

[17] Fresard (2010) and Huang et al. (2016) examine an indicator for significant tariff rate decreases, whereas we use a continuous measure that reflects both increases and decreases in the tariff rate. In subsequent analyses we separate tariff decreases and increases and find similar results for both. However, we choose not to model the effect of tariffs using an indicator because we believe the continuous measure reflects more informative variation and is therefore more powerful in our setting.

differential trends around changes in tariff rates by estimating the following generalized differences-in-differences specification:

$$
\begin{aligned}
\textit{Patent Disclosure Delay}_{i,j,t} = {} & \beta_0 + \beta_1 \ln(\textit{1-Tariff Rate}_{i,t}) + \beta_2 \ln(\textit{1-Tariff Rate}_{i,t+1}) + \\
& B_3 \ln(\textit{1-Tariff Rate}_{i,t+2}) + \beta 4 \ln(\textit{1-Tariff Rate}_{i,t+3}) + \gamma' X_{i,t-d} + \\
& \eta' Y_{j,t} + \textit{FirmFE} + \textit{FiscalYearFE} + \\
& \textit{PatentClass*ApplicationYearFE} + \varepsilon_{i,j,t} \qquad (3)
\end{aligned}
$$

Eq. (3) is identical to Eq. (2), except that we include three leads of ln(*1-Tariff Rate*). The coefficient estimates on these leads measure the degree to which the disclosure policies of firms that experience a change in tariff rates in the future differ prior to the change. Statistically insignificant and economically small coefficient estimates would suggest that these firms did not behave differently prior to the change in the tariff rate, and would support the validity of the parallel trends assumption.

A potential concern with the parallel trends assumptions is that firms may lobby for tariff increases, and that firms more likely to withhold their patent disclosures are more likely to succeed in their lobbying efforts. This could be the case if American policymakers feel some American firms require or deserve tariff protections because their foreign competitors are willing to ignore or are otherwise unaffected by American patents. Firms facing competition from such foreign competitors would presumably be more willing to delay their patent disclosures to delay these foreign competitors from learning the nature of their innovations as long as possible. Although our use of time series variation in tariffs and disclosure should minimize this concern, we nonetheless conduct an additional test to alleviate this concern.

Specifically, we separately examine the effects of tariff rate increases and decreases. We anticipate that firms are unlikely to lobby to decrease competitors' tariff rates (while, e.g., Wal-mart might lobby to decrease tariffs on foreign-manufactured goods, domestic manufacturing firms are unlikely to do so). Consequently, we expect to find a greater relation between tariff increases and patent disclosure timeliness, than between tariff decreases and patent disclosure timeliness if lobbying is the source of the relation between patent disclosure delays and tariff rate changes. To test for a differential effect of tariff increases and decreases, we first begin with the following generalized differences-in-differences specification:

$$\textit{Patent Disclosure Delay}_{i,j,t} = \beta_0 + \beta_1 \textit{Tariff Rate}_{i,t} + \gamma' X_{i,t-d} + \eta' Y_{j,t} + \textit{FirmFE} + \textit{FiscalYearFE} + \textit{PatentClass*ApplicationYearFE} + \varepsilon_{i,j,t} \quad \text{(4a)}$$

Eq. (4a) is identical to Eq. (2) except that we replace ln(*1-Tariff Rate*) with $\textit{Tariff Rate}_i$. We then disaggregate $\textit{Tariff Rate}_{i,t}$ into the prior year's tariff rate, any increase since the prior year, and any decrease since the prior year:

$$\textit{Tariff Rate}_{i,t} = \textit{Tariff Rate}_{i,t-1} + \textit{Tariff Decrease}_{i,t} + \textit{Tariff Increase}_{i,t}$$

We then substitute the components of *Tariff Rate* into Eq. (4a), subtract each from one, and permit each component to have a separate coefficient. The resulting equation is given by Eq. (4b):

$$\textit{Patent Disclosure Delay}_{i,j,t} = \beta_0 + \beta_1(\textit{1-Tariff Rate}_{i,t-1}) + \beta_2(\textit{1-Tariff Decrease}_{i,t}) + \beta_3(\textit{1-Tariff Increase}_{i,t}) + \gamma' X_{i,t-d} + \eta' Y_{j,t} + \textit{FirmFE} + \textit{FiscalYearFE} + \textit{PatentClass*ApplicationYearFE} + \varepsilon_{i,j,t} \quad \text{(4b)}$$

Finally, we modify Eq. (4b) by taking the natural logarithms of our independent variables of interest:

$$\begin{aligned} \textit{Patent Disclosure Delay}_{i,j,t} = \beta_0 &+ \beta_1 \ln(\textit{1-Tariff Rate}_{i,t-1}) + \beta_2 \ln(\textit{1-Tariff Decrease}_{i,t}) \\ &+ \beta_3 \ln(\textit{1-Tariff Increase}_{i,t}) + \gamma' X_{i,t-d} + \eta' Y_{j,t} + \textit{FirmFE} \\ &+ \textit{FiscalYearFE} + \textit{PatentClass*ApplicationYearFE} \\ &+ \varepsilon_{i,j,t} \qquad (4c) \end{aligned}$$

We predict that β_2 and β_3 are statistically different from one another if lobbying explains the relation between patent disclosure delays and tariff rate changes.

A second assumption necessary for causal inference is the Stable Unit Treatment Value Assumption (SUTVA). SUTVA requires that the treatment status of one firm does not affect other firms' potential outcomes (see Glaeser and Guay, 2017 and Armstrong, Glaeser, and Huang, 2018 for discussions of SUTVA in the context of accounting research). In our setting, SUTVA requires that the decision by some firms to accelerate their patent applications in response to product market competition does not affect the patent disclosure decisions of other firms not exposed to the same level of competition.

SUTVA is often a concern in innovation studies because of the presence of knowledge spillovers. For example, knowledge spillovers imply that the patenting rates of treatment firms can affect the patenting rates of control firms (Glaeser, 2018). However, this is less of a concern in our setting because we do not examine patenting rates, but instead examine disclosure decisions conditional on filing a patent. Additionally, we include controls for technological competition, which can produce knowledge spillovers: (ln(*Technological Competition 1*), *Technological Competition 2*), and indicators for each patent class in each year (*PatentClass*ApplicationYearFE*), which should mitigate the influence of potential knowledge spillovers. In total, we expect SUTVA to be satisfied in our setting.

4. Sample and descriptive statistics

4.1 Sample

Our sample begins with all successful patent applications filed with the USPTO after the American Inventors Protection Act (AIPA) became effective on November 29, 2000.[18] We examine the post-AIPA period because of data constraints and because the AIPA introduces the 18-month disclosure deadline for applicants seeking foreign protection. We require non-missing data on all control variables and tariff rates in all tests. We follow Hall et al. (2001) and remove the final three years of the patent database, which ends in 2010, from the sample to address potential truncation bias resulting from patent applications appearing in the database only after they are granted. Our final sample consists of 206,636 patent applications filed between November 29, 2000 and December 31, 2006.

We focus on successful applications because unsuccessful applications may never be disclosed. It is unclear how to treat nondisclosure in our empirical tests, or whether unsuccessful and successful applications are comparable. Focusing on successful applications also allows us to isolate applicants' disclosure decisions from the underlying economics of successfully patenting. Nonetheless, it is unlikely that the exclusion of unsuccessful patent applications presents a serious sampling issue because the USPTO granted between 89% and 98% of applications each year of our sample period (Cotropia, Quillen, and Webster, 2014.

We also focus on patent applications made by public firms to ensure the necessary data to calculate controls and moderating variables. Consequently, our results may not generalize to the behavior of private applicants, abandoned patent applications, or unpatented innovations (Glaeser and Guay, 2017). However, we believe that our theoretical foundations

[18] We thank the authors of Kogan et al. (2017) for making this data available on Noah Stoffman's website: http://iu.box.com/patents.

should help assuage these concerns, and that public firms' successful patent disclosures are inherently interesting and economically important (e.g., Kogan et al., 2017, Kim, 2018, Valentine, 2018).

4.2 Disclosure measures

We use two measures of patent disclosure timeliness. Our focus on the timeliness of disclosure mirrors prior work that examines voluntary manager earnings forecasts (see Hirst et al., 2008 for a review). Earnings forecasts serve to accelerate earnings news from the 10-K release date to the forecast date. Similarly, voluntary patent disclosures serve to accelerate information about the existence and nature of innovations from the mandatory disclosure date to the voluntary disclosure date.

Both of our measures of patent disclosure timeliness reflect the degree to which applicants delay disclosure, and are therefore inverse measures of timeliness. The first is ln(*Days to Actual Disclosure*) which is calculated as the natural logarithm of the number of days between the patent application date and the date the USPTO publicly discloses the patent application (either at the request of the applicant or because the disclosure deadline passes). Figure 2 presents the frequency histogram of *Days to Actual Disclosure*. We include ln(*Days to Latest Possible Disclosure*) as a control when using ln(*Days to Actual Disclosure*) as the dependent variable. Ln(*Days to Latest Possible Disclosure*) is the natural logarithm of the number of days until the applicant must disclose its application.[19] Figure 3 presents the frequency histogram of *Days to Latest Possible Disclosure* .

Our second measure of the degree to which applicants delay disclosure is *Percentage Disclosure Delay*, which we calculate as *Days to Actual Disclosure* divided by *Days to Latest*

[19] The application disclosure deadline is 18-months in days for applications for which *Foreign Protection* equals one, and the number of days until application approval for all others.

Possible Disclosure. While applicants likely have some foresight regarding *Days to Latest Possible Disclosure*, this foresight is imperfect when the disclosure deadline is the decision date. For example, the USPTO provides data useful for estimating *Days to Latest Possible Disclosure*, such as the backlog of unexamined applications, but does not commit to a decision date.[20] As a result, *Percentage Disclosure Delay* likely measures disclosure decisions with error. However, any measurement error in *Percentage Disclosure Delay* is unlikely to be correlated with product market competition, and therefore only serves to attenuate our empirical estimates of the association between product market competition and disclosure timeliness.

Percentage Disclosure Delay ranges from zero to one and is increasing in the degree to which the firm delays disclosure (e.g., values of one suggest the firm delays disclosure as long as possible and discloses only when required to do so). Figure 4 presents the frequency histogram of *Percentage Disclosure Delay*. The histogram highlights that patent applicants wait until the mandatory deadline to disclose for slightly over 20% of patent applications. The histogram also highlights that there is a great deal of variation in when the firm discloses the remainder of applications.

4.3 Product market competition measures

We examine several measures of product market competition because our view is that there is no measure that perfectly encapsulates all dimension of product market competition (e.g., competition from foreign entrants, competition from potential entrants, etc.). We take the natural logarithm of our competition measures because we expect the effect of competition on patent disclosure to be proportional.

[20] https://www.uspto.gov/dashboards/patents/main.dashxml

Our first measure of product market competition, ln(*Product Market Competition*), is the natural logarithm of the Herfindahl-Hirschman Index of industry concentration, multiplied by negative one to ease interpretation. We calculate the Herfindahl-Hirschman Index as the sum of the squared market share of each publicly traded company in a particular four-digit SIC code in a given year. We calculate market share using the sales of a particular company divided by the total sales of the SIC code.

We use industry concentration as our first measure of product market competition because the U.S. Department of Justice and the Federal Trade Commission explicitly view increases in the Herfinahl-Hirschman Index as anti-competitive decreases in product market competition (U.S. Department of Justice and Federal Trade Commission, 2010). Nonetheless, industry concentration may measure the underlying construct of product market competition with error (e.g., Ali et al., 2014; Lang and Sul, 2014). Although no measure of product market competition is likely to be a perfect empirical measure of the underlying construct, we do not expect measurement error in industry concentration to relate endogenously to patent disclosure timing. Further, we examine several distinct measures of product market competition to ensure our results are not driven by the choice of any one measure.

We use changes in tariff rates as a second measure of product market competition. Tariff rates are also a source of plausibly exogenous variation in product market competition. We measure tariff rates using the ad valorem most favored nation tariff rate recorded by the United States International Trade Commission (USITC).[21] The USITC tracks tariff rates by harmonized tariff schedule eight-digit merchandise categories (HTS8 industries). We use the concordance developed by Pierce and Schott (2012) to average HTS8 industry tariffs at the

[21] Available at, e.g., https://www.usitc.gov/tariff_affairs/documents/tariff_data/tariff_database_2000.txt.

four-digit SIC level.[22,23] Figure 5 presents the frequency histogram of the 73,113 in-sample tariff rate changes that are non-zero. The histogram suggests that there is a great deal of variation in tariff rate changes, and that changes can be substantial. Because tariffs are levied on the value of the good, and not the seller's profits, even a 1% tariff substantially reduces importers' profit margins.

Finally, we use a third, text-based, measure of product market competition. The natural logarithm of the number of occurrences of competition-related words per 1,000 total words in the 10-K, or Ln(*Manager Perception of Competition*) (Li et al., 2012).[24]

4.4 Descriptive statistics

Table 1 presents sample descriptive statistics. In-sample applications must be disclosed an average of 949 days after filing. Applicants choose to accelerate their application on average; in-sample applications are disclosed an average of 446 days after filing. The mean of *Percentage Disclosure Delay* is 53%, suggesting applicants accelerate their disclosure by approximately half the possible delay. The standard deviation of *Percentage Disclosure Delay* is 30%, indicating that there is a great deal of variation in applicant disclosure choices (see also Figure 4). We identify 28% of applications as seeking foreign protection (i.e., where *Foreign Protection* = 1). Although we examine different samples, our 28% rate is similar to the 25% rate for domestic applicants in Johnson and Popp (2001), the 18.7% rate for litigated and matched applications in Graham and Harhoff (2014), and the 28.5%-43.4% for U.S. large inventors in different technology fields post-AIPA in Graham and Hegde (2015).

[22] We thank the authors of Pierce and Schott (2012) for making the data available on Peter Schott's website: http://faculty.som.yale.edu/peterschott/sub_international.htm.

[23] While foreign importers may be able to fully appropriate disclosed process innovations due to limited overseas protections, most patents protect product innovations that foreign importers cannot fully appropriate (see, e.g., Cohen, Nelson, and Walsh, 2000).

[24] We thank the authors of Li et al. (2012) for making these data publicly available on Feng Li's website: http://webuser.bus.umich.edu/feng/competition_sasdata.zip.

5. Results

5.1 Competition and patent disclosure delays

Table 2 presents the results of estimating Eq. (1) with ln(*Product Market Competition*) as our measure of product market competition. Columns (1) and (2) present findings using ln(*Days to Actual Disclosure*) and *Percentage Disclosure Delay* as the dependent variable. The results in column (1) suggest that a 1% increase in product market competition results in a 0.26% decrease in the time until patent disclosure (*t*-statistic = -2.74). This result suggests that a one standard deviation increase from the mean of industry concentration from the mean of industry concentration and disclosure results in 94.53 additional days until patent disclosure.[25] The results in column (2) suggest that a 1% decrease in product market competition results in a 0.12 percentage point decrease in the delay until disclosure (*t*-statistic = -2.76). Together, the results in Table 2 are consistent with increases in product market competition, as measured by decreases in industry concentration, resulting in decreases in patent disclosure delays.

Turning to the control variables for which we make predictions, the coefficient estimate on *Blockholders* in column (1) suggests that one additional blockholder is associated with a 9.4% greater delay until disclosure (*t*-statistic = 5.35).[26] The results in column (2) suggests that one additional blockholder is associated with a 4.3 percentage point increase in *Percentage Disclosure Delay* (*t*-statistic = 4.23). Together, these results are consistent with

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[25] .22/.27 * 0.26 * 446.2.

[26] The coefficient estimate of 0.09 refers to the natural logarithm of *Days to Actual Disclosure*, so that one additional blockholder is associated with a $100*(\exp^{0.09} – 1) = 9.4\%$ increase in *Days to Actual Disclosure*.

blockholders facilitating private communication and reducing the pressure from managers' career concerns to reveal publicly their innovative successes.

The coefficient estimate on *External Capital Reliance* in column (1) suggests that a one standard deviation increase in *External Capital Reliance* is associated with a 5.1% decrease in *Days to Actual Disclosure* (*t*-statistic = –5.20). The results in column (2) suggest that a one standard deviation increase in *External Capital Reliance* is associated with a 2.4 percentage point decrease in *Percentage Disclosure Delay* (*t*-statistic = –4.89). Together, these results are consistent with firms more reliant on external capital revealing publicly their innovative successes to reduce their cost of capital.

Regarding technological competition, the coefficient estimate on ln(*Technological Competition 1*) in column (1) suggests that a 1% increase in realized technological competition results in a 0.03% increase in the number of days until patent disclosure (*t*-statistic of 3.52). The results in column (2) suggest that a 1% increase in knowledge spillovers results in a 0.027 percentage point increase in the delay until disclosure (*t*-statistic of 4.99). Together, these results suggest that disclosure delays are increasing in the degree of technological competition, as measured by knowledge spillovers.

In contrast, there is no relation between disclosure delays and the second measure of technological competition, *Technological Competition 2*, as evidenced by small and statistically insignificant coefficient estimates in both columns (1) and (2). However, we caution readers against interpreting the insignificant and small coefficient as evidence that technological competition does not affect disclosure for two reasons. First, the inclusion of Patent Class x Year fixed effects may reduce the power to detect an effect of *Technological Competition 2*. Second, the inclusion of ln(*Technological Competition 1*) in the regression, itself a measure of technological competition, further reduces the power to detect an effect of *Technological Competition 2*. We make these research design choices because our goal is to control for technological competition, not document its effect.

5.2 Competition and patent disclosure delays, differences-in-differences

Table 3 presents the results of estimating Eq. (2). Columns (1) and (2) present findings using ln(*Days to Actual Disclosure*) and *Percentage Disclosure Delay* as the dependent variable. The results in column (1) suggest that a 1% decrease in the tariff rate results in a 0.6% decrease in the delay until patent disclosure (*t*-statistic = –8.44). The results in column (2) suggests that a 1% decrease in the tariff rate results in a 0.27 percentage point decrease in the delay until disclosure (*t*-statistic = –4.20). Taken together, the results suggest a negative relation between changes in product market competition and changes in patent disclosure delays.

Many of the coefficient estimates on control variables that are statistically significant in Table 2 are statistically insignificant in Table 3. This is possibly because these control variables are largely time-invariant, such that little variation remains after including the firm fixed effects. The notable exception is the coefficient on ln(*Technological Competition 1*), which is statistically significant (*t*-statistics = 3.13 and 5.21 in columns (1) and (2)). This result highlights that knowledge spillovers discourage disclosure, which is consistent with the assumptions of Hughes and Pae (2015) and explains why patent applicants do not always disclose, despite the product market benefits of patent disclosure.

5.3 Competition and patent disclosure delays, text-based measure of competition

Table 4 presents the results of estimating Eq. (1) with ln(*Manager Perception of Competition*) as an alternative measure of product market competition. Columns (1) and (2) present findings using ln(*Days to Actual Disclosure*) and *Percentage Disclosure Delay* as the dependent variable. For the sake of parsimony, we do not report coefficient estimates or test statistics for control variables. The results in column (1) suggest that a 1% increase in the manager's perception of competition results in a 0.04% decrease in the delay until disclosure. The results in column (2) suggest that a 1% increase in the manager's perception of competition results in a 0.02 percentage point decrease in the delay until disclosure. Taken together, the results in Table 4 suggest that our inferences are robust to measuring competition using an alternative, text-based measure of competition.

5.4 Competition and patent disclosure delays, differences-in-differences parallel trends

Table 5 presents the results of estimating Eq. (3). Column (1) and (2) present findings using ln(*Days to Actual Disclosure*) and *Percentage Disclosure Delay* as the dependent variable. We find no evidence that firms respond to changes in future tariff rates prior to the change, i.e., we find no evidence of differential pre-treatment trends. In particular, none of the six coefficient estimates on future tariff rates in columns (1) or (2) is statistically significantly different from zero. More importantly, the coefficients estimates themselves do not seem to suggest a progressively larger negative relation between changes in disclosure and future changes in tariff rates, prior to the change.

In contrast, as in Table 3, Table 5 reveals a relation between changes in concurrent tariff rates and changes in manager disclosure choices. In particular, the results in column (1) suggest that a 1% decrease in the tariff rate yields a 0.47% decrease in the delay until patent disclosure (t-statistic = –3.91). The results in column (2) suggest that a 1% decrease in the tariff rate results in a 0.12 percentage point decrease in *Percentage Disclosure Delay* (t-

statistic = –1.93). Taken together, the results in Table 5 suggest that differential pre-treatment trends do not drive our results.

5.5 Competition and patent disclosure delays, tariff decreases and increases

Table 6 presents the results of estimating Eq. (4c). Columns (1) and (2) present findings using ln(*Days to Actual Disclosure*) and *Percentage Disclosure Delay* as the dependent variable. The findings in column (1) reveal no evidence that tariff decreases or tariff increases differentially affect firms' disclosure choices. In particular, the coefficients on ln(*1-Tariff Decrease*) and ln(*1-Tariff Increase*) are not statistically different (*F*-statistic of the equality of coefficients of 0.03).[27] These findings are inconsistent with lobbying explaining the negative relation between changes in disclosure choices and changes in tariff rates. The findings in column (2) yield the same inferences as those in column (1), i.e., tariff decreases or increases do not differentially affect firms' disclosure choices. In particular, the coefficients on ln(*1-Tariff Decrease)* and ln(*1-Tariff Increase*) are not statistically different (*F*-statistic of the equality of coefficients = 0.09).

In both columns (1) and (2) the coefficients on ln(*1-Tariff* $Rate_{t-1}$), ln(*1-Tariff Decrease*), and ln(*1-Tariff Increase*) are statistically negative (*t*-statistics = –1.69 to –3.81). The coefficient estimate on ln(*1-Tariff Decrease*) is somewhat less statistically significant than the coefficient estimate on ln(*1-Tariff Increase*), particularly in column (1); *t*-statistic of -1.69 for the coefficient estimate on ln(*1-Tariff Decrease*) compared to a *t*-statistic of -3.66 for the coefficient estimate on ln(*1-Tariff Increase*). However, this difference is attributable to the larger standard error of the estimate for the coefficient estimate on ln(*1-Tariff*

[27] The coefficients on both ln(*1-Tariff Decrease)* and ln(*1-Tariff Increase*) are negative because disclosure choices are negatively correlated with both increases and decreases in tariff rates. We find a positive coefficient on ln(*1-Tariff Decrease*) when we take the absolute value of tariff decreases.

Decrease). In fact, the coefficient estimate on ln(*1-Tariff Decrease*) is *greater* in magnitude than the coefficient estimate on ln(*1-Tariff Increase*); coefficient estimate of –0.453 on ln(*1-Tariff Decrease*), compared to a coefficient estimate of -0.390 on ln(*1-Tariff Increase*). We attribute the higher standard error of the coefficient estimate on ln(*1-Tariff Decrease*) to the smaller sample of tariff decreases (there are 46,044 tariff increases in sample, compared to 27,069 tariff decreases). Regardless, taken together, the results in Table 6 suggest tariff decreases and increases have economically similar effects on firms' disclosure choices.

5.6 Patent disclosure and subsequent competitor behavior

The findings discussed so far suggest that firms respond to product market competition by speeding their disclosure of innovation. If firms do so to deter product market competitors, then competitors should avoid the disclosing firm's product market. In turn, this should decrease the similarity between the firm's products and those of their product market competitors. Alternatively, if firms respond to product market competition by speeding their disclosure of innovation to market their innovations to competitors, then competitors should license the firm's innovation (Hegde and Luo, 2017). In turn, this should increase the similarity between the firm's products and those of their product market competitors. Consequently, how the timeliness of the disclosure of innovation affects product similarity can reveal firms' primary motivation for disclosing their innovations.

To examine how timelier disclosure of innovation affects product market similarity, we estimate the following specification:

$$\ln(\textit{Product Similarity}_{i,j,t+3}) = \beta_0 + \beta_1 \ln(\textit{Days Since Disclosure}_{i,j,t}) + \gamma' X_{i,t\text{-}d} + \eta' Y_{j,t} + \textit{WithinFE} + \textit{FiscalYearFE} + \textit{PatentClass*ApplicationYearFE} + \varepsilon_{i,j,t}\,, \qquad (5)$$

where ln(*Days Since Disclosure*) is the natural logarithm of the number of days between the patent approval date and the patent disclosure date, and *Product Similarity* is a measure of the similarity between the patent filing firm's products and those of its competitors. We construct *Product Similarity* as the cosine similarility between the firm's 10-K product descriptions and that of its competitor, summed across all competitors and weighted by competitor market value (Hoberg and Phillips, 2010, 2016).[28] We measure *Product Similarity* 3 years after the first 10-K filing subsequent to the patent approval date to allow sufficient time for competitors to change their production decisions. If future product similarity is lower when disclosure is timelier then β_1 will be negative.

Table 7 presents the results of estimating Eq. (5). Columns (1) and (2) use industry fixed effects for *WithinFE*, and columns (3) and (4) use firm fixed effects for *WithinFE*. Columns (2) and (4) include ln(*Days to Latest Possible Disclosure*) as an additional control in the vector *X*.

The results suggest that a 1% increase in the time since disclosure is associated with a 0.01% to 0.015% decrease in the similarity of competitors' products (*t*-statistics of -1.96 to -2.02). This finding provides additional support that the positive relation between disclosure timeliness and product market competition is attributable, at least in part, to disclosing firms' desire to deter product market competitors. However, we note that the findings do not rule out the possibility that other economic forces are at work, including the incentive to disclose early to gain patent royalties. Nonetheless, finding that product similarity decreases rather than increases when patent disclosure is timelier suggests that deterrence plays a more prominent role than royalty seeking.

[28] We thank the authors of Hoberg and Phillips (2010, 2016) for making the data available on their website: http://hobergphillips.tuck.dartmouth.edu/.

5.7 Extensions

5.7.1 Alternative information sources and patent disclosure

Table 8 presents the results of estimating Eqs. (1) and (2), after splitting the sample on cross-sectional differences in the quality of the patenting firm's information environment. We predict that firms with high-quality information environments will be able to rely on alternative methods of communicating a product market advantage (e.g., a firm with high-quality financial statements may be able to credibly communicate the presence of a cost-saving innovation in their financial reports). Consequently, we predict that firms with higher-quality information environments will be less likely to rely on costly patent disclosures to deter product market competitors.

To test this prediction, we split the sample on the median of two measures of the quality of the information environment. In Panel A, we measure the quality of the information environment with the absolute value of the mean analyst forecast error as of the most recent fiscal year end (*Absolute Analyst Forecast Error*). For each specification, we first report results for firms with a higher-quality information environment (*Absolute Analyst Forecast Error* less than the median). Consistent with our predictions, we find that the relation between product market competition and the timeliness of patent disclosure is stronger, and sometimes manifests solely, in the subsample of firms with lower-quality information environments (*F*-stats of the difference of coefficients of 3.80 through 6.05).

In Panel B, we measure the quality of the information environment with the industry component of the Barth, Konchitchki, and Landsman (2013) measure of earnings transparency: the R^2 from a cross-sectional regression of stock returns on earnings and change in earnings for all firms in the two-digit SIC industry in which the firm competes (see Barth et al., 2013, Appendix for details). We use the industry component of the Barth et al. (2013) measure of earnings transparency because we expect this component to reflect differences in industry characteristics that are not controllable by individual firms.

For each specification, we first report results for firms with a higher-quality information environment (*Industry Earnings Transparency* greater than the median). In columns (1) and (2), we find no evidence that the relation between product market competition and the timeliness of innovation disclosure depends on earnings transparency. In contrast, we find consistent evidence in columns (3) and (4) that the relation is stronger in industries with low earnings transparency (*F*-stats of the difference of coefficients of 3.31 and 3.76). In total, the results in Table 8 suggest that the relation between product market competition and the timeliness of the disclosure of innovation is stronger when the information environment is lower quality.

5.7.2 Excluding industries regulated by the Food and Drug Administration

Table 9 presents the results of estimating Eqs. (1) and (2), after removing firms potentially regulated by the FDA (those firms in Fama-French 48 industries 2, 3, 4, 5, 12, and 13). FDA regulated firms are required to disclose results from clinical trials. To the extent that disclosure of any trials occur before the patent applications, it is possible that our prior findings could understate the effect of product market competition on the timeliness of patent disclosure because our sample includes firms potentially regulated by the FDA. However, we find that the results in Table 9 are largely similar to the results reporting in Tables 2 and 3 (*t*-statistics of -3.01 to -5.73).

5.7.3 Controlling for patent values

Product market competition potentially may affect the value of innovation (e.g., Aghion and Griffith, 2008). If more valuable innovations are more or less likely to be disclosed earlier, then changes in the value of patents may represent an alternative channel through which product market competition could affect the timeliness of patent disclosure. We examine this alternative mechanism by modifying Eqs. (1) and (2) to include the value of individual patents. We follow Kogan et al. (2017) and measure patent values using the stock market's assessment of the patent value (*Patent Value*).[29] Table 1 reports summary statistics for *Patent Value*. On average, in-sample patents are worth $8.6 million and the average in-sample firm files 68 successful patent applications a year, suggesting the average in-sample firm produces innovation worth approximately 1.6% of its total equity market value, *each year*.

Table 10 reports the results from estimating Eqs. (1) and (2) after including *Patent Value*. Inferences regarding the association between the product market competition variables and timeliness of patent disclosure are the same as those based on the results reported in Tables 2 and 3 (*t*-statistics ranging from -2.85 to -9.70). We also find little evidence that *Patent Value* is related to the timeliness of patent disclosure (the coefficient estimate on

[29] To calculate the market's assessment, Kogan et al. (2017) begins with the market reaction to the news that the patent application was successful (i.e., the grant date return). The authors recognize that information related to the content of the patent application is likely already in the public domain by the grant date (e.g., from pre-grant disclosures). As a result, the grant date return represents the market's response to the resolution of uncertainty about the patent application's success and underestimates the value of the patent. To account for this discrepancy, Kogan et al. (2017) models the market's updating process using trading volume, the grant date return, and distributional assumptions. The authors posit, and present evidence consistent with, the market's updating being relatively constant across patents. Therefore, they transform the grant date return by a fixed constant to recover the market's assessment of the patent's value. We exclude all patents that were not disclosed prior to the grant date when estimating *Patent Value* because the market reaction to the grant reflects both the market reaction to the existence of the patent application and its approval, which potentially biases the measure's coefficient. Findings from untabulated analyses reveal that our inferences are unchanged if we do not exclude these patents (corresponding *t*-statistics for the coefficient estimates on our measures of product market competition of -2.77, -2.80, -8.32, and -4.18).

Patent Value is statistically insignificant in two out of four columns, and is of opposite signs in the two columns in which it is statistically significant).

6. Conclusion

We document how product market competition affects the disclosure of innovation. We find that firms relatively accelerate their patent disclosures when facing more intense product market competition (Jansen, 2005; Hughes and Pae, 2015). Our inferences are largely unchanged across multiple measures of product market competition, and when using changes in tariff rates as a source of plausibly exogenous variation in product market competition. These latter results do not appear to be the result of differential pre-treatment trends, nor do they appear to be explained by firm lobbying.

In total, our results suggest that product market competition increases the speed of patent disclosure, consistent with firms "weaponizing" the disclosure of innovation to deter product market competitors. Our work contributes to the literature on voluntary disclosure and firms' responses to product market competition by documenting the relation between product market competition and the voluntary disclosure of innovation. Our work may also inform the regulatory debate on mandatory patent deadlines by shedding light on when and why firms voluntarily accelerate their patent disclosures.

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Appendix A. Variable Definitions

Patent variables

Days Since Disclosure	The number days of between the disclosure of a patent filing and the patent application decision date.
Days to Latest Possible Disclosure	The number of days until the patent application must be published (18-months for applications seeking foreign protection and the patent decision date for all others).
Days to Actual Disclosure	The number of days until the USPTO disclosures the patent filing either at the request of the applicant or because the disclosure deadline passes.
Foreign Protection	An indicator equal to one if the applicant also applies for patent protections for this innovation overseas according to the OECD patent family database.
ln(*Technological Competition 1*)	The natural logarithm of one plus the number of citations the patent receives.
Patent Value	The value of the patent, in tens of millions of dollars, as calculated by Kogan et al. (2017) using the stock market reaction to the patent's approval.
Percentage Disclosure Delay	The number of days until the disclosure of a patent filing, divided by the number of days until the latest possible disclosure.

Firm variables

Absolute Analyst Forecast Error	The absolute value of mean analyst forecast errors.
Blockholders	The number of shareholders listed on Thomson Reuters with 5% or more ownership of the firm.
External Capital Dependence	Capital expenditures plus R&D expenditures minus operating activities net cash flow, divided by capital expenditures plus R&D expenditures (Rajan and Zingales, 1998).
Industry Earnings Transparency	The industry component of the Barth, Konchitchki, and Landsman (2013) measure of earnings transparency, multiplied by ten to ease interpretation.
Leverage	Book value of total debt, divided by book value of total assets plus book value of total debt.
ln(*Manager Perception of Competition*)	The nautral logarithm of the number of occurrences of competition-related words per 1,000 total words in the 10-K, as calculated by Li et al. (2012).
ln(*Equity Market Value*)	The natural logarithm of the market value of the firm's equity.
ln(*Product Market Competition*)	The natural logarithm of the sum of the squared market share of each publicly traded company in a particular four-digit SIC code in a given year, multiplied by negative one to ease interpretation. Market share is calculated as the sales of a particular company divided by the total sales of the SIC code.
ln(*Product Similarity*)	The cosine similarity between the 10-K product descriptions of the firm and its competitor, summed across all competitors and weighted by competitor market value (Hoberg and Phillips, 2010, 2016).
Loss	An indicator equal to one if net income is negative.
Market to Book	Market value of assets to book value of assets.
Missing R&D	An indicator equal to one if data on R&D spending is missing.
R&D	R&D expenditures scaled by total assets. Missing values of R&D are replaced with zeroes.
Return	Buy and hold return over the fiscal year.

Return on Assets	Income before extraordinary items scaled by total assets.
sigma(*Returns*)	The standard deviation of monthly returns.
Tariff Decrease	The change in the tariff rate since the prior year if the change was negative, and zero otherwise.
Tariff Increase	The change in the tariff rate since the prior year if the change was positive, and zero otherwise.
Tariff Rate	The most favored nation ad valorem tariff rate. Eight-digit U.S. harmonized tariff schedule rates are averaged to four-digit SIC levels following the industry concordance developed by Pierce and Schott (2012).
Technological Competition 2	*Technological Competition 2* begins with the Jaffe (1986) measure of technological proximity: $$Technological\ Proximity_{i,j} = \frac{(T_i T_j')}{(T_i T_i')^{1/2}(T_j T_j')^{1/2}}$$ where T is the vector of firm *i* or *j*'s share of patenting activity across each of the 426 patent classes over the period 1970 to 2006. $Technological\ Proximity$ measures the degree of technological overlap between two firms and ranges from 0 to 1. *Technological Competition 2* is the pool of potential knowledge spillovers for firm *i* in year *t*: $$Technological\ Competition_{i,t} = \sum_{j \neq i} Technological\ Proximity_{i,j} \times R\&D\ Stock_{j,t}$$ *R&D Stock* is calculated from current and historical R&D spending using the perpetual inventory method assuming a 15% depreciation rate (Hall, Jaffe, Trajtenberg, 2005). We divide *Technological Competition 2* by 100,000 to ease interpretation. See Bloom et al. (2013, 2018).

Figure 1

This figure presents a graphical representation of the different types of competition, and how they theoretically affect the disclosure of innovation (Smiley, 1988; Jansen, 2005, 2011; Hughes and Pae, 2015).

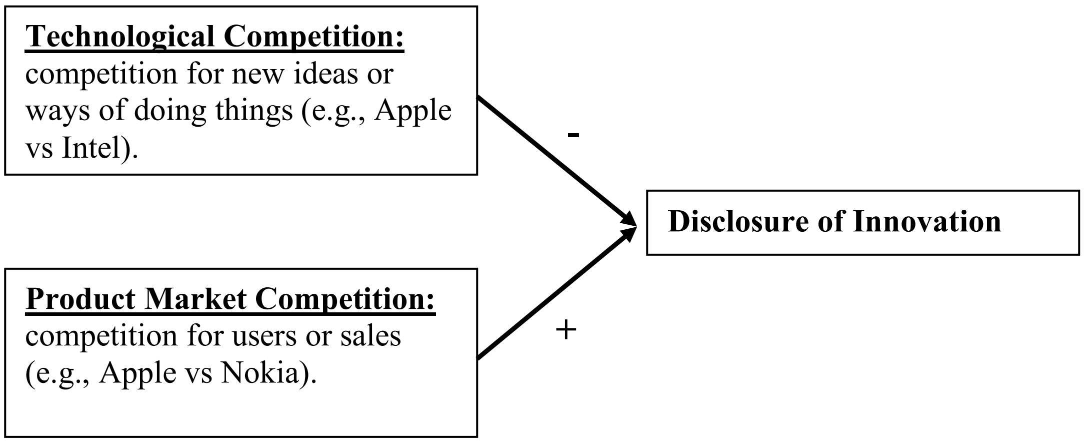

Figure 2

This figure presents the frequency histogram of the days until patent disclosure.

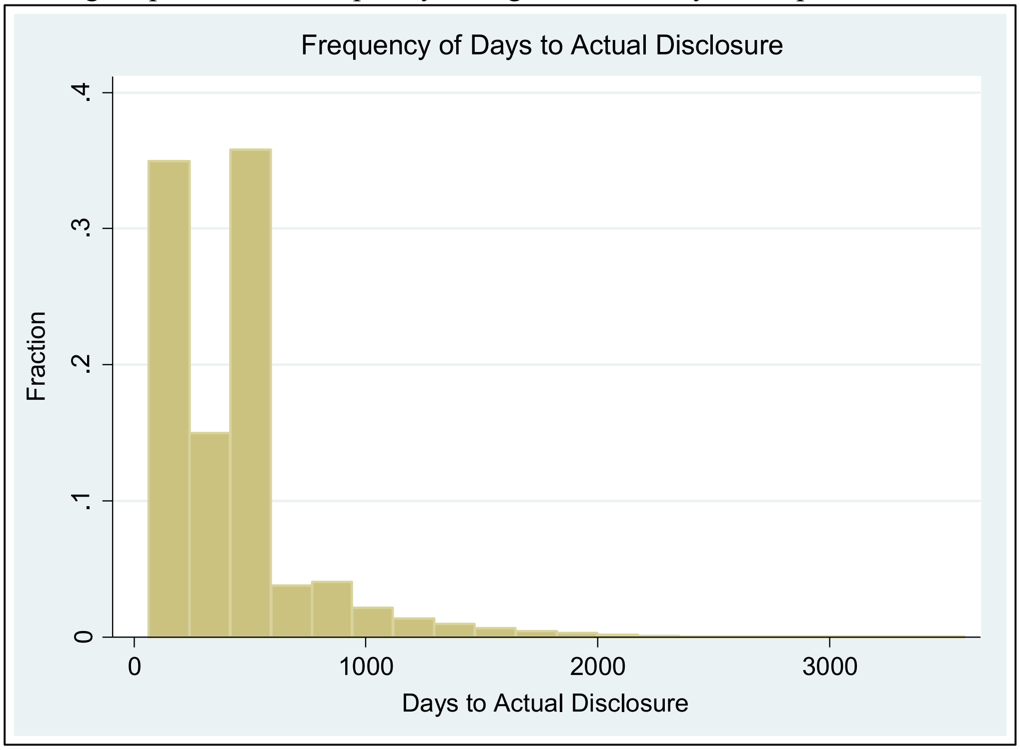

Figure 3

This figure presents the frequency histogram of the days until the latest possible patent disclosure.

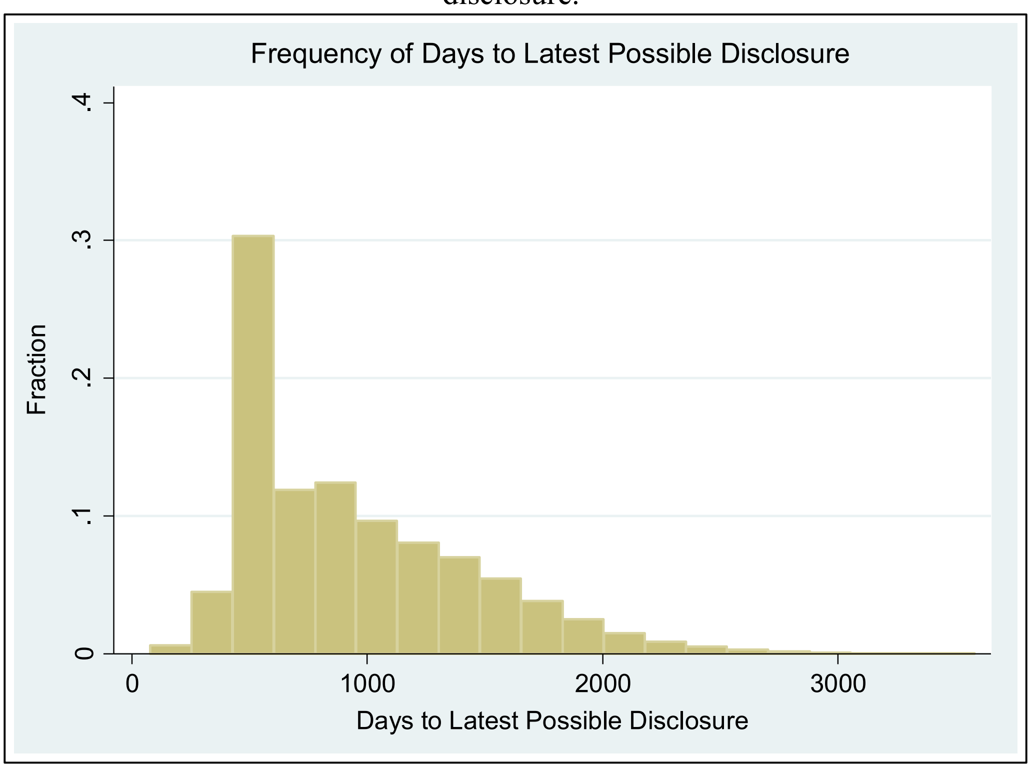

Figure 4

This figure presents the frequency histogram of the days until patent disclosure divided by the days until the latest possible disclosure.

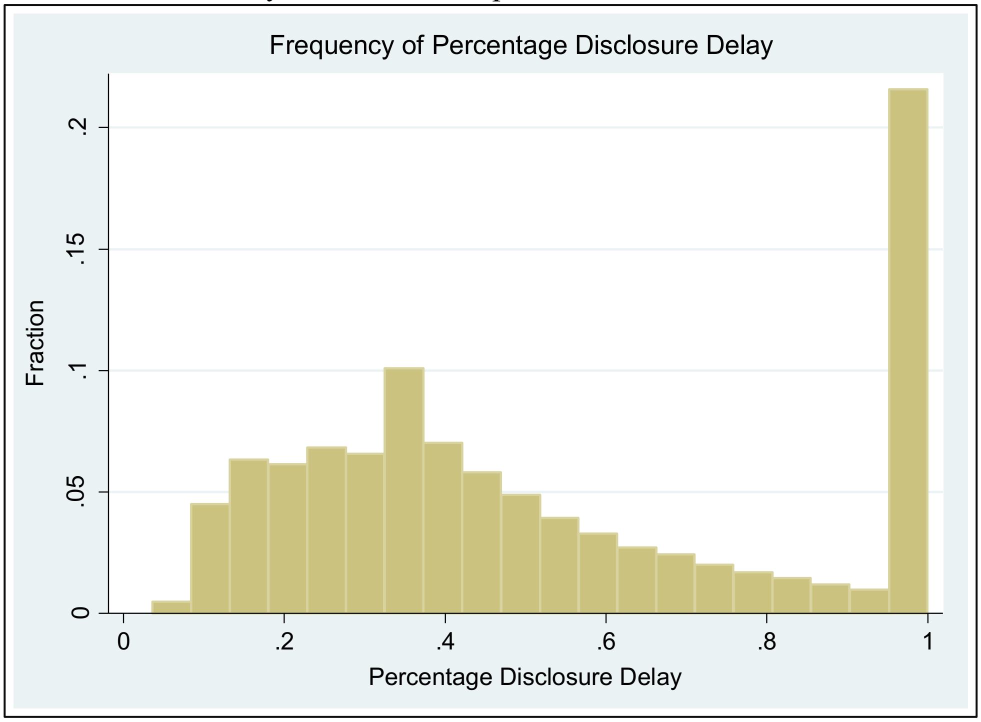

Figure 5

This figure presents the frequency histogram of the 73,113 in-sample tariff rate changes that are non-zero.

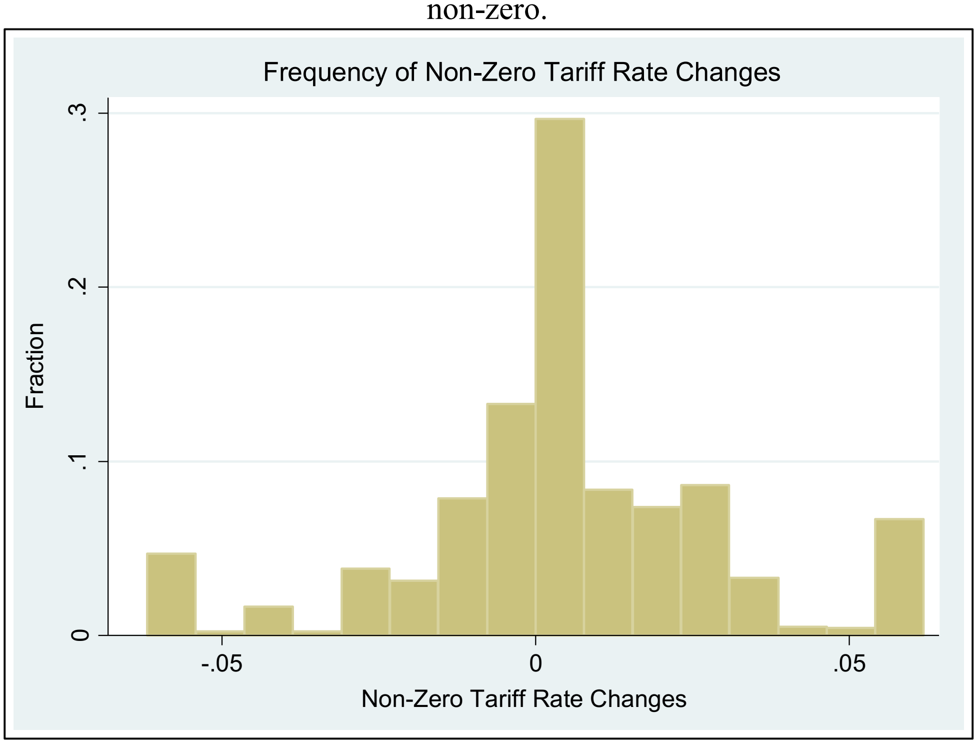

Table 1

Descriptive statistics

This Table presents descriptive statistics for our sample. The main sample is constructed from all successful patent applications filed with the USPTO from November 29, 2000 (post-AIPA) to December 31, 2006, intersected with CRSP and Compustat (stock price and accounting data). The final sample consists of 206,636 patent applications.

Variable	Observations	Mean	Std	25th	Median	75th
Patent variables:						
Citations	206,636	3.43	6.03	0.00	1.00	4.00
ln(*Technological Competition 1*)	206,636	0.97	0.94	0.00	0.69	1.61
Days Since Disclosure	108,861	689.08	534.28	270.00	633.00	1031.00
ln(*Days Since Disclosure*)	108,861	5.38	5.57	5.60	6.45	6.94
Days to Latest Possible Disclosure	206,636	949.30	479.00	547.00	815.00	1250.00
ln(*Days to Latest Possible Disclosure*)	206,636	6.74	0.48	6.30	6.70	7.13
Days to Actual Disclosure	206,636	446.20	301.20	199.00	415.00	553.00
ln(*Days to Actual Disclosure*)	206,636	5.90	0.63	5.29	6.03	6.32
Foreign Protection (% of applications)	206,636	28%	.	.	.	.
Patent Value	163,773	0.86	1.87	0.02	0.25	0.81
Percentage Disclosure Delay	206,636	53%	30%	28%	44%	82%
Firm variables:						
Absolute Analyst Forecast Error	170,668	0.12	0.24	0.01	0.04	0.10
Blockholders	206,636	0.74	1.18	0.00	0.00	1.00
External Capital Reliance	206,636	0.05	0.69	-0.31	0.10	0.42
Industry Concentration	206,636	0.27	0.22	0.10	0.19	0.34
ln(Product Market Competition)	206,636	1.59	0.75	1.09	1.66	2.31
Industry Earnings Transparency	206,636	0.30	0.73	0.02	0.05	0.16
Leverage	206,636	0.14	0.10	0.05	0.13	0.21
ln(*Equity Market Value*)	206,636	9.74	1.48	8.95	9.98	10.74
Loss (% of firm-years)	206,636	19%	.	.	.	.
Manager Perception of Competition	82,027	0.57	0.55	0.21	0.40	0.67
ln(*Manager Perception of Competition*)	82,027	-0.95	0.88	-1.56	-0.93	-0.40
Market to Book	206,636	1.84	1.79	0.64	1.20	2.50
Missing R&D	206,636	1%	.	.	.	.
Product Similarity	108,861	0.03	0.04	0.02	0.03	0.04
ln(*Product Similarity*)	108,861	-3.70	0.82	-3.98	-3.53	-3.20
R&D	206,636	0.07	0.04	0.04	0.07	0.10
Return	206,636	0.06	0.52	-0.27	-0.02	0.25
Return on Assets	206,636	0.04	0.10	0.01	0.04	0.09
sigma(*Returns*)	206,636	0.13	0.07	0.07	0.11	0.16
Tariff Decrease (nonzero subsample)	27,069	-1.8%	2.0%	-2.4%	-1.2%	-0.1%
ln(*1 – Tariff Decrease*)	206,636	0.00	0.01	0.00	0.00	0.00
Tariff Increase (nonzero subsample)	46,044	1.7%	1.9%	0.1%	1.3%	2.4%

Table 1, continued

Descriptive statistics

This Table presents descriptive statistics for our sample. The main sample is constructed from all successful patent applications filed with the USPTO from November 29, 2000 (post-AIPA) to December 31, 2006, intersected with CRSP and Compustat (stock price and accounting data). The final sample consists of 206,636 patent applications.

Variable	Observations	Mean	Std	25th	Median	75th
Firm variables, continued:						
ln(*1 – Tariff Increase*)	206,636	-0.00	0.01	0.00	0.00	0.00
Tariff Rate	206,636	0.7%	1.5%	0%	0%	0.3%
ln(*1 – Tariff Rate*)	206,636	-0.01	0.01	0.00	0.00	0.00
Technological Competition 2	206,636	40.23	16.45	29.25	41.48	52.36

Table 2

Competition and patent disclosure delays

This Table presents OLS regressions of patent disclosure choices as a function of product market competition. All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Actual Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)
ln(*Product Market Competition*)	-0.259***	-0.122***
	(-2.74)	(-2.76)
Blockholders	0.090***	0.043***
	(5.35)	(4.23)
External Capital Reliance	-0.076***	-0.035***
	(-5.20)	(-4.89)
Foreign Protection	0.213***	0.189***
	(4.38)	(8.81)
Leverage	0.586**	0.267**
	(2.42)	(2.62)
ln(*Technological Competition 1*)	0.031***	0.027***
	(3.52)	(4.99)
ln(*Equity Market Value*)	0.011	-0.001
	(0.64)	(-0.17)
Loss	0.044	0.027**
	(1.56)	(2.35)
Market to Book	0.017	0.006
	(0.95)	(0.82)
Missing R&D	-0.146	-0.065
	(-0.82)	(-0.86)
R&D	1.162***	0.567**
	(3.15)	(2.58)
Return	-0.037	-0.014
	(-1.43)	(-1.23)
Return on Assets	0.043	0.034
	(0.24)	(0.35)
sigma(*Returns*)	0.832***	0.388***
	(3.72)	(3.76)
Technological Competition 2	-0.003	-0.001
	(-0.84)	(-0.73)
ln(*Days to Latest Possible Disclosure*)	0.590***	.
	(17.47)	.

Table 2, continued

Competition and patent disclosure delays

This Table presents OLS regressions of patent disclosure choices as a function of product market competition. All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Patent Class x Year Fixed Effects	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	206,636	206,636
Adjusted R^2	0.327	0.300

Table 3

Competition and patent disclosure delays, differences-in-differences

This Table presents OLS regressions of patent disclosure choices as a function of industry-level tariff rates. All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Actual Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)
ln(*1 – Tariff Rate*)	-0.603***	-0.273***
	(-8.44)	(-4.20)
Blockholders	-0.006	-0.005**
	(-1.43)	(-2.15)
External Capital Reliance	-0.017	-0.005
	(-1.56)	(-1.06)
Foreign Protection	0.258***	0.212***
	(5.80)	(10.63)
Leverage	-0.014	0.012
	(-0.10)	(0.14)
ln(*Technological Competition 1*)	0.017***	0.020***
	(3.13)	(5.21)
ln(*Equity Market Value*)	-0.029	-0.019
	(-0.81)	(-1.06)
Loss	0.005	0.008
	(0.29)	(0.95)
Market to Book	0.005	0.003
	(1.00)	(1.23)
Missing R&D	-0.069	-0.029
	(-0.94)	(-1.10)
R&D	-0.062	-0.055
	(-0.14)	(-0.24)
Return	0.005	0.002
	(0.57)	(0.46)
Return on Assets	-0.087	-0.035
	(-1.56)	(-1.10)
sigma(*Returns*)	-0.032	0.045
	(-0.35)	(1.12)
Technological Competition 2	-0.002	-0.001
	(-0.67)	(-0.79)
ln(*Days to Latest Possible Disclosure*)	0.584***	.
	(19.79)	.

Table 3, continued

Competition and patent disclosure delays, differences-in-differences

This Table presents OLS regressions of patent disclosure choices as a function of industry-level tariff rates. All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Patent Class x Year Fixed Effects	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	206,636	206,636
Adjusted R^2	0.432	0.413

Table 4

Competition and patent disclosure delays, text-based measure of competition

This Table presents OLS regressions of patent disclosure choices as a function of an alternative, text-based measure of product market competition. Controls are included in both columns, except ln(*Days to Latest Possible Disclosure*) which is only included in column (1). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Actual Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)
ln(*Manager Perception of Competition*)	-0.037***	-0.020***
	(-3.60)	(-3.36)
Controls?	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	82,027	82,027
Adjusted R^2	0.307	0.256

Table 5

Competition and patent disclosure delays, differences-in-differences parallel trends

This Table presents OLS regressions of patent disclosure choices as a function of industry-level tariff rates and industry-level tariff rates in each of the next three years. Controls are included in both columns, except ln(*Days to Latest Possible Disclosure*) which is only included in column (1). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Actual Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)
ln(*1 - Tariff Rate*)	-0.468***	-0.115*
	(-3.91)	(-1.93)
ln(*1 - Tariff Rate$_{t+1}$*)	0.563	0.044
	(1.48)	(0.37)
ln(*1 - Tariff Rate$_{t+2}$*)	0.174	0.215
	(0.69)	(1.44)
ln(*1 - Tariff Rate$_{t+3}$*)	-0.010	-0.151
	(-0.03)	(-0.98)
Controls?	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	206,636	206,636
Adjusted R^2	0.432	0.413

Table 6

Competition and patent disclosure delays, tariff decreases and increases

This Table presents OLS regressions of patent disclosure choices as a function of prior year industry-level tariff rates and increases and decreases in the tariff rate from the prior year. Controls are included in both columns, except ln(*Days to Latest Possible Disclosure*) which is only included in column (1). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)
ln(*1 – Tariff Rate$_{t-1}$*)	-0.701***	-0.317***
	(-3.81)	(-3.42)
ln(*1 – Tariff Decrease*)	-0.453*	-0.212**
	(-1.69)	(-2.10)
ln(*1 – Tariff Increase*)	-0.390***	-0.259***
	(-3.66)	(-2.66)
F-test ln(*1-Tariff Decrease*) = ln(*1-Tariff Increase*)	0.03	0.09
F-test *p*-value	0.86	0.77
Controls?	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	206,636	206,636
Adjusted R^2	0.432	0.413

Table 7

Patent disclosure and subsequent competitor behavior

This Table presents OLS regressions of the similarity of the competitors' products to the firms' products after patent issuance as a function of firms' patent disclosure choices during the patent application process. Controls are included in all columns, except ln(*Days to Latest Possible Disclosure*) which is only included in columns (1) and (3). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Product Similarity*)			
	(1)	(2)	(3)	(4)
ln(*Days Since Disclosure*)	-0.015**	-0.014**	-0.012*	-0.010**
	(-1.99)	(-2.02)	(-1.96)	(-2.01)
Competition Measure?	Yes	Yes	Yes	Yes
Controls?	Yes	Yes	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	No	No
Firm Fixed Effects	No	No	Yes	Yes
Observations	108,861	108,861	108,861	108,861
Adjusted R^2	0.531	0.531	0.656	0.656

Table 8, Panel A

Alternative information sources and patent disclosure

This Table presents OLS regressions of patent disclosure choices as a function of product market competition, after splitting the sample on moderating characteristics of the firm. In Panel A the sample is split based on *Absolute Analyst Forecast Error* and in Panel B the sample is split based on *Industry Earnings Transparency*. Controls are included in all columns, except ln(*Days to Latest Possible Disclosure*) which is only included in columns (1) and (3). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Disclosure*)		*Percentage Disclosure Delay*		ln(*Days to Disclosure*)		*Percentage Disclosure Delay*	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Moderating variable:	*Absolute Analyst Forecast Error*				*Absolute Analyst Forecast Error*			
Sample restriction:	< Median	> Median	< Median	> Median	< Median	> Median	< Median	> Median
ln(*Product Market Competition*)	-0.136**	-0.432***	-0.065	-0.211***	.	.	.	.
	(-2.10)	(-3.03)	(-1.55)	(-2.97)	.	.	.	.
ln(*1 - Tariff Rate*)	.	.	.	.	0.334	-0.880***	0.170	-0.552***
	.	.	.	.	(0.68)	(-12.69)	(0.49)	(-7.70)
F-statistic of the difference	4.80		6.05		4.88		3.80	
F-statistic p-value	0.03		0.02		0.03		0.05	
Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	92,648	78,020	92,648	78,020	92,648	78,020	92,648	78,020
Adjusted R^2	0.344	0.400	0.344	0.400	0.426	0.475	0.396	0.451

Table 8, Panel B

Alternative information sources and patent disclosure

This Table presents OLS regressions of patent disclosure choices as a function of product market competition, after splitting the sample on moderating characteristics of the firm. In Panel A the sample is split based on *Absolute Analyst Forecast Error* and in Panel B the sample is split based on *Industry Earnings Transparency*. Controls are included in all columns, except ln(*Days to Latest Possible Disclosure*) which is only included in columns (1) and (3). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Disclosure*)		*Percentage Disclosure Delay*		ln(*Days to Disclosure*)		*Percentage Disclosure Delay*	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)	(4a)	(4b)
Moderating variable:	*Industry Earnings Transparency*				*Industry Earnings Transparency*			
Sample restriction:	> Median	< Median	> Median	< Median	> Median	< Median	> Median	< Median
ln(*Product Market Competition*)	-0.206***	-0.200**	-0.092***	-0.103**	.	.	.	.
	(-3.23)	(-2.24)	(-3.06)	(-2.13)	.	.	.	.
ln(*1 - Tariff Rate*)	.	.	.	.	-0.558**	-2.117**	-0.236***	-0.822**
	.	.	.	.	(-2.47)	(-2.40)	(-2.77)	(-2.45)
F-statistic of the difference	< 0.01		0.04		3.31		3.76	
F-statistic p-value	0.95		0.85		0.07		0.06	
Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	No	No	No	No
Firm Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	91,282	115,354	91,282	115,354	91,282	115,354	91,282	115,354
Adjusted R^2	0.353	0.344	0.319	0.320	0.447	0.445	0.416	0.434

Table 9

Excluding industries regulated by the Food and Drug Administration

This Table repeats the results of Table 2 (columns 1 and 2) and Table 3 (columns 3 and 4) after excluding firms operating in industries that can be regulated by the FDA (Fama-French 48 industries 2, 3, 4, 5, 12, and 13). Controls are included in all columns, except ln(*Days to Latest Possible Disclosure*) which is only included in columns (1) and (3). All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Disclosure*)	*Percentage Disclosure Delay*	ln(*Days to Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)	(3)	(4)
ln(*Product Market Competition*)	-0.281***	-0.132***	.	.
	(-3.03)	(-3.01)	.	.
ln(*1 - Tariff Rate*)	.	.	-0.703***	-0.313***
	.	.	(-5.73)	(-3.49)
Controls?	Yes	Yes	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	No	No
Firm Fixed Effects	No	No	Yes	Yes
Observations	190,492	190,492	190,492	190,492
Adjusted R^2	0.331	0.308	0.435	0.419

Table 10

Controlling for patent values

This Table repeats the results of Table 2 (columns 1 and 2) and Table 3 (columns 3 and 4). Prior controls are included in all columns, except ln(*Days to Latest Possible Disclosure*) which is only included in columns (1) and (3). Controls for the value of the patent are included in all columns. All variables are as defined in Appendix A. t–statistics appear in parentheses and are based on standard errors clustered by industry and date. ***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels (two–tail). Sample descriptive characteristics are found in Table 1. All industry variables are based on SIC 4-digit classifications.

Variable:	ln(*Days to Disclosure*)	*Percentage Disclosure Delay*	ln(*Days to Disclosure*)	*Percentage Disclosure Delay*
	(1)	(2)	(3)	(4)
ln(*Product Market Competition*)	-0.132***	-0.044***	.	.
	(-2.85)	(-3.02)	.	.
ln(*1 - Tariff Rate*)	.	.	-0.391***	-0.090***
	.	.	(-6.15)	(-9.70)
Patent Value	0.007	0.004*	-0.005**	0.001
	(1.09)	(1.95)	(-2.49)	(0.86)
Controls?	Yes	Yes	Yes	Yes
Patent Class x Year Fixed Effects	Yes	Yes	Yes	Yes
Fiscal Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	No	No
Firm Fixed Effects	No	No	Yes	Yes
Observations	163,776	163,776	163,776	163,776
Adjusted R^2	0.363	0.262	0.436	0.328