Does Shareholder Overlap Alleviate Patent Holdup?

Heng Geng*
Victoria University of Wellington

Harald Hau**
University of Geneva and SFI

Sandy Lai***
National Taiwan University

Pengfei Liu****
University of Auckland

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Abstract

Patent protection can generate holdup problems for follow-on innovators when technologies protected in early patents complement their inventions. This study investigates whether institutional shareholder overlap between firms with precursory patents and follow-on innovators can reduce such patent holdup problems. Using patent citation links to track complementary patents, we find empirical support for such a holdup attenuation hypothesis of institutional shareholder overlap. Follow-on innovators with greater institutional shareholder overlap to precursory patent owners enjoy greater success with their patent portfolio, face less patent conflict as measured by patent litigation, and feature higher levels of R&D investments. The holdup attenuation effect is stronger if product complexity makes securing ex ante patent licenses more difficult.

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*School of Economics and Finance, Victoria University of Wellington, New Zealand. Tel.: (+64) 4 463 5523. E-mail: griffin.geng@vuw.ac.nz.

**University of Geneva, 40 Bd du Pont d'Arve, 1211 Genève 4, Switzerland. Tel.: (++41) 22 379 9581. E-mail: prof@haraldhau.com. Web page: http://www.haraldhau.com.

***College of Management, National Taiwan University, No.1, Sec. 4, Roosevelt Rd., Taipei City 106. Tel.: (+886) 2 33661087. E-mail: sandylai@ntu.edu.tw.

****Department of Accounting and Finance, University of Auckland, Auckland, New Zealand. E-mail: liupengfei2016@163.com.

1 Introduction

New technological discoveries often follow a cumulative innovation process, where later innovations build on a foundation provided by early innovators. Under patent laws, any second-generation innovator seeking to incorporate technologies protected by precursory patents must obtain a license from the first-generation innovator, or risk being sued for patent infringement.[1] Consequently, patent protection on early inventions implies that the full economic value of a later innovation can be unlocked only if the follow-on innovator can simultaneously secure access to many complementary upstream patents.[2] However, negotiating ex ante license agreements is costly because of contractual frictions that manifest in two ways. First, predicting the exact nature of follow-on innovations is challenging, which exacerbates the issue of incomplete contracts. Second, disclosing valuable information about potential development pathways might inadvertently benefit competitors. These contractual frictions create patent holdup problems (Aghion and Tirole, 1994).

In this paper, we study if overlapping (or common) institutional shareholders between upstream patent holders and downstream innovators (i.e., follow-on innovators) can provide holdup relief.[3] From the property rights perspective of the firm (Grossman and Hart, 1986; Hart and Moore, 1990; Hart, 1995), such institutional shareholder overlap should *extend the effective boundary of the downstream firm* —potentially allowing for the internalization of patent conflicts in the absence of efficient ex-ante contracting. Yet, to our knowledge, no systematic empirical evidence exists that would validate the holdup attenuation effect of institutional shareholder overlap. Such a holdup attenuation hypothesis follows when applying the property rights perspective of the firm to patent investment.

Measuring the holdup risk of any patent requires the identification of its complementary precursory patents. Our methodology follows the literature (Galasso and Schankerman, 2015; Noel and Schankerman, 2013; Ziedonis, 2004) and tracks the patents cited by a downstream

[1] Lanjouw and Schankerman (2001) find evidence that upstream firms often file lawsuits to protect patents that form the base of a cumulative chain in order to extract rents from subsequent follow-on inventions.

[2] Follow-on inventions can still be patented, but they cannot be worked for *commercial* purposes if the follow-on products infringe on the patent rights of the earlier inventions. This situation is also referred to as patent thicket, see Shapiro (2000).

[3] The terms up- and downstream refer to the timeline or time flow of the patent approval process. The upstream firm is the one owning a precursory patent and the downstream firm pursues a follow-up patent.

firm. Such citations of precursory patents identify patent owners (i.e., upstream firms) that represent a potential source of holdup risk. Anecdotal evidence supports such an approach. For instance, some patent consultants acknowledge that they assist their clients (i.e. upstream firms) in identifying potential patent licensees among downstream firms that cite upstream firms' patents.[4] Consistent with the anecdotal evidence, Figure 1 demonstrates that firm pairs with patent citation links in the past are 16 times more likely to engage in patent-related lawsuits than those without citation links, which highlights the usefulness of patent citations in identifying complementary patents.[5]

[Insert Figure 1 about here.]

Our exploration of the influence of institutional shareholder overlap proceeds in two steps. First, we begin by assessing the overall effect of institutional shareholder overlap on holdup attenuation, focusing on changes in future patent citations. As patent holdup manifests in a multi-faceted manner, we rely on future patent citations to quantify the overall economic effect of holdup mitigation. Future patent citations are widely used to capture the long-run success of a patent in the innovation process (Hall and Ziedonis, 2001; Lerner and Seru, 2022).

Second, we draw on the theoretical literature and discern the ex-ante and ex-post effects of patent holdup. The ex-post effect primarily manifests as patent conflicts such as patent litigation (Lemley and Shapiro, 2006), while the ex-ante effect refers to underinvestment, which arises as downstream inventors anticipate potential difficulties in navigating through patent holdup, thereby decreasing or even eliminating R&D investments in socially desirable innovation projects (Shapiro, 2000). Our empirical analyses separately examine if institutional shareholder overlap can reduce the likelihood of patent litigations and mitigate underinvestments.

In Section 4, our main empirical results support the hypothesis that institutional shareholder overlap attenuates patent holdup. First, we demonstrate that institutional shareholder overlap relates positively to the downstream firm's patent success. A one-standard-deviation increase in firm-level institutional shareholder overlap increases the average forward patent citation count

[4] Ziedonis (2004) discusses three cases in her paper (Mogee Associates, InteCap, and Delphion). Ambercite, another intellectual property consulting company, advocated a similar approach in a recent internet posting (www.ambercite.com, 2014).

[5] The robustness of this relationship between citation links and patent litigation is confirmed in a more rigorous regression analysis using industry and firm pair fixed effects in Table A4 of the Appendix.

by 10.55%. Second, institutional shareholder overlap comes with a significantly lower likelihood of downstream firms being sued by an upstream firm for patent infringement. A one-standard-deviation increase in institutional shareholder overlap with firms owning precursory patents is associated, *ceteris paribus*, with a 12% reduction in the patent litigation risk for the downstream innovating firms. Third, we also find evidence that the investment incentives change for the downstream firms. A one-standard-deviation increase in institutional shareholder overlap is associated with a 5.5% increase in downstream firms' R&D investments.

To reinforce our baseline findings, Section 5 provides additional analyses about the heterogeneity in the effect of institutional shareholder overlap along several dimensions. First, we conjecture that the holdup attenuation effect of institutional shareholder overlap varies with product complexity. "Complex products" covering many complementary patents tend to have a higher cost of ex ante contracting—resulting in more severe holdup issues compared to "discrete products" that require fewer complementary patents for their exploitation (Cohen et al., 2000). We confirm this conjecture by showing that industries with "complex products" (i.e., information technology) benefit more from institutional shareholder overlap than those with "discrete products" (i.e., pharmaceuticals). Second, we explore if institutional shareholder overlap curtails the incentive for strategic patenting, which has become an increasingly important consideration for patent filings in certain industries (Hall and Ziedonis, 2001; Torrisi et al., 2016). For this investigation, we use two different measures to gauge the share of strategic patent filings and uncover that institutional shareholder overlap is associated with a reduction of strategic patents. This finding suggests that the positive correlation between institutional shareholder overlap and the downstream firm's patent output does not stem from an increase in strategic patents, but rather from a surge in patents with an innovation focus. Third, we explore how upstream patents held by foreign firms influence our estimate for institutional shareholder overlap. Due to the ownership data constraint, our analysis does not account for overlapping ownership with foreign upstream firms. We show that the holdup attenuation effect is less pronounced for firms that cite relatively more international upstream patents than firms that cite mostly upstream patents owned by domestic firms. This is consistent with the finding that foreign firms are less inclined to initiate patent infringement litigations in US courts, partly due to higher enforcement costs (Lanjouw and Schankerman, 2001). Therefore, excluding foreign upstream firms from our measurement of shareholder overlap introduces an attenuation bias, which becomes more pronounced as a firm's citations of foreign upstream patents increase.

In Section 6, we address concerns about ownership endogeneity and reverse causality. A key endogeneity concern is that institutional investors are able to select stocks with higher earnings prospects. This implies an endogenous positive relationship between institutional ownership and firm performance measures including patent success. We separately account for this channel by including the share of institutional ownership as a control variable, but find that it is not systematically related to patent success, unlike the specific institutional shareholder overlap with the upstream firms owning precursory patents. Also, the inclusion of institutional ownership as a control variable does not significantly alter the inferred holdup attenuation effect as one expects under the hypothesis of endogenous institutional ownership. Second, to address the concern that common trends faced by upstream and downstream firms drive institutional investors to invest in both firms, we conduct placebo tests that replace the upstream firm owning the specific holdup patent with similar (pseudo) firms in terms of product offerings and technology expertise. The underlying assumption is that any commercial and technological trends experienced by upstream firms should also extend to the matched pseudo firms. If these trends drive our findings, we would expect to find that the institutional shareholder overlap with pseudo upstream firms (without a true citation link) correlates with the patent success of downstream firms in the same way as the shareholder overlap with upstream firms that actually own precursory patents. But no such statistically significant relationship emerges—suggesting that the holdup attenuation effect is thus highly specific to the citation link. The third endogeneity concern is that institutional investors anticipate holdup and strategically create institutional shareholder overlap with respect to the specific firm pair involved. Here, we undertake an event study that tracks the evolution of such institutional shareholder overlap around the occurrence of the citation link that reveals potential holdup. We find no evidence of anticipation effects that cause institutional shareholder overlap to surge before the occurrence of the holdup situation.

A potential concern about our analysis is the limited ability of institutional investors to influence corporate policy. It is important to note that our investigation is confined to coordination observed in selective corporate situations like patent conflicts and holdup. While institutional investors may not always have the knowledge or capacity to align firm conduct with their own portfolio maximization objective, they can recognize these specific situations in which two of their portfolio firms engage in patent litigation or patent holdup, which clearly results in negative-sum interactions. Anecdotal evidence supports the proactive role that institutional investors play in resolving conflicts between portfolio firms. For example, Albert J. Wilson, Vice President and Secretary of TIAA-CREF, noted in a public speech that given his fund's joint ownership in both sides of the litigation cases of Pennzoil vs. Texaco and Apple vs. Microsoft, his fund was able to apply pressure on the litigants to speed up their conflict resolution (Hansen and Lott, 1996). Shekita (2022) provides evidence that overlapping institutional investors' influence is beyond conflict resolution based on 30 specific cases on public records.

2 Related Literature

Our paper is situated at the intersection of three strands of literature; namely on (i) the determinants of patent innovation and patent success; (ii) optimal property rights in situations of incomplete contracting and the role of patent holdup; and (iii) the real effects of institutional cross-ownership.

First, the early literature on cumulative (or sequential) innovation emphasizes a positive externality of early innovators on later innovators via knowledge spillover (e.g., d'Aspremont and Jacquemin, 1988). A seminal paper by Green and Scotchmer (1995) argues that in a perfect contracting environment, ex-ante licenses are optimal and will be negotiated. In their framework, efficient bargaining ensures that upstream patent rights do not impede downstream innovation. More recent studies (e.g., Heller and Eisenberg, 1998), however, argue that various transaction costs exist and can result in inefficient bargaining and patent holdup risk for downstream innovators. Bargaining failure due to information asymmetry (Bessen and Maskin, 2009; Galasso and Schankerman, 2015) and/or excessive royalty stacking (Galasso and Schankerman, 2010) can even block downstream innovation completely. Empirically, Murray and Stern (2007), Williams (2013), and Galasso and Schankerman (2015) find evidence that patent holdup reduces downstream research and development by about 10% to 50%. Lanjouw and Schankerman (2001) further document the litigation risk faced by downstream innovators as upstream patent owners try to maximize their overall patent rents. In particular, upstream firms are more likely to file infringement lawsuits to protect patents that form the base of a cumulative chain and patents that are cited by more follow-on patentees. Our paper contributes to this empirical literature on the corporate innovation process and represents (to our knowledge) the most comprehensive empirical study on potential holdup risk.

Second, the property rights literature (Grossman and Hart, 1986; Hart and Moore, 1990; Hart, 1995) suggests that joint asset ownership attenuates holdup problems under conditions of asset specificity and ex-ante incomplete contracting. In the case of cumulative innovation, the first condition (i.e., asset specificity) is fulfilled for many new downstream patents because by law a downstream innovating firm must license upstream patents before it can market its follow-on (or second generation) products that use features under the IP protection of upstream patents. The second condition (ex-ante incomplete contracting) is also fulfilled. Various contingencies can arise during an innovation process. Unforeseen outcomes of any innovation project make it impossible for an innovating firm to write an ex-ante complete contract. The difficulty of ex-ante contracting is further compounded by the requirement for secrecy: Disclosure of private information about the patent opportunity in ex-ante license negotiation invites rival patent pursuit. The need for ex-post negotiation thus creates a patent holdup problem for the downstream firm after specific investments are sunk.

Notwithstanding its prominence in economic theory, the property rights view of firm boundaries has seen few empirical applications. A variety of empirical problems explains the scarcity of evidence. First, *non-contractible holdup problems* are often difficult to identify in a complicated business environment. Second, *underinvestment at the project level* requires a level of data disaggregation typically not available from corporate investment data, and any firm-level analysis is clouded by the fact that a firm can shift investments to other projects for which holdup problems are less severe. Third, investments may involve intangible resources (such as managerial attention), which pose additional *measurement problems* for empirical analyses. Patent data are particularly suited to addressing these issues. First, they allow the identification of potential holdup risk directly through the explicit citation of precursory patents in patent filings. Though imperfect, this identification idea pinpoints a large set of firm pairs where bilateral patent conflict is latent. Second, we can infer (latent) *within-firm* underinvestment in specific patent projects from the diminished success of the patent captured by future patent citations. Aggregate firm-level investment in innovation can be inferred directly from the reported firm-level R&D expenditure (or indirectly from the aggregate success of all patents filed by a firm).

Third, our work relates to a growing literature on the real effect of institutional cross-firm (or overlapping) ownership. Since Rubinstein and Yaari (1983) and Rotemberg (1984), a number of theoretical studies have argued that overlapping shareholders might coordinate to reduce competition in product markets. The increasing economic significance of institutional ownership has fostered an interest in this channel. Some recent industry studies provide evidence consistent with the anti-competitive argument. For example, Azar et al. (2018) suggest that overlapping ownership softens product market competition in the U.S. airline industry. Similar evidence is also documented by Aslan (2019) for the consumer goods industry, by Azar et al. (2022) for the banking industry, and by Newham et al. (2018) and Gerakos and Xie (2019) for the pharmaceutical industry. He and Huang (2017) also show that large overlapping shareholders facilitate product market collaboration among their portfolio firms in the same industry, and that these firms experience greater profitability and market share growth.[6] He et al. (2020) show that during corporate litigation, media companies that share common institutional ownership with the defendant provide more favorable news coverage of the defendant and allow common owners to exit at more favorable prices. Two recent studies demonstrate that overlapping ownership also matters for startups. Using project-level data, Li et al. (2019) document that, under some circumstances, common venture capitalists stifle the competition among jointly owned startups by discontinuing the competing project of the lagging startup. Eldar et al. (2020) find that common venture capitalists contribute to startup growth by facilitating information exchange and efficient opportunity allocation among their commonly owned startups. By contrast, Koch et al. (2021) question any general aggregate link between overlapping shareholder ownership

[6] Antón et al. (2024) and López and Vives (2019) argue that overlapping ownership between rival firms on the one hand mitigates their R&D disincentives caused by the free-riding problems in the presence of technological spillover, but, on the other hand, softens product market competition, which in turn reduces these firm's R&D incentives. Shradha (2019) finds that for firms operating in industries with similar products, overlapping ownership does indeed lead to less R&D investment. In contrast, our study predicts and finds a positive relation between a downstream firm's R&D investment and its overlapping ownership with upstream firms that own complementary patents.

and industry profitability.[7] While broad evidence beyond a particular industry is desirable, research progress is most likely to come from a more conditional analysis that accounts for the specific firm pair problem on which cross-ownership imprints a potential effect. Our focus on patent holdup represents such a conditional analysis.

Last, we highlight empirical work that finds a complementarity between equity market development and the degree of patent innovation (Brown et al., 2013, 2017; Hsu et al., 2014). Insofar as equity market development allows better internalization of holdup problems (through enhanced and adjustable *shareholder overlap*), this paper offers a deeper microeconomic interpretation rooted in the theory of the firm for the documented findings.

We highlight that our paper explores the holdup attenuation effect of common ownership via a novel research design that focuses on upstream and downstream innovating firms holding complementary patents. We hypothesize that common shareholders have incentives to internalize negative between-firm externalities, thereby mitigating patent holdup problems in their portfolio firms. This holdup attenuation hypothesis predicts an increase in R&D expenditure and patent output, but a decrease in the likelihood of patent litigation for downstream firms that have high institutional shareholder overlap with their upstream patent-owning firms. We describe our research methodology in more detail in the next section.

3 Sample Selection and Measurement Issues

3.1 Data

To obtain data on innovation and institutional ownership, we use firm-level information drawn from multiple sources. We begin with Compustat, which contains financial data for all US publicly listed firms since the mid-1950s. Our patent data is sourced from the data set provided by Kogan et al. (2017), which includes all USPTO granted patents from 1926 to 2020.[8] The authors match patent assignees to firms in Compustat, providing a comprehensive data set for our analysis.

[7] Schmalz (2018) provides an updated review of the literature.

[8] The original patent data set used in Kogan et al. (2017) was till 2010. In a more recent effort, the authors expanded their data set to include patent data up to 2020. The extended data can be found at https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data. We thank the authors for making the data set available to us.

Our ownership data is drawn from the Refinitiv 13F database (formerly Thomson Reuters). The SEC requires all institutional organizations, companies, universities, etc., that exercise discretionary management of investment portfolios over \$100 million in equity assets to report their holdings quarterly. All common stock positions greater than 10,000 shares or \$200,000 must be reported. Aghion et al. (2013) show reporting inconsistencies in ownership data prior to 1991, so we use ownership data only from 1991 onwards.

These data sets do not overlap perfectly, so our baseline regressions run between 1991 (the first year of clean ownership data) and 2017, which allows for a three-year window of future citations up to 2020 to correct various truncation issues (Hall et al., 2001). While the number of observations varies across regressions, the baseline sample contains $29,196$ observations on 3,487 firms.

3.2 Institutional Shareholder Overlap

The key explanatory variable in our analysis is *institutional shareholder overlap*. We define it at the patent-pair (or corresponding firm-pair) level, the (downstream) patent level, and the (downstream) firm level, respectively. We highlight that each firm can file multiple patents in a year, and each patent may cite several precursory patents from different upstream firms. In the following variable descriptions, we omit the time subscript to simplify the notation. Let s designate the downstream innovating firm owning patent p, and s' represent the upstream firm owning patent p_u cited in the filings of patent p.

The *pairwise institutional shareholder overlap* between the downstream patent p and an upstream patent p_u measures the overlapping institutional ownership overlap between firms s and s', which is defined as

$$psol_{p,p_u} = \sum_i \min[O_i(s), O_i(s')], \tag{1}$$

where $O_i(s)$ and $O_i(s')$ are the ownership share (relative to the total institutional ownership of the respective firm) of institutional investor i in firms s and s', respectively. As an illustration, consider the following example: Two investors A and B, respectively, own 3% and 5% in the downstream firm s, and 2% and 6% in the upstream firm s'. Both investors' combined institutional shareholder overlap for the patent pair (p, p_u) amounts to $psol_{p,p_u} = min(3\%, 2\%) + min(5\%, 6\%) = 7\%$. We apply a one-year time lag to the ownership measurement relative to the application year of patent p.[9]

The *patent-level institutional shareholder overlap* (sol_p) follows as the importance-weighted average of $psol_{p,p_u}$ over the N_u upstream patents cited by patent p, given by

$$sol_p = \sum_{u=1}^{N_u} w(p_u) \times psol_{p,p_u}, \tag{2}$$

where the importance weight $w(p_u)$ is based on the relative similarity between the downstream patent p and all upstream patents p_u. Formally,

$$w(p_u) = \frac{sim_{p,p_u}}{\sum_{u=1}^{N_u} sim_{p,p_u}}, \tag{3}$$

where patent similarity sim_{p,p_u} between patents p_u and p measures the textual similarity of patent claims between these two patents, as proposed in Whalen (2018) and Whalen et al. (2020). A higher sim_{p,p_u} suggests greater bargaining power for the owner of the upstream patent p_u in pursuit of rent from the owner of the downstream patent p. We use patent claims to construct the weight measure because the claims define the boundaries of the property rights attached to a patent (Marco et al., 2019).

The *firm-level institutional shareholder overlap* (SOL_s) is obtained by averaging sol_p over all N_p patents filed by firm s in a given year, given by

$$SOL_s = \frac{1}{N_p} \sum_{p=1}^{N_p} sol_p = \frac{1}{N_p} \sum_{p=1}^{N_p} \sum_{u=1}^{N_u} w(p_u) psol_{p,p_u}. \tag{4}$$

Not all institutional investors are interested in engaging in corporate governance. Passive institutional investors tracking stock indexes may have little incentive to resolve inter-firm conflicts. For this reason, we exclude ownership by ETF funds. To do so, we follow Antoniou et al. (2023) and identify all U.S. equity ETFs by merging the CRSP stock database with the CRSP Survivor-Bias Free Mutual Fund database. We then exclude overlapping ownership created by these ETFs from our analyses. In addition, we drop upstream patents that have

[9] Our evidence remains qualitatively robust when extending the time lag to two or three years for the ownership measurement relative to the patent application year.

expired by the time the institutional shareholder overlap measure is constructed.

3.3 Measuring Innovation Success

We use the total number of a patent p's future citations ($cites_p$) from the patent filing year t to 2020 as our proxy for patent success. Studies show that future citation count correlates positively with the economic value of a patent (e.g., Harhoff et al., 1999, 2003; Kogan et al., 2017) and with firm value (e.g., Hall et al., 2005; Farre-Mensa et al., 2020).[10]

We aggregate the patent-level citation count $cites_p$ to the total number of future citations generated by the cohort of patents filed by firm s in year t, denoted by $CITES_{s,t}$. Self-citations are excluded. We set $cites_p$ to zero for patents receiving no citations until the end of our sample period. If a firm-year has no patent, we set $CITES_{s,t}$ to missing. Because patent citation is highly skewed, we apply a logarithmic transformation $ln(1 + CITES_{s,t})$ to obtain a more normally distributed variable for the OLS regression analysis. In Section 7, we demonstrate that our findings remain robust when using the negative binomial model and the quasi-maximum likelihood Poisson model, where we do not apply the logarithmic transformation to the citation measure.

Our analysis also examines the extensive margin and intensive margin of patent production. The extensive margin, $N_{s,t}$, represents the total number of patent filings by firm s in year t. The intensive margin, $\overline{cites}_{s,t}$, is defined as the average number of citations per patent, calculated by dividing the total citations $CITES_{s,t}$ by the number of patents $N_{s,t}$.

We implement standard procedures to adjust for biases related to patent and citation truncation. First, since our patent data set only includes patents that are eventually granted, we limit our empirical analysis to patents granted until 2017. This adjustment ensures that each patent has at least three years to accumulate citations by 2020. Second, we incorporate year fixed effects in all our regressions. This approach helps to control for variation in the time span over which patent citations accumulate.

[10] Although forward citation count is an indirect measure of patent success, it has the advantage that it is directly observable for a large number of firms with a long history. The measure used in Harhoff et al. (1999) is based on a survey conducted in 1999 and is available for only a small number of U.S. and German patents. The precision of the dollar values of patents estimated by Kogan et al. (2017) relies on the validity of the model assumptions they use to obtain the estimates. Among other things, they assume that investors have perfect knowledge about the market value of a patent before it is granted by USPTO. Any violation of the model assumptions can cause the estimates to deviate away from their true values.

3.4 Summary Statistics

Institutional ownership in U.S. stocks has grown rapidly, from an average of 24% in 1991 to 55% in 2017. The corresponding share is considerably larger for patent-filing firms and rises from 41% in 1991 to 73% in 2017. Patent-filing firms tend to be larger, and institutional investors typically prefer large firms. Graphs A and B in Figure 2 depict the distributions of institutional ownership and firm-level institutional shareholder overlap, respectively, for the period 1991–2017. The average firm-level institutional shareholder overlap fluctuates in our sample. In our analysis, year fixed effects are included in all regressions to ensure that the observed institutional shareholder overlap effect does not capture any parallel time trend in patent success. Cross-sectionally, institutional shareholder overlap is positively related to institutional ownership in the downstream firm and even more strongly with its market capitalization, as shown in Figure 2, Graphs C and D. Institutional shareholder overlap also varies substantially across firms with similar levels of institutional ownership and market capitalization. Such large heterogeneity in a firm's indirect control over complementary upstream patents via overlapping institutional shareholders can plausibly condition patent holdup and determine a firm's long-run patent success.

[Insert Figure 2 about here.]

[Insert Table 1 about here.]

Table 1, Panel A, reports the summary statistics of the 29,196 firm-year observations for the period 1991–2017. A median firm-year in our sample has about 7 ($= e^{1.609}-1$) patents and 54 ($= e^{4.007}-1$) forward citations. The firm-level institutional shareholder overlap ($SOL_{s,t-1}$) features an average of 6.6% with a standard deviation of 6.4%. The median institutional ownership ($Institutional\ Ownership_{s,t-1}$) is high at 59.1%. We provide detailed definitions of all variables in the Appendix, Table A1.

4 Main Findings

4.1 Institutional Shareholder Overlap and Patent Success

In this section, we test the main hypothesis by examining several variables of patent production and relate them to firm-level institutional shareholder overlap with the relevant upstream firms.

Our baseline regression relates a firm's patent success [measured in log terms as $ln(1+CITES_{s,t})$] to institutional shareholder overlap in the following linear regression

$$ln(1 + CITES_{s,t}) = \beta_0 + \beta_1 SOL_{s,t-1} + \beta_2 Controls_{s,t-1} + \epsilon_I + \mu_t + \eta_{s,t}, \quad (5)$$

where $SOL_{s,t-1}$ is the institutional shareholder overlap of firm s at the end of year $t-1$. For control variables, $ln(Assets_{s,t-1})$ represents the natural logarithm of the firm's total assets. $R\&D\ Stock/Assets_{s,t-1}$ measures the R&D stock divided by total assets, where $R\&D\ Stock_{s,t} = R\&D\ Exp_{s,t} + 0.85 \times R\&D\ Stock_{s,t-1}$. In calculating $R\&D\ Stock_{s,t}$, we follow Hall et al. (2005) and use a 15% depreciation rate for R&D expenditure. When a firm's R&D expenditure is missing for a year, we adopt the common practice in management literature and replace the missing value with the average R&D expenditure of other firms in the same four-digit SIC industry for that year (Koh and Reeb, 2015).[11] Additional control variables include the (log) capital-labor ratio, $ln(Capital/Labor)_{s,t-1}$, with $Capital$ measured by property, plant, equipment and $Labor$ by the number of employees, and financial leverage, $Leverage_{s,t-1}$, calculated as long-term liabilities divided by total assets. Finally, we control for the $Private\ Patent\ Share_{s,t-1}$, which measures the average share of privately owned upstream patents for each downstream firm s. This control variable addresses the data limitation that some upstream patents are held by privately-held firms, for which institutional ownership is not reported. Whenever privately owned upstream patents constitute a significant proportion of all upstream firms, our institutional shareholder overlap measurement is less precise, which can result in attenuated point estimates for SOL.

Our regression controls for the year fixed effects (μ_t) and industry fixed effects (ϵ_I). Industry is defined based on four-digit SIC industry classification. In addition, we use the pre-

[11] We note that our results remain robust if we replace the missing R&D expenditure by zero values, as reported in Internet Appendix Table A3.

sample mean scaling method proposed by Blundell et al. (1999) to control for firm fixed effects. This method helps address estimation inconsistencies that arise if firm dummies are used in situations where independent variables are not strictly exogenous, as noted by Imbens and Wooldridge (2007).[12] To apply this method, we calculate the mean of the dependent variable (i.e., $CITES_{s,t}$) for each firm over a 25-year pre-sample period from 1976 to 1990, and include this pre-sample mean in the regression as a control variable.[13] The pre-sample mean, calculated with long-run historical patent data, serves as a suitable proxy for a firm's latent innovation capability. Various studies use this methodology, including those by Blundell et al. (1999) on the relationship between innovations and market shares, Aghion et al. (2013) on innovations and institutional ownership, and Blanco and Wehrheim (2017) on innovations and option trading.

[Insert Table 2 about here.]

In Table 2, Columns 1 and 2 present the results for the firm-level aggregated patent success. Robust standard errors, clustered at the firm level, are reported in parentheses. The baseline regression in Column 1 shows that institutional shareholder overlap represents a statistically highly significant explanatory variable with the predicted positive coefficient. Column 2 additionally controls for firm fixed effects, using the pre-sample mean scaling estimator by Blundell et al. (1999). The coefficient of institutional ownership overlap is also economically highly significant: A point estimate of 6.623 for $SOL_{s,t-1}$ suggests that an increase in institutional shareholder overlap by one standard deviation (or 0.064) increases patent success in terms of a firm's log patent citations $[ln(1 + CITES_{s,t})]$ by 19.28% of its standard deviation (2.199) or 10.55% of its mean (4.018). This shows that institutional shareholder overlap with upstream firms owning complementary patents correlates strongly with the patent success of the downstream firm—consistent with the holdup attenuation hypothesis.

We next examine the intensive and extensive margin of patent success. The intensive margin, $\overline{cites}_{s,t}$, is defined as the average number of citations per patent. Again, we use the logarithmic

[12] The asymptotic bias is especially large for samples with small T. Specifically, Imbens and Wooldridge (2007) show that under contemporaneous exogeneity the fixed effect estimator with firm dummies has the property: $plim\ \hat{\beta} = \beta + O(T^{-1})$.

[13] For firms with less than 25 years of data, we use the maximum available years, requiring at least one year of history to include the firm in the sample. Our results remain qualitatively unchanged even if alternative cutoffs of 20, 15, or 10 years are used.

transformation $ln(1 + \overline{cites}_{s,t})$ to obtain a suitable dependent variable for the linear regression

$$ln(1 + \overline{cites}_{s,t}) = \gamma_0 + \gamma_1 SOL_{s,t-1} + \gamma_2 Controls_{s,t-1} + \epsilon_I + \mu_t + \eta_{s,t}, \quad (6)$$

where $SOL_{s,t-1}$ is firm-level institutional shareholder overlap of firm s at the end of year $t-1$. A positive value of γ_1 points to ex-post patent value destruction for patents developed under holdup threat, where the patent conflict is not attenuated through institutional shareholder overlap. As shown in Table 2, Column 4, the point estimate (1.126) implies that an increase in institutional shareholder overlap by one standard deviation (or 0.064) corresponds to an increase in the average citation count per patent of about 5.43% (3.06%) of its standard deviation (mean) of 1.328 (2.355).

The analogous specification for the extensive margin uses the log number of granted patents [$ln(1 + N_{s,t})$] applied by firm s in year t as the dependent variable in the linear regression

$$ln(1 + N_{s,t}) = \psi_0 + \psi_1 SOL_{s,t-1} + \psi_2 Controls_{s,t-1} + \epsilon_I + \mu_t + \eta_{s,t}. \quad (7)$$

The coefficient ψ_1 captures the relation between institutional shareholder overlap ($SOL_{s,t}$) and the log number of granted patents. Column 6 of Table 2 again reports a positive point estimate $\widehat{\psi}_1 = 4.568$. A one-standard-deviation increase in $SOL_{s,t-1}$ is associated with a 29.23% increase in the number of patents—suggesting an economically strong nexus between holdup attenuation and the number of successful patents a firm files.

Overall, the results suggest that holdup attenuation through institutional shareholder overlap is associated with both more citations for each patent granted (i.e., the intensive margin of patent success) and the pursuit of more patents (i.e., the extensive margin of patent production). The latter effect is of particularly high economic significance and indicative of a severe underinvestment problem, as it reflects a reduced number of patent ideas pursued in cumulative innovation processes.

4.2 Institutional Shareholder Overlap and Litigation Risk

If institutional shareholder overlap can attenuate patent holdup, it should also attenuate patent conflicts mutating into costly patent litigation. Existing studies (e.g., Gerakos and Xie, 2019; He and Huang, 2017; Newham et al., 2018) show some evidence that investors internalize conflicts among firms within their equity portfolios. We extend this work to patent litigation based on patent litigation data from Public Access to Court Electronic Records (PACER) covering the period from 1992 to 2015.

During the sample period, our data identify 5,463 patent litigation cases comprising 7,547 plaintiff-defendant firm pairs for which both plaintiff and defendant can be identified in Compustat.[14] If the same plaintiff and defendant are involved in multiple litigation cases in a year, we count them as one plaintiff-defendant firm pair referred to as a litigation pair hereafter. We only include litigation pairs where the defendant firm has cited a patent from the plaintiff in its own patent filings within the 10 years prior to the litigation year. After applying these criteria, 1,345 patent litigation pairs remain. As illustrated in Figure 1, intra-industry pairs of patent-filing firms that have a citation link between them face a 16.8 times higher bilateral litigation risk (an absolute risk of 0.168%) compared to intra-industry pairs without such a link, where the absolute risk is only 0.010%. This suggests that patent citation links are a significant indicator of potential patent conflicts and holdup scenarios.

Next, we construct a sample of patent litigation pairs and similar firm pairs without litigation for further regression analyses. Each patent litigation pair, denoted by $[D, P]$ involving a defendant firm D and a plaintiff firm P, is matched to a new firm pair, denoted by $[D', P]$. In a matching firm pair, the original defendant D is replaced by a firm D' that satisfies the following three criteria: (i) D' must have cited the plaintiff P in its patent filings over the past 10 years, similar to D, but is *not* involved in litigation with P. (ii) D' must operate within the same Fama-French 49 industry as D. Among all qualified firms, we pick the firm D' that (iii) minimizes the Mahalanobis distance between D and D' involving six determinants of patent litigation identified by Cohen et al. (2019), namely the log of total assets $[ln(Assets_{s,t-1})]$, the log of market capitalization $[ln(MktCap_{s,t-1})]$, Tobin's q ($Tobin\ Q_{s,t-1}$), the log of R&D expenditure $[ln(1 + R\&D\ Exp_{s,t-1})]$, the cumulative patent filings from $t-5$ to $t-1$ ($Patent\ Stock_{s,t-1}$), and the previous year's stock return ($Past\ Return_{s,t-1}$).

For each firm D, we select not only the matching firm D' with the shortest Mahalanobis

[14] We have more plaintiff-defendant firm pairs than litigation cases because a litigation case can consist of several plaintiffs or several defendants. For example, if a case has two plaintiffs and three defendants, this case generates six plaintiff-defendant firm pairs.

distance, but also the second closest firm D'', if available, to obtain two matched firm pairs for any litigation pair. This procedure results in a sample comprising 846 actual litigation pairs and 1,536 matched firm pairs without patent litigation. Indexing each firm pair in the sample by j, we create a litigation dummy $Litigation_{j,t}$ equal to one if firm pair j is an actual litigation pair and equal to zero if j is a matched firm pair. We estimate the following pair-level regression

$$Litigation_{j,t} = \lambda_0 + \lambda_1 psol_{j,t-1} + \lambda_2 Controls_{D,t-1} + \epsilon_m + \mu_t + \eta_{j,t}, \tag{8}$$

where the key variable of interest is the shareholder overlap $psol_{j,t-1}$ of the firm pair j, as defined in Equation 1 earlier. Our specification includes time fixed effects (μ_t) and matched group fixed effects (ϵ_m) that identify each matched group m, which comprises an actual litigation pair ($[D, P]$) and its two corresponding matched pairs, $[D', P]$ and $[D'', P]$. Because all three firm pairs within each matched group share the same plaintiff, these matched group fixed effects essentially control for any plaintiff firm characteristics. Firm characteristic controls for actual defendant firms or their matched counterparts include all six firm characteristics used for the Mahalanobis distance matching.

[Insert Table 3 about here.]

Table 3, Panel A compares the defendant firm and its matched counterparts along all the firm characteristic variables used for the Mahalanobis distance matching. The comparison shows no systematic differences. However, in terms of pairwise institutional shareholder overlap with the corresponding plaintiff firm, the defendant firms show a notably lower value by 0.019 than the pseudo defendants, which represents 8.3% of the average overlap value of 0.23. This discrepancy may reflect a selection effect: potential defendants that have high institutional shareholder overlap with their potential plaintiffs can avoid being sued, and thus do not appear in our dataset, which is constructed based on firm pairs that have entered into patent litigation. This parsimonious comparison supports our hypothesis that institutional shareholder overlap with upstream firms reduces the likelihood of downstream firms being sued.

To perform the analysis more rigorously, we run the pair-level regression, as specified in Equation 8, with all control variables and fixed effects included. The regression results are tabulated in Panel B of Table 3. In Column 2, a point estimate of -0.637 for $psol_{j,t-1}$ implies that a one-standard-deviation (or 0.188) increase in pairwise institutional shareholder overlap decreases the litigation likelihood by 12 percentage points. We conclude that institutional shareholder overlap with a potential upstream plaintiff predicts a reduction in patent litigation risk by an economically significant magnitude. The result echoes the finding by Chiao et al. (2020), who document a lower litigation risk for same-industry firms with more overlapping institutional ownership.

4.3 Institutional Shareholder Overlap and R&D Expenditure

The holdup attenuation hypothesis implies that institutional shareholder overlap should not only foster patent success, but also reduce ex-ante firm underinvestment in R&D. R&D expenditure is directly reported and thus provides a useful accounting statistic to assess firm-level inputs into the patent development process.

[Insert Table 4 about here.]

We regress a firm's log of one plus R&D expenditure [$ln(1+R\&D\ Exp_{s,t})$] on its institutional shareholder overlap with the relevant upstream firms owning complementary patents; formally

$$ln(1 + R\&D\ Exp_{s,t}) = \kappa_0 + \kappa_1 SOL_{s,t-1} + \kappa_2 Controls_{s,t-1} + \epsilon_s + \mu_t + \eta_{s,t}, \quad (9)$$

where institutional shareholder overlap $SOL_{s,t-1}$ is again the key variable of interest. Table 4 reports regression results. The most comprehensive specification in Column 4 shows a statistically significant point estimate of 0.861 for $SOL_{s,t-1}$. Specifically, an increase in institutional shareholder overlap by one standard deviation (0.064) results in a 5.5% increase in R&D expenditure. This finding supports our hypothesis that firms increase R&D investments in response to the mitigation of patent holdup.

5 Heterogeneity in Holdup Attenuation

In this section, we present additional results that explore heterogeneity in the holdup attention effect of institutional shareholder overlap. These results pertain to differences in product complexity, the share of strategic patents, and downstream firms' dependence on foreign upstream firms. All three dimensions of heterogeneity are related to the logic of patent holdup and therefore support the holdup attenuation hypothesis indirectly.

5.1 Product Complexity

Theoretical considerations suggest that the patent holdup problem becomes more severe with the complexity of the product (Cohen et al., 2000). "Complex products" comprise numerous complementary patents, which increase the *ex ante* contracting cost and augment the potential for patent holdup. By contrast, "discrete products" incorporate fewer prior patents and are therefore less susceptible to patent holdup.

Accordingly, we conjecture that institutional shareholder overlap is more effective at reducing patent holdup in complex product industries than in discrete product industries. To test this conjecture, we compare the information technology industry, known for its complex products, with the pharmaceutical industry, which typically produces discrete products often based on a single new active substance. We use the Fama-French 49 (FF49) industry classification to categorize the industries. The information technology industry comprises firms assigned to Electronic Equipment category (FF49 code = 37) and Computer category (FF49 code = 35), while the pharmaceutical industry consists of firms assigned to Drug and Pharmaceutical category (FF49 code = 13).

[Insert Table 5 about here.]

Table 5 presents the regression results for the two industries. We find that institutional shareholder overlap is a highly significant explanatory variable for patent success in both complex and discrete product industries. However, a comparison of the coefficients indicates that the effect of institutional shareholder overlap in complex product industries is 70% higher than in the discrete product industries. This is consistent with our hypothesis that the holdup attenuation effect of institutional shareholder overlap is more pronounced in industries where the patent holdup problem is structurally more severe.

5.2 Strategic Patenting

Patent holdup spurs firms to produce patents for strategic purposes. Rather than commercializing the protected technologies, firms use these patents as bargaining chips for licensing or cross-licensing (Hall and Ziedonis, 2001). If the observed patent success of downstream firms in our baseline findings stems from increased strategic patenting activities, the validity of the holdup attenuation hypothesis would be questioned. We address this concern in two steps.

First, studies indicate that strategic patents are usually of low quality (Abrams et al., 2013). However, our evidence in Section 4.1 on the increased intensive margin of patent production [Table 2, Columns 3–4] indicates that average patent quality improves if shareholder overlap is larger. This evidence contradicts the idea that increased strategic patenting drives our findings.

Second, following Mezzanotti (2021), we construct a measure for strategic patenting. Because the primary purpose of strategic patents is to serve as a tool in litigation, this purpose implies two key features for such patents, namely low quality and broad coverage of different technologies. The rationale here is that these patents do not necessarily need to carry much commercial value, but should cover a wide range of technologies so they can be used in many potential litigation cases. We use forward citations to gauge patent quality and a measure for patent originality developed in Hall and Ziedonis (2001) to gauge the breadth of technology coverage. A patent is then considered strategic if it ranks in the top 25% for originality among all patents in the same CPC class and year, but falls into the bottom three quartiles in terms of future citations for the same cohort.

[Insert Table 6 about here.]

Table 6, Columns 1–2 report regression results where the share of strategic patents filed by a firm is the dependent variable. In Column 2, a coefficient estimate of -0.137 indicates that a one-standard-deviation increase (0.064) in institutional shareholder overlap is related to a 39.9% decrease in the share of strategic patents relative to its mean value (0.022). A reduced share of strategic patents suggests that changes in strategic patents cannot explain our main findings of increased patent counts and patent citations when institutional shareholder overlap is larger.

To provide more direct evidence of strategic patenting, we focus on business method patents, which are typically used for strategic purpose. Following Mezzanotti (2021), we define business method patents as those patents assigned to the US patent class of 705. Table 6, Column 3, presents results from a parsimonious regression specification without any control variables. Again, we find that the increased institutional shareholder overlap is significantly associated with a decreased share of strategic patents. Although the coefficient for institutional shareholder overlap becomes insignificant in Column 4 when controlling for other variables, it remains negative, which is inconsistent with the notion that strategic patenting behavior can explain our baseline findings.

In summary, the three pieces of evidence presented in this subsection collectively indicate that changes in strategic patents do not represent a plausible explanation for our findings. We conclude that the increased patent count and patent citations are primarily driven by patents with a focus on innovation when patent holdup is attenuated through shareholder overlap.

5.3 Upstream Patents Held by Foreign Firms

Thus far, our study has not accounted for upstream patents owned by foreign firms for which institutional ownership data is not available to us. Although these foreign upstream firms could pose a holdup risk for downstream firms, the impact is likely to be limited. This is due to the high litigation costs faced by these foreign firms in the U.S., which hinder their ability to impose patent holdup on U.S. downstream innovators. Lanjouw and Schankerman (2001) documented that even when engaging in domestic legal representation, foreign firms incur higher costs in communications and in translating business documents into a form that will be understood by a U.S. court.

Nevertheless, we conduct additional analyses to assess the impact of omitting foreign upstream firms. We categorize firms based on the proportion of foreign upstream firms they cite. Specifically, we calculate a firm-year's dependence on foreign upstream firms as the share of the firm's patents filed in that year that cite at least one foreign upstream firm. Since our institutional shareholder overlap measure includes only U.S. upstream firms, it is likely to understate the effective shareholder overlap for firms exposed heavily to foreign upstream firms.

[Insert Table 7 about here.]

We evenly sort all firm-years into high and low groups according to the dependence on foreign upstream firms. We conduct separate regressions for each subsample presented in Table 7. While institutional shareholder overlap yields a statistically significant positive coefficient for both the high and low dependence groups, the coefficient size is much smaller for the high dependence group. This observation is consistent with our prediction that omitting foreign upstream patents in the institutional shareholder overlap introduces an attenuation bias in the regression estimates.

6 Endogeneity Concerns about Institutional Shareholder Overlap

Our primary endogeneity concern involves the buildup of institutional ownership. It is conceivable that institutional investors select stocks based on their growth and innovation potential. For example, if both upstream and downstream firms exhibit these qualities, the observed positive relationship between institutional ownership overlap and patent performance could be more a consequence of stock selection than a resolution of patent holdup. In this section, we conduct three tests to mitigate this and other endogeneity concerns.

6.1 Controlling for Institutional Ownership

Our first test involves directly controlling for institutional ownership in the regression. If a firm's patent potential, as observed by institutional investors, constitutes an omitted variable, it should be captured by their institutional ownership, provided that their investment activities reflect their perception of the firm's patent potential.

[Insert Table 8 about here.]

In Table 8, Columns 1–6, we include $Institutional\ Ownership_{s,t-1}$ as an additional explanatory variable of patent success and find that institutional shareholder overlap retains its high positive level of statistical significance. Surprisingly, after including the new control variable, Columns 2 and 6 even suggest a negative relationship between institutional ownership and patent success.

6.2 Two Placebo Tests

Our second approach employs two placebo tests. While we regard firms linked by patent citations as holding complementary patents, these firms may also share other commonalities that attract institutional investors. Therefore, the institutional shareholder overlap identified through citation links may also reflect these investors' preferences for specific traits common among firms connected by patent citations. To address this endogeneity issue, for each downstream firm, we replace its institutional shareholder overlap (identified through patent citations) with a placebo institutional shareholder overlap from a 'similar' upstream firm without a citation link. We explore whether using the placebo institutional shareholder overlap is sufficient to eliminate the positive effects on patent outcomes documented in previous sections.

The first placebo measure, $SOL\_Placebo1_{s,t-1}$, replaces each cited upstream firm with a "similar" firm from the same product market (proxied by four-digit SIC industry) that is not cited by the downstream firm in the given year. The "similar" firm is selected based on its closeness to the actual upstream firm in terms of total assets and the number of patent filings over the past five years. The second placebo measure, $SOL\_Placebo2_{s,t-1}$, follows a similar methodology, but selects the "similar" firm based solely on technological proximity, as defined by Bloom et al. (2013).[15]

If the high patent potentials concurrently experienced by upstream and downstream firms result from common product or technological trends and a criterion for institutional investments, the overlapping ownership between the same downstream firm and the "similar" upstream firms should also show a significantly positive correlation with the downstream firm's patent success.

[Insert Table 9 about here.]

The regression results are presented in Table 9. Unlike the true institutional shareholder overlap ($SOL_{s,t-1}$), its placebo equivalents ($SOL\_Placebo1_{s,t-1}$ and $SOL\_Placebo2_{s,t-1}$) do not feature any statistically significant correlation with patent success. Therefore, the positive correlation between institutional shareholder overlap and patent success is contingent on picking exactly those upstream firms that are cited by the downstream firm in its patent filings.

[15] We provide detailed definitions of all variables in the Appendix Table A1.

6.3 Shareholder Anticipation of Holdup?

A more elaborate endogeneity argument might claim that institutional investors systematically invest in upstream and downstream firms in order to alleviate patent conflict and earn rents from such conflict resolution. We note that this argument does not question the beneficial role of institutional ownership in mitigating patent holdup, but asserts that a liquid equity market is well-suited to deal with patent holdup through dynamic ownership adjustment.

To probe the empirical validity of such endogenous ownership adjustment to holdup, we analyze the evolution of institutional shareholder overlap around the year of patent filings. Initially, our baseline measure of institutional shareholder overlap, $SOL_{s,t-1}$, is based on the ownership stake from one year prior to the patent filing year t. For clarity, we will refer to this baseline measure as $SOL_s(t,-1)$, where t represents the patent filing year, and -1 indicates that the ownership data is measured one year before the patent filing year. To expand our analysis, we introduce additional measures of institutional shareholder overlap, denoted as $SOL_s(t,k)$, where k ranges from -5 to 5. These measures use ownership stakes from five years before to five years after the patent filing year t. Thus, each firm-year could correspond up to 11 measures of institutional shareholder overlap.

Next, we calculate the institutional shareholder overlap based on placebo citation links as in Section 6.2 and define corresponding (placebo) institutional shareholder overlaps, $SOL\_Placebo1_s(t,k)$ and $SOL\_Placebo2_s(t,k)$. These placebo measures serve as a benchmark, which enables us to assess the evolution of $SOL_s(t,k)$ with the correct upstream citation link.

In Figure 3, $\overline{SOL}(k)$, denoting the average of $SOL_s(t,k)$ across all sample firm-years, is plotted against k. For benchmarking purpose, Figure 3 also depicts $\overline{SOL}\_Placebo1(k)$ and $\overline{SOL}\_Placebo2(k)$, which, respectively, represent the averages of $SOL\_Placebo1_s(t,k)$ and $SOL\_Placebo2_s(t,k)$ across all sample firm-years.

[Insert Figure 3 about here.]

Figure 3 shows that around the patent filing year ($k=0$), the average institutional shareholder overlap $\overline{SOL}(k)$, depicted in red, evolves similarly to the two placebo benchmarks, $\overline{SOL}\_Placebo1(k)$ and $\overline{SOL}\_Placebo2(k)$, depicted in blue. The vertical line marks one standard deviation around the mean value for each measure. We find no evidence that the institutional shareholder overlap $\overline{SOL}(k)$ endogenously reacts in anticipation of patent rents of future patent filing. Instead, its evolution mimics that of the two benchmark measures, which are by construction devoid of future patent rents.

This finding may not be surprising for at least two reasons: First, patent developments are generally kept secret so that public information should be extremely scarce. Second, legal restrictions on insider trading limit the scope for stock trading on private information. We conclude that equity market liquidity is not a sufficient condition to produce an optimal endogenous adjustment of institutional ownership structure to minimize patent holdup.

7 Robustness

Our analysis uses one-year lagged ownership data (relative to patent filing year) to construct institutional shareholder overlap and investigates its impact on patenting outcome. But any influence of ownership overlap does not stop within a year, but should persist over a more extended period. We therefore conjecture that the institutional shareholder overlap based on lagged ownership measurement (by multiple years) still exerts a holdup attenuation effect. However, a larger temporal separation between the ownership measurement and the real effects makes the reverse causality from patent success to (prior) institutional ownership much less plausible.

To this end, we modify our baseline measure of institutional shareholder overlap $SOL_{s,t-1}$, which relies on the ownership stake at the end of year $t-1$, and replace it with an alternative institutional shareholder overlap measurement taken up to five years prior to the patent filing. The results, as reported in Internet Appendix Table A5, show that various measures of institutional shareholder overlap based on ownership data measured from $t-5$ to $t-2$ remain highly statistically and economically significant, albeit with a lesser economic magnitude.

[Insert Table 10 about here.]

Additionally, we follow Table 1 of Aghion et al. (2013) to model citations (i.e. the variable CITES in our paper) using both negative binomial and Poisson models. We report the results of negative binomial regressions in Table 10 and the results of Poisson regressions in Table A2. We note that according to Hilbe (2014) and Xie and Xiao (2020), the negative binomial model is a more flexible regression model, capable of handling the overdispersion feature often found in empirical data. By contrast, the Poisson count model imposes a restrictive assumption that the variance equals the mean. Therefore, we only report the results of negative binomial models in the main text. As shown in Table 10, the estimates of SOL from negative binomial regressions are qualitatively similar to those obtained from the OLS regressions reported in earlier tables, suggesting that our results are robust to using this count model specification. The estimation results of Poisson regressions, reported in Table A2, again show qualitatively similar results to those from the OLS regressions or negative binomial models. Overall, our findings remain highly robust when using those alternative models, suggesting that the results of this study are not artifacts of the specific regression model used.

8 Discussion and Conclusion

According to Shapiro and Lemley (2020), *"Patent holdup has proven one of the most controversial topics in innovation policy, in part because companies with a vested interest in denying its existence have spent tens of millions of dollars trying to debunk it. Notwithstanding a barrage of political and academic attacks, both the general theory of holdup and its practical application in patent law remain valid and pose significant concerns for patent policy."* As they concede, a major research obstacle resides in the difficulty of identifying actual holdup situations in large firm samples. Our paper makes progress in this critical direction by using citation links from downstream patent filings to precursory patents, as first proposed by Galasso and Schankerman (2015).

We show that such patent citation links feature a high correlation with the probability of patent litigation between firms. We then use the citation links to construct holdup-specific institutional shareholder overlap between the downstream firm filing a new patent and the upstream firm owning the cited precursory patent. From a property rights perspective of the firm, a downstream firm with a large holdup-specific institutional shareholder overlap benefits from an extended firm boundary and faces reduced holdup risk.

The full sample of U.S. (patent filing) listed firms in 1991–2017 with 29,196 firm-years reveals an economically and statistically significant relationship between a firm's patent success and its institutional shareholder overlap with firms owning upstream patents. A one-standard-deviation increase in the holdup-relevant shareholder overlap increases patent success [captured by (log) citations] by almost 20% of its standard deviation. This economically strong relationship extends to both the extensive margin (patent count based) and the intensive margin (average citation count based) of patent production. Also, consistent with the holdup attenuation hypothesis, we find that increased institutional shareholder overlap with upstream firms is associated with a lower likelihood of being sued by these upstream firms and much higher R&D expenditures.

To further support the holdup attenuation hypothesis, we explore heterogeneity effects as well as potential endogeneity concerns. First, a sector analysis reveals that the role of institutional shareholder overlap in mitigating holdup risk is more prominent in industries with complex products, for which *ex ante* contracting is more difficult. Second, we show that institutional shareholder overlap promotes innovation-focused patenting but curtails the incentive for strategic patenting. Third, we find that the exclusion of foreign firms due to missing ownership data tends to underestimate the economic magnitude of the holdup attenuation effect. Lastly, we perform several placebo tests to mitigate endogeneity concerns as well as exploring the possibility of reverse causality, whereby (anticipated) patent success drives institutional ownership.

In this study, we primarily focus on the 'bright' side of institutional ownership overlap by exploring how overlapping institutional shareholders between upstream and downstream innovating firms mitigate the patent holdup problem. However, we note that overlapping (or common) ownership between industry peers can influence innovation through decreased product market competition. Several recent studies have investigated this rivalry effect in the product market. In particular, Azar et al. (2018) document that increases in common ownership concentration on an airline route lead to route-level increases in ticket prices by 3-7%. He and Huang (2017) show that within-industry institutional shareholder overlap increases a firm's market power, operating profitability, profit margins, and R&D productivity. Chiao et al. (2020) provide evidence that within-industry institutional shareholder overlap reduces a firm's R&D expenditure, patent output, and citations, consistent with an anti-competitive effect of overlapping ownership. Antón et al. (2024) consider two effects of innovation, technological spillover and product market rivalry. They find that institutional shareholder overlap impedes (increases) innovation when the latter (former) effect dominates.

These aforementioned studies examine institutional shareholder overlap in firms competing directly in the product markets. By contrast, our study focuses on institutional shareholder overlap between upstream and downstream innovating firms that hold complementary patents, which may not be direct competitors in the product markets. The difference in the pair of firms for which shareholder overlap is measured likely explains the different findings between our study and these earlier studies.

We acknowledge that our identification of holdup risk through citation links can be refined in future research and possibly fine-tuned to fit specific institutional and technological conditions found in each industry. Such refined measurements of patent holdup promise a more informed public policy debate on how to make an economy increasingly dominated by technological firms more innovative and competitive. In addition, the holdup attenuation effect identified in this paper is only one facet of institutional shareholder overlap. Future studies could provide further insights by conducting conditional analyses focusing on specific problems of interfirm coordination and conflicts.

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Table 1: Descriptive Statistics

Firm-level dependent variables are (i) $CITES_{s,t}$, the number of future citations received by the cohort of patents filed by firm s in year t; (ii) $N_{s,t}$, the number of patents filed by firm s in year t; (iii) $\overline{cites}_{s,t}$, the average future citation count per patent for the cohort of patents filed by firm s in year t; (iv) $R\&D\ Exp_{s,t}$, R&D expenditure; (v) $Strategic\ Patent\ Share_{s,t}$, the share of strategic patents; and (vi) $BM\ Patent\ Share_{s,t}$, the share of business method patents. $SOL_{s,t-1}$ refers to the average institutional shareholder overlap of a downstream firm with all potential holdup firms owning precursory patents to those filed by the downstream firm s in year $t-1$. $SOL\_Placebo1_{s,t-1}$ and $SOL\_Placebo2_{s,t-1}$ are two placebo institutional shareholder overlap measures based on counterfactual (pseudo) citation links. $Institutional\ Ownership_{s,t-1}$, is the percentage institutional ownership share of firm s. The control variables include log total assets [$ln(Assets_{s,t-1})$], cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), log capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. The source and exact definition of each variable are provided in the Appendix A, Table A1.

	Obs. (1)	Mean (2)	Median (3)	S.D. (4)	Min. (5)	P25 (6)	P75 (7)	Max (8)
$ln(1+CITES_{s,t})$	29,196	4.018	4.007	2.199	0.000	2.485	5.501	11.965
$ln(1+\overline{cites}_{s,t})$	29,196	2.355	2.398	1.328	0.000	1.386	3.258	7.586
$ln(1+N_{s,t})$	29,196	2.096	1.609	1.430	0.693	1.099	2.833	9.094
$ln(1+R\&D\ Exp_{s,t})$	29,196	3.195	3.118	1.845	0.000	1.899	4.312	10.269
$Strategic\ Patent\ Share_{s,t}$	29,196	0.022	0.000	0.125	0.000	0.000	0.000	1.000
$BM\ Patent\ Share_{s,t}$	26,106	0.019	0.000	0.118	0.000	0.000	0.000	1.000
$SOL_{s,t-1}$	29,196	0.066	0.050	0.064	0.000	0.014	0.101	0.528
$SOL\_Placebo1_{s,t-1}$	29,196	0.178	0.173	0.094	0.000	0.111	0.239	0.933
$SOL\_Placebo2_{s,t-1}$	29,196	0.151	0.148	0.092	0.000	0.087	0.209	0.683
$Institutional\ Ownership_{s,t-1}$	29,196	0.550	0.591	0.289	0.000	0.310	0.790	1.000
$ln(Assets_{s,t-1})$	29,196	6.168	5.953	2.332	0.209	4.435	7.716	14.761
$R\&D\ Stock/Assets_{s,t-1}$	29,196	0.636	0.273	1.469	0.000	0.089	0.620	21.587
$ln(Capital/Labor)_{s,t-1}$	29,196	3.730	3.627	1.077	−3.157	3.077	4.298	10.723
$Leverage_{s,t-1}$	29,196	0.144	0.088	0.169	0.000	0.000	0.240	0.811
$Private\ Patent\ Share_{s,t-1}$	29,196	0.752	0.786	0.190	0.000	0.639	0.894	1.000

Table 2: Institutional Shareholder Overlap and Innovation Success

This table reports firm-level OLS regressions of patent success using a sample of publicly listed innovating firms during 1991–2017. Patent success is proxied by $ln(1+CITES_{s,t})$, which is the log number of future citations received by the cohort of patents filed by firm s in year t. We decompose patent success into its intensive margin $ln(1+\overline{cites}_{s,t})$, i.e., the log average future citation count per patent for the cohort of patents filed by firm s in year t; and its extensive margin, $ln(1+N_{s,t})$, i.e., the log number of successful patent applications filed by firm s in year t. The key explanatory variable of interest $SOL_{s,t-1}$ measures the lagged average institutional shareholder overlap at the end of year $t-1$ between the innovating firm s and its upstream firms owning complementary patents. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variables:	Firm Aggregate $ln(1+CITES_{s,t})$		Intensive Margin $ln(1+\overline{cites}_{s,t})$		Extensive Margin $ln(1+N_{s,t})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$SOL_{s,t-1}$	10.126***	6.623***	0.869***	1.126***	7.790***	4.568***
	(0.436)	(0.429)	(0.162)	(0.207)	(0.380)	(0.306)
Controls:						
$ln(Assets_{s,t-1})$		0.348***		−0.008		0.297***
		(0.020)		(0.009)		(0.016)
$R\&D\ Stock/Assets_{s,t-1}$		0.053***		−0.010		0.055***
		(0.013)		(0.007)		(0.009)
$ln(Capital/Labor)_{s,t-1}$		0.104***		0.030**		0.081***
		(0.026)		(0.015)		(0.017)
$Leverage_{s,t-1}$		−0.475***		−0.100		−0.289***
		(0.125)		(0.064)		(0.078)
$Private\ Patent\ Share_{s,t-1}$		0.570***		0.178***		0.286***
		(0.103)		(0.057)		(0.065)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,196	29,196	29,196	29,196	29,196	29,196
Adjusted R^2	0.484	0.532	0.547	0.549	0.532	0.607

Table 3: Institutional Shareholder Overlap and Patent Litigation

Panel A compares defendant firms across 846 actual litigation pairs and 1,536 matched litigation pairs, with the matching procedure detailed in Section 4.2. Panel B conducts OLS regression on this matched sample to investigate the impact of institutional shareholder overlap on patent litigation. The dummy variable $Litigation_{j,t}$ equal to one if firm pair j is an actual litigation pair and equal to zero if j is a matched firm pair. The key variable of interest is the shareholder overlap $psol_{j,t-1}$ of the firm pair j, as defined in Equation 1. Control variables for the actual or matched defendants are the log of total assets [$ln(Assets_{s,t-1})$], the log of market capitalization [$ln(MktCap_{s,t-1})$], Tobin's q ($Tobin\ Q_{s,t-1}$), the log of R&D expenditure [$ln(1 + R\&D\ Exp_{s,t-1})$], the log number of patent filings over the past five years ($Patent\ Stock_{s,t-1}$), and last year's stock return ($Past\ Return_{s,t-1}$). The inclusion of matching group dummies identifies each actual litigation pair and its matched pairs. Because all three firm pairs within each matched group share the same plaintiff, these matched group fixed effects essentially control for any plaintiff firm characteristics. Robust standard errors clustered at the matching group level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Panel A: Summary Statistics

	Litigated Firms $Litigation_{j,t} = 1$		Matched Firms $Litigation_{j,t} = 0$		Difference
	Obs.	Mean	Obs.	Mean	(2)-(4)
	(1)	(2)	(3)	(4)	(5)
$psol_{j,t-1}$	846	0.230	1,536	0.249	-0.019^{*}
$ln(Assets_{s,t-1})$	846	8.315	1,536	8.262	0.062
$ln(MktCap_{s,t-1})$	846	15.561	1,536	15.611	−0.042
$TobinQ_{s,t-1}$	846	0.389	1,536	0.363	0.026
$ln(1 + R\&D\ Exp_{s,t-1})$	846	5.528	1,536	5.625	−0.087
$Patent\ Stock_{s,t-1}$	846	5.271	1,536	5.368	−0.093
$Past\ Return_{s,t-1}$	846	0.178	1,536	0.166	0.012

Panel B: Regression analysis

Dep. Variable:	$Litigation_{j,t}$ (0/1)	
	(1)	(2)
$psol_{j,t-1}$	-0.688^{***}	-0.637^{***}
	(0.175)	(0.186)
Controls:		
$ln(Assets_{s,t-1})$		0.234^{***}
		(0.047)
$ln(MktCap_{s,t-1})$		0.044
		(0.041)
$TobinQ_{s,t-1}$		0.360^{**}
		(0.153)
$ln(1 + R\&D\ Exp_{s,t-1})$		-0.174^{***}
		(0.037)
$Patent\ Stock_{s,t-1}$		-0.095^{***}
		(0.027)
$Past\ Return_{s,t-1}$		0.033
		(0.058)
Year FEs	Yes	Yes
Matching Group FEs	Yes	Yes
Observations	2,382	2,382
Adjusted.R^2	−0.539	−0.476

Table 4: Institutional Shareholder Overlap and R&D Expenditure

This table reports the results for the regression of the log of R&D expenditure $[ln(1 + R\&D\ Exp_{s,t})]$ of a downstream firm s facing potential patent holdup on its institutional shareholder overlap $SOL_{s,t-1}$ in year $t-1$. The control variables include the log of total assets $[ln(Assets_{s,t-1})]$, the log of capital to labor ratio $[ln(Capital/Labor)_{s,t-1}]$, firm leverage $(Leverage_{s,t-1})$, and the average proportion of privately owned upstream patents $(Private\ Patent\ Share_{s,t-1})$ for firm s in year $t-1$. We control for a full set of year dummies and industry dummies based on four-digit SIC codes (or firm dummies). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variable:	$ln(1 + R\&D\ Exp_{s,t})$			
	(1)	(2)	(3)	(4)
$SOL_{s,t-1}$	12.801***	2.683***	2.031***	0.861***
	(0.480)	(0.241)	(0.161)	(0.131)
Controls:				
$ln(Assets_{s,t-1})$		0.605***		0.531***
		(0.013)		(0.019)
$ln(Capital/Labor)_{s,t-1}$		0.039**		0.015
		(0.017)		(0.013)
$Leverage_{s,t-1}$		−0.242***		−0.079
		(0.077)		(0.057)
$Private\ Patent\ Share_{s,t-1}$		0.042		0.109***
		(0.058)		(0.037)
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	No	No
Firm FEs	No	No	Yes	Yes
Observations	29,196	29,196	29,196	29,196
Adjusted R^2	0.574	0.797	0.905	0.929

Table 5: Holdup Attenuation by Product Complexity

We compare the holdup attenuation effect of institutional shareholder overlap ($SOL_{s,t-1}$) across industries of different product complexity. The outcome variable $ln(1 + CITES_{s,t})$ is the log number of future citations received by the cohort of patents filed by firm s in year t. Holdup attenuation is measured by the (positive) OLS coefficient for the institutional shareholder overlap ($SOL_{s,t-1}$). Based on the Fama-French 49 industry classification, we sort firms into "complex product industries" if they belong to the electronic equipment (FF49: 37) and computer (FF49: 35) industries and into "discrete product industries" if they belong to the drug and pharmaceutical industry (FF49: 13). The control variables include the log of total assets [$ln(Assets_{s,t-1})$], the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variable:	$ln(1 + CITES_{s,t})$			
	Complex Product Industries		Discrete Product Industries	
	(1)	(2)	(3)	(4)
$SOL_{s,t-1}$	14.024***	8.687***	8.219***	5.036***
	(0.906)	(0.892)	(1.214)	(1.427)
Controls:				
$ln(Assets_{s,t-1})$		0.430***		0.250***
		(0.043)		(0.057)
$R\&D\ Stock/Assets_{s,t-1}$		0.041		0.016
		(0.037)		(0.020)
$ln(Capital/Labor)_{s,t-1}$		0.172**		0.066
		(0.067)		(0.049)
$Leverage_{s,t-1}$		−0.843***		0.108
		(0.316)		(0.269)
$Private\ Patent\ Share_{s,t-1}$		0.802***		0.176
		(0.227)		(0.247)
Year FEs	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes
Observations	5,338	5,338	4,038	4,038
Adjusted R^2	0.470	0.538	0.471	0.501

Table 6: Institutional Shareholder Overlap and Strategic Patenting

This table presents the regression results exploring the relationship between strategic patenting and the downstream firm's overlapping institutional ownership with upstream firms. Following Mezzanotti (2021), we employ two measures to assess firms' strategic patenting behavior. The first measure, $Strategic\ Patent\ Share_{s,t}$, shown in Columns (1)–(2), is the share of strategic patents among all patents filed by firm s in year t. A patent is defined as strategic if it ranks in the top 25% in terms of originality among all patents in the same coordinated patent class and year, but only in the bottom 75% in terms of future citations for the same cohort. The patent originality measure, defined using the Herfindahl-Hirschman Index, gauges the concentration of its citations across various technology classes, with higher originality indicated by a broader distribution of citations (Hall et al, 2001). The second measure, $BM\ Patent\ Share_{s,t}$, shown in Columns (3)–(4), is the share of business method patents, which refer to those patents assigned to the US patent class 705. Because US patent classification stopped updating on 2015, the sample for business method patent is smaller. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variables:	$Strategic\ Patent\ Share_{s,t}$		$BM\ Patent\ Share_{s,t}$	
	(1)	(2)	(3)	(4)
$SOL_{s,t-1}$	-0.178^{***}	-0.137^{***}	-0.052^{***}	-0.033
	(0.032)	(0.040)	(0.020)	(0.024)
Controls:				
$ln(Assets_{s,t-1})$		-0.003		0.002^{**}
		(0.002)		(0.001)
$R\&D\ Stock/Assets_{s,t-1}$		0.000		-0.000
		(0.002)		(0.000)
$ln(Capital/Labor)_{s.t-1}$		-0.002		-0.003^{**}
		(0.003)		(0.001)
$Leverage_{s,t-1}$		0.004		-0.010^{*}
		(0.013)		(0.006)
$Private\ Patent\ Share_{s,t-1}$		-0.006		0.033^{***}
		(0.014)		(0.007)
Year FEs	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes
Observations	29,196	29,196	26,106	26,106
Adjusted R^2	0.0464	0.0471	0.346	0.349

Table 7: Institutional Shareholder Overlap and Foreign Upstream Firms

This table reports regression results for the cross-sectional analysis by downstream firms' dependence on foreign upstream firms. We evenly separate firm-years by the share of patents citing foreign upstream firms. Those firm-years with above-median share of patents citing foreign upstream firms are sorted to high dependence group and the remaining firms to low dependence group. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

	Low Dependence			High Dependence		
Dep. Variables:	Firm Aggregate $ln(1+CITES_{s,t})$ (1)	Intensive Margin $ln(1+\overline{cites}_{s,t})$ (2)	Extensive Margin $ln(1+N_{s,t})$ (3)	Firm Aggregate $ln(1+CITES_{s,t})$ (4)	Intensive Margin $ln(1+\overline{cites}_{s,t})$ (5)	Extensive Margin $ln(1+N_{s,t})$ (6)
$SOL_{s,t-1}$	7.131***	1.755***	4.703***	5.943***	0.800***	4.119***
	(0.653)	(0.295)	(0.484)	(0.547)	(0.271)	(0.377)
Controls:						
$ln(Assets_{s,t-1})$	0.381***	−0.019	0.334***	0.340***	−0.011	0.296***
	(0.031)	(0.014)	(0.023)	(0.027)	(0.013)	(0.021)
$R\&D\ Stock/Assets_{s,t-1}$	0.053***	−0.016	0.058***	0.059***	−0.008	0.058***
	(0.015)	(0.010)	(0.009)	(0.020)	(0.009)	(0.016)
$ln(Capital/Labor)_{s,t-1}$	0.049	0.013	0.046	0.117***	0.036*	0.087***
	(0.045)	(0.023)	(0.029)	(0.033)	(0.019)	(0.020)
$Leverage_{s,t-1}$	−0.395**	−0.122	−0.260**	−0.539***	−0.086	−0.350***
	(0.197)	(0.099)	(0.126)	(0.159)	(0.081)	(0.097)
$Private\ Patent\ Share_{s,t-1}$	0.458***	0.183**	0.240***	0.569***	0.214***	0.209**
	(0.149)	(0.085)	(0.093)	(0.135)	(0.075)	(0.085)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE (BGV)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,414	10,414	10,414	18,782	18,782	18,782
Adjusted. R^2	0.519	0.546	0.614	0.561	0.554	0.634

Table 8: Institutional Ownership versus Institutional Shareholder Overlap

This table presents a robustness analysis that incorporates institutional ownership ($Institutional\ Ownership_{s,t-1}$), defined as the proportion of equity held by institutional investors relative to the total outstanding shares. Patent success is proxied by $ln(1 + CITES_{s,t})$, which is the log number of future citations received by the cohort of patents filed by firm s in year t. We decompose patent success into its intensive margin $ln(1 + \overline{cites}_{s,t})$, i.e., the log of average future citation count per patent for the cohort of patents filed by firm s in year t; and its extensive margin, $ln(1 + N_{s,t})$, i.e., the log number of successful patent applications filed by firm s in year t. The key explanatory variable of interest $SOL_{s,t-1}$ measures the lagged average institutional shareholder overlap at the end of year $t-1$ between the innovating firm s and its upstream firms owning complementary patents. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variables:	Firm Aggregate $ln(1 + CITES_{s,t})$		Intensive Margin $ln(1 + \overline{cites}_{s,t})$		Extensive Margin $ln(1 + N_{s,t})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$SOL_{s,t-1}$	9.547^{***}	6.816^{***}	0.816^{***}	1.108^{***}	7.298^{***}	4.764^{***}
	(0.452)	(0.427)	(0.161)	(0.206)	(0.403)	(0.307)
$Institutional\ Ownership_{s,t-1}$	0.457^{***}	-0.417^{***}	0.041	0.042	0.371^{***}	-0.403^{***}
	(0.083)	(0.087)	(0.040)	(0.043)	(0.057)	(0.066)
Controls:						
$ln(Assets_{s,t-1})$		0.378^{***}		-0.011		0.328^{***}
		(0.023)		(0.010)		(0.018)
$R\&D\ Stock/Assets_{s,t-1}$		0.049^{***}		-0.009		0.051^{***}
		(0.012)		(0.007)		(0.009)
$ln(Capital/Labor)_{s,t-1}$		0.102^{***}		0.030^{**}		0.078^{***}
		(0.026)		(0.015)		(0.017)
$Leverage_{s,t-1}$		-0.466^{***}		-0.101		-0.284^{***}
		(0.124)		(0.064)		(0.078)
$Private\ Patent\ Share_{s,t-1}$		0.597^{***}		0.176^{***}		0.314^{***}
		(0.103)		(0.057)		(0.065)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE (BGV)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,196	29,196	29,196	29,196	29,196	29,196
Adj. R^2	0.486	0.533	0.547	0.549	0.536	0.611

Table 9: Placebo Tests

This table reports the regression results for two placebo measures for institutional shareholder overlap. For $SOL\_Placebo1_{s,t-1}$, we replace each cited upstream firm with a similar firm that is not cited by the downstream firm in the given patent application year. A placebo firm is selected based on having the same four-digit SIC codes as the true upstream firm. From the qualified firms, we choose the one that most closely matches the true upstream firm in terms of the log of total assets and the number of patents filed in the past five years. $SOL\_Placebo2_{s,t-1}$ is constructed similarly, but the placebo firms are matched to the true upstream firms based on their technological proximity. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variables:	Firm Aggregate $ln(1+CITES_{s,t})$		Intensive Margin $ln(1+\overline{cites}_{s,t})$		Extensive Margin $ln(1+N_{s,t})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$SOL\_Placebo1_{s,t-1}$	0.015		0.102		0.084	
	(0.201)		(0.099)		(0.140)	
$SOL\_Placebo2_{s,t-1}$		0.031		−0.111		0.186
		(0.188)		(0.099)		(0.120)
Controls:						
$ln(Assets_{s,t-1})$	0.448***	0.447***	0.007	0.012	0.364***	0.362***
	(0.021)	(0.020)	(0.009)	(0.008)	(0.018)	(0.017)
$R\&D\ Stock/Assets_{s,t-1}$	0.061***	0.061***	−0.008	−0.008	0.060***	0.060***
	(0.014)	(0.014)	(0.007)	(0.007)	(0.010)	(0.010)
$ln(Capital/Labor)_{s,t-1}$	0.101***	0.101***	0.029**	0.030**	0.079***	0.079***
	(0.027)	(0.027)	(0.015)	(0.015)	(0.017)	(0.017)
$Leverage_{s,t-1}$	−0.631***	−0.631***	−0.124*	−0.130**	−0.393***	−0.391***
	(0.130)	(0.129)	(0.063)	(0.063)	(0.083)	(0.083)
$Private\ Patent\ Share_{s,t-1}$	−0.512***	−0.512***	−0.007	−0.003	−0.462***	−0.464***
	(0.098)	(0.099)	(0.052)	(0.052)	(0.062)	(0.062)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,196	29,196	29,196	29,196	29,196	29,196
Adjusted R^2	0.518	0.518	0.548	0.548	0.592	0.592

Table 10: Results using Negative Binomial Model

This table repeats all citation regressions reported in earlier tables using the Negative Binomial model. The dependent variable, $CITES_{s,t}$, is total future citation count for the cohort of patents filed by firm s in year t. The control variables include the log of total assets [$ln(Assets_{s,t-1})$], the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

	Baseline	Product Complexity		Foreign Dependence		Add IO	Placebo SOL	
		Complex	Discrete	Low	High		Placebo 1	Placebo 2
Dep. Variables:	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$SOL_{s,t-1}$	6.621***	9.632***	3.127**	7.275***	5.571***	6.850***		
	(0.494)	(1.047)	(1.390)	(0.703)	(0.628)	(0.504)		
$Institutional\ Ownership_{s,t-1}$						−0.337***		
						(0.091)		
$SOL\_Placebo1_{s,t-1}$							0.182	
							(0.284)	
$SOL\_Placebo2_{s,t-1}$								0.041
								(0.275)
Controls:								
$ln(Assets_{s,t-1})$	0.322***	0.340***	0.308***	0.363***	0.317***	0.342***	0.425***	0.429***
	(0.019)	(0.048)	(0.053)	(0.029)	(0.024)	(0.020)	(0.020)	(0.019)
$R\&D\ Stock/Assets_{s,t-1}$	0.063***	−0.000	0.050	0.036*	0.106***	0.057***	0.081***	0.081***
	(0.022)	(0.048)	(0.042)	(0.020)	(0.039)	(0.020)	(0.024)	(0.024)
$ln(Capital/Labor)_{s,t-1}$	0.080***	0.122*	−0.009	0.007	0.089**	0.080***	0.065**	0.065**
	(0.031)	(0.067)	(0.075)	(0.039)	(0.039)	(0.031)	(0.030)	(0.030)
$Leverage_{s,t-1}$	−0.363**	−0.541*	0.711*	−0.351*	−0.349*	−0.346**	−0.447***	−0.449***
	(0.149)	(0.322)	(0.391)	(0.190)	(0.191)	(0.150)	(0.158)	(0.157)
$Private\ Patent\ Share_{s,t-1}$	0.823***	2.150***	−0.280	0.711***	0.595***	0.855***	−0.297*	−0.300*
	(0.153)	(0.431)	(0.395)	(0.180)	(0.190)	(0.154)	(0.160)	(0.160)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,196	5,338	4,038	10,414	18,782	29,196	29,196	29,196

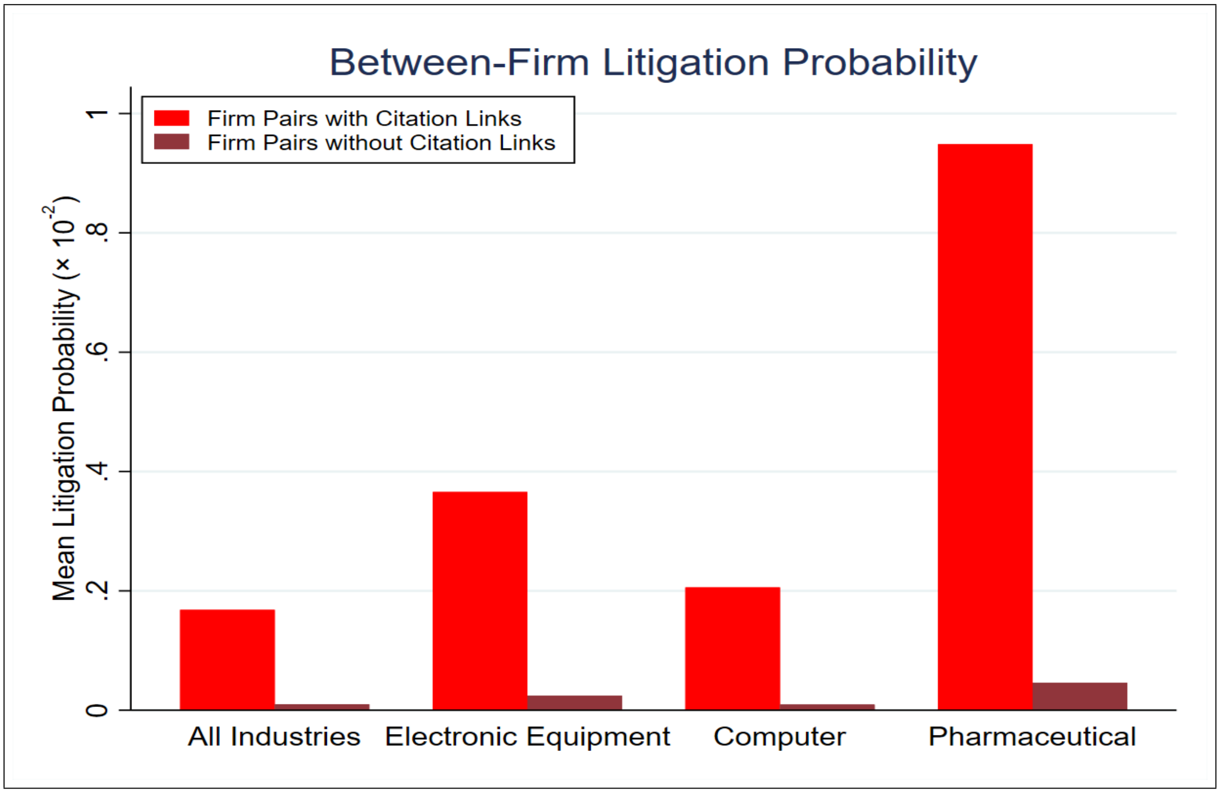

Figure 1: This figure compares the between-firm patent litigation probability for listed firm pairs with patent citation links and those without any citation link. The litigation cases are drawn from the PACER database for the sample period of 1992 to 2015. For each year we form intra-industry firm pairs (based on the Fama-French 49 industry classification scheme) of all U.S. listed firms with at least one patent in the patent database and sort them into pairs with at least one patent citation link and pairs without any such link. The litigation probability is 0.168% for the pairs with patent citation links and 0.010% for the pairs without. The corresponding probabilities are 0.366% and 0.024% for the Electronic Equipment industries, 0.206% and 0.010% for the Computer industries, and 0.949% and 0.046% for the pharmaceuticals sector.

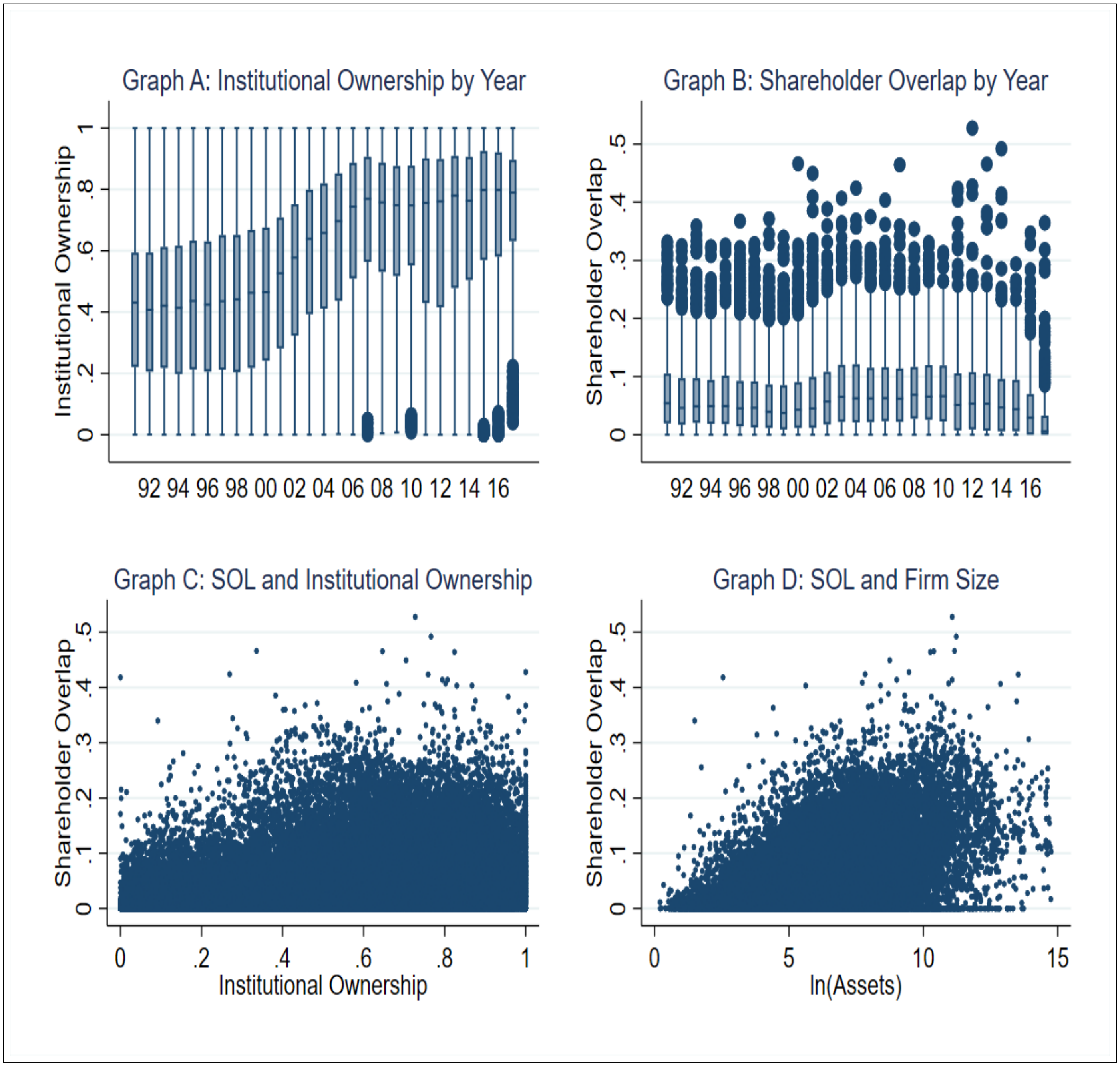

Figure 2: Institutional ownership and institutional shareholder overlap. Graphs A and B are the box plots for the distribution of institutional ownership ($Institutional\ Ownership_{s,t}$) and institutional shareholder overlap ($SOL_{s,t}$), respectively, by year from 1991 to 2017. The top, middle, and bottom values of each box represent the 75th, 50th, and 25th percentile of the distribution in the given year; the maximum and minimum of each vertical bar represent the upper and lower adjacent values, and the dots denote the observations outside the adjacent values. Graph C plots our sample along the dimension of institutional shareholder overlap $SOL_{s,t}$ and institutional ownership $Institutional\ Ownership_{s,t}$, whereas Graph D plots along the dimension of institutional shareholder overlap $SOL_{s,t}$,t and firm size $ln(Assets_{s,t})$ for all firm-years.

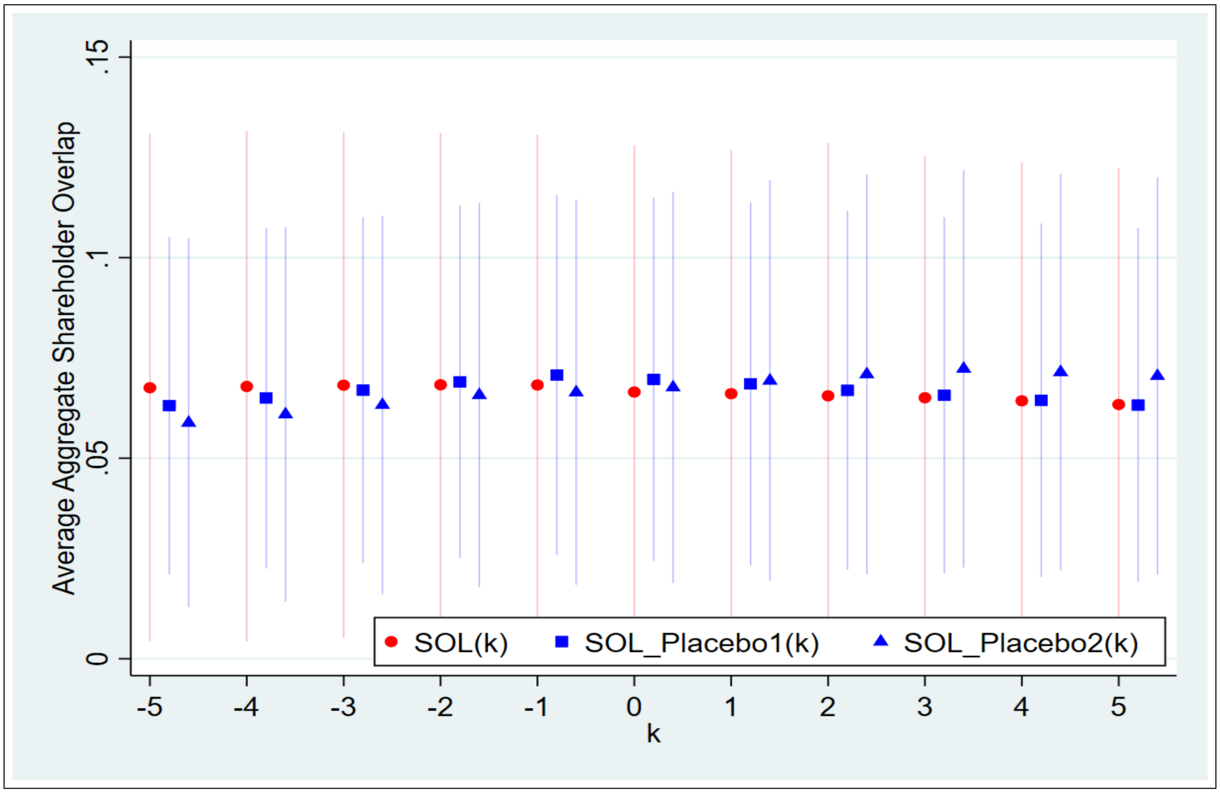

Figure 3: The evolution of the average institutional shareholder overlap $\overline{SOL}(k)$ between the innovating (downstream) firm and other firms owning the complementary precursory patents is plotted for the period from five years prior to the patent filing year to five years after the filing (i.e., k $= -5$ to 5), with the patent filing year denoted by k $= 0$. $\overline{SOL}(k)$ is calculated according to Eq. (10). Each dot in the figure denotes the mean value of institutional shareholder overlap for the given year k relative to the patent filing year, and the vertical segment above and below the dot denotes the standard deviation of the distribution of institutional shareholder overlap for the given year. The evolution of the two placebo measures of institutional shareholder overlap are also plotted. For ease of comparison, in the plot we divide the value of $\overline{SOL}\_Placebo1(k)$ and $\overline{SOL}\_Placebo2(k)$ by 2.36 and 2.06, respectively, so that they would have the same mean value as $\overline{SOL}(k)$.

Appendix

Not for Journal Publication

Appendix A. Additional Results

Table A1: Variable Definitions

Variable	Description
$CITES_{s,t}$	Total future citation count for the cohort of patents filed by firm s in year t. Only those patents that are subsequently granted by USPTO are included in our sample. [Source: Kogan *et al.*, 2017]
$N_{s,t}$	Number of patents filed by firm s in year t. Only those patents that are ultimately granted are included in our sample. [Source: Kogan *et al.*, 2017]
$\overline{cites}_{s,t}$	Average future citation count per patent for the cohort of patents filed by firm s in year t. [Source: Kogan *et al.*, 2017]
$R\&D\ Exp_{s,t}$	$R\&D$ expenditure (XRD) in year t. [Source: CRSP/Compustat Merged Database (CCM)]
$Strategic\ Patent\ Share_{s,t}$	The share of strategic patents filed by firm s in year t. A patent is defined as a strategic one if it is in bottom three quality quartiles in terms of future citations among all USPTO patents filed in the same coordinated patent class and year and highest patent originality quartile in the same cohort. The patent originality measure, defined using the Herfindahl-Hirschman Index, is the concentration of a patent's future citations across various technology classes, with higher originality indicated by a broader distribution of citations. [Source: Kogan *et al.*, 2017]
$BM\ Patent\ Share_{s,t}$	The share of business method patents filed by firm s in year t. A business method patent is defined as a patent with US patent class code of 705. [Source: Kogan *et al.*, 2017]
$Litigation_{j,t}$	Indexing each firm pair in the sample by j, we create a litigation dummy $Litigation_{j,t}$ equal to one if firm pair j is an actual litigation pair and equal to zero if j is a matched firm pair. [Source: LitAlert Database and Public Access to Court Electronic Records (PACER)]
$psol_{p,p_u}$	Pairwise institutional shareholder overlap ($psol_{p,p_u}$) between the downstream patent p and an upstream patent p_u essentially measures the overlapping institutional ownership overlap between downstream firm s that owns patent p and upstream firm s' that owns patent p_u. It is measured according to Eq.(1). [Source: Kogan *et al.*, 2017; Thomson Reuters 13F]
sol_p	Patent-level institutional shareholder overlap for patent p. It is the weighted average of $psol_{p,p_u}$ across all upstream patents (p_u, $u = 1, 2, .., N_u$) cited by patent p. The weight is the claim similarity between p and p_u normalized by the aggregate of claim similarity between p and each of its upstream patent p_u. In cases where multiple upstream patents are owned by the same firm, we aggregate their citation count and treat them as one single patent. [Source: Kogan *et al.*, 2017; Thomson Reuters 13F]
$SOL_{s,t}$	Firm-level institutional shareholder overlap for firm s in year t. It is the average of sol_p across all patents p filed by firm s in year t. [Source: Kogan *et al.*, 2017; Thomson Reuters 13F]
$SOL\_Placebo1_{s,t}$	First firm-level placebo institutional shareholder overlap measure for firm s in year t. It is constructed in the same way as $SOL_{s,t}$ except that we replace every cited upstream firm with a *similar* firm that is *not* cited by the downstream firm s in the patent application year t. A placebo firm is chosen based on the criteria that it must have the same four-digit SIC code as the true upstream firm and that it has the shortest Euclidean distance from the upstream firm in terms of total assets and number of patents filed during $t-4$ to t. Both firm-level measures are log-transformed and scaled by their respective four-digit industry average. The Euclidean distance between firm $X = (X_{Assets}, X_{Patents})$ and $Y = (Y_{Assets}, Y_{Patents})$ is defined as $\sqrt{(X_{Assets} - Y_{Assets})^2 + (X_{Patents} - Y_{Patents})^2}$ [Source: Kogan *et al.*, 2017; CRSP/Compustat Merged Database (CCM)]

Variable	Description
$SOL\_Placebo2_{s,t}$	Second firm-level placebo institutional shareholder overlap measure for firm s in year t. It is constructed in the same way as $SOL\_Placebo1_{s,t}$ except that the placebo firms are matched to the true upstream firms based on their technological proximity. Following Bloom et al. (2013), we measure technological proximity between a true upstream firm u and a placebo firm x by $\frac{T_u T_x'}{\sqrt{T_u T_u'}\sqrt{T_x T_x'}}$, where $T_u = (T_{u,1}, ..., T_{u,K})$ and $T_x = (T_{x,1}, ..., T_{x,K})$. $T_{u,k}$ denotes the ratio of the number of patents filed by firm u in technological field $k \in [1, K]$ in the past three years to the total number of patents it filed during the same period. $T_{x,k}$ is defined analogously. The chosen placebo firm features the greatest value in the technological proximity measure among all firms not cited by the downstream firm in the given year. [Source: Kogan *et al.*, 2017]
$Institutional\ Ownership_{s,t}$	Aggregate institutional ownership percentage of firm s in year t. It is the ratio of the number of shares held by institutional investors to the total number of shares outstanding for firm s at the end of year t. [Source: Thomson Reuters 13F and CCM]
$Assets_{s,t}$	Total assets value (AT) of firm s in year t, measured in USD millions. [Source: CCM]
$R\&D\ Stock/Assets_{s,t}$	Cumulative R&D investment normalized by total assets of firm s in year t. Following Hall *et al.* (2005), we measure $R\&D\ Stock/Assets_{s,t}$ as $R\&D\ Expenditure_{s,t} + 0.85 R\&D Stock_{s,t-1}$. [Source: CCM]
$Capital/Labor_{s,t}$	Capital ($PPENT$) to labor (EMP) ratio for firm s in year t. [Source: CCM]
$Leverage_{s,t}$	Leverage ratio for firm s in year t, defined as long-term debt ($DLTT$) divided by total assets (AT). [Source: CCM]
$Private\ Patent\ \ \ Share_{s,t}$	Average proportion of private upstream patents for firm s in year t. For each patent p filed by firm s in year t, we calculate the share of privately owned upstream patents. We then average this private patent share across all patents filed by firm s in year t. [Source: Kogan *et al.*, 2017]
$MktCap_{s,t}$	Market capitalization value for firm s in year t, which is measured at the end of the year in USD thousands. [Source: CRSP]
$Past\ Return_{s,t}$	The buy-and-hold stock return of firm s over the past 12 months before the patent litigation. [Source: CRSP]
$PatentStock_{s,t}$	Number of patents filed over the past five years. [Source: Our own calculation]
$TobinQ_{s,t}$	Tobin's q of firm s in year t, which is calculated as the sum of stockholders equity(SEQ), deferred tax and investment tax credit ($TXDITC$) minus preferred stock ($PSTKL$), then divided by the product of fiscal-year end stock price ($PRCC\_F$) and common shares outstanding ($CSHO$). [Source: CCM]

Table A2: Estimation of Poisson Regressions

This table repeats all citation regressions reported in earlier tables using the quasi-maximum likelihood Poisson model. The dependent variable, $CITES_{s,t}$, is total future citation count for the cohort of patents filed by firm s in year t. The control variables include the log of total assets $[ln(Assets_{s,t-1})]$, the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log of capital to labor ratio $[ln(Capital/Labor)_{s,t-1}]$, firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies, industry dummies, and firm fixed effects. Industry dummies are based on Fama-French 30 industries to keep the estimation converge. Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

	Baseline	Product Complexity		Foreign Dependence		Add IO	Placebo SOL	
		Complex	Discrete	Low	High		Placebo 1	Placebo 2
Dep. Variables:	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$	$CITES_{s,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$SOL_{s,t-1}$	3.353***	6.478***	−3.170*	6.306***	1.434*	3.374***		
	(0.680)	(1.113)	(1.792)	(0.804)	(0.868)	(0.677)		
$Institutional\ Ownership_{s,t-1}$						−0.120		
						(0.130)		
$SOL\_Placebo1_{s,t-1}$							0.490	
							(0.352)	
$SOL\_Placebo2_{s,t-1}$								0.117
								(0.318)
Controls:								
$ln(Assets_{s,t-1})$	0.417***	0.447***	0.451***	0.397***	0.438***	0.420***	0.483***	0.492***
	(0.031)	(0.050)	(0.084)	(0.036)	(0.041)	(0.032)	(0.030)	(0.029)
$R\&D\ Stock/Assets_{s,t-1}$	0.023	0.013	0.064**	0.065***	0.003	0.020	0.036	0.035
	(0.023)	(0.044)	(0.031)	(0.023)	(0.033)	(0.023)	(0.023)	(0.023)
$ln(Capital/Labor)_{s,t-1}$	0.045	0.275***	0.176**	0.146**	0.015	0.044	0.046	0.048
	(0.059)	(0.088)	(0.082)	(0.074)	(0.081)	(0.059)	(0.059)	(0.059)
$Leverage_{s,t-1}$	−1.121***	−0.611*	0.777	−0.536*	−1.419***	−1.111***	−1.301***	−1.319***
	(0.255)	(0.367)	(0.537)	(0.300)	(0.325)	(0.253)	(0.257)	(0.256)
$Private\ Patent\ Share_{s,t-1}$	−0.187	0.772**	−0.482	0.284	−0.620***	−0.186	−0.952***	−0.963***
	(0.177)	(0.359)	(0.354)	(0.235)	(0.232)	(0.176)	(0.155)	(0.157)
	(0.032)	(0.059)	(0.095)	(0.052)	(0.042)	(0.033)	(0.033)	(0.033)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	28,396	5,338	4,038	10,115	18,281	28,396	28,396	28,396

Table A3: An Alternative Approach to Deal With Missing R&D Information

This table reports the regression results for employing alternative method to handle the missing R&D information. In this alternative method, we directly fill the missing values with zero without interpolation. Patent success is proxied by $ln(1 + CITES_{s,t})$, which is the log number of future citations received by the cohort of patents filed by firm s in year t. We decompose patent success into its intensive margin $ln(1 + \overline{cites}_{s,t})$, i.e., the log average future citation count per patent for the cohort of patents filed by firm s in year t; and its extensive margin, $ln(1 + N_{s,t})$, i.e., the log number of successful patent applications filed by firm s in year t. The control variables include the log total assets $[ln(Assets_{s,t-1})]$, the cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), the log capital to labor ratio $[ln(Capital/Labor)_{s,t-1}]$, firm leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. Variables:	Firm Aggregate $ln(1 + CITES_{s,t})$		Intensive Margin $ln(1 + \overline{cites}_{s,t})$		Extensive Margin $ln(1 + N_{s,t})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$SOL_{s,t-1}$	10.126***	6.456***	0.869***	1.115***	7.790***	4.450***
	(23.229)	(15.137)	(5.377)	(5.411)	(20.480)	(14.719)
Controls:						
$ln(Assets_{s,t-1})$		0.384***		−0.006		0.326***
		(18.542)		(−0.592)		(20.116)
$R\&D\ Stock/Assets_{s,t-1}$		0.361***		−0.006		0.304***
		(8.794)		(−0.240)		(11.986)
$ln(Capital/Labor)_{s,t-1}$		0.117***		0.030**		0.090***
		(4.465)		(2.058)		(5.414)
$Leverage_{s,t-1}$		−0.520***		−0.105*		−0.323***
		(−4.275)		(−1.654)		(−4.231)
$Private\ Patent\ Share_{s,t-1}$		0.613***		0.176***		0.325***
		(5.982)		(3.087)		(5.032)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	29,196	29,196	29,196	29,196	29,196	29,196
Adjusted R^2	0.484	0.536	0.547	0.549	0.532	0.614

Table A4: Patent Citations and Patent Litigation Likelihood

We construct a panel of 3,810,291 yearly firm pairs observations comprising 661,697 distinct firm pairs during the sample period 1992-2015. Panel A reports summary statistics on variables of the the firm pair panel, and Panel B presents an OLS regression characterizing the likelihood of patent litigation, respectively. $Litigation_{p,t}$ is a dummy equal to one if two firms in pair p are involved in at least one patent litigation in year t. $Citation\_10yrs_{p,t-1}$ is a dummy identifying whether there is any citation link between the firm pair p in the years $t-10$ to $t-1$. The pair-level control variables comprise the arithmetic average of log assets [$Pair\ ln(Assets)_{p,t-1}$], of the log Market Capitalization [$Pair\ ln(MktCap)_{p,t-1}$], of the Tobin's q ($Pair\ TobinQ_{p,t-1}$), of the log of one plus R&D expenditure [$Pair\ ln(1+R\&D)_{p,t-1}$], of the number of patent filings over the past five years ($Pair\ Patent\ Stock_{p,t-1}$), and of last year's stock return ($Pair\ Past\ Return_{p,t-1}$). Year dummies, industry dummies based on the Fama-French 49 industry classification, and firm pair fixed effects are included in the different regression specifications. Robust standard errors are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Panel A: Summary Statistics

	Obs. (1)	Mean (2)	Median (3)	S.D. (4)	Min. (5)	P25 (6)	P75 (7)	Max (8)
$Litigation_{p,t} \times 100$	3,810,291	0.036	0.000	1.909	0.000	0.000	0.000	100.000
$Citation\_10yrs_{p,t-1}$	3,810,291	0.042	0.000	0.202	0.000	0.000	0.000	1.000
$Pair\ ln(Assets_{p,t-1})$	3,810,291	5.315	5.117	1.722	−0.598	4.070	6.371	14.764
$Pair\ ln(MktCap_{p,t-1})$	3,810,291	12.522	12.423	1.600	5.427	11.404	13.558	19.746
$Pair\ TobinQ_{p,t-1}$	3,472,504	0.489	0.409	0.381	−1.189	0.244	0.647	4.239
$Pair\ ln(1+R\&D_{p,t-1})$	3,810,291	2.501	2.454	1.480	0.000	1.463	3.451	9.234
$Pair\ Patent\ Stock_{p,t-1}$	3,810,291	2.235	2.047	1.432	0.000	1.151	3.103	9.839
$Pair\ Past\ Return_{p,t-1}$	3,810,291	0.393	0.125	1.537	−0.991	−0.153	0.528	112.927

Panel B: Regression Results

Dep. Variable:	$Litigation_{p,t} \times 100$			
	(1)	(2)	(3)	(4)
$Citation\_10yrs_{p,t-1}$	0.368***	0.302***	0.046**	0.054**
	(0.016)	(0.017)	(0.022)	(0.026)
Controls:				
$Pair\ ln(Assets_{p,t-1})$		0.027***		0.030***
		(0.002)		(0.004)
$Pair\ ln(MktCap_{p,t-1})$		0.008***		0.010***
		(0.002)		(0.003)
$Pair\ TobinQ_{p,t-1}$		0.007***		−0.004
		(0.002)		(0.003)
$Pair\ ln(1+R\&D_{p,t-1})$		0.025***		0.031***
		(0.002)		(0.004)
$Pair\ Patent\ Stock_{p,t-1}$		−0.022***		−0.006**
		(0.002)		(0.003)
$Pair\ Past\ Return_{p,t-1}$		0.002		−0.000
		(0.001)		(0.001)
Industry FEs	Yes	Yes	No	No
Pair FEs	No	No	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes
Intra-industry firm pairs	661,697	661,697	661,697	661,697
Observations	3,810,291	3,472,504	3,687,998	3,350,570
Adjusted R^2	0.002	0.003	0.071	0.077

Table A5: Lagged Institutional Shareholder Overlap and Innovation Success

Reported are firm-level OLS regressions of patent success on various lagged institutional shareholder overlap measures. Column (1) repeats the baseline specification in Table 2, Column (2), which uses institutional shareholder overlap based on one-year lagged institutional ownership. Columns (2)–(5) respectively use institutional shareholder overlap based on two-year, three-year, four-year, and five-year lagged ownership information. The lagged control variables include log total assets [$ln(Assets_{s,t-1})$], cumulative R&D investment normalized by total assets ($R\&D\ Stock/Assets_{s,t-1}$), log capital to labor ratio [$ln(Capital/Labor)_{s,t-1}$], leverage ($Leverage_{s,t-1}$), and the average proportion of privately owned upstream patents ($Private\ Patent\ Share_{s,t-1}$) for firm s in year $t-1$. All regressions control for a full set of year dummies and industry dummies based on four-digit SIC codes. Firm fixed effects are based on Blundell *et al.* (1999). Robust standard errors clustered at the firm level are reported in parentheses. Also reported are the total number of observations and the adjusted R-squared. ***, **, and * denote the 1%, 5%, and 10% significance level, respectively.

Dep. variable:	$ln(1+CITES_{s,t})$				
	(1)	(2)	(3)	(4)	(5)
$SOL\ using\ one-year\ lagged\ ownership$	6.623***				
	(0.429)				
$SOL\ using\ two-year\ lagged\ ownership$		5.392***			
		(0.404)			
$SOL\ using\ three-year\ lagged\ ownership$			4.295***		
			(0.403)		
$SOL\ using\ four-year\ lagged\ ownership$				3.788***	
				(0.405)	
$SOL\ using\ five-year\ lagged\ ownership$					3.670***
					(0.421)
Controls:					
$ln(Assets_{s,t-1})$	0.348***	0.372***	0.397***	0.413***	0.423***
	(0.020)	(0.021)	(0.021)	(0.021)	(0.022)
$R\&D\ Stock/Assets_{s,t-1}$	0.053***	0.054***	0.059***	0.063***	0.067***
	(0.013)	(0.013)	(0.013)	(0.014)	(0.014)
$ln(Capital/Labor)_{s,t-1}$	0.104***	0.105***	0.109***	0.114***	0.112***
	(0.026)	(0.027)	(0.028)	(0.028)	(0.029)
$Leverage_{s,t-1}$	−0.475***	−0.512***	−0.560***	−0.579***	−0.574***
	(0.125)	(0.127)	(0.131)	(0.134)	(0.137)
$Private\ Patent\ Share_{s,t-1}$	0.570***	0.317***	0.116	0.009	−0.025
	(0.103)	(0.102)	(0.105)	(0.107)	(0.111)
Year FEs	Yes	Yes	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes
Firm FEs (BGV)	Yes	Yes	Yes	Yes	Yes
Observations	29,196	28,283	27,240	26,063	24,780
Adjusted R^2	0.532	0.526	0.522	0.518	0.516