Bonding or Disruption? The effect of IDD on supply chain relationship

ABSTRACT

We examine the effect of Inevitable Disclosure Doctrine (IDD) on reducing frictions arising from incomplete contracts in supply chain relationships. We find that firms increase relationship specific investments (RSI) when their supplier is in a state that adopts IDD. The effect is stronger for firms that face higher ex-ante risk of losing trade secrets or other proprietary information and with suppliers that are difficult to substitute. Additionally, IDD plays a more prominent role in the absence of alternate mechanism that reduce contracting frictions such as shared directors, common ownership, and joint ventures. Collectively, our findings suggest that proprietary information protection enables firms to avoid underinvestment in relationship-specific assets by strengthening informal contracting relationship with the supply chain partners.

JEL Classification: G34; L14

Keywords: Relationship-specific investment; trade secrets; IDD adoption; contracting friction; supplier; customer; information asymmetry

1. Introduction

Firms rely on their supply chain partners for strategic activities, such as manufacturing. For instance, in 2020 Apple Corporation relied on its outside supply chain network to produce 98% of its products. A cooperative customer-supplier relationship provides competitive advantage, fosters innovation, and creates significant value for all parties involved. However, contracts between supply chain partners are usually incomplete which can lead to opportunistic behavior ex-post and underinvestment ex-ante. Existing literature has examined potential solutions to mitigate the underinvestment problem. These include vertical integration (Klein, Crawford, and Alchian, 1978; Williamson, 1979), equity ownership (Dasgupta and Tao, 2000; Fee, Hadlock, and Thomas, 2006; Freeman 2021), long-term contracts (Joskow, 1985; 1987), capital structure design (Titman, 1984; Kale and Shahrur, 2007), and governance (Minnick and Raman, 2017). Successful supply chain relationships often require the sharing of proprietary information (Anderson and Dekker, 2005). In this paper, we examine whether the ability to protect partner's proprietary information minimizes contracting frictions which leads to an increase in relationship specific investments (RSI) between partners.

We propose that firms risk losing proprietary information through supply chain partners.[1] Ability to protect proprietary information has a significant effect on a firm's propensity to invest in R&D and innovate (Zhao, 2006). For firms that establish supply chain relations, it is inevitable that partners exchange proprietary information and share knowledge, specifically when firms

[1] There are several anecdotal examples about information spillover between supply-chain partners. Apple filed a patent infringement lawsuit against one of its major suppliers Samsung in April 2011, accusing Samsung of copying the designs and technologies from several of its products. The knowhow about these products is widely believed to be transferred through supply chain links. In another example, Nippon Steel sued their customer Toyota for patent infringement of a specialized steel accusing Toyota of passing on the knowledge gained through supply chain to their competitor Bao Steel. All these examples establish that there is extensive knowledge transfer between supply chain partners which leads to significant economic losses if revealed to competitors. https://www.bbc.com/news/business-44248404

make relationship specific investments. By sharing information with their supply chain partners, firms can achieve significant efficiency gains and develop more innovative technologies (Bourland et al. 1996; Chen 1998; Gavirneni et al. 1999). However, firms that share important proprietary information with their supply chain partners risk losing competitive advantages if information is revealed to rivals (Lee and Whang,2002; Baiman and Rajan,2002). The fear of information leakage deteriorates the efficacy of the supply chain relationship (Majewski and Williamson, 2003; Li and Zhang, 2008; Anand and Goyal, 2009).

One channel through which information leakage occurs is when key employees join rival firms (Klasa, Ortiz-Molina, Serfling, and Srinivasan, 2018). Firms may also lose information when supply chain partners' employees switch jobs, as firms share important proprietary information with supply chain partners.[2] The threat of losing proprietary information through supply chain should increase contracting frictions. Given that relation specific investments are uniquely tied to the relationship and hence are exposed to risks arising from incomplete contracts (Williamson, 1975), we examine whether the enhanced proprietary information protection by a firm's supply chain partner reduces contracting frictions and facilitate RSI.

Specifically, we use the recognition of the Inevitable Disclosure Doctrine (IDD) to understand whether the risk of information leakage due to the mobility of a supply chain partner's key employees affect a firm's investment in RSI. IDD is a common law principle that allows firms to prevent its former employees from joining other firms if the new employment would inevitably result in revelation of firm's proprietary information such as trade secrets

[2] An anecdotal example of information leakage through employees is when Nippon Steel sued Korean steel maker POSCO as one of POSCO's employees sold Nippon's technology to Bao Steel.
https://www.lexology.com/library/detail.aspx?g=9383e917-0f55-4c13-ad83-697a9afac2ce

(Klasa et al., 2018; Kim et al., 2021).[3] The adoption of IDD in the supply chain partner's state acts as an exogenous shock that decreases the risk of losing proprietary information through the supply chain. IDD allows us to make causal inferences from our tests for two reasons. First, IDD is a legal doctrine (i.e., recognized by the courts) and not subject to biases associated with a single shock because it is adopted by different states in a staggered manner from 1977-2011. Further, as IDD is court based, it is not correlated with changes in political and economic conditions in the state, or lobbying activities (Klasa et al., 2018).

By exploiting the staggered adoption of IDD in the states of supply chain partners, our difference-in-difference analysis reveals that firms increase RSI by 0.08 percentage points when their supplier's state adopts IDD, which is approximately 16% higher compared to the sample median. In contrast, a supplier's RSI is not affected by IDD adoption in the customer's state, potentially because suppliers have less discretion in RSI decisions owing to higher bargaining power of customers.[4] We conduct a timing test to examine the parallel trends in the pre-IDD adoption period and to identify how long IDD adoption take to reduce contracting frictions. We find that there is no difference in RSI between the control and the treatment firms during pre-IDD years, confirming the parallel trend assumptions. Further, we find that the coefficient increases sharply (both in magnitude and economic significance) in the post IDD period, strengthening the causal interpretation of our finding.

[3] Kim et al. (2021) summarizes Inevitable Disclosure Doctrine (IDD) as a common law principle that prevents a firm's employee who has knowledge of the firm's proprietary information from working for its rivals. In states where the courts have recognized the IDD, a firm's former workers can be prevented from working for its competitors if this would "inevitably" lead them to divulge the firm's proprietary information to the competitors. The IDD is considered a powerful legal tool in protecting proprietary information because, in theory, the IDD is applicable even if the employee does not sign a non-compete or non-disclosure agreement with the firm, there is no evidence of bad faith or actual wrongdoing, or the rival is in another state (Klasa et al., 2018).

[4] Huang, Shang, and Zhang (2021) show that suppliers may have to make RSI to show commitment to the supply chain relationship, as customers have higher bargaining power in the relationship.

We conduct several cross-sectional tests to support our results and to identify the channel through which supplier's IDD adoption affects a firm's RSI. First, we examine whether the relation between partner's IDD adoption and firm RSI varies with ex-ante risk of losing proprietary information through employee mobility. We propose that firms with greater human capital (more employee importance) face a higher threat of losing proprietary information because employees at these firms possess critical information about the firm's operations. Using industry wages, intangible intensity, and labor to capital ratio as three proxies of human capital (Dey and White 2021), we find that firms are more likely to increase RSI post supplier's IDD adoption when suppliers have greater human capital. Next, we show that supplier's IDD adoption matters more for firms that are more innovative and have a greater need for proprietary information protection. These results support our argument that IDD adoption by suppliers reduces a firm's risk of losing proprietary information through their supply chain, which in turn encourages them to make higher RSI.

In our next tests, we examine whether the relation between supplier IDD adoption and firm RSI varies with the strength of their supply chain relationship. Since firms in strong supply chain relationships share more knowledge with their partners and face higher risk of losing the shared information due to employee mobility in their partners, such firms should care more about their partner's IDD adoption. Indeed, we find that IDD adoption in a supplier's state has a stronger effect on the partner firm's RSI when their relationship is longer, unique (i.e., firms have only one major trade partner), and accounts for a greater percentage of the firm's COGS. The effect of IDD adoption by a supplier's headquarter state is also augmented for suppliers in more concentrated industries, and for suppliers with lower product fluidity, i.e., product

uniqueness. Overall, these results establish that IDD adoption in supplier states matters for a firm's RSI when the supply chain relationship is not easily substitutable.

Through our next cross-sectional tests, we examine whether IDD adoption facilitates higher RSI by reducing holdup risks. We show that supplier's IDD adoption has a greater effect on customer's RSI for relationships with low common ownership, when customers and suppliers are not engaged in a joint venture or strategic alliance, and trade partners do not have directors on each other's board. Thus, supplier's IDD adoption reduces holdup frictions especially when other mechanism of holdup reduction is weak or missing.

Next, we address alternate channels that may affect the relationship between IDD and RSI. While the primary purpose of IDD adoption is to protect trade secrets by restricting employee mobility, it also increases human capital motivated acquisitions (Chen, Gao, and Ma, 2021; Dey and White, 2021). Dey and White (2021) document that firms face a 27% increase in takeover probability post IDD adoptions and firms strengthen antitakeover provisions to protect themselves against hostile takeovers. Acquisitions of trade partners can disrupt supply-chain relationships. Therefore, IDD adoption in supply chain partner states may result in lower RSI by firms if the elevated takeover threat dominates the positive effect of proprietary information protection. However, our baseline results do not support this assertion. One possible explanation why potential takeover threat do not drive our results is because suppliers may adopt anti-takeover measures which deters potential takeover threats. To test our hypothesis, we hand collect data on poison pill activation for suppliers in states that adopted IDD in the period around the adoption and find the number of suppliers with active poison pills almost doubles during the post three-year period of IDD adoption. Further, we examine whether the relation between RSI and supplier's IDD adoption varies for supply chain partners with and without active poison

pills. We find that firms make higher RSI if suppliers adopt poison pills following IDD adoption. The adoption of antitakeover provisions mitigates takeover related disruptions to supply chain relationships, facilitating higher RSI by firms.

Finally, we assess the robustness of our findings by using IDD rejection as an alternative shock that increases employee mobility thereby increasing the risk of losing proprietary information. We expect firms to reduce RSI when supply chain headquarter states rejects IDD. Indeed, we find that for supplier's state that rejects IDD, firms reduce RSI by 0.14%, a 30% lower RSI compared to median RSI of 0.46%.

Our paper contributes to two strands of literature. First, it relates to the literature on transactions cost economics that examines incomplete contracts in a supply chain relationship. The literature identifies mechanisms such as vertical integration, equity ownership, and the choice of capital structure to mitigate the potentially adverse consequences of contracting frictions between firms and their non-financial stakeholders such as supply chain partners (Fee, Hadlock, and Thomas, 2006; Kale and Shahrur, 2007). We examine a less explored aspect of contracting frictions that arises from risk of losing proprietary information through supply chain partners. We show that the ability to protect proprietary information reduces contracting frictions, strengthens supply chain relationship, and facilitates relationship specific investment. Our findings also suggests that regulations can reduce frictions due to incomplete contracts and strengthen supply chain relationship.

Second, we extend the literature that examines how IDD adoption impacts corporate decisions. Prior literature finds that IDD adoption is associated with higher leverage (Klasa et al, 2018), lower innovation (Contigiani, Hsu, and Barankay, 2018), and higher takeover threats (Chen, Gao, and Ma, 2021; Dey and White, 2021). We show that IDD adoption has an indirect

effect on the investment decisions of non-financial stakeholders like supply chain partners and affects the strength of supply chain relationship.

The rest of the paper is structured as follows. We develop the hypotheses and discuss related literature in Section 2. We describe the sample formation and key variables in Section 3. In Section 4, we discuss the empirical results. Section 5 concludes the study.

2. Hypothesis

Williamson's seminal papers (1975, 1985) developed the theory of transaction costs economies. The theory posited that incomplete contracts and specific relationships lead to opportunism and asymmetric information. Teece (1976) finds that even if contracts were complete, i.e., all potential contingencies are specified, there exists the risk that the contract is not honored. Klein et al. (1978) furthered the transaction cost economy theory by introducing the idea of a holdup problem; the risk that a firm makes a specific investment that creates quasi-rents which partners may try to opportunistically extract.[5] They find that as assets become more specific or unique (like proprietary information or trade secrets), greater quasi-rents are created, leading to increase in opportunistic behavior.

Often, successful collaborations between supply chain partners require sharing of detailed proprietary information (Anderson and Dekker, 2005; Bensaou and Venkatraman, 1995; Cole and Yakushiji, 1984). Shared manufacturing and logistics, collaboration in the development of innovative technology and operations are some examples of sources of synergy/efficiency gains that can be achieved by sharing information between supply chain partners (Bourland, et al. 1996;; Gavirneni et al., 1999; Aviv and Federgruen, 1998; Cachon and Fisher, 2000; Li, 2022).

[5] Quasi-rents occur when assets are extremely specialized or expensive to change so that if the price paid to the owner was reduced, the value to the user would not change (Klein et al., 1978).

Even if firms do not actively share information between trade partners, by actively working together such as investing in RSI, it is inevitable that proprietary information gets shared between partners (Armour and Teece, 1980; Dyer and Singh, 1998, Cachon and Fischer, 2000). Such transfer or sharing of proprietary information also makes a firm vulnerable to opportunistic rent seeking behavior by supply chain partners who can exploit the new-found knowledge to enhance their bargaining power. The risk of rent-extraction by supply chain partners is magnified when firms invest in relationship specific assets because the value of relationship-specific investments undertaken by the supply chain partners is lower outside the relationship (Williamson, 1975). Thus, the supply chain partner's access to firm's proprietary information affects the ex-ante incentives of the firm to invest in relationship-specific assets because the ex-post share of surplus gained by the partners depends on their relative bargaining power (Baiman and Rajan, 2002).

Goldberg (1976) suggests that one potential solution for the holdup problem and contracting frictions may be legal or government regulation. IDD is a common law under which courts recognize firms' rights to stop employees from joining rival firms if doing so may lead to loss of important proprietary information. A recognition of IDD by a state court, therefore, provides firms with enhanced proprietary information protection by restricting employee mobility and reduces the tradeoff between the benefits of sharing information and facilitating relationship-specific investments with supply chain partners over the adverse consequences of revealing/losing proprietary information to the supply chain partner. In this section, we present a two-sided hypothesis relating to whether IDD reduces contracting frictions and impacts the level of relationship-specific investments undertaken by the supplier/customer.

2.1 Proprietary Information Protection hypothesis

Intellectual property is a critical revenue generating asset which is essential to maintaining a competitive advantage position and good performance (Arundel, 2001; Cohen, Nelson, and Walsh, 2000; Shapiro and Hassett, 2005). The importance of intellectual property is evident as firms potentially lose over $50 billion annually from divulgence of proprietary information (Lerner, 2006).

Baiman and Rajan (2002) find that when firms provide proprietary information to supply chain partners, they put themselves at a disadvantage because the partner can misappropriate the information for their own private gain. Li (2002) and Li and Zhang (2008) suggest two ways partners may misuse the proprietary information, resulting in a firm losing its competitive position. First, the partners may use the knowledge of the proprietary information to change how they interact with the firm. Second and more relevant for us the proprietary information can be leaked indirectly to the firm's competitors through horizontal information leakage (Lee and Whang, 2002). Li and Zhang (2008) suggest that information leakage occurs when competitors observe a firm's partner's behavior as a response to the proprietary information the firm shared with them. Mohamed et al. (2006) suggest that information leakage can also occur through employee migration, particularly for firms those are dependent on a specific group of knowledgeable workers for R&D. Faisal et al., (2007) suggest that employees may intentionally leak confidential information like proprietary information when incentives like new job opportunities occur.

Prior literature shows that IDD adoption is effective in enhancing proprietary information protection by reducing employee mobility, especially for knowledgeable employees (Klasa et al, 2018). Qiu and Wang (2018) find that enhanced proprietary information protection arising from IDD adoption reduces information leakage and is associated with higher firm value and larger

investment in knowledgeable assets such as SG&A and R&D. Since important supply chain relationships involve extensive knowledge sharing, firms face risk of information leakage through supply chain partner's employee mobility. Further, the possibility of misappropriation of (shared) information by trade partners can distort investment decisions of firms and their supply chain partners, resulting in a decrease in relationship specific investments. Therefore, a supply chain partner's ability to protect proprietary information should affect the firm's RSI decisions. Since IDD adoption by a supply chain partner's headquarter state reduces the risk of losing proprietary information, we propose the *information protection hypothesis* as follows:

H1: IDD adoption by supply chain partners is associated with higher investments in relationship specific assets.

2.2. Disruption hypothesis

While the primary purpose of IDD is to provide enhanced proprietary information protection to firms, prior studies have documented several unintended consequences of IDD adoption such as reduction in innovation and increase in takeover threats. Both adversely affect supply chain relationship and predict a negative relation between firm RSI and supply chain partner's IDD adoption. Next, we discuss the two consequences in details.

2.2.1. Innovation reduction

Hellmann and Perotti (2011) find that reduced employee mobility due to IDD adoption limits the circulation of ideas across networks, which subsequently reduces innovation. Contigiani, Hsu, and Barankay (2018) add that lower employee mobility after IDD adoption reduces employee incentives to enhance their firm-specific human capital and diminishes employee effort, resulting in lower employee innovation efforts and output.

Relating specifically to supply chain relationships, a managerial challenge organizations face is in developing supply chains capable of producing innovative products (Roy et al., 2004). Fynes et al., (2005) show that supply chain partners are vital in helping firms develop and launch innovative products. Firms use shared innovation from their partners to collaborate and are therefore more willing to invest in technology and innovation themselves. Azadegan et al., (2008) find that supply chain partner's innovation is embedded in a firm's own R&D investments and therefore their partner's innovation directly impacts the firm's innovation and performance. Since IDD adoption can reduce innovation, we expect that IDD adoption in a partner's state will result in a decrease in relationship specific investment by the firm.

2.2.2. Elevated Takeover threat

The second unintended consequence of IDD adoption is a heightened takeover threat. Since IDD makes it difficult to poach employees by rival firms, rivals are more likely to use acquisitions to acquire intellectual capital (Chen, Gao, and Ma, 2021). Dey and White (2021) find a 27% increase in takeover probability for firms headquartered in states adopting IDD.

Enhanced takeover threats after the adoption of IDD should affect supply chain relationship negatively. Cen, Dasgupta, and Sen (2016) show that acquisition of trade partners imposes costs on a firm due to disruption in supply-chain relationship. Dow Jones lists mergers and acquisitions as one of the ten major risks faced by supply chain relationships. The importance of a smooth supply chain relationship is also evident from the fact that firms support their trade partners with higher trade credit and prompt payment when partners face financial distress to avoid supply chain disruptions (Banerjee, Dasgupta, and Kim, 2004). Cen et al. (2016) show that markets react positively to the acquisition of trade partners particularly when firms acquire trade-partners of rival firms. Overall, the literature establishes that takeover threats

weaken supply chain relationships. Therefore, we propose that firms will be wary of increased takeover threats when their partner's state of headquarter adopts IDD and will reduce RSI in response.

In conclusion, the innovation reduction and the enhanced takeover threats are two potential disruptive consequences of IDD adoption in supply chain partner's states. Both channels predict a negative relation between firm RSI and partner's IDD adoption, as firms would be wary of reduced innovation and takeover disruptions post IDD adoption. Specifically, we propose the *Disruption Hypothesis* as following:

H2: Firms reduce their relationship specific investment after partners adopt IDD because of the reduced innovation and the elevated threat of takeover.

3. Sample, Data and Empirical Methods

3.1 The Inevitable Disclosure Doctrine (IDD)

The focus of our paper is the adoption (and rejection) of the IDD by a state. IDD helps with the legal protection of proprietary information in a firm by limiting employees with access to this knowledge from moving to competitors or start their own firm using the proprietary information. The essence of IDD is that if new employment inevitably leads to disclosure of a firm's proprietary information and may cause the firm to lose its competitive advantage, state courts can grant an injunction preventing the employee from working for the rival or limit the employee's responsibilities at the new firm.

IDD is considered a powerful legal tool in protecting proprietary information because it is applicable even if the employee does not sign a non-compete or non-disclosure agreement with the firm. Even if there is no evidence of bad faith or actual wrongdoing, a "threat of

misappropriation" is sufficient to grant an injunction even when the rival is in another state (Klasa et al., 2018). Therefore, the adoption of IDD provides an ideal setting for us to understand the role of information protection in supply chain relationships.

The staggered adoption of IDD by states provides a good setting to examine our hypothesis because it is an exogenous shock to firm's ability to protect firm specific knowledge. Prior literature suggests reasons to validate this assumption. First, IDD adoption/rejection is a judicial decision that aims to provide firms with adequate protection against losing proprietary information. Courts are unlikely to be influenced by R&D investment concerns while deciding on IDD adoption or rejection. Since IDD is adopted by presiding judges of the courts and not state legislature, IDD adoption is also unlikely to be correlated with political or economic conditions in a state or driven by lobbying activities of affected firms (Klasa et al, 2018; Na 2020; Dey and White 2021).

Table 1 lists all the states that adopt or reject IDD and the year of event. Twenty-one states adopt IDD during the span of 1919-2006. Out of these 21 states, 10 later reject IDD. Six states reject IDD but never adopt it. Twenty-three states neither adopt nor reject IDD.

We create an IDD indicator variable based on identifying the precedent-setting case in which the court decides that a firm can prevent a former employee from joining a rival firm. For the 21 states for which courts recognize IDD, we set the value of the IDD indicator, *IDD*, as zero for all the years prior to the date of the precedent-setting case and equal to one for all the years on and after the date of the precedent-setting case. For the 10 states that later reject IDD, we revert the value of *IDD* to zero. For the firms that do not adopt IDD or explicitly reject IDD, *IDD* equals zero for the entire sample.

For IDD rejection, the precedent-setting case is the first case in which the court does not justify the use of IDD. For the 10 states that explicitly reject IDD, we create an indicator variable, *IDDReject*, that takes a value of one for all the years after the precedent-setting case in which IDD is rejected, and zero in the prior years. For states that do not reject IDD, *IDDReject* takes a value of zero during the entire sample.

3.2 Sample construction

We begin with all US listed firms covered by the Compustat customer segment database between 1980 and 2019.[6] SFAS 14 (before 1997) and SFAS 131 (after 1997) require firms to report sales to all customers which account for more than 10% of total sales. Some firms voluntarily report customers that account for less than 10% of total sales. To avoid potential biases due to firms' voluntary reporting, we limit our sample to relationships in which customers account for at least 10% of the total supplier sales (Cen, Maydew, Zhang, and Zuo, 2017; Cohen and Frazzini, 2008; Minnick and Raman, 2017). Further, we require firms to have data in CRSP and Compustat annual file. This results in a sample of 47,760 relationship-years. Limiting our sample to firms that report all control variables reduces our sample to 34,190 relationship-years for customers and 34,407 relationship-years for suppliers. Table 2 provides distribution of our sample over the entire period. Our sample distribution spreads across the sample period and is consistent with the prior literature (Raman and Shahrur, 2008; Minnick and Raman, 2017; Harford, Schonlau, and Stanfield, 2019).

[6] The database links customer identifiers with historical CRSP and Compustat company fields using fuzzy name-matching algorithm along with manual verification. The records are further calibrated and complemented by publicly available data and data contributed by researchers (Cen, Maydew, Zhang, and Zuo, 2017; Cohen and Frazzini, 2008).

3.3 Relationship specific investment (RSI)

Following prior literature, we use R&D intensity, i.e., R&D expense divided by assets, to measure relationship specific investment (Aghion and Tirole, 1997; Kale and Shahrur, 2007; Banerjee, Dasgupta, and Kim, 2008; Raman and Shahrur, 2008; Minnick and Raman, 2017). There are several instances of customers and suppliers working together to develop innovative technologies. Toyota and Nippon steel collaborated to produce specialty steel which allowed Toyota to improve its electric cars.[7] Meyer, Milgrom and Roberts (1992) finds that software companies develop customized products for their customers. A vast literature shows that customers and suppliers work in a collaborative manner to develop relationship specific assets which provides them with a sustainable competitive advantage (Williamson, 1985; Perry, 1989; Clark and Fujimoto, 1991). Overall, high R&D investment by firms in a supply chain relationship reflects a close relationship and high interdependence among trade partners.

3.4 Summary statistics

Table 3 provides summary statistics of main variables in our sample separately for customers and suppliers. Like prior studies, we find that suppliers report significantly higher RSI compared to customers. The mean RSI is 7.7% for suppliers and 3.3% for customers. We find that 36.1% of customers have partners headquartered in states that adopt IDD and 41.3% of suppliers have their partners headquartered in states that recognizes IDD. In our sample, 25.4% of customers and 22.3% of suppliers have partners whose states reject IDD.

Table 3 also presents the summary statistics of various firm characteristics. On average suppliers are smaller, less profitable, generate lower free cash flows, or have less leverage

[7] There was a fallout between the partners later and Nippon sued Toyota for patent infringement when Toyota switched supplier (https://www.reuters.com/business/nippon-steel-sues-toyota-baoshan-patent-infringement-2021-10-14/).

compared to the customers. In addition, suppliers realize a significantly higher sales growth rate compared to the customers in our sample. Suppliers are also more dependent on their supply chain partners compared to customers; suppliers realize 24% of sales from their key customers while suppliers account for just 2.3% of total COGS of customers on average. All these characteristics point to customers enjoying a higher bargaining power in the relationship owing to their size and industry leadership (Hennessy and Livdan, 2009).

4. Empirical findings

In this section, we provide our main empirical estimations. First, we examine whether the adoption of IDD by supply chain partner's state is related to the firm's relationship specific investment. We then conduct several cross-sectional tests to augment our findings and identify the channel through which IDD affects RSI.

4.1. Baseline results

Table 4 reports the difference-in-difference estimates of the recognition of IDD by the headquarter state of the supply chain partner on a firm's RSI using the following model:

$$RSI_{i,t} = \beta_{0+}\beta_1 IDD\_PTR_{j,t} + \beta_2 PTR\_DEP_{i,j,t} + \beta_3 X_{i,t-1} + +\beta_3 X_{j,t-1} + Yr\ FE + Firm\ FE + \mu_2 \quad (1),$$

The dependent variable in equation (1) is the relationship specific investment (*RSI*, which is R&D Intensity). *IDD_PTR* is the indicator which captures whether the supply chain partner is headquartered in a state that adopted IDD. *PTR_DEP* captures the supply chain partner's dependence on the firm and is measured as relationship-specific sales (SALECS) divided by COGS if the firm is a customer and SALECS divided by total sales if the firm is a supplier. X_i and X_j are the vectors of (lagged) controls for the firm and their supply chain partner, respectively. *Yr FE* and *Firm FE* represent the year and firm fixed effects.

Following prior research (e.g., Darrough and Rangan, 2005; Coles, Daniel, and Naveen, 2006; Kale and Shahrur, 2007; Raman and Shahrur, 2008), the control variables for equation (1) include *Size, Book-to-market, Leverage, ROA, free cash flow (FCF), Sales Growth, institutional investor (IO) Holding, HHI, and state GDP growth for both the firm and the supply chain partner.*

Models 1, 2, and 3 focus on firms that are major customers in a supply chain relationship and estimate the effect of supplier's IDD adoption on the firm's RSI. Recognition of IDD by a supplier's headquarter state has a positive and significant effect on the firm's RSI. After IDD adoption by their suppliers, firms increase RSI by 0.08% which is an approximate 16% increase compared to median RSI of 0.46%.

Among the control variables, our results are consistent with existing literature. For instance, we find higher R&D intensities for firms that are smaller, less levered, that have higher cash ratios, higher ROA, or lower book-to-market ratios (see, e.g., Darrough and Rangan, 2005; Coles, Daniel, and Naveen, 2006; Kale and Shahrur, 2007; Raman and Shahrur, 2008).

Model 2 estimates results for the subsample in which the firms and their suppliers are headquartered in different states, which helps mitigate several concerns. First, since the firms and suppliers are in different states, firm RSI will be less likely to be affected by state level omitted variable that may drive both RSI and partner's IDD adoption. Second, since only partner's state gets IDD treatment, the relation between partner's IDD adoption and firm's RSI is more cleanly identified. To control for state-level economic condition, Model 3 adds a control for state GDP growth for both customers and suppliers. Models 2 and 3 report results that are similar to Model 1, which supports our main finding.

The positive coefficient for IDD_PTR is consistent with the explanation that IDD in supplier's states reduces contracting frictions for the firm and builds trust between the firm and the supplier, and thereby alleviates frictions arising from (fear of) losing proprietary information from RSI. These results support our *Information Protection Hypothesis* but are inconsistent with the *Disruption Hypothesis*.

Models 4, 5, and 6 focus on firms that are suppliers in a supply chain relationship and estimate the effect of customer's IDD adoption on the firm's RSI. While the coefficients of customer's IDD adoption are positive, these are not statistically significant. This result is understandable given the existing literature shows that suppliers typically have less flexibility in making RSI decisions because their customers enjoy a higher bargaining power in the relationship owing to customer size and industry leadership position. Moreover, given that customers usually have higher bargaining power, suppliers may use RSI as a signal of their commitment to the relationship (Huang et al., 2021), and hence IDD adoption by customers may not be a significant factor in making RSI decisions for suppliers.

4.2. Timing of the effect of partner's IDD adoption and firm RSI

Table 5 examines the timeline over which IDD adoption by supply chain partners affects firm's RSI. This test helps validate parallel trend assumptions in the pre period and rules out reverse causality concerns. In a difference-in-difference analysis, parallel trend in the pre period is an important assumption, which shows that the effect observed is not on account of inherent differences between treatment and control firms before the treatment. To examine this, we include indicator variables, *IDD_PTR (-3) to IDD_PTR (+3)*, that take value of ones for supply chain partner in years relative to the IDD adoption year (0). For example, *IDD_PTR (-3)* variable takes value of one for at least three years prior to IDD adoption and zero otherwise. *IDD_PTR*

(0) takes value of one for the year of IDD adoption and zero otherwise. *IDD_PTR (+3)* takes value of one for three year and onwards after IDD adoption and zero otherwise. By using these indicator variables, we can identify when the effect of IDD kicks in and whether there is any pre trend before the IDD adoption, which casts doubt on the validity of the empirical design. All models include controls from Table 4 including firm and year fixed effects. Model 1 estimates the results for firms whose suppliers adopted IDD and Model 2 estimates the results for firms whose customers adopted IDD.

For parallel trend assumption to hold, the coefficient of variables that indicate years prior to IDD adoption, i.e., *IDD_PTR (-3), IDD_PTR (-2),* and *IDD_PTR (-1)* should be insignificant. A positive and significant coefficient in the post period, i.e., *IDD_PTR (+3), IDD_PTR (+2),* and *IDD_PTR (+1)* mitigates concerns of reverse causality. Model 1 shows that the coefficients for all pre-IDD variables are insignificant which validates our parallel trend assumption. We also rule out reverse causality as the coefficients increase sharply in the first year after IDD adoption and becomes both economically and statistically significant from second year onward. IDD adoption by customer's headquarter state does not affect a firm's RSI, which is consistent with our findings in Table 4. These results add insight into our *Information Protection Hypothesis* and show that it takes about two years for IDD to reduce contracting frictions, which in turn results in an increase in the firm's RSI.

4.3. Cross-sectional variation in the effect of supplier's IDD adoption on customer RSI

We conduct several cross-sectional tests to support our main findings. These tests help understand the channel through which supplier IDD adoption affects a firm's RSI. The tests also provide additional evidence that our main findings are causal, as otherwise an omitted variable would have to explain the cross-sectional variation in our results. We limit these tests to

instances where the supplier's state adopted IDD as customer's state IDD adoption does not impact a firm's RSI in our baseline results. All cross-sectional tests include controls for firm characteristics from Table 4 and include firm and year fixed effects.

4.3.1. Cross-section variation with level of supplier's human capital

The effect of IDD permeates through employees. IDD adoption improves the ability to protect proprietary information by limiting mobility of employees who may be in possession of proprietary information. Given that IDD adoption restricts employees from freely moving from one firm to another, the effect of IDD adoption on corporate decisions is stronger for firms with greater human capital (Klasa et al, 2018; Dey and White, 2021; Chen, Gao, and Ma, 2021).

Our first cross-section test examines whether the effect of supplier's state IDD adoption on a firm's RSI is stronger when suppliers have high human capital as there is greater ex-ante risk of losing proprietary information through employee mobility. We use three proxies to identify suppliers with high human capital. First, we propose that firms for which employees play a more significant role will pay higher wages to their employees. We collect data on industry wages from Bureau of Economic Analysis (BEA) and divide our supplier sample into above and below median (supplier) industry wages. Second, we propose that firms with greater human capital should have more intangible assets. Therefore, we use intangible intensity. i.e., ratio of intangible assets divided by total assets, to divide suppliers into high and low human capital suppliers. Finally, we divide suppliers into high and low labor to capital ratios, i.e., number of employees divided by property, plant, and equipment (PPE). If ability to protect proprietary information drives our results, IDD should have a stronger effect when suppliers have greater human capital.

We estimate the same model as Equation (1) and Table 4 on a subsample of high and low human capital suppliers. Table 6 reports the results of our analysis. We find that firm RSI increases when IDD is adopted in subsamples of suppliers with higher industry wages, greater intangible intensity, or larger labor to capital ratio. IDD has an insignificant effect on RSI of firms where suppliers have low human capital. The effect is economically strong as firm RSI increases RSI by 0.10% to 0.18% (which is 21% to 32% of median RSI) for the three proxies for human capital.[8] These results support our assertion that firms that face higher ex-ante risk of losing proprietary information through suppliers' employee mobility benefit more by offsetting such risk from IDD adoption.

4.3.2. Cross-section variation with customer innovation

Second, we propose that IDD adoption should matter more for firms that have a greater need for proprietary information protection. More innovative firms would typically have more proprietary information to protect and face a higher risk of losing these secrets when supplier's employees switch jobs. Therefore, we conjecture that more innovative firms should benefit more from supplier IDD adoption. We use two proxies to identify innovative firms: 1) firm's industry R&D expenses, where industry is defined using SIC four-digit code and 2) number of patents granted to the firm. Innovative firms invest more on R&D and develop important technologies. Since our dependent variable is itself R&D investment, to avoid circular logic we use industry R&D expenses to divide firms into subsamples of high and low innovation. Second, we use the number of patents held by the firm as a proxy for innovation, as more innovative firms typically file more patents.

[8] The median RSI for the sample with available BEA industry wage information is 0.57%. When IDD is adopted in a supplier's state with above median industry wages, RSI increases by approximately 32 percent.

Table 7 reports the results of our subsample analysis using the same OLS model as Table 4 segmented on firm innovation. We find that effect of supplier IDD adoption on firm RSI is observed for firms that belong to industries with above median R&D, have any patent at all, and have above median number of patents. Specifically, more innovative firms increase RSI by approximately 26 percent after the adoption of IDD compared to the sample median. Moreover, we find no significant effect of supplier IDD adoption on RSI with less innovative firms (below median industry R&D, no patents, and below median number of patents). These results support our assertion that supplier's IDD adoption is more relevant for more innovative firms as they may have more trade secrets to protect.

4.3.3. Cross-section variation with importance of supply chain relationship

Next, we examine whether the effect of IDD on RSI varies with relationship strengths and supplier characteristics. Firms in strong supply-chain relationships work closely and exchange knowledge with each other, and hence are more at risk of losing proprietary information when their partner's employees switch jobs. Therefore, we expect firms in strong supply chain relationship to benefit more from partner's IDD adoption. We use three proxies of relationship strength: 1) relationship duration, 2) unique relation i.e., supplier and customers do not have any other partners, and 3) customer's dependence on the supplier. Specifically, we hypothesize that correlation between RSI and partner IDD should be more positive for relationships that are more durable, are unique and when customers have high dependence on supplier.

We first estimate regression separately for subsamples of long and short supply chain relations based on the duration of the relationship. Table 8 Columns 1 and 2 segment the duration of the relationship by median and find that IDD is positively associated with firm RSI

only for relationship that have above median relationship duration. The effect of IDD adoption by supplier's headquarter state on RSI is approximately two-folds higher for firms with longer supply chain relationships versus shorter relationships. Columns 3, and 4 estimate the regression for firms with exclusive supply chain partners versus firms with multiple supply chain partners and show that the effect of IDD on RSI is economically stronger when trade relations are unique. Specifically, RSI increases by 78 percent after supplier's IDD adoption for firms that have a unique relationship whereas RSI increases by only 14 percent for relations that are not unique. Next, we divide our sample into above and below median values of supplier dependence, defined as relationship sales divided by firm COGS, and estimate the coefficients separately for these subsamples. Columns 5 and 6 show that positive association between firm RSI and supply IDD adoption is stronger for firms that have a greater supplier dependence compared to those with less supplier dependence. These results affirm that firms in strong supply chain relationships care more about partner's IDD adoption.

We further propose that firms should care more about partner's IDD adoption when suppliers are less substitutable. We propose that suppliers that belong to concentrated industries are less substitutable as there are fewer firms to substitute them with. We capture the extent to which product market space is more contracted using sales Hirschman-Herfindahl Index (HHI). In addition, we use Hoberg, Phillips, and Prabhala's product fluidity as another aspect of substitutability. Hoberg, Phillips, and Prabhala (2014) define product fluidity as overlap between a firm's product description with rivals' product description. The fluidity measures dynamic competitive threats faced by a firm by capturing how rivals are changing the product word that overlaps with the firm. A lower (higher) product fluidity reflects less (more) competitive threat that arises due to rival actions. While a lower fluidity signifies a lower threat from rival, it also

reflects more product uniqueness since the products are dissimilar to rival's products. We hypothesize that RSI by a firm is more positively associated with IDD adoption by supply chain partner when suppliers belong to high HHI industries and have low product market fluidity, as there are fewer alternatives.

Consistent with our hypothesis, the subsample analysis shows that supplier IDD adoption is positively associated with firm RSI only for suppliers that belong to high HHI industries and have low product fluidity. Overall, the results in Table 8 confirm that IDD adoption by suppliers facilitates higher firm RSI when supply chain relationship is important for them.

4.3.4. Cross-section variation and contracting frictions

Through our final set of cross-sectional tests, we examine whether IDD adoption by partners acts as a substitute for other measures that mitigate frictions from incomplete contracts in supply chain relationships. Prior literature suggests that supply chain relationships with cross ownership, having supply chain partner on the board of directors, having joint ventures and strategic alliances face lower contracting frictions and invest more in RSI (Minnick and Raman, 2017; Harrigan, 1988; Houston and Johnson, 2000; Fee, Hadlock and Thomas, 2006; Freeman 2021). If IDD also attenuates holdup problem in the supply chain relationship, IDD adoption should have a stronger role in the absence of alternate ways to reduce frictions. Therefore, we hypothesize that effect of supplier IDD adoption should be stronger on firm RSI for relationships where there is no other mechanism to alleviate contracting frictions.

To test this hypothesis, we use three characteristics that existing literature proposes as potential mitigators of holdup problem 1) common institutional ownership (overlapping institutional owners), 2) joint ventures/strategic alliances, and 3) interlocking boards. The

subsample analysis in Table 9 reveals that IDD is positively associated with firm RSI only for relationships with low common ownership, without joint ventures and strategic alliance, and without shared directors. Specifically, RSI increases by 16 percent when IDD is adopted for firms without common ownership, 15 percent for firms without joint ventures, and 20 percent for firms without interlocking boards. These results provide evidence that IDD adoption by suppliers reduces contracting frictions and facilitates higher firm RSI when marginal benefit is higher (i.e., alternate mechanism to reduce holdup problem are absent).

4.4. Alternate explanations: IDD adoption and takeover threat

While the primary purpose of IDD adoption is to protect proprietary information, prior studies document that firms face enhanced takeover threat post IDD adoption. Since IDD makes it difficult to hire employees from other firms, rivals rely on acquisitions to acquire human capital (Chen, Gao, and Ma, 2021; Dey and White, 2021). Takeover of trade partners by other firm can cause major disruption to supply-chain relationship. Our disruption hypothesis discussed earlier suggests IDD adoption by suppliers should result in lower RSI by firms as they face increased supply chain disruption on account of elevated takeover threat. Contradictory to the disruption hypothesis, our baseline results in Table 4 find a positive correlation between IDD adoption and RSI. In this section we explore further why enhanced takeover threat does not drive our results, despite the increased takeover threat being a major disruption for supply chain relationships.

Dey and White (2021) find that firms strengthen anti-takeover provisions after IDD adoption to mitigate takeover threats. Therefore, one possible explanation for lack of support for takeover threat effect is that suppliers respond to IDD adoption by taking anti-takeover protection (ATP) measures to defend against hostile takeovers. Consequently, the adoption of

ATP measures may be a potential remedy to protect supply chain relations from the elevated takeover threat after IDD adoption. We hypothesize that RSI will increase for firms whose suppliers strengthen ATP measures after IDD adoption and RSI will be negatively correlated with IDD if suppliers do not adopt anti-takeover provisions.

To test this hypothesis, we limit our sample to only those suppliers whose states adopted IDD and include all observations during three years before and after IDD adoption, as we want to examine the effect of ATP measures taken around the period of IDD adoption. We use active poison pill as a proxy for takeover defense.[9] We hand collect data using Capital IQ on active poison pill around IDD adoption for all suppliers that adopt IDD (treated suppliers) and record timing of takeover defense measures.

We first examine whether treated suppliers activate poison pill after IDD adoption by their states. Table 10 Panel A estimates a linear probability model to examine whether treated suppliers have significantly more active poison pills after their state adopts IDD. We control for supplier characteristics and include supplier fixed effects and year fixed effects in our model. Consistent with our expectation, the coefficient on *PostIDD* variable is statistically significant. The result indicates that suppliers whose state adopt IDD have two times greater likelihood of having an active poison pill in place after three years of IDD adoption compared to the pre-IDD adoption period.

Then, we test our hypothesis that supplier's activation of poison pill facilitates customer RSI by mitigating takeover related disruptions on account of IDD adoption. To examine our

[9] Ideally, we would like to consider other antitakeover measures too, but we are restricted by data availability. The corporate governance database (ISS governance) covers only large firms and do not cover entire sample period. Since suppliers are usually small firms, only a few of these are covered by ISS sample. Another limitation is that electronic filing of 10-Ks is not available before 1994, therefore we cannot hand collect data on other ATP measures.

hypothesis, we conduct a difference-in-difference analysis on the subsample of suppliers with IDD adoption, where the new treatment group is suppliers with IDD adoption and having active takeover defense. Suppliers with IDD adoption but without active takeover defense become the control firms. Table 10 Panel B reports the results. Model 1 uses an indicator variable, *ActivePoisonpill*, which takes a value of one if a supplier has an active position pill at the time of IDD adoption and zero otherwise. Models 2 and 3 use indicator variables, *Poisonpill_adoption,* which take a value of one if suppliers activate poison pill within one year and within three years of IDD adoption, respectively. All models include controls from Table 4 and have firm and year fixed effects. The coefficient on *PostIDD* is negative and significant in all models, which implies that the elevated takeover threat has negative effect on firms RSI when partner state adopts IDD. This negative coefficient is consistent with takeover related disruption hypothesis, as it indicates that firms reduce RSI post supplier's IDD adoption if suppliers do not have ATP. However, firms make higher RSI when suppliers that get an IDD shock also have an active poison pill or adopt poison pill within one year to three years after IDD adoption. Overall, supplier's adoption of antitakeover provisions (to mitigate takeover related disruptions to their supply chain) facilitates higher RSI by partner firms.

In conclusion, Table 10 finds evidence for both our information protection hypothesis as well as our takeover related disruption hypothesis. Our analysis in Table 10 reveals that one reason takeover threat does not show up in our baseline results is because antitakeover protection adopted by suppliers alleviates the elevated takeover threat by IDD adoption.

4.5. Robustness tests: IDD rejection by suppliers and customer RSI

Finally, we assess the robustness of our baseline results using IDD rejections. As defined in section 3.1, 16 states explicitly reject IDD during the period of 1999 and 2014. Ten of these

states reject IDD after recognizing it earlier. Recent literature shows that IDD rejection can potentially function as a catalyst for entrepreneurial activity and innovation because employees do not feel hindered in their productivity (Patel and Devaraj, 2022). When a state rejects IDD, employees can move freely from one firm to another even if such moves may reveal important information about the previous firm. Consequently, there is more risk of losing valuable proprietary information when IDD is rejected.

We use IDD rejection as an alternate shock which lowers firms' ability to protect proprietary information due to unrestricted employee mobility. If the *Information Protection Hypothesis* is true, we expect firms to reduce RSI if supplier states reject IDD. To evaluate if this holds true, we re-estimate Equation (1) but replace *IDD_PTR* with *IDDReject_PTR. IDDReject_PTR is* an indicator variable that takes a value of one for all the years after IDD rejection by a supplier's state and zero otherwise. For suppliers that do not reject IDD, *IDDReject_PTR* takes a value of zero for all the years.

The results are reported in Table 11. Our difference-in-difference analysis shows that firms reduce RSI by 0.14%, which is a 29.6% decrease (relative to the sample median) of RSI after IDD rejection by supplier state. These results provide additional support for the information protection hypothesis suggesting that firms reduce RSI when there is more risk of losing proprietary information.

5. Conclusion

We examine whether firms consider the proprietary information protection laws in their supply chain partners states when optimally choosing their relationship-specific investments (RSI). Examining a large sample of actual suppliers and customers of U.S. firms between 1980

and 2019 and using a difference-in-difference approach to control for endogeneity in the RSI decisions, we find that a firm is more likely to invest in relationship-specific assets following IDD adoption by its supply chain partner's state. We find that the effects of enhanced proprietary information protection take between one to three years to be fully actualized. Our results suggest that the greater proprietary information protection resulting from IDD adoption reduces contracting frictions in the firm-supplier relationship.

The results are stronger among relationships where supplier employees are more knowledgeable, firms are more innovative, and if the supplier is more dependent on the firm. In addition, we find a significant increase in the levels of relationship-specific investments by firms when the firms do not have alternate mechanisms to reduce contracting frictions like common ownership, interlocking boards, or joint ventures. Collectively, these tests suggest that supplier IDD adoption allows firms, and their supply chain partners to overcome the contracting frictions inherent in the relationships.

Collectively, the findings in this study suggest that proprietary information protection enables firms to avoid underinvestment in relationship-specific assets by mitigating the risks arising from asymmetric information and by strengthening supply chain partner's informal contracting relationship with the firm. The study contributes to the literature by identifying IDD adoption as a mechanism to alleviate contracting frictions between firms along the supply chain.

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Appendix: Variable Definition

Variable Name	Definition
Relationship level Variables	
Relationship duration	The number of years since the initiation of the customer-supplier relation
Unique relation	Equals to one if both customer and supplier have each other as the only trade partner
Supplier dependence	Percentage of COGS sourced from the supplier, measured as relationship specific sales (SALECS) divided by customer COGS.
Customer dependence	Sales to the customer as a fraction of total sales, measured as relationship specific sales (SALECS) divided by total supplier sales (SALE).
Common ownership	The percentage of common shares outstanding held by common block holding institutions. A common block holding institution is defined if a block holding institution owns both customer and supplier in a given quarter. A block holding institution is defined as 13F institution holding more than 5% of common shares outstanding in a firm.
Joint Venture/Strategic Alliances (JV/SA)	Equals to one if customer and supplier pair participate in joint ventures or strategic alliances (from SDC Platinum)
Shared Director (C)	Suppliers have a seat on the customer board of directors.
Shared Director (S)	Customers have a seat on the supplier board of directors.
Other Key Variables	
Relation specific investments (RSI)	Relation specific investment, R&D expenditure scaled by total assets
Size	Market value of equity at the end of year
Book-to-Market	Book-to-market ratio, calculated as the book value of equity divided by the market value of equity at the end of the year.
Return on Assets (ROA)	Return on assets, calculated as income before extraordinary items scaled by the average of total assets of the year and prior year.
Leverage	Leverage calculated as the sum of long-term debt (DLTT) and short-term debt (DLC) scaled by total asset.
Free Cash Flow (FCF)	Free cash flow, calculated as the operating income after depreciation minus changes in net working capital plus depreciation scaled by the lagged total assets.
Sales Growth	The percentage change in sales from prior year.
HHI	Herfindahl-Hirschman Index of sales, calculated as the sales market share within SIC 4-digit industries.
IO holding	The percentage of common shares outstanding held by 13F institutional investors
Product market fluidity	The product market fluidity measure by Hoberg and Phillips (2014), which captures how intensively the product market is changing each year. Measures of fluidity are customized to each firm based on each firm's unique product market vocabulary (from 10-K).
Patents	The number of patents filed by firms between 2003 and 2017. We source patent data from the Global Corporate Patent Dataset (GCPD) compiled by the University of Virginia Darden School of Business. The GCPD is constructed based on the matching algorithm described in Bena, Ferreira, Matos, and Pires (2017).
Industry wages	Average wages per year from Bureau of Economic Analysis (BEA). The data is collected at the NAICS industry level. We match NAICS with SIC to get wage data for firms in our sample.
Intangible Intensity	Intangible assets (INTAN) divided by the total assets.
Labor-to-capital	Labor to capital intensity calculated as the number of employees (EMP) divided by

net property, plant, and equipment (PPENT).

Table 1: Timeline of IDD adoption and rejection

The table lists the timeline (year) of precedent-setting cases in which states either adopted or rejected the Inevitable Disclosure Doctrine. In ten states, which are in highlighted in bold and italicized, courts rejected IDD after adopting it earlier.

State	Decision	Year	State	Decision	Year
AR	Adopt	1997	AK	Reject	2009
CT	Adopt	1996	CA	Reject	2002
DE	Adopt	1964	***FL***	***Reject***	***2001***
FL	Adopt	1960	***GA***	***Reject***	***2013***
GA	Adopt	1998	MD	Reject	2004
IA	Adopt	1996	***MA***	***Reject***	***2012***
IL	Adopt	1989	***MI***	***Reject***	***2002***
IN	Adopt	1995	NH	Reject	2010
KS	Adopt	2006	***NC***	***Reject***	***2014***
MA	Adopt	1994	***NJ***	***Reject***	***2012***
MI	Adopt	1966	***NY***	***Reject***	***2009***
MN	Adopt	1986	***OH***	***Reject***	***2008***
MO	Adopt	2000	***TX***	***Reject***	***2003***
NC	Adopt	1976	VA	Reject	1999
NJ	Adopt	1987	***WA***	***Reject***	***2012***
NY	Adopt	1919	WI	Reject	2009
OH	Adopt	2000			
PA	Adopt	1982			
TX	Adopt	1993			
UT	Adopt	1998			
WA	Adopt	1997			

Table 2: Customer-supplier relationship: Sample information

This table provides details of the number of relationships, number of customers and number of unique suppliers across different time-periods in our sample.

Years	#Relationship	# Customers	#Suppliers
1980-1984	4,682	1,857	3,702
1985-1989	6,092	2,221	4,774
1990-1994	7,157	2,513	5,550
1995-1999	8,461	2,846	6,321
2000-2004	6,823	2,285	4,887
2005-2009	5,806	2,002	4,192
2010-2014	4,907	1,690	3,530
2015-2019	3,832	1,357	2,833
Total	47,760	16,771	35,789

Table 3: Summary statistics

This table presents the summary statistics of key variables in our regression for all relationships in our sample spanning 1980 and 2019. A detailed variable definition is available in Appendix A.

	Customers			Suppliers		
	Mean	Median	SD	Mean	Median	SD
RSI	3.302	0.464	5.242	7.682	1.513	14.005
IDD_PTR	0.361	0.000	0.480	0.413	0.000	0.492
IDDReject_PTR	0.223	0.000	0.416	0.254	0.000	0.435
Controls						
Book-to-market	0.599	0.475	0.468	0.664	0.514	0.719
FCF	0.138	0.137	0.118	-0.036	0.091	0.596
HHI	2,273	1,696	1,809	1,708	1,648	2,158
IO Holding	0.578	0.578	0.328	0.406	0.348	0.318
Leverage	0.253	0.238	0.156	0.223	0.176	0.228
PTR_DEP	2.313	0.227	8.274	23.798	17.200	17.375
ROA	0.051	0.052	0.074	-0.032	0.031	0.228
SalesGrowth	0.115	0.080	0.227	0.513	0.098	17.360
Size	9.497	9.778	1.994	5.176	5.083	2.162

Table 4: Recognition of IDD by supply chain partner and relationship specific investment

This table examines the effect of IDD adoption by partner's state on the firm's relationship specific investment, measured as R&D expenses divided by total assets. We regress firm RSI on supplier state IDD adoption in Models 1, 2, and 3 and customer state IDD adoption in Models 4, 5, and 6. Models 2, and 5 exclude observations for which firms and supply chain partners are headquartered in the same state. Models 3, and 6 include controls for state GDP growth which is available from 1997 onwards. All models include firm characteristics and supply chain partner characteristics controls. We include firm, and year fixed effects. All variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Relationship specific investment (RSI)					
	IDD Adoption by Supplier State			IDD Adoption by Customer State		
	All	Diff states	State	All	Diff states	State
IDD_PTR	0.075**	0.078**	0.092**	0.054	0.142	0.235
	(2.13)	(2.04)	(2.20)	(0.39)	(0.85)	(1.62)
PTR_DEP	0.003	0.007	-0.002	0.010	0.014	0.012*
	(0.47)	(0.86)	(-0.34)	(1.46)	(1.56)	(1.65)
Firm controls						
Size	-0.534***	-0.429***	-0.565***	-0.437***	-0.411***	-0.329**
	(-3.59)	(-3.15)	(-3.44)	(-3.10)	(-2.60)	(-2.34)
Book-to-market	-0.727***	-0.665***	-0.757***	-1.330***	-1.481***	-1.202***
	(-3.54)	(-2.78)	(-3.17)	(-9.67)	(-9.10)	(-8.58)
Leverage	-4.346***	-3.797***	-4.177***	-5.724***	-6.111***	-5.164***
	(-6.37)	(-6.14)	(-5.80)	(-6.94)	(-6.61)	(-6.06)
ROA	3.121***	4.171***	2.503**	-8.651***	-8.969***	-7.886***
	(3.06)	(3.57)	(2.36)	(-8.55)	(-8.25)	(-7.08)
FCF	1.357**	1.405***	1.377**	1.103***	1.181***	1.071***
	(2.26)	(2.66)	(2.12)	(4.32)	(4.30)	(3.78)
SalesGrowth	0.168	0.076	0.253	-0.002**	0.001	-0.002
	(0.80)	(0.36)	(1.00)	(-2.14)	(0.08)	(-0.51)
IOHolding	0.098	0.074	0.038	-1.396**	-1.546**	-1.846***
	(0.63)	(0.48)	(0.07)	(-2.45)	(-2.30)	(-3.09)
HHI	-0.000	-0.000	-0.000	0.000	-0.000	0.000
	(-1.35)	(-1.01)	(-1.23)	(0.16)	(-0.24)	(0.37)
GDPGrowth			0.655			6.023**
			(0.36)			(2.00)
Supply Chain Partner controls						
Size	0.028	0.028	0.030	-0.046	-0.051	-0.076
	(1.58)	(1.41)	(1.49)	(-1.05)	(-0.92)	(-1.49)
Book-to-market	0.030	0.018	0.031	-0.029	-0.093	-0.181
	(1.23)	(0.66)	(1.08)	(-0.24)	(-0.64)	(-1.33)
Leverage	0.029	0.019	0.038	0.617	0.734	0.576
	(0.41)	(0.24)	(0.51)	(1.38)	(1.46)	(1.10)
ROA	-0.125	-0.104	-0.148	3.678***	3.605***	3.399***
	(-1.32)	(-1.06)	(-1.53)	(3.45)	(2.76)	(2.72)
FCF	-0.038	-0.028	-0.034	-0.738	-0.584	-0.875
	(-0.83)	(-0.82)	(-0.72)	(-1.25)	(-0.80)	(-1.31)
SalesGrowth	-0.001**	-0.001	-0.001	0.656**	0.491	0.811**
	(-2.32)	(-0.69)	(-1.33)	(2.40)	(1.52)	(2.53)
IOHolding	0.108	0.079	0.097	-0.287	-0.355	-0.766**
	(1.27)	(0.87)	(0.99)	(-1.48)	(-1.55)	(-1.98)
HHI	-0.000	-0.000**	-0.000	-0.000	-0.000	-0.000
	(-0.96)	(-1.99)	(-0.69)	(-0.20)	(-0.25)	(-0.03)
GDPGrowth			1.863**			0.199
			(2.19)			(0.10)
Observations	34,190	28,244	27,998	34,407	28,270	28,142
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes

Adjusted R-squared	0.872	0.87	0.868	0.772	0.767	0.768

Table 5: The timing test for the effect of IDD adoption on RSI

This table extends the results of Table 4 by examining the timeline over which IDD adoption affects RSI. We regress firm RSI on IDD adoption by the headquarter states of suppliers in Model 1 and of customers in Model 2. We include indicator variable IDD_PTR (t) which takes a value of 1 if IDD was adopted by partner's headquarters in the t years relative to the IDD adoption year of observation (t=0). All models include controls for standard firm characteristics and supply chain partner characteristics and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
	Relationship specific investment (RSI)	
	IDD Adoption by Supplier State	IDD Adoption by Customer State
IDD_PTR (-3)	0.185	-0.418
	(1.58)	(-1.45)
IDD_PTR (-2)	0.012	-0.414
	(0.10)	(-1.35)
IDD_PTR (-1)	0.100	-0.577*
	(0.98)	(-1.83)
IDD_PTR (0)	0.049	-0.621*
	(0.43)	(-1.66)
IDD_PTR (+1)	0.195	-0.195
	(1.54)	(-0.73)
IDD_PTR (+2)	0.163*	-0.274
	(1.65)	(-0.70)
IDD_PTR (+3)	0.218***	0.077
	(3.06)	(0.41)
Observations	34,190	34,407
Firm Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Controls	Yes	Yes
Adjusted R-squared	0.872	0.772

Table 6: Supplier human capital and the effect of supplier IDD adoption on customer RSI

This table examines whether the effect of IDD adoption by a supplier's state on customer RSI varies cross-sectionally with supplier's human capital importance. We divide suppliers into high and low human capital using three proxies; industry wages (Models 1, and 2), intangible intensity i.e., intangible assets divided by property, plant, and equipment (Models 3, and 4), and labor to capital ratio which is the number of employees divided by property, plant, and equipment (Models 5 and 6). All models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Relationship specific investment (customer)					
	Industry wages(S)		Intangible Intensity(S)		Labor to capital(S)	
	High	Low	High	Low	High	Low
IDD_PTR	0.182**	-0.002	0.099**	0.068	0.098*	0.055
	(2.08)	(-0.04)	(2.29)	(1.44)	(1.91)	(1.24)
Observations	7,570	9,053	17,049	16,855	16,463	16,640
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.888	0.896	0.892	0.873	0.862	0.889

Table 7: Firm innovation and the effect of supplier IDD adoption on customer RSI

This table examines whether the effect of supplier IDD adoption on customer RSI varies cross-sectionally with innovation intensity, as more innovative firms should benefit more from proprietary information protection provided by IDD adoption. We divide firms into subsamples using two proxies of innovation: industry R&D expense (column 1 and 2) and number of patents (column 2 and 3 divides firms into patent versus no patents and column 3 and 4 into firms with above and below median number of patents). All models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Relationship specific investment (customer)					
	Industry R&D (C)		#Patents (C)		#Patents (C)	
	High	Low	Yes	No	High	Low
IDD_PTR	0.115**	0.006	0.116***	-0.003	0.122**	-0.017
	(2.11)	(0.72)	(2.62)	(-0.17)	(2.48)	(-0.56)
Observations	17,070	17,010	21,494	12,478	17,346	16,703
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.829	0.757	0.860	0.936	0.842	0.917

Table 8: Relationship importance and the effect of supplier IDD adoption on customer RSI

This table examines whether the effect of supplier IDD adoption on customer RSI varies cross-sectionally with relationship characteristics. We divide firms into subsamples using several relationship characteristics; relationship duration (Models 1, and 2), Unique Relation, i.e., customers and suppliers do not have any other trade partner (Models 3, and 4), Supplier Dependence, i.e. percentage of COGS sourced from supplier (Models 5, and 6), supplier industry HHI (Models 7, and 8), and product market fluidity (Models 9, and 10), All models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Relationship specific investment (customer)									
	Relationship duration		Unique Relation		Supplier Dependence		HHI (S)		Product fluidity (S)	
	Long	Short	Yes	No	High	Low	High	Low	Low	High
IDD_PTR	0.103**	0.052	0.360**	0.067*	0.120**	0.045	0.097**	0.042	0.070*	0.093
	(2.20)	(1.13)	(2.36)	(1.88)	(2.21)	(1.20)	(2.12)	(0.92)	(1.67)	(1.64)
Observations	15,904	18,024	2,431	31,319	16,953	16,798	16,920	16,955	13,844	13,586
Firm Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.885	0.870	0.907	0.872	0.868	0.877	0.874	0.878	0.888	0.873

Table 9: Alternate bonding mechanism and the effect of supplier IDD adoption on customer RSI

This table examines whether the effect of supplier IDD adoption on customer RSI varies with the presence of alternate measures taken to mitigate holdup risk. We divide firms into subsamples using different measures that typically mitigate holdup risk; high and low common ownership between suppliers and customers (Models 1, and 2), whether customers and suppliers have joint venture or strategic alliance with each other (JV/SA) (Models 3, and 4), whether customers have shared directors with suppliers (Models 5, and 6), and whether suppliers have shared directors with customers (Models 7, and 8). All models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Relationship specific investment (customer)							
	Common ownership		JV/SA		Shared Director(C)		Shared Director (S)	
	High	Low	Yes	No	Yes	No	Yes	No
IDD_PTR	0.038	0.079**	0.038	0.069**	0.070	0.096**	-1.611	0.100***
	(0.41)	(2.38)	(0.12)	(1.99)	(0.46)	(2.45)	(-1.18)	(2.63)
Observations	3,794	30,191	1,462	32,697	556	20,098	125	20,537
Firm Fixed Effect	Yes	Yes	1,462	32,697	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.932	0.869	0.869	0.874	0.888	0.868	0.868	0.867

Table 10: Takeover protection and the effect of supplier IDD adoption on customer RSI

This table explores supplier's reaction to enhanced takeover threat on account of IDD adoption. Our sample is limited to suppliers that adopt IDD and include all observations during three years before and after the IDD adoption. We use active poison pill as a proxy for takeover defense. Panel A examines whether suppliers activate poison pills after IDD adoption. Panel B examines whether the effect of supplier IDD adoption on customer RSI varies with supplier's anti-takeover provision (ATP) measures. Model 1 uses an indicator variable, *ActivePoisonpill*, that take a value of one if suppliers have an active position pill at the time of IDD adoption and zero otherwise. Models 2 and 3 use an indicator variable, *Poisonpill_adoption*, that take a value of one if suppliers adopt poison pill within one year (Model 2) and within three years (Model 3). *PostIDD* takes a value of one for years after IDD adoption, and zero otherwise. All models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

Panel A: Do suppliers activate poison pills after IDD adoption?

	(1)
	Poison pill adoption by suppliers
PostIDD	0.027***
	(3.54)
Observations	2,452
Firm Fixed Effect	Yes
Year Fixed Effect	Yes
Controls	Yes
Adjusted R squared	0.545

Panel B: Does poison pill activation alleviate disruptive effect of IDD adoption on firm RSI?

	(1)	(2)	(3)
	Relationship specific investment (customer)		
	Active poison pill	Ppill adopted within 1 year	Ppill adopted within 3 years
ActivePoisonpill * PostIDD	**0.474****		
	(2.04)		
ActivePoisonpill	-0.684**		
	(-2.00)		
Poisonpill_adoption * PostIDD		**0.654***	**0.604****
		(1.67)	**(2.00)**
Poisonpill_adoption		-1.106**	-0.726
		(-2.24)	(-1.61)
PostIDD	-0.654***	-0.641***	-0.645***
	(-3.95)	(-3.93)	(-3.96)
Observations	2,452	2,452	2,452
Firm Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Adjusted R-squared	0.492	0.492	0.492

Table 11: Rejection of IDD by supply chain partner and relationship specific investment

This table examines the effect of IDD rejection by supplier's state on customer's relationship specific investment, measured as R&D expenses divided by total assets. We regress customer RSI on supplier state IDD rejection. Column 1 includes our full sample, and Column 2 exclude observations for which firms and supply chain partners are headquartered in the same state. Both models include controls from Table 4 and include firm, and year fixed effects. All independent variables are defined in Appendix A. Standard errors are clustered by firm, t-stats are reported in parenthesis; ***, **, and * denote significance at 1%, 5%, and 10% level, respectively.

	(1)	(2)
	Relationship specific investment (customer)	
	All	Diff states
IDDReject_PTR	-0.136***	-0.032
	(-2.61)	(-0.64)
Observations	34,190	28,244
Firm Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Adjusted R-squared	0.872	0.87