Chained Innovation: Response to Customer Covenant Violations

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Version: October 25, 2021

Abstract

Customers' financing frictions increase their marginal net benefits from technology sharing with suppliers as seeking supplier cooperation and reducing costs become significant concerns, thereby increasing collaboration and supplier innovation. Using U.S. data, we find that suppliers of customers violating covenants become more innovative, specialize in niche areas, and exhibit greater tendencies to cite and coordinate with customer innovation. These gains are stronger when suppliers have greater financing flexibility and when customers are highly specialized and trustworthy. In addition, innovative suppliers seem to thrive post-customer covenant violations. Overall, our evidence indicates that financing frictions shape suppliers' relationship-specific investments and innovation.

JEL Classification: O30, L14, L24, G32, G33

Keywords: Innovation, Customer-Supplier Relationship, Debt Covenant Violations, Firm Performance

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The authors would like to thank Shaun Bond, Ling Cen, Hasibul Chowdhury, Sudipto Dasgupta, Hai Lin, Shuqing Luo, William Mbanyele, Micah Officer, Barry Oliver, Terry Pan, David Reeb, Elvira Sojli, Paula Suh, Wing Wah Tham, Ying Xia, Jiajie Xu, Frank Zhang, Le Zhang, Minjie Zhang, and Zilong Zhang for feedback. We also like to thank the seminar participants at the University of Adelaide, the University of Queensland, Queensland University of Technology, Swansea University, University of Western Australia, the Boca Corporate Finance and Governance Conference, the FIRN virtual seminar series, the FIRN Corporate Finance Meeting, Australasian Finance and Banking Conference, Conference on Asia-Pacific Financial Markets (CAFM), Eastern Finance Association's Annual Meeting (EFA), Financial Markets and Corporate Governance Conference, and Conference on the Theories and Practices of Securities and Financial Markets (SFM).

Introduction

Incomplete contracting in customer-supplier relationships influences the level of relationship-specific investments (hereafter, *RSI*) and the severity of hold-up problems (e.g., Hart, 1988; Fresard, Hoberg, and Phillips, 2019). However, far from being static, as indicated by theory, the incentives of trading partners vary dramatically with their financial circumstances (e.g., Klein and Leffler, 1981), and this fact may account for the observed breadth of product-market relationship strengths. For example, customers can earn rents by frequently contracting with new suppliers, maintaining a diverse base of suppliers, and pitting them against each other for contracts, keeping all the suppliers at arm's length with minimum information sharing. However, when financially constrained, customers lose their attractiveness as trading partners. They, therefore, face greater incentives to seek cooperation from existing suppliers and willingness to share more information, who at the same time face disincentives in committing more resources to the relationship. Thus, customers may offer improved trading terms for self-preservation to navigate the new financing realities they face. However, such contract terms are made more difficult by customers' financial conditions. Thus, customers may substitute trading terms with non-monetary incentives, such as shared technology with implications for supplier innovation. In this paper, we examine these key dynamics from the perspective of supplier innovation when customers become more financially constrained.

Examining supplier innovation is important for several reasons. Suppliers and other small businesses form the backbone of the economy in terms of output and employment; hence, their innovation, which affects their competitiveness and survival, is a central economic issue (Porter, 1992). Furthermore, the increasing role of suppliers in new product development (e.g., Walter, 2003) and the salience of supplier innovation in cementing product-market relationships (Pisano, 1990) make supplier innovation key to their entire vertical industry. Moreover, the potential for supplier innovation to decrease the operational costs of a customer (Wagner and Bode, 2014) can mitigate the financial constraints of a customer. Thus, when constrained, customers are more incentivized to seek stronger cooperation with suppliers.

In product-market relationships, customers usually possess stronger bargaining power with suppliers, as suppliers are smaller, less profitable (Banerjee, Dasgupta, and Kim, 2008), and experience longer payback periods on their *RSI* (Irvine, Park, and Yıldızhan, 2016). Given the objective functions and constraints of trading partners, customers would share some baseline level of information and innovation activity with suppliers (e.g., Almazan, Suarez, and Titman,

2007). However, frictions such as financing constraints place upper limits on trading terms and impede new supplier acquisitions, creating paradigm shifts in product market interactions. Thus, customers perceive altered marginal net benefits to collaborate with suppliers, such as by sharing technology, thus providing an ideal setting to examine how customers influence supplier innovation. To examine this issue, we propose two competing hypotheses, namely, the *bonding* and *dissociation* hypotheses, both of which are carefully developed herein.

The *bonding* hypothesis is based on the premise that financing frictions incentivize *bonding* between customers and suppliers, with the increased interdependence being mutually beneficial. To relieve some financing constraints, financially troubled customers increasingly rely on suppliers to provide certain remedies, such as supplier cost-reducing innovations, higher *RSI*, or the provision of more flexible trade credit. However, to entice suppliers to undertake such risky actions despite the customer's adversity, the customer should offer more non-monetary incentives, such as innovation inputs and close collaboration opportunities.[1] Such good faith actions by the customer can encourage suppliers to commit more resources to the relationship, allowing the suppliers to exploit the opportunities and increase the supplier innovation output.[2] In return, any cost-saving innovation by suppliers can directly reduce the customers' costs. Moreover, a closer working arrangement can also facilitate the co-investment of suppliers in customer innovation (i.e., a substitution effect), which can benefit both trading partners.

The *dissociation* hypothesis is built on the view that customers may behave opportunistically when in trouble and that hence suppliers may take actions to minimize the

[1] Although for suppliers, customers have a large repertoire of non-monetary incentives, such as sharing information with supply-chain lenders (Cen et al., 2016), the timely sharing of demand information to decrease supplier inventories (Bourland, Powell, and Pyke, 1996), and initiating strategic collaborations (Johnson and Houston, 2000), a sudden increase in financing frictions makes these alternatives financially more expensive and unattractive than sharing knowledge with respect to innovation, especially if knowledge sharing can reduce costs. For example, even though the customer might provide more private information to the lenders about the supplier, lenders may not be keen to increase exposure to financially constrained firm's trading partners. In addition, customer incentives to minimize their inventory, which is more important when facing financing frictions, often come at the cost of higher levels of supplier inventory. Thus, a financially constrained customer may be less willing to provide more timely demand information to decrease supplier inventory, as doing so would conflict with their own inventory policies. In addition, when faced with financing frictions, customers may rely more on flexible trade credit and be unable to establish joint ventures that require new investments, thus making such non-monetary options that require further investments unattractive.

[2] Alternatively, despite the gains, if the customer fails or the relationship becomes economically unviable, the increased supplier innovation and knowledge obtained from the failed customer can increase the attractiveness of the supplier to a new customer, especially when the suppliers are able to produce quality goods and services at lower costs (e.g., Ellram, 1990; Pisano, 1990; Tracey and Tan, 2001), thereby reducing the suppliers' willingness to pursue a risky choice.

damage or exposure to financially troubled customers (Williamson, 1975; Klein, Crawford, and Alchian, 1978; Shleifer and Vishny, 1989), which is a strategy with subsequent implications for supplier claims (Zhang, 2019), including their innovation. Supplier innovation will be negatively affected when 1) hold-up problems are exacerbated (e.g., Macleod and Malcomson, 1993), 2) a contagion effect of customer financial distress exists (e.g., Hertzel et al., 2008; Lian, 2017), and 3) complementary supplier innovation decreases with customers' shrinking innovation activities. However, considering customer financial difficulties, supplier innovation may benefit from necessity when the supplier strives to diversify their customer base and undertake risky actions to minimize the costs of inaction. Thus, the *dissociation* hypothesis predicts that by altering suppliers' incentives to maintain customer relationships and customers' ability to finance innovation, supplier innovation can be positively or negatively affected.

We rely on our empirical tests to see which of these two competing hypotheses is supported. To overcome endogeneity concerns, we examine the existing customer-supplier relationships that are subject to an exogenous shock in the form of a customer's debt covenant violation.[3] Using the customer-supplier data from Compustat Business Segment and syndicated loan data from DealScan, we identify the current ratio and net worth covenant violations of customers by comparing covenant thresholds set out in the loan agreement and quarterly financial reports. With the identified covenant violations, we perform a Regression Discontinuity Regression (RDD) analysis by focusing on customers who are close to covenant violation thresholds based on tight distances around the threshold.

Using the RDD sample, we find that the suppliers of customers who just violate their covenants increase their innovation output measured by the number of patents (quantity), as well as citations (quality), supporting the *bonding* hypothesis. With respect to economic magnitude, after controlling for the standard determinants of innovation, compared with suppliers whose customers have not violated covenants in the RDD sample, a supplier whose principal customer faces a covenant violation produces 27.6% and 23.1% additional patents in the first two supplier fiscal years, respectively, following the covenant violation. The patents

[3] When customers violate their loan covenants, creditors obtain the rights to accelerate or restructure the loan. Although such covenant violations do not cause an outright default in all cases, it increases the bargaining power of the creditors and their say in the day-to-day operations of the firms. Prior studies have found that increases in creditor rights affects the financial policies of firms, such as the reduction in net debt issuance (Roberts and Sufi, 2009), an increase in the pledging of assets (Mann, 2014), and lower investments (Chava and Roberts, 2008; Christensen, Macciocchi, and Nikolaev, 2019); they also cause large employment cuts (Falato and Liang, 2016); and encourage bondholders to adopt dual ownership (Hamilton, Irlbeck, and McKee, 2018).

of the former suppliers also receive 7.1% additional citations per patent in the supplier fiscal year following the covenant violation, suggesting that the spillover from customer financing problems to supplier innovation is nontrivial. We also find that these suppliers increase their search depth in their patenting activity, which indicates that they are developing expertise in a narrower area. These results remain robust when controlling for supplier fixed effects and polynomial terms of the distance to covenant violation thresholds, and in samples based on alternative RDD bandwidths.

The logic of our results is exemplified by the actions of Chrysler Corporation in 1989 when it was struggling to survive, as reported by the Boston Consulting Group.[4] Bob Lutz, the president of Chrysler operations, met with 25 of the company's largest suppliers and asked for their help in reducing costs by stating, "All I want is your brainpower, not your margins". This strategy was rewarded by enhanced buyer-supplier collaboration, which allowed Chrysler's program called SCORE (or Supplier Cost Reduction Effort) to produce billions of dollars in savings and helped them turn around a corner, as well as made Chrysler more willing to share the benefits with these suppliers.

To further determine whether the increase in supplier innovation has a *bonding* or *dissociation* motivation, we examine the propensity of suppliers to cite their customer patents following covenant violations. We find that the likelihood of citing customer patents and the frequency of citations in the RDD sample is higher among suppliers whose customers have violated their covenants than among suppliers whose customers have not violated their covenants within two years of the violation. We also document evidence that these supplier patents involve larger inventor teams, suggesting more collaborative innovation post customer covenant violations.

Familiarity can also explain our results thus far, such as the propensity to cite customer patents. To explore this possibility, we examine the coordination of innovation activities between customers and suppliers in the post-covenant-violation period. We find that covenant violation increases contemporaneous coordination while decreasing the lead-lag coordination between customer and supplier innovation, indicative of the higher customers' willingness to

[4] In 2013, the Boston Consulting Group published the supplier cooperation efforts at Chrysler as a "Buyer-Supplier Collaboration" case study and used it to demonstrate a roadmap for success in supply chain management. For more details, please refer to https://www.bcg.com/en-au/publications/2013/procurement-supply-chain-management-buyer-supplier-collaboration

coordinate innovation with suppliers when the former face more financing frictions. All of these findings lend further support to the *bonding* hypothesis.

Examining the cross-sectional variations in our baseline findings, we observe that supplier innovation is more sensitive to the financial shock of the customers when suppliers with the financial flexibility to pursue more innovation experience more "*bonding*". Specifically, our main results are more pronounced when the suppliers are less leveraged, more profitable, and more likely to offer their goods on credit. We also find that the innovation sensitivity of suppliers is higher when the customers are more innovative, have more expertise, and are more trustworthy based on their geographic location. Together, these findings suggest that supplier innovation is more responsive when suppliers have more incentives to learn and when noncontractability frictions are lower.

Additionally, we find that innovative suppliers experience higher odds of survival as a public firm and increase their net worth following the covenant violation. Our collective evidence suggests that '*bonding*' with a financially weakened customer can have long-term positive consequences.

This paper makes the following contributions. First, our results provide an explanation for why small suppliers with low bargaining power may willingly invest in costly relationship-specific investments with their large customers who may behave opportunistically. Our findings illustrate that by maintaining good relationships with customers, there could be significant non-monetary benefits, such as technology and expertise spillovers. Our results complement various studies that examine the *RSI* determinants, such as positive economic spillovers (Kang, Mahoney, and Tan, 2009), reliable contract enforcement systems (Nunn, 2007), higher average life-cycle profitability despite initial losses (Irvine, Park, and Yıldızhan, 2016), social connections between managers or board members of customers and suppliers (Dasgupta, Zhang, and Zhu, 2015), lower takeover defenses (Johnson, Karpoff, and Yi, 2015, Cen, Dasgupta, and Sen, 2016), and the geographic proximity between customers and suppliers (Chu, Tian, and Wang, 2019, Dasgupta et al., 2020).[5] Specifically, by showing that covenant

[5] Our paper is closely related to Chu, Tian, and Wang (2019) and Banerjee, Dasgupta, and Shi (2019), who document positive and negative factors for innovation diffusion along the supply chain, respectively. Although complementing the findings of both studies by using a different setting, our paper differs in important ways. First, by making use of a shock to the use of non-monetary incentives by customers, our study permits an examination of the larger question of whether supplier innovation substitutes or complements customer innovation, with evidence favoring the former. Second, while Chu, Tian, and Wang (2019) establish geographic proximity as a key channel that facilitates knowledge transfer between customers and suppliers, what motivates customers to share

violations can facilitate innovation diffusion along the supply chain, we complement the findings of a contemporaneous paper by Banerjee, Dasgupta, and Shi (2019), who document a negative effect due to customer fraud, and we thereby highlight the heterogeneity in supplier innovation responses to negative customer-specific events. Negative events such as fraud destabilize the existing implicit commitments made by the customer, and thus may irrevocably harm supplier relationships. On the other hand, our results indicate that hardships such as financial constraints may provide opportunities for suppliers to gain non-monetary benefits and enhance relationships at the cost of sharing some short-term pain.

Second, our study illustrates whether supplier innovation can substitute or complement customer innovation, providing an understanding that can have important implications for policymaking and economic growth. If supplier innovation largely complements innovation by the customer, then an increase in creditor rights for customers can lead to a substantial drop in innovative activity, affecting the economy's overall competitiveness and highlighting the dark side of increased creditor rights. On the other hand, as our results show, supplier innovation substitutes for customer innovation and increases knowledge sharing across the supply chain. These could be viewed as the positive externalities of increased creditor rights, consistent with Gu, Mao, and Tian (2017), who document more focused innovation for a borrower despite an overall innovation reduction when creditor rights increase. Our findings complement their study and indicate that suppliers address the slack in innovation quantity and prevent creditors from distorting the equilibrium in innovation output in the economy.

2. Data, Sample Selection, and Key Variables

Our primary sources of data include the following: the Loan Pricing Corporation's DealScan database for syndicated loans and covenants; the Compustat Business Segment File for customer-supplier relationships,[6] and Kogan et al. (2017) for utility patents and citations data for patents filed with the United States Patents and Trademark Office (USPTO).

knowledge is left unexplored. Our study shows that financing frictions could be a potential motivator for customers to collaborate with suppliers in innovation, whereas Banerjee, Dasgupta, and Shi (2019) document customer fraud as having a negative influence on collaboration for the supplier.

[6] Both of our hypotheses rely on the argument that incentives of both customers and suppliers are altered following a covenant violation, which is readily justifiable when the trading partners are similarly sized. However, the Compustat Segment Customer database generally consists of large customers and relatively smaller suppliers, and this size difference may affect differently the incentives of both customers and suppliers. Thus, to generalize our

We construct our sample in the following manner. We begin with all Compustat firms incorporated in the United States with one or more loans covered by the DealScan database between 1994 and 2010.[7] To perform RDD analyses, we restrict those firms with a current ratio or net worth covenant on loan. We then merge this initial sample with the customers in the customer-supplier relationships dataset constructed using the Compustat Business Segment File. The Financial Accounting Standards Board's Statement of Financial Accounting Standards No. 14 (SFAS No. 14 - "Financial Reporting for Segments of Business Enterprise") requires a firm to disclose sales to its customers if the revenue generated exceeds 10% of the firm's total revenue or if the customer is vital to its business.[8] However, firms are required to report only the names of customers. We identify these customers by matching their names in the Business Segment File with the historical names in the CRSP/Compustat merged data file using a fuzzy name-matching algorithm (Cohen and Frazzini, 2008; Cen et al., 2017) supplemented by manual verification (Fee and Thomas, 2004; Banerjee, Dasgupta, and Kim, 2008).[9]

To obtain information on innovation, we merge the combined dataset of customers (with at least one loan in DealScan) and their suppliers with firm-level utility patents and citations data from Kogan et al. (2017). The utility patents that are eventually granted are measured at the firm-year level according to the filing date with the USPTO. The patent filing date provides a more timely measure of innovation activity than the grant date because between the two dates, there is a significant lag due to delays at the USPTO (Griliches, Pakes, and Hall, 1986). We also complement the patent measures with a measure of citations. Although the number of patents captures the extent of firm innovation activity, it fails to capture the quality or

predictions, we check the sensitivity of our findings among large suppliers alone. In untabulated tests, we find that our results remain robust when we split our sample according to the median ratio of supplier size to customer size, measuring size as the market value of equity.

[7] Our sample period begins in 1994 to coincide with the reliable availability of covenants data in DealScan (Chava and Roberts, 2008).

[8] In 1997, SFAS 131 superseded SFAS 14, which allowed firms to report sales to significant customers without revealing their identity. However, firms are still required to disclose their customers' identity when the customers account for more than 10% of overall sales or if the loss of a customer would have a material adverse impact on the firm under the Securities and Exchange Commission (SEC) Regulation S-K (Ellis, Fee, and Thomas, 2012; Banerjee et al., 2014).

[9] When matching is not possible, we make use of SEC filings to help determine a customer's true identity; information concerning large customers is typically disclosed in the Management Discussion and Analysis section of the 10-K, as well as in the business description and the risk sections of the prospectus. We further supplement our search with the Lexis/Nexis Academic Universe and Factiva databases and company websites to further ascertain customer identities. In cases where the customer name refers to a public firm's subsidiary, then the parent firm in CRSP/Compustat is used as the matched firm.

importance of innovation. Therefore, in the spirit of Fang, Tian, and Tice (2014), we construct a measure based on the number of non-self-citations received by each patent in the future.

Additionally, to examine the type of innovation, following Katila and Ahuja (2002), we compute search scope and search depth measures based on the types of citations included in the patent. Search depth and search scope are firm-year measures based on the repetition rate and novelty of citations, respectively, among patents filed by the firm in the previous five years. A higher rate of repetition implies higher search depth and suggests exploitative innovation, i.e., that the firm develops expertise or focuses on a narrow domain in its patents. The higher use of new and previously unused citations indicates higher search scope and suggests exploratory innovation; i.e., it indicates that the firm is exploring new horizons in its innovation activity.

All the variables used in the study are defined in the Appendix.

3. Research Design

Examining the effect of customer financing constraints using any proxy on supplier innovation is subject to severe endogeneity concerns. Thus, for identification, we use an exogenous event that does not involve the confounding effect of other economic drivers of supplier innovation, alters financing constraints, and amends customers' preferences towards using non-monetary incentives with suppliers.[10] Violating a covenant, termed a 'technical default', accelerates the debt obligations. Although, in most cases, the debt is not repaid immediately and is often renegotiated (Roberts and Sufi, 2009), a covenant violation paves the way for the transference of control rights to the creditor. For the following two reasons, such covenant violations by customers present an ideal setting to examine the effect of customers on supplier innovation.[11]

[10] Furthermore, customers and suppliers self-select their trading partners, which introduces an additional twin-matching problem. Thus, we focus on existing relationships where customers and suppliers have maintained ties in the past, thereby limiting the effect of selection among trading partners.

[11] Financial covenants, being set ex ante, incentivize borrowers to avoid violating them, even through manipulation if need be. Such actions can imply that violators are substantially different from non-violators, even when both are close to the violation thresholds. This will violate the exogeneity assumption in the RDD framework, making it unsuitable. However, as argued by other studies that rely on covenant violations for identification (e.g., Chava and Roberts, 2008), lenders also are well aware of such concerns. Therefore, to reduce manipulation, lenders spell out the precise definition and computation of covenant-based measures and also choose a reporting frequency that minimizes such actions. Furthermore, since corporate lending is a repeated game, even reputational concerns can discourage manipulation. Moreover, Chava and Roberts (2008) also find that accounting-based measures, such as accruals, are not systematically different around the covenant thresholds,

First, transferring control rights can reset the existing implicit contract environment between various stakeholders. For example, Falato and Liang (2016) find that increased creditor rights lead to larger and substantial employment cuts. Shleifer and Summers (1988) argue that takeovers, a form of change in control, radically alters the environment under which managers, employees, and/or suppliers act based on implicit contracts. Thus, in the context of suppliers, when control rights are transferred to creditors, customers may need to revitalize their relationship to maintain the renewed commitment of the supplier. Alternatively, customers can use this reset to engage in rent-seeking behavior with regard to already committed *RSI* but at the risk of experiencing more severe hold-up problems. Offering economic incentives to the supplier is subject to creditor review and hence is unavailable to assuage supplier concerns about the future. Without the power of economic incentives, the customer faces altered incentives to offer non-monetary benefits in their trading relationships.

Second, the prevalence of covenants between borrowers and creditors (Smith and Warner, 1979; Bradley and Roberts, 2015) does not affect supplier contracting decisions. Additionally, the covenants' binary nature allows us to use a regression discontinuity design that mitigates the concern about endogeneity between a customer's financial health and supplier innovation activity. In particular, the distance between the covenant threshold of the customer and their accounting variables provides an exogenous source of variation in customer financing frictions, thereby allowing us to identify the effect of covenant violations on supplier innovation. By focusing on a small range of distances between the covenant thresholds and accounting variables, we can homogenize the violation and non-violation firms by restricting the analyses to highly similar firms in most aspects, except for the covenant violation (Chava and Roberts, 2008). Thus, this process helps us isolate the effect of covenant violations on supplier innovation.

Our empirical specification closely follows that of Chava and Roberts (2008) and Falato and Liang (2016). First, we use a treatment variable, *Customer covenant violation*$_{jt,}$ as a dummy variable for covenant violation, defined as follows:

$$Customer\ covenant\ violation_{jt} = \begin{cases} 1 & z_{jt} - z_{jt}^{0} < 0 \\ 0 & z_{jt} - z_{jt}^{0} \geq 0 \end{cases}$$

suggesting that concerns about manipulation are limited. Finally, we also perform McCrary density tests to examine whether there is manipulation of narrow bandwidths around the covenant thresholds and plot the distribution in the Online Appendix, and the distribution shows no remarkable discontinuity.

where *j* indexes the firm (i.e., customer) and *t* indexes time (year).[12] z_{jt} is the actual accounting measure (current ratio and net worth), and z_{jt}^{0} is the threshold specified by the covenant in the loan agreement.[13] We restrict our attention to the current ratio and net worth covenants, as they frequently appear in the DealScan data (Chava and Roberts, 2008; Dichev and Skinner, 2002). Furthermore, these two accounting measures that determine whether these covenants are violated are straightforward to identify. Other covenants, such as those based on debt, leverage, or coverage ratios, can vary widely in the definitions of these measures and thus do not allow the precise identification of covenant violations (Falato and Liang, 2016).[14] However, to mitigate concerns about focusing on only two types of covenants, following Nini, Smith, and Sufi (2012), we also perform additional tests based on text-based covenant violations. The text-based covenant violations are inferred from filings, are much more comprehensive in capturing potential covenant violations, and also overcome concerns regarding covenants with dynamic thresholds. Our results based on the text-based covenants are similar, thus allowing us to generalize our findings to all covenants beyond just the current ratio and net worth covenants.

Our baseline regression specification using $Customer\ covenant\ violation_{jt}$ as the key explanatory variable is specified as follows:

$$Innov_{i,j,t+1,2} = \alpha + \beta Customer\ covenant\ violation_{j,t} + \gamma Customer\ default\ distance_{j,t} + \sigma X_{i,t} + \varphi_i + \theta_t + \epsilon_{i,j,t} \quad (1)$$

where *i* indexes the supplier and $Innov_{i,j,t}$ is a measure of innovation and is obtained using patenting activity. Patenting activity is broadly measured in the following two ways: (1) the logarithm of one plus the number of supplier patents filed that are eventually granted, and (2) the logarithm of one plus the number of citations received for successful supplier patents.

[12] To match the customers' debt covenant violations information to the frequency of the customer-supplier information, we follow Falato and Liang (2016) and convert quarterly violations information to annual violations information.

[13] Our identification of covenant violation can be considered as a fuzzy RDD implementation rather than a sharp RDD because a loan can be considered as being in violation of covenants if any of the existing covenants are violated, not only the current ratio and the net worth covenants. Moreover, some of the covenants may be based on measures not computed using GAAP rules (e.g., Li, 2010), suggesting that the difference between the covenant threshold and the GAAP accounting variable is a noisy measure of whether a covenant is violated.

[14] In the DealScan database, during our sample period, approximately 11.75% and 40.92% of loans have current ratio and net worth covenants, respectively. Thus, a combined 45.80% of DealScan loans have one of these covenants that we examine. Furthermore, other quantitative covenants that use numerical thresholds may be subject to interpretation and based on custom defined measures that are not observable from public information (e.g., Chava and Roberts, 2008). For example, debt-based ratios rely on the lender's definition of debt, such as obligations with the inclusion/exclusion of short-term liabilities. Given these constraints, the current ratio and net worth covenants are reasonable proxies to identify covenant violations in our setup.

Additionally, we also use measures of search scope and search depth, as described in Section 2. *Customer default distance* is the difference between the actual accounting measure and the threshold specified by the covenant in the loan agreement. We control for the following: supplier characteristics (*X*) to control for the determinants of firm-level innovation activity identified from prior studies (e.g., Fang, Tian, and Tice, 2014); supplier industry-fixed effects (φ); and year fixed effects (θ). Including industry and year fixed effects for suppliers allows β to capture within-industry and time-independent variation in supplier innovation due to a covenant violation by their largest principal customer, thus mitigating the concern that industry or time trends in the supplier industry or the economy may drive our findings, respectively. Furthermore, for examining the robustness of our findings, we also replace supplier industry-fixed effects with supplier firm-fixed effects to rule out time-invariant supplier firm characteristics.

To capture the effect of customer covenant violation in a timely manner, we focus on the two supplier fiscal years immediately following the covenant violation. The coefficient of interest is β, the treatment effect, which represents the effect of customer covenant violation on supplier innovation outcomes. The nonlinear relationship at the covenant threshold in equation (1) allows for the identification of the treatment effect under mild conditions. As long as the unobserved component of innovation $\epsilon_{i,j,t}$ does not have an identical discontinuity at the covenant threshold, the treatment effect is well identified (Chava and Roberts, 2008; Falato and Liang, 2016). Therefore, β is unbiased even if $\epsilon_{i,j,t}$ is correlated with the distance from the customer covenant threshold; i.e., $z_{jt} - z_{jt}^{0}$, but not with $Customer\ covenant\ violation_{j,t-1}$.

To make a causal interpretation of the estimation of equation (1), the following two conditions need to be satisfied. First, the local continuity assumption needs to hold, i.e., all factors other than the treatment variable need to be continuous at the covenant threshold. To verify whether this assumption has been met in our setting, we examine the difference between the treatment (customers who violate their covenants) and control (customers who do not violate their covenants) firms within a narrow bandwidth of covenant thresholds and discuss those findings in Section 4.1. Second, firms should not be able to manipulate themselves into the treatment and control groups precisely, i.e., the covenant violations should be random. In our setting, customers are unlikely to be able to precisely manipulate the reported ratios for the following three reasons: (1) the private reporting standards with lenders can be stricter than the regular SEC reporting requirements, thus increasing monitoring and reducing managerial

discretion; (2) the reputational costs in the syndicated loan market can be high if any manipulation is detected by lenders (Chava and Roberts, 2008), and (3) rational lenders can factor in the possibility of manipulation into the contracts and interest rates by rewarding (punishing) accounting conservatism (aggressiveness) (Li, 2013). Furthermore, the ability of customers to influence the choice of threshold in the loan contract is weak because these thresholds are set at the initiation of the loan agreement, while actual violations happen much later. Using the McCrary density tests, we also explore whether customers precisely manipulate their reported ratios graphically, which are detailed in the Online Appendix. We find no results that suggest precise manipulation around the covenant thresholds.

As the discontinuity at the covenant threshold is the source of identification, following Chava and Roberts (2008), we also include the smoothing functions of the distance (*Customer default distance*) from the technical default boundary in our baseline specification. Specifically, for the current ratio and net worth covenants, we include the product of an indicator function that takes the value of one if the loan agreement has a current ratio (net worth) covenant and the difference between the latest current ratio (net worth) and the threshold specified in the covenant separately. The inclusion of these variables helps isolate the treatment effect to the point of discontinuity and mitigates the concern that the distance to the covenant threshold contains information relevant to future customer-supplier innovation that is not captured by the other controls, such as supplier characteristics. We estimate equation (1) using a sample of supplier-year observations that are close to the point of discontinuity, where we define closeness as the absolute value of the relative distance between the accounting variable and the corresponding covenant threshold of the customer, which is a bandwidth less than 0.20 (Chava and Roberts, 2008).[15] To remove the arbitrariness in choosing a numerical bandwidth, we also define closeness by estimating the optimal bandwidth using a nonparametric density function (Silverman, 2018). The optimal bandwidth is defined based on the coverage error rate (CER) algorithm that allows bandwidth choice that minimizes the coverage error probability. Specifically, the CER bandwidth is obtained by estimating a constant and then multiplying with a rate of $n^{-1/4}$, where n is the number of observations (Cattaneo, Titiunik, and Vazquez-Bare, 2020).

[15] We also check the frequency distribution of the assignment variable and find no evidence suggesting precise manipulation by customers around the bandwidth of 0.2 denoting the relative distance between the accounting variable and the corresponding covenant threshold. The assignment variable density function (McCrary, 2008) shows that there is no precise manipulation around the debt covenant violation threshold, i.e., no significant discontinuity around the thresholds. The figure is presented in Online Appendix Figure 1.

4. Results

4.1. Summary Statistics

Table 1 presents the summary statistics of a supplier's innovation and the relationship to its customers. Panel A shows how firm innovation varies according to whether the firm has a concentrated customer or not. On average, we find that firms with one or more concentrated customers generate more innovation output than firms with no concentrated customers. These trends are observable in terms of innovation quantity (i.e., patent counts) and innovation quality (scientific value, such as citations, and economic value, such as patent value). Even when we examine the type of innovation activity based on the scope and depth (or whether it is explorative or exploitative) (e.g., Lin, Liu, and Manso, 2020), we find that both dimensions of innovation are greater for firms with concentrated public customers than for those that do not have public customers. The differences across all our innovation measures are statistically significant at the 1% level of significance. These findings oppose the common perception that large consumer-facing firms (i.e., at the end of the supply chain) might be more innovative in order to differentiate themselves from their rivals, and the findings suggest that firms in the supply chain play a disproportionately large role in innovation, raising questions as to the suppliers' motivation to innovate. Next, we examine whether the suppliers' levels of innovation vary by industry and how the level of innovation affects the suppliers' product-market relationships.

[Insert Table 1 about here]

Panel B of Table 1 provides univariate comparisons by industry of patent and citation counts of firms with and without concentrated customers. As illustrated in the panel, for the most part, the number of patents (citations) is significantly higher for firms with concentrated customers across all industries, especially in consumer durables, manufacturing, business equipment and healthcare, medical equipment, and drugs, all of which are regarded as sectors that produce both socially and economically valuable innovation. Thus, the role played by suppliers in innovation is not only quantitatively superior but also more prominent in industries that are vital to economic development. In Panel C of Table 1, we examine whether being innovative will help a supplier in its product-market relationships. We find that innovative suppliers, which are defined as those filing one or more patents that year, have more

concentrated customers and sell cumulatively more to such concentrated customers on average. Additionally, innovative suppliers sell more on a relative (to supplier total sales) and absolute basis to each individual concentrated customer and have longer-lasting durable relationships with their concentrated customers.

In Table 2, we show the difference in firm characteristics between public customers who face a covenant violation and those that do not, using a sample of public customers whose distance from covenant violation thresholds of networth and/or current ratio covenants are observable. We present evidence using a full sample of customers and using a subsample of customers who are within a narrow bandwidth of covenant thresholds, i.e., customers who are either very close to covenant violation or have just violated the covenant by a small margin. As discussed earlier, examining customers who are very near the covenant thresholds will ensure that we focus on customers who are similar in most aspects, i.e., local continuity. This local continuity will then allow us to isolate the effect of covenant violations on our main outcome variable: innovation performance.

Panel A of Table 2 indicates that the RDD samples of customers who violate covenants and those that do not violate covenants seem statistically similar, thus implying that compared to the differences in the full sample, the observable firm characteristics in the RDD sample are indistinguishable. Specifically, in the full sample, customers facing covenant violations have higher R&D expenditures, ROA, and Tobin's *q* but lower leverage levels, capital expenditures, and asset tangibility, with the differences being significant at the 1% level of significance. Such differences suggest that examining the effect of covenant violations in the full sample will confound our findings due to the vast dissimilarities among the customers (i.e., sample selection problem). However, the differences in these variables (except for market capitalization and Tobin's *q*) are no longer statistically and significantly different from zero when we focus on the RDD sample.

[Insert Table 2 about here]

Panel B presents the univariate analysis of the effect of customer covenant violations on supplier innovation. Consistent with the *bonding* hypothesis, the univariate *t*-tests reveal that in the RDD sample, the suppliers of firms that violate their covenants are more likely to increase their innovation, such as patents and citations. Additionally, the suppliers show an increased propensity to cite the customer's patent who has violated the covenant. When examining the difference between various kinds of innovation, we find that suppliers of firms

that violate their covenants are more likely to increase their exploitative innovation, i.e., leverage their specialization to become more innovative. All these univariate differences are statistically significant at least at the 5% level of significance.

4.2. Effect of Customer Covenant Violation on Supplier Innovation

To graphically explore the discontinuity in supplier innovation around the covenant violation thresholds of their customers, in Figure 1, as a function of the distance from the covenant threshold of the suppliers' principal customer, we plot the average measures of supplier innovation, including patent and citation counts, and the search depth of the supplier. We use the sample of supplier-year observations, where using the bandwidth of 0.2 on either side of the covenant thresholds, their principal customers are close to covenant violations. We also include on both sides of the thresholds the fitted lines and the 95% confidence interval. The distance from the covenant threshold standardized by dividing by the standard deviation of either the current ratio or the net worth is shown on the x-axis. Negative values of the distance indicate a violation, whereas positive values indicate that the covenants are not violated. Figure 1 indicates that the suppliers of customers who violate covenants have a discontinuous jump in the number of patents, the number of citations, and search depth. Therefore, Figure 1 presents graphical evidence of discontinuity in supplier innovation around customer covenant violations.

[Insert Figure 1 about here]

To test our hypothesis in a multivariate setting, we investigate the effect of customer covenant violation on supplier innovation by using the RDD sample and specification in equation (1). Table 3 presents the regression results with three different measures of innovation and an indicator for customer covenant violation and the control variables.[16] We double cluster the standard errors by suppliers and customers to account for the time-series correlation in the supplier's innovation and the correlation of the treatment variable among suppliers that share a given customer, respectively. From Columns (1) to (6), the innovation measures are calculated in year t+1, while in Columns (7) to (9), they are measured two years following the debt covenant violation (denoted by year t+2). The coefficients on each customer covenant violation indicator (i.e., *Customer covenant violation*) are positively significant at the 5%

[16] We also use average patent value and search scope as additional measures of innovation but find that our results do not suggest that they are affected by customer covenant violations, and hence, for the sake of brevity, we do not report the findings.

significance level in Columns (1) and (2), suggesting that customer covenant violation is more likely to increase suppliers' innovation in terms of both quantity and quality of innovation, which also supports the prediction of our *bonding* hypothesis.

Our main results are also economically significant. For example, in Columns (1) and (2), the coefficients on *Customer covenant violation* show that after customers experience a covenant violation, their number of patents and citations increase by 27.6% = $e^{0.244}$-1 and 7.1%= $e^{0.069}$-1 in the year following the covenant violation, respectively. Given that the mean number of patents and citations in the RDD sample are 1.64 and 0.14, respectively, these results suggest an additional 0.45 patents and 0.01 citations per patent per year for the supplier following their customers' covenant violation.

Although we find strong evidence of an increase in innovation quantity and marginal evidence of innovation quality, these findings do not indicate whether these suppliers explore or diversify to new areas of innovation or build on their existing specialization strengths. Therefore, to illustrate such drivers, we focus on the results for search scope and search depth. The coefficient on customer covenant violation is insignificant when using search depth as the dependent variable and always insignificant with search scope (untabulated results). However, search depth does become significant in future years and alternate specifications. These insignificant (significant) results on search scope (search depth) suggest that the suppliers do not diversify away from (bond more with) their existing troubled customers.

[Insert Table 3 about here]

In Columns (4) to (6) replacing supplier industry fixed effects with supplier firm fixed effects, we find that *Customer covenant violation* is positive and significant in all the three columns. Results in Column (6) also additionally suggest that these suppliers rely more on their core innovation areas or expertise to file new patents rather than on the exploration of new or less familiar areas. In Columns (7) to (9), examining supplier innovation in year *t*+2, we still find a positive and significant coefficient for the number of patents and search depth, suggesting that the effect of customer covenant violation prevails even in the second year following. Additionally, to the extent that innovation comes from knowledge sharing with customers, the results in Columns (3) and (9), when viewed together may suggest that developing expertise or specialization from acquired knowledge is time-consuming and may

show up later rather than sooner.[17] Furthermore, the results on search depth also help rule out the diversification motivation for supplier innovation; i.e., when their principal customer faces trouble, suppliers may want to diversify by exploring new innovation areas to minimize the cost of inaction, which may intensify financial contagion. However, the increase in search depth (with no increase in search scope, as found in untabulated tests) following covenant violations suggests that suppliers are not engaging in diversifying innovation behavior such as into less explored areas; instead, they rely on their existing knowledge and expertise. their customers' covenant violation.

Since our estimation of innovation at the supplier firm-level includes suppliers with both terminated and ongoing relationships with customers, relationship survival bias is less of a concern. However, to mitigate this concern further, in untabulated tests, we split the sample into those that are terminated and those that are not terminated within two years following the covenant violation and find that our results remain the same in both subsamples, although weaker in the sample of terminated relationships (the coefficient on *Customer covenant violation* becomes insignificant at year t+2 in the terminated sample). These findings may also be consistent with the *dissociation* hypothesis prediction of an unintended positive effect on supplier innovation. We further examine the effect on supplier innovation using the sample of suppliers that face an immediately terminated relationship (i.e., in the same year as the covenant violation) and do not find any significant increase in innovation in any of the future years, which rejects the *dissociation* hypothesis predicting a positive effect on innovation. Thus, in addition to mitigating relationship survival bias, these tests further support the *bonding* hypothesis.

To examine the robustness of our RDD specifications, we experiment with the inclusion of polynomial functions of the forcing variable, i.e., the distance to the customer covenant violation thresholds and alternate bandwidths of the RDD samples. In the first three columns of Panel A in Table 4, we include a polynomial of order two and a polynomial function of order three in the next three columns. In all these specifications, we find that the coefficient on *Customer covenant violation* is positive and significant in models using the number of patents

[17] However, the finding that suppliers engage in more exploitative innovation (i.e., greater search depth) cannot rule out the possibility that suppliers decide to protect trade secrets already available through patents because of the higher possibility of customer failure. In Section 4.6, we examine the coordination among the patenting behavior of customers affected by covenant violations and their suppliers and find evidence that supports the view that in the post-covenant-violation period, these affected suppliers' innovation inputs and outputs are more synchronous with their customers' innovation. This finding partially mitigates the concern that the observed increase in innovation might be a simple decision to patent existing knowledge.

or search depth, consistent with findings in Table 3. In the last three columns, instead of an arbitrary bandwidth of 0.2, we use a data-driven optimal bandwidth based on the coverage error rate (CER) algorithm. We still observe that customer covenant violation is associated with an increase in patent filings and citation counts. These results suggest that the findings on supplier innovation are robust to RDD specifications.

[Insert Table 4 about here]

Despite our results being robust, the external validity of our findings may be limited as our customer covenant violation measure is based on the quantitative thresholds of debt covenants, i.e., estimated debt covenant violations, limiting the sample of customers to those with specific debt covenants. To overcome this concern, we repeat our analyses using a text-based covenant violation, which is likely more comprehensive. That is because a text-based covenant violation captures most types of covenant violations and has greater ex-post precision, as it is based on the ex-post reporting of the violations in annual reports. Using the data on text-based covenant violations from Nini, Smith, and Sufi (2012), we present the results in Panel B of Table 4.

In the first and last three columns of Panel B of Table 4, we focus on supplier innovation in years t+1 and t+2, respectively. The coefficient estimates on *Text-based customer covenant violation* are positively significant at the 10% significance level in three of the six columns, specifically using *Ln (no of patents)* in years t+1 and t+2 and using *Search depth* in year t+1. However, citations of suppliers appear unrelated to text-based customer covenant violations. Ex-ante weaker findings are expected in this sample due to endogeneity concerns that suppliers of customers violating covenants may systematically have inferior prospects than those suppliers whose customers are financially healthy. Thus, finding a relationship despite the bias against us in this broader sample increases the confidence in the external validity of our Table 3 findings.

4.3. Effect of Customer Covenant Violation on Supplier Innovation Input

The long-term and time-consuming nature of innovation implies a lag between investment in innovation and eventual commercial success. Although we record patents when they are filed and not when they are granted, as is the common practice in the literature, there still could be a lag between investment in innovation and a stage when patents are ready to be filed. Thus, our findings, although robust, indicate shorter innovation development cycles for the suppliers. To investigate this further, in this section, we examine the responsivity of supplier investment

in innovation to customer covenant violations by focusing on their innovation input, i.e., research and development (R&D) expenditures. Table 5 presents the results of the analyses.

[Insert Table 5 about here]

To get a clear picture of the exact timing of the effect on innovation inputs, we examine supplier R&D in a five-year window around customer covenant violations. Using both the ratio of R&D expenditure to assets and R&D expenditure to sales as dependent variables in Table 5, we employ a specification similar to that in Table 3. Using the ratio of R&D expenditure to assets and controlling for supplier industry fixed effects, we find in Panel A of Table 5 that the coefficient on *Customer covenant violation* indicator is significant only in the year (i.e., t+1) and two years (i.e., t+2) after the violation and is insignificant in all prior years. The positive coefficient on *Customer covenant violation* remains robust even after the inclusion of supplier firm fixed effects in year t+1 in Column (9). Using the ratio of R&D expenditure to sales as the dependent variable, the results in Panel B mirror those in Panel A. Additionally, the coefficient on *Customer covenant violation* is also significant in year t in Column (3), indicating the high responsivity of suppliers to customer covenant violations.

Overall, these findings suggest that suppliers increase their investment in innovation following the covenant violation of their customers and no anticipated pre-violation changes towards innovation.

4.4. Dynamic Effects

To examine the time-series variation in supplier innovation around a customer's covenant violation, in Figure 2, using all customer-supplier pairs in which the customer has either violated a covenant or not, we plot the average number of patents, citations per patent, and the search depth of the supplier in the seven-year window around a customer's covenant violation. We restrict the sample to those customers who violate the covenant only once in year t and not in any other year in the seven-year window. There is an apparent uptick in supplier innovation in the post-covenant violation period, which is observable in all three innovation measures in the sample of suppliers of those customers who have violated their covenants (i.e., *Treated Suppliers*). Moreover, we also notice that the increasing trends coincide with the supplier fiscal year immediately following the year of covenant violation. If there is a long lag between investment in innovation and innovation output, the quick response of supplier patents to covenant violations may seem less plausible. However, such quick innovation responses of

firms are supported both anecdotally and in prior studies. For example, in their survey of firm innovation, de Rassenfosse and Guellec (2009) find that the lag between R&D expenditures and patent applications, on average, is ten months.[18] Most importantly, in contrast to the *Treated Suppliers*, among the *Control Suppliers*, i.e., those suppliers whose customers have not violated their covenants, we find that their innovation remains flat in terms of supplier search depth and dips marginally in terms of patents and citations. Furthermore, the decrease in patents and citations is relatively small in magnitude when compared to the changes witnessed by the *Treated Suppliers*.

[Insert Figure 2 about here]

Table 6 presents the dynamic analysis of the effect of customer covenant violation on supplier innovation using the treated (i.e., *Customer covenant violation (indicator)* equals 1) and control supplier samples (i.e., *Customer covenant violation (indicator)* equals 0). We summarize the mean supplier innovation measures during the seven-year window (t-3; t+3) around customer covenant violation at year t for treated suppliers' customers. Across all three measures, including patents, citations, and search depth, we find that innovation increases in the post-covenant violation period for treated suppliers. Furthermore, these findings also rule out the concern that our findings may be driven by some kind of information leakage in the years before the covenant violation. Looking at comparable measures for control suppliers, we find no discernible increases around year t. Moreover, the difference in the average number of patents and search depth between the treated and control suppliers are all significant at the 5% level or better in the year of and years after the customer covenant violation. However, in terms of citations, we do observe that treated suppliers enjoy higher citations that control suppliers pre-covenant period, and the difference is statistically significant, but the magnitude of the difference almost doubles post-covenant violation. These results mirror those in Figure 2 and indicate a shift in supplier innovation post-customer covenant violations.

[Insert Table 6 about here]

[18] Anecdotally, in innovative industries, such as pharmaceuticals, patent applications are made at a very early stage in the drug development, particularly by small- and medium-size firms, which need the patent protection to secure financing for clinical trials (Whenman and Matveenko, 2020). For example, in an effort to develop a vaccine for the Covid-19 in 2020, a leading contender Moderna Inc. made three patent applications between February and June of 2020 related to the vaccine under development, while their human trials started in March/April 2020, with the commencement of phase 3 trials in July 2020 (Silbersher, 2020).

4.5. Collaborating with Customers

To examine whether the uptick in supplier innovation may occur through the suppliers' learning from the customer-facing financing frictions or independent of them, we perform further tests. Table 7 presents the findings. We examine the probability that following the covenant violation, a supplier is likely to cite its troubled customer patents in its newly filed and granted patents. We also analyze the frequency at which the financially constrained customer's patents are cited. To examine whether these supplier innovations result from increasing collaboration, we also investigate the number of inventors included in the patent application. The findings of these tests will likely provide indirect evidence on whether supplier innovation is inspired by the troubled customers.

From the results in Table 7, we find that customer covenant violation increases the likelihood of citing the covenant violated customer's patents. Specifically, when we use a linear probability model with supplier fixed effects in Columns (1) and (2) of Table 7 and an indicator for citing any covenant violated customer patent as the dependent variable, the coefficients on *Customer covenant violation* are statistically significant at the 5% significance level for the regressions in year 2 in Column (2). These results show that suppliers are more likely to cite their customer patents when the latter has violated debt covenants than when they have not. For robustness, we rerun our tests with an OLS regression with the logarithm of one plus the number of times the covenant violated customer patents are cited by the supplier as the dependent variable in Columns (3) and (4) and find that the number of citations of the covenant violating customer is positively associated with customer covenant violation in the first year after covenant violation.

But the findings in the first four columns could be simply the mechanical result of suppliers filing more patents, thereby citing any other patents (including patents from their customers) more often in the process. To overcome such concerns, ideally, we would like to document direct evidence of collaborative patents between suppliers and customers. However, due to a lack of data on inventor-employment information, we are unable to provide such direct evidence of collaborative patents between supplier and customer employees. We resolve to an alternative approach. In Columns (5)-(8), we use the total and the average number of inventors included in each of the supplier patents as the dependent variable and observe a positive relationship between customer covenant violation and size of inventor teams in the second year following the violation. These findings may indicate that supplier innovation is becoming more

collaborative post their customer's covenant violation. Alternatively, these findings may also indicate that their innovation is becoming more complex, consistent with our earlier findings on supplier search depth. Due to a lack of data on inventor-employment information, we are unable to provide direct evidence of collaborative patents between supplier and customer employees, and our results only suggest such a potential nexus.

[Insert Table 7 about here]

4.6. Innovation Coordination between Trading Partners

Table 8 reports the innovation coordination between suppliers and customers by regressing measures of supplier innovation on the customers' contemporaneous and lagged innovation. In addition to the measures of innovation used in previous tables, we also use an indicator variable for whether the supplier has a patent and the ratio of supplier R&D expenditures to sales as additional dependent variables. Using a logit specification in Columns (1) and (2), we find a significantly positive coefficient (significantly negative coefficient) on the interaction between *Customer covenant violation* and an indicator for a contemporaneous (lagged) customer patent, denoted by $a \times c$ ($a \times b$), respectively. These findings suggest that following a customer covenant violation, there is a more contemporaneous effect than lead-lag effect on innovation coordination between suppliers and customers. Overall, Table 8 suggests that following a customer covenant violation, the timing of treated suppliers' innovation engagement activities is more in sync with that of treated customers.

[Insert Table 8 about here]

The rest of the specifications produce similar results. For example, when we use a linear probability model based on an OLS specification rather than a logit specification and include supplier (and customer) industry-fixed effects in Column (3) (Column (4)), we find qualitatively similar results that after a customer covenant violation, there is stronger contemporaneous innovation coordination between the trading partners. In Columns (5)–(8), when we replace the dependent variable with four different innovation measures used in previous tables, we still find that patents produce similar results. Specifically, Column (5) shows that when customers violate their covenants, contemporaneous customer innovation has a positive effect on supplier innovation. Finally, in Column (9), replacing the dependent

variable with the R&D-to-sales ratio, we find that upon customer debt covenant violation, contemporaneous customer R&D expenditure is related to supplier R&D expenditure.[19]

Overall, the findings in Table 8 show that when customers violate their covenants, the contemporaneous relationship between supplier and customer innovation becomes stronger, while the lead-lag relationship becomes weaker. These findings demonstrate that customer debt covenant violations facilitate customer-supplier coordination in innovation. For example, generally, customers may tend not to share with their suppliers much information regarding their upcoming innovation. However, when customers violate debt covenants, suppliers' trade credit provision may become more important; hence, customers can be more willing to offer non-monetary incentives, such as offering their technical know-how to their suppliers, thereby improving the innovation output of their suppliers. Furthermore, the findings refute the *dissociation* hypothesis with its prediction of a positive effect on innovation. The ongoing coordinated knowledge transfer strongly refutes the view that suppliers that dissociate themselves from customers might innovate to survive.

4.7. Cross-sectional Tests

4.7.1 Variation according to suppliers' abilities to innovate

To examine the robustness of our baseline findings, we examine whether our results are more pronounced among suppliers with a better ability to innovate following a shock to their principal customers. Therefore, we perform cross-sectional analyses of our main findings by adding several interaction terms along two major dimensions of the supplier ability: 1) suppliers' financial flexibility and 2) suppliers' abilities to help their customers. Table 6 reports the findings.

[Insert Table 9 about here]

First, to measure suppliers' financial flexibility, we use measures of financial leverage and operating performance. i.e., industry-adjusted ROA. In the context of these two measures, Columns (1)-(6) of Table 9 reports the cross-sectional variation in the effect of covenant

[19] However, Koh and Reeb (2015) find that firms still file patents even when they do not report any R&D expenditures, suggesting that the patent measure might be the broadest approach to capture innovation. Furthermore, by using innovation measures rather than R&D as our dependent variables, our study is not subject to the criticism that without externally exhibiting less innovation than that demonstrated by overconfident CEOs, cautious CEOs may under report their R&D (Koh, Reeb and Zhao, 2018).

violation on supplier innovation. Consistent with our previous findings in Table 3, the coefficients on *Customer covenant violation* are all positively significant in all regressions, . Using supplier innovation measures as the dependent variable, the coefficients on the interaction term between *Customer covenant violation* (*a*) and our moderating variable (*b*) reveal the following: $a \times b$ are significant at least at the 10% significance level in four out of the six specifications and in all specifications using patents and search depth. These results weakly support the notion that suppliers with lower leverage and higher profitability are more likely to increase innovation and pursue more exploitative innovation.

Columns (7)-(12) of Table 9 demonstrate how the baseline results vary according to the suppliers' ability to help their customers facing financing frictions. We measure the ability of the supplier to help by using proxies for the operating cycle and receivable ratios of the supplier. These two measures are computed as the ratio of net receivables minus net payables and the ratio of net receivables to the total sales of the supplier, respectively. A higher value of these two ratios suggests that the suppliers often extend credit to their customers on more relaxed terms. Thus, when facing higher financing frictions, customers can count on trade financing from these suppliers to alleviate some of the pressure. Using these two measures as the moderating variables, the results show that the coefficients on the interaction terms (between *Customer covenant violation* and each of these two ratios) are positive and significant at least at the 10% level of significance in three of the six specifications, and focusing on year t+1, they are significant at least at the 10% level of significance in all specifications using citations. These results indicate that the innovation of suppliers with a greater ability to extend trade credit to their customers is most sensitive to covenant violations by customers. In other words, these results suggest that there might be some reciprocity between customers and suppliers in the sense that suppliers lend a helping hand to a customer during the crisis, and, in return, suppliers can learn more from customers to produce more scientifically advanced patents in the future. To examine this situation much more directly, in the next set of tests, we focus on the sensitivity of supplier innovation according to customer innovation strategies.

4.7.2 Variation according to suppliers' incentives to innovate

We also expect that our baseline results will be more pronounced among suppliers with the appropriate incentives to innovate. Again, we examine their incentives from two specific dimensions: 1) when suppliers have more opportunities to learn from their customers and 2) when suppliers believe that their assistance will be reciprocated by the customer. Therefore,

we perform cross-sectional analyses of our main findings by adding an interaction term between the *Customer covenant violation* variable and different measures of these incentives of suppliers.

[Insert Table 10 about here]

Columns (1)-(6) of Table 10 present the results using measures of supplier opportunities to learn from customers as the moderating variable. Specifically, we use customer R&D expenditures (scaled by total assets) and customer search depth (a measure of exploitative innovation by customers) as the moderating variables (*b*). Using year *t*+1 measures of supplier innovation, the coefficient estimates of $a \times b$ are positive in all the specifications and significant in four of six specifications. These results indicate that when customers are more innovative and especially when they are specialists in their area, as proxied by a greater search depth in their patenting activity, suppliers have more things to learn from these customers. Therefore, by sticking with customers subject to more financing frictions through tough periods, these suppliers exhibit strong commitment (Johnson, Karpoff, and Yi, 2015), and their innovation mutually benefits from this commitment through the sharing of customer technological know-how.

Columns (7)-(12) of Table 10 present the results using measures of societal trust between customers and suppliers.[20] Trust plays an important role in opaque information environments (Guiso et al., 2008), such as the environment between trading partners. Suppliers usually face an information asymmetry problem with respect to the financial health of their customers, as evidenced by common underinvestment and hold-up problems in trading relationships. The existence of information asymmetry between major trading partners is also strongly supported by the literature (Titman, 1984; Shleifer and Summers, 1988; Goffin, Szwejczewski, and New, 1997; Raman and Shahrur, 2008). Thus, to examine the variation in our findings according to levels of trust between trading partners, we construct a firm-year measure of societal trust based on the Rupasingha, Goetz, and Freshwater (2006) index.

Based on the societal trust index, we first construct a variable defined as the absolute difference between the trust indexes of the customer and supplier, which forms our first moderating variable (i.e., *b*). This measure allows us to examine whether any distrust in the

[20] Following Guiso et al. (2004), we regard social capital as the level of mutual trust between the managers representing the customers and those representing the suppliers and operationalize the concept by using the prevailing level of social trust in the headquarters locations of the customer and of the supplier.

relationship (irrespective of the party) affects our findings. Second, we use the individual customer and supplier trust indexes as separate moderating variables (i.e., *c* and *d*), which we interact with the indicator for *Customer covenant violation* (*a*), allowing us to examine whose credibility is more important for supplier innovation.

In the first three specifications (Columns 7 to 9), the coefficients on the interaction term between *Customer covenant violation* (*a*) and the absolute difference in trust indexes (*b*), $a \times b$, are significant at the 10% significance level or better in all three columns, suggesting that higher dissonance in trust lowers the sensitivity of supplier innovation to the covenant violation.

In the last three columns in Table 10, we split the trust measure further into separate measures for the customer (*b*) and the supplier (*c*). We find that the interaction terms $a \times b$ and $a \times c$ are significant at the 5% level when examining patents in the year $t+1$ following the covenant violation. $a \times b$ remains significant when examining citations in Column (11), while $a \times c$ remains significant when examining the search depth in Column (12).[21] These findings suggest that the suppliers' innovation is more responsive when both suppliers and customers can trust each other more.

Overall, the findings in Tables 9 and 10 indicate that supplier innovation has a stronger reaction to customer covenant violation under the following conditions: when suppliers have higher financing flexibility and use trade financing as a core strategy with customers; when the customers are innovative and exhibit higher levels of expertise; and when mutual trust between the trading partners is higher. These results add further support to the '*bonding*' hypothesis by suggesting that suppliers who are able and willing to lend a hand to troubled customers can receive greater non-monetary benefits from their customers that face more financing frictions.

4.8. Consequences of Supplier Innovation Following Customer Covenant Violations

Although extending a helping hand to a customer facing more binding financing frictions and pursuing more innovation appears to be a risky strategy, there are likely some benefits of

[21] The coefficients on the moderating variables, i.e., the individual measures of customer and supplier trust levels, are negative and significant in Columns (10)–(12) in Table 10, which suggests that suppliers might innovate less if either trading partner operates in an area with high trust. A potential explanation for these counter-intuitive findings is that the trading partners in high trust areas might share innovation sooner rather than wait until the period of financial difficulty of the customer.

having a committed relationship with a large customer. Therefore, we investigate whether such actions by a supplier affect its future survival. We proxy the survival likelihood based on whether the supplier remains a public firm in the future and its future net worth. We present the regression results in Table 11. The results show that in the three and five years following their customer's covenant violation, becoming more innovative (i.e., *Supplier patent indicator* in year t+1) increases the probability of the supplier remaining public. Moreover, the net worth of the innovative supplier is also higher following customer covenant violation in three years following the violation. Unsurprisingly, these effects dissipate over a longer time window (i.e., seven years). In short, our analysis suggests that by being a more innovative supplier, suppliers increase their survival probability compared to that of other non-innovative suppliers.

[Insert Table 11 about here]

5. Additional Tests

In this section, we provide a brief description of additional tests that are performed and reported in the Online Appendix, notwithstanding the various robustness tests reported alongside our key results. Specifically, we report the following: 1) the results of the placebo analyses; and 2) the cross-sectional variation in supplier propensity to cite customer patents according to supplier ability and incentives to help customers.

First, we perform placebo analyses by assuming that a customer covenant violation happens five years before the actual estimated covenant violation or that it happens randomly (by defining a random uniformly distributed variable in the sample and assuming covenant violation when the variable is above the sample median). Neither analysis reported in Online Appendix Table OA1 yields any significant effect of customer covenant violation on supplier innovation.

Second, to pinpoint when exactly suppliers learn more from their customers' innovation, we also run cross-sectional analyses similar to those in Tables 9 and 10. In Online Appendix Table OA2, we interact the *Customer covenant violation* variable with the measures for the suppliers' financing flexibility, trade credit provisions, the opportunity to learn from the customer, and the difference in mutual trust levels, using the indicator for citing any customer patent as the dependent variable and a linear probability model specification. Specifically, in terms of supplier ability, we find that the interaction term is significant in at least three of the four measures in at least one of the two years following customer covenant violations. In terms

of supplier incentives to help the customer, we find that suppliers are more likely to cite the troubled customer's patents when the customers invest more intensively in R&D and have higher search depth themselves. In summary, these findings illustrate that suppliers learn from their customers, who are more willing to share their expertise with suppliers when facing financial frictions, especially when the supplier can and is willing to help the customer and innovate.

6. Conclusion

In this study, we develop two competing views, namely, the *bonding* and *dissociation* hypotheses, to explain the effect of customer financing frictions on supplier innovation. The *bonding* hypothesis states that financing frictions increase the net benefits from sharing technology with the suppliers. The inability to attract new suppliers and disincentives to allow less willing suppliers to outbid each other, increases the relative attractiveness of cooperating with the supplier. Such actions help relieve financing frictions by enabling the provision of cheaper inputs from suppliers. Additionally, the customers decreased ability to invest in innovation motivates them to encourage their suppliers to substitute capital for innovation investment. Therefore, the suppliers collaborate more with their financially constrained customers to learn from them and improve supplier innovation. This hypothesis predicts that customer financing frictions increase supplier innovation and foster strong relationships. On the other hand, the *dissociation* hypothesis suggests that customers take advantage of their suppliers, especially when the customers face financial difficulties. Customers with increased creditor rights appropriate past supplier *RSI*, which increases hold-up problems and disincentivizes the supplier from further investing in the relationship. This view predicts that due to a lack of incentives to work alongside the customer and due to a fear of their customers' free-riding on any innovation output, suppliers decrease innovation when their customers are financially troubled. The *dissociation* view also predicts a positive spillover of customer financing frictions on supplier innovation when that innovation is born out of the necessity of the supplier to survive. However, such supplier innovation is less likely to be in collaboration or coordinated with a troubled customer.

Using data on customer-supplier relationships from Compustat and using loan data from DealScan, we find that following customer covenant violations in the RDD sample, suppliers

produce more innovation outputs. We also find that these main results are more pronounced when suppliers have a greater ability to invest in innovation or have more incentives to learn from the customer. Furthermore, following covenant violations, suppliers show an increased propensity to cite customer patents and the contemporaneous coordination between customer and supplier innovation activity increases. Finally, we also find that following customer covenant violations, innovative suppliers become more sustainable. In sum, our evidence illustrates the determinants of supplier innovation and provides a plausible explanation for the suppliers' *RSI* investments even when the immediate monetary benefits are not apparent.

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Table 1: Summary of Innovation and Product Market Relationships with Customers

This table presents summary statistics of firm innovation categorized by-product market customer relationships in Panel A, by industry in Panel B and by product market customer relationships according to measures of firm innovation in Panel C. In Panels A and B, the sample consists of 185,797 Compustat firm-years during the sample period of 1994 to 2009 obtained by merging firms in Compustat with firm-specific Google patent data (Kogan et al., 2017) and with product market relationships based on the Compustat segment database. In Panel C, the sample consists of a subsample of 26,022 supplier-years and 41,060 supplier-customer-years in Compustat, where the suppliers have one or more publicly listed customers. The test of the difference in means (medians) is computed as a simple *t*-test (nonparametric K-sample equality of medians test). All variables are defined in the appendix.

Panel A: Firm Innovation According to Whether Firms Have a Public Customer

	Full sample		Firms that have one or more concentrated customers		Firms that do not have a concentrated customer		Test of difference in mean	
	Mean	Median	Mean	Median	Mean	Median	Difference	*t*-statistic
Measures of innovation	Obs. = 185,797		Obs. = 26,022		Obs. = 159,775			
No. of patents	1.10	0.00	2.37	0.00	0.90	0.00	1.47	(39.07)
No. of citations	0.09	0.00	0.20	0.00	0.07	0.00	0.13	(56.19)
Avg. patent value	0.45	0.00	0.89	0.00	0.38	0.00	0.51	(34.39)
Search scope (or explorative)	0.07	0.00	0.15	0.00	0.06	0.00	0.09	(60.70)
Search depth (or exploitative)	0.07	0.00	0.17	0.00	0.06	0.00	0.11	(50.64)

Panel B: Firm Innovation (mean) According to Whether Firms Have a Public Customer by Industry

	Full sample		Firms that have one or more customers		Firms that do not have a customer		Test of difference in mean	
Industry	No. of patents [no. of citations]	Obs.	No. of patents [no. of citations]	Obs.	No. of patents [no. of citations]	Obs.	Difference	*t*-statistic
Consumer Nondurables	0.67 [0.07]	7,981	0.74 [0.07]	2,000	0.64 [0.07]	5,981	0.10 [0.00]	(1.00) [(0.05)]
Consumer Durables	2.96 [0.19]	3,774	3.97 [0.23]	1,145	2.52 [0.17]	2,629	1.45 [0.06]	(4.49) [(3.82)]
Manufacturing	2.54 [0.17]	15,060	3.05 [0.25]	3,178	2.40 [0.15]	11,882	0.65 [0.10]	(3.92) [(11.46)]
Oil, Gas, and Coal	0.66 [0.03]	8,978	0.33 [0.02]	1,760	0.75 [0.03]	7,218	-0.42 [-0.01]	(-3.31) [(-2.90)]
Chemicals	4.49 [0.20]	3,485	3.15 [0.23]	632	4.79 [0.19]	2,853	-1.64 [0.04]	(-3.17) [(2.25)]
Business Equipment	2.70 [0.21]	30,547	3.87 [0.32]	7,921	2.29 [0.18]	22,626	1.58 [0.14]	(13.65) [(19.77)]
Telephone and TV Transmission	0.62 [0.05]	6,474	0.43 [0.11]	874	0.66 [0.04]	5,600	-0.23 [0.07]	(-1.47) [(6.83)]
Utilities	0.05 [0.01]	5,433	0.06 [0.02]	418	0.04 [0.01]	5,015	0.02 [0.01]	(0.71) [(1.31)]
Wholesale and Retail	0.11 [0.02]	14,156	0.19 [0.06]	950	0.11 [0.02]	13,206	0.08 [0.04]	(1.50) [(7.10)]
Healthcare, Medical Equipment, and Drugs	2.00 [0.22]	16,530	3.55 [0.35]	3,019	1.66 [0.19]	13,511	1.89 [0.16]	(13.76) [(14.30)]

Finance	0.05 [0.01]	45,425	0.51 [0.03]	1,302	0.04 [0.01]	44,123	0.47 [0.02]	(14.93) [(8.91)]
Others	0.18 [0.02]	27,954	0.30 [0.05]	2,823	0.17 [0.02]	25,131	0.13 [0.03]	(3.01) [(9.66)]

Panel C: Effect of Innovation on Trading Relationships of Suppliers with One or More Public Customers

	Full sample		Suppliers that have one or more patents		Suppliers that do not have a patent		Test of difference	
Relationship measures	Mean [median]	Obs.	Mean [median]	Obs.	Mean [median]	Obs.	Difference	*t*-statistic [χ^2-statistic]
				Aggregate customer relationships				
Customer concentration ratio	0.10 [0.03]		0.11 [0.04]		0.10 [0.03]		0.01 [0.01]	(3.79) [(33.86)]
Cumulative sales to all customers	0.28 [0.21]	26,022	0.30 [0.23]	5,857	0.27 [0.20]	20,165	0.03 [0.03]	(8.83) [(43.04)]
Count of all customers	1.90 [1.00]		1.89 [1.00]		1.90 [1.00]		-0.01 [0.00]	(-0.61) [(2.31)]
				Existing individual customer relationships				
Supplier sales fraction	0.18 [0.13]	41,060	0.19 [0.14]	9,259	0.17 [0.13]	31,801	0.02 [0.01]	(9.92) [(133.50)]
Log (supplier sales)	3.14 [2.97]	37,165	3.68 [3.52]	8,758	2.97 [2.81]	28,407	0.71 [0.71]	(33.00) [(507.54)]
Future relationship duration	5.16 [4.00]	35,226	5.76 [4.00]	8,268	4.98 [3.00]	26,958	0.78 [1.00]	(19.94) [(72.44)]

Table 2: RDD Sample and Univariate Analysis of the Effect of Customer Covenant Violations on Supplier Innovation

This table presents summary statistics of the regression discontinuity design (RDD) samples of customer firm characteristics (Panel A) and supplier innovation (Panel B). The sample in Panel A consists of 4,091 customers identified from the Compustat segment database merged with loan data from Dealscan from 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Covenant violations are identified as those firms that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. In Panel B, the sample consists of 3,387 suppliers identified from the Compustat segment database as being the suppliers of the customers in Panel A. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). In Columns (5)–(8) of Panel A and Columns (4)–(7) of Panel B, the sample is restricted to the customers and suppliers where the customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 853 customer-years and 687 supplier-years, respectively. The test of the differences in means in Panels A and B is computed as a simple *t*-test. The standardized difference in Panel A is computed as the standardized imbalance in firm characteristics to assess covariate balance. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Tests of Covariate Imbalance Among Customers With and Without Covenant Violations

	Using Full Sample				Using Discontinuity Sample			
Firm characteristics	Customer facing covenant violations	Customer not facing covenant violations	Mean difference (*p*-value)	Standardized difference	Customer facing covenant violations	Customer not facing covenant violations	Mean difference (*p*-value)	Standardized difference
	Obs. = 603	Obs. = 3,488			Obs. = 539	Obs. = 314		
Ln (market equity)	9.72	9.81	-0.09 (0.08)	12.61	9.74	9.36	0.38 (0.00)	-61.28
R&D/assets	0.02	0.03	-0.01 (0.00)	11.15	0.02	0.01	0.01 (0.20)	-5.82
ROA	0.03	0.09	-0.06 (0.00)	51.53	0.03	0.04	-0.01 (0.33)	14.81
Leverage	0.52	0.50	0.02 (0.00)	-7.35	0.52	0.52	0.00 (0.78)	2.52
Tobin's *q*	1.37	1.70	-0.33 (0.00)	60.11	1.35	1.27	0.08 (0.00)	-21.29
Capex/assets	0.06	0.05	0.01 (0.00)	-12.10	0.06	0.06	0.00 (0.57)	-3.72
PPE/assets	0.33	0.24	0.09 (0.00)	-35.75	0.33	0.33	0.00 (0.79)	1.04
Herfindahl index	0.01	0.01	0.00 (0.63)	-20.53	0.01	0.01	0.00 (0.22)	-19.32
Avg. supplier fraction	0.16	0.18	-0.02 (0.00)	13.73	0.17	0.17	0.00 (0.57)	0.83
Ln (supplier count)	2.01	2.12	-0.11 (0.00)	28.57	2.00	2.06	-0.06 (0.41)	14.51
Avg. past supplier duration	2.74	3.07	-0.33 (0.51)	12.83	2.81	3.18	-0.37 (0.78)	15.29

Panel B: Effect of Covenant Violation on Supplier Innovation Univariate Analysis

		Using Full Sample		Using Discontinuity Sample			
	Full sample	Suppliers of customer facing covenant violations	Suppliers of customers not facing covenant violations	Suppliers of customer facing covenant violations	Suppliers of customers not facing covenant violations	Test of the Difference in Means in the Discontinuity Sample	
Innovation measures	Obs. = 3,387	Obs. = 473	Obs. = 2,914	Obs. = 413	Obs. = 274	Difference	*t*-statistic
No. of patents	2.651	2.258	2.714	2.199	0.792	1.407	(2.69)
No. of citations	0.203	0.179	0.207	0.169	0.092	0.077	(2.21)
Avg. patent value	1.081	0.602	1.159	0.603	0.369	0.234	(1.30)
Citing customer patents (indicator)	0.038	0.044	0.037	0.041	0.000	0.041	(3.42)
No. of citations of customer patents	0.724	1.072	0.667	1.128	0.000	1.128	(1.88)
Search scope (or explorative)	0.148	0.113	0.154	0.114	0.078	0.036	(1.72)
Search depth (or exploitative)	0.183	0.149	0.189	0.149	0.060	0.089	(2.54)

Table 3: Baseline Regressions of the Effect of Customer Covenant Violations on Supplier Innovation

This table presents regression estimates of supplier innovation on customer covenant violation and control variables using the RDD sample. The RDD sample begins with 3,387 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from Dealscan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 687 supplier-years. From Columns (1) to (6), the innovation measures are calculated in year *t*+1, while in Columns (7) to (9), they are measured two years following the debt covenant violation (denoted by year *t*+2). Columns (4) to (6) add supplier firm fixed effects to the settings in Columns (1) – (3). Supplier industry fixed effects based on the Fama-French 30 industry classification are included and *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
Independent variables	Year *t*+1						Year *t*+2		
Customer covenant violation (indicator)	0.244**	0.069**	0.116	0.315**	0.113**	0.195**	0.208*	0.037	0.185**
	(2.445)	(2.247)	(1.568)	(2.396)	(2.267)	(2.149)	(1.794)	(1.013)	(2.202)
Customer default distance (CR)	0.863	0.082	0.472	0.892	-0.936	-4.127	0.377	-0.216	0.487
	(1.560)	(0.319)	(1.207)	(0.488)	(-0.810)	(-1.245)	(0.683)	(-1.547)	(1.266)
Customer default distance (NW)	-0.000	-0.000*	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000**	-0.000
	(-1.564)	(-1.938)	(-1.139)	(-0.873)	(-1.216)	(-0.755)	(-1.215)	(-1.985)	(-1.461)
Supplier characteristics									
Ln (market equity)	0.099***	0.011	0.033*	0.001	-0.014	-0.014	0.110**	0.014	0.040*
	(2.878)	(1.472)	(1.878)	(0.028)	(-0.913)	(-0.800)	(2.499)	(1.430)	(1.838)
R&D/assets	0.844*	0.336**	0.853**	-1.000	1.239	2.743	0.749	0.281	0.544
	(1.940)	(2.446)	(2.384)	(-0.789)	(1.238)	(1.297)	(1.549)	(1.604)	(1.396)
ROA	-0.174	-0.027	-0.076	0.064	0.003	0.015	-0.279*	-0.031	-0.200**
	(-1.606)	(-1.066)	(-0.824)	(0.998)	(0.070)	(0.361)	(-1.941)	(-0.906)	(-1.979)
Leverage	0.043	-0.012	0.084	0.074	0.015	0.029	-0.011	-0.018	-0.046
	(0.540)	(-0.492)	(0.928)	(1.221)	(0.370)	(0.426)	(-0.131)	(-0.676)	(-0.881)
PPE/assets	-0.091	0.001	-0.160	0.187	-0.039	0.051	-0.354	-0.025	-0.334**

	(-0.474)	(0.023)	(-1.440)	(0.783)	(-0.518)	(0.467)	(-1.541)	(-0.350)	(-2.155)
Capex/assets	-0.023	0.009	0.223	-0.281	-0.036	0.019	0.181	0.030	0.067
	(-0.060)	(0.085)	(0.872)	(-1.014)	(-0.456)	(0.160)	(0.392)	(0.249)	(0.249)
Herfindahl index	-13.904*	-5.328**	-0.522	-6.443	-4.239	17.964	-8.319	-0.590	-7.030
	(-1.927)	(-2.103)	(-0.074)	(-0.422)	(-0.617)	(1.512)	(-1.063)	(-0.192)	(-0.946)
Herfindahl index square	91.359**	26.856	0.981	57.051	28.580	-98.223	51.037	-10.119	51.454
	(2.071)	(1.580)	(0.022)	(0.840)	(0.787)	(-1.496)	(1.057)	(-0.478)	(0.958)
Tobin's *q*	0.007	0.001	0.020	0.037*	0.018	0.008	-0.013	-0.001	-0.005
	(0.354)	(0.250)	(1.276)	(1.859)	(1.291)	(1.094)	(-0.575)	(-0.146)	(-0.454)
Whited-Wu index	-2.838***	-0.720***	-1.988***	-0.956*	-0.696***	-0.981*	-2.952*	-0.496	-2.317**
	(-2.999)	(-3.205)	(-3.003)	(-1.890)	(-3.207)	(-1.720)	(-1.885)	(-1.398)	(-2.244)
Ln (age)	0.095	-0.034	0.062	0.841**	0.031	0.428	0.042	-0.014	0.044
	(0.658)	(-1.114)	(0.860)	(2.114)	(0.109)	(1.445)	(0.281)	(-0.464)	(0.513)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Supplier firm fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Observations	525	525	525	346	346	346	455	455	455
Adj. R-sq	0.289	0.143	0.243	0.899	0.606	0.772	0.269	0.130	0.170

Table 4: Robustness Tests

This table presents regression estimates of robustness tests of supplier innovation on customer covenant violation and control variables using the RDD sample in Panel A and regression estimates of supplier innovation on text-based customer covenant violation in Panel B. In Panel A, the RDD sample begins with 3,387 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from Dealscan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). In Panel A, the sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold in columns (1)-(6) and a data-driven optimal bandwidth based on the coverage error rate algorithm in columns (7)-(9). The median bandwidth is selected among the three obtained by applying the algorithm on the three dependent variables. In Panel A, a polynomial of order two or three based on the distance to covenant violation is included. In Panel B, text-based covenant violations of Compustat firms are obtained from Amir Sufi's website for a sample of customer-suppliers between 1994 and 2009. Text-based covenant violations are identified by Nini, Smith, and Sufi (2012) based on keywords mentioned in the reported filings. Year and supplier firm fixed effects (or supplier industry fixed effects based on the Fama-French 30 industry classification) are included in all the models and *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants and control variables are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Robustness of RDD Analyses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Bandwidth of 0.2 around covenant thresholds			Bandwidth of 0.2 around covenant thresholds			Optimal bandwidth based on coverage error rate algorithm		
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
Independent variables	Year *t*+1								
Customer covenant violation (indicator)	0.252**	0.038	0.142*	0.249**	0.038	0.139*	0.184**	0.041**	0.074
	(2.328)	(1.034)	(1.784)	(2.317)	(1.018)	(1.781)	(2.220)	(2.168)	(1.119)
Controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Polynomial order	2	2	2	3	3	3	3	3	3
Observations	525	525	525	525	525	525	1,373	1,373	1,373
Adj. R-sq	0.288	0.144	0.242	0.288	0.143	0.244	0.340	0.154	0.241

Panel B: Using All Covenant Violations Based on Text-based Method

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
Independent variables	Year *t*+1					
Text-based customer covenant violation (indicator)	0.107*	0.019	0.069*	0.053*	-0.007	-0.003
	(1.695)	(0.949)	(1.767)	(1.774)	(-0.449)	(-0.134)
Supplier characteristics in Table 3	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	No	No	No
Supplier firm fixed effects	No	No	No	Yes	Yes	Yes
Observations	11,067	11,067	11,067	10,115	10,115	10,115
Adj. R-sq	0.285	0.161	0.166	0.854	0.569	0.681

Table 5: Effect of Customer Covenant Violations on Supplier Innovation Input

This table presents regression estimates of supplier innovation input measured as ratio of R&D expenditure to assets in Panel A and as ratio of R&D expenditure to sales in Panel B in the five years (two years prior and after) around customer covenant violation in year *t* using the RDD sample. The RDD sample begins with 3,387 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from Dealscan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Customer covenant violation in year *t* is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 687 supplier-years. Supplier industry fixed effects based on the Fama-French 30 industry classification are included and *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants and control variables in Table 3 are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Variation in R&D / assets according to Customer Covenant Violation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	R&D / assets									
Independent variables	Year *t*-2	Year *t*-1	Year *t*	Year *t*+1	Year *t*+2	Year *t*-2	Year *t*-1	Year *t*	Year *t*+1	Year *t*+2
Customer covenant violation	0.009	0.016	0.003	0.032**	0.027*	-0.000	0.006	0.001	0.011*	-0.010
(indicator)	(0.844)	(1.469)	(0.280)	(1.970)	(1.913)	(-0.004)	(0.694)	(0.094)	(1.928)	(-0.784)
Controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Supplier firm fixed effects	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	595	602	602	546	498	393	397	397	365	329
Adj. R-sq	0.396	0.424	0.575	0.410	0.444	0.792	0.831	0.915	0.881	0.873

Panel B: Variation in R&D / sales according to Customer Covenant Violation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	R&D / sales									
Independent variables	Year *t*-2	Year *t*-1	Year *t*	Year *t*+1	Year *t*+2	Year *t*-2	Year *t*-1	Year *t*	Year *t*+1	Year *t*+2
Customer covenant violation	0.057	0.071	0.071*	0.157**	0.072*	0.011	0.013	-0.005	0.021**	-0.010
(indicator)	(0.961)	(1.629)	(1.714)	(2.278)	(1.905)	(1.042)	(0.884)	(-0.432)	(2.137)	(-1.097)
Controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
Supplier firm fixed effects	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Observations	595	602	602	544	493	393	397	397	361	325
Adj. R-sq	0.288	0.415	0.351	0.210	0.461	0.854	0.921	0.836	0.930	0.982

Table 6: Dynamic Analysis of the Effect of Customer Covenant Violations on Supplier Innovation

This table presents summary statistics of mean innovation among a subsample of suppliers whose customer(s) witness a covenant violation in around the year of covenant violation. The treated sample consists of 1,352 supplier-years in a seven-year window corresponding to 231 customer covenant violations during the year 1994 to 2009. We restrict the sample to those customers who violate the covenant only once at year *t* and not in any other year in the seven-year window. The control sample includes all other supplier-years in Compustat segment database corresponding to customer years when a covenant is not violated during 1994 to 2009. Customers are identified from the Compustat segment database as those with an outstanding loan with a quantitative covenant as identified in Dealscan between 1994 and 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding that specifies a quantitative covenant (i.e., either current ratio or net worth covenants). Customer covenant violations are identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively, based on *t*-statistics for the test of difference in supplier mean innovation metrics.

Covenant violation year	Year *t* - 3	Year *t* - 2	Year *t* - 1	Year *t*	Year *t* + 1	Year *t* + 2	Year *t* + 3	Total
	Treated: customer covenant violation (indicator) equals one							
No. of patents	1.438	1.515	1.704	1.805	2.824	2.628	3.000	2.070
No. of citations	0.170	0.185	0.170	0.181	0.214	0.187	0.241	0.190
Search depth	0.112	0.109	0.116	0.106	0.165	0.161	0.208	0.135
	Control: customer covenant violation (indicator) equals zero							
No. of patents	1.166	1.303	1.374	1.070	0.847	0.936	0.843	1.137
No. of citations	0.096	0.105	0.115	0.087	0.067	0.075	0.064	0.093
Search depth	0.056	0.073	0.087	0.070	0.066	0.072	0.076	0.071
	Treated - Control Difference							
No. of patents	0.272	0.212	0.330	0.735**	1.977***	1.692***	2.157***	0.933***
No. of citations	0.074***	0.080***	0.055***	0.094***	0.147***	0.112***	0.177***	0.097***
Search depth	0.056**	0.036	0.029	0.036	0.099***	0.089***	0.132***	0.064

Table 7: Effect of Customer Covenant Violations on Supplier Propensity to Collaborate and Cite Customer Patents

This table presents regression estimates of the likelihood of a supplier citing its customer's patent and OLS regressions of the number of citations of the customer made by the supplier and the number of inventors in supplier patent applications on customer covenant violation and control variables using customer-supplier pairs. The sample consists of 4,424 customer-supplier pair-years identified from the Compustat segment database as being the suppliers of the customers with an outstanding loan with a quantitative covenant as identified in Dealscan between 1994 and 2009. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample is further restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 1,048 customer-supplier pair years. Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The first two models are estimated as a linear probability model with supplier firm fixed effects. The last six models are estimated as OLS models with supplier firm or supplier industry fixed effects based on the Fama-French 30 industry classification being included. *t*-statistics based on robust standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Citing covenant violated customer patents (indicator)		Ln (1+no. of citations) of covenant violated customer patents		Ln (1+no. of inventors) in supplier patents		Ln (1+avg. no. of inventors) in supplier patents	
Independent variables	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2
Customer covenant violation (indicator)	0.070	0.113**	0.060*	0.040	0.040	0.087*	0.014	0.048**
	(1.320)	(1.971)	(1.789)	(1.134)	(0.436)	(1.891)	(0.369)	(2.463)
Other controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	No	No	Yes	Yes	No	No	No	No
Supplier firm fixed effects	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	684	684	587	424	612	579	612	579
Adj. R-sq	0.176	0.364	0.081	0.108	0.905	0.904	0.824	0.851

Table 8: Effect of Customer Covenant Violations on Customer-Supplier Investment Coordination

This table presents regression estimates of supplier innovation on customer's contemporaneous and lagged innovation. The sample consists of 4,424 customer-supplier pair-years identified from the Compustat segment database as being the suppliers of the customers with an outstanding loan with a quantitative covenant as identified in Dealscan between 1994 and 2009. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample is further restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 1,048 customer-supplier pair years. Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. Industry fixed effects based on the Fama-French 30 industry classification are included. In columns (1) and (2), *z*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. In Columns (3)-(8), *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants and customer default distance for current ratio and net worth covenants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Logit		OLS					
	Supplier patent (indicator)$_{t+1}$				Supplier ln (1+no. of patents)$_{t+1}$	Supplier ln (1+no. of citations)$_{t+1}$	Supplier search depth$_{t+1}$	Supplier R&D/ sales$_{t+1}$
Customer covenant violation (indicator): a	-0.843**	-0.738	-0.039**	-0.046**	-0.028	0.004	-0.006	0.037
	(-2.107)	(-1.526)	(-2.210)	(-2.320)	(-0.498)	(0.205)	(-0.121)	(0.755)
Customer patent (indicator)$_t$: b	16.757***	15.876***	0.211**	0.195*	0.353*	0.075	0.191	
	(11.726)	(12.082)	(2.090)	(1.674)	(1.671)	(1.053)	(1.655)	
Customer patent (indicator)$_{t+1}$: c	-14.636***	-15.138***	-0.131*	-0.131*	-0.261*	-0.051	-0.086	
	(-13.078)	(-15.755)	(-1.699)	(-1.711)	(-1.705)	(-1.066)	(-1.131)	
Supplier patent (indicator)$_t$	4.673***	4.320***	0.616***	0.613***	1.409***	0.321***	0.715***	
	(10.354)	(8.794)	(11.347)	(14.192)	(9.761)	(6.993)	(6.128)	
Customer R&D/sales$_t$: d								0.102
								(0.348)
Customer R&D/sales$_{t+1}$: e								-0.066
								(-0.154)
Supplier R&D/sales$_t$								0.784***
								(2.868)
a × b	-16.674***	-16.559***	-0.233*	-0.213	-0.360	-0.073	-0.197	
	(-8.984)	(-10.610)	(-1.826)	(-1.526)	(-1.608)	(-0.945)	(-1.593)	
a × c	15.858***	16.426***	0.199*	0.185*	0.354**	0.055	0.074	
	(9.995)	(13.507)	(1.887)	(1.738)	(2.104)	(1.023)	(0.907)	
a × d								-1.526
								(-1.397)
a × e								2.430**
								(2.159)
Customer distance from thresholds	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Customer industry fixed effects	No	No	No	Yes	No	No	No	No
Observations	748	470	746	746	746	746	746	779
Pseudo/Adj. R-sq	0.510	0.524	0.536	0.534	0.520	0.316	0.373	0.540

Table 9: Cross-sectional Variation According to Supplier Ability

This table presents regression estimates of supplier innovation on customer covenant violation and control variables using the RDD sample according to suppliers' abilities to innovate. Specifically, the table reports the cross-sectional variation in the effect of covenant violations on supplier innovation in the following year according to suppliers' financial flexibility and suppliers' abilities to help their customers. The RDD sample begins with of 3,387 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from Dealscan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 687 supplier-years. Supplier industry fixed effects based on the Fama-French 30 industry classification are included and *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
	Supplier financing flexibility						Supplier trade credit provision					
	Moderating variable: Supplier leverage			Moderating variable: Supplier industry-adjusted ROA			Moderating variable: Supplier operating cycle			Moderating variable: Supplier receivables		
Independent variables	Year t + 1											
Customer covenant violation (indicator): a	0.333**	0.075*	0.269***	0.251**	0.068**	0.139*	0.202*	0.051*	0.095	0.164	0.036	0.081
	(2.472)	(1.933)	(2.623)	(2.457)	(2.277)	(1.860)	(1.953)	(1.748)	(1.215)	(1.485)	(1.179)	(0.981)
Moderating variable: b	0.138	-0.006	0.223*	1.654	-0.060	0.681	0.009	-0.001	0.015	0.028	0.000	0.029
	(1.536)	(-0.269)	(1.878)	(1.034)	(-0.140)	(0.547)	(0.434)	(-0.261)	(1.015)	(0.995)	(0.030)	(1.300)
a × b	-0.190*	-0.018	-0.293**	0.148**	0.034	0.246**	0.090**	0.034**	0.046	0.075	0.032**	0.029
	(-1.700)	(-0.631)	(-2.534)	(2.084)	(1.345)	(2.173)	(2.134)	(2.322)	(1.493)	(1.513)	(1.990)	(0.805)
Other controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	525	525	525	525	525	525	511	511	511	511	511	511
Adj. R-sq	0.291	0.154	0.257	0.292	0.153	0.254	0.308	0.172	0.256	0.310	0.170	0.257

Table 10: Cross-sectional Variation According to Supplier Incentives

This table presents regression estimates of supplier innovation on customer covenant violation and control variables using the RDD sample according to supplier incentives to innovate. Specifically, the table reports the cross-sectional variation in the effect of covenant violations on supplier innovation in the following year according to measures of supplier opportunities to learn from customers and measures of societal trust between customers and suppliers. The RDD sample begins with of 3,387 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from Dealscan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants). Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 687 supplier-years. In both panels, the moderating variables are measured on the basis of customers who have outstanding covenants that are within the bandwidth of 0.2 of the covenant thresholds. Supplier industry fixed effects based on the Fama-French 30 industry classification are included and *t*-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
	Customer innovation expertise						Societal trust					
	Moderating variable: Customer R&D/Assets			Moderating variable: Customer search depth			Moderating variable: Absolute difference in societal trust between customer and supplier (b)			Moderating variable: Customer societal trust (b) and supplier societal trust (c)		
Independent variables	Year $t+1$											
Customer covenant violation (indicator): a	0.185*	0.051	0.103	0.195*	0.055*	0.088	0.998***	0.229***	0.783***	1.148**	0.293**	0.863**
	(1.747)	(1.606)	(1.284)	(1.919)	(1.842)	(1.134)	(2.766)	(2.608)	(2.931)	(2.428)	(2.183)	(2.460)
Moderating variable: b	-0.278	-0.333	-0.339	0.032	0.002	0.012	0.639***	0.139***	0.474***	-0.545**	-0.144**	-0.355**
	(-0.159)	(-1.122)	(-0.247)	(0.381)	(0.134)	(0.203)	(3.095)	(3.048)	(2.825)	(-2.264)	(-2.035)	(-2.005)
a × b	4.648**	1.137	0.947	0.297**	0.070*	0.206**	-0.640***	-0.106*	-0.507***	0.575**	0.141**	0.321
	(2.069)	(1.580)	(0.586)	(2.305)	(1.851)	(2.026)	(-2.896)	(-1.876)	(-2.932)	(2.121)	(2.007)	(1.529)
Moderating variable: c										-0.453**	-0.074	-0.375**
										(-2.007)	(-1.153)	(-2.210)
a × c										0.489**	0.109	0.400**
										(2.028)	(1.599)	(2.352)
Other controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	525	525	525	525	525	525	120	120	120	120	120	120
Adj. R-sq	0.302	0.159	0.242	0.317	0.169	0.273	0.524	0.231	0.532	0.506	0.214	0.501

Table 11: Effect of Supplier Innovation on Firm Sustainability Post Customer Covenant Violations

This table presents linear probability model regression estimates of whether remain a publicly listed firm and OLS estimates of supplier networth according to their innovation output following their customer's covenant violations. The sample consists of exclusively of 699 suppliers with one or more customers with covenant violations. The sample is restricted to the customers of suppliers in the Compustat segment database that have a current loan outstanding that specifies a quantitative covenant (i.e., either current ratio or net worth covenants). Customer covenant violations are identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. Similar to Table 5, the sample is also restricted to those customers who violate the covenant only once at year *t* and not in any other year in a seven-year window around violation. The dependent variable in Columns (1)–(3) is an indicator variable that takes the value of one when the supplier continues to remain a publicly listed firm in the Compustat database at the end of years *t*+3, *t*+5, and *t*+7, respectively, where year *t* corresponds to the year of customer covenant violation. The dependent variable in Columns (4)–(6) is the networth of the supplier at the end of years *t*+3, *t*+5, and *t*+7, respectively. Supplier networth is defined as the ratio of difference between total assets and total liabilities to total assets. All the models are estimated with supplier industry fixed effects based on the Fama-French 30 industry classification. *t*-statistics based on robust standard errors double clustered by supplier industry and year are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Indicator for whether supplier remains a public firm until			Supplier networth		
Independent variables	Year *t*+3	Year *t*+5	Year *t*+7	Year *t*+3	Year *t*+5	Year *t*+7
Customer covenant violation (indicator): a	-0.404***	-0.249*	-0.140	-0.050	0.007	-0.068
	(-3.173)	(-1.988)	(-1.058)	(-0.388)	(0.087)	(-1.055)
Supplier patent (indicator)$_{t+1}$: b	-0.034	-0.002	0.009	0.172**	0.119**	0.061
	(-0.519)	(-0.042)	(0.113)	(2.403)	(2.220)	(0.745)
a × b	0.261***	0.224*	0.172	0.177**	0.142	0.188
	(4.333)	(2.010)	(1.225)	(2.190)	(1.325)	(1.680)
Ln (market equity)	0.013	0.024**	0.023	-0.011	-0.026**	-0.028*
	(1.007)	(2.174)	(1.614)	(-0.468)	(-2.224)	(-1.850)
ROA	-0.006	0.024	0.071	0.318	0.216	0.242
	(-0.095)	(0.348)	(0.944)	(0.565)	(1.592)	(1.327)
Leverage	-0.000	0.001***	0.000	0.001***	-0.001	0.004
	(-1.105)	(6.459)	(1.717)	(3.722)	(-0.291)	(0.389)
Tobin's *q*	-0.003	-0.006	-0.002	-0.000	-0.022*	-0.007
	(-0.285)	(-0.613)	(-0.161)	(-0.021)	(-2.052)	(-0.479)
Altman Z	-0.000	-0.001	-0.001	0.004	-0.004	-0.004
	(-0.070)	(-0.622)	(-0.811)	(0.211)	(-1.254)	(-1.096)
Supplier industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	565	565	565	454	383	334
Adj. R-sq	0.009	0.020	0.037	0.022	0.103	0.155

Appendix

This appendix provides a detailed description of all the variables in the tables.

Variables	Definition
Altman Z	The sum of 3.3 times pre-tax income, sales, 1.4 times retained earnings, and 1.2 times net working capital all divided by total assets, i.e., (3.3 × pi + revt + 1.4 × re + 1.2 × wcap)/at (Chava and Roberts, 2008)
Avg. past supplier duration	The number of continuous past years the customer-supplier link is observed in the Compustat segment database, averaged across all suppliers for each customer-year
Avg. patent value	Product of the estimate of the stock return due to the value of the patent and market capitalization of the firm divided by number of patents granted on the same day and multiplied by 2.27 (1 / (1-0.56), where 0.56 is the unconditional probability of a successful patent application (Kogan et al., 2017)
Avg. supplier fraction	Supplier sales fraction, averaged across all the principal customers for each supplier-year
Capex/assets	Ratio of capital expenditure to total assets
Citing covenant violated customer patents (indicator)	Indicator for whether a supplier cites any of its customers' patents in the post-covenant violation year(s) provided that customer has violated a covenant in the post-violation year(s) for each supplier year
Citing customer patents (indicator)	Indicator for whether a supplier cites any of its customers' patents for each supplier-year
Cumulative sales to all customers	Sum of the ratio of sales to customer to total sales across all identified publicly disclosed principal customers
Customer concentration ratio	Sum of the squares of supplier sales fraction to each of its principal customers for each supplier-year
Customer covenant violation (indicator)	Indicator for whether a customer has violated a debt covenant based on current ratio or networth thresholds in the latest fiscal year of the supplier
Customer default distance (CR)	Difference between latest current ratio and current ratio threshold specified in the current ratio covenant, and zero if the loan does not have a current ratio covenant
Customer default distance (NW)	Difference between latest net worth and net worth threshold specified in the net worth covenant, and zero if the loan does not have a net worth covenant
Future relationship duration	The number of continuous future years the customer-supplier link is observed in the Compustat segment database
Herfindahl index	Sum of the squares of the market shares of all firms in the same industry, where industry is defined according to the Fama-French 30 industry classification
Industry-adjusted ROA	Difference between firm-specific ROA and industry median ROA, where industry is defined based on the Fama-French 30 industry classification
Leverage	Sum of long-term and short-term debt divided by total assets
Ln (age)	Natural logarithm of the age of the firm based on the first reported fiscal period end date on Compustat
Ln (market equity)	Natural logarithm of market value of equity
Ln (1+avg. no. of inventors)	Natural logarithm of the ratio of the total number of individuals included as inventors on all filed patents to the total filed patents for each firm-year
Ln (1+no. of inventors)	Natural logarithm of the total number of individuals included as inventors on all filed patents for each firm-year
Ln (1+no. of citations)	Natural logarithm of one plus the total number of non-self-adjusted citations received on the firm's patents filed and eventually granted, scaled by the number of patents filed and eventually granted. Adjusted citations are the total number of citations divided by average number of citations in the industry (Mudambi and Swift, 2014), where industry is defined at the three digit SIC code level.
Ln (1+no. of patents)	Natural logarithm of one plus the number of patents filed by the firm that are eventually granted
Operating cycle	Net accounts receivable minus net accounts payable, scaled by total revenue
PPE/assets	Ratio of fixed assets to total assets
R&D/assets	Maximum (0, Research & Development expenditures/total assets)
R&D/sales	Maximum (0, Research & Development expenditures/total revenue)
Receivables	Ratio of accounts receivables to total revenue
ROA	Ratio of operating income after depreciation to total assets

Search depth	Ratio of repeated citations to total citations made by a firm in patents filed and eventually granted, where citation repetition is computed by looking at the firm's historical patent filings
Search scope	Ratio of new citations to total citations made by a firm in patents filed and eventually granted
Societal trust	County level measure of social capital index assigned to each firm based on the headquarter location in each firm-year. The index is based on Rupasingha, Goetz, and Freshwater (2006), who construct it using a principal component analysis for each county based on the number of social and civic associations, the voter turnout in the presidential election, the census response rate, and the number of non-government organizations. Based on data from the Northeast Regional Center for Rural Development in the College of Agricultural Sciences at Pennsylvania State University, this index is computable for the years 1990, 1997, 2005, and 2009. For missing years, the index is interpolated (Huang and Shang (2019))
Supplier sales fraction	Ratio of sales to customer to total assets
Supplier networth	Ratio of difference between supplier's total assets and total liabilities to total assets
Tobin's *q*	[Total assets + market value of equity - book value of equity]/total assets
Whited-Wu index	Computed as −0.091× [(income before extraordinary items + depreciation and amortization)/total assets] – 0.062 × [indicator for dividends for common shares or preferred shares] + 0.021× [long-term debt/total assets] – 0.044 × [log (total assets)] + 0.102 × [average industry sales growth (two-digit SIC)] – 0.035 × sales growth (Whited and Wu, 2006)

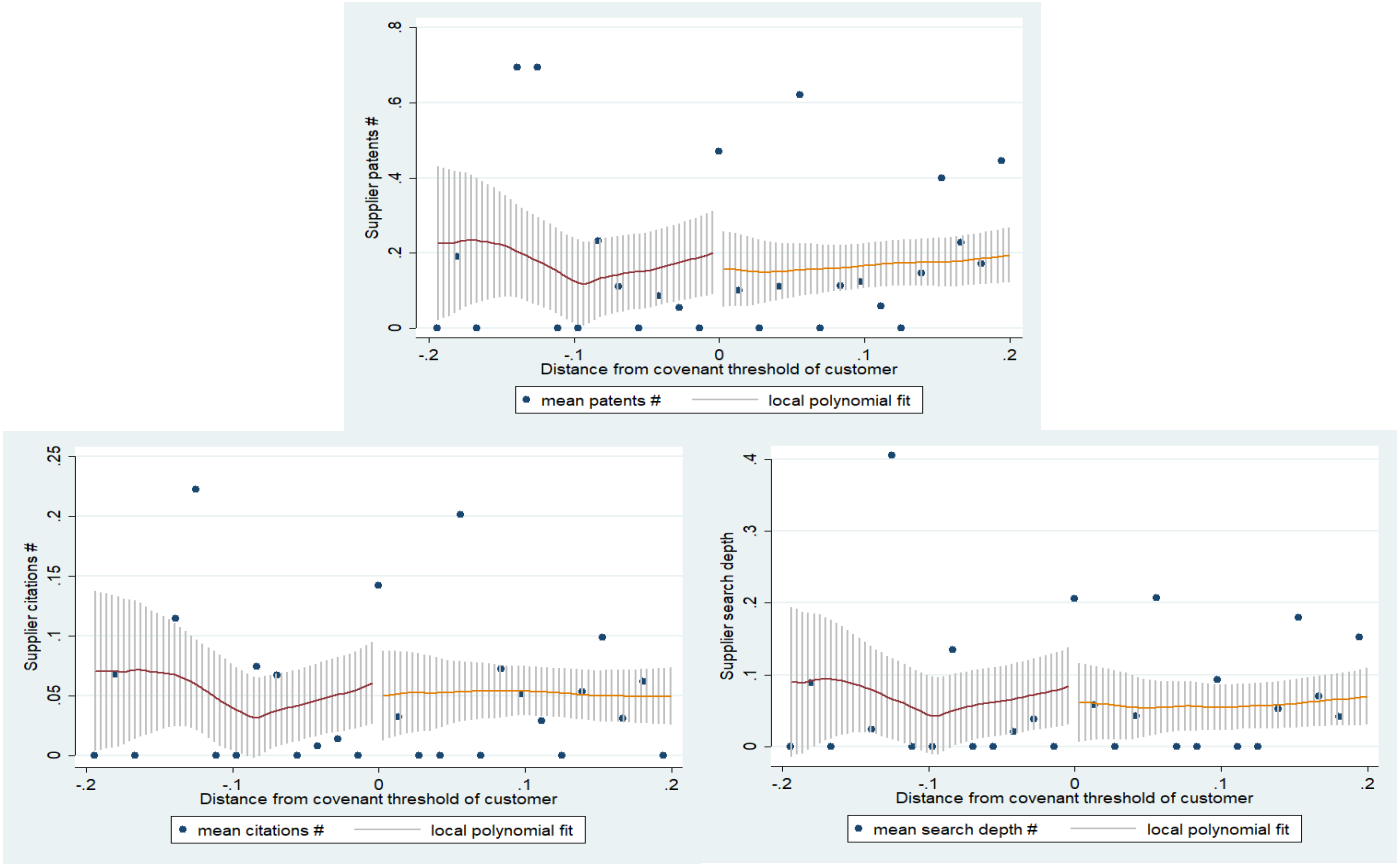


Figure 1: Regression discontinuity of supplier innovation measures according to distance from covenant threshold of their principal customer with a 95% confidence interval. The RDD sample consists of 687 supplier-years identified from the Compustat segment database as being the suppliers of customers from the Compustat segment database merged with loan data from DealScan during 1994 to 2009. The sample is restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants) which is within a bandwidth of 0.2 of the covenant threshold (i.e., discontinuity sample). The x-axis is the distance from the covenant threshold, which is standardized by the standard deviation of the relevant measure (i.e., current ratio or net worth according to the type of financial covenant). A negative distance implies a covenant violation. The dots represent the average measures of supplier innovation, including the number of patents (top), number of citations (bottom-left), and search depth (bottom-right) around the covenant threshold of their principal customer. The grey lines represent the confidence interval.

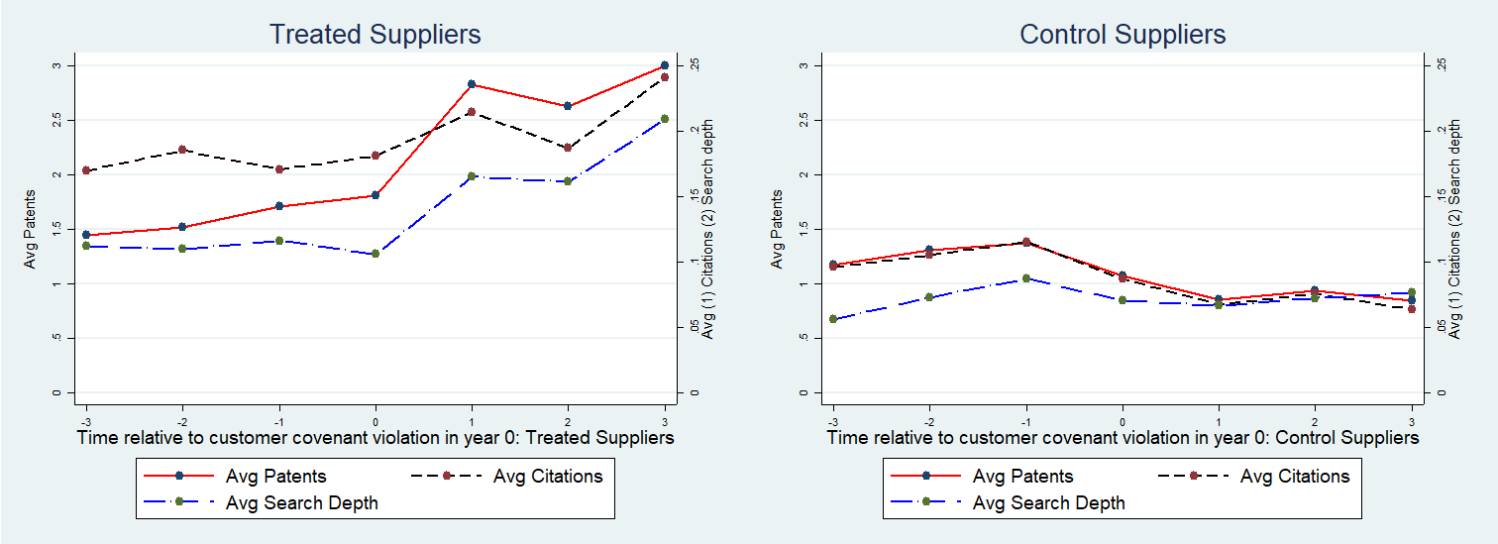


Figure 2: Time trend in supplier innovation around the years of customer covenant violation using samples of supplier-years in a seven-year window corresponding to customers who violate their covenants (treated suppliers) and those customers that do not violate their covenants (control suppliers) during 1994 to 2009. We impose further filters on treated suppliers to restrict the sample to those customers who violate the covenant only once at year *t* and not in any other year in the seven-year window.

Online Appendix for
"Chained Innovation: Response to Customer Covenant Violations"

Srinivasan Selvam and Kelvin Jui Keng Tan

This Appendix presents tables for additional analyses that are discussed but not reported in the main manuscript. Section 1 presents McCrary Density tests and the findings of the placebo tests, where the customer covenant violation is assumed to have occurred five years before the actual violation or is assumed to have occurred randomly. Section 2 presents the variation in our baseline findings of supplier propensities to cite customer patents.

Specifically, the Appendix includes the following:

- Online Appendix Figure 1. McCrary Density Tests
- OA Table 1. Effect of Customer Covenant Violations on Supplier Innovation Placebo Analysis
- OA Table 2. Cross-sectional Variation in Supplier Propensity to Cite Customer Patents

1. McCrary Density Tests and Placebo Analyses

Online Appendix Figure 1 presents the frequency distribution of the covenant violation variable around the violation thresholds (McCrary, 2008) using both the bandwidth choices used in the analyses in the main manuscript. The figure does not support the view that there is a precise manipulation by the customers around the violation thresholds within both the bandwidth of 0.20 (in the left panel) and a data-driven optimal bandwidth based on the CER algorithm of 0.71 (in the right panel) on each side of the covenant thresholds. The distance from covenant violation thresholds is measured as the standardized relative distance from the violation for both the current ratio and the net worth covenant thresholds. We do not find any remarkable discontinuity around the thresholds. Specifically, the 95% confidence bands overlap in both graphs, indicating the densities of the distribution on either side of the thresholds are not significantly different.

[Insert OA Figure 1 about here]

OA Table 1 presents the placebo analyses of the effect of customer covenant violation on supplier innovation. Panel A shows the effect of a pseudo customer covenant violation, which

we assume to have occurred five years before the actual estimated covenant violation, on supplier innovation using a full sample of customers with one or more outstanding loans with a covenant in the DealScan database. Consistent with our expectation, the pseudo covenant violation indicator has no association with supplier innovation in the full sample, which is not tabulated for the sake of brevity. We repeat the same placebo analysis with the discontinuity sample (those within a bandwidth of 0.2 from covenant threshold in year *t*) rather than with the full sample and report the results in Panel A adopting the same specifications as those in Table 3 in the main manuscript. Panel A shows a similar finding; i.e., the past five-year period prior to a customer covenant violation cannot predict supplier innovation activities in the subsequent years. In Panel B, we randomize the effect of customer violation using a discontinuity sample. Specifically, we create a random variable and assign the *Pseudo customer covenant violation* indicator, the key variable of interest, to be one if it is greater than the sample median. The *Pseudo customer covenant* violation indicator appears to be not significantly related to supplier innovation activities, which confirms that our main results are not due to chance.

[Insert OA Table 1 about here]

2. Cross-sectional variation in supplier propensity to cite customer patents

To pinpoint when suppliers learn more from their customers' innovation, we also run cross-sectional analyses similar to those in Tables 9 and 10 in the main manuscript. In OA Table 2, we interact the *Customer covenant violation* variable with the measures for the suppliers' financing flexibility, trade credit provisions, the opportunity to learn from the customer, and the difference in mutual trust levels, using the indicator for citing any customer patent as the dependent variable and a linear probability model specification.

[Insert OA Table 2 about here]

In Panel A, we find that the interaction term between *Customer covenant violation* and supplier leverage is negative and significant in years *t*+1 and *t*+2 (Columns (1) and (2) show that the coefficient estimates on a × b are -0.335 and -0.334, respectively, which are statistically significant at the 5% significance level). These results suggest that when customers violate debt covenants, less leveraged suppliers with the financial flexibility to innovate are more likely to cite customer patents. In contrast, the interaction terms using supplier industry-adjusted ROA are not statistically meaningful (Columns (3)–(4)). Similarly, the results in specifications five to eight support our prior findings that these suppliers are more likely to offer trade credits,

showing a greater propensity of suppliers to cite their customer patents in the post-covenant violation years (positive and significant interaction term at least at the 10% level of significance in three of four specifications in Columns (5)–(8)).

Further, in Panel B, in Columns (1)–(4), we find that when customers are large R&D spenders and specialize in niche innovation areas, suppliers show a greater willingness to file patents citing such customers after covenant violations. However, in Columns (5)–(8), we find that the interaction variable is insignificant in all the columns, thus not showing a relationship between differences in trust levels and supplier propensities to cite customer patents. In summary, the findings in OA Table 2 clearly illustrate that suppliers learn from their customers, who are more willing to share their expertise with suppliers when facing financial frictions, especially when the supplier has the ability and willingness to help the customer to innovate.

References

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman, 2017, Technological innovation, resource allocation, and growth, *Quarterly Journal of Economics* 132, 665-712.

McCrary, Justin, 2008, Manipulation of the running variable in the regression discontinuity design: A density test, *Journal of Econometrics* 142(2), 698-714.

OA Table 1: Effect of Customer Covenant Violations on Supplier Innovation Placebo Analysis

This table presents regression estimates of different types of supplier innovation on customer covenant violation and control variables. The customer covenant violation is assumed to have occurred five years prior to the actual violation in Panel A. In Panel B, covenant violation is randomly assigned in the sample. The sample consists of 2,998 suppliers identified from the Compustat segment database as being the suppliers of customers with an outstanding loan with a quantitative covenant as identified in Dealscan between 1994 and 2009. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample of suppliers is restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample). *Customer covenant violation* is an indicator for customer covenant violations in Panel A, identified as those customers that have fallen below the covenant-specified threshold of the current ratio or net worth during the life of one of their outstanding loans. In Panel A, other control variables are lagged with respect to the year of innovation. In Panel B, *Customer covenant violation* is randomized by generating a random number that is uniformly distributed between 1 and 0. *Pseudo customer covenant violation* is defined as an indicator variable that takes the value of one for customer-supplier pairs when the random variable is greater than the sample median and zero otherwise. In both the panels, supplier industry fixed effects based on the Fama-French 30 industry classification are included and t-statistics based on standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Effect of Customer Covenant Violation (at year *t*-5)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
Independent variables	Violation year+1						Violation year+2		
Customer covenant violation	-0.018	-0.015	-0.108	0.007	-0.002	-0.087	0.081	0.033	-0.060
(indicator)	(-0.170)	(-0.461)	(-1.423)	(0.116)	(-0.042)	(-1.345)	(0.709)	(0.991)	(-0.809)
Customer default distance (CR)	3.411**	0.675**	-0.337	0.391	-0.052	1.257	3.848**	1.015**	2.654*
	(2.163)	(2.024)	(-0.807)	(0.578)	(-0.104)	(0.943)	(2.535)	(2.287)	(1.694)
Customer default distance (NW)	-0.000	-0.000	-0.000	0.000*	0.000	0.001	-0.000	-0.000	-0.000
	(-0.910)	(-1.534)	(-0.486)	(1.670)	(0.542)	(1.179)	(-1.108)	(-1.439)	(-0.771)
Supplier characteristics									
Ln (market equity)	0.114***	0.029***	0.007	0.064	0.029	-0.006	0.138***	0.029**	0.010
	(3.039)	(2.625)	(0.309)	(1.352)	(1.086)	(-0.309)	(3.416)	(2.442)	(0.507)
R&D/assets	1.733***	0.660***	0.980***	1.001	0.494	0.490***	1.558**	0.456**	0.849**
	(3.080)	(2.597)	(2.944)	(1.360)	(0.599)	(3.230)	(2.201)	(2.138)	(2.339)
ROA	-0.127	-0.025	-0.074	-0.021	-0.053	-0.157*	-0.171	-0.035	-0.061
	(-1.297)	(-0.773)	(-1.275)	(-0.229)	(-0.685)	(-1.712)	(-1.621)	(-1.431)	(-1.046)
Leverage	0.057	0.019	0.020	-0.001	0.052	-0.086	0.058	0.025*	0.010
	(1.267)	(1.568)	(1.010)	(-0.007)	(0.748)	(-1.266)	(1.206)	(1.853)	(0.413)
PPE/assets	-0.324	-0.094	-0.265**	0.772	0.195	-0.001	-0.322	-0.073	-0.142
	(-1.558)	(-1.577)	(-2.121)	(1.545)	(1.202)	(-0.003)	(-1.510)	(-1.277)	(-1.119)
Capex/assets	0.391	0.124	0.456	0.508	0.048	0.165	0.294	0.068	0.435
	(0.745)	(0.761)	(1.514)	(1.280)	(0.239)	(0.797)	(0.633)	(0.482)	(1.346)
Herfindahl index	-10.646	-0.867	-4.884	24.450***	6.303	13.497	-15.037	-4.886*	-5.611

	(-1.143)	(-0.307)	(-0.818)	(2.819)	(1.132)	(1.259)	(-1.623)	(-1.805)	(-1.174)
Herfindahl index square	62.914	9.256	25.502	-84.589**	-26.491	-52.643	77.115**	23.567**	27.214
	(1.589)	(0.813)	(0.973)	(-2.537)	(-1.361)	(-1.297)	(1.976)	(2.081)	(1.248)
Tobin's *q*	0.009	0.002	0.008	-0.026	-0.021	-0.002	0.005	-0.002	0.012
	(0.787)	(0.436)	(1.516)	(-1.120)	(-0.614)	(-0.073)	(0.429)	(-0.520)	(1.527)
Whited-Wu index	-1.682*	-0.441	-1.660**	0.095	-0.054	-0.161	-1.609	-0.443	-1.416**
	(-1.666)	(-1.472)	(-2.561)	(0.300)	(-0.239)	(-0.787)	(-1.601)	(-1.507)	(-2.222)
Ln (age)	0.341**	0.079*	0.224**	-0.519***	-0.333**	-0.358*	0.361**	0.081*	0.202**
	(2.256)	(1.790)	(2.208)	(-2.968)	(-1.991)	(-1.857)	(2.405)	(1.808)	(2.170)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Supplier firm fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Observations	378	378	378	249	249	249	378	378	378
Adj. R-sq	0.388	0.307	0.239	0.945	0.732	0.802	0.405	0.289	0.236

Panel B: Effect of Randomized Customer Covenant Violation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth	Ln (1+no. of patents)	Ln (1+no. of citations)	Search depth
Independent variables	Violation year+1						Violation year+2		
Pseudo customer covenant violation	-0.063	-0.010	-0.025	0.008	-0.005	0.051	-0.019	0.029	-0.036
(indicator)	(-0.882)	(-0.663)	(-0.670)	(0.152)	(-0.234)	(0.740)	(-0.280)	(1.514)	(-0.812)
Supplier characteristics									
Ln (market equity)	0.100***	0.011	0.033*	0.001	-0.009	-0.010	0.113**	0.015	0.042*
	(2.841)	(1.537)	(1.847)	(0.022)	(-0.598)	(-0.528)	(2.515)	(1.491)	(1.897)
R&D/assets	0.865**	0.333**	0.866**	-0.783	1.142	2.187	0.723	0.257	0.531
	(2.010)	(2.367)	(2.509)	(-0.634)	(1.233)	(0.911)	(1.521)	(1.469)	(1.391)
ROA	-0.174	-0.028	-0.076	0.059	0.007	0.031	-0.291**	-0.036	-0.209**
	(-1.624)	(-1.088)	(-0.847)	(0.887)	(0.179)	(0.527)	(-2.003)	(-1.047)	(-2.067)
Leverage	0.019	-0.018	0.073	0.067	0.007	0.014	-0.038	-0.023	-0.070
	(0.242)	(-0.743)	(0.825)	(0.961)	(0.157)	(0.214)	(-0.464)	(-0.861)	(-1.386)
PPE/assets	-0.037	0.014	-0.133	0.204	-0.050	0.011	-0.317	-0.025	-0.299*
	(-0.191)	(0.219)	(-1.207)	(0.798)	(-0.576)	(0.103)	(-1.366)	(-0.350)	(-1.885)
Capex/assets	-0.056	0.010	0.204	-0.350	-0.054	0.095	0.224	0.052	0.096
	(-0.140)	(0.086)	(0.760)	(-1.119)	(-0.638)	(0.513)	(0.455)	(0.413)	(0.333)
Herfindahl index	-9.674	-4.288	1.527	-17.034	-8.464	6.945	-5.900	-0.532	-4.687
	(-1.275)	(-1.597)	(0.212)	(-1.113)	(-1.271)	(0.523)	(-0.735)	(-0.170)	(-0.636)

Herfindahl index square	68.600	21.367	-9.950	108.906	49.056	-48.974	39.559	-9.756	39.997
	(1.472)	(1.171)	(-0.226)	(1.569)	(1.352)	(-0.714)	(0.815)	(-0.459)	(0.759)
Tobin's *q*	0.006	0.001	0.019	0.022	0.016	0.001	-0.014	-0.001	-0.007
	(0.313)	(0.215)	(1.271)	(1.143)	(1.165)	(0.038)	(-0.678)	(-0.134)	(-0.629)
Whited-Wu index	-2.559***	-0.635***	-1.859***	-0.485	-0.453**	-0.348	-2.709*	-0.448	-2.101**
	(-2.738)	(-2.948)	(-2.810)	(-1.107)	(-2.265)	(-0.970)	(-1.762)	(-1.296)	(-2.061)
Ln (age)	0.078	-0.036	0.054				0.025	-0.014	0.028
	(0.543)	(-1.245)	(0.767)				(0.170)	(-0.480)	(0.329)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supplier industry fixed effects	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Supplier firm fixed effects	No	No	No	Yes	Yes	Yes	No	No	No
Observations	525	525	525	346	346	346	455	455	455
Adj. R-sq	0.282	0.135	0.240	0.890	0.596	0.765	0.266	0.131	0.162

OA Table 2: Effect of Customer Covenant Violations on Supplier Propensity to Cite Customer Patents

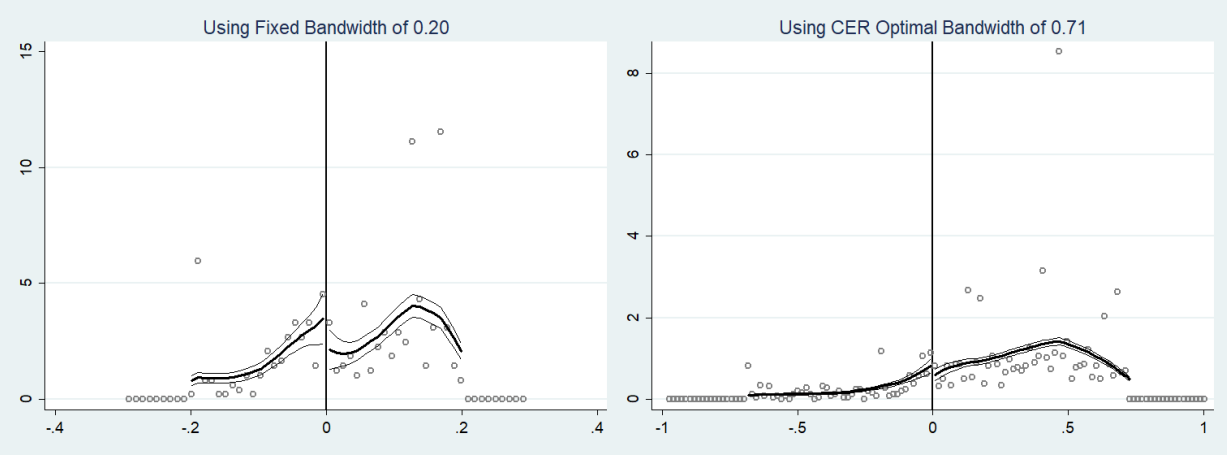
This table presents regression estimates of the likelihood of a supplier citing its customer's patent on customer covenant violation and control variables along the following two dimensions of suppliers. First, Panel A reports the cross-sectional variation based on supplier ability to innovate, such as suppliers' financial leverage, suppliers' industry-adjusted ROA, suppliers' operating cycle and suppliers' receivables). Second, Panel B reports the cross-sectional variation based on suppliers' incentives to innovate, such as customers' R&D/Assets, Customers' search depth, and the difference in social trust between customers and suppliers. The sample consists of 4,424 customer-supplier pair-years identified from the Compustat segment database as being the suppliers of the customers with an outstanding loan with a quantitative covenant as identified in Dealscan between 1994 and 2009. The supplier data are merged with firm-specific Google patent data (Kogan et al., 2017). The sample is further restricted to the suppliers whose customers are within a bandwidth of 0.2 of the covenant threshold (discontinuity sample), i.e., 1,048 customer-supplier pair years. Customer covenant violation is an indicator for customer covenant violations identified as those customers that have fallen below the covenant specified threshold of the current ratio or net worth during the life of one of their outstanding loans. In both panels, all models are estimated as a linear probability model with firm (i.e., supplier) fixed effects. In Panel B, the moderating variables are measured on the basis of customers who have outstanding covenants that are within the bandwidth of 0.2 of the covenant threshold. Supplier industry fixed effects based on the Fama-French 30 industry classification are included in all the panels. *t*-statistics based on robust standard errors double clustered by supplier and customer firms are reported in parentheses. Constants are included in all the regressions but not reported. All variables are defined in the appendix. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Cross-sectional Variation in the Likelihood of Citing Customer Patents According to Supplier Ability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Citing covenant violated customer (indicator)							
	Moderating var: Supplier Leverage		Moderating var: Supplier Industry-adjusted ROA		Moderating var: Supplier Operating Cycle		Moderating var: Supplier Receivables	
	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2
Customer covenant violation (indicator): a	0.208***	0.251***	0.068	0.112*	-0.022	-0.001	-0.010	0.017
	(2.601)	(2.954)	(1.289)	(1.954)	(-0.314)	(-0.013)	(-0.129)	(0.227)
Moderating variable: b	0.302	0.289	-0.142	-0.164	-0.357***	-0.342***	-0.175***	-0.164***
	(1.366)	(1.604)	(-0.416)	(-0.652)	(-3.209)	(-3.062)	(-3.379)	(-3.762)
a × b	-0.335*	-0.334**	-0.065	-0.003	0.165**	0.198***	0.083	0.096*
	(-1.964)	(-2.180)	(-0.275)	(-0.014)	(2.297)	(2.627)	(1.607)	(1.779)
Other controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	684	684	684	684	667	667	667	667
Adj. R-sq	0.182	0.371	0.172	0.363	0.201	0.390	0.197	0.385

Panel B: Cross-sectional Variation in the Likelihood of Citing Customer Patents According to Supplier Incentives

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Citing covenant violated customer (indicator)							
	Moderating variable: Customer R&D/Assets (b)		Moderating variable: Customer search depth (b)		Moderating variable: Absolute difference in societal trust between customer and supplier (b)		Moderating variable: Customer stakeholder orientation (b)	
	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2	Year *t*+1	Year *t*+2
Customer covenant violation (indicator):	0.038	0.055	0.026	0.065	0.094	0.315*	0.122	0.131
a	(0.562)	(0.792)	(0.435)	(0.990)	(0.497)	(1.916)	(0.610)	(0.738)
Moderating variable: b	-1.449	-5.603	-0.279	-0.338	0.142	0.218	-0.219	0.004
	(-0.216)	(-0.991)	(-1.569)	(-1.454)	(0.834)	(1.171)	(-0.976)	(0.036)
a × b	4.081	7.400*	0.326*	0.362*	-0.045	-0.224	0.100	0.097
	(1.055)	(1.741)	(1.960)	(1.855)	(-0.384)	(-1.426)	(0.824)	(0.996)
Moderating variable: c							-0.033	0.180
							(-0.164)	(1.057)
a × c							0.001	-0.024
							(0.010)	(-0.179)
Other controls in Table 3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Customer state fixed effects	No	No	No	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	684	684	684	684	143	143	143	143
Adj. R-sq	0.173	0.367	0.178	0.369	0.294	0.404	0.297	0.379



Online Appendix Figure 1: The McCrary Test of density around the customer covenant violation threshold to examine whether there is any discontinuity around the threshold boundary suggesting significant manipulation by firms. The sample consists of customers identified from the Compustat segment database merged with loan data from Dealscan from 1994 to 2009, restricted to the customers in the Compustat segment database that have a current loan outstanding with one or more quantitative covenants (i.e., either current ratio or net worth covenants) with distance from the covenant threshold being within a data-driven bandwidth of 0.71 in the right panel and a bandwidth of 0.20 in the left panel, respectively. The x-axis is the distance from the covenant threshold, which is standardized by the standard deviation of the relevant measure (i.e., current ratio or net worth according to the type of financial covenant). A negative distance implies a covenant violation. The y-axis is the estimated density. The dots represent the average estimated density of the sample binned by default. The solid lines represent the fitted lines. The lighter solid lines represent the 95% confidence interval.