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Innovation Disclosure and Supply Chain Risk: Networks, Collaboration, and Spillovers

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Abstract

Supply chain risk management has become a core element of corporate strategy, yet systematic evidence on how innovation information disclosure affects supply chain risk remains scarce. We study how innovation information disclosure in firms' MD&A sections affects supply chain risk. Using data on Chinese A-share listed firms from 2012 to 2023, we find that firms disclosing more innovation-related content face significantly a lower supply chain risk. This result remains true following instrumental variable estimation, propensity score matching, entropy balancing, and controlling for province- and industry-specific time trends. We provide supportive evidence for three circumstances: firms that disclose more have a broader and more diverse set of supply chain partners; they engage in more joint patenting with partners, consistent with higher switching costs and more stable relationships; and they exhibit stronger reputations and commercial credit capacity, consistent with partnerships reinforced through both trust and financial ties. The effect is concentrated among non-SOEs, high-tech firms, firms in competitive industries, and firms outside the digital economy, all settings in which information asymmetry is more severe and alternative channels for conveying innovation capabilities are limited. We also document asymmetric vertical spillovers: downstream customers' innovation disclosure prompts upstream suppliers to become more transparent, but the reverse does not hold. Supply chain risk, by contrast, affects connected firms in both directions. These findings extend the literature on the economic consequences of innovation disclosure from capital markets to supply chain management.

Keywords: innovation information disclosure; supply chain risk; information transparency; supply chain network

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1. Introduction

Global supply chains are undergoing a period of deep restructuring driven by pandemic disruptions, geopolitical shifts, extreme weather, and commodity price volatility. Recent studies have reported that supply chain shocks have persistent effects on firm performance and propagate across connected partners [1–3]. Against this backdrop, managing supply chain risk has become central to corporate strategy. At the same time, firms' innovation capabilities and how they communicate them to outsiders have become increasingly important for market expectations and investment decisions [4–6]. Innovation disclosure, then, is no longer simply a matter of regulatory compliance; it has become a tool firms use to signal quality and build relationships with external stakeholders.

Despite this progress, we know little about whether and how innovation disclosure matters for supply chain risk. Information frictions are a well-recognized source of inefficiency in supply chains [7,8], but existing work on innovation disclosure concentrates on capital markets [4,9] and bank lending [5]. There are good reasons to think the supply chain setting is different. Financial metrics are backward-looking and largely standardized; ESG disclosures primarily address compliance and reputational concerns. Innovation information, by contrast, is forward-looking. It reflects a firm's technological trajectory and R&D commitments, which are precisely what supply chain partners need to assess when evaluating technical compatibility and the long-term value of cooperation. Because this information cannot be readily inferred from financial statements or third-party ratings, voluntary disclosure through MD&A sections may be an unusually important channel for reducing information asymmetry between supply chain partners. Yet the mechanisms through which such disclosure shapes supply chain risk have received almost no attention.

Our paper connects to several lines of prior work. A growing body of literature examines the economic consequences of innovation disclosure, mostly in capital market and lending settings. Brown and Martinsson [9] analyze the link between transparency and innovation, Huang et al. [4] show that innovative firms increase management guidance to meet investor demands, and He and Lee [10] document how post-innovation disclosure choices affect the cost of capital. On the financing side, Saidi and Žaldokas [5] exploit the American Inventors Protection Act and find that innovation disclosure helps firms switch lenders, lower debt costs, and access syndicated and public capital markets, while Francis et al. [11] confirm that innovation information matters for bank valuations. Other work examines broader economic effects: Zhou et al. [12] show that innovation disclosure facilitates access to R&D subsidies, and Kim and Valentine [13] reveal the complex consequences of mandatory patent disclosure for innovation activity. What these authors have not done is look beyond capital markets and lending relationships to ask whether innovation disclosure also matters for supply chain risk. A second line of work studies how information flows through supply chains and shapes firm behavior. Cho et al. [14] find that information externalities from major customers' earnings announcements affect suppliers' voluntary disclosure, and Cai et al. [15] study the determinants and value relevance of voluntary supply chain disclosure. Zhong et al. [16] show that supply chain transparency reduces stock price crash risk; Zheng et al. [17] document its effect on idiosyncratic risk for newly listed firms, with digitalization playing a moderating role. In a comprehensive review, Ho et al. [18] identify information sharing and transparency as critical components of effective supply chain risk management. The information studied in this part of the literature, however, is predominantly financial or ESG-related. Innovation disclosure as a distinct category has received little attention. Third, a subset of studies on disclosure spillovers examine how one firm's disclosure decisions affect others. Seo [19] document significant peer effects, Durnev and Mangen [20] show that peers' MD&A content influences investment decisions, and Liu et al. [21] find that peers' innovation-related MD&A content stimulates R&D spending. In the vertical dimension, Song et al. [22] show that downstream customers' environmental disclosures influence upstream suppliers' emissions. Most of this body of work, however, focuses on horizontal spillovers within industries. Vertical spillovers of innovation information between supply chain partners, and the associated risk contagion, remain largely unexamined. Our paper also speaks to a broader research focus on risk propagation through interconnected economic networks. Recent work in financial markets has shown that risk spillovers exhibit strong frequency heterogeneity and asymmetric amplification under market stress [23,24]. This existing research documents how price-level shocks propagate across listed firms and across commodity markets, while we shift the object of analysis from market-level price connectedness to firm-level supply

chain relationships and examine how information disclosure, rather than realized shocks, shapes the transmission of risk between connected firms.

In this study, we ask whether and how innovation information disclosure affects firms' supply chain risk. We construct firm-level measures of both innovation disclosure and supply chain risk from the MD&A sections of annual reports for Chinese A-share listed firms over 2012 to 2023, using textual analysis methods. Our main finding is that firms with greater innovation disclosure face a lower supply chain risk. The result is robust to instrumental variable estimation, propensity score matching, entropy balancing, and the inclusion of province × year and industry × year fixed effects. Our mechanism tests provide supportive evidence for three pathways: greater innovation disclosure is associated with increasingly diverse supply chain partners, with more joint patenting with those partners and with stronger reputation and commercial credit capacity. The effect is concentrated among non-SOEs, high-tech firms, firms in competitive industries, and firms outside the digital economy. Finally, we document that innovation disclosure spills over asymmetrically along the supply chain: downstream customers' disclosure prompts upstream suppliers to become more transparent, but the reverse does not hold. Supply chain risk, by contrast, is transmitted between connected firms in both directions.

Our study makes four contributions. First, prior work on the economic consequences of innovation disclosure focuses on capital markets and bank lending [4,5,13]. Our contribution is not simply to extend this line of research to a new setting but to show that innovation disclosure plays a distinctive role in shaping supply chain relationships that other disclosure types do not. Because innovation information is forward-looking and capability-oriented, rather than backward-looking like financial disclosure or compliance-oriented like ESG disclosure, it speaks directly to the technical-coordination and partner-selection decisions that define supply chain cooperation. Our analysis points to three channels consistent with this role: partner diversification, collaborative innovation, and reputation building. This responds to Roychowdhury et al. [25]'s call for research on how financial reporting shapes real economic decisions. Second, the existing literature on disclosure spillovers largely addresses horizontal effects within industries [19–21]. We provide evidence of vertical spillovers along supply chains. Downstream customers' disclosure drives upstream suppliers to become more transparent, while supply chain risk spreads in both directions but with asymmetric intensity. These findings offer a richer picture of how information propagates through supply chain networks. Third, the supply chain risk literature has focused on operational factors like supplier concentration and financial factors like leverage [18], with little attention to the role of information. We show that a firm's information environment, specifically its innovation disclosure, is a meaningful determinant of supply chain risk in its own right. Fourth, our results have practical relevance. They suggest that firms can use innovation disclosure not only to improve capital market relationships but also to strengthen supply chain resilience and that regulators designing disclosure requirements should take these supply chain effects into account.

The rest of the paper is organized as follows. Section 2 develops the hypotheses. Section 3 describes variable construction and the empirical strategy. Section 4 presents the results. Section 5 presents the conclusions.

2. Hypothesis Development

2.1. Innovation Information Disclosure and Supply Chain Risk

Information asymmetry is a critical source of friction in supply chain relationships. When a firm cannot accurately assess a potential partner's technological capabilities, operational stability, or growth prospects, the result is inefficient matching and elevated risk [26]. Sodhi and Tang [7] and Gardner et al. [8] both identify information asymmetry

as a key structural source of supply chain vulnerability and point to transparency as a natural remedy.

How might innovation disclosure help? Signaling theory provides a useful starting point. In environments with asymmetric information, high-quality firms can credibly convey their type by sending signals that are costly or difficult to imitate [27,28]. Innovation disclosure fits this description: when firms reveal information about their technological assets, R&D capabilities, intellectual property, and strategic direction in the MD&A sections of annual reports, they provide supply chain partners with a basis for evaluating compatibility and cooperation value. Baruffaldi et al. [6] offer direct support for this view, showing that firms facing greater information asymmetry significantly increase voluntary R&D disclosures, with the effect concentrated among firms with tighter financing constraints, consistent with a signaling motive. Signaling theory rests on the idea that when one party to a transaction has quality attributes that the other party cannot directly observe, high-quality senders can distinguish themselves from low-quality ones by undertaking actions that are costly or difficult for low-quality senders to imitate. Such signals carry credible information precisely because their cost differs across quality types, so that only high-quality senders can bear, or are willing to bear, the cost. Innovation disclosure has this property. Firms without genuine R&D substance find it difficult to disclose technology roadmaps, R&D plans, and intellectual property positions in a sustained and specific way, since hollow claims tend to be falsified by later operating outcomes and invite reputational loss. This differential cost across firm types is what makes innovation disclosure a credible quality signal and allows it to meaningfully reduce information asymmetry between supply chain partners.

The signaling value of innovation disclosure stands out in the supply chain context in a way that sets it apart from other disclosure categories. Financial disclosure is largely backward-looking and highly standardized, and supply chain partners can readily access the relevant information through financial statements and third-party ratings. ESG disclosure serves mainly compliance and external legitimacy purposes and has only a loose connection to the specific technical coordination issues that define supply chain partnerships. Innovation disclosure, by contrast, is forward-looking and capability-oriented. It reveals a firm's technological trajectory, R&D priorities, and future product plans, which are exactly the kinds of information supply chain partners need when deciding whether to enter a partnership, how to coordinate technically, and whether the relationship can be sustained over in the long term. Relative to equity investors, supply chain partners have more specific and greater operational information needs. Suppliers must judge whether a customer's technology roadmap is compatible with their own capacity planning, and customers must assess whether a supplier's technological reserves can support future product iterations. Questions of this kind cannot be answered with financial data or credit ratings alone. Huang et al. [4] show that innovative firms proactively increase management guidance to satisfy stakeholders' information demands, and Saidi and Žaldokas [5] demonstrate that innovation disclosure improves financing relationships and market contestability. If innovation disclosure can reduce asymmetry and strengthen relationships in capital markets, it is plausible that it does the same in supply chains, where the information needs are even more pointed.

A natural concern is that innovation disclosure may also impose costs, such as imitation risk, erosion of competitive advantage, and shifts in bargaining power. Whether these costs offset or even outweigh the signaling benefits discussed above warrants careful consideration.

Regarding imitation risk, disclosing detailed technological information can indeed lower competitors' costs of learning and replication. Bhattacharya and Ritter [29] note in their classic analysis that R&D-related disclosure inherently involves a disclosure-versus-secrecy tradeoff. In our setting, however, this risk is limited in scope: the content disclosed in MD&A sections primarily concerns strategic direction, R&D priorities, and capability signals rather than specific technical details such as formulas, algorithms, or process parameters, so the room for direct technological spillovers is narrow. On erosion of competitive advantage, Anand and Galetovic [30] show theoretically that when firms build dynamic capabilities through relationship-specific investments, complementary assets, or sustained innovation iteration, the disclosure of static information does little to undermine their competitive position. This mechanism is particularly relevant for listed firms' innovation disclosures: what generates durable competitive value is typically the firm's R&D execution capability and its pace of iteration, not any point-in-time technological description. On shifts in bargaining power, innovation disclosure may give supply chain partners better insight into a firm's technological position, which they could exploit in negotiations. This concern is muted in supply chain relationships because partners are fundamentally collaborators rather than competitors, and their interests are largely tied to those of the focal firm, so that exploiting informational advantages would damage the long-term relationship. Relationship-specific investments and joint R&D activities further raise switching costs and constrain opportunistic behavior on both sides [31].

Taken together, both the benefits and costs of innovation disclosure are real, and the net effect depends on the institutional and relational context. In the setting we examine, that is, Chinese A-share listed firms and their supply chain partners, we expect the signaling benefits to predominate for three reasons. First, the strategic-level nature of MD&A disclosure limits the scope for technological leakage. Second, the collaborative rather than competitive role of supply chain partners reduces the likelihood that disclosed information will be exploited against the firm. Third, relationship-specific investments raise the cost of withdrawing from an existing relationship. Whether the net effect is negative is ultimately an empirical question, which the analysis that follows is designed to address.

If innovation disclosure does reduce information asymmetry in supply chains, it should attract higher-quality partners, facilitate more stable matching, and lower cooperation frictions. We therefore propose the following hypothesis:

Hypothesis 1. *Innovation information disclosure is negatively associated with supply chain risk.*

2.2. Mechanisms

2.2.1. Supply Chain Network Optimization

The first channel we consider is supply chain network diversification. The logic is straightforward: firms that rely on a small number of suppliers or customers are exposed to severe disruption risk if any one partner encounters difficulties. Diversifying the partner base reduces this exposure, much as diversifying a financial portfolio reduces risk. Grossman et al. [32] develop this argument theoretically, showing that supply chain diversification enhances resilience. Lin et al. [33] exploit the COVID-19 shock and find that more diversified Chinese manufacturers exhibited greater earnings resilience, and Piprani et al. [34] confirm a positive relationship between supply chain flexibility and resilience along multiple dimensions.

Innovation disclosure is one of several information channels that shape partner search in supply chains. Partner search itself is a complex, bilateral, and resource-intensive process in which firms invest time and effort through reputation, prior transactions, and formal due diligence. Conditional on these conventional channels, innovation disclosure

provides additional forward-looking information about a firm's technological assets and R&D direction, which can marginally lower the informational friction that prospective suppliers and customers face when evaluating whether cooperation makes sense. In this way, innovation disclosure complements rather than substitutes for the established channels of partner search, and can help broaden the pool of interested partners at the margin. Ambulkar et al. [31] show that firm resilience is closely tied to network structure, and Hosseini et al. [35] confirm that diversified supplier networks reduce supply chain risk.

Diversification matters in two dimensions. The first is simply the number of partners: more partners provide more substitution options when any single one exits. The second is the composition of the partner base. Partners with different ownership structures face systematically different risk exposures. State-owned enterprises are primarily affected by industrial policy shifts and government reform initiatives; private firms are more sensitive to market demand fluctuations and financing conditions; foreign-invested enterprises are disproportionately exposed to trade policy changes and exchange rate movements. Because these risk drivers are largely uncorrelated, combining partners across ownership types reduces systematic supply chain risk through portfolio effects. Innovation disclosure can attract this kind of diversity because different types of firms look for different things in a partner's innovation profile: state-owned enterprises may care most about indigenous innovation and strategic technology positioning, private firms about commercialization prospects, and foreign-invested firms about international compatibility of technical standards. We therefore propose the following hypothesis:

Hypothesis 2. *Innovation information disclosure is positively associated with the number of supply chain partners.*

Hypothesis 3. *Innovation information disclosure is positively associated with supply chain partner ownership diversity.*

2.2.2. Collaborative Innovation

The second channel is collaborative innovation. Cross-firm technological cooperation requires that partners understand each other's capabilities, R&D directions, and resources well enough to identify productive areas of joint work. Liu et al. [21] find that innovation content in firms' MD&A generates significant spillover effects on peers' R&D investment, which suggests that innovation disclosure can facilitate technological cooperation. When firms hold innovation information tightly, potential collaborators face high costs in evaluating whether their technologies are compatible and whether joint projects would be worthwhile. By disclosing innovation information systematically, firms lower these evaluation costs and create conditions for deeper collaboration.

What makes this channel particularly relevant for supply chain stability is that technology-based collaboration tends to be relationship-specific. When a firm and its supply chain partner jointly invest R&D resources, share technological outcomes, and develop joint intellectual property, both sides accumulate relationship-specific assets that would be lost if the partnership dissolved. The resulting switching costs give both parties strong incentives to maintain the relationship. Collaborative innovation therefore stabilizes supply chains not just through the direct benefits of risk sharing and cost pooling but also through the lock-in that comes from joint investments in technology. We therefore propose the following hypothesis:

Hypothesis 4. *Innovation information disclosure is positively associated with collaborative innovation activities between supply chain partners.*

2.2.3. Reputation and Commercial Credit

The third channel works through corporate reputation and commercial credit capacity, which reinforce supply chain relationships in complementary ways. Consider reputation first. Connelly et al. [27] argue that reputation functions as a cumulative signal, conveying information about a firm's capabilities and credibility to outside parties. In the supply chain context, a strong reputation lowers counterparties' perceived risk and makes potential partners more willing to enter and maintain relationships. Innovation disclosure is a natural way to build this kind of reputation, especially as innovation capability has become a central indicator of competitiveness. Taj [28] identify three dimensions that determine how effective a signal is: strength, observability, and consistency. Innovation disclosure through MD&A checks all three boxes. Annual reports are subject to regulatory and audit oversight, which gives the signal credibility. MD&A sections are publicly available, which makes the signal observable. Finally, because firms disclose annually on a regular cycle, the signal is temporally consistent. The practical payoff is that firms with strong reputations tend to enjoy more stable partnerships. When a firm encounters an external shock or a period of temporary difficulty, the trust built through reputation can act as a buffer, giving partners reason to stay rather than exit.

Commercial credit works through a different but complementary logic. When a firm discloses detailed innovation information, it signals favorable growth prospects and profitability to external financiers. Saidi and Žaldokas [5] confirm that innovation disclosure helps firms secure better financing terms. Firms with stronger financial positions can in turn offer their supply chain partners more flexible payment conditions, creating financial ties that align both sides' economic interests and raise the cost of walking away from the relationship. Reputation, then, stabilizes supply chains through trust, while commercial credit stabilizes them through financial interdependence. We therefore propose the following hypotheses:

Hypothesis 5. *Innovation information disclosure is positively associated with corporate reputation.*

Hypothesis 6. *Innovation information disclosure is positively associated with commercial credit provision.*

3. Research Design

3.1. Variable Construction

3.1.1. Dependent Variable: Supply Chain Risk (*SCR*)

A key step in our analysis is measuring supply chain risk at the firm level. Traditional approaches use supplier or customer concentration indices or counts of disruption events. Both have drawbacks: concentration indices capture structural features of the supply chain but do not directly measure risk exposure, and disruption events can only be observed after the fact, making them poorly suited to tracking how risk evolves over time. Text-based risk measures have emerged as an alternative in recent years [2,36]. The MD&A section of annual reports is where management discusses operating conditions, risk factors, and forward-looking assessments [37]. Relative to financial statement data, MD&A text has several advantages for measuring supply chain risk: it is forward-looking, capturing exposures that have not yet shown up in the numbers; it covers multiple dimensions of risk, including cost, market, and geopolitical factors; and it varies across firms in ways that reflect genuinely different risk profiles. Following Ersahin et al. [3], we build our supply chain risk measure from MD&A text.

We construct the measure in two steps. First, following Ersahin et al. [3] and adapting to the Chinese context, we compile a keyword dictionary covering three categories of

supply chain risk: cost and commodity price risk (40 keywords, including terms such as raw material prices, exchange rate fluctuations, and procurement costs), climate and public health risk (28 keywords, including natural disasters, pandemic prevention, and carbon emissions), and market uncertainty and regional risk (19 keywords, including geopolitical risk, trade restrictions, and supply disruptions). The complete keyword dictionary is provided in Appendix Table A1. Second, we process the MD&A sections of annual reports for Chinese A-share listed firms over 2012 to 2023 using Python 3.9, performing text cleaning, Chinese word segmentation with the jieba module, and counting the frequency of dictionary keywords.

Our supply chain risk measure (*SCR*) is the percentage of supply chain risk keywords relative to total MD&A word count:

$$SCR_{it} = \frac{N_{it}^{risk}}{N_{it}^{total}} \times 100 \quad (1)$$

where N_{it}^{risk} is the number of times supply chain risk keywords appear in firm i's MD&A in year t, and N_{it}^{total} is the total word count. A higher value indicates greater supply chain risk exposure as perceived and disclosed by management. Because the measure is derived from MD&A narratives rather than from realized disruption events, it captures the risk profile that firms communicate to external parties, which is the object of interest for our research question on how innovation disclosure shapes the information environment facing supply chain partners.

3.1.2. Key Explanatory Variable: Innovation Information Disclosure (*IID*)

We measure innovation information disclosure from the same MD&A sections, where management typically discusses technological progress, R&D plans, intellectual property, and innovation strategy. MD&A text captures the breadth of a firm's innovation communication more fully than any single financial metric such as R&D expenditure.

We build the innovation keyword dictionary in three stages. We begin by manually extracting core innovation terms from the annual reports of representative firms across industries. We then broaden coverage by incorporating terminology from policy documents, including the Global Innovation Index Report 2021 and national innovation strategy guidelines. Finally, we use Word2Vec models to identify semantically related terms that the first two stages missed. The resulting dictionary contains 230 keywords organized into 16 categories: R&D activities, technological innovation, intellectual property, emerging technologies, digital technologies, new energy, biomedical innovation, advanced manufacturing, new materials, semiconductors, innovation management, infrastructure, talent, finance, technology standards, and innovation risk. The complete dictionary is provided in Appendix Tables A2 and A3.

IID is the proportion of innovation keywords relative to total MD&A word count:

$$IID_{it} = \frac{N_{it}^{innov}}{N_{it}^{total}} \quad (2)$$

where N_{it}^{innov} is the number of innovation keyword occurrences in firm i's MD&A in year t. Higher values indicate more intensive innovation disclosure. It is worth emphasizing what *IID* is intended to capture. *IID* measures innovation *disclosure intensity*, not innovation capability or substantive innovativeness. This construct alignment is intentional: our theoretical argument in Section 2 is about the signaling role of disclosure, and the relevant object for that mechanism is what firms communicate about innovation rather than what they substantively are at a given point in time. Measures of realized innovation capability,

such as R&D intensity or patent counts, would address a different research question. The same logic applies to *SCR*, which captures the supply chain risk profile that management discloses to external parties rather than realized disruption events. Because both *IID* and *SCR* are derived from MD&A text, one might worry about common-source bias. The two measures, however, draw on entirely separate keyword dictionaries and capture fundamentally different constructs: *IID* measures how much a firm communicates about its innovation activities, while *SCR* measures the extent to which management discusses supply chain risk exposures. We further address this concern through alternative variable definitions in our robustness tests.

3.1.3. Control Variables

Following Guo and Li [38] and Song et al. [39], we control for firm age (*Age*, the natural logarithm of years since establishment plus one), state ownership (*SOE*, a dummy for state-owned enterprises), debt-to-asset ratio (*DAR*), return on assets (*ROA*), gross profit margin (*GPM*), liquidity ratio (*LR*), current ratio (*CR*), long-term liability ratio (*LLR*), and ownership concentration (*OCR*, the combined shareholding of the top ten shareholders).

3.2. Data and Sample

Our sample consists of Chinese A-share listed firms from 2012 to 2023. We start in 2012 because the revised Industry Classification Guidelines for Listed Companies standardized industry codes that year, and the quality of MD&A sections improved markedly afterwards, making the text suitable for systematic analysis. MD&A text and financial data come from the CSMAR database, supplier–customer relationship data from the CNRDS database, and patent data from the Chinese Research Data Services Platform. We drop financial firms, firms classified as ST, *ST, or insolvent, and observations with missing key variables. All continuous variables are winsorized at the 1st and 99th percentiles. The final sample contains 24,152 firm–year observations.

3.3. Empirical Model

Our baseline specification is

$$SCR_{it} = \alpha_0 + \alpha_1 IID_{it} + \boldsymbol{\alpha}' \mathbf{X}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

where SCR_{it} is supply chain risk for firm i in year t, IID_{it} is innovation disclosure intensity, $\mathbf{X}_{it}$ is a vector of controls, and μ_i and λ_t are firm and year fixed effects. The coefficient of interest is α_1, which we expect to be negative. Standard errors are clustered at the firm level. In robustness tests, we also use two-way clustering at the firm–year level and replace the year fixed effects with province $\times$ year and industry $\times$ year fixed effects.

Table 1 reports summary statistics. The supply chain risk measure *SCR* averages 1.769 with a standard deviation of 1.083 and ranges from near zero to 15.479, so there is plenty of cross-sectional variation to work with. Innovation disclosure intensity *IID* averages 0.047 (s.d. = 0.047) and reaches a maximum of 0.707; some firms devote a substantial share of their MD&A to innovation-related content, while others barely mention it. The control variables look as expected for a sample of Chinese A-share firms: average leverage is 44.3%, average ROA is 3.5%, and state-owned enterprises make up 38.9% of the sample.

Table 1. Descriptive statistics.

Variables	Description	Obs.	Mean	Std. Dev.	Min	Max
SCR	Supply chain risk, keyword share in MD&A (%)	24,152	1.7688	1.0825	0.0000	15.4790
IID	Innovation disclosure intensity (ratio, 0–1)	24,152	0.0474	0.0474	0.0000	0.7073
Age	Firm age, ln(years + 1)	24,152	2.9318	0.3239	1.0986	4.0073
DAR	Total liabilities/total assets (ratio)	24,152	0.4428	0.2082	0.0446	1.1123
ROA	Net income/total assets (ratio)	24,152	0.0346	0.0654	−0.4579	0.2576
LR	Current assets/total assets (ratio)	24,152	0.5569	0.2033	0.0246	1.0000
CR	Current assets/current liabilities (ratio)	24,152	2.2207	2.1251	0.1914	20.9377
LLR	Long-term debt/total assets (ratio)	24,152	0.1883	0.1795	−0.2175	0.9420
GPM	Gross profit/revenue (ratio)	24,152	0.2786	0.1714	−0.1403	0.8861
OCR	Top 10 shareholders' holdings (ratio, 0–1)	24,152	0.5685	0.1499	0.1982	0.9529
SOE	State-owned enterprise (0/1 dummy)	24,152	0.3889	0.4875	0.0000	1.0000

Note: Units and scaling are indicated in the Description column. *SCR* is expressed as a percentage of total MD&A word count. *IID* is expressed as a proportion of total MD&A word count. All continuous ratio-type variables are unitless. All continuous variables are winsorized at the 1st and 99th percentiles.

4. Empirical Results

4.1. Baseline Estimates

Table 2 reports the baseline results. Column (1) includes only *IID*, along with firm and year fixed effects; the coefficient is −1.2609, which is significant at the 1% level. When we add the full set of controls in column (2), the coefficient barely moves, changing to −1.2752, which suggests that the result is not picking up observable firm characteristics. In economic terms, a one-standard-deviation increase in innovation disclosure (0.047) corresponds to a reduction in supply chain risk of about 3.4% of the sample mean. The control variables carry the expected signs. Return on assets (*ROA*) is significantly negative, indicating that more profitable firms have greater resources to absorb supply chain fluctuations and thus face lower risk exposure. Gross profit margin (*GPM*) is also significantly negative, consistent with stronger cost management capacity buffering price volatility along the supply chain. State ownership (*SOE*) is significantly negative, suggesting that state-owned enterprises benefit from policy support and resource advantages that reduce supply chain risk. Ownership concentration (*OCR*) is marginally positive, potentially reflecting decision-making rigidity associated with concentrated ownership structures that may hinder flexible supply chain risk management. The debt-to-asset ratio (*DAR*) and liquidity ratio (*LR*) are both significantly negative, indicating that firms with moderate leverage and higher liquidity face lower supply chain risk. These results provide initial support for Hypothesis 1.

Table 2. Baseline results.

Variables	(1) *SCR*	(2) *SCR*
IID	−1.2609 ***	−1.2752 ***
	(0.3205)	(0.3233)
Age		−0.2399
		(0.1606)
DAR		−0.1911 *
		(0.1097)
ROA		−0.6696 ***
		(0.1325)

Table 2. *Cont.*

Variables	(1) *SCR*	(2) *SCR*
LR		−0.2462 **
		(0.1014)
CR		0.0055
		(0.0085)
LLR		−0.0762
		(0.0732)
GPM		−0.2697 **
		(0.1367)
OCR		0.2011 *
		(0.1081)
SOE		−0.1415 ***
		(0.0531)
Constant	1.8285 ***	2.7952 ***
	(0.0152)	(0.4892)
Firm FE	YES	YES
Year FE	YES	YES
Observations	24,152	24,152
Adj. R^2	0.5278	0.5306

Note: This table reports the baseline regression results. The dependent variable is *SCR* (Supply Chain Risk). All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.2. Addressing Endogeneity

The baseline results are consistent with Hypothesis 1, but the relationship between innovation disclosure and supply chain risk could be driven by reverse causality (firms facing higher supply chain risk may adjust their disclosure behavior) or by omitted time-varying factors that affect both disclosure and risk simultaneously. We address these concerns in several ways. Table 3 reports the results. We begin with instrumental variable estimation using two different instruments. The first (*IV1*) is investor inquiry frequency on the listed firms' online interactive platforms. The logic is that investor attention creates pressure for firms to disclose more (satisfying the relevance condition), while individual investors do not participate in supply chain management decisions (satisfying the exclusion restriction). The second (*IV2*) follows Lewbel [40]'s heteroskedasticity-based approach and uses the cubic deviation of *IID* from its industry mean as an instrument. Both instruments produce first-stage F-statistics well above conventional thresholds, and the second-stage coefficients on *IID* are negative and significant in all specifications (columns 1–4), supporting a causal interpretation of the baseline results. We also use propensity score matching and entropy balancing to deal with potential selection bias. Within each industry–year group, we classify firms in the top 30% of innovation disclosure as the treatment group and those in the bottom 30% as the control group. Both approaches produce significant negative treatment effects of approximately −0.09 (columns 5–6), in line with the baseline estimates. As a final check, columns (7) and (8) replace the baseline year fixed effects with province × year and industry × year fixed effects, which absorb any differential time trends across regions and sectors. The coefficient on *IID* remains significant at the 1% level and is very close to the baseline estimate, indicating that the results are not driven by location- or industry-specific trends.

Table 3. Addressing endogeneity concerns.

Variables	(1) *IID*	(2) *SCR*	(3) *IID*	(4) *SCR*	(5) *SCR*	(6) *SCR*	(7) *SCR*	(8) *SCR*
IV1	0.0010 ***							
	(0.0002)							
IV2			4.6479 ***					
			(0.6403)					
IID		−15.3679 **		−0.5945 *			−1.2221 ***	−1.1644 ***
		(6.7638)		(0.3530)			(0.3226)	(0.3191)
Treat					−0.0925 ***	−0.0910 ***		
					(0.0286)	(0.0287)		
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Province × Year	NO	NO	NO	NO	NO	NO	YES	NO
Industry × Year	NO	NO	NO	NO	NO	NO	NO	YES
Observations	23,210	23,210	24,152	24,152	15,253	15,253	24,152	24,151
F statistics	30.75		52.69					

Note: Columns (1)–(2) and (3)–(4) present first-stage and second-stage 2SLS estimates using investor inquiry frequency (*IV1*) and heteroskedasticity-based instrument (*IV2*), respectively. Columns (5) and (6) report propensity score matching and entropy balancing results. Columns (7) and (8) include province × year and industry × year fixed effects. Control variables are included but not reported for brevity. F statistics are reported for first-stage IV regressions. Standard errors clustered at the firm level are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3. Robustness Checks

We probe the robustness of the baseline result along four dimensions: how we measure the key variables, how we measure supply chain risk itself, how we handle the standard errors, and which firms are in the sample. Table 4 reports the results. Column (1) replaces the ratio-based innovation disclosure measure with the natural logarithm of the innovation keyword count plus one (*lnIID*), which helps address potential measurement error in the baseline specification. The coefficient remains significantly negative. Column (2) addresses a potential common-source concern, namely that both *IID* and *SCR* are constructed from the same MD&A text and could in principle be jointly driven by firm-specific narrative style (e.g., verbosity or optimism). To rule out this mechanical channel, we construct a non-textual measure of supply chain risk based on realized fluctuations in supplier and customer relationships. Following the idea that supply chain instability manifests in changing partner shares over time, we define supply chain volatility (*SCV*) as the year-over-year change in the sum of top-five supplier and customer share ratios, adjusted by the total shares in the current year. Specifically, *SCV* captures the absolute change in the top-five supplier (customer) purchase (sales) shares between year $t-1$ and t, scaled by the current-year total; higher values indicate greater instability in supply chain relationships. Column (2) re-runs the baseline specification with *SCV* as the dependent variable. The coefficient on *IID* is −0.247, significant at the 1% level, which confirms that innovation disclosure reduces supply chain instability measured outside the MD&A text. Column (3) clusters standard errors at both the firm and year level instead of at the firm level alone. The point estimate on *IID* is unchanged and remains significant at the 1% level, so the results do not depend on how we treat the error structure. We then check whether the results are sensitive to sample composition. Column (4) drops the COVID-19 years (2020–2021), since pandemic-related disruptions could be driving the baseline relationship. The coefficient decreases somewhat in magnitude but remains significant at the 1% level. Column (5) removes high-tech firms to verify that the effect is not confined to technology-intensive sectors; the coefficient remains significantly negative. Column (6) excludes firms with poor disclosure quality ratings (C or D), which could introduce noise into our text-based measures if the MD&A

content is thin or boilerplate. The results are again very similar to the baseline. The core finding holds across all of these checks: firms that disclose more about their innovation activities face lower supply chain risk.

Table 4. Robustness tests.

Variables	(1) *SCR*	(2) *SCV*	(3) *SCR*	(4) *SCR*	(5) *SCR*	(6) *SCR*
lnIID	−0.0418 **					
	(0.0203)					
IID		−0.2470 ***	−1.2752 ***	−0.8847 ***	−1.1673 **	−1.2104 ***
		(0.0769)	(0.2198)	(0.3098)	(0.5594)	(0.3297)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	24,152	19,146	24,152	19,277	10,761	23,763
Adj. R^2	0.5301	0.1925	0.5306	0.5012	0.5257	0.5326

Note: Column (1) uses the natural logarithm of innovation keyword count plus one as an alternative measure of innovation disclosure. Column (2) replaces the dependent variable with supply chain volatility (*SCV*), a non-textual measure based on year-over-year changes in top-five supplier and customer shares, to address common-source concerns. Column (3) applies two-way clustering at the firm-year level. Column (4) excludes COVID-19 years (2020–2021). Column (5) excludes high-tech firms. Column (6) excludes firms with poor information disclosure ratings (C or D). Control variables are included but not reported for brevity. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses unless otherwise noted. *** and ** indicate significance at the 1% and 5% levels, respectively.

4.4. Mechanism Tests

We now examine three potential channels through which the baseline relationship may operate. As described in Section 2, we consider three mechanisms: network diversification, collaborative innovation, and reputation and commercial credit. Table 5 reports the results.

Table 5. Mechanism analysis.

Variables	(1) *SC_Disp*	(2) *Partner_Div*	(3) *uni_inv*	(4) *uni_uti*	(5) *TC*	(6) *Reputation*
IID	11.0989 **	0.9042 *	1.5189 ***	0.6667 **	0.1274 ***	0.6305 **
	(4.7202)	(0.4716)	(0.4690)	(0.3072)	(0.0344)	(0.2907)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	23,115	8576	24,103	24,103	24,030	23,020
Adj. R^2	0.6903	0.8879	0.7004	0.6832	0.8348	0.6959

Note: Column (1): supply chain partner dispersion, measured as (1 − top 5 suppliers' procurement share) + (1 − top 5 customers' sales share). Column (2): supply chain partner ownership diversity, measured as the number of ownership types among top 5 suppliers and customers. Columns (3)–(4): collaborative innovation, measured by joint invention and utility model patent applications, respectively. Column (5): trade credit, measured as (accounts payable + notes payable)/total assets. Column (6): corporate reputation, measured as the natural logarithm of positive online news coverage plus one. Control variables are included but not reported for brevity. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.4.1. Network Diversification

Firms that depend on a small number of supply chain partners are vulnerable to severe disruption if any one of them encounters difficulties [31,35]. Conditional on the conventional search and due-diligence process through which firms identify potential

partners, innovation disclosure can help broaden the partner base at the margin by providing additional forward-looking information that prospective partners can use when evaluating cooperation opportunities. We test this in two dimensions. Column (1) regresses supply chain dispersion (*SC_Disp*, defined as the inverse of top-five supplier and customer concentration) on *IID*. The coefficient is positive and significant at the 5% level, indicating that firms with more innovation disclosure have less concentrated supply chains. Column (2) uses ownership diversity (*Partner_Div*, the number of distinct ownership types among top-five partners) as the dependent variable and finds a similar positive association. Together, these results are consistent with innovation disclosure being associated with more diversified supply chain networks in both the number and composition of partners, in line with Hypotheses 2 and 3.

4.4.2. Joint Patenting Evidence

Meaningful technological cooperation between supply chain partners requires that each side understands the other's capabilities and R&D direction well enough to identify productive areas of joint work. Innovation disclosure provides this informational foundation. When firms and their partners move from arm's-length transactions to joint R&D, shared intellectual property, and co-developed technology, both sides accumulate relationship-specific assets and face higher switching costs, which stabilizes the partnership [21]. Columns (3) and (4) test this channel using joint patent applications as a proxy for collaborative innovation. *IID* is significantly positively associated with both joint invention patents (*uni_inv*) and joint utility model patents (*uni_uti*). The effect is considerably larger for invention patents, which is intuitive: invention patents involve greater technical complexity, making external collaboration and the information that facilitates it more valuable. Joint patenting is a conservative proxy for collaborative innovation. Actual technology-based cooperation extends to joint R&D projects, technology licensing, shared testing platforms, and other activities that we do not observe. To the extent that innovation disclosure is also associated with these unmeasured forms of collaboration, our estimates likely understate the relationship. These results are consistent with Hypothesis 4.

4.4.3. Reputation and Trade Credit

The third channel works through reputation and commercial credit, which stabilize supply chain relationships in different but complementary ways. Innovation disclosure helps build a firm's reputation by signaling innovation capability, which lowers counterparties' perceived risk and provides a buffer when the firm faces temporary difficulties. It also signals favorable growth prospects to external financiers, enabling firms to strengthen their financial position and offer supply chain partners more flexible payment terms, creating financial ties that align economic interests on both sides. Column (5) shows that *IID* is significantly positively associated with commercial credit provision (*TC*), and column (6) shows a significant positive association with corporate reputation (*Reputation*). These findings are consistent with Hypotheses 5 and 6.

4.4.4. Ruling out a Generic Communication Interpretation

A natural concern about the mechanism results above is whether they reflect the specific informational content of innovation disclosure or merely a firm's general disposition to communicate with external stakeholders. Several features of our design and findings argue against a generic-communication interpretation. The firm fixed effects in our specifications absorb time-invariant communication style at the firm level, including managerial preferences for openness and persistent investor-relations practices, while the instrumental variable strategies in Section 4.2 isolate variation in *IID* that comes from external sources rather than from unobserved firm-level communication propensity. More substantively, the

joint-patenting result in Section 4.4.2 requires the kind of content-specific information that innovation disclosure conveys, and the fact that the effect is substantially larger for joint invention patents than for joint utility model patents (invention patents demand more specific technological coordination) points to a content-based rather than a communication-volume mechanism. The heterogeneity patterns in Section 4.5 reinforce the same conclusion: the effect is concentrated precisely in settings where information asymmetry about innovation is severe and where alternative content channels are limited. Together, these features make a content-based interpretation more plausible than a generic-communication one.

4.5. Heterogeneous Effects

We next ask whether the baseline effect varies across firm and industry characteristics. Table 6 reports subsample results along four dimensions.

Columns (1) and (2) split the sample by ownership. The coefficient on *IID* is significant for non-state-owned enterprises but not for state-owned enterprises. This is not surprising. State-owned firms benefit from implicit government backing and policy support that stabilize supply chain relationships regardless of what the firm discloses about its innovation activities. Non-state-owned firms lack this backstop and depend more on market-based signals to build trust with partners, so innovation disclosure carries more weight.

Columns (3) and (4) split by technology intensity. The effect is significant for high-tech firms but insignificant for non-high-tech firms. In technology-intensive industries, supply chain partners care a great deal about a firm's technological capabilities and R&D trajectory, so innovation disclosure has high informational content and is directly relevant to partnership decisions. In non-high-tech sectors, supply chain relationships are shaped more by traditional factors like price, production capacity, and delivery reliability, and innovation information matters less at the margin.

Columns (5) and (6) split by industry competition. The effect shows up in competitive industries but not in less competitive ones. When partners have many outside options, supply chain relationships are inherently more fragile, and innovation disclosure becomes more valuable as a way to differentiate the firm and retain partners. In concentrated industries, lower substitutability creates natural stickiness in relationships, so the marginal contribution of disclosure is smaller.

Columns (7) and (8) are split by digital economy classification. The effect is significant in non-digital-economy industries but insignificant in digital-economy industries. This might seem counterintuitive, but it makes sense once we consider the information environment. Firms in digital sectors already operate with rich information infrastructure, data-sharing platforms, and real-time digital channels that reduce information asymmetry between supply chain partners. The marginal value of formal disclosure through annual reports is therefore lower. In traditional industries, supply chain partners have fewer alternative ways to learn about a firm's innovation capabilities, and formal disclosure through MD&A sections plays a correspondingly larger role.

A common thread runs through all four sets of results. The effect of innovation disclosure on supply chain risk is largest in settings where information asymmetry between supply chain partners is most severe and where alternative channels for communicating innovation capabilities are most limited.

Table 6. Heterogeneity analysis.

	(1) SOE	(2) Non-SOE	(3) High-Tech	(4) Non-High-Tech	(5) Comp.	(6) Non-Comp.	(7) Digital	(8) Non-Digital
IID	−0.8026	−1.4215 ***	−1.1423 ***	−0.7978	−1.1754 ***	−0.9730	−0.6167	−1.2173 ***
	(0.6344)	(0.3744)	(0.3828)	(0.6362)	(0.3906)	(0.6876)	(0.4738)	(0.4359)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Obs.	9335	14,738	13,228	10,137	17,059	6310	3509	20,615
Adj. R^2	0.5280	0.5393	0.5553	0.5392	0.5564	0.5061	0.5698	0.5278

Note: This table reports heterogeneity analysis results. Columns (1)–(2) split the sample by state ownership. Columns (3)–(4) split by high-tech industry classification. Columns (5)–(6) split by industry competitiveness. Columns (7)–(8) split by digital economy industry classification. The dependent variable is *SCR* in all columns. Control variables are included but not reported for brevity. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses. *** indicates significance at the 1% level.

4.6. Spillover and Risk Contagion Effects

Firms linked through supply chains do not operate in isolation: one firm's disclosure behavior and risk exposure may spill over to its partners. The baseline and mechanism results above establish how innovation disclosure shapes a firm's own supply chain risk; this subsection asks whether the same information dynamics also operate at the network level by propagating between connected firms. Prior work has documented information spillovers along supply chains [41], but most of this research looks at horizontal effects within industries [20,21]. Here, we examine whether innovation disclosure and supply chain risk propagate vertically between suppliers and customers. We use supplier–customer matched data from the CNRDS database to test how one firm's innovation disclosure or supply chain risk affects its counterpart. Table 7 reports the results. Columns (1) and (2) look at how upstream suppliers' disclosure and risk affect downstream customers; columns (3) and (4) look at the reverse direction.

Table 7. Supply chain spillover and risk contagion effects.

Variables	**(1)** ***IIDC***	**(2)** ***SCRC***	**(3)** ***IIDS***	**(4)** ***SCRS***
IID	−0.0422		0.2820 ***	
	(0.0512)		(0.0502)	
SCR		0.0777 **		0.1199 ***
		(0.0384)		(0.0313)
Controls	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	778	778	1525	1525
Adj. R^2	0.8990	0.6399	0.1594	0.2480

Note: Columns (1)–(2) examine how upstream suppliers' innovation disclosure (*IID*) and supply chain risk (*SCR*) affect their downstream customers' innovation disclosure (*IIDC*) and supply chain risk (*SCRC*), respectively. Columns (3)–(4) examine how downstream customers' *IID* and *SCR* affect their upstream suppliers' innovation disclosure (*IIDS*) and supply chain risk (*SCRS*), respectively. Control variables are included but not reported for brevity. All regressions include firm and year fixed effects. Standard errors clustered at the firm level are in parentheses. *** and ** indicate significance at the 1% and 5% levels, respectively.

4.6.1. Vertical Spillovers in Innovation Disclosure

We first ask whether innovation disclosure spills over between suppliers and customers, and if so, in which direction. Column (1) regresses customers' innovation disclosure (*IIDC*) on their suppliers' disclosure (*IID*). The coefficient is insignificant: suppliers' dis-

closure does not appear to change customers' transparency. Column (3) tests the other direction, regressing suppliers' disclosure (*IIDS*) on their customers' disclosure. Here the coefficient is positive and significant at the 1% level. Downstream customers' innovation disclosure does appear to push upstream suppliers toward greater transparency. The spillover, then, runs in one direction only: from downstream to upstream. This is consistent with the typical power structure of supply chain relationships. Downstream customers usually hold stronger bargaining power and more control over partner selection, which gives their behavior an outsized influence on suppliers. When a customer raises its own disclosure standards, suppliers face pressure to follow suit, particularly if transparency becomes part of how the customer evaluates and selects its suppliers. Suppliers, by contrast, are generally in a weaker position and have less leverage over their customers' disclosure choices.

4.6.2. Bidirectional Risk Contagion

We then ask whether supply chain risk itself is contagious between connected firms. Column (2) shows that suppliers' supply chain risk (*SCR*) significantly increases their customers' risk (*SCRC*), and column (4) shows that the reverse also holds: customers' risk significantly increases their suppliers' risk (*SCRS*). Risk, unlike disclosure, travels in both directions. The downstream-to-upstream effect is noticeably larger, however, which makes intuitive sense. Suppliers are directly exposed to fluctuations in customer demand; when a customer's orders shrink or become uncertain, the supplier's revenue and cash flows are immediately affected, and there may be limited scope for finding replacement demand quickly. Customers facing upstream risk have more room to maneuver, since they can often switch to alternative suppliers.

Putting the disclosure spillover and risk contagion results together, a clear pattern emerges. Innovation disclosure flows from downstream to upstream, while supply chain risk spreads in both directions. This means that improving innovation transparency at key downstream nodes can have a multiplier effect: it directly reduces the disclosing firm's own supply chain risk, and it also encourages upstream suppliers to become more transparent, which further strengthens resilience across the network.

5. Conclusions

This paper asks whether innovation information disclosure affects firms' supply chain risk. Using data on Chinese A-share listed firms from 2012 to 2023, we find that it does: firms that disclose more about their innovation activities in their MD&A sections face a significantly lower supply chain risk. This result holds up under instrumental variable estimation, propensity score matching, entropy balancing, alternative variable definitions, alternative clustering, and the inclusion of province- and industry-specific time trend controls.

The results are consistent with the three channels proposed. Firms with more innovation disclosure have broader and more diversified supply chain networks, a pattern consistent with disclosure lowering the search costs faced by prospective partners and attracting a more diverse set of suppliers and customers. They also engage in more collaborative innovation with supply chain partners, consistent with disclosure providing an informational foundation for joint patenting and deeper technological cooperation, which would strengthen relationship specificity and raise switching costs. And they exhibit stronger reputation and commercial credit capacity, consistent with partnerships being reinforced through trust on one side and financial ties on the other. The effect is concentrated among non-SOEs, high-tech firms, firms in competitive industries, and firms outside the digital economy, consistent with innovation disclosure being most effective where informa-

tion asymmetry between supply chain partners is more severe. Moving from the firm level to the network level, we find that disclosure and risk propagate differently through supply chain networks. Disclosure spills over asymmetrically: downstream customers' disclosure prompts upstream suppliers to become more transparent, but the reverse does not hold. Supply chain risk, by contrast, is contagious in both directions, with stronger transmission from downstream to upstream.

Because our empirical setting is Chinese A-share listed firms, it is worth clarifying which of our findings are likely to travel to other contexts and which may be more context-specific. The core logic of our argument, that innovation disclosure reduces information asymmetry and thereby supports partner selection, coordination, and stability in supply chain relationships, rests on signaling theory and should apply wherever supply chains operate under information asymmetry. Our heterogeneity results offer a tentative internal benchmark, although they cannot substitute for cross-country evidence. The effect is concentrated among non-state-owned firms, in competitive industries, and outside the digital economy; that is, in subsamples that most closely resemble market-driven environments with limited alternative information channels. Whether the same patterns hold in other institutional and linguistic settings is an empirical question that internal heterogeneity alone cannot settle, and we view comparative replication in non-Chinese economies as an important direction for future research. At the same time, we acknowledge that institutional factors such as state ownership, the specific form of disclosure regulation, and the influence of industrial policy are likely to shape the magnitude of the effect and the relative salience of particular channels. For instance, the attenuation of the effect among state-owned enterprises is plausibly tied to implicit policy support that substitutes for market-based signaling, and the relative intensity of the asymmetric vertical spillover may reflect buyer–supplier power dynamics that vary across institutional settings.

Our results have four practical implications. First, firms should treat innovation disclosure as part of their supply chain management strategy and not just heir investor relations efforts. Our results show that transparent innovation disclosure reduces supply chain risk through network diversification, collaborative innovation, and stronger reputation and credit capacity. Firms would benefit from establishing systematic mechanisms to communicate technological progress, R&D plans, and intellectual property through formal channels such as MD&A sections. This is particularly relevant for non-state-owned and high-tech firms, where the risk-reducing effect of disclosure is most pronounced. In practice, coordinating disclosure efforts across supply chain management and investor relations functions allows firms to serve both capital market communication and supply chain relationship objectives at the same time.

Second, regulators should strengthen institutional arrangements for innovation disclosure, taking advantage of the multiplier effects we document at key supply chain nodes. Our finding that downstream customers' disclosure incentivizes upstream suppliers to become more transparent suggests that promoting disclosure by influential firms can improve the information environment across the entire network. One way to do this is to enhance MD&A disclosure guidelines with more structured requirements for innovation-related content, covering R&D investments, technological breakthroughs, patent portfolios, and innovation partnerships. Incentive mechanisms such as disclosure ratings and best-practice recognition can amplify the demonstration effects of core firms.

Third, policymakers should recognize the systemic nature of supply chain risk and promote collaborative risk management across firm boundaries. Our evidence of bidirectional risk contagion, with stronger transmission from downstream to upstream, implies that individual firms' risk management efforts alone are not sufficient. Governments and industry associations can facilitate this by building supply chain risk information-sharing

platforms that enable coordinated early warning, risk assessment, and emergency response among connected firms.

Fourth, collaborative innovation should be used as a binding mechanism for supply chain stability. Our finding that innovation disclosure promotes joint patenting, which in turn strengthens relationship specificity and raises switching costs, suggests that firms should incorporate technological compatibility and collaborative innovation potential into their partner selection criteria. At the policy level, governments can lower barriers to supply chain collaborative innovation through dedicated funds, fee reductions for joint patent applications, and tax incentives, all of which would help strengthen stability and resilience across the industrial chain.

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Appendix A. Supply Chain Risk Vocabulary

We select a total of 87 supply chain risk keywords, including 40 keywords for cost and commodity price risks, 28 keywords for climate and pandemic risks, and 19 keywords for market uncertainty and regional risks. The supply chain risk vocabulary is shown in Table A1.

Table A1. Supply chain risk vocabulary.

Category	Keywords
Cost and Commodity Price Risk	price risk, cost increase, cost pressure, natural resources, energy prices, oil prices, natural gas prices, exchange rate fluctuation, energy costs, inflation, tariffs, raw material prices, economic volatility, procurement costs, production costs, commodities, foreign exchange risk, procurement risk, inventory management, supply chain disruption, transportation risk, logistics disruption, demand uncertainty, quality control, supply risk, price volatility, resource shortage, logistics costs, price changes, supply capacity, quality risk, supply bottleneck, transshipment risk, price elasticity, option trading, hedging, futures contracts, risk hedging
Climate Risk and Pandemic Risk	flood, hurricane, drought, climate change, disaster, pandemic, epidemic, COVID-19, uncertainty, prevention and control, operational risk, earthquake, sustainability, carbon emissions, climate policy, carbon pricing, greenhouse gas, climate vulnerability, climate adaptation, environmental impact, environmental assessment, climate data, outbreak risk, public health, health, health security, quarantine, natural disasters
Market Uncertainty and Regional Risk	market risk, regional risk, geopolitical risk, political risk, regional policy, geoeconomics, political uncertainty, policy uncertainty, global risk, volatility, supply disruption, trade restrictions, monopoly, political change, procurement risk, logistics risk, war, terrorism

Appendix B. Innovation Keywords Vocabulary

We construct a comprehensive innovation keywords dictionary containing 230 innovation-related terms across 16 major categories. The complete vocabulary is presented in Tables A2 and A3.

Table A2. Core innovation keywords dictionary.

Category	Keywords
R&D Activities	research and development, R&D investment, R&D management, independent research, collaborative research, R&D platform, R&D capability, R&D planning, R&D progress, R&D cooperation, R&D process, R&D evaluation, R&D optimization, R&D standards
Technology Innovation	technological innovation, technical innovation, core technology, independent innovation, original technology, disruptive innovation, innovation-driven, innovation ecosystem, innovation strategy, technology strategy, technology layout, technology planning, technology roadmap, technology breakthrough, technology barriers
Intellectual Property	invention patent, utility model, design patent, patent authorization, patent portfolio, intellectual property, patent transformation, patent analysis, patent cooperation, trade secrets, copyright protection, trademark registration, intellectual property management, patent assets
Emerging Technologies	artificial intelligence, cloud computing, big data, blockchain, Internet of Things, 5G technology, 3D printing, biotechnology, gene editing, quantum computing, virtual reality, autonomous driving, robotics technology, machine learning, deep learning
Digital Technologies	digital transformation, digitalization, industrial internet, digital twin, intelligent algorithms, data governance, data assets, data security, edge computing, computing power, automation, smart manufacturing
New Energy & Green Tech	new energy technology, energy storage technology, carbon neutrality, carbon peak, clean energy, photovoltaic technology, wind power technology, hydrogen energy technology, energy saving technology, environmental protection technology, green manufacturing
Biomedical Innovation	new drug development, clinical trials, biopharmaceuticals, gene therapy, vaccine development, drug synthesis, pharmaceutical research, innovative drugs, precision medicine
Advanced Manufacturing	intelligent manufacturing, precision manufacturing, flexible manufacturing, automated production, capacity enhancement, yield improvement, process improvement, quality control, lean production

Table A3. Core innovation keywords dictionary—continued.

Category	Keywords
New Materials	new materials, composite materials, nanomaterials, biomaterials, smart materials, functional materials, high-performance materials, advanced materials
Semiconductor Technology	chip technology, semiconductor, integrated circuits, microelectronics, power devices, display technology, OLED technology, communication chips
Innovation Management	innovation management, technology management, knowledge management, lean production, agile development, quality system, standardization, process reengineering, digital management
Innovation Infrastructure	laboratory, R&D center, technology center, innovation center, incubator, accelerator, science park, testing platform, pilot platform, shared platform
Innovation Talents	technical team, R&D team, innovation team, expert team, chief scientist, technical director, engineers, technical talents, talent development, talent introduction

Table A3. *Cont.*

Category	Keywords
Innovation Finance	technology investment, R&D investment, innovation fund, technology finance, intellectual property financing, technology valuation, venture capital, angel investment
Technology Standards	technology standards, industry standards, national standards, international standards, technical specifications, technology roadmap, technology assessment, technology certification
Innovation Risks	technology risk, R&D risk, innovation risk, patent risk, infringement risk, technology security, technical compliance

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