

The Impact of Supply Chain Resilience on Corporate Green Innovation: Evidence from Chinese A-Share Listed Firms

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Abstract. Against a backdrop of frequent external shocks and an accelerating green transition, this study examines whether supply chain resilience improves firms' current green innovation. Using 2004-2024 panel data for Chinese A-share listed firms, we construct supply chain resilience as the sum of entropy-weighted resistance and recovery indices. Two-way fixed-effects estimates show that all three measures significantly increase green patent applications. The findings remain robust to leave-one-out industry-year instrumental-variable estimation, alternative samples, expanded controls, and an alternative resilience measure. Mechanism tests indicate that resilience supports green R&D by easing financing constraints and reducing agency costs, while corporate reputation and ownership concentration improve the conversion of resilience resources into innovation. The effect differs across listing boards, ownership types, and factor intensities: it is stronger for non-GEM, state-owned, and labor-intensive firms, but becomes negative for GEM firms. Supply chain resilience is therefore not merely an operational safeguard; it is also an organizational capability that sustains green innovation. The evidence provides a firm-level basis for jointly advancing supply chain security and green transformation.

Keywords: supply chain resilience, supply chain resistance, supply chain recovery, green innovation, financing constraints

1. Introduction

Green innovation supports decarbonization and long-term competitiveness, but its knowledge and environmental spillovers leave firms bearing substantial costs and failure risks. Its long cycle and uncertain return make it unusually dependent on stable financing, materials, production, and interfirm knowledge coordination [1-3]. Trade frictions, public-health emergencies, extreme weather, and geopolitical disruptions can interrupt supply and crowd out long-horizon green R&D.

Supply chain resilience is a firm's capacity to resist shocks and restore operations. Prior studies describe secure networks, preparedness-response-recovery processes, and the matching of vulnerabilities with capabilities [4-7]. Chinese firm-level research separates resistance from recovery and combines observable indicators by entropy weighting [8]. Although data assets, technology-finance policies, collaborative innovation, and green technology strengthen resilience [9-12], its consequences for green innovation remain underexamined.

Resistance can limit the immediate disruption of materials, working capital, and production, whereas recovery can shorten deviations from normal operations. Together they stabilize resource allocation, reduce the probability that short-term risk compresses green R&D, and facilitate the transmission of green demand, process knowledge, and environmental standards. Related evidence shows that supply chain ESG consistency, network position, transparency, finance, and low-carbon policies all affect green innovation [13-18]. This makes supply chain capability a plausible antecedent of firms' current green innovation.

Using 2004-2024 panel data for Chinese A-share listed firms, this study estimates the effects of resilience, resistance, and recovery on current green innovation and conducts endogeneity, robustness, mechanism, and heterogeneity tests. It shifts attention from the antecedents of resilience to its innovation consequences, distinguishes resistance from recovery, and identifies financing, governance, and firm-type boundary conditions.

2. Literature review

2.1. Concept, measurement, and determinants of supply chain resilience

Early studies conceptualized resilience through continuity and restoration [4], network redesign and risk visibility [5], preparedness-response-recovery processes [6], and capability-vulnerability alignment [7]. Resilience therefore requires coordinated preparation, adaptation, and recovery rather than simple redundancy.

At the firm level, Zhang and Gu measure resistance using inverse fund occupation and customer stability, and recovery using inverse supply-demand deviation and operating restoration; entropy weighting combines the two [8]. Later studies link data assets, technology finance, collaborative innovation, and green technology to resilience [9-12], but say less about resilience-generated outcomes.

2.2. Determinants of corporate green innovation

Because firms cannot fully appropriate environmental benefits, green innovation is sensitive to financing, regulation, and governance. The Porter hypothesis emphasizes innovation compensation under suitable regulation [2], while financing research highlights long-term R&D funding [3]. Recent Chinese evidence also identifies big-data pilots, artificial intelligence, and patient capital as important conditions [19-21].

Supply-chain conditions also matter: ESG consistency can promote green innovation [13, 14]; network position shapes resource access [15]; transparency builds legitimacy and trust [16]; supply-chain finance works through financing and peer effects [17]; and low-carbon policies propagate through supply chains [18]. Green innovation is therefore embedded in upstream-downstream networks.

2.3. Research hypotheses

Existing research rarely tests how a firm's own supply chain resilience affects current green innovation; studies of the reverse effect [22, 23] cannot answer this capability-based question. Resistance should stabilize materials, orders, and cash flow, while recovery should shorten disruptions and restart long-term R&D and patenting.

H1: Supply chain resilience significantly promotes corporate green innovation.

H1a: Supply chain resistance significantly promotes corporate green innovation.

H1b: Supply chain recovery significantly promotes corporate green innovation.

Green R&D requires persistent investment and is often cut first when financing tightens. Stable supply, orders, and collections improve expected cash flow and can ease external financing pressure. Resilience building also requires information integration, process clarification, and accountability, which may reduce inefficient administrative spending and agency losses. Lower financing constraints and agency costs leave more resources available for long-horizon green projects.

H2a: Financing constraints transmit the effect of supply chain resilience to green innovation; higher resilience eases those constraints.

H2b: Agency costs provide a second transmission channel; higher resilience reduces agency costs.

Operational stability does not automatically become innovation output. Strong reputation reduces supplier and financier uncertainty about long-term commitments, while concentrated ownership can strengthen monitoring of long-horizon projects. When external trust or internal oversight is weak, redundancy, inventory buffers, and relationship maintenance may initially absorb scarce resources. Reputation and ownership concentration should therefore determine whether resilience resources move from protecting delivery toward supporting innovation.

H3a: Corporate reputation strengthens the positive effect of supply chain resilience on green innovation.

H3b: Ownership concentration strengthens the positive effect of supply chain resilience on green innovation.

3. Research design

3.1. Sample and data

The study uses a 2004-2024 firm-year panel of Chinese A-share listed companies. It excludes financial and real-estate firms, ST and *ST firms, observations missing core variables or controls, and duplicates; winsorizes continuous variables at the 1st and 99th percentiles; and retains an unbalanced panel. Singleton observations are removed in fixed-effects estimation. The common baseline sample contains 41,472 firm-year observations from 4,354 firms.

Green patent applications come from CNRDS; reputation comes from the China Financial News Database; and financial, governance, ownership, and listing-board data come mainly from CSMAR and annual reports. Resilience follows Zhang and Gu [8], and factor intensity follows CSRC codes and Yin et al. [24]. Sources are merged by stock code and year.

3.2. Variable definitions

Dependent variable. Corporate green innovation (GI) is $\ln(1 + \text{current green invention and utility-model patent applications})$. Applications are used because they are closer to current innovation decisions than grants.

Core explanatory variables. Following Zhang and Gu [8], resistance (Resis) combines inverse fund occupation and customer stability, while recovery (Recov) combines inverse supply-demand deviation and operating restoration. Entropy weighting produces each index, and SCR equals Resis plus Recov.

Controls. Baseline models include leverage, cash flow, independent-director ratio, board size, CEO-chair duality, managerial ownership, and asset turnover; robustness tests add ownership

concentration and asset growth.

Other variables. SCR2 is $\ln(\text{inventory turnover})$ [25]. FC is the estimated probability of financing constraints based on firm characteristics [26]; AC is administrative expenses divided by operating revenue [27]; and Reputation is $\ln(1 + \text{positive online and newspaper reports})$.

Table 1. Main variable definitions

Variable type	Symbol	Variable name	Measurement
Dependent variable	GI	Corporate green innovation	$\ln(1 + \text{green invention applications} + \text{green utility-model applications})$
Core explanatory variable	SCR	Supply chain resilience	Sum of supply chain resistance and recovery
Core explanatory variable	Resis	Supply chain resistance	Entropy-weighted index of inverse fund occupation and customer stability
Core explanatory variable	Recov	Supply chain recovery	Entropy-weighted index of inverse supply-demand deviation and performance recovery
Controls	Lev	Leverage	Total liabilities / total assets
Controls	CF	Operating cash flow	Net operating cash flow / beginning total assets
Controls	Indep	Independent-director ratio	Independent directors / board members (%)
Controls	Board	Board size	$\ln(1 + \text{number of directors})$
Controls	Dual	CEO-chair duality	1 if the chair also serves as CEO; 0 otherwise
Controls	Mshare	Managerial ownership	Management-held shares / total shares
Controls	ATO	Total asset turnover	Operating revenue / ending total assets
Additional control	Top1	Ownership concentration	Shareholding of the largest shareholder
Additional control	Growth	Total asset growth	$(\text{Ending assets} - \text{lagged ending assets}) / \text{lagged ending assets}$
Alternative explanatory variable	SCR2	Inventory-turnover resilience	$\ln(\text{cost of goods sold} / \text{average net inventory})$
Mechanism variable	FC	Financing constraints	Estimated probability of financing constraints based on firm characteristics
Mechanism variable	AC	Agency costs	Administrative expenses / operating revenue
Moderator	Reputation	Corporate reputation	$\ln(1 + \text{original positive online and newspaper reports})$
Moderator	Top1	Ownership concentration	Shareholding of the largest shareholder

Note: Continuous variables are winsorized at the 1st and 99th percentiles. Resis and Recov are entropy-weighted composites of their underlying indicators, and SCR = Resis + Recov.

3.3. Model specification

To test the effect of supply chain resilience on current green innovation, we estimate the following firm and year two-way fixed-effects model:

$$GL_{it} = \alpha + \beta Core_{it} + \gamma Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Core denotes SCR, Resis, or Recov; Controls is the firm-level control vector; and firm and year fixed effects absorb time-invariant heterogeneity and common shocks. Standard errors are clustered by industry-year to reflect shared supply, demand, and regulatory shocks.

3.4. Descriptive statistics

Table 2. Descriptive statistics

Variable	Observations	Mean	Std. dev.	Minimum	Median	Maximum
GI	41,472	0.763	1.100	0.000	0.000	4.357
SCR	41,472	0.323	0.347	0.007	0.146	0.976
Resis	41,472	0.230	0.337	0.002	0.014	0.903
Recov	41,472	0.093	0.051	0.005	0.073	0.176
Lev	41,472	0.439	0.198	0.057	0.438	0.908
CF	41,472	0.056	0.077	-0.170	0.052	0.296
Indep	41,472	37.289	5.365	0.000	33.330	57.140
Board	41,472	2.246	0.181	1.792	2.303	2.773
Dual	41,472	0.267	0.442	0.000	0.000	1.000
Mshare	41,472	11.159	17.705	0.000	0.211	67.189
ATO	41,472	0.632	0.428	0.077	0.533	2.544

Note: Statistics use the common effective sample of the six baseline regressions. Continuous variables are winsorized at 1%, and statistics are reported to three decimal places.

GI has a mean of 0.763 and a median of zero, indicating substantial right skew. SCR averages 0.323 with a standard deviation of 0.347; Resis is more dispersed than Recov and contributes more to cross-sectional variation.

4. Empirical results

4.1. Baseline regressions

Table 3. Baseline results for supply chain resilience and corporate green innovation

Variable	Without controls			With 7 controls		
	(1)SCR	(2)Resis	(3)Recov	(4)SCR	(5)Resis	(6)Recov
SCR	0.027** (0.013)			0.027** (0.013)		
Resis		0.027** (0.013)			0.027** (0.013)	
Recov			1.332*(0.751)			1.453***(0.736)
Controls	No	No	No	Yes	Yes	Yes

Table 3. (continued)

Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	41,472	41,472	41,472	41,472	41,472	41,472
R-squared	0.679	0.679	0.679	0.680	0.680	0.680
Within R-squared	0.000	0.000	0.000	0.005	0.005	0.005

Note: Parentheses contain standard errors clustered by industry-year. All models include firm and year fixed effects. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Without controls, SCR and Resis both equal 0.027 and are significant at 5%, while Recov equals 1.332 and is significant at 10%. With seven controls, the coefficients are 0.027, 0.027, and 1.453, all significant at 5%, supporting H1, H1a, and H1b. A one-standard-deviation increase in SCR raises GI by about 0.009 log points, approximately 0.94% more green patent applications or 1.23% of mean GI.

Resistance protects working capital and input supply; recovery accelerates supplier reconfiguration and production restoration. Because their scales differ, their coefficient magnitudes are not directly comparable.

4.2. Endogeneity test

Reverse causality and time-varying omitted factors may remain after fixed effects. We therefore instrument each resilience measure with its leave-one-out industry-year peer mean and require at least three consecutive valid observations.

Industry peers share material markets, logistics technologies, and risks, making the peer mean relevant; excluding the focal firm removes mechanical correlation. The exclusion restriction assumes that peer resilience affects the focal firm's green innovation mainly through its own resilience. Industry shocks may still matter, so IV evidence is treated as complementary.

Table 4. Instrumental-variable results

Variable	First stage			Second stage		
	SCR	Resis	Recov	SCR	Resis	Recov
Industry-year IV (SCR)	0.194*** (0.037)					
Industry-year IV (Resis)		0.194*** (0.037)				
Industry-year IV (Recov)			0.479*** (0.050)			
SCR				1.039* (0.579)		
Resis					1.006* (0.575)	

Table 4. (continued)

Recov						14.290** (5.617)
Kleibergen-Paap rk Wald F				27.510	27.410	91.050
Durbin-Wu-Hausman p-value				0.063	0.072	0.031
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm/year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,274	40,274	40,274	40,274	40,274	40,274

Note: The instrument is the leave-one-out industry-year mean of the corresponding resilience measure. Parentheses contain industry-year clustered standard errors. *, **, and *** indicate significance at the 10%, 5%, and 1% levels.

All first-stage coefficients are significant at 1%, and Kleibergen-Paap rk Wald F statistics of 27.510, 27.410, and 91.050 exceed 10. Durbin-Wu-Hausman p-values are 0.063, 0.072, and 0.031. In the second stage, SCR and Resis are positive at 10% and Recov at 5%, consistent in direction with the baseline results.

4.3. Robustness tests

Four tests assess robustness: retaining firms with at least three consecutive observations; excluding 2015-2016 from that sample to remove abnormal stock-market volatility; expanding the controls from seven to nine; and replacing SCR with the inventory-turnover-based SCR2 measure [25].

Table 5. Robustness-test results

Variable	Firms observed for 3+ consecutive years			Excluding 2015–2016; 3+ consecutive years			9 controls			Alternative explanatory variable
	SCR	Resis	Recov	SCR	Resis	Recov	SCR	Resis	Recov	SCR2
SCR	0.027** (0.013)			0.031** (0.014)			0.028** (0.013)			
Resis		0.027** (0.013)			0.031** (0.014)			0.028** (0.013)		
Recov			1.508** (0.736)			1.520* (0.793)			1.405* (0.738)	
SCR2										0.037*** (0.013)
Controls	7	7	7	7	7	7	9	9	9	7
Firm/year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5. (continued)

Observations	40,362	40,362	40,362	36,654	36,654	36,654	41,472	41,472	41,472	41,049
R-squared	0.676	0.676	0.676	0.680	0.680	0.680	0.680	0.680	0.680	0.681

Note: Parentheses contain industry-year clustered standard errors. The alternative-variable test replaces only SCR with SCR2; all other settings remain unchanged. *, **, and *** indicate significance at the 10%, 5%, and 1% levels.

SCR, Resis, and Recov remain positive and significant at 5% in the three-year sample. After excluding 2015-2016, SCR and Resis remain significant at 5% and Recov at 10%. With nine controls, all three remain significant at least at 10%. SCR2 has a coefficient of 0.037 and is significant at 1%. The conclusion is therefore insensitive to panel continuity, exceptional years, the control set, or the resilience measure.

4.4. Mechanism tests

4.4.1. Transmission through financing constraints and agency costs

The channel analysis reports the total effect, SCR's effect on each channel, and the GI equation including SCR and the channel. Following Jiang [28], these regressions are interpreted as mechanism rather than definitive causal mediation evidence.

Table 6. Mechanism tests
Panel A: Transmission-channel regressions

Variable	(1)	(2)	(3)	(4)	(5)
	GI: SCR	FC: SCR -> FC	GI: SCR + FC	AC: SCR -> AC	GI: SCR + AC
SCR	0.027** (0.013)	-0.008*** (0.003)	0.022* (0.014)	-0.002** (0.001)	0.025* (0.013)
FC			-0.566*** (0.042)		
AC					-0.837*** (0.086)
Controls	Yes	Yes	Yes	Yes	Yes
Firm/year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	41,472	41,472	41,472	41,469	41,469
Clusters	351	351	351	351	351
R-squared	0.680	0.817	0.684	0.683	0.681

Panel B: Indirect effects and Sobel tests

Channel variable	Path a	Path b	Total effect	Direct effect	Indirect effect	Sobel Z	p-value	Conclusion
FC	-0.008***	-0.566***	0.027**	0.022*	0.005	2.708	0.007	Significant at 1%
AC	-0.002**	-0.837***	0.027**	0.025*	0.002	2.288	0.022	Significant at 5%

Note: FC denotes financing constraints and AC denotes agency costs. The indirect effect equals path a x path b; Sobel Z tests the product term [29]. Parentheses contain industry-year clustered standard errors in Panel A. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

SCR reduces FC, and FC suppresses GI, producing a 0.005 indirect effect significant at 1% by the Sobel test. SCR also lowers AC; its 0.002 indirect effect is significant at 5%. The direct effect remains positive at 10%, supporting H2a-H2b and partial transmission through financing and agency costs.

4.4.2. Moderation by corporate reputation and ownership concentration

Moderators are lagged one year, and SCR and each moderator are standardized. For each moderator, the first model includes SCR, the moderator, and controls; the second adds their interaction. Reputation and monitoring should improve the conversion of resilience resources into green R&D.

Table 7. Moderating effects and simple slopes
Panel A: Moderating-effect regressions

Variable	(1)	(2)	(3)	(4)
	Reputation	Reputation×SCR	Top1	Top1×SCR
SCR	0.015***(0.005)	0.008(0.006)	0.013***(0.006)	0.016****(0.005)
Moderator (lagged one year)	0.100****(0.010)	0.103****(0.010)	-0.001(0.011)	0.005(0.011)
SCR x moderator		0.049****(0.008)		0.036****(0.005)
Controls	Yes	Yes	Yes	Yes
Firm/year fixed effects	Yes	Yes	Yes	Yes
Observations	33,339	33,339	34,576	34,576
Clusters	329	329	331	331
R-squared	0.701	0.702	0.696	0.696

Panel B: Simple slopes

Moderator	Low (-1 SD)	Mean	High (+1 SD)
Reputation	-0.042****(0.010)	0.008(0.006)	0.057****(0.010)
Top1	-0.020****(0.006)	0.016****(0.005)	0.053****(0.009)

Note: Moderators are lagged one year and standardized. Reputation is $\ln(1 + \text{positive media reports})$, and Top1 is the largest shareholder's ownership. Simple slopes are evaluated at -1, 0, and +1 SD. Parentheses contain industry-year clustered standard errors in Panel A and standard errors in Panel B. *, **, and *** denote significance at the 10%, 5%, and 1% levels.

The Reputation x SCR and Top1 x SCR coefficients are 0.049 and 0.036, both significant at 1%. SCR slopes are negative at low Reputation (-0.042) and low Top1 (-0.020), but positive at high values (0.057 and 0.053). This sign reversal supports the resource-conversion logic and H3a-H3b.

4.5. Heterogeneity analysis

Heterogeneity is examined by listing board, ownership, and factor intensity. Resilience resources may compete with green R&D in cash-constrained GEM firms; SOEs may benefit from financing and supply advantages; and material- and delivery-dependent labor-intensive firms may obtain a larger buffering value.

Table 8. Heterogeneity tests

Variable	Listing board		Ownership		Factor intensity		
	Non-GEM	GEM	Non-SOEs	SOEs	Technology-intensive	Capital-intensive	Labor-intensive
SCR	0.063*** (0.014)	-0.085*** (0.027)	0.013 (0.014)	0.093*** (0.025)	-0.003(0.030)	0.029(0.026)	0.093*** (0.028)
Constant	-0.020 (0.105)	0.064 (0.265)	-0.163 (0.109)	0.164 (0.156)	0.298** (0.137)	-0.022 (0.230)	-0.262 (0.170)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm/year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	34,641	6,831	25,139	16,223	14,605	6,723	11,687
R-squared	0.677	0.702	0.680	0.710	0.726	0.647	0.657
Between-group difference	GEM - non-GEM: -0.149*** (p<0.001)		SOE - non-SOE: 0.080** (p=0.010)		Labor - technology: 0.097** (p=0.036)		

Note: Parentheses contain industry-year clustered standard errors. Coefficient differences are tested in fully interacted pooled regressions, allowing control slopes and firm and year fixed effects to vary by group. *, **, and *** indicate significance at the 10%, 5%, and 1% levels.

SCR is 0.063 for non-GEM firms and -0.085 for GEM firms, both significant at 1%; the -0.149 difference has p<0.001. The GEM result is consistent with short-run resource competition when resilience lacks matching long-term capital, not with an inherent innovation penalty.

SCR is 0.093 and significant at 1% for SOEs but 0.013 and insignificant for non-SOEs; the 0.080 difference is significant at 5% (p=0.010). Financing, supply guarantees, and policy coordination may help SOEs channel resilience into long-term green projects.

SCR is 0.093 and significant at 1% for labor-intensive firms but insignificant for technology- and capital-intensive firms. The labor-technology difference is 0.097 and significant at 5% (p=0.036), consistent with a larger buffering value where continuous material supply and delivery are critical.

5. Conclusion

5.1. Main findings

Supply chain resilience, resistance, and recovery all increase firms' current green innovation after firm and year fixed effects and seven controls. The one-standard-deviation effect is modest annually

but can accumulate by protecting continuous R&D. IV and robustness tests reduce concerns about reverse causality, sample selection, exceptional years, control choice, and measurement.

Financing constraints and agency costs are observable channels, while reputation and ownership concentration improve resource conversion. Negative slopes among low-reputation, low-concentration, and GEM firms indicate short-run competition for scarce resources rather than a universal innovation penalty.

5.2. Policy implications

Firms should manage resistance and recovery separately within green R&D budgets, monitoring receivable occupation, customer stability, alternative suppliers, material substitution, and restoration time. Persistent information sharing, joint development, flexible contracts, and ring-fenced green R&D budgets are more useful than one-off inventory accumulation.

Financial institutions can incorporate contract continuity, customer stability, and recovery time into credit assessment and align green credit or supply-chain finance with R&D cycles. Guarantees, intellectual-property pledges, and staged lending are especially relevant for non-SOEs and GEM firms.

Governance and disclosure should cover supplier substitutability, recovery time, green procurement, and joint R&D. Low-reputation firms need ring-fenced funds and milestone reviews; boards and large shareholders should jointly monitor supply recovery and green-project progress. Policy should support digital coordination for GEM firms, long-term funding for non-SOEs, and green supply-chain upgrading in labor-intensive firms.

5.3. Limitations and future research

Four limitations remain. Public data miss hidden supplier links and real-time delivery; the peer-mean instrument depends on an exclusion restriction; patent applications capture quantity more than quality; and the mechanism tests show channels rather than definitive causal mediation. Network data, external shocks, patent citations, and dynamic designs can address these limitations.

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