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Mechanisms Through Which Supply Chain Vertical Integration Improves Corporate Debt Financing Costs: A Multi-Case Study of BYD, NIO and XPeng

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Abstract

Against the backdrop of volatile global raw material prices and supply chain restructuring, the new energy vehicle (NEV) industry exhibits two coexisting modes of supply chain organization, namely vertical integration on the one hand and external procurement or contract manufacturing on the other. Taking BYD as the focal case and NIO and XPeng as comparative cases, and drawing on the three companies' public annual reports, bond offering circulars, credit rating reports and ESG reports for 2020 to 2025, this paper investigates through which channels supply chain vertical integration affects corporate debt financing costs. The analysis proceeds along the transaction cost line and the information disclosure line, and examines under what conditions digitalization, institutional complexity and ESG performance strengthen or weaken this process. The findings are interpreted on the basis of transaction cost theory and information asymmetry theory, and the divergence in measurement arising from accounting-based indicators of debt cost is clarified.

Keywords: Supply Chain Vertical Integration; Debt Financing Cost; Transaction Costs; Information Asymmetry; Information Disclosure Quality; ESG Performance

1. Introduction

Inter-firm collaboration along the supply chain has replaced competition among individual firms as the dominant mode of industrial organization (Cull and Xu, 2005). The NEV industry is emblematic in this respect. On the one hand, the price and supply stability of core components such as traction batteries and IGBTs directly determine the cost and delivery capability of vehicle manufacturers; on the other hand, the industry is simultaneously exposed to institutional shocks arising from the phasing out of purchase subsidies, the dual-credit scheme, international trade barriers and local protectionism. Against this background, the supply chain organization of firms

has diverged markedly. Vehicle makers represented by BYD have extended upstream and built a highly vertically integrated system covering complete vehicles, the three-electric systems and semiconductors, whereas new-generation carmakers represented by NIO and XPeng mainly rely on external procurement of core components, with vehicle assembly carried out in self-built plants or, at an early stage, outsourced to contract manufacturers.

Existing theory suggests two traceable lines of inquiry. The first is the transaction cost line. Integration places search, bargaining, contract enforcement and quality control within firm boundaries, which in theory alters the cost structure, makes it possible for operating liabilities to substitute for part of interest-bearing debt, and reshapes the firm's dependence on debt financing. The second is the information line. Integrated firms can use internal data penetration to raise the verifiability of their supply chains, in principle reducing the information asymmetry between creditors and the firm (Akerlof, 1970), thereby improving disclosure quality and lowering the cost of debt (Sengupta, 1998). In addition, supply chain digitalization, institutional complexity and ESG performance may determine whether these two lines can operate; this paper treats them as boundary conditions.

Existing research nevertheless suffers from three shortcomings. First, the mechanism remains opaque. Most studies establish only a macro-level association between supply chain management and financing outcomes and lack a systematic framework linking transaction costs, trade credit and interest-bearing debt pricing. Second, industry context is under-specified. Industry is treated as a generic variable rather than comparing the differentiated consequences of different supply chain models within the same industry. Third, measurement bias has not been adequately uncovered. The accounting-based ratio of interest expense to average interest-bearing debt is distorted by interest capitalization, convertible instruments and denominator inflation, which may reverse the conclusion. This paper responds to these gaps with three typical firms in the NEV industry.

The marginal contributions of this paper are threefold. First, it proposes and tests a three-layer transmission structure running from transaction costs through trade credit to interest-bearing debt pricing. Second, it uses the public data of the three companies to expose systematic measurement bias in accounting-based indicators of debt financing cost. Third, it provides a traceable and auditable data handling protocol for the application of case study methods at the intersection of supply chain finance and corporate finance.

2. Literature Review

2.1. Research on the Economic Consequences of Supply Chain Vertical Integration

2.1.1. Vertical Integration from a Transaction Cost Perspective

Transaction cost economics holds that firm boundaries are determined by the trade-off between market transaction costs and internal organization costs. Coase (1937) argues that the firm is a substitute for the price mechanism. Williamson (1979) further explains vertical integration in terms of asset specificity, uncertainty and transaction frequency: when asset specificity and transaction frequency are high and uncertainty is strong, the governance cost of market contracting rises and

integration becomes the superior governance structure. Klein, Crawford and Alchian (1978) introduce the notion of appropriable quasi-rents and argue that integration mitigates the hold-up problem after contracting. Monteverde and Teece (1982) draw on quasi-vertical integration to explain the allocation of quasi-rents in relationship-specific investment. From the perspective of incomplete contracts and residual control rights, Grossman and Hart (1986) and Hart and Moore (1990) show that vertical integration affects ex ante investment incentives by reallocating control rights.

2.1.2. Incomplete Contracts, Asset Specificity and Vertical Boundaries

At the empirical level, Fan and Lang (2000) measure the degree of vertical integration using input-output tables and main-business concentration. Acemoglu, Johnson and Mitton (2009) find that the level of financial development and contracting costs are important determinants of vertical integration. Using data on Chinese manufacturing firms, Du, Lu and Tao (2012) show that the weaker the contracting institutional environment, the more likely firms are to adopt vertical integration. These studies provide the basis for positioning the degree of integration of the case firms examined in this paper.

2.1.3. The Risk-Mitigation and Information Effects of Supply Chain Digitalization

With the development of Industry 4.0 technologies, blockchain, the Internet of Things and big data analytics have become important instruments for supply chain risk management. Chod et al. (2020) demonstrate that supply chain transparency and blockchain adoption generate financing benefits. Cui, Gaur and Liu (2024) discuss the relationship between supply chain transparency and blockchain design. Sun et al. (2022) and Majeed and Yan (2021) verify the effects of digital transformation and of financial statement comparability on corporate debt financing costs, respectively. Digitalization reduces information asymmetry by improving supply chain traceability and constitutes an important technological foundation for the information disclosure quality mediator employed in this paper.

2.2. Research on the Determinants of Debt Financing Cost

2.2.1. Information Asymmetry and Debt Financing Cost

Akerlof (1970) shows in his theory of the market for lemons that information asymmetry leads to market failure. Jensen and Meckling (1976) and Myers and Majluf (1984) show, from the perspectives of agency costs and pecking order respectively, that information asymmetry raises the cost of external financing. In debt markets, Diamond (1985) discusses the optimal information release strategy of firms, Diamond and Verrecchia (1991) show that disclosure improves liquidity and lowers the cost of capital, and Easley and O'Hara (2004) argue from an information-structure perspective that information risk affects the cost of capital. In the accounting literature, Sengupta (1998) finds that disclosure quality is negatively related to the cost of debt; Botosan (1997) and Botosan and Plumlee (2002) provide classic evidence on the relation between disclosure level and the cost of equity capital; Verrecchia (1983, 2001), Healy and Palepu (2001), Core (2001), Kim and Verrecchia (2001), Lang and Lundholm (1993) and Hail and Leuz (2006) together form the research foundation for the relation between information disclosure and the cost of capital.

2.2.2. The Mediating Role of Information Disclosure Quality and Transaction Costs

Francis et al. (2004) and Dechow and Dichev (2002) show, from the perspectives of earnings attributes and accrual quality, that information quality affects capital pricing. Graham, Harvey and Rajgopal (2005) survey the economic implications of corporate financial reporting. Armstrong, Guay and Weber (2010) systematically discuss the role of information in debt contracting and corporate governance. Bonsall and Miller (2017) show directly that the readability of narrative disclosure in annual reports affects bond ratings and the cost of debt. This paper therefore traces information disclosure quality and transaction costs as the two intermediate links through which integration acts upon debt financing conditions.

2.3. Research on the Relationship Between Supply Chain Management and Debt Financing Cost

2.3.1. Supply Chain Concentration, Trade Credit and Financing Pricing

Supply chain structure directly affects the financing conditions of firms. Chod et al. (2020) and Cui, Gaur and Liu (2024) show that improvements in supply chain transparency reduce financing costs. Yang et al. (2021) verify, using data on Chinese firms, that ESG disclosure affects the credit spreads of corporate bonds. Lian et al. (2023) and Li, Chen and Xiang (2021) examine the effects of ESG performance and of social responsibility and green finance policies on debt financing costs, respectively. These studies suggest that supply chain management can substitute accounts payable for interest-bearing debt and thereby change the structure of debt financing costs.

2.3.2. The Path Roles of Institutional Complexity and ESG Performance

With respect to institutional complexity, Cull and Xu (2005) illustrate the interaction between institutions and the financial environment, while industry policy shocks, such as subsidy phase-out, the dual-credit scheme and trade barriers, affect financing pricing by altering cost and demand expectations. With respect to ESG performance, Dhaliwal et al. (2011), El Ghoul et al. (2011), Goss and Roberts (2011), Cheng, Ioannou and Serafeim (2014), Chava (2014), Servaes and Tamayo (2013) and Flammer (2015) report that ESG and CSR are negatively related to the cost of capital; Bolton and Kacperczyk (2021) focus on the pricing of carbon risk; Christensen, Serafeim and Sikochi (2022) and Berg, Kölbel and Rigobon (2022) reveal severe divergence among ESG ratings and show that such divergence weakens the stability of the effect through which ESG lowers the cost of capital. This paper draws on these sources for its two paths, namely institutional complexity and ESG performance.

2.4. Research Gaps and Contributions of this Paper

Existing research provides a theoretical basis for the study of supply chain management and debt financing costs, but three key gaps remain. First, the intermediate process has not been opened up. Most studies stop at the judgement that the two are related and lack a coherent account of the intervening links. Second, comparison within industries is insufficient. Existing studies mostly treat industry as a background condition and rarely compare the consequences of different supply chain models within the same industry. Third, the divergence in measurement has not been clarified. The research emphasis has fallen on the pricing side of debt, with little discussion of how accounting-

based indicators distorted by interest capitalization and financial instruments may produce the opposite answer. Taking three typical firms as case units and drawing on publicly available archival materials, this paper responds to these gaps by characterizing the divergence in debt financing conditions across different models and clarifying the divergence in measurement.

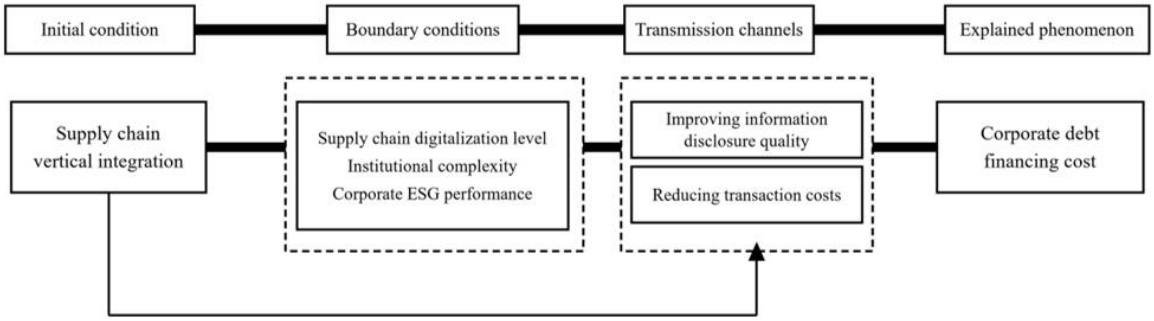


Figure 1. Conceptual Model

3. Case Analysis

3.1. Vertical Integration Case: BYD

3.1.1. Strategic Background and Integration Path

BYD is a typical representative of vertical integration in China's NEV industry and has built a full-industry-chain system covering complete vehicles, traction batteries, automotive-grade semiconductors (IGBTs), motors and electronic controls. The credit rating report issued by China Chengxin International notes the following: compared with peers, the company is more focused on new energy vehicles and enjoys greater advantages in vehicle sales and industrial chain integration; the company maintains a very high in-house production rate for core components, and its technological level in traction batteries, IGBTs and other components is advanced, which helps it control costs and safeguard supply chain stability; and core components such as engines and batteries are fully self-supplied.

3.1.2. Path One: Supply Chain Digitalization and Information Disclosure Quality

BYD achieves four-tier data penetration in its supply chain through the CAMDS system and conducts product carbon footprint accounting through the i-D Carbon Chain platform, in compliance with ISO 14064 and ISO 14067. Internal data penetration renders the cost, inventory and quality information of core components traceable, thereby reducing the information asymmetry between creditors and the firm with respect to supply chain stability, which corresponds to the information environment improvement mechanism identified by Easley and O'Hara (2004) and Verrecchia (2001). The improvement in the quality of information disclosure brought about by digitalization constitutes one piece of supporting evidence for this link.

3.1.3. Path Two: Coping with Institutional Complexity

The NEV industry faces a series of institutional shocks, including the phase-out of purchase subsidies, dual-credit assessment, European Union countervailing duties, the foreign entity of concern (FEOC) rules under the US Inflation Reduction Act, and the development of a unified

national market. Vertical integration helps secure stable unit prices and supply volumes of raw materials, thereby buffering external price volatility. In 2025, BYD's overseas revenue amounted to RMB 310,740,988 thousand, accounting for 38.65% of operating revenue, which indicates that the company is simultaneously exposed to international trade barriers. On 29 October 2024, the European Commission issued its definitive countervailing duty ruling on electric vehicles from China, with BYD subject to a countervailing duty rate of 17.0% (EC IP/24/5589), levied from 31 October 2024 for a period of five years. Through internal transfer pricing and self-supply buffering, the integrated model reduces the immediate transmission of institutional and price shocks to the cost side.

3.1.4. Path Three: ESG Performance

China Chengxin International includes an ESG analysis section in its rating report, yet the model notes state explicitly that the adjustment item for the current status has no significant impact on the company's base credit rating. With respect to external ratings, BYD attained an MSCI ESG rating of AA and a Wind ESG rating of AAA in 2025, together with an EcoVadis Silver Medal and an S&P CSA score of 60. With respect to greenhouse gas accounting, BYD's 2025 ESG report discloses Scope 3 emissions of 140,014,002.65 tCO2e across nine categories, of which the use of sold products amounts to 89,500,953.79 tCO2e. These findings indicate that although ESG performance has been incorporated into the rating process, it had not yet been converted into quantifiable debt cost benefits during the sample period.

3.1.5. Debt Financing Cost Outcomes

BYD's financing cost advantage is reflected mainly in two respects, namely observable market pricing and debt structure. In terms of pricing, the range of bank borrowing rates at the end of 2024 was 1.85%–2.98%; the second tranche of science and technology innovation bonds (RMB 5 billion, 184 days) carried an issuer rating of AAAsti, although the final coupon rate was not disclosed, and the subscription range for the fourth tranche (RMB 5 billion, 3 years) was 1.50%–2.50%; the senior tranche of 24 Fudi Leasing ABN001 issued by a subsidiary was priced at 1.70%. In terms of structure, the credit rating report shows that accounts payable at the end of 2024 amounted to RMB 241.643 billion, whereas total debt at the same date was RMB 57.738 billion, implying that operating liabilities were approximately 4.19 times the size of interest-bearing debt; the total capitalization ratio stood at 23.90%, far below the asset–liability ratio of 74.64%, indicating that the integrated firm has substituted trade credit for part of its interest-bearing debt. BYD holds a long-term issuer credit rating of AAAsti with a stable outlook.

3.2. Comparative Cases of External Procurement or Contract Manufacturing: NIO versus XPeng

3.2.1. NIO: Asset-Light External Procurement and the Battery Swap Ecosystem

(1) External procurement model and transaction cost characteristics

NIO adopts an external procurement model for core components, carries out vehicle manufacturing in self-built plants, and has constructed a differentiated ecosystem around its battery swap network. Its annual reports do not disclose the share of purchases accounted for by the top

five suppliers, disclosing only the share of the single largest supplier (Supplier A), which stood at 20%, 20%, 15%, 13% and 14% for 2021 to 2025 respectively. With respect to transaction costs, NIO's selling, general and administrative (SG&A) expense ratio over the period 2020 to 2025 was 24.19%, 19.03%, 21.39%, 23.17%, 23.95% and 18.39%, significantly higher than that of BYD over the same period. With respect to financing costs, its ratio of interest expense to average interest-bearing debt was 5.13% in 2025.

(2) Digitalization and user enterprise governance

Through its Transparent Chain platform, NIO promotes real-time two-way sharing of supply chain carbon data, connecting 63 core partners and more than 14,000 materials through real-time direct links, with cumulative alerts exceeding 200,000. In terms of ESG disclosure, NIO's 2025 ESG report discloses Scope 3 emissions of 52,180.95 tCO2e.

3.2.2. XPeng: Contract Manufacturing plus External Procurement, and an R&D-Driven Model

(1) Supply chain under external procurement and contract manufacturing

XPeng initially achieved mass production through contract manufacturing by Haima Automobile and subsequently built its own plants in Guangzhou, Wuhan and Zhaoqing, although core components such as batteries remain mainly externally procured. XPeng discloses the share of purchases accounted for by its top five suppliers, which stood at 31.9%, 34.2%, 21.6%, 33.6%, 27.8% and 33.4% from 2020 to 2025, while the share of the single largest supplier declined from 22.7% to 12.3%. Its R&D-driven character is pronounced: XPeng's R&D expense ratio over the period 2020 to 2025 was 29.53%, 19.60%, 19.42%, 17.20%, 15.80% and 12.37%, significantly higher than that of BYD in the early years and converging in recent years.

(2) Digital carbon management and ESG performance

XPeng has built a digital carbon management system covering 125 suppliers and employs AI models for supply chain risk early warning. In terms of ESG disclosure, XPeng's 2025 ESG report discloses Scope 3 emissions of 10,098,220 tonnes; the company has held an MSCI ESG rating of AAA for three consecutive years and a CDP rating of B, and was recognised in the S&P Sustainability Yearbook as the Industry Mover. In terms of green financing, it issued RMB 895 million of green asset-backed notes through XPeng Financial Leasing in April 2025 and RMB 710 million of green asset-backed securities in September 2025, both receiving the highest green rating of G1, bringing total financing for green business to RMB 1.605 billion.

3.3. Cross-Case Comparison and Findings

Table 1 shows that all three firms have established supply chain digital platforms and disclose both the number of suppliers and the frequency of supplier ESG on-site audits. BYD's transparency derives mainly from four-tier data penetration inside the integrated system through CAMDS, which affords strong verifiability; NIO and XPeng, by contrast, rely on external collaborative platforms, namely Transparent Chain and the digital carbon management system, to obtain supplier data and are therefore constrained by the degree of supplier cooperation. The differences in the number of supplier ESG on-site audits are striking, at 1,569 for BYD, 96 for NIO and 18 for XPeng, reflecting

the greater depth of control that integrated firms exert over supply chain sites, which corresponds to the differences in disclosure quality emphasized by information asymmetry theory.

Table 1. Overall comparison of the three cases

Dimension	BYD	NIO	XPeng
Supply chain model	Complete in-house production covering vehicles, three-electric systems and semiconductors; highly vertically integrated	External procurement of core components; self-built battery swap network and user ecosystem	Early-stage contract manufacturing plus external procurement of core components; self-built plants at a later stage
Self-supply of core components	Engines, batteries and other core components fully self-supplied	Batteries and other core components externally procured; share of top five suppliers not disclosed	Batteries and other core components externally procured; share of top five suppliers disclosed
Supply chain digital platform	Four-tier data penetration through CAMDS; i-D Carbon Chain	Transparent Chain platform with real-time two-way links to 63 core partners	Digital carbon management system covering 125 suppliers, plus AI-based risk early warning
Number of suppliers	15,628	764	848
Supplier ESG on-site audits (number)	1,569	96	18
Scope 3 GHG emissions (tCO2e)	140,014,002.65	52,180.95	10,098,220

Table 2 and table 3 shows that over the comparable period 2020 to 2025, BYD's SG&A expense ratio remained within the range of 5.46% to 6.42%, whereas those of NIO and XPeng fell within the ranges of 18.39% to 24.19% and 12.25% to 49.97% respectively. The savings in transaction costs and the cost controllability brought about by self-supply of core components are further transformed into stronger trade credit capacity: BYD substitutes operating liabilities for interest-bearing debt, with accounts payable at the end of 2024 amounting to approximately 4.19 times total debt, and a total capitalization ratio of 23.90% that is far below its asset–liability ratio of 74.64%. This confirms the governance advantage of integration predicted by transaction cost theory (Williamson, 1979).

Table 2. Comparison of core financial data

Indicator	BYD	NIO	XPeng
Operating revenue (RMB thousand)	803,964,958	87,487,510	76,719,742
Interest expense (RMB thousand)	2,551,657	885,248	379,931
Total interest-bearing debt (RMB thousand)	119,120,640	13,974,153	12,708,815
Asset–liability ratio (%)	70.74	89.80	70.56
Gross margin (%)	17.74	13.62	18.86
SG&A expense ratio (%)	5.77	18.39	12.25
R&D expense ratio (%)	7.21	12.12	12.37
Interest expense / average interest-bearing debt (%)	3.20	5.13	3.06

Table 3. Comparison of selling, general and administrative expense ratios (%)

Year	BYD	NIO	XPeng
2020	5.99	24.19	49.97
2021	5.46	19.03	25.28
2022	5.91	21.39	24.90
2023	6.42	23.17	21.38
2024	5.50	23.95	16.81
2025	5.77	18.39	12.25

Table 4 shows that in 2022 and 2023, NIO's ratio of interest expense to average interest-bearing debt was only 2.01% and 2.07%, below BYD's 4.44% and 5.17%; XPeng also remained stable within the range of 2.79% to 3.17% over the period 2021 to 2025. This apparent advantage stems mainly from three sources of bias. First, NIO and XPeng capitalize part of their interest, so the interest expense recorded in finance costs is understated. Second, NIO historically carried low-coupon convertible notes, which lowered its nominal interest rate. Third, the denominator, average interest-bearing debt, includes lease liabilities and asset-backed securities, which inflates the denominator. By contrast, it is observable market pricing that reflects the true cost of financing: BYD's bank borrowing rates of 1.85%–2.98% and the subscription range of 1.50%–2.50% for its science and technology innovation bonds are both below the 3.50% on NIO-affiliated ABN. This paper therefore emphasizes the use of market pricing rather than accounting-based measures as the basis for judging debt financing cost.

Table 4. Comparison of debt financing cost (interest expense / average interest-bearing debt, %)

Year	BYD	NIO	XPeng
2021	4.35	5.12	3.17
2022	4.44	2.01	2.79
2023	5.17	2.07	2.87
2024	4.79	3.68	2.99
2025	3.20	5.13	3.06

All three firms face common institutional shocks such as subsidy phase-out, the dual-credit scheme and trade barriers. BYD's overseas revenue share reached 38.65% in 2025, exposing it to risks such as European Union countervailing duties, while integration has buffered part of these shocks through self-supply and internal transfer pricing. With respect to ESG, Table 1 shows that all three firms disclose Scope 3 emissions, but the categories covered differ substantially, so emission intensity cannot be compared directly. With respect to external ratings, BYD holds MSCI AA, XPeng holds MSCI AAA and NIO does not disclose its rating, while China Chengxin International states explicitly that ESG adjustment items have no significant impact on the base credit rating. This indicates that ESG had not yet been stably converted into debt cost benefits during the sample period, which is consistent with the findings of Christensen (2022) and Berg (2022) that ESG rating divergence weakens pricing effects.

3.4. Conclusions of the Case Analysis and Theoretical Contributions

3.4.1. Practical Implications

Firm level: The choice of supply chain model should match the core risks of the industry. In segments where raw material prices fluctuate sharply and asset specificity is high, vertical integration is better able to control costs and secure supply; in segments where demand is volatile and technology iteration is rapid, external procurement and collaborative innovation offer greater flexibility.

Creditor and investor level: The assessment of debt financing cost should give priority to observable market pricing, and accounting-based indicators should be adjusted for capitalization and financial instruments, so as to avoid being misled by denominator inflation.

Regulator level: Disclosure guidance tailored to supply chain-integrated firms could be explored, requiring disclosure of self-supply rates, the stability of key component supply and the category breakdown of Scope 3 emissions, thereby reducing the information processing costs of rating agencies and creditors.

3.4.2. Theoretical Contributions

This paper makes three theoretical contributions. First, it induces from the cases a three-layer transmission structure running from transaction costs through trade credit to interest-bearing debt pricing, grounding the governance advantage of vertical integration in observable manifestations of debt financing conditions. Second, it clarifies the divergence in measurement among accounting-based indicators of debt cost, showing that interest capitalization, convertible notes and denominator inflation can lead different measures to give opposite answers, and reminding subsequent research to attend to the boundary conditions of indicator selection. Third, through a traceable and auditable evidence ledger and coding process, it responds to challenges to the reliability of case study research and leaves a comparable record for case studies in the field of supply chain finance.

4. Conclusions and Implications

4.1. Conclusions

Taking BYD, NIO and XPeng as cases and drawing on their public annual reports, bond offering circulars, credit rating reports and ESG reports for 2020 to 2025, this paper reaches four conclusions. First, supply chain vertical integration significantly reduces transaction costs. Over the period 2020 to 2025, BYD's SG&A expense ratio ranged from 5.46% to 6.42%, lower than NIO's 18.39%–24.19% and XPeng's 12.25%–49.97%, and it substitutes trade credit for interest-bearing debt. Second, accounting-based measures of debt financing cost suffer from measurement bias. Because of interest capitalization, low-coupon convertible bonds and denominator inflation, the ratios of interest expense to average interest-bearing debt of NIO and XPeng are lower than that of BYD, yet this does not represent a genuine financing advantage; observable market pricing supports the hypothesis that integration reduces debt financing costs. Third, information disclosure quality and digitalization act as mediators. The internal data penetration and high-frequency supplier audits of integrated firms improve information transparency and reduce the information asymmetry faced by creditors. Fourth, institutional complexity and ESG performance constitute important paths whose effects are not yet fully realized.

4.2. Practical Implications

4.2.1. For Firms

Firms should choose their supply chain model according to the core risks of the industry. For core segments with high asset specificity and large price fluctuations, vertical integration or long-term contracts should be used to lock in supply and cost; for general segments with rapid technology iteration, external procurement and multi-source supply should be maintained in order to preserve flexibility. At the same time, priority should be given to building a traceable supply chain digital platform and to the complete disclosure of Scope 3 emission categories, so as to enhance verifiability for creditors.

4.2.2. For Creditors and Investors

When assessing debt financing costs, creditors should rely primarily on observable market pricing such as bank loan rates and bond coupon or subscription rates, and should make three adjustments to accounting-based indicators: removing the effect of interest capitalization, identifying financial instruments such as low-coupon convertible notes, and unifying the definition of the interest-bearing debt denominator. For integrated firms, particular attention should be paid to verifying the fairness of internal transfer pricing and related-party procurement; for firms relying on external procurement or contract manufacturing, supplier concentration and supply chain disruption risk should be the focus of assessment.

4.2.3. For Regulators

Regulators could issue disclosure guidance for supply chain-integrated firms, requiring disclosure of the self-supply rate of key components, the concentration of the top five suppliers and customers, the coverage ratio of supply chain digital platforms and the category breakdown of Scope 3 emissions. At the same time, they should promote convergence in ESG rating methodology so as to mitigate the distortion of capital allocation caused by rating divergence, and should update auditing and ongoing supervision standards to incorporate supply chain risk assessment.

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Conceptualization, L. S and Q. Y.; methodology, L. S.; software, L. S.; validation, L. S.; formal analysis, L. S and Q. Y.; investigation, L. S.; resources, L. S.; data curation, L. S.; writing—original draft preparation, L. S.; writing—review and editing, Q. Y.; visualization, L. S.; supervision, Q. Y.; project administration, Q. Y.; All authors have read and agreed to the published version of the manuscript.

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