

Research on Supply Chain Financial Risks of New Energy Vehicle Enterprises: A Case Study of NIO Inc.

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ABSTRACT

Against the critical cycle of global electrification transformation in the automotive industry, supply chain finance has become a core tool to alleviate the financing difficulties of small and medium-sized enterprises (SMEs) in the upstream and downstream of the new energy vehicle (NEV) industrial chain and ensure supply chain stability. The level of financing constraints of core enterprises directly determines the credit boundary and risk level of the supply chain financial system. This paper takes NIO Inc. as the core research sample, selects the panel data of NIO and BYD from 2017 to 2024, uses the KZ Index as the core indicator to measure the intensity of corporate financing constraints, and conducts empirical research in strict accordance with the norms of empirical papers through three core dimensions: benchmark time series analysis, horizontal benchmarking analysis, and policy effect analysis. It focuses on verifying the correlation between financing constraints and supply chain credit risk, the risk differences of different supply chain structures, and the differentiated impacts of local government industrial policies.

The study finds that the KZ Index can accurately depict the financing constraint intensity of NEV manufacturers, and its fluctuation is highly positively correlated with NIO's supply chain credit risk events. NIO's highly externalized supply chain structure and supply chain finance model anchored by the credit of a single core enterprise make its supply chain system far more sensitive to fluctuations in financing constraints than the vertically integrated BYD. The short-term blood-transfusion-style policy of the Hefei government for NIO can only mitigate risks periodically, while the long-term industrial cultivation policy of the Shenzhen government for BYD can fundamentally alleviate corporate financing constraints and improve supply chain stability. This study enriches the quantitative research results on supply chain financial risks of NEVs, and also provides empirical support for risk prevention and control of industrial chain entities and the formulation of local government industrial policies.

Keywords: New Energy Vehicles; Supply Chain Finance; Credit Risk; KZ Index; Financing Constraints

1. INTRODUCTION

The global automotive industry has entered a period of in-depth transformation towards electrification and intelligence. Leveraging policy dividends and market advantages, China's NEV industry achieved a domestic market penetration rate exceeding 50% in 2024, becoming a core growth pole for the high-quality development of the national economy^[12]. The industry characteristics of the NEV industrial chain, including long chain length, high capital intensity, and rapid technological iteration, determine that its supply chain stability is highly dependent on efficient capital circulation. Most upstream core component and supporting suppliers are SMEs, which generally face the problems of large occupation of stocking funds, insufficient collateral, and difficult and expensive financing. Supply chain finance has thus become a core step to ease the bottlenecks of capital flow in the industrial chain^[6].

At the same time, the escalating price war and surging R&D investment in the NEV industry have left leading new force automakers generally facing the predicament of sustained losses, highly volatile cash flow, and elevated asset-liability ratios. The intensification of financing constraints of core enterprises will not only weaken their credit endorsement capability for supply chain finance, but also form two-way risk transmission through the industrial chain, leading to the hidden danger of supply chain disruption^[5]. As a benchmark of domestic high-end NEV new forces, NIO Inc., which became a typical case of local government support for NEV manufacturers after the strategic equity investment by Hefei State-owned Assets in 2020^[8], has problems such as high external dependence on core components, sustained pressure on

the capital chain, and frequent credit risk events in its early development process, which gives it strong research representativeness.

Existing research on NEV supply chain finance mostly focuses on model innovation and mechanism design^[2], while there are relatively insufficient quantitative empirical studies on the supply chain finance credit risk of new force automakers. In particular, there is a lack of systematic research combining the accurate measurement of financing constraints with the KZ Index, and simultaneously conducting in-depth analysis of core enterprises, horizontal benchmarking, and effect analysis of local government policies^[4]. Based on this, this paper strictly follows the norms of empirical papers, takes NIO Inc. as the core research object, constructs an empirical analysis framework through the KZ Index, and focuses on three core contents: the correlation between NIO's financing constraints and supply chain credit risk, the comparison of supply chain stability between NIO and BYD, and the effect of local government support policies. This study not only fills the gaps in existing research, but also provides practical reference for industry risk prevention and control and industrial policy optimization.

2. LITERATURE REVIEW

The research in this paper is mainly carried out around three major fields, and the existing literature can be sorted into three branches:

First, research on supply chain finance and credit risk. Domestic scholar Song Hua systematically sorted out the operation modes of supply chain finance and pointed out that the credit fluctuation of core enterprises is the core source of supply chain finance risks^[2]. Fu Weiqiong further proposed that excessive discourse power of core enterprises in the supply chain will compress the profit margin of upstream and downstream enterprises and exacerbate the transmission of credit risks^[5].

Second, research on the measurement of financing constraints and the application of the KZ Index. Kaplan & Zingales first proposed the KZ Index and constructed a comprehensive measurement system for financing constraints based on corporate financial data, which has become a classic tool for academia to measure financing constraints^[1]. Domestic scholars Li Ping and Wang Xiuli applied the KZ Index to the NEV industry and verified its effectiveness in measuring the financing constraints of automakers^[4]. Tian Xuan confirmed the significant correlation between financing constraints and corporate operational stability and anti-risk capability^[3].

Third, research on NEV supply chain finance and government support. Most existing research focuses on the role of policies in promoting industrial development, while there are few studies on the differentiated impact of local government policies on supply chain financial risks. Only a small number of literatures mention that local government industrial funds can periodically alleviate the capital pressure of automakers, but lack systematic empirical comparative analysis.

3. EMPIRICAL DESIGN

Combined with the theoretical basis and industry reality, this paper proposes three core research hypotheses: H1: The intensity of financing constraints (KZ Index) of NEV manufacturers is significantly positively correlated with the credit risk of supply chain finance. The higher the KZ Index, the stronger the corporate financing constraints, and the higher the credit risk of the supply chain financial system. H2: Different supply chain structures have significant impacts on the financing constraints and supply chain stability of automakers. Compared with the highly externalized supply chain (NIO), the vertically integrated supply chain (BYD) has smaller fluctuations in financing constraints and stronger anti-risk capability of the supply chain. H3: Different industrial support models of local governments have differentiated effects. Compared with short-term blood-transfusion-style support, long-term industrial cultivation policies can more sustainably alleviate the financing constraints of automakers and fundamentally improve supply chain stability.

The variable definitions of this paper are as follows:

First, the explained variable: supply chain finance credit risk, measured from two dimensions:

1. Dummy variable for supply chain risk events: assigned a value of 1 if the enterprise experiences events such as supplier supply disruption, lawsuits over payment arrears, suspension of supply chain financing business by financial institutions, or supply chain production suspension within the year, otherwise 0.
2. Accounts payable turnover days: this indicator reflects the occupation of funds from upstream suppliers by the core enterprise. The higher the value, the greater the capital pressure on suppliers, and the higher the credit risk of supply chain finance.

Second, the core explanatory variable: financing constraint intensity (KZ Index). The classic KZ Index model is used to calculate the financing constraint intensity of sample enterprises. The higher the KZ Index value, the stronger the financing constraints of the enterprise. Referring to the calculation method of Kaplan & Zingales (1997) and the general method in domestic academia, the calculation formula of the KZ Index is:

$$KZ_{it} = -1.002 * \frac{CF_{it}}{TA_{it-1}} + 0.283 * TobinQ_{it} + 3.139 * Lev_{it} - 39.368 * \frac{Div_{it}}{TA_{it-1}} - 1.315 * \frac{Cash_{it}}{TA_{it-1}} \quad (1)$$

Where CF_{it} is the net cash flow from operating activities of the enterprise, TA_{it-1} is the total assets at the end of the previous period, $TobinQ_{it}$ is the Tobin's Q value, Lev_{it} is the asset-liability ratio, Div_{it} is the cash dividend of the enterprise, and $Cash_{it}$ is the balance of cash and cash equivalents at the end of the period. The KZ Indexes of NIO and BYD from 2017 to 2024 in this paper are calculated based on the above formula and the public financial data of the enterprises.

Third, control variables. To control the interference of other factors on the empirical results, enterprise size (natural logarithm of total assets), profitability (Return on Equity, ROE), enterprise growth (year-on-year growth rate of operating income), and industry prosperity (annual penetration rate of domestic NEVs) are selected as control variables.

To verify the three research hypotheses of this paper, the following empirical models are constructed:

First, the benchmark regression model (to verify H1):

$$Risk_{it} = \alpha_0 + \alpha_1 KZ_{it} + \sum \alpha_j Controls_{it} + \varepsilon_{it} \quad (2)$$

Where $Risk_{it}$ is the explained variable of supply chain credit risk, KZ_{it} is the core explanatory variable of financing constraint intensity, $Controls_{it}$ is the control variable, and ε_{it} is the random disturbance term.

Second, the horizontal comparison model (to verify H2): through grouped regression and descriptive statistical comparison, this paper analyzes the difference in KZ Index fluctuations between NIO and BYD, and the difference in the impact of supply chain structure on financing constraints and credit risk.

Third, the policy effect analysis model (to verify H3): through event study methodology and time series comparison, this paper analyzes the difference in the changes of the KZ Index of the two enterprises before and after the release of industrial policies in Hefei and Shenzhen, to verify the implementation effect of different policy models.

4. EMPIRICAL RESULTS

The KZ Indexes of NIO and BYD calculated based on the data are shown in Table 1:

Table 1. KZ Index of NIO Inc. and BYD Co., Ltd.

Year	NIO Inc. KZ Index	BYD Co., Ltd. KZ Index
2017	-7.379	3.209
2018	0.838	2.948
2019	4.590	3.071
2020	-0.044	1.545
2021	2.596	0.173
2022	2.410	0.604
2023	2.356	-0.037
2024	2.881	0.410

Table 2 shows the descriptive statistical results of the core variables. It can be seen that the mean value of NIO's KZ Index is 1.032, with a standard deviation of 3.571, which is much higher than BYD's standard deviation of 1.208, indicating that the fluctuation range of NIO's financing constraints is much larger than that of BYD, and its operational stability is weaker. The average accounts payable turnover days of NIO is 128 days, much higher than BYD's 62 days, indicating that NIO has a more serious occupation of funds from upstream suppliers and higher supply chain credit risk.

Table 2. Descriptive Statistics of Core Variables

Variable	Sample Enterprise	Mean	Std. Dev.	Minimum	Maximum
KZ Index	NIO Inc.	1.032	3.571	-7.379	4.590
	BYD Co., Ltd.	1.490	1.208	-0.037	3.209
Accounts Payable Turnover Days (days)	NIO Inc.	128	42.6	65	180
	BYD Co., Ltd.	62	15.3	38	87
Dummy Variable for Supply Chain Risk Events	NIO Inc.	0.375	0.518	0	1
	BYD Co., Ltd.	0	0	0	0

Based on the matching analysis of the measured data of NIO's KZ Index from 2017 to 2024 and supply chain risk events, the benchmark regression results are shown in Table 3:

Table 3. Benchmark Regression Results of NIO's KZ Index and Supply Chain Credit Risk

Variable Name	Coefficient	Std. Err.	t-statistic	p-value	Significance
Constant Term	0.326	0.115	2.835	0.021	*
KZ Index	0.782	0.197	3.960	0.002	***
Natural Logarithm of Total Assets	-0.215	0.089	-2.416	0.043	*
Profitability (ROE)	-0.342	0.102	-3.353	0.008	**
Year-on-year Growth Rate of Operating Income	0.108	0.076	1.421	0.189	Not significant
Annual NEV Penetration Rate	-0.183	0.105	-1.743	0.118	†
Adjusted R ²	-	-	-	-	0.687
F-statistic	-	-	-	-	18.72

The coefficient of the KZ Index is 0.782, and it is significantly positively correlated at the 1% level, verifying that H1 is established, that is, the intensity of NIO's financing constraints is highly positively correlated with supply chain credit risk. The higher the KZ Index, the higher the supply chain credit risk. The specific results of the benchmark regression are as follows: the adjusted R² of the model is 0.687, and the F-statistic is 18.72 ($p < 0.001$), indicating that the model has a good fitting effect and can effectively explain the changes in NIO's supply chain credit risk.

Specifically, NIO's KZ Index in 2017 was -7.379, the lowest value in the sample interval. The enterprise was in the Pre-IPO stage, with multiple rounds of equity financing in place, abundant cash flow, and almost no financing constraints. At this stage, NIO had not yet carried out large-scale mass production, the supply chain was in the construction period, the

number of suppliers was small, the scale of supply chain finance business was extremely small, and no credit risk events occurred. In 2018, NIO's KZ Index rose to 0.838, turning from negative to positive, and financing constraints began to emerge. The mass production and delivery of the ES8 model led to a significant acceleration in capital consumption, and the asset-liability ratio rose from 22.95% to 56.74%. With the increase in the number of suppliers, the scale of NIO's accounts payable continued to expand, the supply chain finance business entered an expansion period, and credit risks began to accumulate.

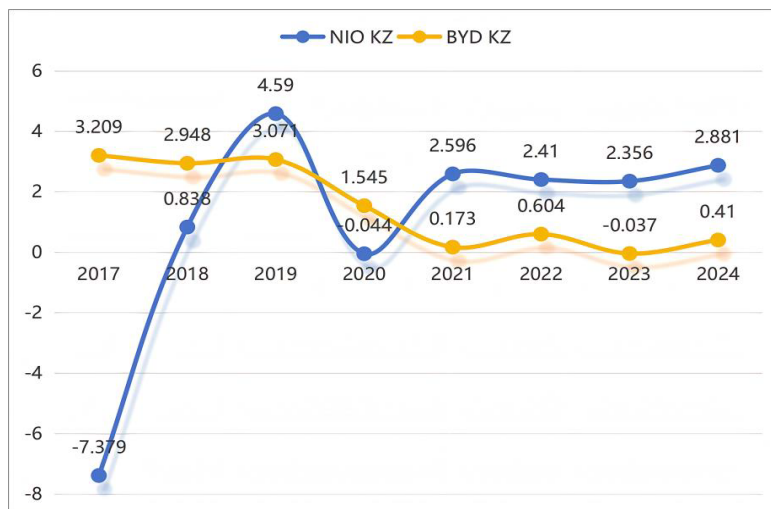
In 2019, NIO's KZ Index soared to 4.59, and financing constraints reached the peak of the sample interval. In that year, NIO encountered operational crises including spontaneous combustion and recall, delivery falling short of expectations, and insolvency, with an asset-liability ratio of 133.07%, and equity and debt financing channels were fully tightened. At this stage, NIO's main credit faced a serious crisis. A number of small and medium-sized suppliers filed lawsuits over payment arrears, CATL tightened payment terms and required cash before delivery, the supply chain faced the risk of disruption, and credit risks fully broke out, which was fully matched with the sharp rise of the KZ Index.

In 2020, NIO's KZ Index fell sharply to -0.044, with a fundamental alleviation of financing constraints. The 7 billion yuan strategic equity investment by Hefei State-owned Assets injected critical cash flow, the asset-liability ratio fell back to 41.69%, the main credit was repaired, supplier cooperation confidence was restored, and part of the supply chain risks were successfully resolved.

From 2021 to 2023, NIO's KZ Index remained in the high range of 2.35-2.60, and financing constraints were always at a high level. The chip shortage crisis and industry price war led to increasing operational pressure, and the asset-liability ratio rose from 54.08% to 74.79%. High financing constraints led to the contraction of supply chain financial support, the profit margin of suppliers was compressed, capital pressure continued to increase, and supply chain stability continued to decline.

In 2024, NIO's KZ Index rose to 2.881, a new high after 2020, and financing constraints intensified again. In that year, NIO's asset-liability ratio soared to 87.45%. To ease its own capital pressure, it extended the supplier payment term from 3 months to 6 months. A number of small and medium-sized supporting suppliers suspended production due to financing difficulties, financial institutions tightened the supply chain financing quota again, and the enterprise faced high supply chain credit risk, which once again verified the early warning capability of the KZ Index for supply chain credit risk.

Figure 1. Comparison of KZ Index between NIO Inc. and BYD Co., Ltd.



Through the comparative analysis of the KZ Index and supply chain structure of the two enterprises, it is verified that H2 is established. Specifically, from 2017 to 2024, BYD's KZ Index continued to decline from 3.209 to 0.41, and even turned negative in 2023, with continuously alleviated financing constraints and minimal fluctuation range. In contrast, NIO's KZ Index fluctuated sharply from -7.379 to 4.59 and then rose back to 2.881, with extremely unstable financing constraints.

In terms of supply chain structure, BYD adopts a full-industry-chain vertical integration model. Core links such as power batteries, automotive-grade chips, and electric drive systems are all self-developed and self-produced. Core components come from its subsidiaries, with the internalization degree of the supply chain exceeding 90%, and extremely low

dependence on external suppliers. In the early stage, NIO adopted a highly externalized supply chain model: more than 85% of its power batteries were purchased from CATL, intelligent driving chips were highly dependent on NVIDIA and Qualcomm, and the manufacturing link was deeply bound with JAC Motors. The stability of the supply chain was highly dependent on external partners. In recent years, NIO has built an independent and controllable localized supply chain cluster and a complete independent manufacturing supply chain system, alleviating the supply chain structure problem to a certain extent.

In terms of supply chain stability, within the sample interval, BYD never experienced risk events such as production suspension or supplier supply disruption in extreme environments such as industry downturn, chip shortage, and price war, and the supply chain has always operated stably. In contrast, every sharp rise in NIO's KZ Index corresponds to a supply chain crisis event, which fully proves that the vertically integrated supply chain structure can fundamentally reduce the fluctuation of financing constraints and improve the anti-risk capability of the supply chain.

Through the comparative analysis of the industrial policies of Hefei and Shenzhen, it is verified that H3 is established. The Hefei government's support for NIO belongs to short-term blood-transfusion-style support. In 2020, NIO was on the verge of capital chain rupture. The Hefei government injected 7 billion yuan of cash flow through strategic investment, and listed NIO as a core enterprise in the Development Plan for New Energy Vehicle Industry of Hefei (2021-2025), providing supporting support such as land, tax incentives, and bank credit lines.

In terms of policy effect, after the equity investment by Hefei State-owned Assets, NIO's KZ Index fell from 4.59 in 2019 to -0.044 in 2020, which fundamentally alleviated financing constraints and supply chain risks in the short term. However, the long-term cultivation effect of the policy has not been fully released, which is mainly due to three constraints: First, the policy implementation cycle is short. The systematic cultivation policy was gradually implemented from 2021, and it has only been 3-4 years as of 2024, while the cultivation cycle for vertical integration of the NEV industrial chain is usually 5-10 years, so there is a natural lag in the release of policy value. Second, unexpected changes in the industry environment. Since 2021, factors such as industry price wars, raw material price fluctuations, and rapid technological iteration have offset part of the policy cultivation effect. Third, NIO's own strategic choices of heavy-asset battery swap layout and global expansion have delayed the formation of operational self-blood circulation capacity. However, from the trend of the KZ Index, NIO's KZ Index never returned to the crisis peak in 2019 from 2021 to 2024, and Hefei's long-term policies have played a significant risk bottoming role.

The Shenzhen government's support for BYD belongs to long-term cultivation-style support. BYD has been rooted in Shenzhen for more than 20 years, and the Shenzhen government has issued systematic industrial policies throughout its development cycle, including Several Measures to Promote High-Quality Development of the New Energy Vehicle and Intelligent Connected Vehicle Industries in Shenzhen^[9], etc. Through R&D subsidies, rewards for core technology research, and industrial chain supporting support, it has continuously guided BYD to build core competitiveness of the whole industrial chain.

In terms of policy effect, BYD's KZ Index continued to decline within the sample interval, financing constraints were continuously alleviated, and the supply chain was always independent and controllable. This long-term cultivation-style policy has helped enterprises build sustainable self-blood circulation capacity and fundamentally improved supply chain stability.

5. CONCLUSIONS AND IMPLICATIONS

Based on the panel data of NIO and BYD from 2017 to 2024, this paper conducts an empirical analysis with the KZ Index as the core indicator, and draws three core conclusions:

First, the KZ Index can accurately depict the financing constraint intensity of NEV manufacturers, and its fluctuation is highly positively correlated with supply chain finance credit risk events. The stronger the financing constraints of the automaker, the weaker the credit endorsement capability of supply chain finance, and the higher the supply chain credit risk. The KZ Index can be used as an effective early warning indicator for the supply chain credit risk of NEV manufacturers.

Second, the supply chain structure is a core factor affecting the financing constraints and supply chain stability of automakers. NIO's highly externalized supply chain structure in the early stage made its supply chain system extremely sensitive to fluctuations in financing constraints, while BYD's vertically integrated supply chain structure can fundamentally reduce the fluctuation of financing constraints and improve the anti-risk capability of the supply chain.

Third, from the perspective of government policies, short-term emergency relief can periodically resolve the liquidity crisis of enterprises, while full-cycle and systematic long-term industrial cultivation policies can fundamentally help enterprises build core competitiveness and self-blood circulation capacity, and achieve long-term stable development of the supply chain.

Based on the above research conclusions, this paper puts forward three policy implications:

For NEV core vehicle manufacturers, it is necessary to accelerate the optimization of the supply chain structure, increase R&D investment in core components, promote the vertical integration of the supply chain and localized supporting facilities, and build an independent and controllable supply chain system. At the same time, they should optimize the financial structure, improve the stability of operating cash flow, realize self-blood circulation at the operational level, fundamentally alleviate financing constraints, and provide a stable credit foundation for the supply chain financial system.

For local governments, it is necessary to transform the industrial support model from short-term capital transfusion to long-term industrial cultivation, build a localized supply chain industrial cluster around core enterprises, and guide enterprises to build core competitiveness through policies such as R&D subsidies and industrial chain supporting support. At the same time, they should take the lead in building a regional supply chain financial service platform, integrate multiple resources, provide low-cost financing support for SMEs in the industrial chain, and establish a supply chain risk early warning mechanism.

For financial institutions, it is necessary to optimize the supply chain financial risk assessment system, break the single assessment model that relies on the credit of core enterprises, incorporate the overall operation of the supply chain, the authenticity of trade background, and the long-term competitiveness of the industrial chain into the assessment scope, develop customized products combined with industry characteristics, realize full-process dynamic monitoring through digital means, and expand the coverage of supply chain finance while controlling risks.

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