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Supply Chain Transformation and Innovation in Global Expansion Amid Geopolitical Challenges: A Case Study of CATL

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Abstract

Amidst a global landscape characterised by the convergence of geopolitical risks and green trade barriers, CATL has overcome geopolitical barriers through its Light Asset technology licensing model, built compliance competitiveness through zero-carbon and smart manufacturing, promoted collaborative global expansion across the industrial chain, and achieved deep localisation. It has successfully transformed geopolitical pressures into strategic opportunities, achieving the upgrading and transformation of its corporate supply chain. This provides a model of sustainable resilience for the global development of China's high-end manufacturing enterprises.

Keywords

CATL; Supply Chain Transformation; Geopolitical Challenges; LRS Model; Zero-carbon Manufacturing.

1. Introduction

Against a backdrop where geopolitical barriers and global carbon neutrality intersect, Chinese high-tech manufacturing enterprises face dual pressures when expanding overseas. This paper analyses CATL's process of overcoming green and technological barriers in Europe and the US, using the evolution of its overseas supply chain from 2019 to 2026 as a case study.CATL has overcome overseas barriers through a dual-track model of "asset-light technology licensing combined with carbon-neutral localisation": in North America, it adopted the LRS model, using technology transfer, management empowerment and equity divestment to circumvent risks associated with the Inflation Reduction Act, whilst collaborating with Ford and Stellantis to reduce political sensitivity.In the European market, CATL simultaneously implemented a strategy of "carbon-neutral manufacturing" and upstream-downstream collaboration. This not only met the compliance requirements of the Carbon Border Adjustment Mechanism (CBAM) and the EU's New Battery Law but also attracted upstream supply chain enterprises to establish operations in Hungary, Spain and other locations. By deeply embedding the concept of "localised production + localised supply chain" in these regions, the company has enhanced its proactive competitiveness.Data indicates that CATL's global market share has risen from 26% in 2020 to 37.9% in 2025, whilst its European market share has grown from zero to 45%, replacing LG Energy Solution and Panasonic as the region's largest battery supplier. This demonstrates the significant success of its model combining asset-light technology licensing with local zero-carbon manufacturing, which effectively mitigates geopolitical risks, reduces operational costs and accelerates market responsiveness.CATL prioritises low-asset technology exports in high-risk regions to mitigate political sensitivity, whilst deepening industrial chain synergy in low-risk areas to consolidate cost advantages, thereby gradually strengthening its dominance in the global supply chain.

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1.1. Research Background and Significance

1.1.1. Research Background

The world is currently undergoing a period of profound transformation unseen in a century, characterised by frequent geopolitical conflicts and the prevalence of unilateralism and trade protectionism.Represented by the US Inflation Reduction Act [1] and the EU Carbon Border Adjustment Mechanism (CBAM, i.e. carbon tariffs) [2], these have become significant external variables influencing the globalisation of the new energy industry. For the power battery industry, which occupies a central position in new energy strategies, the security and resilience of supply chains have become the focal point of political manoeuvring among nations.

1.1.2. Significance of the Study

Taking CATL as a case study, this research integrates geopolitical economics with supply chain management theory,analysing at the corporate level how the company proactively identifies changes in external regulations and implements strategic supply chain innovations under the dual pressures of 'green barriers' and 'technological barriers'. This not only addresses the shortcomings in existing academic research regarding the micro-mechanisms of industrial chain restructuring, but also, through an analysis of its LRS model and zero-carbon factory practices, provides practical guidance for Chinese new energy and high-tech manufacturing enterprises expanding overseas. By providing technical alternatives to capital-intensive factory construction and localized operations for political risk mitigation, this paper delivers actionable guidance amid intensifying Sino-U.S. strategic competition.

1.2. Research Methodology

Case Study Method: CATL was selected as a single in-depth case study, with longitudinal tracking of its overseas expansion from 2019 to 2026.

Comparative Analysis: A horizontal comparison of supply chain differences between CATL and BYD (vertically integrated model) as well as Japanese and Korean firms (patent pool model); a vertical comparison of market share changes before and after the transformation.

Data Analysis Method: Utilising quantitative indicators such as global installed capacity, carbon emission intensity and production capacity planning to objectively evaluate the effectiveness of CATL's supply chain innovations.

2. Theoretical Framework and Industry Environment Assessment

2.1. Mechanisms Through Which Geopolitics Influences Corporate Supply Chains

In today's globalised world, geopolitical risks are no longer merely a macro-level backdrop detached from corporate operations; rather, they permeate directly and profoundly every aspect of corporate procurement, production, logistics, sales and even after-sales services through national governments' industrial policies, trade agreements and market access standards. According to the core tenets of geopolitical economics, strategic competition between nations reshapes global market rules and the flow of resources [3].For enterprises pursuing global expansion strategies, the supply chain network is no longer merely a vehicle for reducing costs and ensuring delivery efficiency; it has become a core battleground for participating in international competition, withstanding external shocks, and securing strategic initiative.

This impact is transmitted primarily through two channels: firstly, the politicisation of 'regulatory barriers'. The EU's Carbon Border Adjustment Mechanism and the localisation requirements in the US Inflation Reduction Act serve as indirect tools that directly raise market entry costs for non-domestic enterprises and erode their competitive advantages. Secondly,

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there is a paradigm shift in supply chain management objectives.Traditional globalised supply chains sought the ultimate in efficiency and cost optimisation under 'just-in-time' production, relying on a finely tuned global division of labour and low-inventory operations. However, in the current climate of geopolitical risk, supply chain resilience and security have superseded mere efficiency as the primary management objectives.Companies are increasingly adopting tiered production capacity backups, diversified supplier portfolios and multi-regional logistics channels to better address the 'supply chain disruption' risks posed by reliance on a single market, a single partner or a single channel. [4]

3. Analysis of the Drivers Behind CATL's Overseas Supply Chain Transformation

CATL's strategic transformation of its overseas supply chain is not a stopgap measure, but a systematic change driven by the company's own development bottlenecks, the evolving needs of the industrial ecosystem, and national strategic direction.

3.1. Corporate Level: Breaking Through the Growth Ceiling and Consolidating Global Leadership

In the domestic market, the power battery sector has shifted from a blue ocean of growth to a red ocean of saturation. BYD has rapidly increased its market share through vertical integration and explosive growth in vehicle sales; second-tier companies such as Zhongchuan New Energy and Guoxuan High-Tech are also striving to catch up. Relying solely on the domestic market can no longer support CATL's expectations for sustained high growth as a listed company.As the world's second and third largest markets for new energy vehicles (after China), Europe and the US have become crucial battlegrounds for CATL to chart a new growth trajectory.

However, the traditional model of overseas expansion through wholly-owned, capital-intensive ventures (such as the factory in Thuringia, Germany) has revealed significant shortcomings: firstly, the high risk of sunk costs, as building overseas factories often requires tens of billions of euros, with long return cycles that exacerbate financial burdens; secondly, the concentration of political risks, where a prominent 'wholly Chinese-owned' label, in the current sensitive political climate, is highly susceptible to becoming a target for regulatory scrutiny and public criticism.Consequently, to strike a balance between rapidly capturing overseas market share and mitigating asset risks, CATL urgently needs to explore a new, more resilient model for supply chain expansion to consolidate its hard-won position as a global leader [5].

3.2. Industry Level: Competing for Technological Leadership and Leading Collaborative Global Expansion of the Industrial Chain

The power battery industry is technology-intensive, features a long supply chain, and relies on deep collaboration.Whoever controls the core technologies and standards dictates the development direction and profit distribution of the entire industry chain. CATL possesses deep technical expertise in areas such as lithium iron phosphate, high-nickel ternary, CTP (Cell-to-Pack, module-free technology) and sodium-ion batteries. Through overseas supply chain deployment, by 'exchanging technology for market access' and 'exchanging standards for market space', it can transform its technological advantages into globally accepted industry standards, thereby securing a position at the top of the value chain.

At the same time, competition in the power battery industry is no longer a matter of individual companies going it alone, but rather systematic competition involving entire industrial clusters. CATL's expansion overseas is not merely a transfer of its own production capacity, but also an opportunity to drive domestic upstream material suppliers (such as anode and cathode manufacturers, separator producers and electrolyte suppliers) and equipment manufacturers to 'go global' together.Co-building industrial clusters overseas to form a regional closed-loop

ISSN: 2692-7608 DOI: 10.6981/FEM.202611_7(11).0020

supply chain-spanning from raw materials to cell manufacturing and on to recycling-will not only significantly reduce logistics and procurement costs but also enhance the collective resilience of the entire industrial cluster against external shocks.

3.3. National Level: Mitigating Systemic Risks and Enhancing the Industry's Global Influence

From the perspective of national strategic security, if the 'heart' of China's new energy vehicle industry-power batteries-were to have its global supply highly concentrated in a single region (such as Europe) or overly reliant on a single model (such as direct exports), the entire industry would face enormous systemic risks. Should drastic policy changes or geopolitical conflicts occur in that region, the consequences would be unimaginable.Consequently, CATL has adopted a 'multi-pronged, diversified model' supply chain strategy involving a presence across multiple European countries, the exploration of new models in North America, and cooperation with countries along the 'Belt and Road' route. This has enabled the diversified allocation of overseas production capacity and market risks, representing a proactive response to the national industrial chain security strategy.

4. Core Pathways for CATL's Overseas Supply Chain Transformation and Innovation

As the core of this thesis, this chapter will systematically analyse the specific measures taken by CATL in its supply chain transformation and innovation from four dimensions: production capacity networks, business models, production systems, and industrial ecosystems.

4.1. Graded Overseas Production Capacity Deployment: Building a Flexible Network "Centred on Europe, Radiating Globally"

CATL has not adopted a 'one-size-fits-all' approach to capacity expansion, but has instead implemented a differentiated, tiered layout based on the geopolitical risk levels, market potential, policy friendliness and inherent resource endowments of different regions.

4.1.1. Strategic Foothold in Western Europe: The Thuringia Plant in Germany

As CATL's first wholly-owned factory in Europe, the site is located in the heart of Germany's automotive industry, adjacent to key clients such as BMW and Volkswagen. Its strategic positioning is not only to achieve the 'first production run' on European soil, but also to serve as a showcase for technology and a customer service centre for the entire European continent.Through this "showcase factory", CATL has provided European vehicle manufacturers with a first-hand demonstration of its advanced production processes and rigorous quality control systems, effectively dispelling potential customer reservations regarding "Made in China" and laying a foundation of trust for future in-depth cooperation. The factory primarily supplies high-end models such as the BMW i Series and Mercedes-Benz EQ Series.

4.1.2. Central and Eastern Europe Hub: Debrecen Plant, Hungary

With a planned production capacity of up to 100 GWh, the Hungarian plant is CATL's largest single investment project in Europe and indeed globally.The choice of Hungary as the location was the result of multiple strategic considerations: firstly, its geographical advantage – situated at the heart of Europe with an extensive transport network, it can efficiently serve the entire Central and Eastern European market, and even Western Europe; secondly, the favourable political climate – Hungary maintains a positive attitude towards cooperation with China, offering a package of incentives including tax breaks and infrastructure support, whilst local labour costs and the quality of skilled workers are more advantageous compared to Germany;thirdly, industrial support, with several Chinese upstream materials companies

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having already established operations there. The plant primarily supplies components for the next-generation vehicle platforms of automakers such as Mercedes-Benz, BMW and Stellantis, serving as the 'keystone' of CATL's European strategy.

4.1.3. Strategic Expansion into Southern Europe: The Aragon Plant in Spain

This project adopts a joint venture model with the domestic vehicle manufacturer SAIC Motor, with plans to produce electric vehicle models suitable for rapidly growing brands in the European market, such as MG.Spain boasts excellent Mediterranean port logistics, facilitating the import of raw materials and the re-export of finished products, whilst also enabling full utilisation of industrial support from the EU's 'Next Generation EU' recovery fund. This deployment further enhances CATL's network coverage in Southern Europe, forming a 'three-point, one-plane' configuration that complements its factories in Germany and Hungary.

4.1.4. North American Differentiation Strategy: A Complete Shift to an Asset-Light Model

Faced with the almost draconian market access barriers erected by the US Inflation Reduction Act, CATL has demonstrated strategic resolve and the courage to innovate its business model. It has completely abandoned the capital-intensive approach of building wholly-owned or majority-owned factories, opting instead for a "soft landing" through the LRS technology licensing model [1].The partnership with Ford marked the pioneering application of this model: CATL invested not a single cent of capital, held no equity stake, and merely licensed battery technology to Ford whilst providing production processes and management services. This ensured the factory was legally recognised as a US domestic enterprise, enabling it to receive the full benefits of the IRA subsidies and skilfully navigate political minefields.

4.2. Supply Chain Model Innovation: The Underlying Logic and Comparative Advantages of the LRS Light-Asset Model

The LRS model is CATL's core innovation in responding to markets with high geopolitical risks, representing a strategic shift from 'manufacturing-driven' to 'technology and brand-driven' [6]

4.2.1. The Core Essence of the LRS Model

The essence of this model lies in "partners providing assets, we providing technology, with no equity ties".

Asset side: All heavy-asset investments, such as factory buildings, equipment and land, are borne by overseas partners, enabling CATL to achieve "zero capital expenditure" and significantly reducing investment risk and cash flow pressure.

Technology side: CATL grants partners access to its core patented technologies, mature manufacturing processes (such as the Extreme Manufacturing System), and expertise in quality control and supply chain management.

Revenue and Control: CATL's revenue is derived from technology licensing fees, production line design fees, operational management service fees, and output-based royalties. At the same time, it retains control over the technical standards, process flows and quality systems of the production lines, ensuring that products meet "CATL standards". As there is no equity link, this partnership enjoys "independence" at both the legal and political levels, effectively circumventing restrictions targeting "foreign entities" [3].

4.2.2. A Comparative Analysis of Mainstream Overseas Expansion Models

CATL's LRS model focuses on "asset-light technology transfer", centring on pure technical services without involving equity control. By reducing capital investment, it mitigates geopolitical risks, whilst the partner bears policy and operational risks. Through technological standardisation, CATL maintains control, thereby achieving technology transfer and brand expansion.**BYD's vertically integrated** model, by contrast, emphasises "control over the entire

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industrial chain". It ensures a closed-loop technology system and product consistency through heavy capital investment and wholly-owned or controlling stakes. Although this entails high capital and risk pressures, it enables the company to achieve scalable profitability by leveraging a stable market. **The patent and alliance** model adopted by **Japanese and South Korean firms** achieves moderate capital investment and risk-sharing through "synergistic cooperation". Relying on cross-shareholdings and joint R&D, it promotes technology sharing and mutual benefit in regional markets with strong industrial complementarity.The differences in these three approaches reflect the differentiated strategic choices made by enterprises based on varying market environments, risk tolerance and resource endowments.

Table 1. Comparison of Mainstream Overseas Expansion Models：

Model Dimensions	**CATL's LRS Model**	**BYD's Vertical Integration Model**	**Japanese and Korean Enterprises' Patent/Alliance Model**
Equity Structure	No equity or minimal equity; purely technical services	Seeks full ownership or absolute control	Cross-shareholding to form an alliance of interests
Capital Expenditure	**Very low** (asset-light operations)	**Very high** (heavy capital investment)	Moderate (concentrated in joint R&D centres)
Risk allocation	Policy/operational risks are primarily borne by the partner	The enterprise bears all risks itself	Shared by the industrial consortium
Control over technology	**Strong** (setting standards, controlling core aspects)	**Very strong** (internal closed loop, absolute control)	Moderate (internal sharing within the alliance, consistent external stance)
Applicable scenarios	Markets with high geopolitical risk and high policy uncertainty	Mature markets characterised by stability, policy-friendly environments and high technological barriers	Markets characterised by strong industrial complementarity and regional alliances

4.2.3. The Strategic Essence of the LRS Model

The LRS model is, at its core, CATL's strategic restructuring of its own global value chain. It anchors the company's core value in 'intangible assets' such as technical standards, management systems and brand licensing-assets that are high in value-added and low in political sensitivity [3].By "de-assetising", it achieves "de-risking" whilst retaining "empowerment" – empowering local partners to jointly serve local markets. This marks the evolution of China's leading manufacturing enterprises from the role of "world's factory" to that of "global technology solutions provider".

4.3. Low-carbon and Smart Upgrades in the Supply Chain: Building Core Barriers for Zero-carbon Smart Manufacturing

In response to "green barriers" such as the EU's carbon border adjustment mechanism and the Battery Regulation, CATL is treating low-carbon and smart initiatives as two foundational projects, transforming compliance costs into competitive advantages.

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4.3.1. Systematic Development of Zero-Carbon Factories

Clean Energy Transition: The company has committed to ensuring that all its European factories (in Germany, Hungary and Spain) utilise 100% green electricity-such as wind and solar power-at the operational level. For instance, the Hungarian factory has signed a long-term power purchase agreement with a local renewable energy supplier [7].

End-to-End Carbon Footprint Traceability: The company has independently developed a battery lifecycle carbon emissions management platform capable of tracking carbon emissions data across the entire supply chain-from upstream mineral extraction, production of cathode and anode materials, cell manufacturing and system integration through to recycling and reuse. It can generate carbon footprint reports compliant with EU requirements in real time, laying solid groundwork for the implementation of digital battery passports.

Significant carbon reduction achievements: According to its published ESG report, through comprehensive measures such as process optimisation, energy-efficient equipment and the substitution of green electricity, the company's greenhouse gas emissions intensity per unit of product has decreased by over 45% compared to the baseline year.

4.3.2. In-depth Transformation of Smart Manufacturing

CATL has deeply integrated technologies such as AI, the Industrial Internet and 5G to create 'lights-out factories' under its 'Extreme Manufacturing' system.In the design of its Hungarian plant, the level of automation and intelligence on the production lines has reached new heights. For example, by deploying thousands of sensors and AI vision inspection systems, the company has achieved online, real-time, and zero-defect quality control across all key processes, from electrode coating to cell formation. A direct result of this intelligent transformation is a reduction of more than 40% in the number of on-site operators required per production line.

4.4. Building a Localised Supply Chain Ecosystem: From 'Going It Alone' to Symbiotic 'Industrial Clusters'

CATL is well aware that establishing a long-term presence overseas cannot rely solely on its own 'going it alone'; it must drive the entire industrial ecosystem to 'take root collectively'.

4.4.1. Upstream and Downstream Collaboration in Going Global

Whilst establishing its factory in Debrecen, Hungary, CATL actively reached out to domestic upstream partners (such as Enjet Co., Ltd. (separators) and Keda Li (structural components)), encouraging and assisting them in setting up supporting facilities in the vicinity of the factory.Consequently, a small industrial cluster centred on CATL and covering key materials and core structural components – embodying the concept of 'Chinese technology + European manufacturing' – is taking shape in north-eastern Hungary. This has not only significantly shortened supply chain response times and reduced inventory costs, but has also strengthened the collective resilience and bargaining power of the entire cluster in the face of local policy changes in Europe.

4.4.2. Deep Localisation of Talent and Culture

The company has proactively established industry-academia partnerships with local universities, such as the University of Debrecen in Hungary and RWTH Aachen University in Germany, launching joint training programmes and internship bases to cultivate engineers and production line managers who possess both technical expertise and an understanding of local culture.At the management level, CATL has also actively recruited local talent with experience in multinational corporations to serve as regional executives. By respecting and integrating local management models and work cultures, the company has effectively reduced cross-cultural conflicts and enhanced team stability and cohesion.

ISSN: 2692-7608 DOI: 10.6981/FEM.202611_7(11).0020

5. Comprehensive Assessment of Implementation Outcomes

This chapter conducts a comprehensive assessment of the effectiveness of CATL's supply chain transformation across three dimensions-market competitiveness, risk resilience and influence within the industrial chain-by combining publicly available industry data with market performance.

5.1. Market Competitiveness and Market Share Changes: A Leap Forward Backed by Data

Global Market: According to SNE Research data, CATL's global market share of power battery installations has risen steadily from 26.0% in 2020 to 37.9% in 2024. It has ranked first globally for eight consecutive years, with the gap to the second-placed competitor widening to nearly 15 percentage points. This strongly demonstrates the global competitiveness of its new model [8].

European Market: In Europe, as production ramped up at the German plant and the Hungarian plant commenced operations, CATL's market position evolved from a 'breakthrough from zero' to 'overtaking the competition'. Data from 2025 shows that its market share in Europe has exceeded 45%, making it the largest battery supplier to major European car manufacturers such as Volkswagen, BMW, Mercedes-Benz and Stellantis, and successfully penetrating the heartland of the traditional automotive industry.

Costs and Finance: The LRS model has significantly optimised CATL's asset structure, alleviated the pressure of capital expenditure on overseas investments, and maintained healthy cash flow and a sound debt-to-equity ratio. Meanwhile, through technological iteration and economies of scale, the pack cost of its lithium iron phosphate batteries has fallen to below 0.4 yuan/Wh-a level that dominates the industry-providing powerful cost 'ammunition' for overseas market expansion [9].

5.2. Resilience to Geopolitical Risks: Success Under Stress Testing

When faced with the most severe geopolitical challenges, CATL's transformation strategy has demonstrated its critical value.

Successfully Breaking Through North American Barriers: Whilst other Chinese battery firms were deterred or struggled to enter the North American market due to the Inflation Reduction Act, CATL achieved a 'soft landing' through its LRS partnership with Ford.This partnership was recognised by the US Treasury Department as meeting domestic production eligibility criteria, enabling products from the joint venture factory to qualify for full subsidies [7]. This not only opened a window for CATL into the future North American market but has also become a classic case study in global industry research.

Overcoming European Green Barriers: By strategically establishing zero-carbon factories and a carbon footprint traceability system in advance, CATL's compliance costs in Europe are significantly lower than those of its Chinese, Japanese and South Korean competitors who were unprepared. As the Carbon Border Adjustment Mechanism (CBAM) is gradually implemented, its products-thanks to data transparency and lower carbon emissions-have instead garnered the "green preference" of certain vehicle manufacturers, transforming compliance pressures into market advantages [7].

5.3. Enhanced Leadership in the Industrial Chain: From Supplier to Rule-Maker

Today, CATL has undergone a fundamental transformation in its identity.

CATL is participating in, and even leading, the technical definition of the next generation of electric vehicles. Its innovative solutions, such as CTP (cell-to-pack) technology, the Kirin battery (third-generation CTP) and the AB battery system, have been adopted by numerous major global automakers as design standards for new vehicle platforms.Through equity

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investments, long-term agreements and strategic partnerships, CATL has secured substantial global reserves of core mineral resources-including lithium, nickel and cobalt-establishing a comprehensive global resource security system spanning the entire chain from 'mine' to 'vehicle' and on to 'recycling'. This control over the entire industrial chain has placed the company in an extremely advantageous position within the global supply chain dynamics.

6. Discussion

This study utilizes the case of CATL to explore how high-tech manufacturing enterprises reconstruct their global supply chains under the dual pressures of geopolitical fragmentation and green trade barriers. The following discussion interprets these findings through the lens of existing theories, highlights theoretical contributions, and outlines managerial implications.

6.1. Dialogue with Existing Theories: From Efficiency to "Resilient Compliance"

Traditional international business theories, such as Dunning's OLI paradigm, have historically emphasized that firms expand abroad to exploit ownership, location, and internalization advantages [10]. However, CATL's practice challenges the traditional trade-off between efficiency and cost, especially in a deglobalizing world.

Redefining Supply Chain Resilience: Existing literature often defines resilience as the ability to recover from disruptions [11]. CATL's case suggests a proactive dimension: **"Institutional Resilience."** By adopting the LRS model, CATL does not merely "bounce back" from political risks (like the US IRA); it structurally bypasses them. This aligns with but extends the "Risk Management" perspective by turning compliance into a competitive moat. It demonstrates that in the face of geopolitical shocks, resilience is not just about operational redundancy but about strategic flexibility in governance structures.

The Evolution of Internalization Theory: Traditional theory suggests firms expand via FDI to internalize transaction costs [12]. Conversely, CATL's "de-equity" LRS model represents a **"Reverse Internalization"** or **"Virtual Integration"** strategy. In high-risk geopolitical zones, the firm chooses *not* to internalize assets to avoid political liability, yet retains control over technology and standards. This indicates that in the era of geopolitical friction, "control" is decoupling from "ownership," a phenomenon that challenges the core tenets of traditional internalization theory.

6.2. Theoretical Contributions

This research contributes to the fields of Supply Chain Management and International Business in three key ways:

Proposing the "Asset-Light Globalization" Framework: We identify a new pathway for emerging market multinationals. Unlike the traditional "Springboard Perspective" which relies on heavy M&A or greenfield investment [13], CATL demonstrates that **intangible assets** (technology, standards, management systems) can substitute for tangible assets (capital, factories) to achieve global market penetration. This offers a theoretical explanation for how firms can globalize under capital constraints and political hostility.

Expanding the Scope of Non-Market Strategy: We integrate "Green Compliance" into supply chain strategy. The study reveals that meeting standards like the EU Battery Law is not just a regulatory cost but a **strategic entry barrier**. By building a "Zero-Carbon Supply Chain," firms can transform external institutional pressures into internal competitive advantages, contributing to the literature on Institutional Theory and non-market strategy [14].

Refining the Concept of Ecosystem Synergy: The study highlights that modern supply chain competition is ecosystem-vs-ecosystem. CATL's strategy of driving upstream suppliers to co-locate in Hungary illustrates a **"Clustered Resilience"** mechanism, where the resilience of the

ISSN: 2692-7608 DOI: 10.6981/FEM.202611_7(11).0020

focal firm is inextricably linked to the collective localization of its industrial chain. This supports Porter's cluster theory but updates it for the context of global value chain (GVC) restructuring [15].

6.3. Managerial Implications

For practitioners, particularly Chinese high-end manufacturing enterprises going global, this study offers three strategic insights:

Flexible Entry Mode Selection: Firms should not rely on a single expansion model. In high-risk markets (e.g., North America), an **asset-light, technology-licensing model** is superior for risk isolation. In friendly markets (e.g., Europe), heavy-asset investment remains necessary to secure market share and deepen localization.

Compliance as a Core Competitiveness: ESG and carbon neutrality must be elevated from corporate social responsibility initiatives to **core supply chain strategies**. Building a transparent carbon footprint tracking system is no longer optional but a prerequisite for accessing Western markets.

6.4. Limitations and Future Research Directions

While this study provides valuable insights, it has limitations. First, as a single case study, the findings may be context-specific to the power battery industry. Future research could employ multi-case studies across different high-tech sectors (e.g., photovoltaics, drones) to test the generalizability of the LRS model. Second, the geopolitical landscape is dynamic. The long-term stability of the LRS model-specifically regarding intellectual property protection and profit distribution in cross-border alliances-requires longitudinal tracking. Future studies should focus on the governance mechanisms of these "non-equity" strategic alliances.

7. Conclusion and Outlook

7.1. Key Research Findings

Through systematic analysis, this study has reached the following core conclusions:

Geopolitical risks have become a key driver of supply chain transformation for high-tech enterprises. Faced with quantifiable green and technical barriers in Europe and the US, the LRS (Light Asset Technology) licensing model offers a novel pathway. This model mitigates risks through 'de-equitisation' whilst maintaining control via 'technology binding', thereby facilitating the transition of Chinese enterprises from merely exporting products to exporting technology, standards and services.

In the development of overseas supply chains, low-carbon and smart manufacturing are fundamental requirements.Carbon-neutral production is the ticket to overcoming green barriers, whilst smart manufacturing is the key to addressing high costs and maintaining efficiency; together, they form the core competitiveness of enterprises. Furthermore, deep localisation is the foundation for long-term success overseas. Enterprises must move away from a single factory-building model and, by driving the collective overseas expansion of industrial chains, deepening the integration of talent and culture, and adhering to compliant operations, build a supply chain system that is deeply rooted in local communities and highly resilient.

7.2. Research Limitations

This study has certain limitations. Firstly, the use of a single-case study, whilst ensuring depth, means that the generalisability of the conclusions still needs to be tested in other overseas industries such as photovoltaics, wind power and high-end equipment. Secondly, the geopolitical landscape is constantly changing; the long-term stability of the LRS model (for

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example, how intellectual property is effectively protected during cooperation and how profit distribution is dynamically adjusted) still requires continuous monitoring and observation [16].

8. Conclusion

This paper takes CATL as its subject to examine how Chinese high-tech manufacturing enterprises can achieve successful global expansion through supply chain transformation and innovation under the dual pressures of geopolitics and carbon neutrality.The paper highlights that CATL has moved away from the traditional, capital-intensive model of wholly-owned factory construction, instead innovatively implementing the 'Light Asset Technology Licensing' (LRS) model in North America. By exporting technology and providing management support, the company has circumvented political barriers; simultaneously, in Europe, it has established 'carbon-neutral manufacturing' and fostered synergy with local industrial chains to comply with local environmental regulations and integrate into the market ecosystem.Research data indicates that this strategy has effectively mitigated geopolitical risks, helping CATL achieve significant market share growth both globally and in Europe, whilst also marking a pivotal shift in China's high-end manufacturing sector from "product export" to "export of rules and standards".

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Appendix

Table 2. Schedule for the Planning and Construction of CATL's Major Overseas Factories (up to 2026)

Plant Location	Country	Planned Capacity	Major Customers	Operating Model	Status
Thuringia	Germany	14 GWh	BMW, Volkswagen	Wholly-owned	In operation
Debrecen	Hungary	100 GWh	Mercedes-Benz, BMW, Stellantis	Wholly-owned	Phase 1 in operation
Aragon	Spain	Planned	SAIC MG	Joint venture	Under construction
Michigan	United States	-	Ford	LRS Technology Licence	Under construction